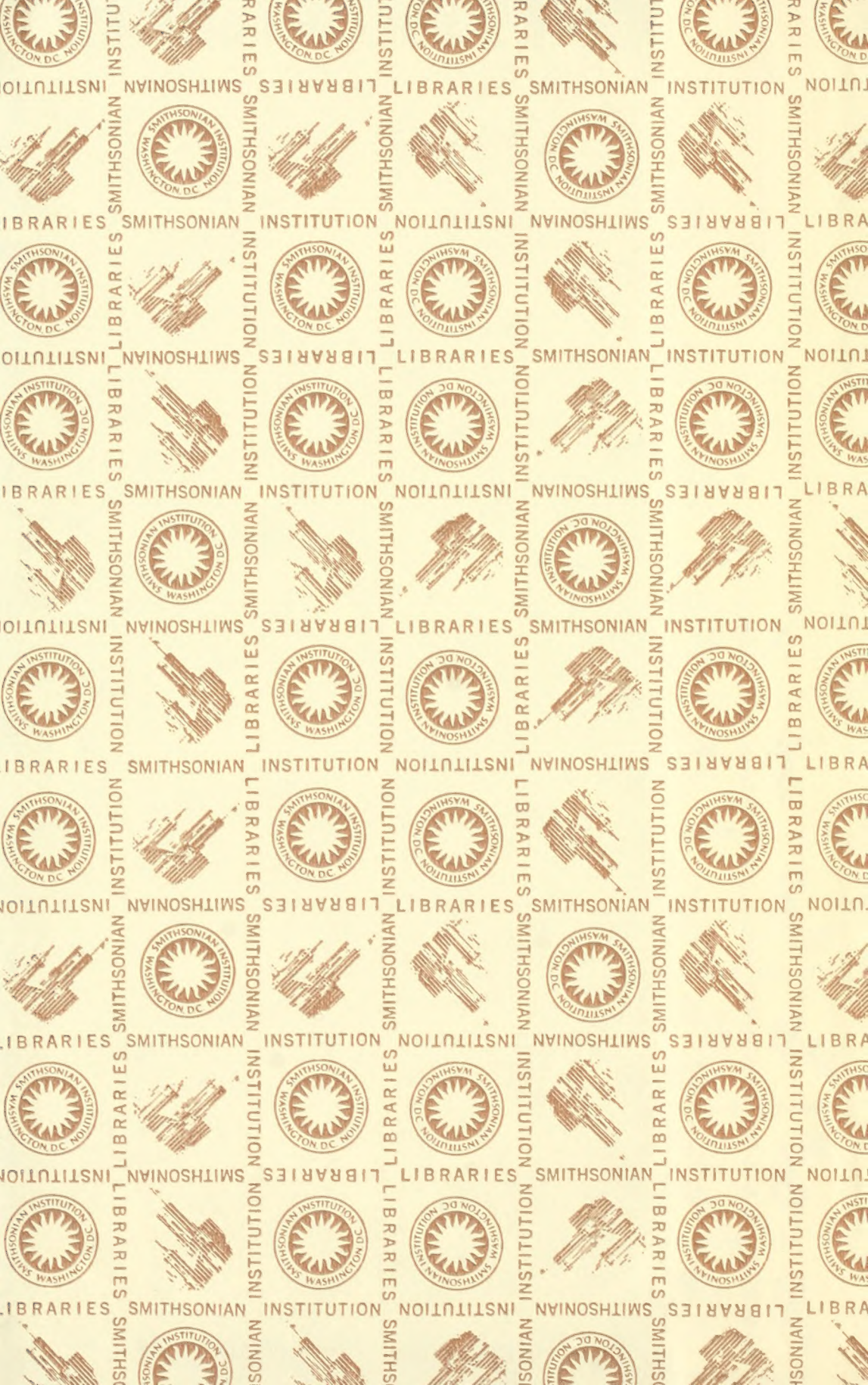
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VOL. 90 JANUARY 1988 NO. 1
(ISSN 0013-8797)

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ENTOMOLOGICAL SOCIETY

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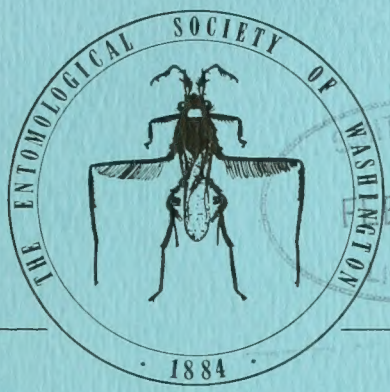

PUBLISHED QUARTERLY

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(*Continued on back cover*)

THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

ORGANIZED MARCH 12, 1884

All correspondence concerning Society business should be mailed to the appropriate officer at the following address: Entomological Society of Washington, c/o Department of Entomology, NHB 168, Smithsonian Institution, Washington, D.C. 20560.

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PROCEEDINGS.—The *Proceedings* are published quarterly beginning in January by The Entomological Society of Washington, % Department of Entomology, NHB-168, Smithsonian Institution, Washington, D.C. Members in good standing receive the Proceedings of the Entomological Society of Washington. Nonmember subscriptions are $35.00 per year, domestic, and $40.00 per year, foreign (U.S. currency), payable in advance. Foreign delivery cannot be guaranteed. All remittances should be made payable to *The Entomological Society of Washington.*

The Society does not exchange its publications for those of other societies.

PLEASE SEE P. 129 OF THIS ISSUE FOR INFORMATION REGARDING PREPARATION OF MANUSCRIPTS.

STATEMENT OF OWNERSHIP

Title of Publication: Proceedings of the Entomological Society of Washington.

Frequency of Issue: Quarterly (January, April, July, October).

Location of Office of Publication, Business Office of Publisher and Owner: The Entomological Society of Washington, c/o Department of Entomology, Smithsonian Institution, 10th and Constitution NW, Washington, D.C. 20560.

Editor: Hiram G. Larew, B-470, ARS, USDA, Beltsville, MD 20705.

Managing Editor and Known Bondholders or other Security Holders: none.

This issue was mailed 27 January 1988

Second Class Postage Paid at Washington, D.C. and additional mailing office.

PRINTED BY ALLEN PRESS, INC., LAWRENCE, KANSAS 66044, USA

PROC. ENTOMOL. SOC. WASH.
90(1), 1988, pp. 1–11

A REVIEW OF THE NEARCTIC SPECIES OF *CRYPTOPRYMNA* FÖRSTER, WITH THE DESCRIPTION OF A NEW GENUS, *POLSTONIA* (HYMENOPTERA: PTEROMALIDAE)

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Abstract.—The genus *Cryptoprymna* Förster, herein reported from the Nearctic region for the first time, is represented by two species, the Holarctic species *C. atra* (Walker) and the Nearctic species *C. dixiana* n. sp. *Cryptoprymna* is redescribed. *C. atra* is reported herein to be a parasitoid of the pupal stages of syrphids on conifers. A new genus, ***Polstonia***, is described with two included Nearctic species: *P. quadriplana* n. sp., the type species, and *P. pelagocorypha* n. sp. A modification of Graham's (1969) key to the genera of the Sphegigasterini is presented to facilitate identification of the genus *Polstonia*. Keys are given to the Nearctic species of both genera.

This is the second, following Heydon and LaBerge (in press), in a series of papers revising the Nearctic miscogasterine Pteromalidae. The specimens upon which this review is based were among the material submitted to me by various collections for that first paper, which was a revision of the genus *Sphegigaster* Spinola. Terminology and methodology follow those used by Heydon and LaBerge (in press) except that descriptions of new species are based on the type-specimens, the "sensillae" of the funicular and club segments are called multiporous plate (abbreviated MPP) sensillae, and the specimens were examined under fluorescent light so may appear more green than described herein when viewed under incandescent light.

This paper contains the first Nearctic record for *Cryptoprymna* Förster. The Nearctic fauna of *Cryptoprymna* contains one Holarctic species, *C. atra* (Walker), and the new Nearctic species *C. dixiana*. Because the original description of the genus (Walker 1833) is now insufficient for distinguishing this genus from several other similar genera erected since 1833, I am redescribing the genus based on my examination of three of the four described species. The original description of *C. atra* is also very short so I am presenting a detailed diagnosis for distinguishing this species from *C. dixiana*. This diagnosis is based on the Nearctic specimens of *C. atra*, which were compared by me with specimens from the Palearctic region from the British Museum of Natural History.

The new genus *Polstonia* is described and followed by descriptions of the two new Nearctic species included in the genus, *P. quadriplana* and *P. pelagocorypha*. The geographic range of this genus extends into the Neotropical region since I have seen specimens from South America that belong to other species in this genus. None of these Neotropical species will be described here due to lack of sufficient material for a thorough study of the fauna of this region.

Both these genera key to the Sphegigasterini in Graham (1969) and are similar in

having the anterior margin of the clypeus without any projecting denticles and reticulate petioles which are distinctly longer than wide. Relationships between these genera and the other genera of the Miscogasterinae will be discussed more fully in a later paper.

Cryptoprymna Förster

Prosodes Walker, 1833: 371, 374 (Preoccupied by Eschscholtz 1829). Type-species: *Prosodes ater* Walker 1833 (monotypy). Lectotype male in the BMNH. Brulle, 1846: 582–583. Gahan and Fagan, 1923: 121.

Cryptoprymna Förster, 1856: 52 (key), pp. 56, 59. Walker, 1872: 97, 98 (key, synonymy). Ashmead, 1904: 330, 332, 372 (key). Nikol'skaya, 1952: 252 (key). Schmiedeknecht, 1909: 375, 376, 380 (key, diagnosis). Gahan and Fagan, 1923: 41. Peck, Boucek, and Hoffer, 1964: 40 (key). Graham, 1969: 124, 140 (key, synonymy). Dzhanokmen, 1978: 77, 80 (key). Farooqi and Subba Rao, 1985: 260, 310G. Farooqi and Subba Rao, 1986: 285.

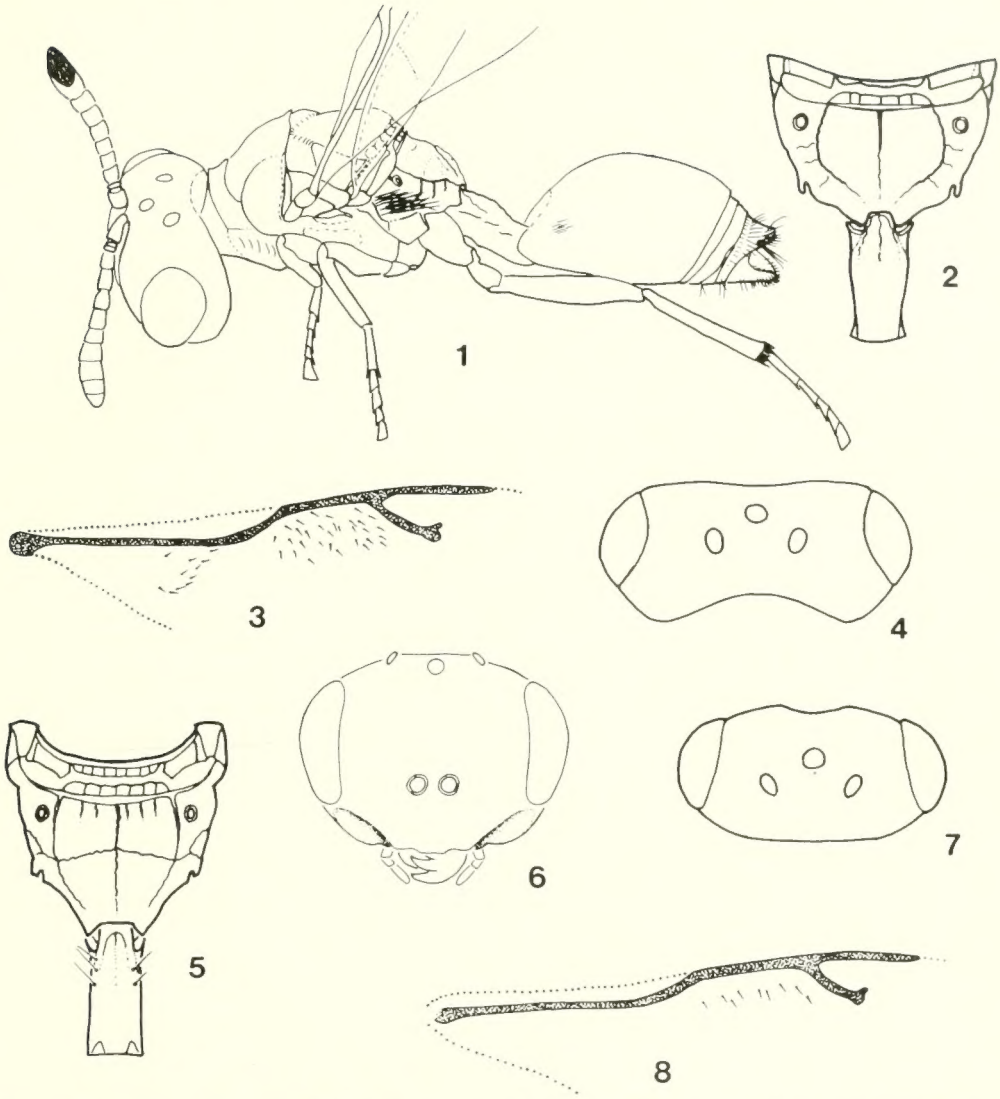
Cryptoprymnus: Thomson, 1878: 17, 22. Cresson, 1887: 75 (key). [Invalid emendation]

Walker (1833) erected the genus *Prosodes* in his *Monographia Chalciditum.* Förster (1856) pointed out that the name *Prosodes* had previously been proposed for a genus of tenebrionid beetles (Eschscholtz 1829), and he renamed the genus *Cryptoprymna.* There are presently three described species: *C. atra* (Walker 1833), a Holarctic species; *C. africanus* Boucek (1976), from southern Africa; and *C. brama* (Motschulsky 1863), from southern Asia. I add a fourth species, *C. dixiana,* from the southeastern United States. Ashmead (1896) described *Cryptoprymna illinoensis* from the Nearctic, but this species was transferred to *Callitula* Spinola (Delucchi 1955) and later synonymized with *Callitula cyrnus* Walker (Burks 1975).

Description.—*Color:* Head, mesosoma, coxae, and petiole black, gaster dark brown. Wing hyaline.

Female.—Head transversely oval in anterior view; 2× as wide as long; clypeus subareolate, anterior margin truncate; gena with broad concavity extending from mouth margin to lower orbit; eye glabrous; occiput concave or straight posteriorly, acarinate. Antenna inserted below middle of face, just above lower orbits; formula 1:1:2:6:3; scape slender, length 8× width, reaching or nearly reaching median ocellus; club distinctly wider than F6, sutures oblique, with a patch of micropilosity on terminal or terminal two segments, terminal spine or projection absent. Mandible 4-tooth, upper two smaller and approximated. Mesosoma compact, rounded dorsally in profile; pronotum with neck short, collar with sharp transverse carina anteriorly and smooth except immediately behind carina; mesoscutum with notauli extending to its hind margin as impressed lines; scutellum as long as wide, frenal sulcus nearly obliterated; prepectus acarinate; mesopleuron with upper epimeron smooth; propodeum as long as scutellum, strongly arched, median carina and plicae sharp, median panels alveolate with some rugae, spiracles round, nucha undeveloped. Wing with basal cell and vein setulose or bare; speculum present; relative lengths of wing veins: marginal > postmarginal > stigmal; stigma unenlarged, only 2–3× as wide as stigmal vein. Legs with coxae relatively small; hind tibia with one apical spur. Petiole much longer than wide, cylindrical; areolate dorsally, strigose laterally; with basal flange laterally and ventrally; lateral setal row sometimes present as a few weak setae anteriorly. Gaster ovate; T1 enlarged, nearly concealing succeeding terga, hind margin convex; hypopygium reaching to tip of gaster.

Male.—Similar to female, but antenna with funiculus parallel-sided, all segments elongate; club lacking area of micropilosity, palps unmodified.



Figs. 1–8. *Cryptoprymna atra* (Walker). 1, Female whole body. 2, Female propodeum and petiole. 3, Female fore wing showing arrangement of dorsal setae along basal vein and admarginal setae. 4, Female head (dorsal view). *C. dixiana* n. sp. 5, Female propodeum and petiole. 6, Female head (anterior view). 7, Female head (dorsal view). 8, Female fore wing showing bare basal vein and arrangement of ventral admarginal setae.

Diagnosis.—*Cryptoprymna* can be distinguished by the following unique combination of characters: edentate clypeus; large area of micropilosity on club; carinate pronotum; propodeum arched and as long as scutellum, median carina and plicae developed; elongate sculptured petiole; enlarged T1; hypopygium extending to tip of gaster; and loss of metallic coloration. Though these character states are all apomorphic within the Miscogasterinae, none of these characters is unique to this genus. This combination of apomorphies is unique, however.

Biology.—Little is known of the biology of the species in this genus. Graham (1969)

mentions specimens of *C. atra* taken on *Abies* sp. and *Pinus sylvestrus* L. Among the Nearctic specimens of *C. atra,* is one from Stockholm, Maine, mounted with a syrphid pupa that has a lateral emergence hole and a label reading "beaten from fir." A specimen of *C. dixiana* n. sp. from Fort Pierce, Florida, was reared from a similar pupa, but there is no information on the plant source of this pupa. It seems likely that species of this genus are parasitoids of syrphids on conifers.

Key to Nearctic Species of *Cryptoprymna* Förster

1. Wing with basal cell and vein setate, ventrally with a patch of setae behind the marginal vein (Fig. 3). Occiput concave in dorsal view (Fig. 4). Petiole bare (Fig. 2) ..... *atra* (Walker)
– Wing with basal cell and vein bare, ventrally with only a single row of setae behind the marginal vein (Fig. 8). Occiput straight in dorsal view (Fig. 7). Petiole with short lateral setal row (Fig. 5) ..... *dixiana* n. sp.

Cryptoprymna atra (Walker)
(Figs. 1–4)

Prosodes atra Walker, 1833: 375. Lectotype male (designated by Graham 1969) in the Westwood collection (BMNH) (not seen). Westwood, 1840: 68–69. Haliday, 1842: V, Plate C (figure). Walker, 1872: 94 (figure); 1873: 371 (figure). Gahan and Fagan, 1923: 41, 121.

Cryptoprymnus cavigena Thomson, 1878: 22. Lectotype female (designated by Graham 1969) in the collection of Universitetets Zoologiska Institutionen, Lund (not seen).

Cryptoprymna atra (Walker): Schmiedeknecht, 1909: 380. Delucchi, 1955: 174 (synonymy). Boucek, 1961: 71 (distribution). Graham, 1969: 140–141 (biology, synonymy, distribution). Boucek, 1976: 14–15. Dzhanokmen, 1978: 80.

Diagnosis.—In addition to the characters given in the key, female *C. atra* differ from *C. dixiana* in the following ways: the truncate portion of the clypeus of *C. atra* has a concave anterior margin and the anterior lateral corners are sharp while the anterior margin is straight and the corners rounded in *C. dixiana*; the antennal flagellum of *C. atra* is longer, 0.89 ± (S.E.) 0.014 (n = 4) times as long as the head width compared with 0.81 times in *C. dixiana*; the antennal club of *C. atra* is more slender, 2.1 ± 0.21 times as long as wide compared to 1.6 times in *C. dixiana*; and the wings of *C. atra* are longer, 2.2 ± 0.13 times the mesosomal length versus 1.7 times in *C. dixiana.*

Biology.—The specimen from Stockholm, Maine, was reared from the pupa of a syrphid which was "beaten from fir."

Nearctic material examined (CNC, INHS, USNM): Canada. BRITISH COLUMBIA: Terrace, 8-VIII-1960, 1 ♀. NEW BRUNSWICK: Acadia Experiment Station (Fredricton) 1·17-VII-1970, 1 ♂, 13-VIII-1970, 1 ♂. QUEBEC: Messines, 10-VII-1947, 1 ♂; Parke Reserve (near St. Eleuthere), 13-VIII-1957, 1 ♂. United States. MAINE: Stockholm, 6-VI-1955, 1 ♀. MICHIGAN: Isle Royale, 3·7-VIII-1936, 1 ♀. OREGON: Saddleback Mt. (near Rose Lodge), 11-VIII-1961, 1 ♀.

The records of *C. atra* from Greenland cited by Bakkendorf (1955) are in error (Boucek 1961).

Cryptoprymna dixiana, New Species
(Figs. 5–8)

Description.—*Holotype female:* Color. Body black with mesosoma tinged blue, scutellum and propodeum tinged gold. Antenna with scape brownish yellow; pedicel and flagellum brown. Legs reddish brown, femora and mid tibia with dark bands; tarsi light brown, pretarsus dark brown. Head and mesosoma with scattered, short (one half ocellar diameter) white setae.

Sculpture.—Clypeus, median area of face subareolate; face laterally and dorsally, frons, vertex finely alveolate; gena coriaceous. Mesosoma with pronotal collar with transverse row of punctures posterior to anterior

transverse carina; mesoscutum alveolate, side lobes more finely so than median lobe; scutellum areolate. Gaster T1 polished; T7 coriaceous.

Structure.—Mesosomal length 0.85 mm. Relative lengths of head, mesosoma, gaster; 16:42.5:33. Head broadly oval in anterior view (Fig. 6), width 1.2× height (33:27), 2.1× length (33:16); clypeus with anterior margin nearly straight mesally, anterior corners rounded; eye height 1.4× length (16:11), 2.1× malar length (16:7.5); POL 1.3× OOL (8:6), 1.5× LOL (8:4); occiput straight in dorsal view (Fig. 7). Antenna inserted a quarter of the way up eye; scape length 0.88× eye height (14:16), reaching to median ocellus, slightly recurved; length of pedicel plus flagellum 0.82× head width (27:33); relative lengths of segments (annelli omitted, club taken as a unit) scape = 14:3:2.5:3:3:2.5:2.5:2:8; widths of F1, F6, club as 2:4:5; F1–2 elongate, F3–4 quadrate, F5–6 transverse; MPP sensillae two thirds length of segment, arranged in single row; club length 1.6× width (8:5), asymmetrically curved to outside, sutures oblique, area of micropilosity extending to midway down C2, C3 pointed apically. Mesosoma with mesoscutal length 0.48× width (12:25); scutellar length 0.93× width (13:14); propodeum with costula rugiform, nucha coriaceous, supracoxal flange drawn out over base of hind coxa. Wing length 2.4× width (71:30); basal cell and basal vein bare (Fig. 8); costal cell with single row of setae; relative lengths of submarginal, marginal, postmarginal, and stigmal veins = 30:14:10:7. Petiole 0.96× as long as propodeum (13:13.5) (Fig. 5); length 2.4× maximum width (13:5.5); with a central and diverging lateral carinae on basal one fourth; lateral setal rows present as a patch of a few setae anteriorly. Gaster 1.6× as long as wide (35:22); T5–6 with distal fringe of setae; hypopygium with short erect white setae.

Allotype male: Color. Similar to female but funiculus, club dark brown; femora dark brown, lighter distally. Structure. Antenna with flagellum parallel-sided, length of pedicel plus flagellum 1.3× head width (39:31); scape length 0.80× eye height (12:15). Petiole longer (petiole 1.2× propodeal length [14:12]), more slender (petiolar length 2.8× width [14:5]). Gaster with terminal segments glabrous.

Diagnosis.—Characters for separating *C. dixiana* from *C. atra* are given in the key to Nearctic species and in the discussion section for *C. atra*. *C. dixiana* can be distinguished from *C. africana* by the same characters given in the key for distinguishing *C. dixiana* from *C. atra*, except that *C. dixiana* and *C. africana* both lack setae on the basal cell and basal vein. The straight occiput and lack of setae on the basal cell of *C. dixiana* distinguishes that species from *C. brama*.

Biology.—The allotype male from Ft. Pierce, Florida, is mounted with a syrphid pupa.

Etymology.—The name is a latinization of Dixie, referring to the southeastern United States distribution of this species.

Type material.—Holotype female is from Andrews, South Carolina, and was collected 8 May 1963 by R. D. Eikenbary (USNM). The allotype male is from Ft. Pierce, Florida, and was collected 26 April 1955 by Holtzburg (USNM).

Polstonia, New Genus

Type-species.—*Polstonia quadriplana* Heydon. The gender is feminine. It is my pleasure to name this genus in honor of Jane Polston with whom I have spent many hours collecting.

Description.—Color: Head, mesosoma, and coxae dark blue to green; metasoma dark reddish brown to black. Wing hyaline.

Female: Face slightly bulging viewed in profile; clypeus subareolate, anterior margin straight or slightly produced; genal concavity short, reaching only one fourth the distance to lower orbit; eye bare, bulging in anterior view; ocellar triangle width 1.5× length; occiput acarinate, moderately concave. Antenna inserted below middle of face,

just above a line between lower orbits; formula 1:1:2:6:3; scape slender (length 7× width), extending to mid ocellus or higher; funicular segments with MPP sensillae in a single row; club with ventral patch of micropilosity and terminal spinelike protuberance on C3. Mandible 4-toothed, upper two smaller and approximated or equally spaced. Mesosoma arched dorsally; pronotum with collar lacking anterior transverse carina, smooth strip along hind margin occupying a third to a half median length; mesoscutum with notauli present as shallow furrows, traceable to hind margin as strip of distinct texture; scutellum as long as wide, with 4–6 pairs of lateral setae, frenal sulcus obscure or absent; prepectus acarinate; mesopleuron with upper epimeron smooth; propodeum with plicae and median carina complete and distinct, median panels alveolate-rugose, nucha obscurely sculptured crescent. Wing with basal vein setate; speculum present; relative lengths of wing veins: marginal > postmarginal ≫ stigmal; stigma small, width only 2–3× width of stigmal vein. Hind tibia with one apical spur. Petiole sculptured dorsally, length 2–3× width; lateral setal row extending nearly entire length of petiole, setae projecting perpendicularly. Metasoma ovate, plicate ventrally near insertion of petiole; T1 and T2 subequal in length, distinctly longer than the succeeding terga, T1 with hind margin straight or sinuate.

Male: Similar to female but club lacking area of micropilosity, palpi unmodified.

Diagnosis.—The possession by *Polstonia* of an edentate clypeus, genal concavities, a thirteen-segmented antenna, the female antennal club with terminal spine and ventral patch of micropilosity, propodeum with distinct median carina and plicae, and an elongate and reticulate petiole makes this genus phenetically similar to *Toxeuma* Walker. It differs from *Toxeuma* by having an acarinate pronotal collar, notauli obscure posteriorly, frenal suture obscured, and lengths of T1 and T2 subequal. In these characters, *Polstonia* resembles *Sphegigaster*. However, *Sphegigaster* species have a bidentate clypeus, never have the female antennal club with a terminal spine and only rarely with a ventral patch of micropilosity, their propodeum lacks the median carina and plicae, and the hind margin of gastral T1 is broadly concave. In contrast, *Polstonia* species have an edentate clypeus, the antennal club in the female with a terminal spine and ventral patch of micropilosity, a distinct median carina and plicae on the propodeum, and gastral T1 has a nearly straight hind margin. The elongate petiole with complete lateral rows of setae that stick out perpendicularly is the one unique apomorphic character defining this genus.

Polstonia can be included in Graham's (1969) key to the Sphegigasterini by modifying the first half of couplet one so it goes to couplet 1a instead of 2, and then inserting the following couplet after the first:

1a. Clypeus simple (Fig. 9). Petiole with lateral row of setae extending at least half its length (Figs. 11 and 12) ..... *Polstonia* Heydon

– Clypeus bidentate or tridentate. Petiole with a short row of setae extending less than half its length 2

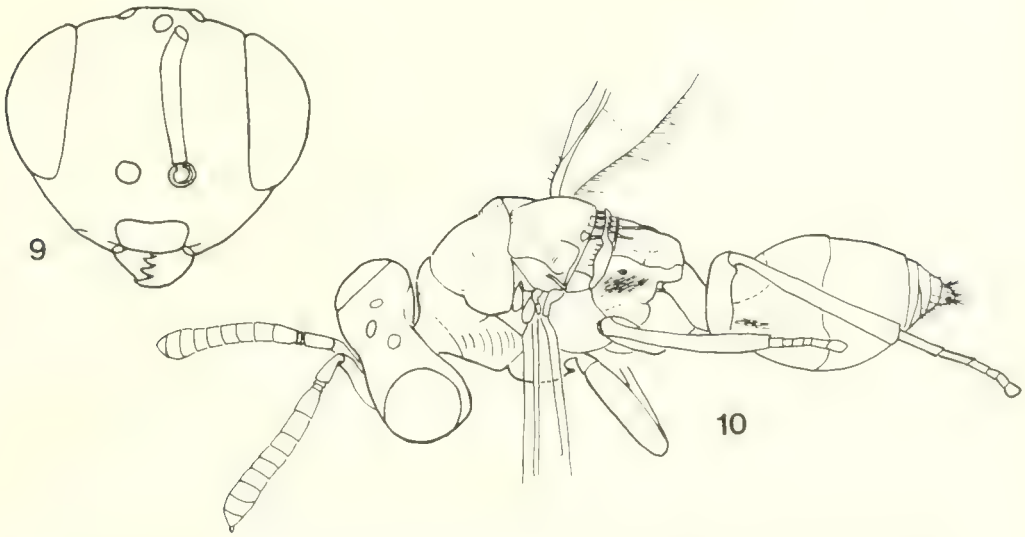
Key to Species of *Polstonia* Heydon

1. Petiole less than 2.3× as long as wide, rounded dorsally, and areolate with reticulations only 2× as long as wide. Propodeum with area between the basal foveae relatively smooth and divided into four equal sized regions (Fig. 11). Usually only the hind femur with basal dark band *quadriplana* n. sp.

– Petiole more than 2.5 · as long as wide, flattened dorsally, and strigulate dorsally with reticulations three or more times as long as wide. Propodeum areolate between basal foveae, sublateral carinae weak or absent (Fig. 12). All femora with dark bands basally .... *pelagocorypha* n. sp.

Polstonia quadriplana, New Species
(Figs. 9–11)

Description.—*Holotype female:* Color. Head, mesosoma, coxae dark green with coppery reflections; occiput, neck, pleural

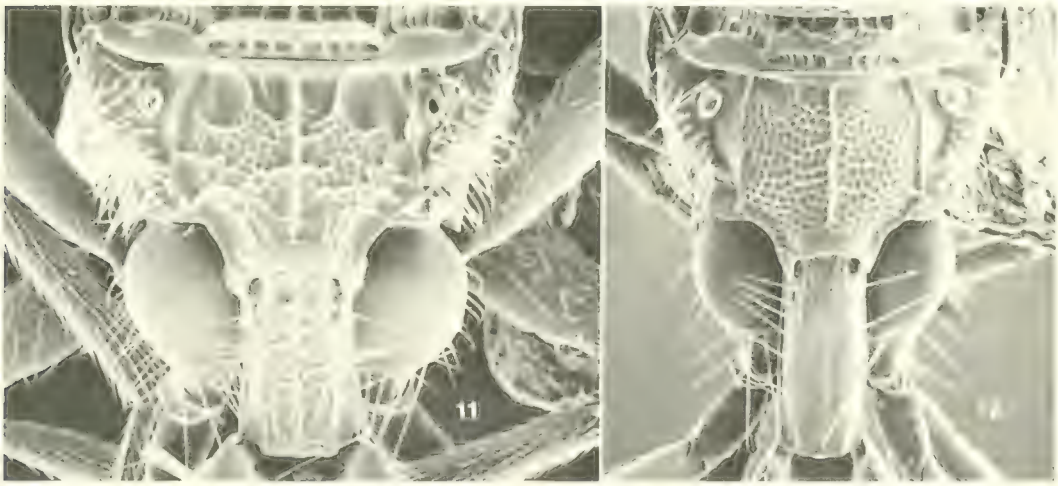


Figs. 9–10. *Polstonia quadriplana* n. sp. 9, Female head (anterior view). 10, Female whole body.

regions, petiole darker; propodeum paler. Gaster black with greenish reflections. Antenna with scape brownish yellow; pedicel brown; flagellum black. Mandible brownish yellow; teeth reddish brown. Legs brownish yellow; strong dark bands on mid tibia and hind femur with greenish reflections, fore femur with weak broad dark band; pretarsus darker. Wing veins pale brown. Head, dorsum of thorax with distinct brown setae.

Sculpture.—Clypeus subareolate; face, frons, vertex, occiput alveolate; neck alveolate; mesoscutum, scutellum, axilla coarsely alveolate; propodeum with median panels areolate-rugose; petiole finely areolate, cells 2× as long as wide; gastral terga 4–7 subimbricate.

Structure.—Mesosomal length 0.96 mm. Relative lengths of head, mesosoma, metasoma = 15:48:42. Head width 1.2× height



Figs. 11–12. *Polstonia quadriplana* n. sp. 11, Female propodeum and petiole. *P. pelagocorypha* n. sp. 12, Female propodeum and petiole.

(37:30) (Fig. 9), 2.5× length (37:15); clypeus with anterior margin slightly produced; eye height 1.3× width (18:13.5), 2.0× malar length (18:9); POL 1.4× OOL (7:5), 2.3× LOL (7:3). Antenna with length of pedicel plus flagellum 0.97× head width (36:37); relative lengths of segments (annelli omitted, club counted as a unit) scape = 17:6:5:4:3.5:2.5:3:3:7.5; widths of F1, F6, club as 3:4.5:5; funicular segments narrowed at bases; F1–2 elongate, F3 quadrate, F4–6 transverse; MPP sensillae prominent; club length 1.5× width (7.5:5), sutures oblique. Mesosomal length 1.7× width (48:29); scutellar length 0.97× width (15.5:16); dorsellum tilted nearly perpendicularly with respect to lateral metanota (Fig. 10), anterior edge regularly rounded, surface with little sculpture; propodeum with spiracles round, groove between basal foveae smooth and divided by the median and two short submedian carinae into four subequal areas (Fig. 11). Wing length 2.2× width (85:38); relative lengths of submarginal, marginal, postmarginal, and stigmal veins = 35:18:16:11; basal vein marked by row of eight setae; basal cell with one seta distally on left wing. Petiole length 1.9× width (13:7); 1.1× as long as propodeum (13:12); rounded dorsally; median carina complete and sharp; length of setae in lateral setal rows a half to three fourths width of petiole. Metasoma broadly oval; length 1.4× width (42.5:32.5); basal region with scattered setae laterally; T4–7 with submarginal row of setae.

Allotype male: Color similar to female except head and dorsum of mesosoma lacking coppery reflections; antennal flagellum brown. Sculpture similar to holotype. Mesosomal length 0.98 mm. Antenna with pedicel plus flagellum 1.2× head width (43:35); relative lengths of segments 15:5:5:4.5:4.5:4.5:4:4:9; width of F1, F6, club as 3:3.5:3.5. Petiole length 2.0× width (14:7). Wings with basal vein having five setae on right wing and four on left.

Variation.—Female mesosomal length varies between 0.76 and 0.96 mm. Body color varies from bluish black, to greenish black, to dark green with coppery reflections like the holotype. A female from Ohio has all the femora with dark bands basally. The groove between the basal foveae is sometimes weakly sculptured posteriorly, but there is always a smooth strip of at least one spiracular outside diameter along anterior margin of propodeum. There are occasional specimens with two strong sublateral carinae on one side or the other. Male mesosomal length varies between 0.90 and 0.98 mm. The body color variation is similar to that of females.

Diagnosis.—In addition to the characters given in the key, the vertex of female *P. quadriplana* is usually nearly concolorous with the dorsum of the mesosoma; in *P. pelagocorypha,* the vertex is distinctly paler. The antenna of female *P. quadriplana* has each funicular segment narrowed basally, the prominent MPP sensillae give the segments a coarse texture, and the club varies between 1.4 and 2.0 times as long as wide. The antenna of female *P. pelagocorypha* has cylindrical funicular segments with a rather smooth texture, and the club varies between 2.0 and 2.6 times as long as wide. In male *P. quadriplana,* the combined length of the pedicel and flagellum is between 4.1 and 4.8 times as long as the club length; it is between 3.6 and 3.9 times as long as the club in *P. pelagocorypha.* The dorsellum of *P. quadriplana* is usually smooth and tilted nearly perpendicularly with respect to the metanota. In *P. pelagocorypha,* the dorsellum is usually alveolate and in nearly the same plane as the metanota. The lateral setae on the petiole are shorter in *P. quadriplana,* only a half to three fourths the width of the petiole (Fig. 11); they are nearly as long as the petiole width in *P. pelagocorypha* (Fig. 12). The petiole always has a distinct and complete median carina in *P. quadriplana* (Fig. 11); in *P. pelagocorypha,* the median carina may be lacking or incomplete, or there may be multiple fine longitudinal rugae (Fig. 12).

Biology.—The host(s) is unknown; however, the numerous specimens from Nova Scotia were collected during a study in which apple trees were fumigated and the arthropods on them were collected on sheets beneath the trees (W. R. M. Mason, pers. comm.).

Etymology.—The name comes from the Latin words *quadrus*, meaning fourfold, and *planus*, meaning flat or level, and refers to the four smoothish areas along the anterior margin of the propodeum, which are diagnostic of this species.

Type material.—Holotype female is from Mt. Ste. Marie Low, Quebec, and was collected 20 September 1965 by J. R. Vockeroth (CNC). The allotype male is from Cooper's Rock State Forest (near Morgantown), West Virginia, and was collected 22 June 1964 by O. Peck (CNC). Fifty-three paratypes are as follows (CNC, INHS, USNM): Canada. BRITISH COLUMBIA: Cultus Lake, 14-VII-1948, 1 ♀. NEW BRUNSWICK: Kouchibouguac National Park, 12-IX-1977, 1 ♀. NOVA SCOTIA: Aldershot, 4-VII-1952, 2 ♂, 1 ♀, 15-VII-1952, 1 ♂, 7 ♀, 28-VII-1952, 11 ♀, 8-VII-1952, 4 ♀, 18-VIII-1950, 4 ♀, 9-IX-1950, 1 ♀. ONTARIO: Innisville, 18-VIII-1963, 1 ♀; Simcoe, 19-VI-1939, 1 ♀. QUEBEC: Lac Brulle, 15-VII-1946, 1 ♂, Mt. Ste. Marie Low, 20-IX-1965, 3 ♀; Old Chelsea, 3-VII-1969, 1 ♂, 5-VIII-1969, 9 ♀. United States. NEW YORK: Lake Placid, 15-VIII-1896, 1 ♀; Otter Lake (near Meridian), 25-VII-1946, 1 ♀. OHIO: Barberton, 30-VI-1936, 1 ♀. VIRGINIA: Monterey, 22-VI-1964, 1 ♂.

Polstonia pelagocorypha, New Species
(Fig. 12)

Description.—*Holotype female:* Color. Head with face, frons dark green; vertex blue-green; occiput greenish black. Antenna with scape brownish yellow; pedicel, flagellum dark reddish brown. Mandible yellowish brown; teeth reddish. Mesosoma with dorsum dark green; pleural area, coxae, propodeum, petiole, gaster bluish black. Legs brownish yellow except trochanters, basal two thirds of fore and mid femora, hind femur brown (hind femur with traces of metallic coloring); pretarsus black. Wing with veins pale brown. Head and mesosoma with pale brown setae.

Sculpture.—Pattern similar to *P. quadriplana* except texture delicate, particularly on head, and petiole strigulate dorsally, cells three or more times as long as wide.

Structure.—Mesosomal length 0.92 mm. Head width 1.2× height (34:27), 2.3× length (34:14.5); clypeus with anterior margin slightly produced and reflexed; eye height 1.2× length (15:12), 1.7× malar length (15:9); POL 1.5× OOL (7.5:5), 2.1× OOL (7.5:3.5). Antenna with length of pedicel plus flagellum 1.0× head width (34.5:34); relative lengths of antennal segments (annelli omitted, club counted as a unit) scape = 15:5:3.5:2.5:3:2.5:3:2.5:10.5; widths of F1, F6, club as 3:3.5:4; funicular segments cylindrical; MPP sensillae fine, club length 2.6× width (10.5:4), sutures only slightly oblique. Mesosoma 1.7× as long as wide (46:26.5); scutellar length 0.86× width (12:14); dorsellum in same plane as metanota, anterior margin scalloped, finely alveolate; propodeum with groove between basal foveae subareolate, with short weak sublateral carinae (Fig. 12). Wing length 2.2× width (89:41); relative lengths of submarginal, marginal, postmarginal, stigmal veins as 32:18.5:17:10; basal vein marked by row of nine setae on left wing; one seta in basal cell of left wing. Petiole length 3.2× width (16:5), 1.3× as long as propodeum (16:12); flattened dorsally; median carina visible only in posterior third; length of lateral setae nearly equal to width of petiole (Fig. 12). Gaster fusiform, length 1.5× width (35:23); succeeding terga withdrawn beneath T2 (specimens air-dried).

Allotype male: Color. Similar to holotype but paler, dorsum of mesosoma green with faint yellowish reflections, antennal pedicel

and flagellum brown, bands on femora dark but extending only one third length of mid and three fourths length of hind femora. Mesosomal length 0.84 mm. Antenna with pedicel plus flagellum 0.98× as long as head width (32.5:33); relative lengths of segments as 13:4.5:4:3.5:3.5:3.5:3.5:3.5:9; parallel-sided, widths of F1, F6, club as 3:3:3. Petiole length 2.6× width (16.6). Wing with basal cell bare except for a couple of setae adjacent to setal row on basal vein on right wing.

Variation.—The female mesosomal length varies between 0.77 and 0.96 mm. Body color varies from bluish black to dark green. The female from North Carolina has the vertex green; in the other females it is blue-green like the holotype. The groove between the basal foveae of the propodeum is sometimes crossed by one or more weak carinae, but these are less than one spiracular outside diameter in length. The petiole varies between 2.6 and 3.0 times as long as wide, and its dorsal surface is either acarinate, with weak or incomplete median carina, or with several long longitudinal rugae. The male mesosomal length varies between 0.67 and 0.94 mm. The color of the males varies from green with coppery reflections to bluish black. The male from Illinois has a brownish yellow flagellum and very weak dark bands on the femora. The petiole varies between 2.7 and 3.0 times as long as wide.

Diagnosis.—For a detailed diagnosis see that of *P. quadriplana* above.

Biology.—The host(s) of this species is unknown.

Etymology.—The name is from the Greek words *pelagos,* meaning sea, and *koryphe,* meaning top of the head, and refers to the sea-green vertex of the female.

Type material.—Holotype female (AMNH) is from 1.5 miles SW of Lolo Hot Springs, Montana, and was collected 22 July 1978 by N. L. Herman. Allotype male (CNC) is from Whiteface Mountain, New York, and was collected 19 July 1962, by J. C. Chillcott. Thirteen additional paratypes are as follows (CMNH, CNC, FSCA, INHS, USNM): Canada. ALBERTA: Edmonton, 20-VI-1937, 1 ♂. NEW BRUNSWICK: Fundy National Park, 10-VII-1970, 1 ♀; Kouchibouguac National Park, 10-XI-1977, 1 ♀. QUEBEC: Duchensay, 5-VII-1953, 1 ♀. SASKATCHEWAN: White Fox, 18-VII-1944, 1 ♀. United States. ALASKA: Matanuska, 6-X-1945, 1 ♂; Palmer, 1-VIII-1948, 1 ♂. ILLINOIS: MacLean Co., 30-V-1883, 1 ♀; Urbana, 10-VI-1928, 1 ♂. MICHIGAN: Manistee Co., 5-VII-1957, 1 ♂. NORTH CAROLINA: Lake Junaluska, 27-V-1954, 1 ♀. WEST VIRGINIA: Spruce Knob, 5-VIII-1960, 1 ♂, Weston, 13·18-IX-1938, 1 ♂.

Acknowledgments

I thank the following persons for the loan of material: M. Favreau, American Museum of Natural History (AMNH), New York, NY; Dr. G. Wallace, Carnegie Museum of Natural History (CMNH), Pittsburgh, PA; Dr. C. M. Yoshimoto, Canadian National Collection (CNC), Ottawa, ON; Dr. H. Weems, Florida State Collection of Arthropods (FSCA), Gainesville, FL; Dr. G. W. Byers, Snow Entomological Collection (SEC), Lawrence, KS; and Dr. E. E. Grissell, United States National Museum (USNM), Washington, D.C. I would like to express my appreciation to J. K. Bousman and Dr. G. L. Godfrey of the Illinois Natural History Survey (INHS), Champaign, IL, and two anonymous readers for reviewing this paper. I would like to thank my advisor, Dr. W. E. LaBerge (INHS) for help and encouragement, J. Sherrod for assistance with the illustrations, and the staff at the Center of Electron Microscopy at the University of Illinois at Urbana-Champaign.

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A NEW GENUS AND TWO NEW SPECIES OF PANGONIINI (DIPTERA: TABANIDAE) OF ZOOGEOGRAPHIC INTEREST FROM SABAH, MALAYSIA

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Abstract.—A new genus of Pangoniini, ***Mesopangonius*** Burger, is described from Mount Kinabalu, Sabah, Malaysia. This is the first representative of this tribe known to occur in the Oriental Region. Although possibly derived from unspecialized Laurasian Pangoniini, its long, slender proboscis is characteristic of specialized genera of the tribe. Two new species, ***philipi*** and ***brackleyae*** are described in the genus, and a key is provided.

A recent small collection of Tabanidae from Mount Kinabalu, Sabah, Malaysia, by entomologists from the Smithsonian Institution, Washington, D.C., yielded two remarkable new species in an undescribed genus of the tribe Pangoniini. These are the first representatives of this tribe known from the Oriental Region, and are particularly interesting because they combine anatomical features of both generalized and specialized genera of Pangoniini.

Mesopangonius Burger, New Genus

Type species.—*Mesopangonius philipi* Burger, Sabah, MALAYSIA, by original designation.

Medium-sized (12–16 mm long) rather slender to moderately stout-bodied *Esenbeckia*-like species with well-developed ocelli; eyes bare with no color pattern; frontal index 2.5–3.0. Antennal bases closely approximated; flagellum subulate, bearing 8 annuli; basal annulation enlarged (Figs. 2C, 4C), about twice as long as high; apical annulation greatly elongated, about one-half length of remaining annulations combined. Proboscis slender, length 1.5–1.9 times height of head; labella long, slender and sclerotized (Figs. 2A, 4A); 2nd maxillary palpomere short and subcylindrical or somewhat flattened on outer surface, and bearing a shallow concavity. Legs long and slender, hind tibial spurs well-developed. Base of vein R_4 with a long spur, basal section of Cu bare or with 2–3 scattered setulae, Sc bare dorsally and ventrally. Female genitalia (Fig. 2E–G): ninth tergite entire, relatively broad and heavily sclerotized laterally, narrowed and weakly sclerotized medianly; tenth tergite divided medially; cerci rounded apically, length and width subequal; eighth sternite shield-shaped, very weakly sclerotized; apical lobes of the anterior gonapophyses deeply divided medially, about as long as wide, distance between lobes about two-thirds width of individual lobes; arms of the genital fork with wing-like expansions apically; distal ends of spermathecal ducts membranous, unexpanded.

Mesopangonius philipi Burger, New Species

Female (Fig. 1).—Length: body 12–14 mm; wing 13–15 mm. Front (Fig. 2B) yel-

Scientific Contribution Number 1485 from the New Hampshire Agricultural Experiment Station.

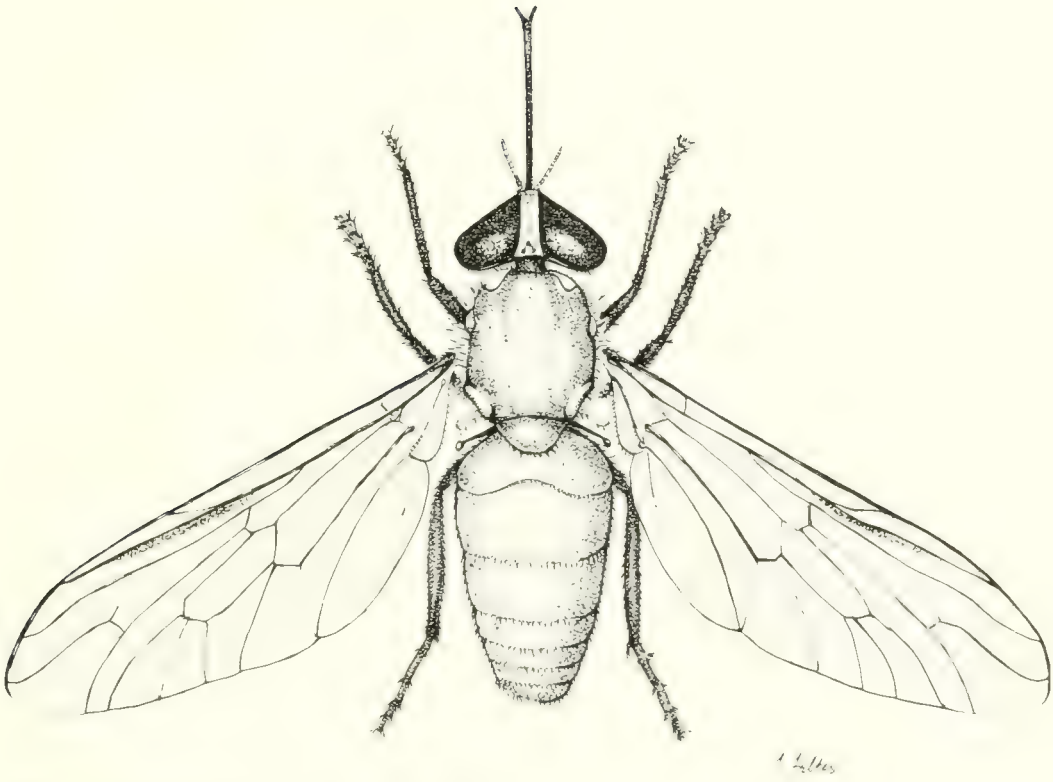

Fig. 1. *Mesopangonius philipi* sp. n., female. (8×)

lowish brown laterally, slightly diverging below, with broad dark brown pollinose ridge in middle extending from subcallus to vertex, bordered by an irregular row of semi-erect black setulae; frontal index 2.8–3.2, divergence index 1.2–1.3. Ocelli large and prominent, borne on a conspicuous tubercle; vertex depressed below upper margin of head. Subcallus, gena and face brown pollinose, gena sparsely clothed with brown hairs; face moderately produced, upper lateral surface with patch of brown hairs; beard rather sparse, with brown hairs anteriorly, pale yellowish ones posteriorly. Antenna (Fig. 2C) yellow brown, slightly darker apically; bases closely approximated, distance between them distinctly less than width of scape; scape and pedicel yellowish brown pollinose, black setose; flagellum subulate, with 8 annuli; basal annulation enlarged, about one-third broader than succeeding annulation and bearing a dense tuft of black setulae at apex of upper margin, apical annulation three times length of penultimate annulation. Proboscis slender (Fig. 2A), length 1.7–1.9 times head height; labella long and slender, sclerotized. Maxillary palpus (Fig. 2D) with apical palpomere short and slender, subcylindrical, length less than one-fifth that of proboscis, bearing long, black semi-erect setae on outer surface, basal palpomere slightly broader than apical segment, bearing long, black semi-erect setae. Eye bare, unpatterned (relaxed), rather coarsely faceted.

Mesonotum light brown, bearing semi-erect brown hairs, except pale yellowish white ones anteriorly near the head; notopleural lobe concolorous with mesonotum; scutellum slightly paler; pleuron paler yellowish brown, bearing pale yellow hairs, except dark brown ones posteriorly on mesan-

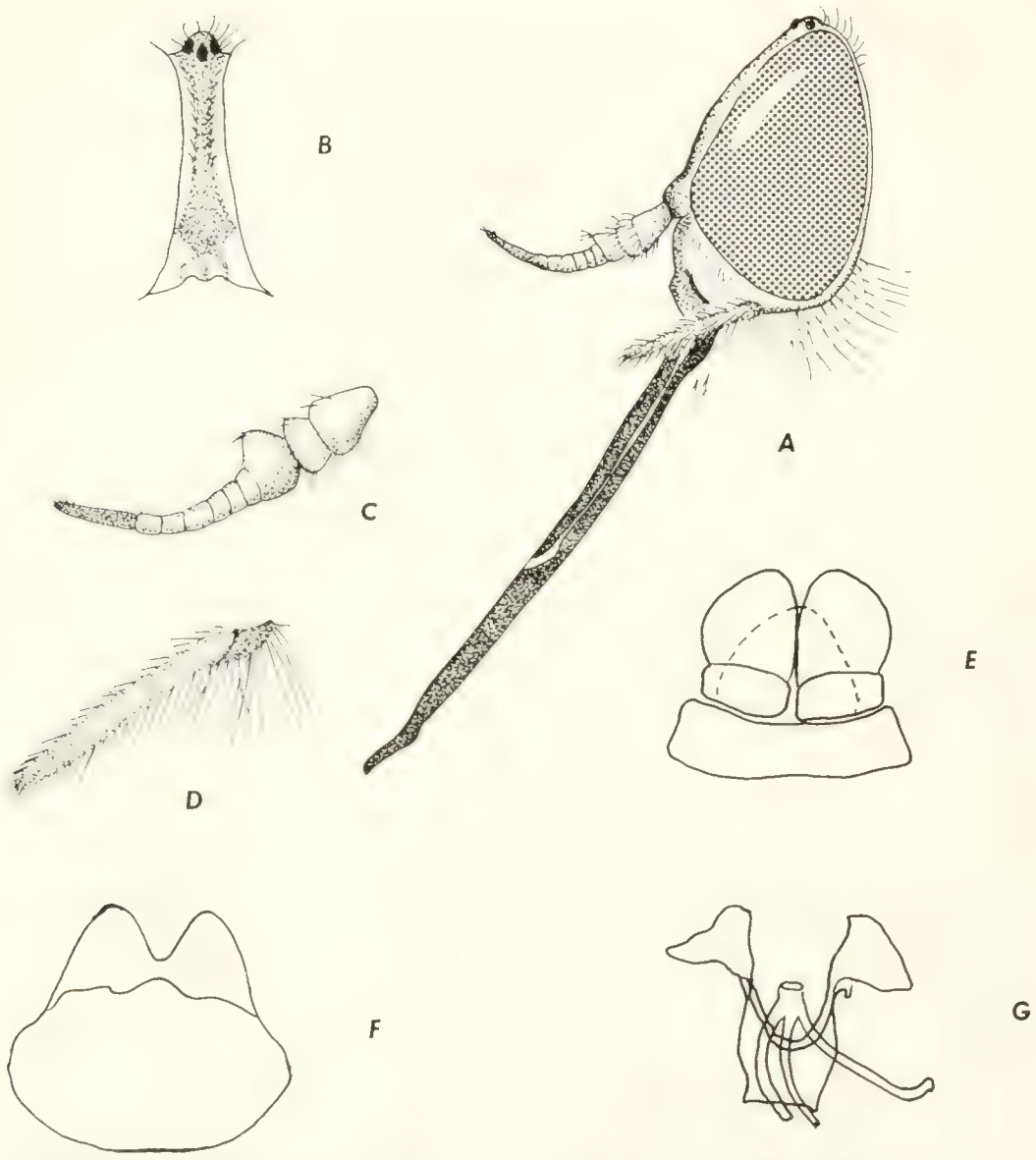

Fig. 2. *Mesopangonius philipi* sp. n., female. A, Profile of head. (16×) B, Frontal view of head. (16×) C, Antenna. (32×) D, Maxillary palpus. (32×) E, Eighth, 9th tergites, cerci, dorsal view. (60×) F, Eighth sternum and anterior gonapophyses. (60×) G, Genital fork and caudal ends of spermathecal ducts. (90×)

episternum. Legs slender, elongate, unicolorous pale yellowish brown, bearing mixed pale yellowish and dark brown hairs; apical spurs on hind tibia nearly as long as those on mid-tibia. Wing lightly brown tinted throughout; R_4 with long spur; cells r_5 and m_3 open to wing margin. Halter light brown.

Abdomen pale greenish brown, with some yellowish tones intermixed but without definite pattern; tergite 1 slightly paler; tergites 5–7 slightly darker; all tergites bearing predominantly dark hairs, with some pale yellowish ones intermixed anteriorly and laterally; ventral surface concolorous.

Holotype ♀, MALAYSIA: Sabah; Kina-

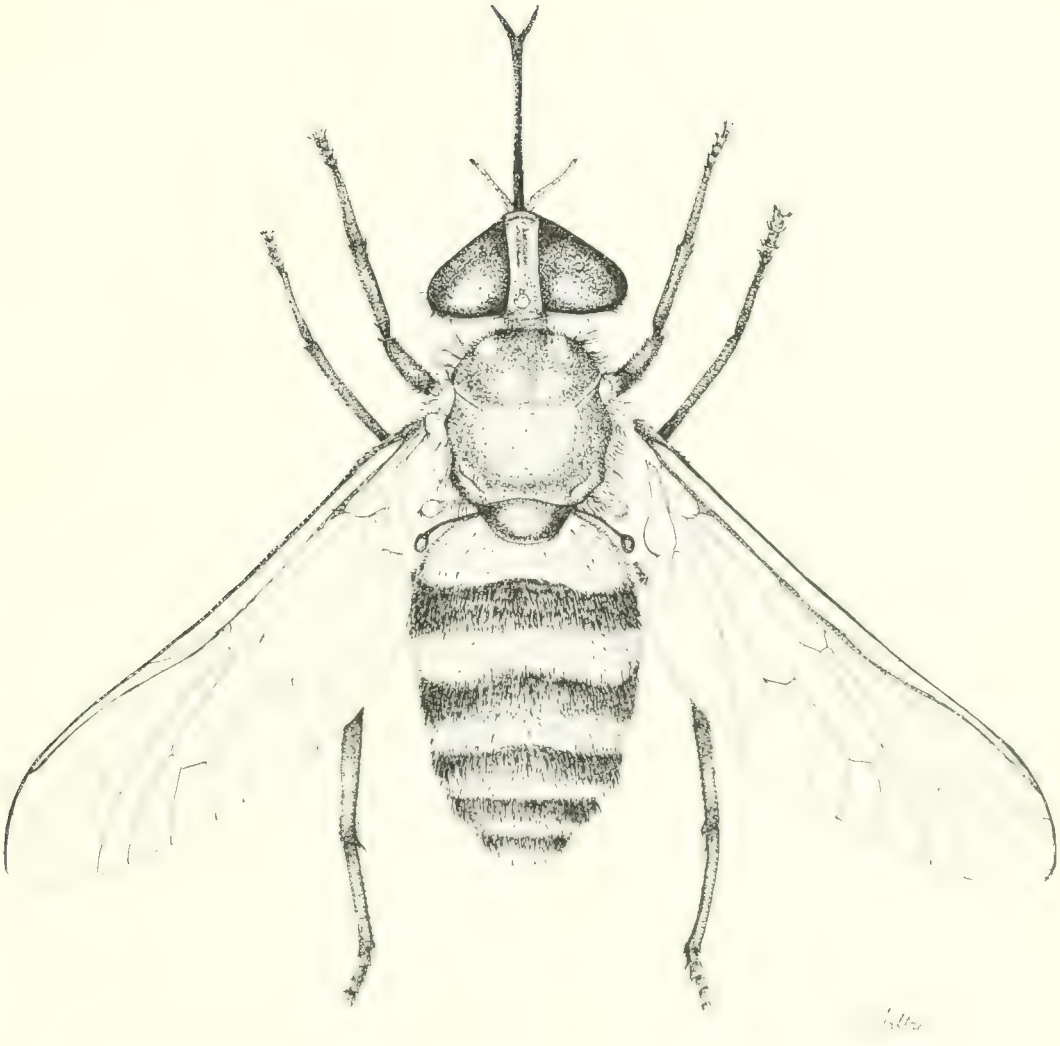

Fig. 3. *Mesopangonius brackleyae* sp. n., female. (8×)

balu National Park, Headquarters area, el. 1560 m, 9 Sept. 1983, G. F. Hevel & W. E. Steiner (National Museum of Natural History, Washington, D.C. (NMNH)).

Paratypes, MALAYSIA: 2 ♀, 8, 13 Sept. 1983. Same data as holotype (NMNH; J. F. Burger Collection).

I take great pleasure in naming this species for the late Cornelius Becker Philip, indefatigable student of Tabanidae, who contributed much to our knowledge of Oriental Tabanidae.

Mesopangonius brackleyae Burger, New Species

Holotype female.—Length: body 15.6 mm; wing 16 mm (Fig. 3). Front (Fig. 4B) dark brown pollinose, slightly diverging below, middle with a poorly-defined raised ridge from subcallus to vertex, bearing an irregular median subshining black area and bordered by an irregular row of black setulae; frontal index 2.5, index of divergence 1.2. Ocelli large and prominent, borne on a

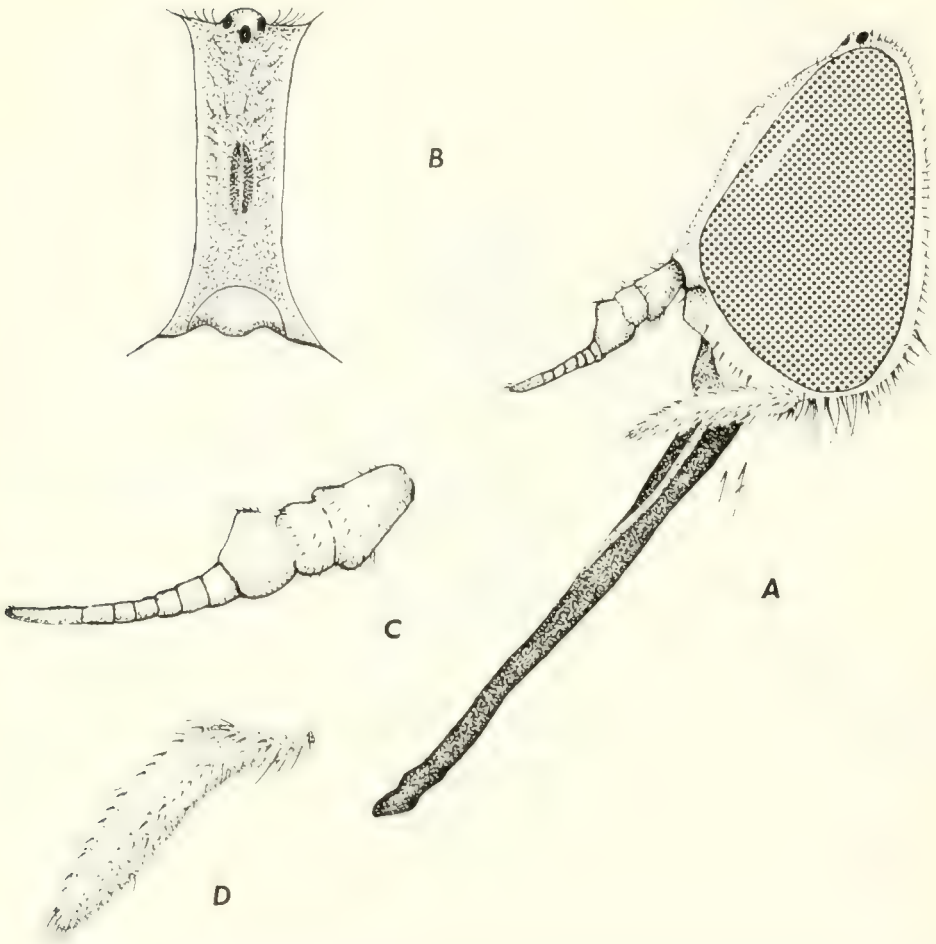

Fig. 4. *Mesopangonius brackleyae* sp. n., female. A, Profile of head. (16×) B, Frontal view of head. (16×) C, Antenna. (32×) D, Maxillary palpus. (32×)

conspicuous tubercle at vertex. Subcallus concolorous with front. Gena and face gray pollinose, except face shining dark brown along lower margin; face moderately produced, dorsolateral surfaces with patch of dark brown hairs; beard mostly pale yellowish, except dark brown hairs anteriorly. Scape and pedicel of antenna yellowish gray pollinose, antennal bases closely approximated, distance between them distinctly less than width of scape; flagellum subulate (Fig. 4C), with 8 annuli, yellowish brown, apical annulation dusky brown; basal annulation conspicuously enlarged, twice as broad as second annulation, bearing 1–2 setulae on upper surface; apical annulation 2.5 times length of penultimate annulation. Proboscis slender (Fig. 4A), length 1.5 times head height, labella long and slender, sclerotized. Maxillary palpus (Fig. 4D) short, apical palpomere brown, distinctly flattened, length one-fourth that of proboscis, bearing long black setae on outer surface and narrow bare median concavity. Eye bare, unpatterned (relaxed), relatively coarsely faceted.

Mesonotum and scutellum subshining dark brown, densely clothed with semi-erect yellowish hairs; postpronotal lobe reddish gray pollinose; notopleural lobe reddish; pleuron grayish pollinose, except mesanepisternum and anterior half of katepisternum with blackish tones, densely yellow pilose.

Legs slender, elongate; coxa and femur dark brown, black pilose, except apex of femur paler; tibia pale brown, bearing yellow hairs; hind tibial spurs well-developed, subequal to mid-tibial spurs; tarsus basally concolorous with tibiae, darker brown apically. Wing light brownish tinted on anterior half, subhyaline posteriorly; R_4 with long spur; cells r_5 and m_3 open to wing margin. Halter pale brown.

Tergite 1 of abdomen entirely pale yellowish brown, pale yellow pilose; tergites 2–4 dark brown on basal three-fourths, contrastingly paler brown on apical fourth, the dark and light areas bearing black and pale yellow hairs respectively; tergites 5–7 dark brown, black-haired, with conspicuous yellow-haired posterior margins (Fig. 3); ventral surface of abdomen with similar pattern as dorsum, except sternite 2 predominantly light brown, and only basal halves of sternites 3–4 dark brown.

Holotype ♀, MALAYSIA: Sabah; Kinabalu National Park, Headquarters area, el. 1560 m, 9 Sept. 1983, G. F. Hevel & W. E. Steiner (National Museum of Natural History, Washington, D.C.).

I take pleasure in naming this striking species for my good friend and colleague, Frances Brackley, a specialist of the Orchidaceae, who first sparked my interest in dipterous pollinators of alpine plants.

The following key will separate the species of *Mesopangonius* described above:

1. Abdominal tergites 2–5 dark brown, with paler brown apices and complete yellow-haired incisures; all femora dark brown, contrasting with light brown tibiae; apical palpomere of maxillary palpus somewhat flattened, outer surface with a bare, shallow concavity ... *brackleyae*, n. sp.
– Abdominal tergites light brown throughout, without strongly contrasting markings or hairs; all femora and tibiae concolorous light brown; apical palpomere of maxillary palpus narrow and subcylindrical, lacking a bare concavity on the outer surface ..... *philipi*, n. sp.

Discussion

Mesopangonius resembles *Esenbeckia* Rondani, a predominantly Neotropical genus, but differs in having the basal annulations of the flagellum not forming a partially-fused, enlarged plate, a more slender proboscis with very narrow, elongate labella, and with cell r_5 of the wing widely open to the wing margin. The female terminalia also are similar to *Esenbeckia*, differing primarily in the broader ninth tergite (Fig. 2E), the more rounded cercus, and the more widely separated apical lobes of the anterior gonapophyses (Fig. 2F).

Mackerras (1955) subdivided the genera of Pangoniini into generalized (Group 1) and specialized (Group 2) moieties. Those genera considered to be more generalized have the r_5 cell of the wing open, proboscis stout and subequal to head height, the labella distinctly enlarged and unsclerotized, and the body usually slender or with the abdomen parallel-sided. Most of the genera included have a south or north temperate relict distribution in montane or desert environments. Fourteen of 18 genera in Mackerras' Group 1 occur in coastal or desert North America (5), the mountains of Chile and Argentina (5), and in Australia (4). Two genera occur in Japan, and one each in Brazil and southern Africa.

Genera of Pangoniini considered to be specialized have cell r_5 closed, or strongly narrowed apically, proboscis slender, as long as to much longer than head height, labella narrow, sclerotized, and sometimes very long, and the body usually stoutly-built. These genera have a predominantly southern Palearctic, amphi-Mediterranean (*Pangonius*), or a new world tropical and subtropical (*Esenbeckia*) distribution. Mackerras considered *Austroplex* Mackerras, from Australia, to be a link between the two groups because of its basally expanded antennal flagellum, but most of its features can be considered generalized.

Mesopangonius also has a preponderance of primitive features, eyes bare and coarsely faceted, cell r_5 of the wing open, relatively slender body (somewhat stouter in *brackleyae*), basal flagellar annulations not consolidated into an enlarged plate, relatively narrow, unspecialized maxillary palpus, the

long, slender legs, and the broad and undivided ninth tergite. The principal specialized features are the long, slender proboscis, the long, narrow, sclerotized labella, and the deeply divided and relatively widely-separated apical lobes of the anterior gonapophyses. The preponderance of primitive features suggests that *Mesopangonius* is closer to the generalized group of genera, and that the elongate, narrow proboscis and labella may be an adaptation to a particular trophic niche. *Mesopangonius* also occurs in a montane "temperate" area on Mount Kinabalu at the northern end of the Crocker Range in Sabah, an environment similar to that where some genera of Pangoniini in Mackerras' Group 1 occur.

Since Borneo is a continental island associated with the Laurasian plate, *Mesopangonius* may be derived from a generalized Laurasian pangoniine stock. Genera of Pangoniini presently known from Eurasia, other than *Mesopangonius,* are *Stonemyia* Brennan (Japan, Southwestern Asia [Caucasus], and possibly China), *Nagatomyia* Murdoch & Takahasi (Japan), and *Pangonius* Latreille (amphi-Mediterranean). *Mesopangonius* differs most conspicuously from *Stonemyia* in having a more slender body, a longer, more slender antennal flagellum, with only the basal annulation enlarged and a much longer apical annulation, a longer, more slender proboscis with a long, narrow, sclerotized labella, shorter palpus, legs longer and more slender, ventral surface of scutellum without bristles, R_4 of the wing with a long spur, the larger, deeply-divided lobes of the anterior gonapophyses, and the caudal ends of the spermathecal ducts membranous and delicate (Fig. 2G). It shares few features with *Nagatomyia* other than the presence of ocelli, the slender body and the open cell r_5. *Mesopangonius* differs from *Pangonius* in having a more slender body, ocelli larger and more prominent, basal annulation of flagellum broader, apical palpomere shorter relative to proboscis length, and with the outer concavity, when present, very shallow, the legs more slender and elongate, cell r_5 of the wing open, and the lobes of the anterior gonapophyses larger and more deeply-divided medianly.

Mesopangonius bears little resemblance to generalized Pangoniini associated with the Australian plate, as one might expect from tectonic evidence. *Ectenopsis* Macquart has coarse eye facets and a narrow cylindrical apical palpomere, but otherwise has little in common with *Mesopangonius.* Some species of *Fidena* Walker, a genus with specialized features in the Scionini that has radiated extensively in the Neotropical Region, have a proboscis configuration like that of *Mesopangonius,* but otherwise are quite distinct.

The only other representatives of the Pangoniinae known from the Oriental Region are in the Philolichini (*Philoliche* Wiedemann). Of these, only species in the subgenus *Buplex* Austen of *Philoliche* share even a superficial resemblance to *Mesopangonius,* and then only because they have ocelli, and some species have a narrow, elongate proboscis. However, they are presently restricted to southern Africa. The Oriental species of *Philoliche* lack ocelli, have strongly produced faces, closed wing cells, lobes of the anterior gonapophyses more widely separated, and other features that clearly exclude them from close relationship with *Mesopangonius.*

It is remarkable that *Mesopangonius* remained uncollected and unknown for so long. Its chance discovery suggests that other representatives of the Pangoniini possibly may be found in remaining "temperate islands" within tropical Asia, given sufficient patience and collecting, before such refuges disappear.

Acknowledgments

I thank G. B. Fairchild, Bureau of Entomology, Florida Department of Agriculture, L. L. Pechuman, Cornell University, and H. J. Teskey, Biosystematics Research Centre, Ottawa, for their helpful comments

about characters of the Pangoniini. I also thank D. S. Chandler and Scott Sherman, University of New Hampshire, for reviewing the manuscript, and Tess Feltes, Portsmouth, New Hampshire, for preparing the illustrations.

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PROC. ENTOMOL. SOC. WASH.
90(1), 1988, pp. 20–27

APTERONA HELIX (LEPIDOPTERA: PSYCHIDAE), A PALEARCTIC BAGWORM MOTH IN NORTH AMERICA: NEW DISTRIBUTION RECORDS, SEASONAL HISTORY, AND HOST PLANTS

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Abstract.—New distribution records for *Apterona helix* (Siebold), an Old World bagworm moth detected in California in 1940 and in New York in 1962, are given for Michigan and Pennsylvania, and additional New York records are provided; populations in western and eastern North America are thought to represent separate introductions from Europe. Seasonal history, habits, and host plants of this parthenogenetic, polyphagous species are reported for populations observed in New York and Pennsylvania, and North American distribution and economic importance in Europe and North America are reviewed. Characters facilitating recognition of this psychid are provided, and the unusual helicoid or snail-like larval case is illustrated.

Members of the psychid genus *Apterona* Millière are endemic to the Palearctic region, with 7 species occurring in the Mediterranean area, west and central Europe, Asia Minor, Crimea, Caucasus, Iranian Plateau, and southcentral Asia (Kozhanchikov 1956). *Apterona helix* (Siebold), a parthenogenetic species, is widely distributed in central and southern Europe, ranging east to European USSR and Kirgiz SSR in central Asia and south to Iran (Strand 1912, Davis 1964).

The first confirmed North American record of *A. helix* was based on an infestation discovered at a private residence in Nevada City, California, in June 1940 (Kiefer 1940, Robinson 1953). In the western states, *A. helix* now occurs in the northern half of California (Eichlin 1985) and in portions of Idaho, Nevada, Utah (Davis 1964), Oregon (Every 1970), and Washington (Suomi 1986).

Apterona helix is also known in eastern North America, having been detected near Albany, New York (Loudonville), in June 1962 (Davis 1964); a second infestation was soon discovered in Albany. Eastern populations are believed to be the result of an independent European introduction rather than to have originated from the established western U.S. populations (Davis 1964). Lenox, Massachusetts (Adamski 1984), is the only other eastern record.

The name *A. crenulella* (Bruand) has been used in early (and some current) literature on this adventive species in North America. Some European workers considered *helix* to be a parthenogenetic form of *crenulella*, whereas others argued that they are distinct species. In revising the Western Hemisphere Psychidae, Davis (1964) retained *helix* as a "facultative, parthenogenetic form," noting interfertility between *crenulella* and *helix* might be expected but that "many

questions remain unanswered." *Apterona helix* is now accorded specific rank (Davis 1983, 1987).

Here we review its status as an economically important species, give additional localities for *A. helix* in New York, and report Michigan and Pennsylvania as new state records. We summarize our observations on seasonal history, habits, and host plants in the East and give morphological characters allowing this immigrant species to be recognized in the North American fauna.

Economic Importance

The European literature indicates that *A. helix* occasionally is injurious. It has been implicated in causing damage to apple, horticultural crops, and olive (*Rev. Appl. Entomol.* (A) 3: 393, 1915; 4: 210, 1916; 56: 553, 1968).

In Utah, *A. helix* has been observed skeletonizing leaves of apple trees and causing extensive damage to many range plants; it sometimes injures various cultivated plants and becomes a nuisance when it congregates on the walls and windows of homes (Tibbetts and Knowlton 1952, Knowlton and Roberts 1968). There also are records of severe damage to cherry foliage in an orchard (Knowlton 1961), leafmining injury to corn (Knowlton and Parrish 1965), and destruction of green color in three acres of barley and four acres of alfalfa (Knowlton 1966). In Idaho, *A. helix* was extremely abundant in alfalfa and sweetclover, causing considerable skeletonizing of the foliage (Gittins 1958). Marshall (1970) recorded heavy damage to strawberry plants in Nevada. In California, where this insect has been called the garden bagworm, considerable damage to several commercial crops such as apple, cruciferous vegetables, and chrysanthemums and other plants grown for cut flowers has occurred when populations are high (Keifer 1947, Robinson 1953). Suomi (1986) reported that baby's breath (*Gypsophila*, Caryophyllaceae) used in dried flower arrangements was so heavily infested in one Washington county that plant material could not be shipped out of state.

There are no reports of damage by *A. helix* to cultivated plants in eastern United States, although Adamski (1984) stated that cases were found attached to planted flowers and vegetables, ornamentals, and shade trees. In New York, the cases have attracted notice when they attach to houses (Davis 1964). Each year homeowners submit larval cases to Cornell University's Insect and Plant Disease Diagnostic Laboratory; their concern is with large number of cases that accumulate on houses and the paint that is sometimes removed when cases are pulled off (Klass 1983).

Distribution in Eastern North America

In addition to published records from the Albany, New York, area and Lenox, Massachusetts, the following new records are available. Michigan, Pennsylvania, and some of the New York records are based on our collecting; other New York records (those without collector names and mostly lacking exact localities) were obtained from the Insect and Plant Disease Diagnostic Laboratory, Cornell University. Voucher specimens have been deposited in the insect collections of Cornell University and the Pennsylvania Department of Agriculture.

MICHIGAN: *Kent Co.*, Wyoming, 5 May 1986, E. R. Hoebeke; Grand Rapids, 6 May 1986, ERH.

NEW YORK: *Albany Co.*, nr. Colonie, Pine Bush, 30 June 1984, ERH and A. G. Wheeler, Jr. *Broome Co.*, Binghamton, 23 July 1983, ERH and AGW. *Chemung Co.*, Rt. 17 N. of Wellsburg, 27 June and 1 August 1982, AGW. *Clinton Co.*, August 1983. *Columbia Co.*, June 1985. *Dutchess Co.*, Stanfordville, October 1984. *Erie Co.*, Tonawanda, 12 June 1983 and 22 June 1985, ERH. *Essex Co.*, May, November 1977. *Livingston Co.*, Dansville, June 1980. *Greene Co.*, East Windham, June 1984. *Monroe Co.*, Greece, 31 July 1982, ERH

and AGW. *Onondaga Co.*, Solvay, 26 June and 4 September 1982, 14 May 1983, ERH and AGW. *Ontario Co.*, Canandaigua, April 1979. *Rensselaer Co.*, Troy, June 1973. *Schenectady Co.*, August 1973. *Tompkins Co.*, Ithaca, 20 April 1987, ERH. *Ulster Co.*, May and September 1982. *Wayne Co.*, Clyde, 25 June 1983, ERH and AGW.

PENNSYLVANIA: *Erie Co.*, Erie, 11 July 1985, AGW. *Lackawanna Co.*, Carbondale, 28 June 1985, AGW. *Lebanon Co.*, I-81 at junc. I-78 NW of Jonestown, 20 August 1982 and March–August 1983, AGW. *Mercer Co.*, Sharon, 29 July 1987, AGW. *Susquehanna Co.*, Thompson, 28 June 1985, AGW.

Our collections of *A. helix* in Broome, Chemung, Erie, Monroe, Onondaga, Tompkins, and Wayne counties in New York; Erie, Lackawanna, Mercer, and Susquehanna counties in Pennsylvania; and Kent County in Michigan were made along or near railroad right-of-ways. In fact, populations were nearly always found only in a small area adjacent to active or abandoned trunk lines. In Lebanon Co., Pennsylvania, *A. helix* apparently is restricted to less than a mile of road near the junction of interstate highways 78 and 81.

It seems reasonable to assume that spread of this flightless, parthenogenetic moth in North America is largely dependent on commerce, especially rail traffic. Mature larvae are known to leave low-growing hosts and to attach to a suitable, usually higher, substrate for pupation (Robinson 1953). A larva could easily attach its case to a rail car in storage and the pupa, female, eggs, or overwintering larvae could be transported many miles to initiate a new colony. In one California orchard a new infestation of *A. helix* was attributed to its introduction as cases attached to a "small private spray rig" that had been used in the infested area (Armitage 1953).

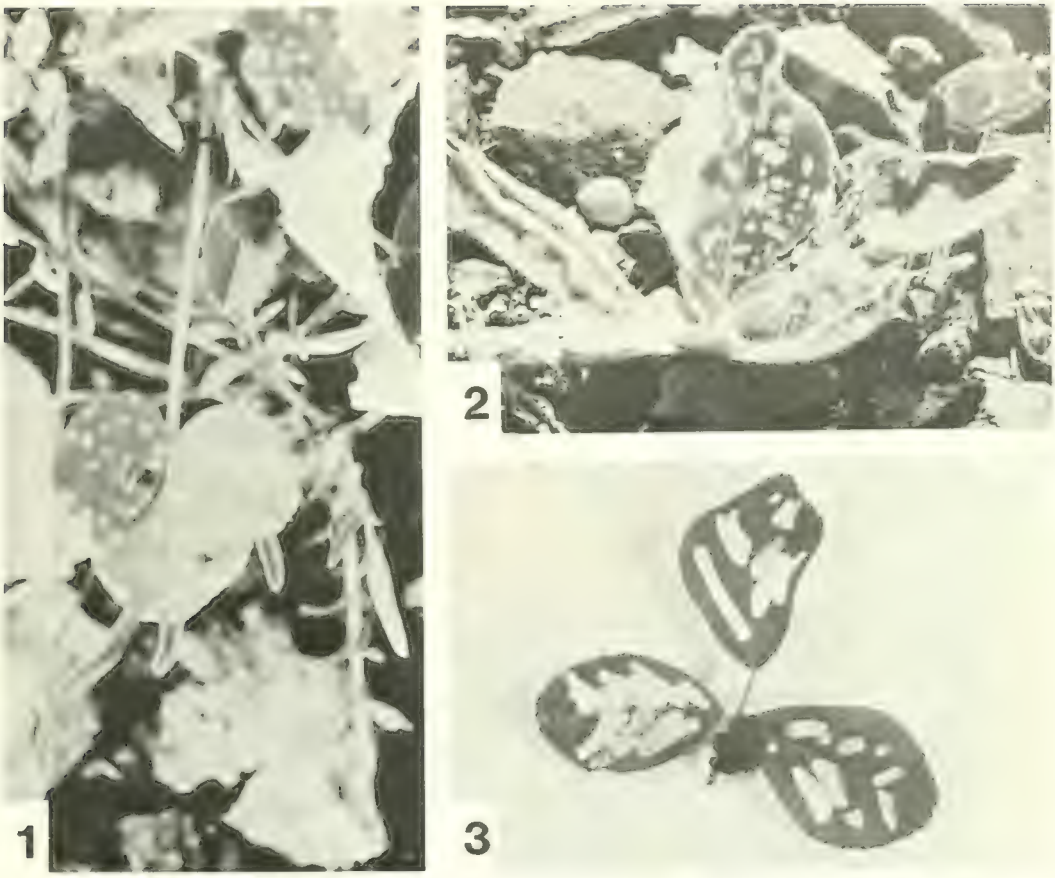
Seasonal History and Habits

To obtain information on phenology of this psychid in eastern North America, collections were made in 1983 from a roadside planting and from guardrails at the junction of interstate highways 78 and 81 in Lebanon Co., Pa. Observations were made and cases collected on 30 March; 1, 13, 22, and 27 April; 5, 11, and 18 May; 2 and 21 June; 15 July; and 3 August. Populations at the site were not as large as the hundreds of old cases adhering to guardrails might suggest, and on several sample dates the bagworms were not easily found on vegetation; cases, which "resist weathering to an amazing degree" (Robinson 1953), probably persist for years in protected places.

Life stages present in the population were approximated by dissecting small numbers of cases (usually only 5–10) on each sample date and, for larvae, measuring widths of head capsules. Such measurements suggested four larval instars: I, 0.28–0.30 mm wide (n = 40); II, 0.36–0.40 mm (n = 16); III, 0.48–0.54 mm (n = 10); and IV, 0.64–0.80 mm (n = 9).

As Robinson (1953) reported for *A. helix* in California, young larvae overwinter within the female's pupal skin. Larvae apparently construct septa within this empty shell so that each is enclosed in its own cell (Davis 1964). In Pennsylvania during late March–early April, 14 occupied cases that were collected on guardrails and examined in the laboratory contained first instars. As many as 42 and 49 larvae emerged from a single case. Several cases were coated with clover mites, *Bryobia praetiosa* Koch, and their egg shells. When cases were brought into the laboratory, larvae soon emerged, began to construct their own cases from sand and soil of old cases, and to feed on foliage, the damage appearing as tiny, circular transparent areas (Fig. 1).

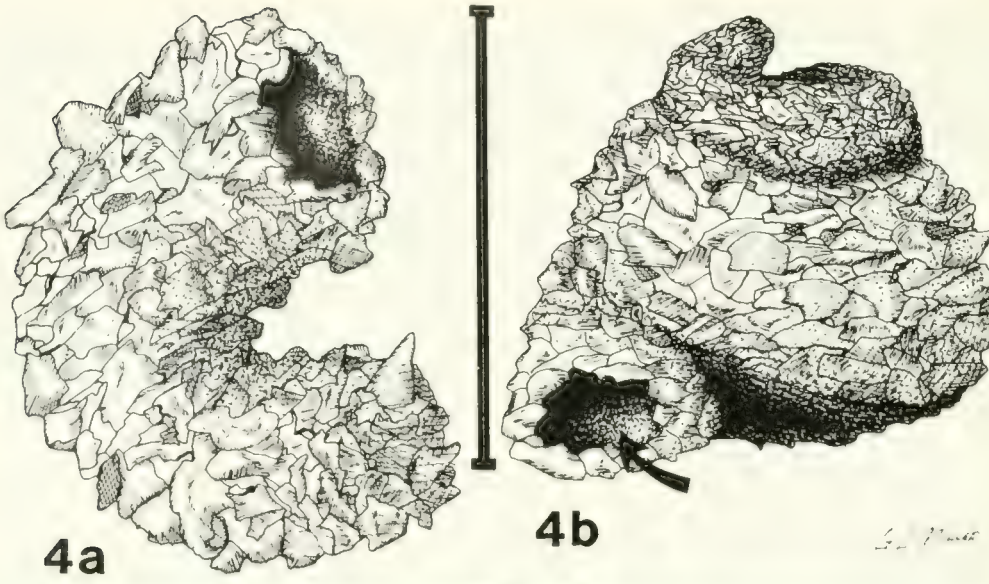
On 13 April, first instars, about 1 mm long and without cases, were active on guardrails, with a few larvae in small cases observed on nearby spotted knapweed, *Centaurea maculosa* Lam. (Asteraceae). These cases consisted merely of a few sand grains on the body. Some knapweed leaves



Figs. 1–3. Feeding damage to foliage by larval stages of *Apterona helix*. 1, Early-stage larvae (with small cases) feeding on black medic, *Medicago lupulina*, causing tiny, circular transparent areas. 2, Feeding injury by mature larvae to leaves of common mullein, *Verbascum thapsus*. 3, Feeding injury by mature larvae to black medic.

showed slight feeding symptoms similar to those observed in the laboratory. First instars were the only stage found in cases taken on 22 and 27 April (n = 7, 10) (Fig. 6). Of 5 larvae collected on 5 May, 3 were first and 2 were second instars; by 11 May only one first instar was present in a collection that contained 8 second instars; and only second instars were present on 18 May (n = 5). Cases observed during May were larger, consisting of a white silken sac impregnated with grains of sand and soil (Fig. 4a). Robinson (1953) described these cases as having the form of an inverted J or U. In May damage on knapweed foliage became more obvious.

Larvae feed mainly at night (Davis 1964). A larva feeds by using silk to fasten its case to a leaf and emerging through an opening near the bottom of the case (see Fig. 4b). It chews a hole in the adaxial or abaxial surface, inserts its head in the opening, and scrapes out tissue between the leaf surfaces, making a nearly oval mine. Davis (1964) noted that this injury closely resembles that made by lepidopteran larvae of the genus *Coleophora* (Coleophoridae). Two, three, or more windowlike areas were observed on some small leaves (Figs. 2, 3). According to Robinson (1953), fecal material is expelled through a lateral aperture in the upper or smallest whorl of the case.



Figs. 4–5. Larval cases of *Apterona helix*. 4a, Case of early-stage larva, consisting of small silken case impregnated with grains of sand and soil. 4b, Mature larval case, usually of 2½ to 3½ whorls; arrow indicates large basal opening through which the larva emerges to feed; scale line = 5 mm. 5, Aggregation of larval cases on trunk of tree sapling.

Ten cases collected on 2 June contained third instars; all nine taken on 21 June yielded fourth instars (Fig. 6). Mature larvae occupy the lower whorl (Robinson 1953, Davis 1964) of the helicoid or snail-like cases (Fig. 4b). On 15 July few active larvae were observed on knapweed, but closed cases were apparent and clumped on small trees (Fig. 5); several cases opened in the laboratory were found to contain pupae. Mature larvae also ascended guardrails for pupation, where current-season cases could not be distinguished in the field from those of previous seasons. At other localities utility poles were used as pupation sites, with large numbers of old cases occurring in cracks and crevices.

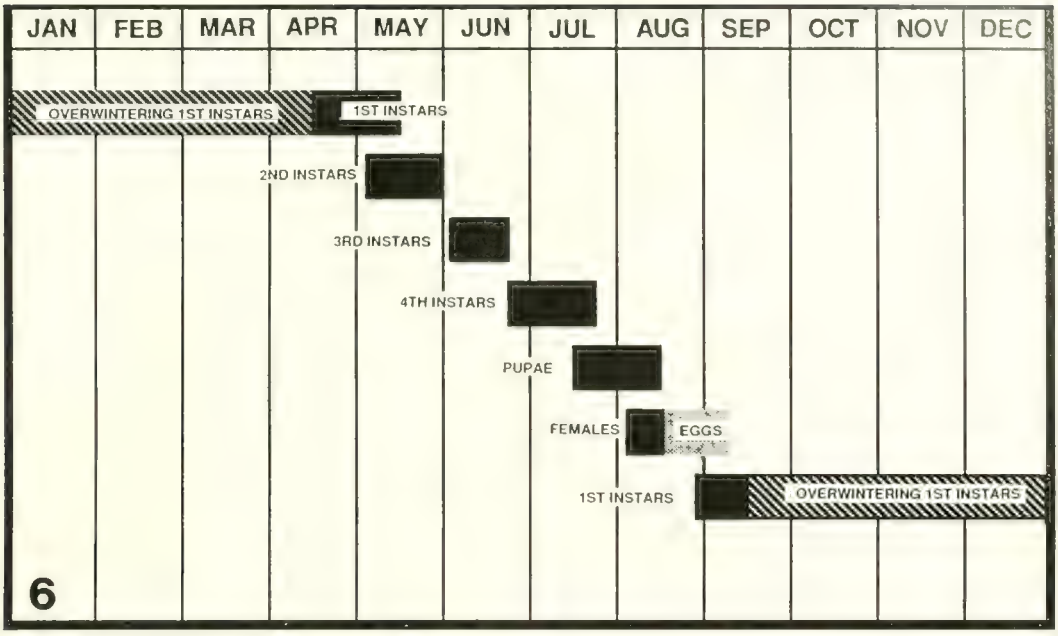


Fig. 6. Inferred seasonal history of *Apterona helix* in Pennsylvania. (Note: stippling indicates period when 1st instars are overwintering inside the female case.)

Females were found in several cases collected on 3 August. Robinson (1953) reported that yellowish-white eggs (about 25/ case) were laid in the pupal skin that remains in the lower whorl and hatch in about 3 weeks; the diapausing larvae remain inside the case through the winter.

Seasonal history of the Pennsylvania population studied was nearly the same as that reported for *A. helix* in northern California (Robinson 1953). Overwintered first-instar larvae became active in mid-April and fed until early to mid-July, with females appearing to oviposit in August.

Host Plants

Spotted knapweed, the most frequently infested host at the study site in Lebanon Co., Pennsylvania, was the most common host plant observed along railroad lines in New York and Pennsylvania. White and yellow sweetclover, *Melilotus alba* Medik. and *M. officinalis* Lam. (Fabaceae), also were infested. The large population of *A. helix* at Solvay, New York, severely damaged these plants and several unidentified hosts. Species that showed occasional injury or moderate to heavy damage at only one or a few sites included green foxtail, *Setaria viridis* (L.) Beauv. (Poaceae); mugwort, *Artemisia vulgaris* L. (Asteraceae); black mustard, *Brassica nigra* (L.) Koch, and peppergrass, *Lepidium virginicum* L. (Brassicaceae); blueweed, *Echium vulgare* L. (Boraginaceae); common mullein, *Verbascum thapsus* L., and yellow toadflax, *Linaria vulgaris* Mill. (Scrophulariaceae); common evening-primrose, *Oenothera biennis* L. (Onagraceae); cinquefoil, *Potentilla* sp. (Rosaceae); buckhorn plantain, *Plantago lanceolata* L., and broadleaf plantain, *P. major* L. (Plantaginaceae); knotweed, *Polygonum* sp. (Polygonaceae); and crownvetch, *Coronilla varia* L., black medic, *Medicago lupulina* L., and alsike clover, *Trifolium hybridum* L. (Fabaceae).

Crownvetch was the dominant plant species at the Pennsylvania study site, but only slight feeding on leaflets of a few plants was observed. Along the railroad in New

York common plants that generally were avoided were hedge bindweed, *Calystegia sepium* (L.) R. Br. (Convolvulaceae); lambsquarters, *Chenopodium album* L. (Chenopodiaceae); chicory, *Cichorium intybus* L., and horseweed, *Conyza canadensis* (L.) Cronq. (Asteraceae); and Queen Anne's-lace, *Daucus carota* L. subsp. *carota* (Apiaceae).

Apterona helix, although a polyphagous insect known from various wild and cultivated plants (Robinson 1953, Davis 1964), fed mainly on low-growing herbs in New York and Pennsylvania. In California, however, Robinson (1953) noted that "foliage of shrubs and trees were freely attacked later in the season." We also observed some feeding on shrubs and trees at the study site and along railroad tracks, but these plants served primarily as sites for pupation (Fig. 5).

Recognition Features

The most characteristic morphological attribute of this small psychid moth is the larval case (Figs. 4a, 4b); it alone will enable recognition of this introduced bagworm moth in North America. The small spiraled case measures approximately 3–5 mm in diameter and 4–5 mm in depth. The mature larval case typically has 2½ to 3½ whorls and is constructed of silk overlain with minute earthen particles. There are three openings present in the case: a small apical opening, a large basal opening through which the larva is able to crawl and feed, and a large slitlike opening in the uppermost whorl through which the shrivelled female reportedly emerges after oviposition (Davis 1964).

Males of *A. helix* are not known. The parthenogenetic females are highly specialized, larviform, wingless or with reduced wings, with a small head with or without small antennal rudiments, with small pigment spots instead of eyes, and with leg rudiments without claws (Kozhanchikov 1956). The females never leave the spiral case.

Acknowledgments

We thank Carolyn Klass (Cornell University) for allowing us to use records of *A. helix* submitted to the Insect and Plant Disease Diagnostic Laboratory, Gary Miller (Auburn University) for illustrating the larval cases in Figs. 4a and 4b, Alan Snook (Pennsylvania Dept. of Agriculture) for dissecting cases and measuring head capsule widths of larvae, Maureen E. Carter (CU) for assistance in the field, James Stimmel (PDA) for helping make field collections and for reproducing Figs. 1–3 and 5, and Karl Valley (PDA) for reviewing an early draft of the manuscript.

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PROC. ENTOMOL. SOC. WASH.
90(1), 1988, pp. 28–36

A REVISION OF THE GENUS *MESTOCHARIS* AND A REVIEW OF THE GENUS *GRAHAMIA* (HYMENOPTERA, EULOPHIDAE)

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Abstract.—The Nearctic and Palearctic species of the genus *Mestocharis* Förster are revised. Three species are recognized, one exclusively Nearctic (*M. tropicalis*), one exclusively Palearctic (*M. maculata*) and one found in both regions (*M. bimacularis*). *Mestocharis nearctica* Yoshimoto is a new junior synonym of *M. bimacularis*. Hosts are known only for *M. bimacularis*, a gregarious endoparasitoid in eggs of larger Dytiscidae (Coleoptera). The two known species of *Grahamia* are reviewed and characters are presented to facilitate their separation. Both species are recorded as new to the Nearctic Region. The biology is known only for *G. clinius*, a parthenogenetic endoparasite of *Haplodiplosis equestris* (Diptera, Cecidomyiidae) in Europe.

Mestocharis has been treated in two rather recent papers, one dealing with the European (Bouček et al. 1963) and the other with the North American species (Yoshimoto 1976). Bouček et al. recognized two species (*M. bimacularis* (Dalman) and *M. maculata* (Förster)) and established two new combinations and three new synonyms. They dealt also with the intraspecific variation of taxonomically important characters and presented a key. Yoshimoto described two new species (*M. nearctica* and *M. tropicalis*), compared them to the European species, and presented a key to the Nearctic species. The material I have at my disposal indicates that the intraspecific variation described in those papers was underestimated. The consequences of this underestimation are that some characters used for separating the species are unsafe and that one of the species is invalid. The biology is known only for *M. bimacularis* (Jackson 1958, 1960, 1964), an endoparasite in eggs of larger Dytiscidae (Coleoptera). Two other Nearctic species were described as *Mestocharis* (*M. wilderi* Howard, *M. williamsoni* Girault), but both have been transferred to *Pediobius* Walker (Burks 1958: 68–69).

The genus *Grahamia* was erected to include *Entedon clinius* Walker and *Grahamia tatrica* Erdös (Erdös 1966). Later, Bouček and Askew (1968) catalogued the Palearctic Eulophidae and added new distribution records and corrected some previous host records for the genus. Hansson (1985) speculated that the two species might be the same because of high intraspecific variation in the length of flagellar segments, the only character separating the two species, but made no definite decision regarding the validity of the two species. Because I have had access to a fairly large sample of these species from Europe and from North America, I conclude that the two species are valid. A key is presented to facilitate their identification. The host is known only for *G. clinius*, a parthenogenetic endoparasite of *Haplodiplosis equestris* (Diptera, Cecidomyiidae) in Europe.

Morphological terms used are explained

in Hansson (1985), the exception being POO, the distance between posterior edge of hind ocelli and occipital margin. Abbreviations of museums and private collections used in the text were as follows: BMNH = British Museum (Natural History), London, England; CH = collection of the author; CNC = Canadian National Collections, Ottawa, Canada; DAFZ = Department of Agriculture and Forest Zoology, Helsinki, Finland; INHS = Illinois Natural History Survey, Champaign, Illinois, USA; HNHM = Hungarian Natural History Museum, Budapest, Hungary; LUZM = Lund University Zoological Museum, Lund, Sweden; SMNH = Swedish Museum of Natural History, Stockholm, Sweden; USNM = National Museum of Natural History, Washington, D.C., USA.

Genus *Mestocharis* Förster

Mestocharis Förster, 1878: 50. Type-species: *Entedon bimacularis* Dalman, 1820: 181 (= *Mestocharis cyclospila* Förster, 1878: 50), by original designation.

Diagnosis.—Species of *Mestocharis* are distinguished from other genera of Entedontinae by the following combination of characters: both sexes with two small and discoid anelli; antennal scrobes adjoining on horizontal line of frontal fork; mandibles tridentate; transverse pronotal carina absent; postmarginal vein about as long as stigmal vein; anterior part of propodeum with two conspicuous indentations laterally; anteromedian part of propodeum with a large and more or less triangular projection.

Remarks.—The monophyly of *Mestocharis* is shown through the following synapomorphies: 1) anterior part of propodeum with two conspicuous indentations laterally; 2) anteromedian part of propodeum with a large triangular projection.

Key to the Holarctic Species of *Mestocharis*

1. Females 2
– Males (that of *M. tropicalis* is unknown) 4
2. Costal cell with a complete row of setae on underside; 2nd tergite smooth and shiny ..... *M. maculata* (Förster)
– Costal cell bare; 2nd tergite microreticulate (Fig. 1) 3
3. Seventh tergite 1.2–2.0× as long as width of base of same tergite (Fig. 8); scutellum smooth and shiny medially along its entire length ..... *M. tropicalis* Yoshimoto
– Seventh tergite 0.4–1.0× as long as width of base; scutellum with weaker reticulation medially, but not smooth (Figs. 1, 6) ..... *M. bimacularis* (Dalman)
4. Costal cell with a row of setae on underside, antenna mainly testaceous ..... *M. maculata* (Förster)
– Costal cell bare, apical part of scape and the antenna beyond usually infuscate ..... *M. bimacularis* (Dalman)

Mestocharis bimacularis (Dalman)

Figs. 1–7

Entedon bimacularis Dalman, 1820: 181.

Entedon arisba Walker, 1839: 121–122. Syn. Bouček et al., 1963: 5.

Mestocharis cyclospila Förster, 1878: 50. Syn. Bouček et al., 1963: 5.

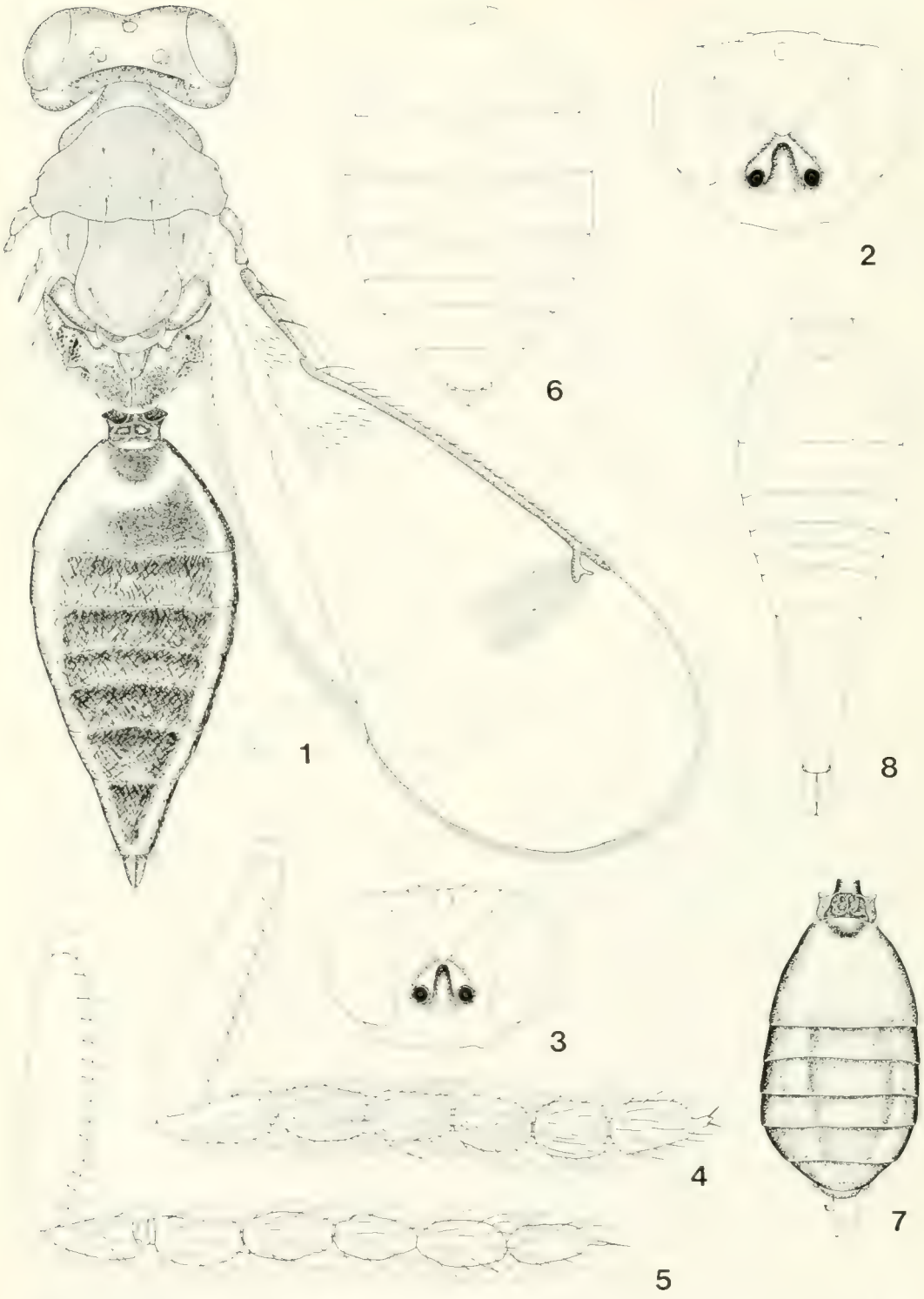
Mestocharis militaris Rimsky-Korsakov, 1933: 232, 244–245. Syn. Bouček et al., 1963: 5.

Mestocharis nearctica Yoshimoto, 1976: 756–757. New synonymy.

Mestocharis bimacularis (Dalman), Bouček et al., 1963: 5.

Diagnosis.—Costal cell bare; second tergite microreticulate; seventh tergite 0.4 to 1.0× as long as wide at base; scutellum reticulate all over; femora usually more or less infuscate.

Description.—*Female:* Entire antenna dark, except scape more or less pale at base. Face and clypeus golden-green, frons completely golden-purple or golden-green below frontal fork. Vertex, mesoscutum and scutellum golden, coppery, golden-green or golden-red. Coxae dark and metallic, major part of femora dark and more or less metallic, tibiae varying from brownish to yellow, base of tibiae occasionally dark, foretarsi dark, mid- and hindtarsi with basal



Figs. 1–8. *Mestocharis* spp. 1–7, *M. bimacularis*. 1, Habitus, female. 2, Front view of head, female. 3, Same, male. 4, Female antenna. 5, Male antenna. 6, Female gaster. 7, Male petiolus and gaster. 8, *M. tropicalis*, female gaster.

three segments pale and with 4th segment dark. Forewing with a large fuscous spot just below stigmal vein, usually also with two much fainter spots below that spot (see remarks for comments on these spots). Propodeum and gaster golden-green. Length of body: 1.6–2.6 mm. Ratios height of eye/malar space/width of mouth opening = 3.1/1.0/2.0. Malar space 2.5–3.0× as wide as width of scape. Frons below fork with very weak reticulation and almost smooth, part between toruli and antennal scrobes raised in a conspicuous, blunt elevation. Frons above fork smooth and shiny in lower part, in upper part reticulate with low and narrow septa, and with small meshes. Horizontal line of frontal fork shaped like a V. Inner orbit of compound eye with 1 to 2 rows of setae. Vertex reticulate with very low and very narrow septa inside ocellar triangle, outside smooth and shiny. Ratios POL/OOL/POO = 6.0/3.1/1.0. Occipital margin with a ±strong carina behind ocellar triangle. Ratio width of head/width of thorax across shoulders = 1.1. Mesoscutum and scutellum reticulate with high and wide septa, median part of scutellum with lower septa. Forewing with speculum closed, base of submarginal vein with a short row of setae on underside. Propodeum with a strong and complete median carina, plicae complete or missing in anterior part of propodeum, propodeal surface rather strongly reticulate, also with irregular carinae. Propodeal callus with 6–9 and lateral part of propodeum inside spiracular sulcus with 3–10 setae. Petiolar foramen rounded. Petiolus transverse, median part with considerably raised carinae, lateral corners protruding and sharp. Shape of gaster varying from ovate (Fig. 6) to lanceolate (Fig. 1). First tergite smooth and shiny, tergites 2–5 microreticulate in anterior 3/4, tergites 6–7 with stronger reticulation. Mean ratio length of thorax + propodeum/length of gaster = 0.82 ± 0.104, n = 10.

Male: Scape pale with apical part dark, pedicel and two first flagellar segments occasionally paler than remaining flagellum, which is dark. Face and frons golden-green or -blue, vertex golden-red. Thorax golden-green, -blue or -red. Coxae dark, remainder of legs yellowish, hindfemur usually dark at base. Forewing immaculate. Metallic coloration much brighter than in female. Length of body: 1.3–1.8 mm. Frons above fork and vertex smooth and shiny. Ratios height of eye/malar space/width of mouth opening = 4.6/1.0/2.6. Malar space as wide as width of scape. Ratio width of head/width of thorax across shoulders = 1.3. Propodeal callus with 4–7 and lateral part of propodeum inside spiracular sulcus with 2–7 setae. Petiolus like in female, but varying in shape from transverse to as long as wide. Mean ratio length of thorax + propodeum/length of gaster = 1.06 ± 0.087 n = 10.

Remarks.—The dark spots on the female forewings are apparently characters that develop with age. Newly emerged females have immaculate forewings, while the same females 8–13 days later have clearly visible spots. In females that have lived 9–10 months the spots are exceptionally dark (Jackson 1964).

The shape of the female gaster is variable in this species, varying from ovate (Fig. 6) to lanceolate (Fig. 1). This character (actually, the shape of last tergite) was used in Bouček et al. (1963) to separate *bimaculatis* from *maculata*: the last tergite was about half as long as its basal width in *bimaculatis* and as long or longer as its basal width in *maculata*. In Swedish specimens of *bimaculatis* last tergite varies from slightly less than half as long to as long as its basal width.

Yoshimoto (1976) separated *nearctica* from *bimaculatis* through several characters presented in a table. However, these characters are either so variable intraspecifically that they have no taxonomic value or are misinterpreted. The propodeal carinae are variable characters. The median carina is usually strong, wide and complete, but in a few specimens it is narrower. The diagonal carina extending from the triangular pro-

jection to the sides of the petiolar foramen varies from strong and complete to completely missing. The hind margin of the first tergite is usually sinuate while the hind margin of the second tergite varies from almost straight to sinuate. The characters of the male antenna of *nearctica* must have been misinterpreted by Yoshimoto. A male paratype of *nearctica* (Can., Ont., Ottawa 19.vii.1939, O. Peck) that I saw showed the following characters: the scape is yellow with apical fourth infuscate and the first flagellar segment is about 1.8× as long as wide. The measurements of the fifth flagellar segment are correct (1.7× as long as wide), but this is also about the same size usually encountered in *bimacularis*. Consequently I regard *nearctica* as a synonym of *bimacularis*.

Material examined.—Two paratypes of *M. nearctica* (1 ♀ and 1 ♂, in CNC); Canada: British Columbia 2 ♀ (CNC, LUZM); Newfoundland 1 ♂ (BMNH); Nova Scotia 1 ♀ (CH); Ontario 1 ♀ (LUZM). Finland: 3 ♂ (DAFZ). Sweden: 40 ♀ 24 ♂ (CH, LUZM). USA: Michigan 1 ♂ (USNM). Lectotype ♀ *E. bimacularis* (not seen) in SMNH.

Hosts.—This species is a solitary or gregarious endoparasitoid in eggs of Dytiscidae (Coleoptera). The size of the egg restricts the number of wasps that can develop successfully, in larger eggs, e.g. those of *Dytiscus marginalis*, up to 12 wasps have been reared, while in smaller eggs, e.g. those of *Ilybius ater*, only one wasp developed (Jackson 1964). Imagines of *M. bimacularis* are most frequently encountered in pond- or marsh vegetation.

Distribution.—Widespread in Europe (Bouček and Askew 1968), in the Nearctic Region this species is recorded from both Canada (Alberta, Manitoba, Ontario and Quebec (Yoshimoto 1976); British Columbia, Newfoundland and Nova Scotia) and the United States (Michigan).

Mestocharis maculata (Förster)

Eulophus maculatus Förster, 1841: 41–42.
Pleurotropis maculata (Förster), Erdös, 1956: 38–39.
Mestocharis maculata (Förster), Bouček et al., 1963: 9.

Diagnosis.—Costal cell with a complete row of setae on underside; second tergite smooth and shiny; femora more or less pale testaceous. In other characters *M. maculata* is very similar to *M. bimacularis*, and the description of *bimacularis* is otherwise applicable to *maculata*.

Material examined.—USSR: Moldavian SSR 1 ♂; Yugoslavia: Beograd 1 ♀. Both specimens are from the Bouček collection. Lectotype ♀ *E. maculatus* (not seen) in the Förster collection in Vienna.

Distribution.—Europe: Czechoslovakia, Germany, Hungary and USSR (Bouček and Askew 1968).

Mestocharis tropicalis Yoshimoto

Fig. 8

Mestocharis tropicalis Yoshimoto, 1976: 757.

Diagnosis.—Seventh tergite 1.2 to 2.0× as long as width of base of same tergite; scutellum smooth and shiny medially along its entire length; costal cell bare; femora pale. Males are unknown for this species.

Remarks.—This species is similar to its two congeners but can be separated from them using the characters given in the key. The 7th tergite shows a great deal of intraspecific variation. I have seen only two specimens, both females, one from Florida (paratype) and one from Illinois. The specimen from Florida had ratio length/basal width of 7th tergite = 1.2, and the specimen from Illinois = 2.0. There is a great gap between these two measurements, but when more material turns up this gap may be filled. The shape of the gaster is more lanceolate than in *M. bimacularis*, which leaves no doubt that *tropicalis* is a valid species. Like *M. bimacularis*, *tropicalis* also has a fuscous spot just below the stigmal vein, but not the two fainter spots present in *bimacularis*.

Material examined.—Paratype ♀ (CNC); 1 ♀ from USA, Illinois, Champaign Co. (INHS). Holotype ♀ (not seen) in CNC.

Distribution.—The United States (Florida, Illinois).

Genus *Grahamia* Erdös

Grahamia Erdös, 1966: 406. Type-species: *Entedon clinius* Walker, 1839: 90, by original designation.

Diagnosis.—Species of *Grahamia* are distinguished from other genera of Entedontinae by the following combination of characters: all flagellar segments free; antenna with only one small and discoid anellus; mandibles tridentate; pronotal collar without transverse carina; costal cell narrow; postmarginal vein about 2× as long as stigmal vein.

Remarks.—The monophyly of *Grahamia* is shown through the single discoid anellus, a synapomorphy for the genus. Two things might argue against the value of this character. First, it is clearly a reduction (the plesiomorphic character state is three anelli, present in the closely related genus *Chrysocharis* Förster). Reductions are sometimes regarded as poor apomorphic character states. Secondly, this character state (one discoid anellus) occurs in other closely related genera (some *Chrysonotomyia* Ashmead and *Closterocerus* Westwood). Nevertheless, I prefer to keep *Grahamia* a separate genus from *Chrysocharis*, the genus to which *Grahamia* shows closest morphological affinity. Among the species-groups of *Chrysocharis* (sensu Hansson 1985), *Grahamia* comes closest to the *mediana*-group. *Grahamia* has, however, some characters that disagree with this assessment: its single discoid anellus of the antenna, all flagellar segments free, and gallmidges as hosts. *Chrysocharis* has three anelli, two apical flagellar segments fused in species of the *mediana*-group, and leafminers as hosts.

Key to the Species of *Grahamia* (Females)

1. First segment of flagellum about 2× and 4th segment about 1.5× as long as wide (Fig. 12); malar space about 1.5× as wide as width of scape; metallic coloration of body comparatively dull ..... *G. clinius* (Walker)

– First segment of flagellum about 1.5× and 4th segment 1× as long as wide (Fig. 10); malar space narrower (as wide as width of scape); metallic coloration of body brighter *G. tatrica* Erdös

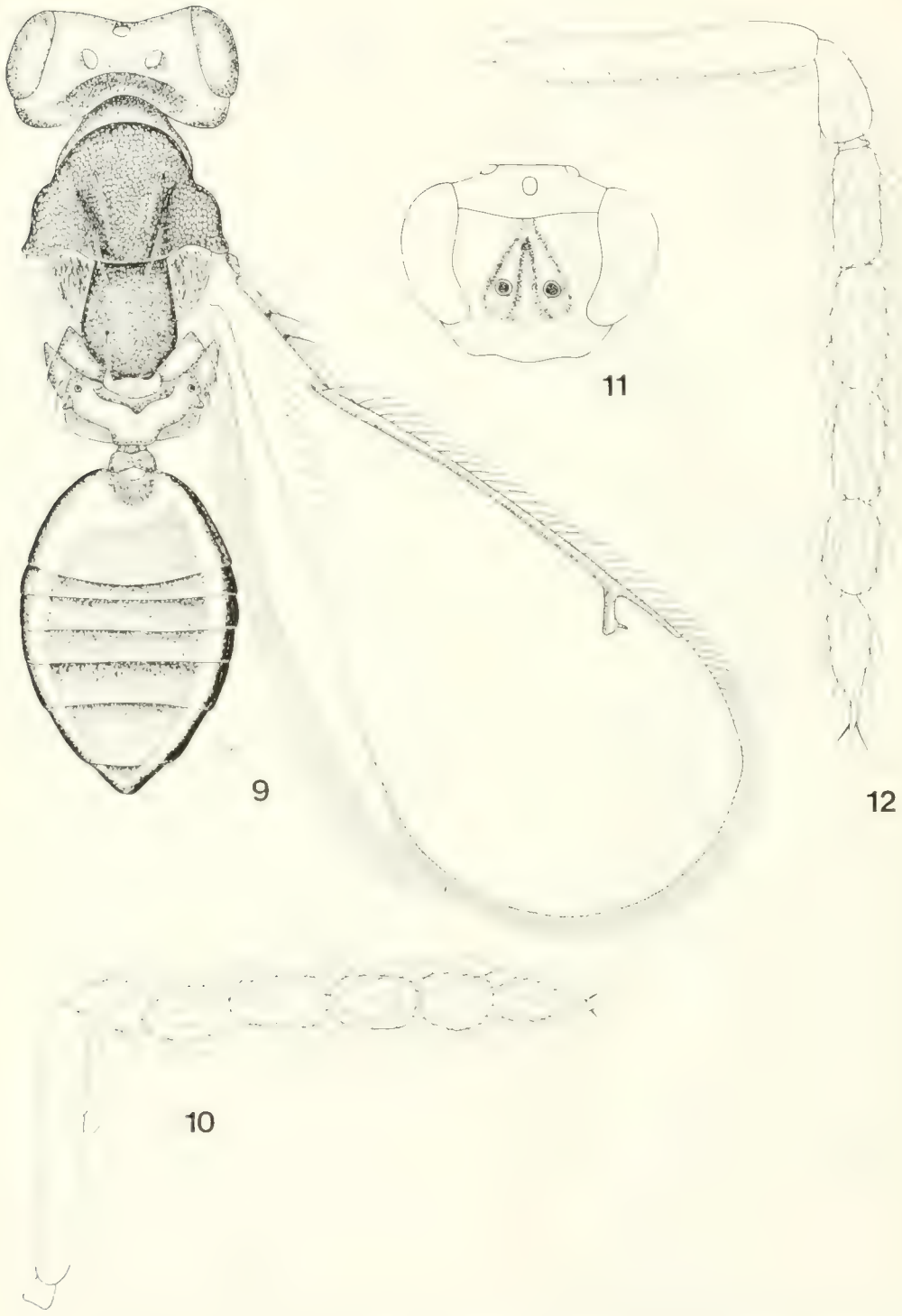
Grahamia clinius (Walker)

Figs. 11–12

Entedon clinius Walker, 1839: 90.
Chrysocharis clinius (Walker), Graham, 1959: 196.
"Chrysocharis" clinius (Walker), Graham, 1963: 204.
Grahamia clinius (Walker), Erdös, 1966: 407.

Diagnosis.—Flagellar segment 1 about 2× and 4 about 1.5× as long as wide; malar space 1.5× as wide as width of scape; metallic coloration of body dull; larger species (1.6–2.1 mm).

Description.—*Female:* Entire antenna dark, scape occasionally paler in basal half. Face and clypeus golden-green. Frons and vertex metallic purple, below fork sometimes golden-purple. Mesoscutum golden-green and scutellum metallic purple. Coxae dark brown and weakly metallic. Femora predominantly dark, fore- and midtibiae varying from pale to infuscate, hindtibia predominantly pale, tarsi ± infuscate, 4th segment dark. Wings hyaline or weakly infuscate. Propodeum and gaster golden-green. Length of body: 1.6–2.1 mm. Ratios height of eye/malar space/width of mouth opening = 3.9/1.0/2.8. Malar space 1.5× as wide as width of scape. Frons below fork reticulate with low and rather narrow septa, meshes small, above fork shiny and almost smooth. Horizontal line of frontal fork almost straight. Inner orbit of compound eye with one row of setae. Vertex reticulate with very low and very narrow septa. Ratios POL/OOL/POO = 3.3/2.2/1.0. Occipital margin with a carina behind ocellar triangle. Ratio width of head/width of thorax across shoulders = 1.3. Mesoscutum reticulate with low and rather narrow septa, meshes small. Scutellum reticulate with low to very low and narrow to very narrow septa, i.e. with finer



Figs. 9–12. 9–10, *Grahamia tatrica,* female. 9, Habitus. 10, Antenna. 11–12, *G. clinius,* female. 11, Front view of head. 12, Antenna.

reticulation than mesoscutum. Anteromedian part of propodeum with a weak triangular fovea, propodeal surface ±reticulate, with or without a weak median carina. Propodeal callus with two setae. Petiolar foramen rounded. Petiolus small and transverse. Gaster elongate, ratio length of thorax + propodeum/length of gaster = 0.67–0.87.

Remarks.—The species *Tetrastichus idothea* Walker, 1844: 409, was regarded as a possible synonym of *G. clinius* by Graham (1961: 62).

Material examined.—Lectotype *E. clinius* ♀ (BMNH Type No. 5.2025); BRD: 1 ♀ ex *Hapl. equestris* (USNM). Canada: British Columbia 3 ♀ (CNC, LUZM). Sweden: 1 ♀ (CH).

Host.—*Grahamia clinius* is known as an endoparasitoid in larvae of *Haplodiplosis equestris* (Diptera, Cecidomyiidae) (Baier, 1963/64, as *Chrysocharis seiuncta*). The sex ratio of reared *G. clinius* (♀:♂ = 100:1) (Baier 1963/64) suggests that the species propagates parthenogenetically.

Distribution.—*Grahamia clinius* is widespread in Europe (Bouček and Askew 1968), and now for the first time recorded from the Nearctic Region (Canada, British Columbia).

Grahamia tatrica Erdös
Figs. 9–10

Grahamia tatrica Erdös, 1966: 407.
Chrysocharis atripes Szelenyi, 1979: 178. Syn. Hansson, 1985: 97.

Diagnosis.—Flagellar segment 1 about 1.5× and 4 about 1× as long as wide; malar space as wide as width of scape; metallic coloration of body brighter; smaller species (1.3–1.5 mm).

Remarks.—Apart from the distinguishing characters *G. tatrica* is very similar to *G. clinius* and the description of *clinius* is applicable to *tatrica*.

Material examined.—Paratypes 2 ♀ *G. tatrica* (HNHM Nos. 6061 & 6062); Canada: Nova Scotia 1 ♀ (LUZM); Finland: 10 ♀ (CH, DAFZ); Sweden: 2 ♀ (CH); USA: Michigan 1 ♀ (USNM), West Virginia 1 ♀ (LUZM). Holotype ♀ (not seen) in HNHM.

Distribution.—*Grahamia tatrica* is recorded from Europe (Finland, Hungary (Erdös 1966), Sweden, Switzerland (Erdös 1966)), Canada (Nova Scotia) and the United States (Michigan, West Virginia). This species was previously not recorded from the Nearctic.

Acknowledgments

I am grateful to Z. Bouček (BMNH), G.A.P. Gibson (CNC), S. L. Heydon (INHS), L. Huggert (same address as author), M. Koponen (DAFZ), J. S. Noyes (BMNH), J. Papp (HNHM), M. E. Schauff (USNM), and C. M. Yoshimoto (CNC) for loan of type- and additional material. My work with this paper was partly financed through a grant from the O. Larsén Foundation.

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PROC. ENTOMOL. SOC. WASH.
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GALL FORMATION BY THE CAPITULUM-INFESTING FRUIT FLY, *TEPHRITIS STIGMATICA* (DIPTERA: TEPHRITIDAE)

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Abstract.—Known heretofore only as a capitulum-infesting species, *Tephritis stigmatica* (Coquillett) also is reported here to develop in galls formed on branches and stems of *Senecio douglasii* (deCandolle) (Asteraceae) in southern California. Two generations of galls occur each year on *S. douglasii*, with immature larvae in juvenile, F_2 galls constituting at least part of the overwintering population. One or more larvae feed gregariously in interconnected, central longitudinal, short-branched feeding tunnels in the expanded pith. As many as six individuals, including five puparia, were found in one F_2 gall. Florets (including ovaries) were fed upon in ungalled capitula and F_1 and F_2 galls were formed on branches and stems of *S. douglasii* at some locations, but gall-formation is the much less common and less widespread mode of development. Galls are described and pictured.

Tephritis stigmatica (Coquillett) is the only tephritid among the 17 species in this genus currently described from North America north of Mexico for which the life history and behavior have been reported in any detail (Foote 1960a, Tauber and Toschi 1965, Foote and Blanc 1979). Tauber and Toschi (1965) studied this species reared from capitula of *Senecio integerrimus* Nuttall (Asteraceae), a common perennial shrub in central- and northeastern-montane California (Munz and Keck 1959, Munz 1968). In 1981, I first reared what appeared to be *T. stigmatica* or an undescribed congener from galls on branches and stems of *Senecio douglasii* (deCandolle), another common perennial shrub in the same genus, but widely distributed below ca. 1500 m in California (Munz and Keck 1959, Munz 1968). The capitula of *S. douglasii* also are widely infested by *T. stigmatica* (Foote and Blanc 1963, Tauber and Toschi 1965, Wasbauer 1972).

Tephritis dilacerata Loew is fairly well known from studies by Berube (1978) and Shorthouse (1980), but this European species is an obligate gall former in capitula *and* stems of its host, unlike the unique host-plant relationship reported herein. Several other species of *Tephritis* are known to form capitulum and stem galls; others to infest capitula without forming galls, but none to do both (Freidberg 1984). The purpose of this report is to describe gall formation by *T. stigmatica* as a unique alternative mode of development for this tephritid heretofore known only from capitula.

MATERIALS AND METHODS

Galls on branches and stems of *S. douglasii* from which adults recently had emerged and galls containing larvae or puparia were sampled at two locations in southern California south of Lamont Peak at Spanish Needle Creek, Sequoia Nat. Forest, Kern Co., on 24 VII 1984, 7 VIII 1984, and 3 III 1987; and 2 km south of Pearblossom, San Bernardino Co., on 22 IV 1985 and 12 II 1987.

Fully-grown larvae and puparia extracted

from some of these galls were placed individually in glass shell vials with perforated plastic caps and held for adult emergence at room temperature in a covered bell jar at near-saturation R.H. The external morphology of adults reared from these and several other collections of galls were compared at magnifications of up to 50× to *T. stigmatica* adults reared from capitula of *S. douglasii* and other Asteraceae sampled throughout southern and central California during 1980–86.

All host-plant identifications were made by or confirmed by A. C. Saunders, Curator of the Herbarium of the University of California, Riverside. The plant nomenclature used is that of Munz and Keck (1959) and Munz (1968, 1974); the insect nomenclature, that of Foote (1959, 1960a).

Results

Taxonomy.—The 26 ♂ and 32 ♀ reared from puparia dissected from branch and stem galls (18 ♂ and 29 ♀ were reared from the first Pearblossom sample) showed no consistent differences compared to adults of *T. stigmatica* reared from capitula. The larvae feed on the florets (including ovaries) but do not gall the capitula of *S. douglasii* (personal observation). Other than body size, body parts examined, measurements taken, and ratios calculated in this study (Table 1) were the same as those used by Quisenberry (1951) of Nearctic *Tephritis,* including *T. stigmatica,* and by Foote (1959) in his diagnosis of the most recently described species of *Tephritis.*

Foote and Blanc (1963, p. 72) termed *T. stigmatica* "the largest of the California *Tephritis* species." *T. stigmatica* adults reared from branch and stem galls on *S. douglasii* were larger on the average than adults reared from capitula of both *S. douglasii* and *S. integerrimus* (Table 1). The size of adults reared from capitula of these and other Asteraceae also varied considerably (Table 1). This probably reflected the different nutritional value of the capitula of varying size and maturity (S. N. Thompson, *in litt.* 1987), as well as the degree of larval development when the heads were sampled. A tiny male reared from a capitulum of *Haplopappus venetus* (Humboldt) Blake ssp. *vernonioides* (Nuttall) Hall, an uncommon and apparently nutritionally ill-suited host (as well as a new host genus and species record, Wasbauer 1972) at Cardiff-by-the-Sea, San Diego Co., on 15 × 1980, illustrates the extreme effect of host-plant unsuitability on adult size in *T. stigmatica* (Table 1). Differences in mean head-part measurements as indices of body size differences (Foote 1960a) between males and females and among flies reared from galls versus capitula of the same or different host plants alone were insufficient to warrant description of the gall-forming flies as a separate species. F. L. Blanc, California Department of Food and Agriculture (Retired), Sacramento, confirmed that specimens in Table 1 were *T. stigmatica* (*in litt.* 1987).

Galls.—*Tephritis stigmatica* overwinters in southern California at least partly as immature larvae in F_2 galls formed mostly on low axillary branches on *S. douglasii* (Fig. 1a). Adults that emerge from heads in late summer and fall also overwinter. Young F_2 galls examined in February (mid-winter) in 1987 at Pearblossom and early March 1987 at Spanish Needle Creek were a third to half of full size. Most F_2 galls (Fig. 1b), like ungalled, elongating current season branches, showed darker (purple) coloration than galls and branch growth formed later in the year. The pigmentation could favor solar energy adsorption and facilitate larval and pupal development as well as adult emergence during cooler months of the year. Galls and ungalled branches that develop during the hot summer are mostly light green (Fig. 1a, 1d). As many as five axillary branches bore F_2 galls along one 10-cm basal section of stem (Fig. 1a). In contrast, F_1 galls usually were isolated on upper parts of aerial stems and usually contained only one or two tephritids (Fig. 1d). Dissection of 72 juvenile

Table 1. Mean (± SE) and range of size and distance measurements (mm)[a] of head parts, and selected ratios thereof ($\bar{x}$ ± SE)[b] of *Tephritis stigmatica* adults reared from galls on *Senecio douglasii* and from capitula of *S. douglasii*, *S. integerrimus*, and *Haplopappus venetus* in California.

Adults Measured		Head			
No.	Sex	Height : Length	Gena Width : Eye Height	Frons Width : Distance from Vertex to Lunule	Frons Width : Eye Width
26	♂[c]	1.00 ± 0.01:0.90 ± 0.01 (0.90–1.05) (0.83–1.00)	0.13 ± 0.00:0.83 ± 0.01 (0.10–0.15) (0.78–0.93)	0.72 ± 0.01:0.58 ± 0.01 (0.65–0.80) (0.53–0.65)	same:0.70 ± 0.01 (0.63–0.75)
		= 1.11 ± 0.01	= 0.16 ± 0.00	= 1.24 ± 0.01	= 1.03 ± 0.01
32	♀	1.01 ± 0.01:0.09 ± 0.01 (0.85–1.10) (0.88–1.13)	0.14 ± 0.01:0.87 ± 0.01 (0.13–0.15) (0.73–0.95)	0.76 ± 0.01:0.60 ± 0.01 (0.68–0.98) (0.53–0.65)	same:0.71 ± 0.01 (0.60–0.98)
		= 1.07 ± 0.01	= 0.16 ± 0.00	=1.29 ± 0.03	= 1.08 ± 0.01
5	♂	0.91 ± 0.01:0.82 ± 0.01 (0.88–0.95) (0.80–0.85)	0.12 ± 0.02:0.76 ± 0.01 (0.10–0.13) (0.75–0.80)	0.60 ± 0.01:0.50 ± 0.03 (0.55–0.63) (0.48–0.53)	same:0.64 ± 0.01 (0.60–0.68)
5	♀[d]	= 1.14 ± 0.01	= 0.15 ± 0.01	= 1.21 ± 0.02	= 0.95 ± 0.01
5	♂	0.91 ± 0.03:0.81 ± 0.02 (0.80–1.00) (0.70–0.88)	0.12 ± 0.01:0.74 ± 0.01 (0.10–0.15) (0.68–0.80)	0.62 ± 0.01:0.48 ± 0.02 (0.58–0.70) (0.43–0.58)	same:0.63 ± 0.02 (0.55–0.70)
5	♀[e]	= 1.13 ± 0.01	= 0.16 ± 0.01	= 1.30 ± 0.04	= 0.99 ± 0.02
1	♂[f]	0.70:0.63	0.10:0.60	0.50:0.40	same:0.48
		= 1.12	= 0.17	= 1.25	= 1.05

[a] After Quisenberry (1951) and Foote (1959).
[b] Calculated from individual micrometer measurements.
[c] Total individuals of this sex reared from galls collected at all locations as recorded in text.
[d] Reared from *S. douglassii* flower heads collected at Cajon Junction, San Bernardino Co., 8 VII 1981.
[e] Reared from *S. integerrimus* flower heads collected at Jackass Meadow, Sequoia Nat. Forest, Tulare Co., 20 VI 1986.
[f] Reared from *Haplopappus venetus* ssp. *vernonioides* flower heads collected at Cardiff-by-the-Sea, San Diego Co., 15 X 1980.

overwintering F_2 galls yielded mostly 2nd instars and small to half-grown 3rd instars. A few fully-grown larvae and puparia also were found in F_2 galls collected in early March at Spanish Needle Creek. From one to five individuals in the same or different stages of growth, e.g. 2nd instars and puparia, were found together in overwintering F_2 galls within interconnected, longitudinal, short-branched feeding tunnels.

Fifty overwintered, fully-formed F_2 galls collected at Pearblossom in April, 1985, contained an average of 1.5 (range, 1–6) fully-grown larvae and intact or empty puparia (Fig. 1c). All but one of the 50 galls were spindle-shaped (Fig. 1b, 1d). These galls either were sessile or born on pedicels of various lengths, up to 5 mm long. These F_2 galls tapered apically as a result of continued apical meristem growth and branch elongation distal to the gall; whereas, death of the apical meristem from larval feeding resulted in a club-shaped gall, or curved gall as a lateral branch assumed apical dominance (Goeden and Ricker 1981, Goeden 1987). Dissections suggested that multiple ovipositions by one or more F_1 females in an axillary bud initiated the formation of a F_2 gall during the previous fall; whereas, a female emerging from these galls the following spring probably oviposited in the apical meristem of an upright aerial stem to initiate F_1 galls. Capitula production was observed to be delayed on F_1 gall-bearing plants sampled at Spanish Needle Creek in early August, 1984.

Branch and stem galls are formed from expanded pith tissue, the branches and stems swelling to about three times normal diameter (Fig. 1b, 1d). Vascular strands were deflected outward and followed the gall contour. Irregular masses of hypertrophied parenchyma cells lined the walls of the feeding chamber(s), resembling round, shiny globules which the larvae scored with mouthhooks while feeding. Frass lined the feeding tunnels of the late-stage 3rd instars (Fig. 1c, 1g). Only part of the gall mass was consumed by a single larva (Fig. 1e, 1g); although, the interiors of smaller galls, especially those containing two or more larvae, were largely consumed (Fig. 1b). Forty-two, spindle-shaped, overwintered, fully formed F_2 galls collected at Pearblossom in 1985 averaged 2.4 ± 0.1 (range, 1.4–3.2) cm in length and 6.5 ± 0.2 (range, 4–10) mm in greatest diameter. These galls incorporated as many as six nodes as indicated by the number of lateral branches arising thereon. The fully-grown larva extends its feeding tunnel distally and outward to, but not through, the epidermis leaving a round, thin, 2-mm dia., translucent window to the outside through which the emerging adult eventually exits (Fig. 1f, 1h, 1i). Once the window is formed, the larva returns to its feeding tunnel and pupariates, often with the anterior part of the puparium projecting into the exit tunnel, and usually facing the window (Fig. 1g). The larval predecessor of one of 75 (1.3%) puparia examined in overwintered Pearblossom galls tunneled basally in constructing its exit tunnel. A maximum of three windows was formed in one gall from Pearblossom that contained five puparia and one larva; otherwise, most galls contained a single window through which as many as three flies emerged. Exit holes

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Fig. 1. Galls of *Tephritis stigmatica* on *Senecio douglasii*: a, overwintering, juvenile, axillary-branch, F_2 galls (0.8 ×); b, fully-formed, dark-pigmented, spindle-shaped, F_2 gall with lateral window (2.1 ×); c, same gall as in b opened to expose four puparia within (3.3 ×); d, fully-formed, compound, F_1 gall showing lateral exit hole (0.8 ×); e, same gall as in d opened to expose two empty puparia in interconnected, central-longitudinal feeding tunnel and two lateral exit tunnels (1.3 ×); f, fully-grown larva just having completed an exit tunnel ending in circular window (4.5 ×); g, puparium at juncture of short feeding tunnel and lateral exit tunnel (4.6 ×); h, closeup view of broken, epidermal window on gall surface (3.6 ×); i, newly-emerged female reared from gall (7.6 ×).


a
b
c
d
e
f
g
h
i

usually were constructed in the distal third or half of the overwintered Pearblossom galls at, below, or between the nodes (Fig. 1b, 1d, 1e, 1f, 1g, 1h). Either one or both sexes of flies (Fig. 1i) emerged from individual F_2 galls.

Among 39 F_1 galls collected at Spanish Needle Creek, only one (2.8%) was club-shaped, and the remainder, spindle-shaped. The 32 spindle-shaped F_1 galls from which flies had emerged in the field in the fall were 4.7 ± 0.3 cm (range, 2.0–7.5) long and 8 ± 1 (range, 5–10) mm wide at their widest. These spindle-shaped galls incorporated an average of 4 (range, 1–8) nodes. The 39 F_1 galls contained one or two, empty, or intact and parasitized, puparia in interconnected central-longitudinal feeding tunnels (Fig. 1e). Thirty-three of these galls had contained a single tephritid and six had contained two tephritids (Fig. 1e), which as noted above was considerably less than the number of individuals in F_2 galls from Pearblossom (Fig. 1c). The feeding tunnels in these F_1 galls averaged 1.3 ± 0.2 (range, 0.5–3.5) cm in length and were 2 mm wide. The exit tunnels averaged 3 (range, 2–5) mm in length and also were circular and 2 mm in cross-sectional width. Ten intact and mostly parasitized empty puparia in these galls averaged 4.2 ± 0.1 (range, 3.6–4.6) mm in length and 1.9 ± 0.0 (range, 1.7–2.0) mm in width. An unidentified species of *Eurytoma* (Hymenoptera: Eurytomidae) was reared from these puparia.

Galls were collected from *S. douglasii* at the following locations in addition to those noted above: 2 ♂ reared from galls collected south of Hesperia at Mojave River Forks, San Bernardino Nat. Forest, San Bernardino Co., on 21 IV 1981; 8 ♂ reared from galls collected at Orcutt, Santa Barbara Co., on 23 VI 1981; 1 ♂ and 1 ♀ reared from galls collected at Cajon Junction, San Bernardino Co., on 8 VII 1981. This represents only a small fraction of uncounted demes of *S. douglasii* examined, but found to lack galls during my many wide-ranging field trips throughout southern California during 1981–1986.

Discussion

Morphological study of *T. stigmatica* from galls and capitula on *S. douglasii* to date has failed to support what otherwise might have been interpreted as sympatric speciation occurring on the same species of host plant. For example, Goeden (1987) reported that the somewhat rare native tephritid, *Trupanea conjuncta* (Adams), facultatively either galls the apical meristems or develops gregariously feeding on florets (including ovaries) in capitula of its sole host plant, *Trixis californica* Kellogg (Asteraceae). This was the first published report of this facultative mode of development in nonfrugivorous Tephritidae (Zwölfer 1983, Freidberg 1984, Price et al. 1986). However, with *T. stigmatica*, a member of the genus most closely allied to *Trupanea* according to Foote (1959, 1960a, 1960b), development in capitula or galls apparently are not mutually exclusive activities on *S. douglasii* at a particular site and season, i.e. both gall formation and feeding in capitula may occur simultaneously during summer into fall. However, gall formation apparently is the requisite mode of development for the F_1 generation on *S. douglasii* earlier in the year. And, I suspect that at least part of the overwintered generation produced in branch (axillary bud) galls begun during the preceding year, as well as overwintered adults produced in *S. douglasii* capitula, reproduce in summer at higher elevations in capitula of a succession of alternate hosts, e.g. *S. integerrimus* and *S. triangularis* Hooker (Wasbauer 1972), on which galls apparently are not formed (Tauber and Toschi 1965). This part of the life history of *T. stigmatica* needs clarification.

Individual host plants were observed at Spanish Needle Creek on March 3, 1987, that bore current and previous year's F_2 galls as well as F_1 galls on dead upright stems that terminated on branches with last year's ca-

pitula containing empty puparia. This provided evidence of three successive generations reproducing as gall formers augmented by a capitula-infesting generation on the same host individuals commensurate with the seasonal development described above.

As previously noted, galls have not been found on *S. douglasii* at most locations where and when plants were examined in the field as opportunity allowed since 1981, indicating the absence of some unknown environmental requisite(s) for gall formation by *T. stigmatica*. This spotty incidence of a gall-forming insect occupying only tiny, discrete, often distant, fractions of the total geographic range of its native host plant also was documented for the stem-galling moth, *Carollela beevorana* Comstock (Lepidoptera: Cochylidae) by Goeden and Ricker (1981). In contrast, a congener of *C. beevorana* commonly forms galls on a related host plant throughout a large part of southern California (Goeden and Ricker 1986).

Acknowledgments

My thanks to F. L. Blanc, R. F. Foote, A. L. Norrbom, and J. D. Pinto for their helpful reviews of earlier drafts of this manuscript. The technical support of D. W. Ricker, including the photography in Fig. 1, also is gratefully acknowledged.

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PROC. ENTOMOL. SOC. WASH.
90(1), 1988, pp. 44–46

NOTES ON THE BIOLOGY OF TWO PHYCITINES (LEPIDOPTERA: PYRALIDAE) ASSOCIATED WITH *TOUMEYELLA PINI* (HOMOPTERA: COCCIDAE) ON PINE

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Abstract.—The phycitines, *Laetilia coccidivora* (Comstock) and *Ribua innoxia* Heinrich were reared from slash pine, *Pinus elliottii elliottii* Engelmann, infested by the striped pine scale, *Toumeyella pini* (King), in northern Florida. *R. innoxia* is new to the USA. It was found previously only in Cuba and Puerto Rico, where it reportedly fed upon fungus on pineapple.

We report here the new distribution and record of association of *R. innoxia*, and its fall emergence and that of *L. coccidivora* in northern Florida. A comparison of the emergence patterns of the 2 species and significant differences in the appearance of their cocoons are presented.

Scale-infested slash pine, *Pinus elliottii elliottii* Engelmann, shoots were collected and caged on 30 September, 1985, at a pine seed orchard near White Springs, Florida, to investigate the natural control factors of the striped pine scale, *Toumeyella pini* (King). Two species of phycitine moths emerged, *Laetilia coccidivora* (Comstock) and *Ribua innoxia* Heinrich. *L. coccidivora* is predaceous on numerous species of scale insects (Heinrich 1956). *R. innoxia* has not been reported from the USA, and information on its biology is fragmentary. It had been found only in Cuba and Puerto Rico and is considered to be a scavenger or mycetophage (Heinrich 1956).

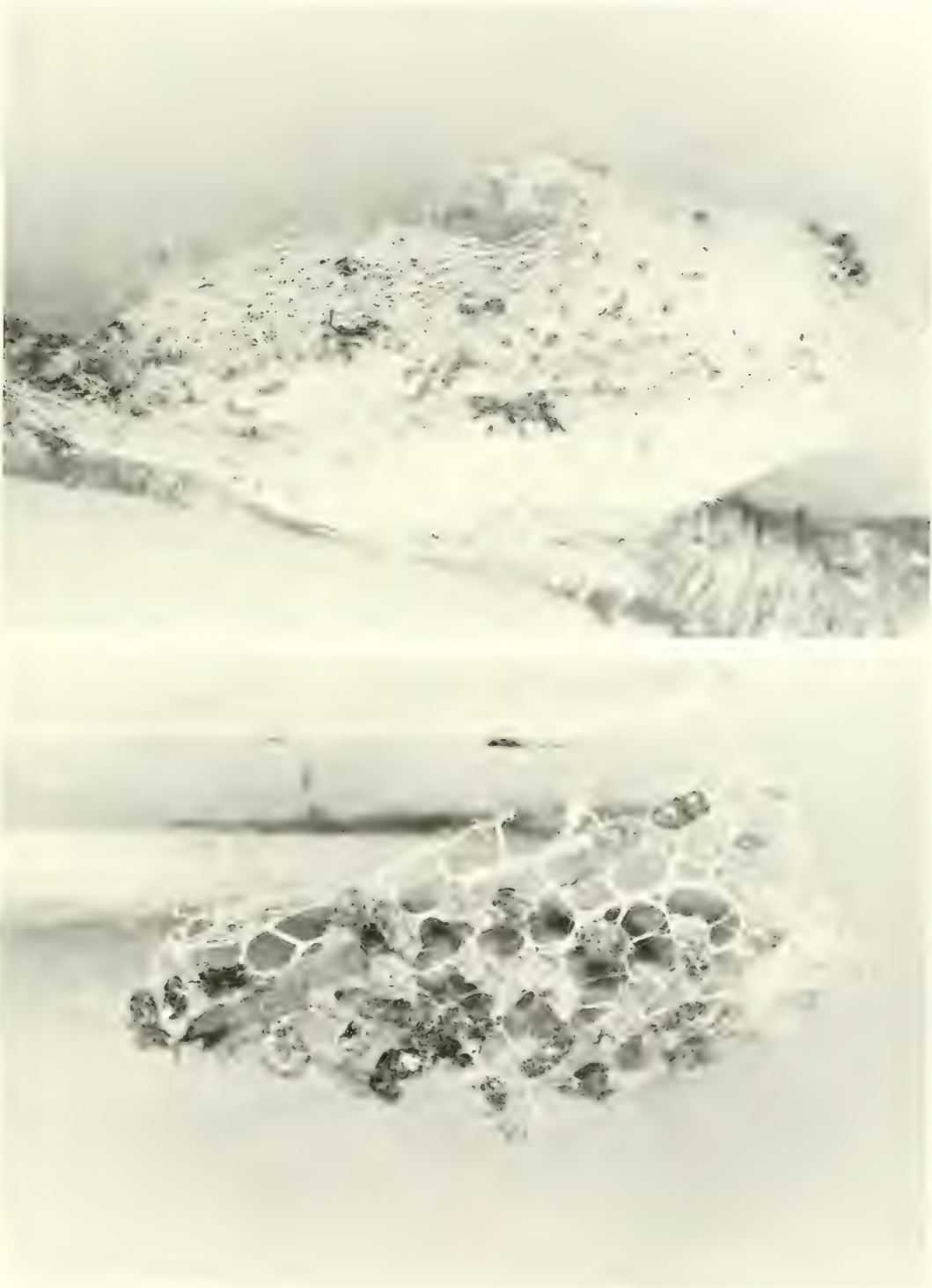
Methods

A total of 100 scale-infested terminals within reach of the ground were cut from a number of pines. The foliage was trimmed to ca. 2 cm to fit the cages and the twigs were cut to 10 cm including the buds. The twigs were caged individually in 5 cm diam. × 8.5 cm long clear plastic vials with snap lids. Water was not used with the twigs, as the scale crawlers were about to hatch. A 1 cm hole was cut out of each lid and a piece of fine mesh nylon was glued to cover the inside of the hole. Thus, aeration was provided, yet scale crawlers and other insects that might emerge were retained. The insects were reared at ambient indoor temperatures. The phycitines were larvae at this time.

The cages were examined daily until no moths appeared over a 2-week period. Moths were removed each evening as they emerged and were frozen until they could be mounted and identified. The number and species of moths emerging by date were recorded.

Results and Discussion

Ninety-four *L. coccidivora* were reared from 46 twigs, and 18 *R. innoxia* came from



Figs. 1, 2. 1, Cocoon of *Laetilia coccidivora*. 2, Cocoon of *Ribua innoxia*.

24 twigs. No moths were found in 39 cages. Cocoons of the two phycitines differed greatly. The cocoon of *L. coccidivora* is similar to that made by many Lepidoptera that pupate above ground: an elongate, white, densely silked, but soft enclosure (Fig. 1). Larvae of *R. innoxia* formed a fragile, mesh or netlike cocoon composed of silk and frass (Fig. 2).

Emergence of *L. coccidivora* started on 18 Oct., with peak emergence between 27 Oct. and 9 Nov. and decreased through 17 Nov., with the last 2 moths appearing between then and 1 Dec. Moths of *R. innoxia* began to emerge on 4 Nov., more than 2 wk after *L. coccidivora*. Only 1 or 2 moths emerged occasionally until the last one appeared on 13 Dec.

Holes in the integument of the scales, caused by feeding of *L. coccidivora* larvae, were common. The relationship between *R. innoxia* larvae and the scales was not established. Large amounts of "honeydew" were produced by the scales, and this substance was infested with sooty mold, *Capnodium* sp.

Heinrich (1956) postulated that *R. innoxia* larvae feed upon fungus; his type series were associated with fungus on pineapple, *Ananas comosus* (L.) Merrill, growing in Cuba. Our brief observations suggests a mycelium-feeding habit for the larvae. The opinion that the larvae of *L. coccidivora* and *R. innoxia* have diverse feeding habits is supported by taxonomic studies of the adults (Heinrich 1956). *Laetilia* and *Ribua* are not closely related genera. *Laetilia* appears to be allied to some of the cactus-feeding phycitines, whereas *Ribua* shows affinities to some of the stored products pests, particularly the Indian meal moth, *Plodia interpunctella* (Hubner). Further work is needed to establish with certainty the feeding habits and host of *R. innoxia*.

Acknowledgments

We thank Douglass R. Miller, USDA, ARS, Systematic Entomology Lab., Beltsville, MD, for identification of the scale, and Charles Lassiter, USDA, Forest Serv., Southeast. Forest Expt. Stn., Naval Stores and Timber Production Lab., Olustee, FL for help in collecting infested twigs. This is paper No. 11072 of the Journal Series of the North Carolina Agricultural Research Service, Raleigh, North Carolina 27695-7601.

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PROC. ENTOMOL. SOC. WASH.
90(1), 1988, pp. 47–51

OCCURRENCE OF SELECTED FLOWER HEAD INSECTS OF *CENTAUREA SOLSTITIALIS* IN ITALY AND GREECE

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Abstract.—A 1984 survey was conducted in the south-Italian mainland and central Greece to locate sites where biocontrol specialists could collect insects of 6 promising biocontrol agents of yellow starthistle (YST), *Centaurea solstitialis* L., for use in host specificity tests. Four of these flower head insects were found: *Urophora quadrifasciata* and *Terellia* sp. (Diptera: Tephritidae) in Italy, and *Eustenopus hirtus* and *Larinus curtus* (Coleoptera: Curculionidae) in Greece. *Urophora jaculata* was the most abundant and ubiquitous species, but it is not a potential biocontrol agent because larvae will not develop in the heads of U.S. forms of YST. New and supplementary information on the distribution of several YST flower head insects and the extent to which they attack heads in Italy and Greece are also presented and discussed in relation to published information.

Centaurea solstitialis L. (yellow starthistle [YST]) is a Eurasian winter annual or biennial plant that has spread to the United States where it is a weed on over 3 million hectares in some western states (Maddox et al. 1985, Maddox and Mayfield 1985). Attempts to control YST biologically in the U.S. began in the 1960's when a flower head gall fly, *Urophora jaculata* Rondani (Diptera: Tephritidae), erroneously called *U. sirunaseva* (Hering) in some earlier references, was introduced from Italy (White and Clement 1987). Repeated efforts to establish this fly on U.S. forms of YST were unsuccessful. However, weed biocontrol workers discovered that a flower head weevil from Greece (*Bangasternus orientalis* (Cap.); Coleoptera: Curculionidae) will attack and complete its development on U.S. plants (Maddox and Sobhian 1987). This weevil, first released in western U.S. in 1985, is now established in California (Maddox et al. 1986).

We assumed that additional biological control agents would be needed to supplement the action of *B. orientalis* so in 1984 we surveyed YST in Italy and Greece to locate populations of promising agents, namely the tephritid flies *Chaetorellia hexachaeta* (Loew), *U. sirunaseva*, *U. quadrifasciata* (Meigen), and an undescribed *Terellia* species (= *T.* cf *virens* (Loew) in Sobhian and Zwölfer [1985]), and the curculionid beetles *Eustenopus hirtus* (Waltl) (= *E.* cf *abbreviatus* Faust in Sobhian and Zwölfer [1985]) and *Larinus curtus* Hochhut. We targeted these six flower head species for study because our preliminary work and unpublished reports at the USDA, ARS Biological Control of Weeds Laboratory—Europe (BCWLE), Rome, Italy, indicated they had restricted host ranges in southern Europe. More than one species may be confused under the name *quadrifasciata* (I. M. White, pers. comm.) and some populations of *C. hexachaeta* may be separate species

Table 1. Sites surveyed in Italy and Greece, collection dates, total number of flower heads of *Centaurea solstitialis* collected and percent damaged by insects at each site, 1984.

Sites Surveyed	Site No	Collection Dates	No. Plants Sampled	No. Heads Collected	% of Heads Damaged
Italy					
5 km E S. Giovanni Rotondo, Promontorio del Gargano, Puglia Region (41°45′N, 15°55′E)	1	July 17 and Aug. 21	10[1]	454	37.89
9 km S S. Giovanni Rotondo	2	July 17 and Aug. 21	20[1]	320	13.75
12 km E S. Giovanni Rotondo	3	July 17 and Aug. 21	10[1]	273	24.54
15 km NW S. Paolo di Civitate, Puglia (41°40′N, 15°20′E)	4	July 17	52	155	14.02
Castel del Monte, Puglia (41°40′N, 16°15′E)	5	July 17 and Aug. 21	16[1]	649	14.19
10 km N Rome, Lazio Region (42°10′N, 12°15′E)	6	July 25, Aug. 14 and Sept. 7	10[1]	1627	18.19
Greece					
5.5 km W Agiokambos (39°45′N, 22°45′E)	1	Aug. 3	5	161	18.01
Xiniada (39°10′N, 22°20′E)	2	Aug. 3	5	179	50.28
ca. 6 km E Karpenissi (38°50′N, 22°50′E)	3	Aug. 4	5	105	41.90
Hounii (38°45′N, 21°30′E)	4	Aug. 4	2	44	65.91
ca. 2 km S Arta (39°10′N, 20°55′E)	5	Aug. 5	10	86	10.41
10 km N Igoumenitsa (39°30′N, 20°15′E)	6	Aug. 5	6	258	19.77

[1] Same plants were sampled each time.

(I. M. White, in press), but further taxonomic study is needed to clarify these possible species groups.

The objective was to locate sources of insects of the aforementioned species for use in host specificity tests and to provide new and supplementary information on the extent to which these and other species attack YST heads in southern Europe. Our approach was to record the occurrence of each flower head species on single host populations at several sites in the south-Italian mainland and central Greece. Information of this type is virtually nonexistent in the literature (Zwölfer 1965, Zwölfer et al. 1971, Sobhian and Zwölfer 1985) on YST flower head insects in Europe.

Methods

Samples were collected at twelve sites during the 1984 flowering season (Table 1). Seven of the sites were sampled once during July and August, but the literature (Sobhian and Zwölfer 1985) and our unpublished data indicate that the six species we were most concerned with can be found on YST during these two months. Therefore, we are reasonably certain that our one-time collections were sufficient to establish the presence or absence of these insects at each site. It was convenient to sample five Italian sites more than once because other studies were being conducted at or near these sites. Survey sites were roadside areas, embankments, and open fields (<3.5 ha) along roads. Each collection consisted of all heads in the flowering and seed formation stages (see Maddox 1981 for description of stages) from five or more randomly selected plants per site, except at one site where only two plants were available for sampling. At five Italian sites, the same plants were sampled two or

Table 2. Occurrence of flower head insects of *Centaurea solstitialis* at several sites in Italy and Greece, 1984.

Species	Relative Occurrence[1]											
	Italian Sites						Greek Sites					
	1	2	3	4	5	6	1	2	3	4	5	6
Diptera												
Tephritidae[2]												
Urophora jaculata Rondani	***	**	**	**	**	***	**	**	**	**		*
U. quadrifasciata (Mg.)				*		**						
Terellia sp.	*	*			*	*						
Acanthiophyllus helianthi (Rossi)					*	**		*	*		**	*
Chaetorellia sp. nr. *C. carthami* Stack.	**	*	**	**	*	**						
Coleoptera												
Curculionidae[3]												
Bangasternus orientalis (Capiomont)							P			P	P	P
Eustenopus hirtus (Waltl)							**	**				
Larinus curtus Hochhut										*		*
Bruchidae												
Bruchidius tuberculatus (Hochhut)[4]				*								
Anobiidae												
Lasioderma sp. nr. *haemorrhoidale* (Illiger)[5]						*						
Lepidoptera												
Cosmopterigidae												
Pyroderces argyrogrammos (Zeller)[6]												*

[1] *** Abundant (>30 specimens emerged). ** Low abundance (5–29 specimens emerged). * Very low abundance (1–4 specimens emerged). P = species present (see text for explanation).

[2] Identity of *A. helianthi* was checked by comparison with specimens identified by Dr. R. H. Foote, former Research Entomologist, Systematic Entomology Laboratory, IIBIII, USDA, Beltsville, Maryland. Other tephritids were identified by Dr. I. M. White, C.A.B. International Institute of Entomology, London, England.

[3] Identified by E. Colonnelli, Dipartimento di Biologia Animale e dell Uomo, Vaile dell Universita, Rome, Italy.

[4] Identified by Dr. M. L. Cox, C.A.B. International Institute of Entomology, London, England.

[5] Identified by Dr. R. Madge, C.A.B. International Institute of Entomology, London, England.

[6] Identified by Dr. R. W. Hodges, Research Entomologist, Systematic Entomology Laboratory, IIBIII, USDA.

three times (Table 1). Samples from each site were pooled to calculate the percentage of heads with insect-damaged seeds.

The relative occurrence of each species and the percentage of heads with damaged seeds and receptacle tissues was assessed for each site by rearing the insects and dissecting all of the heads in a laboratory at the BCWLE. A species was artibrarily rated as abundant, low in abundance, or very low in abundance according to the number of emerging adults (see Table 2). Reared insects were identified to species. Because less than 10% of the eggs of *B. orientalis* survive to the adult stage (Sobhian and Zwölfer 1985, Clement and Sobhian, unpub. data), we assumed that very few, if any, adults would be reared-out. Thus, we recorded the presence or absence of this weevil at each site by looking for its eggs, which are usually laid singly on leaflets near a flower bud (Bu 1–2 stages of Maddox 1981) and are covered by a characteristic black cap.

Results and Discussion

The percentage of heads with insect-damaged seeds varied from 13.75–37.89% (average of 20.43% of heads attacked) in Italy and 10.41–65.91% (average 34.38%) in Greece; less than 20% of the heads were

damaged at 4 Italian and 3 Greek sites (Table 1). Species packing (no. of species) per site ranged from 2–6 (average 3.67) in Italy and 2–5 (average 3.0) in Greece (Table 2). In contrast, Sobhian and Zwölfer (1985) reported average levels of resource utilization (% of heads attacked) and species packing of 36.9% and "above" 4 species for Italy, and 77.3% and 9.5 species for Greece, but these higher levels were based on samples from the south-Italian mainland and Sicily, and northern Greece. The average levels reported above for central Greece are comparable to the ones Sobhian and Zwölfer (1985) reported for Yugoslavia, Bulgaria and Romania (35.6% and 3.4 species). Thus, the collective evidence suggests that predispersal seed predation by YST flower head insects is not markedly high in many areas of southern Europe, including Greece where Sobhian and Zwölfer (1985) and Zwölfer (1985) reported that average levels of resource utilization and species packing were significantly higher than they were in the western Mediterranean (Italy and France). High rates of parasitization of several species (Sobhian and Zwölfer 1985) might account for the fairly low levels of resource utilization in many areas.

In all, we found 11 species of seed predators to be associated with YST heads (Table 2). Three of these, *Acanthiophyllus helianthi* (Rossi) (Diptera: Tephritidae), *Lasioderma* sp. nr. *haemorrhoidale* (Illiger) (Coleoptera: Anobiidae) and *Pyroderces argyrogrammos* (Zeller) (Lepidoptera: Cosmopterigidae) use plants in several genera as hosts, and 8, *B. orientalis, E. hirtus, L. curtus* (Coleoptera: Curculionidae), *Terellia* sp., *U. quadrifasciata, U. jaculata* Rondani, *Chaetorellia* sp. nr. *carthami* Stack. (Diptera: Tephritidae), and *Bruchidius tuberculatus* (Hochhut) (Coleoptera: Bruchidae) appear to be restricted to the genus *Centaurea* in the field (Sobhian and Zwölfer 1985, Clement, unpub. data). *Urophora jaculata* was the most ubiquitous and abundant species, but this tephritid is not a candidate biocontrol agent because it will not develop in the heads of U.S. forms of YST (White and Clement 1987). *Chaetorellia* sp. nr. *carthami* was widespread in Italy; however, this species will form hybrids with *C. carthami* Stack., a pest of cultivated safflower, so its safety as a biocontrol agent has been questioned by biocontrol workers (Sobhian and Zwölfer 1985). A third stenophagous species (i.e. restricted to *Centaurea* spp.), *B. tuberculatus,* has been disqualified because adults were found in the heads of cultivated safflower, *Carthamus tinctorius* L., in northern Greece (Sobhian and Zwölfer 1985). Four of the 6 species that we set out to find were detected; *U. quadrifasciata* and *Terellia* sp. were represented in the guild of flower head insects in Italy while *E. hirtus* and *L. curtus* were detected in Greece. None of these 4 species were abundant at any site (Table 2).

The failure of this survey to detect *U. sirunaseva* and *C. hexachaeta* was unexpected because Sobhian and Zwölfer (1985) reported that both species occur throughout much of southern Europe. However, recent taxonomic studies (White and Clement 1987, White in press) have revealed a more restricted distribution for these tephritids. This new information on *U. sirunaseva* and *C. hexachaeta,* together with information from this survey and the literature on *E. hirtus* (Ter-Minasyan 1967, Fremuth 1982, Sobhian and Zwölfer 1985) and *L. curtus* (Zwölfer et al. 1971, Fremuth 1982, Sobhian and Zwölfer 1985) suggest that none of these 4 species are rare but the 2 weevil species are better able to exploit YST over a much wider geographical area than are the 2 tephritid species. The seemingly broad ecoclimatic tolerances of *E. hirtus* and *L. curtus* would improve their chances for establishment in the western U.S. where YST occurs in markedly different climatic and vegetational zones (Maddox 1981, Maddox et al. 1985, Maddox and Mayfield 1985, Roché et al. 1986).

In summary, this survey has enabled us to: pinpoint sites where biocontrol special-

ists might be able to collect insects of 4 potential agents for use in host-specificity tests; clarify the Palearctic distribution of several YST flower head insects, including 6 species that are promising biocontrol agents; and contribute towards a better understanding of the extent to which YST flower heads are attacked by insects in southern Europe.

Acknowledgments

We are grateful to the taxonomic specialists (listed in Table 2) who identified specimens, I. White, D. Maddox and an anonymous reviewer for comments on the manuscript, and S. Craig for typing the manuscript.

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PROC. ENTOMOL. SOC. WASH.
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UNUSUAL OVIPOSITION BEHAVIOR ON EVERGREEN AZALEA BY THE ANDROMEDA LACE BUG *STEPHANITIS TAKEYAI* (DRAKE AND MAA) (HETEROPTERA: TINGIDAE)

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Abstract.—The andromeda lace bug, *Stephanitis takeyai* (Drake and Maa), an adventive tingid from Asia, has a feeding host range in North America of twelve species in the Lauraceae, Salicaceae, Ericaceae and Styracaceae. Hybrid evergreen azalea (*Rhododendron* sp.) is reported as a new feeding and breeding host. Females oviposit in the midrib of the azalea leaf, a behavior different from that on its preferred host, Japanese andromeda (*Pieris japonica*). A comparison is made of oviposition site behavior between the andromeda lace bug, and *S. pyrioides* (Scott) the azalea lace bug.

Stenophagous lace bugs in North America have been assigned common names based on the major reproductive hosts. Minor feeding hosts usually involve congeneric species. Drake and Ruhoff (1965) report that "All species [of lace bugs] are rather highly specialized in their food habits, and generation after generation live on the same kind of plant or closely related ones." Host plants of the andromeda lace bug *Stephanitis takeyai* (Drake and Maa) (= *S. globulifera* Matsumura), an adventive tingid from Asia (Schread 1953), have been reported by Drake and Ruhoff (1965), Schread (1953), Dunbar (1974), and Wheeler (1977) and world-wide include 12 species in Lauraceae, Ericaceae, Salicaceae and Styracaceae. Bailey's (1951) review of New England tingids contains a report that a few *S. takeyai* were found in association with azalea lace bug, *S. pyrioides* (Scott), on a single deciduous azalea *Rhododendron* sp. in Connecticut. Bailey (1974) also reported *S. takeyai* on *Rhododendron calendulaceum* (Michx.) Torr. Wheeler (1977) reported specimens in the U.S. National Museum of Natural History from azalea at a nursery in Falls Church, Virginia, June 1969.

Dunbar (1974) reported that *S. takeyai* oviposits on the abaxial leaf surface, usually along the side of the midrib of the Japanese andromeda *Pieris japonica* (Thunb.) D. Don, and that overwintering eggs are found along the midrib but on occasion were distributed over the undersurface of the leaf.

I observed adults of *S. takeyai* in low numbers on evergreen and deciduous azaleas throughout Prince George's and Howard counties, Maryland. These observations suggested that azalea is used by *S. takeyai* as a minor host, and prompted this study and report of insect behavior, host fitness and potential pest status.

MATERIALS AND METHODS

Containerized Japanese andromeda harboring all stages of *S. takeyai* were purchased from a retail nursery in Burtonsville,

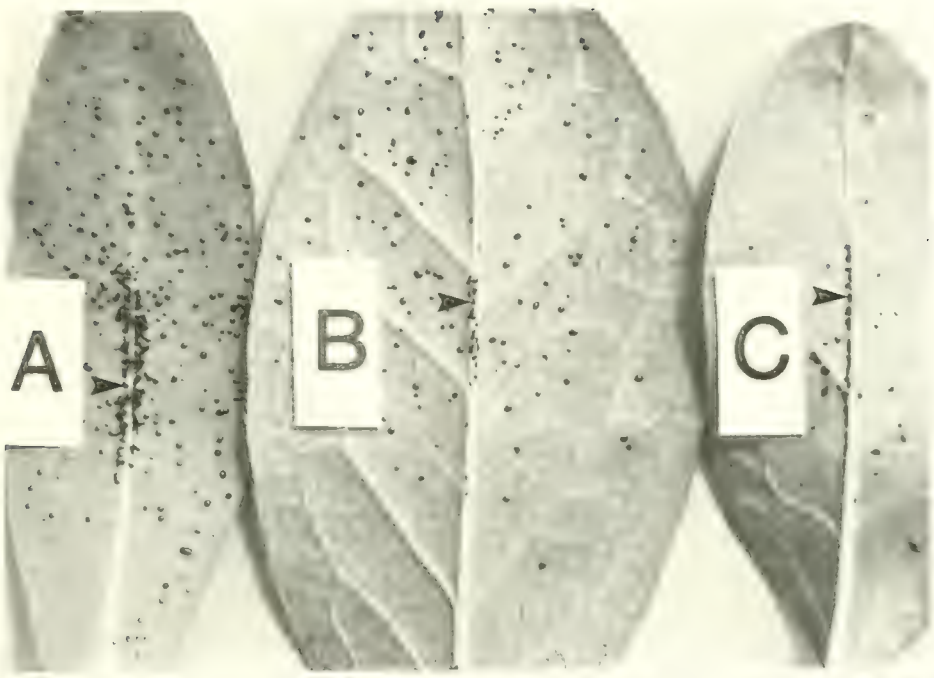

Fig. 1. (A) Frass-covered eggs of *S. takeyai* placed lateral to the midvein of an andromeda leaf, (B) Eggs of *S. takeyai* placed in the midvein of an azalea leaf. (C) Eggs *S. pyrioides* placed lateral to the midvein of an azalea leaf. Arrow identifies one of several frass-covered eggs.

Maryland. Plants were transplanted to 11.6 liter (3 gal) containers, held in a heated greenhouse, and watered as needed. Stems of various lengths were removed periodically to a bottle of water and placed in a gauze covered plexiglass cylindrical cage (32 cm high × 31 cm dia.) in a Sherer walk-in rearing chamber programmed at 26.1 ± 1°C, with a photoperiod of 14:10 (L:D).

To test for host preference and acceptability, stems of the evergreen hybrid azalea 'Martha Hitchcock' (*Rhododendron mucronatum* × Shinnyo-no-tsuki) were placed in the cylinder contiguous to the infested andromeda cuttings. Leaves with adults and nymphs of *S. takeyai* found on the azalea during daily observations were transferred for isolation to a similar cage containing an uninfested second azalea cutting. Transferred adults were allowed to feed and oviposit. Water was added to the bottle as needed. Both azalea and andromeda cuttings were introduced weekly to the cylinder with andromeda lace bugs, and the transfer of adults from andromeda to azalea was conducted over several weeks.

Leaves with eggs of *S. takeyai* were compared against leaves with eggs of *S. pyrioides* removed from the same azalea cultiver used as host plants to maintain a greenhouse colony.

Results

Tingids that leaf feed in an inverted position defy gravity and deposit their fecal material on the abaxial surface at random. Preliminary tests confirmed that by removing all frass by rinsing the leaf with warm running water, *S. takeyai* and *S. pyrioides* confined their egg laying either in or adjacent to the midrib or at major lateral veins depending on host. Defecation by the female on the operculum leaves a prominent mark at the egg site (Fig. 1, arrows). *Stephanitis takeyai* fed and oviposited on azalea cuttings. Originally some eggs on this host

hatched, but most failed to produce second instars. Washing leaves prior to hatch to remove sticky plant exudate greatly reduced first instar mortality; nymphs developed to the adults when foliage was washed. The presence of plant exudates on the cuttings is a phenomenon due to the growing of azaleas in the protective greenhouse environment. Exudates are normally reduced by rain or rendered non-sticky by the accumulation of airborne particles.

Stephanitis takeyai oviposited only in and along the midrib in all azalea leaves observed (Fig. 1B), whereas *S. pyrioides* deposited its eggs below and lateral to the midrib (Fig. 1C). Oviposition by *S. takeyai* on Japanese andromeda included periodic placement below and lateral to the midrib, but eggs were never inserted in the midrib (Fig. 1A). Andromeda leaves have conspicuous midribs, but they are not raised as in other hosts such as azalea, possibly accounting for this change in oviposition behavior. Wheeler (1977) found *S. takeyai* eggs inserted in the midvein of spicebush, *Lindera bezoin* (L.) Blume, and sassafras, *Sassafras albidum* (Nutt.). This ovipositional site preference by the andromeda lace bug on azalea and other hosts is unusual, because when compared, the andromeda lace bug oviposits on andromeda lateral to the unraised midrib which is similar to oviposition by the azalea lace bug below and lateral to the raised midrib on azalea. This behavior by *S. takeyai* on azalea raises the question what would be the oviposition site on andromeda if the midrib were raised.

These findings determined that an evergreen azalea can be a suitable feeding-breeding host for *S. takeyai*. Further, it was found that females oviposit in and along the midvein of the azalea leaf which is different than when on andromeda. Fertilized eggs hatched and nymphs developed to adults normally. These results suggest that *S. takeyai* could develop to be a late season threat to azalea production. There is, however, no data to suggest that eggs of *S. takeyai* overwinter on azalea.

Acknowledgments

Thanks are extended to Richard C. Froeschner (USNM) and Thomas J. Henry (USDA, SEL) for constructive comments and helpful suggestions on an early draft of the manuscript.

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PROC. ENTOMOL. SOC. WASH.
90(1), 1988, pp. 55–61

A REVIEW OF THE SOUTH PACIFIC GENUS *AUSTROMEGALOMUS* ESBEN-PETERSEN (NEUROPTERA: HEMEROBIIDAE) WITH A DESCRIPTION OF A NEW SPECIES FROM RAPA

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Abstract.—The hemerobiid genus *Austromegalomus* Esben-Petersen is reviewed. *Austromegalomus* and its type species *A. brunneus* are redescribed and *A. insulanus* is described as new. Figures, known distributions and a key to the two recognized species are provided. Several shared characters of the male ectoprocts, mediuncus and parameres suggest that the genera *Austromegalomus*, *Conchopterella* and *Drepanacra* are closely related.

The genus *Austromegalomus* Esben-Petersen, 1935, was proposed to accommodate the single species *A. brunneus* Esben-Petersen which was described in the same paper from three male specimens collected on the South Pacific island of Tahiti. Until now no additional specimens or species of *Austromegalomus* have been recorded in the literature. In this paper *Austromegalomus insulanus* is described as new, from 20 specimens collected on the island of Rapa located approximately 1200 km (750 mi.) SSE of Tahiti, and the genus *Austromegalomus* and the male of *A. brunneus* are redescribed.

As with many early hemerobiid descriptions, the original descriptions of *Austromegalomus* and *A. brunneus* are based almost entirely upon venational characters. *Austromegalomus insulanus* is shown here to exhibit a wide range of intraspecific variation in a variety of forewing venational traits and venation is judged inadequate to confidently separate the two species. The descriptions presented here emphasize characters of the male genitalia.

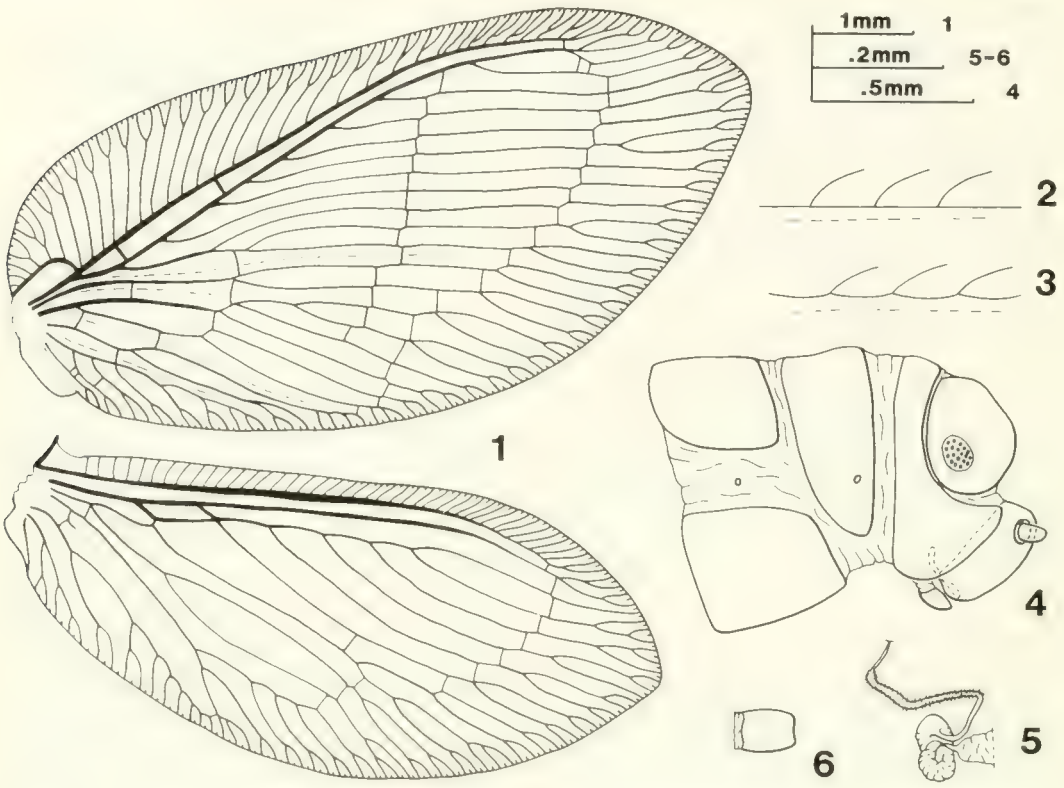
Intraindividual, as well as interindividual, variation in venational characters is common in *Austromegalomus*. In tabulating the variability of several forewing venational traits, both forewings of each individual were scored for each trait. Estimates of mean forewing length were based on measurements of a single forewing of each specimen. Consequently, the sample sizes given in the species descriptions for venational traits are twice those given for estimates of mean forewing lengths.

Austromegalomus Esben-Petersen

Austromegalomus Esben-Petersen, 1935: 139. Type species: *Austromegalomus brunneus* Esben-Petersen, 1935: 140, by original designation.

Diagnosis.—*Head:* Temporal sutures well developed, marked internally by prominent costae; epicranial suture absent; labial palp three segmented, distal segment longest and with an apical subsegment, palpimacula present; maxillary palp five segmented, distal segment longest and with an apical subsegment.

Forewing: Length 5–9 mm, hind margin rounded, apex broadly pointed; costal area

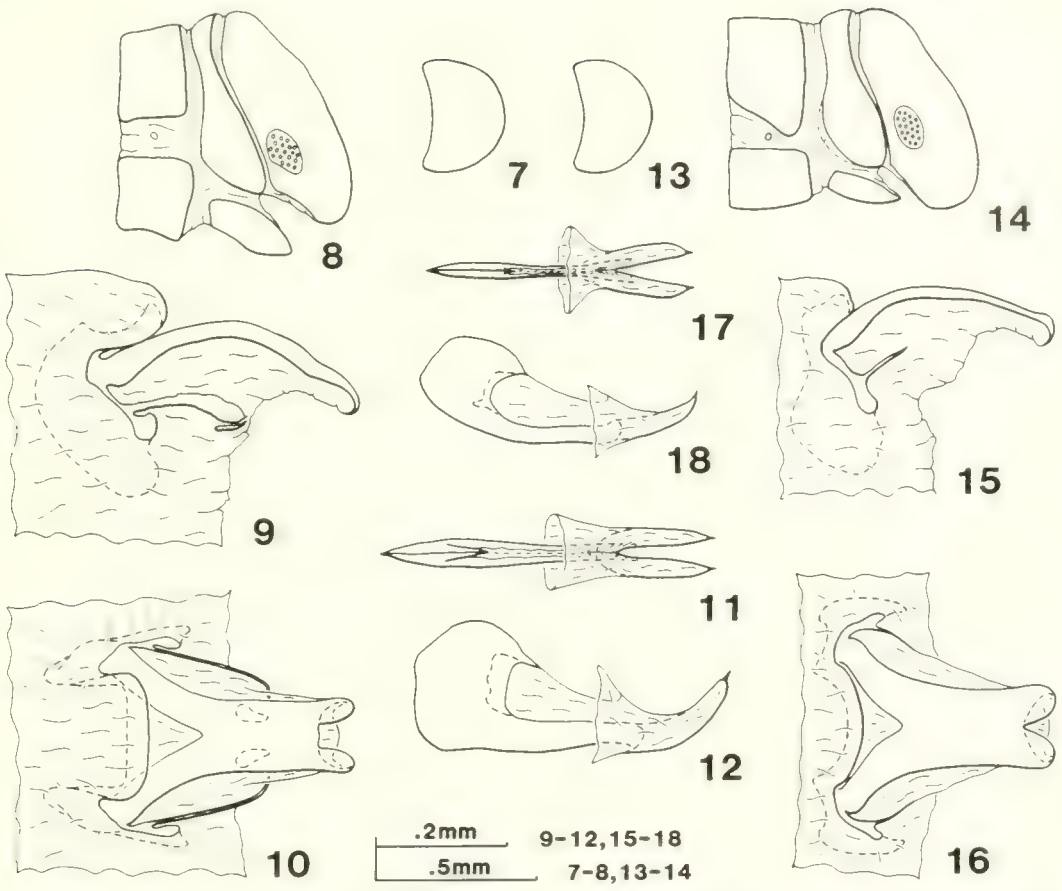


Figs. 1–6. *Austromegalomus insulanus*. 1, venation of forewing and hindwing. 2–3, two possible states of the first (proximal) oblique branch of the forewing radius (diagrammatic). 4–6. Female. 4, apex of abdomen (lateral view). 5, spermatheca and apex of bursa. 6, subgenitale (ventral view).

broad proximally, recurrent vein pectinately branched; proximal half of subcostal space with 2 crossveins (the distal of these rarely absent); radius with 4–10 oblique branches; 2 well developed, posteriorly convergent, gradate series in outer half of wing.

Hindwing: Radius with 2 oblique branches; Cu2 frequently, though not always, traceable to near the posterior margin either as a distinct or indistinct vein or a row of setae; outer gradate series well developed; inner gradate series with 1–3 crossveins or absent.

Male genitalia: Tergite nine a sclerotized arch, lateral lobes dilated ventrally; sternite nine in ventral view a remiform plate (Figs. 7, 13), shallowly arched in anterior view; ectoproct elongate oval, without narrowed projecting lobes; gonarcus with arms of moderate size the greater part of which project free into body cavity, exposed surface limited to a narrow strip to which the mediuncus and epimeres are fused; mediuncus a rigid plate dorsal to epimeres and parameres, bilobed proximally and distally, longitudinal midline shallowly depressed, proximal lobes strongly divergent and fused to gonarcus at a pair of widely separated points on opposite sides of gonarcus bridge, medial margins of proximal lobes and posterior margin of gonarcus bridge enclosing a triangular membranous fenestra; epimeres a pair of elongate strips of sclerotized membrane lying in the membranous sack supported dorsally by the mediuncus, fused to gonarcus ventral to fusion of mediuncus with gonarcus; parameres with internal end of apophysis proxima enlarged in lateral view,



Figs. 7–18. 7–12. *Austromegalomus brunneus,* male. 7, ninth sternite (ventral view). 8, apex of abdomen (lateral view). 9, gonarcus, mediuncus and epimere (lateral view). 10, gonarcus, mediuncus and epimere (dorsal view). 11, parameres (dorsal view). 12, parameres (lateral view). 13–18. *A. insulanus,* male. 13, ninth sternite (ventral view). 14, apex of abdomen (lateral view). 15, gonarcus, mediuncus and epimere (lateral view). 16, gonarcus, mediuncus and epimere (dorsal view). 17, parameres (dorsal view). 18, parameres (lateral view).

external lobes narrow and linear in dorsal view but with their apices upturned in lateral view, medioventral surfaces of lobes sclerotized, laterodorsal aspects membranous.

Female genitalia: See below under *A. insulanus.*

Natural history and immature stages.—Unknown.

Distribution.—Known only from the French Polynesian islands of Tahiti and Rapa.

Etymology.—Name unexplained but almost certainly from the Latin "australis," southern, and "*Megalomus,*" a hemerobiid genus to which Esben-Petersen allied *Austromegalomus.* Gender: masculine.

Discussion.—Esben-Petersen diagnosed *Austromegalomus* by the branching arrangement of the first oblique branch of the radius ("basal Rs" of Esben-Petersen). In *Austromegalomus* the vein track which anteriorly parallels the median flexion line is nearly straight. The curvature of vein segments confluent at forks along this track are usually somewhat asymmetric. The branches originating at these forks tend to form a linear series on the anterior side of the track

(Fig. 2). In an alternate state found in many other hemerobiid genera, the vein forks along this track are more symmetric giving the track a more or less undulate appearance (Fig. 3). Though these states are rather distinctive when viewed as the opposite ends of a morphocline, intraspecific variation within *A. insulanus* encompasses both states. Too few specimens are available to adequately assess the degree of intraspecific variation of this trait in *A. brunneus*. Furthermore, as pointed out by Esben-Petersen (1935) and Handschin (1955), similar asymmetric patterns of veins along this track are found in other hemerobiid genera (e.g. *Drepanacra* and *Conchopterella*). For these reasons this character cannot be used as a synapomorphy of *Austromegalomus*. Due to still unresolved questions concerning the homologies and polarities of diagnostic characters of the male genitalia, I have been unable to confidently identify any synapomorphic characters for this taxon.

Key to Adult Males of *Austromegalomus*

1a. Emargination separating distal lobes of mediuncus V-shaped (Fig. 16); gonarcus bridge arcuate in dorsal view (Fig. 16); epimeres short and narrow and not subtended by an accessory sclerite (Fig. 15) (Rapa) *A. insulanus* n. sp.

1b. Emargination separating distal lobes of mediuncus quadrate (Fig. 10); gonarcus bridge quadrate (Fig. 10); epimeres long and broad and subtended distally by a small accessory sclerite (Fig. 9) (Tahiti) . . . . . *A. brunneus* Esben-Petersen

Austromegalomus insulanus, New Species
Figs. 1–6, 13–18

Diagnosis.—Diagnosed by characters in key couplet 1a. The longer forewing length and the alternating light and dark brown segments of the forewing longitudinal veins may also be diagnostic, though not enough specimens of *A. brunneus* are available to fully assess the potential overlap of these characters with those found in *A. insulanus*.

Description.—*Forewing* (Fig. 1): Length 6.09–8.48 mm ($\bar{x}$ = 7.06, N = 20); longitudinal veins mostly marked with alternating light and dark brown segments, though several specimens (likely teneral) with venation nearly evenly pale; membrane hyaline to brown, darker adjacent to dark vein segments. Venation (Fig. 1, N = 40): Number of subcostal crossveins in proximal half of subcostal space = 2 (39 wings), 3 (1 wing); number of oblique radial branches proximal to stigmal subcostal crossvein = 6 (1 wing), 7 (6 wings), 8 (16 wings), 9 (14 wings), 10 (3 wings); number of inner gradate crossveins anterior to cubitus = 10 (3 wings), 11 (7 wings), 12 (20 wings), 13 (8 wings), 14 (2 wings); number of outer gradate crossveins anterior to cubitus = 11 (2 wings), 12 (2 wings), 13 (8 wings), 14 (15 wings), 15 (13 wings); number of forkings of first oblique radial branch proximal to inner gradate series = 1 (7 wings), 2 (29 wings), 3 (4 wings).

Male genitalia: Apex of abdomen as in Fig. 14. Gonarcus (Figs. 15, 16): gonarcus bridge arcuate in dorsal view. Mediuncus (Figs. 15, 16): distal pair of lobes contiguous medially at their bases. Epimeres (Figs. 15, 16): short and very narrow, weakly tanned and easily overlooked; not extending as far posteriorly as in *A. brunneus* and not subtended distomedially by a pair of accessory sclerites. Parameres (Figs. 17, 18): internal end of apophysis proxima enlarged but not as prominently as in *A. brunneus*; apices of external lobes tipped with a minute spine.

Female genitalia (Figs. 4, 5, 6): Gonapophyses laterales remiform, styli arising dorsad of middle of sclerites; gonapophyses posteriores present as a pair of narrow rods; subgenitale present, attached to ventral body wall by a short membranous tube, apex emarginate; spermatheca composed of a darkly tanned bulb and a pair of ducts—a short duct joining the bulb to the bursa and a longer convoluted duct arising from the distal end of the bulb.

Etymology.—An adjective from the Latin "insula," island, in reference to the island type locality.

Distribution.—Known only from the type series from the South Pacific island of Rapa (French Polynesia, Austral Islands).

Primary type material examined.—Male holotype (USNM). Verbatim label data: "Rapa/Anatakuri/Bay 28 XI 63," "J. F. G. Clarke/Thelma M. Clarke," "USNM Loan/USNM Loan," "Holotype/Austromegalomus/insulanus Oswald/J. D. Oswald 1987." Condition: Excellent, no parts missing. Genitalia cleared and placed in a glycerin filled microvial pinned below the specimen.

Other material examined.—19 paratypes. RAPA ISLAND: 2 ♂, Anatakuri Bay, 28.xi.1963 (Clarke) (USNM); 3 ♂, 2 ♀, Haurei, 15.x.–3.xii.1963 (Clarke) (USNM); 1 ♂, 1 ♀, Maii Bay, 23.x.1963 (Clarke) (USNM); 2 ♀, Maugaoa, 244 m & 290 m, 18.ix.–23.xi.1963 (Clarke) (USNM); 1 ♂, 1 ♀, Mangaoa [sic = Maugaoa] Pk., NE ridge, 305–366 m, 6.vii.1934 (Zimmerman) (BPBM); 1 ♂, 2 ♀, Maurua, 61 m & 183 m, 25.ix.–25.x.1963 (Clarke) (USNM); 1 ♀, Mt. Ororangi, SE valley, 183–244 m, 3.vii.1934 (Zimmerman) (BPBM), 2 ♀, Point Teakaurae, 61 m, 7.x.1963 (Clarke) (USNM).

Note.—For a general account of the Clarke Expedition to Rapa, including collecting localities and physiography, see Clarke (1971).

Austromegalomus brunneus Esben-Petersen
Figs. 7–12

Austromegalomus brunneus Esben-Petersen, 1935: 140 (original description, figures): Esben-Petersen 1937: 51 (listed); Handschin 1955: 9 (compared to *Conchopterella*).

Diagnosis.—Diagnosed by characters in key couplet 1b. The shorter forewing length and the uniform brown coloration of the forewing longitudinal veins may also be diagnostic, though not enough specimens of *A. brunneus* are available to adequately assess the potential range of intraspecific variation in these characters.

Description.—*Forewing:* Length 5.37–5.56 mm ($\bar{x}$ = 5.47, N = 2); longitudinal veins uniformly brown, membrane also brown. Venation (N = 4): Number of subcostal crossveins in proximal half of subcostal space = 2 (4 wings); number of oblique radial branches proximal to stigmal subcostal crossvein = 4 (3 wings), 5 (1 wing); number of inner gradate crossveins anterior to cubitus = 8 (1 wing), 9 (1 wing), 10 (2 wings); number of outer gradate crossveins anterior to cubitus = 11 (2 wings), 12 (2 wings); number of forkings of first oblique radial branch proximal to inner gradate series = 3 (4 wings).

Male genitalia: Apex of abdomen as in Fig. 8. Gonarcus (Figs. 9, 10): gonarcus bridge quadrate in dorsal view; anterodorsal region of gonarcus arm broader in lateral view than in *A. insulanus*. Mediuncus (Figs. 9, 10): distal pair of lobes separated medially at their bases by a space about equal to width of each lobe. Epimeres (Fig. 9, 10): prominent, long and broad relative to *A. insulanus*; apex of each epimere subtended medially by a small, weakly sclerotized and poorly delimited accessory sclerite. Parameres (Figs. 11, 12): internal end of apophysis proxima considerably enlarged in lateral view; apices of external lobes tipped with a minute spine.

Female: Unknown.

Etymology.—An adjective from the Latin "brunneus," dusky or tawny, in reference to the brownish coloration of the body and forewing.

Distribution.—Known ony from the type series from the South Pacific island of Tahiti (French Polynesia, Society Islands).

Primary type material examined.—Male holotype (BPBM). Verbatim label data: "Society Is./1500'/Tahiti I.," "Fautaua Val./IX-11-28," "A. M. Adamson/Collector," "Pacific Entomological Survey," "TYPE 791," "Austromegalo=/mus brunneus/♂ n. sp./det. Esben-Petersen." Condition: Excellent, only several small pieces of wings missing. Genitalia cleared and placed in a glycerin filled microvial pinned below the specimen.

Other material examined.—One male paratype (BPBM). Collection data same as holotype. A second paratype stated in the original description to have been retained by Esben-Petersen has not been traced.

Phylogenetic Position of *Austromegalomus*

The morphology of the male genital structures of *Austromegalomus* suggests that it is closely related to the southern hemisphere genera *Drepanacra* and *Conchopterella*, which are known from the Australian region and the Juan Fernandez islands respectively. This evidence supports the conclusions of Esben-Petersen (1935) and Handschin (1955) based on venational characters. The following three shared traits appear to support the hypothesis that these genera are closely related:

(1) The male ectoprocts are elongate oval without projecting narrow lobes. The ectoprocts of many other hemerobiid genera are variously lobed.

(2) The mediuncus forms a rigid horizontal plate which is bilobed distally and attached to the gonarcus by a pair of widely divergent proximal arms. The full distribution of this state and its possible derivatives within the Hemerobiidae needs additional investigation.

(3) The parameres consist of a prominent, anteriorly projecting apophysis proxima and a pair of small apical lobes. The medioventral surfaces of the apical lobes are sclerotized, the dorsolateral surfaces membranous. The parameres of many other hemerobiid genera possess various other dorsal and/or lateral lobes and patterns of sclerotization.

Though one or more of the preceding characters may in the future prove synapomorphic of a clade (*Austromegalomus* + *Conchopterella* + *Drepanacra*), at present, the polarities of these shared traits in relation to their homologues found in other hemerobiid genera are not known with confidence. Consequently, firm conclusions about the relative relationships among these three genera are presently impossible.

Currently available comparative analyses of important hemerobiid character complexes (e.g. wing venation and male genitalia) are in most cases insufficiently detailed, with regard to hypotheses of homologies and/or polarities, to allow confident differentiation of synapomorphies and symplesiomorphies. Consequently, it has not been possible to fully assess the status of some *Austromegalomus* character states which might later prove to be useful indicators of phylogenetic relationships.

Several factors have contributed to the dilemma described above. First, no recent comprehensive revision of the Hemerobiidae, with attention to character analysis, is available. Second, many terms widely employed in the current nomenclature of neuropterous genital structures were originally proposed expressly as labels of convenience, without critical investigation of the homologies of the labeled structures. Though some of these terms have apparently been applied to homologous structures (e.g. the gonarcus), others have not (e.g. the mediuncus-arcessus). Uncritical application of existing genitalic terms has hindered the improvement of hypotheses of homology for some genitalic structures.

Most hemerobiid genera are currently diagnosed, at least in part, on the basis of distinctive combinations of male genitalic characters. Given the importance of this character complex, additional comparative morphological studies are needed to clarify the homologies and polarities of genitalic characters. Until such analyses are undertaken, the phylogenetic position of *Austromegalomus*, and many other hemerobiid genera, will likely remain unclear.

Acknowledgments

I thank Oliver S. Flint, Jr., of the National Museum of Natural History (USMN), Washington, D.C., and Gordon M. Nishida of the Bernice P. Bishop Museum (BPBM),

Honolulu, Hawaii, for loaning material used in this study. I also thank James K. Liebherr and Quentin D. Wheeler, Department of Entomology, Cornell University and an anonymous reviewer for providing comments on an earlier draft of this paper.

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PROC. ENTOMOL. SOC. WASH.
90(1), 1988, pp. 62–65

LECTOTYPE DESIGNATION FOR *EMPIS CHICHIMECA* WHEELER AND MELANDER (DIPTERA: EMPIDIDAE)

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Abstract.—A lectotype and six paralectotypes for *Empis* (= *Lamprempis*) *chichimeca* Wheeler and Melander are designated from the syntype series. Diagnostic leg features of the lectotype male are discussed and illustrated. Comments concerning the lectotype and its presumed detached hind leg are provided.

The Neotropical genus *Lamprempis* Wheeler and Melander presently includes 22 species of metallic greenish blue to black flies with an evanescent anal wing vein and peculiarly ornamented legs. The often dimorphic sexes show presence or absence of pennate hair fringes and other modifications of the legs. Several species are known from one sex only. Little information is available about the biology and habits for species of *Lamprempis*. Smith (1975) reports that one species, *L. sazimae*, occurs in great numbers in the highlands of Minas Gerais, Brazil, where it serves as an important pollinating agent for certain Umbelliferae and Eriocaulaceae growing in meadows at 1300 m above sea level.

The purpose of this paper is to report the interesting results of my study of the available syntype series for *Empis chichimeca* Wheeler and Melander (1901: 368), the type species of *Lamprempis*, and to designate a lectotype for this species.

In 1981, while examining the A. L. Melander types of *Empis* Linnaeus at the National Museum of Natural History (USNM), I found several syntype specimens of *E. chichimeca*. The original series consisted of nine specimens (two males and seven females) collected by H. H. Smith in Amula, Guerrero, Mexico. I could find only three female specimens in the USNM type collection. Also present was the apparent right hind leg of a male, glued to a card rectangle and labeled "type" in Melander's hand. It had been attached on its anterior side and embedded in an unknown adhesive, but the characters of the exposed posterior surface are easily visible and match the description of the species provided by Wheeler and Melander (1901). At that time I supposed that the leg, which possesses characters sufficient for recognizing the species, was the only portion remaining of one male, the remainder destroyed by pests or otherwise lost.

Later, in the collection of the American Museum of Natural History (AMNH), I discovered another part of the same syntype series (one male, three females). All specimens are in good condition. Interestingly, I found that the AMNH male is intact except for the missing right rear leg. After re-examining the USNM point-mounted leg, I concluded that it likely represents the missing leg from the AMNH specimen.

There is no indication when the leg of the male syntype was broken or removed from the otherwise intact specimen. One can only speculate why the leg was not kept with the associated male. The detached leg, however, possesses the diagnostic features of the species (see Smith 1975) and it serves as an

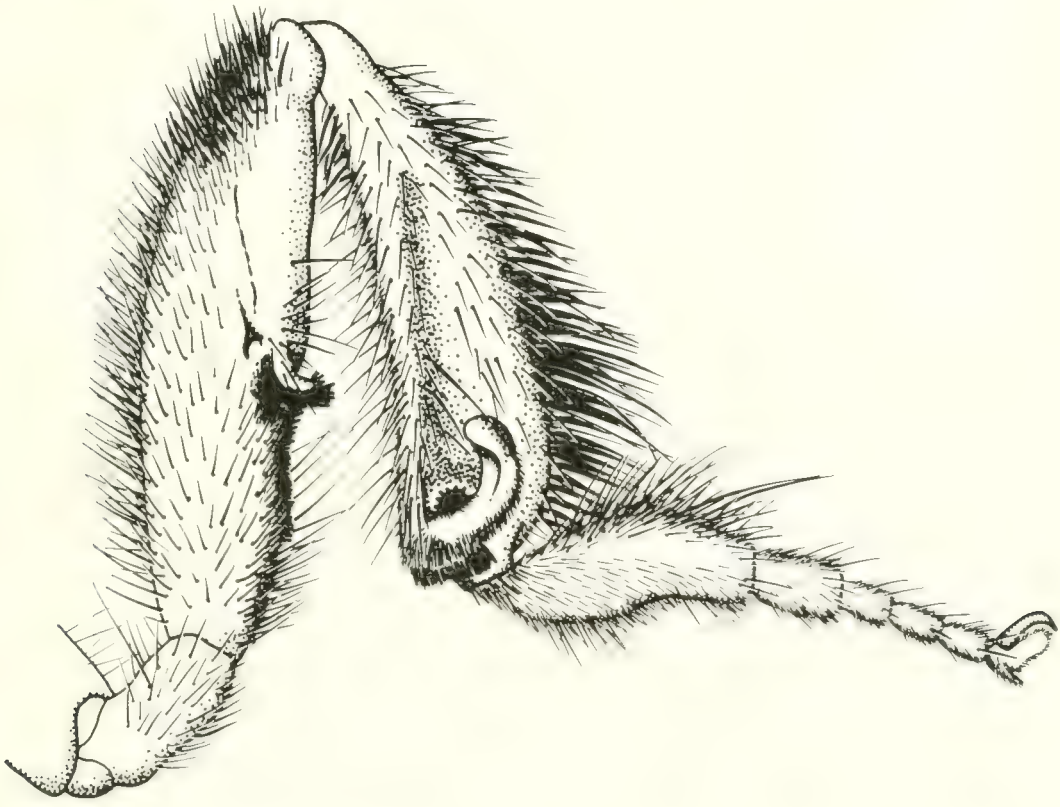

Fig. 1. Right hind leg (detached) of *Empis* (= *Lamprempis*) *chichimeca*, lectotype male, in posterior view.

excellent reference even without the intact specimen itself. The leg may have permitted Melander to have the ideal "reference specimen" in his collection while Wheeler had the remainder of the specimen. Because I cannot find the other male in the syntype series, I assume that the detached leg may have served this function for Melander.

Because this male and especially its detached leg bear the diagnostic features of the species, and nearly intact AMNH male is hereby designated the lectotype of *Empis* (= *Lamprempis*) *chichimeca* and its detached right rear leg (in the USNM) is similarly marked with my red lectotype label. I have illustrated the detached right leg (Fig. 1) along with the left hind leg (Fig. 2). The remaining six females of the known syntype series have been labeled paralectotypes.

The male specimen (AMNH) selected as lectotype is in excellent condition, except for the missing right rear leg, and bears the following label data: "Amula, Guerrero, 6000 ft., Sept., H. H. Smith/W. M. Wheeler Collection/TYPE NO. ____ AMNH [red label]/AMNH, DIZ No. 918 [white label]/ LECTOTYPE, Empis (= Lamprempis) chichimeca Wheeler and Melander, des. W. J. Turner 1988 [red label, hand written]."

The point-mounted leg (USNM) lacks a locality label but has the following label data: "E. chichimeca W & M TYPE [white label in Melander's hand]/Cotype Lamprempis chichimeca W & M [red cotype label in Melander's hand]/A L Melander Coll. 1961 [white label with green checked margin]/ LECTOTYPE (part), Empis (= Lamprempis) chichimeca Wheeler and Melander, des. W. J. Turner 1988 [red label, hand written]."

Besides the lectotype male, I found that

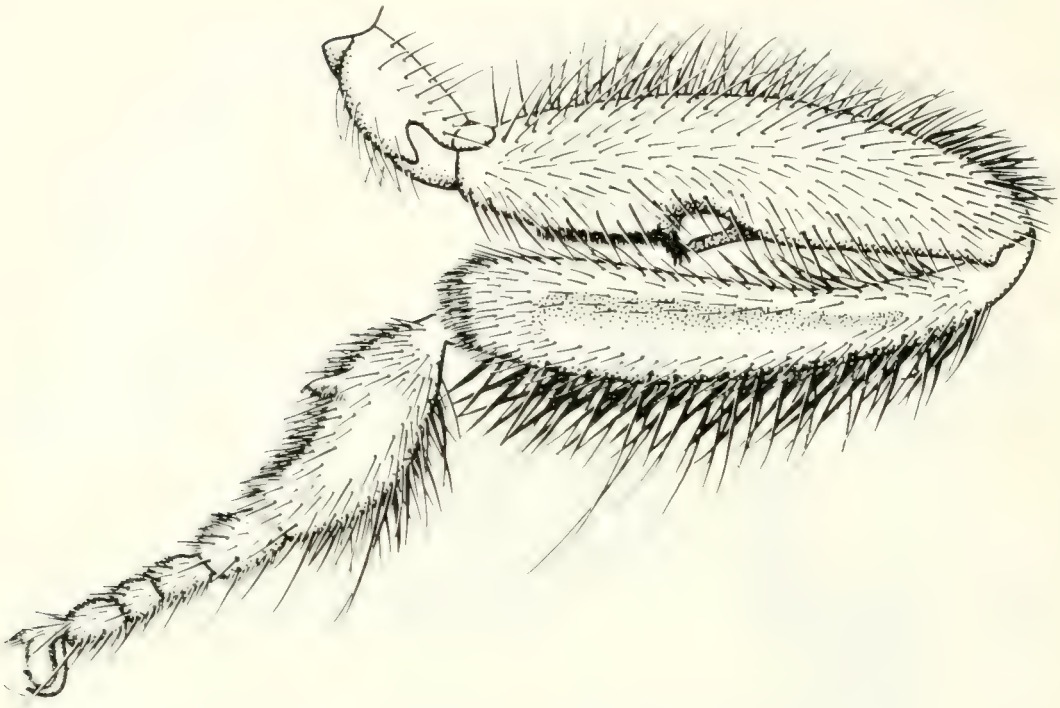

Fig. 2. Left hind leg of *Empis* (= *Lamprempis*) *chichimeca*, lectotype male, in anterior view.

only two of the available females (AMNH) bear the same label data. The remaining four females (USNM, AMNH) have identical labels but were collected in August.

Only seven specimens (one male, six females) from the original syntype series of nine specimens have been accounted for. The location of one additional male and female remain unknown. Because much of the insect material described in the Biologia Centrali Americana was subsequently deposited in the British Museum (Natural History) (BM), I asked John Chainey, Curator of Diptera (BM), to check for syntype specimens of this species. He was unable to locate any representatives of *chichimeca* under either *Empis* or *Lamprempis* in the BM collection. Further, there was no reference made to the species in any lists of holdings by the museum. All of the known syntypes, now in either the USNM or AMNH, were originally in the collections of W. M. Wheeler or A. L. Melander respectively, as indicated by the personal collection labels attached to the specimens. Only one USNM female lacks such a label probably because it was placed in that collection by the authors shortly after the species was described.

Discussion

In 1901 *Empis chichimeca* was described by W. M. Wheeler and A. L. Melander, and placed into their new subgenus *Lamprempis* along with five other species from Mexico. Coquillett (1903) elevated *Lamprempis* to generic rank and designated *E. chichimeca* as the type species. Although the diagnostic features for this species have never been illustrated, the species is easily keyed. Smith (1975) includes *E. chichimeca* in his tentative key to the described species of *Lamprempis* and uses essentially the same wording as in the original description by Wheeler and Melander for describing the unique features of the hind leg: "Hind femora pos-

teroventrally with two slender finger-like processes, with an emargination between them; hind tibia posteriorly with a stout scoop-shaped process truncated and flattened at the extremity; hind basitarsus incrassate with an anterior projection tipped with two small black spines."

The hind legs of this species are somewhat asymmetrical with minor differences in structures from left to right. Similar asymmetry can be found in the armature of the hind legs of males of *Empis* (*Enoplempis*) *mira* Bigot. In the case of *E. chichimeca* the right femur appears to have a small hooked process on the posterior surface near the base of the larger, digitate process. Proximal to the small hook is a low, irregular carina with toothlike projections running obliquely across the subbasal fourth of the hind surface. Unfortunately the leg is embedded in an adhesive glue matrix and the edge of the glue follows along the carina. On the left femur, in comparison, the small hook is lacking as is the oblique carina. The description was likely made from the right (detached) appendage as it refers to the two, slender, fingerlike processes, probably the thicker digitate process and the small hooked one. I found that the similar digitate processes located medially on the posteroventral margin of both hind femora also differ from left to right in orientation, the left one being more linear, the right more oblique. One will also see from the illustrations that the general outline of each femur is different as well.

Both hind tibiae are moderately concave medially on both the anterior and posterior surfaces along nearly their entire length. The concavities appear natural and not simply artifacts of the legs having collapsed at death. Although the surrounding areas are heavily bristled, the depressed spaces remain essentially bare.

Smith (1975) indicates in couplet 14 of his key that *E. chichimeca* has only simple leg bristles. However, pennate bristles can be found in two irregular rows along the entire dorsal surface of each hind tibia and flanked by fewer, less developed but still flattened bristles. An additional five or six pennate setae can be found at the extreme base of the tibiae ventrally while each femur bears a cluster on its inner and dorsal surfaces apically. Although pennate leg bristles are not uncommon in females of some Empidinae (e.g., *Rhamphomyia* species), they are unusual in males and appear restricted to *Lamprempis*.

Acknowledgments

I thank Lloyd Knutson, Systematic Entomology Laboratory, USDA, % National Museum of Natural History, Washington, D.C., and Pedro Wygodzinsky, Department of Entomology, American Museum of Natural History, New York, New York, who made syntype specimens of *Empis* (*Lamprempis*) *chichimeca* in their respective collections available for study. Dr. Knutson also provided work space and optical equipment in his office during my sabbatical stay in Washington, D.C. John Chainey at the British Museum (Natural History) checked for additional syntype material and his efforts are appreciated. Thanks also to Paul Arnaud, Jr., James Johnson and Norman Woodley who reviewed this manuscript. Scientific Paper No. 7622, Agricultural Research Center, College of Agriculture and Home Economics, Washington State University, Pullman, Washington. The work was conducted under Project 9043.

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PROC. ENTOMOL. SOC. WASH.
90(1), 1988, pp. 66–75

MAYACNEPHIA SALASI (DIPTERA: SIMULIIDAE), A NEW BLACK FLY SPECIES FROM COSTA RICA

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Abstract.—The female, male, pupa and larva of ***Mayacnephia salasi,*** new species, are described and illustrated. This genus is recorded from Costa Rica for the first time, and is now known from western North America, Mexico, Guatemala, Costa Rica and Panama. A key to the species of *Mayacnephia* known in the pupal stage is provided.

The genus *Mayacnephia* Wygodzinsky and Coscarón (1973) was established to include six Mesoamerican species that had been placed previously in the genus *Cnephia* Enderlein. Díaz Nájera (1971) described another new species in the genus *Cnephia* that belongs in *Mayacnephia,* and J. L. Petersen (1985) described a new species from Panama. B. V. Peterson (1981), using an expanded concept of the genus, assigned two species to it from western United States and an undescribed species from Canada. The species described below is the eleventh described species now assigned to the genus and the first to be reported from Costa Rica. We describe this new species to make its name available for biological studies currently being conducted on black flies in Costa Rica. We also provide a key to the known pupae of *Mayacnephia,* including the undescribed species from Canada, and include distributions and references to published figures of these species.

Mayacnephia salasi Ramírez-Pérez, Peterson, and Vargas, New Species

Figs. 1–18

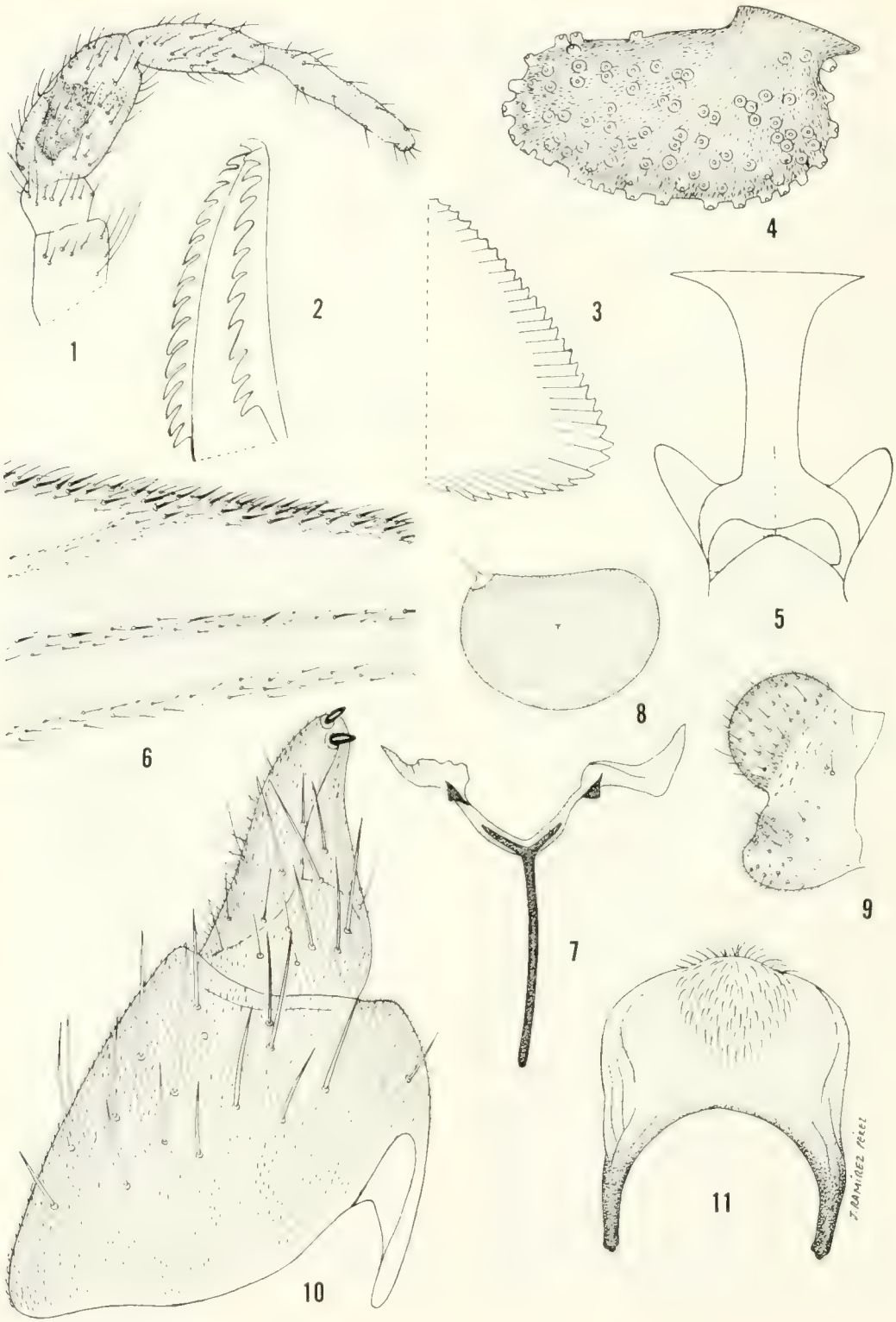
Female (preserved in alcohol).—General body color dark brown. Length: body, 2.88 mm; wing, 3.48 mm.

Head: Lightly grayish pollinose. Frons (Fig. 5) narrow, nearly parallel sided, only slightly widening dorsally, about five times as long as width at narrowest point, about ⅙ width of head; slightly paler than occiput, densely covered with long, decumbent, pale yellow pile, and with a few black setae laterally. Clypeus concolorous or slightly lighter than frons; slightly longer than wide; densely covered with long, ventromedially directed, pale yellow pile interspersed with some dark setae laterally and ventrally. Occiput densely covered with long, pale yellow pile and with a few dark setae mid-dorsally; postocular setae black, closely bending over eye margin. Antenna with nine flagellomeres; scape and pedicel pale yellowish, contrasting with rest of flagellum which is dark brown; pedicel and first flagellomere larger than other antennomeres and subequal in length and width; remaining flagellomeres subequal in length to each other but tapering in width distally; fine pubescence and longer setae dark. Mandible (Fig. 3) with 33–40 serrations. Blade of maxilla (Fig. 2) with 21–25 retrorse teeth. Palpus (Fig. 1) dark brown to black, proximal two palpomeres pale brownish, distal two palpomeres slightly lighter brownish than palpomere three, all with black setae; palpomere five about ⅓ longer than palpomere three. Sen-

sory vesicle as in Fig. 4, about ½ as long as its segment, proximally situated, its neck short, arising anterodorsally and extending vertically, with an enlarged ovoid mouth. Median proximal space of cibarium shallow, broadly U-shaped, and without denticles; dorsolateral arms short, rather broad, sclerotized, inner surface of each arm with a rather extensive patch of minute setulae arising from dark granular bases.

Thorax: Antepronotal lobe concolorous with scutum, with dense, long, pale yellow pile interspersed with a few dark setae. Postpronotum yellowish brown, distinctly paler than scutum, covered with long, semi-erect pale yellow pile. Scutum dark brown to blackish brown except lateral margins which are narrowly paler, and with a grayish pollinose border extending around lateral and hind margins, posterior declivity broadly grayish pollinose; each anterolateral corner of scutum, adjacent to postpronotal lobes, a paler yellowish brown color which, in posterior view, extends posteriorly as a faint, narrow, submedian line, and with a similar faint, slender, median line or vitta that extends to posterior declivity, these lines not visible in anterior view; scutum densely covered with short, recumbent, pale yellow pile that is longer along anterior and lateral margins and still longer posteromedially, also a few scattered dark setae present. Scutellum paler brownish than scutum, lightly grayish pollinose, densely covered with long, pale yellow and dark setae. Postnotum only faintly darker than scutellum, with a faint pollinosity. Anterior half of pleuron dark brown mottled with some paler areas, and distinctly paler brown on posterior half that is mottled with some darker areas; presternal lobe with moderately long pale yellow pile; anepisternal membrane distinctly paler than rest of pleuron; mesepimeral tuft dark. Wing (Fig. 6) membrane hyaline but with a light brownish tinge; veins yellowish brown. Base of C, stem vein, and other veins with dark pile; Sc setose ventrally; R_1 setose dorsally; R_{4+5} setose ventrally; cell bm present; C with spiniform setae as long as regular setae, apical half of R_1 with a few similar spiniform setae; fringe of anal lobe and calypter pale yellow. Stem of halter and base of knob brownish yellow, rest of knob yellow; stem with pale yellow pile. Legs rather uniformly dark brown; all coxae with both pale and dark setae but pale setae more numerous on fore and midcoxae, rest of setae on legs dark; hind basitarsus about seven times as long as broad. Calcipala short but distinct, broadly rounded; pedisulcus absent. Claw only slightly curving from base, with a prominent, bluntly pointed, basal tooth that is wider than claw and over ½ as long.

Abdomen: Yellowish brown, basal scale (tergite one) dark brown, with a fringe of long, pale yellow pile; tergites broad, tergite two widest, others decreasing in width posteriorly; tergites yellowish centrally with darker brown margins, sparsely covered with short, pale yellow setae; pleural membrane paler and more yellowish brown, with both pale yellow and dark setae; sternites scarcely distinguishable; venter of abdomen pale brownish yellow, with mostly short, dark setae but with some scattered pale yellow setae. Terminalia as in Figs. 7–9. Anal lobe (Fig. 9) narrow dorsally, broadening ventrally, widest at about midheight, broadly rounded ventrally, with a slight but distinct notch posteroventrally, not produced beneath cercus, moderately setose. Cercus subrectangular, hind margin varying from strongly rounded to nearly straight. Hypogynial valves short, barely reaching to bases of cerci; valves subtruncate posteriorly, their medial margins lightly sclerotized; lightly setose. Stem of genital fork (sternite nine) (Fig. 7) long, heavily sclerotized, slightly more than ⅓ longer than arms; arms short, rather weakly sclerotized except for a short, heavily sclerotized rodlike extension on each side emanating from stem of genital fork; arm with a sclerotized subtriangular toothlike process on anterior margin; arms rather broadly attached to tergite nine. Spermathe-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J. RAMIREZ PEREZ

ca (Fig. 8) kidney-shaped, moderately sclerotized, with a faint, loose reticulate pattern but without internal spicules; with only a small clear area at junction with spermathecal duct.

Male (preserved in alcohol).—General body color velvety dark brown to black. Length: body, 3.12 mm; wing, 3.18–3.45 mm.

Head: Frons and clypeus lightly grayish pollinose, with erect, black pile. Occiput with long, dark brown to black setae. Antenna entirely dark brown; first flagellomere angularly broadened distally, slightly longer than pedicel; fine pubescence pale yellow, longer setae black. Palpomere three darker than other palpomeres, all with black pile interspersed with a few more yellowish setae; palpomere five about ⅓ longer than palpomere three and about ½ longer than palpomere four. Sensory vesicle about ⅓ as long as its segment; neck short, enlarging to form a round mouth.

Thorax: Antepronotum and postpronotum concolorous, slightly paler brown than scutum; with some dark setae and some pale yellow pile having dark bases. Scutum with a light grayish pollinosity; densely covered with short, recumbent, pale yellow pile that is longer anteriorly, laterally and posteromedially. Scutellum brown, paler than scutum; densely covered with long, erect, dark setae and some decumbent, pale yellow setae. Postnotum concolorous with scutellum, lightly grayish pollinose. Pleuron brown anteriorly, grayish pollinose, becoming paler brown medially and posteriorly; anepisternal membrane brownish yellow; mesepimeral tuft dark. Wing membrane hyaline but with a distinct brownish tinge, veins yellowish brown. Base of C, stem vein, and other veins with dark pile; Sc lightly setose ventrally; R_1 setose dorsally; R_{4+5} setose ventrally; C and about distal ⅔ of R_1 with spiniform setae that are about as long as regular setae; cell bm present; fringe of anal lobe brownish yellow; fringe of calypter pale yellow. Knob of halter brown, stem yellow with pale yellow pile. Legs rather uniformly dark brown, with dark pile; hind basitarsus swollen, about 3.5 times as long as broad; calcipala short but distinct, rounded apically; pedisulcus absent.

Abdomen: Basal scale dark brown, with a fringe of long dark pile; tergites with darkened margins, paler medially, covered with short, brown pile; sternites concolorous with tergites, with long, dark setae. Terminalia as in Figs. 10 and 11. Gonocoxite (Fig. 10) subtriangular to conical, greatest length and width nearly equal, covered with pile on all but basal ¼ to ⅓. Gonostylus short, about ½ longer than greatest width at base; tapering to a bluntly pointed, apical margin bearing two tiny terminal spines. Body of ventral plate of aedeagus (Fig. 11) subrectangular, broader than long, with a short, ventrally directed hirsute lip; in ventral view, apical margin slightly convex and shortly produced nipplelike medially, lateral margins slightly concave just distal to junction with basal arms; basal arms bowed, nearly equal in length to body of ventral plate; median sclerite of aedeagus short, Y-shaped, stem variably longer than arms; aedeagal membrane rather densely covered with numerous groups of 8–10 minute setulae arranged in rows. Plate of endoparameral organ an elongate subtriangular shape, moderately sclerotized; arm moderately long, and twisting.

Pupa.—Length of specimens at hand 3.5 mm. Respiratory organ (gill) (Fig. 12) 1.62 mm long; consisting of four rather short but

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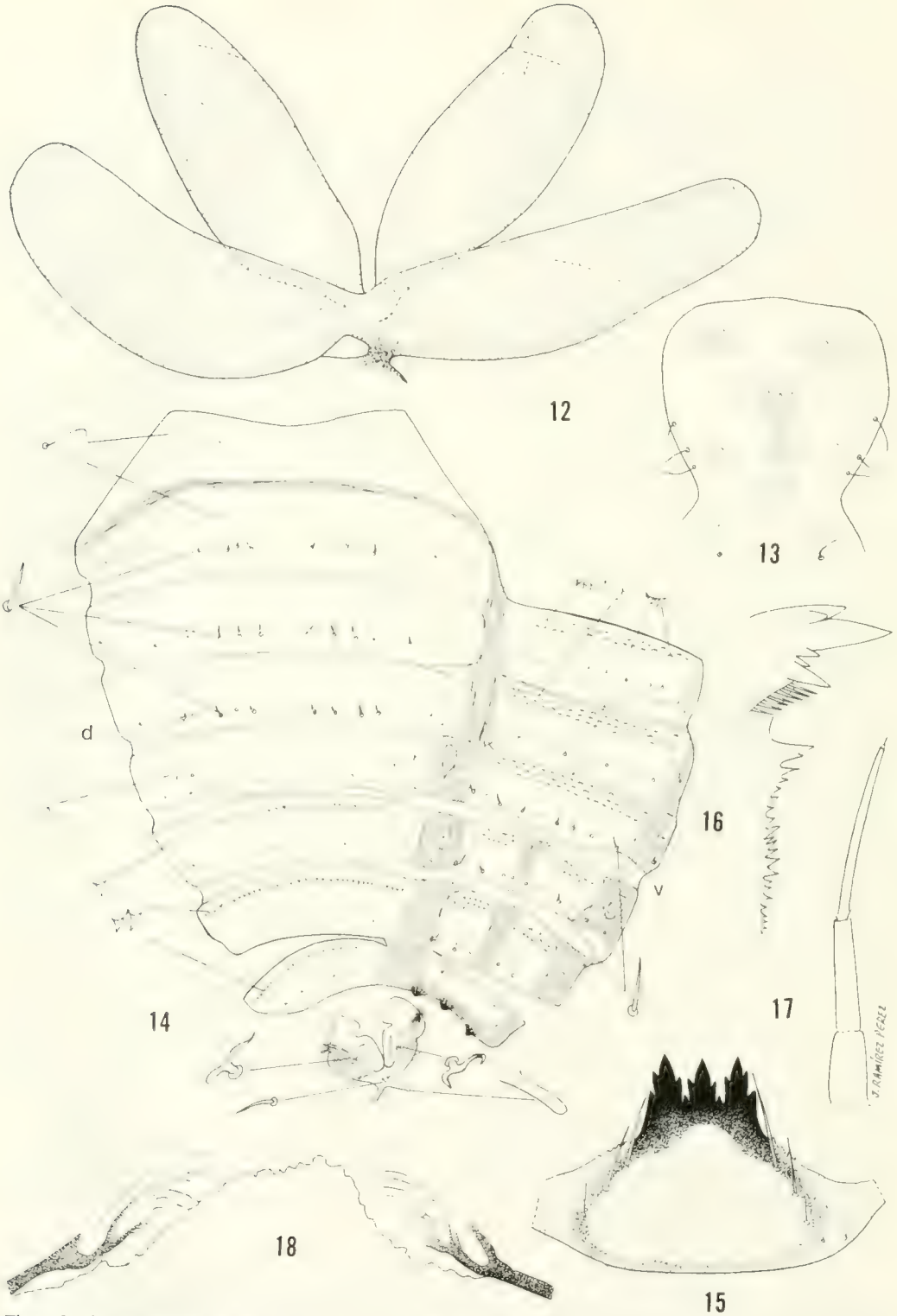
Figs. 1–11. *Mayacnephia salasi.* Figs. 1–9, female. 1, Maxillary palpus. 2, Blade of maxilla showing retrorse teeth. 3, Tip of mandible showing serrations. 4, Enlarged view of sensory organ of third palpomere. 5, Front view of frons and ocular notches. 6, Portion of wing showing setation. 7, Genital fork (sternite 9). 8, Spermatheca. 9, Anal lobe and cercus. Figs. 10–11, male. 10, Gonocoxite and gonostylus (dorsal (inner) surface). 11, Ventral plate of aedeagus, ventral view.



Figs. 12–18. *Mayacnephia salasi*. Figs. 12–14, pupa. 12, Respiratory organ (gill). 13, Frons. 14, Abdomen showing chaetotaxy on dorsal (d) and ventral (v) surfaces. Figs. 15–18, Larva. 15, Hypostoma. 16, Inner distal and subapical margins of mandible showing dentation. 17, Antenna. 18, Hypostomal cleft.

cylindrical, inflated saclike filaments originating from a common short, rather broad base covered with minute spicules; these saclike filaments are rather uniform in length and width, nearly transparent and have a minutely granular texture that is visible only at high magnifications. Head and thoracic integument glabrous; antenna of male extending about ½ distance to hind margin of head; antenna of female extending about ¾ or more of distance to hind margin of head; a single stout seta present near inner corner of each antenna, and two or three, somewhat separated, shorter and more slender setae present along outer margin of frons at about midlength of antenna (Fig. 13). Dorsum of thorax without any trace of integumental pattern; each side of thorax with about two anterodorsal and one posterodorsal, and one anteroventral and one posteroventral long, simple trichomes, anterodorsal trichomes stoutest. Chaetotaxy of each lateral half of abdominal tergites as follows (Fig. 14): tergite one with five or six fine setae; tergite two with four or five fine setae and four stouter hooks; tergites three and four each with 2–5 minute setae and four anteriorly directed spines along posterior margin; tergite five with about seven minute setae; tergite six with two or three minute setae and a row of minute, posteriorly directed spinules along anterior margin; tergite seven with three minute setae and an anterior row of minute spinules; tergite eight with two minute setae and an anterior row of minute spinules; tergite nine with a few minute spinules anteriorly, and two long caudal spines situated on two slightly swollen convexities, these spines slightly curved, tips divergent, each with a long, stout seta near base posteriorly. Chaetotaxy of each lateral half of sternites as follows: sternite three with three or four weakly sclerotized hooklets and one fine seta; sternites four and five each with four or five hooklets; sternite six with three well-developed hooks; sternite seven with two well-developed hooklets, and one pale, medial oval area; sternite eight with one strong hooklet, and one fine seta; sternite nine with two fairly strong setae in striated membrane, plus a strong seta at base of caudal spine, otherwise bare; sternites three to eight each with a variably sized but distinct patch of minute spinules. Striated pleural membrane on each side of: segment five with two fine setae one of which is in a platelet-like sclerite; segment six with one hooklet and one fine seta in a platelet-like sclerite; segment seven with one hooklet; segment eight with one fine seta; segment nine with eight stout hooks that may be simple, bifurcate, or grapnel-shaped; intersegmental membranous area between segment eight and nine with three short but distinct nipple-like bumps on each half. Cocoon a loosely wooven, saclike structure without any definite shape, and covered by detritus.

Larva (mature, with fully developed respiratory histoblasts).—Length 6.5–8.5 mm. General body color pale creamy brown; intersegmental lines narrow, slightly lighter than rest of abdomen. Head capsule pale yellowish brown; head spots pale brown but darker than surrounding fulvus area, anteromedian and posteromedian spots slender, elongate, the two sets of spots well separated, first and second anterolateral spots roundish, about equal in size and distinctly separated, posterolateral spots slightly darkened and somewhat obscure; eye spots small. Postocciput with broad gap dorsally, enclosing small cervical sclerites. Antenna (Fig. 17) pale brownish; about ¾ as long as stalk of labral fan; proportions of segments (basal to apical) 1:7.7:2.6. Labral fan with 25–33 (av. 29) primary rays. Hypostoma as in Fig. 15, with 13 teeth arranged in three main groups of 4 + 3 + 4 plus a small tooth on each side of base of median tooth; median tooth long, subequal to longest lateral teeth of each side; each lateral group of teeth similar in structure to median group, consisting of one main tooth and a smaller tooth on each inner and outer margin, and a short, more ventral, lateral tooth; outer lateral

margins of hypostoma with 3–6 weak serrations and two or three long and one or two short hypostomal setae, with longest seta reaching tip of longest hypostomal tooth. Hypostomal cleft (Fig. 18) poorly defined, a broad, shallow, U-shaped excavation extending about ⅜ distance to base of hypostoma. Hypostomal bridge distinctly longer (25:18) than hypostoma. Mandible (Fig. 16) with one large apical tooth, three stout preapical teeth followed by a series of six or seven more seta-like teeth, and two outer teeth; inner subapical ridge with about 16–25 fine serrations. Maxillary palpus about 2.5 times as long as width at base. Lateral plate of proleg extending about ½ or more length of apical segment; irregularly subquadrate to subtriangular, greatest width and height nearly equal; lightly sclerotized, with about 20 very slender rod-like extensions projecting distally toward bases of hooks; circlet of apical hooks arranged in about 17 rows. Segment eight of abdomen with two short, broadly rounded tubercles that extend about ⅙ to ⅐ depth of abdomen below their points of attachment. Anal papillae with three simple lobes; minute rectal setulae present lateral to anterodorsal arms of anal sclerite. Anterodorsal arms of anal sclerite about ½ as long as posteroventral arms; anterior arms slender, posterior arms considerably broader; sclerotized platelike junction of arms bearing 8–10 fine setae, these setae short but conspicuously longer than rectal setulae. Posterior circlet of hooks consisting of about 8–10 hooks in about 62–65 rows.

Types.—Holotype, ♀ (mounted on five slides), temporary stream (#45a) located at one side of the road between km 96 and 97, near La Georgina on route from Cartago to San Isidro del General, Provincia San José, Costa Rica, November 14, 1983, C. R. Méndez and A. Solano V.

Paratypes.—1 ♀, 1 ♂, same data as type except preserved in alcohol and terminalia of both specimens mounted on slides; 1 ♂, same data except November 1, 1983 (mounted on three slides); 1 ♂, same data except November 6, 1983 (mounted on three slides); 1 ♀, same data except November 12, 1983 (mounted on four slides); 2 ♀♀, 1 ♂ (all pinned), same data except October 28, 1983, A. Solano V. and H. Mayreno; 1 ♂ (mounted on six slides), same data except October 24, 1983, and 1 ♂ (mounted on six slides), same data except November 7, 1983, A. Solano V. and H. Mayreno; 2 pupae, same data except October 28, 1983 (one pupa mounted on two slides, the other pupa mounted on four slides); 30 pupae (four mounted on slides), same data except October 28, 1983, A. Solano V. and H. Mayreno; 13 pupae, same data except July 14, 1986, A. Solano V. and H. Mayreno; 1 larva, same data except June 7, 1983 (mounted on five slides); 1 larva, same data except June 17, 1983 (mounted on six slides); 12 larvae (five mounted on six slides each), same data except July 14, 1986, A. Solano V. and H. Mayreno.

Holotype deposited in the collection of the U.S. National Museum of Natural History, Washington, D.C. Paratypes are deposited in the U.S. National Museum of Natural History, and the entomology collection of the Department of Parasitology, University of Costa Rica.

This species is dedicated to Eng. Luis Angel Salas F., a distinguished acarologist, and Professor Emeritus at the School of Agronomy, University of Costa Rica.

Biological notes.—All available specimens of *M. salasi* came from the same temporary stream (numbered 45a) at the type locality. This small, shallow, clean-water stream is situated at an elevation of 3150 meters in the bottom of a deep, steep-sloped gulley in an area partially to heavily shaded by forest, and with a moderate amount of vegetation on the banks. The stream is about one meter wide, with a bed of rocky sections and muddy areas. The water flows at a slow to moderate rate, has a temperature that ranges between 10–14°C, and pH values are between 7.1 and 7.8. Larvae are present in the stream throughout the year.

Remarks.—Wygodzinsky and Coscarón

(1973) recognized two groups of species in *Mayacnephia* based on the chaetotaxy of the abdomen and the form of the respiratory gills of the pupae. The new species described here belongs to their "apomorphic" group having a reduced number of filaments and without at least an apical filamentous portion to the filaments, as well as having a larger number of sternal setae and hooks. *Mayacnephia salasi* has only four simple, inflated, saclike filaments in the respiratory organ, and has more numerous spines on the sternal sclerites (sternite five with about 5+5, sternite six with about 3+3, and sternite seven with about 2+2) characteristic of this group of species. The recently described *M. fortunensis* Petersen (1985), from Panama, also belongs to this group.

Mayacnephia salasi appears to be most similar to *M. grenieri* (Vargas and Díaz Nájera) in the adult and pupal stages. The female of *M. salasi* can be most easily differentiated from *M. grenieri* by the antenna, which has a yellowish scape and pedicel that contrast with the dark brown flagellum (in *grenieri* the antenna is entirely yellow except for the black first flagellomere), the halter with its yellow knob and brownish yellow stem (knob black, stem whitish), and the genital fork whose arms diverge from the stem in a broad V-shape and have rectangular plates that are wider than long, each plate with a small, sclerotized, toothlike process on its anterior margin (arms of genital fork diverge from the stem at nearly right-angles so the posterior space between the arms is broadly U-shaped, the plates are shorter, broader and subrectangular, and each has a prominent tooth-like process). The male of *M. salasi* can be distinguished from *M. grenieri* by the all black antenna (in *grenieri* the antenna is yellow except for the black first flagellomere), the pale yellow, recumbent pile of the scutum (recumbent pile light brown), halter brown with a yellow stem (halter entirely black), and by the shape of the ventral plate of the aedeagus which, in ventral view, is more rectangular with a more broadly rounded distal margin, and longer basal arms (more triangular in ventral view, with narrower and more pointed apical margin and much shorter basal arms).

Larvae of *M. salasi* can be distinguished from *M. grenieri* by the following combination of characters: length 6.5–8.5 mm (larvae of *grenieri* range from 8.0—9.0 mm), pale creamy brown color (distinctly yellowish but more opaque especially posteroventrally), antenna about ¾ length of stalk of labral fan (antenna as long as stalk of labral fan), labral fan with 25–33 primary rays (40–45 primary rays), hypostoma with 13 apical teeth (9 apical teeth), hypostomal bridge distinctly longer (25:18) than hypostoma (hypostomal bridge and hypostoma nearly equal in length), and posterior circlet with 62–65 rows of hooklets (76 rows of hooklets in *grenieri*).

The species of *Mayacnephia*, as with some other groups of Simulidae, are most easily differentiated on the basis of the number and shape of the filaments of the pupal respiratory organ (gill). The following key to the pupae of the species of *Mayacnephia* will differentiate *M. salasi* from the other described species of the genus. The pupa of *M. osborni* (Stains and Knowlton), a species described from California, does not appear in the key because it is unknown. We are unable to prepare a reliable key to the other stages of the species of *Mayacnephia* for lack of specimens. Dalmat (1955) and Díaz Nájera (1962) provided keys that include the larvae of various species now included in *Mayacnephia*, and Dalmat provided a key to the males and females of the three species known from Guatemala.

Key to Species of *Mayacnephia* Pupae

1. Respiratory organ with two long, swollen tubular filaments arranged in the form of a V (figs. 17–18 in Dalmat 1949; fig. 10B in Wygodzinsky and Coscarón 1973). Highlands of Guatemala, Mexico (Chiapas) *aguirrei* (Dalmat)
– Respiratory organ with three or more filaments of varying form and arrangement ... 2
2. Respiratory organ with three long, swollen, tubular filaments (fig. 20 in Díaz Nájera 1962). Mexico (Oaxaca) ..... *mixensis* (Díaz Nájera)

– Respiratory organ with four or more filaments of varying form 3
3. Respiratory organ with four filaments 4
– Respiratory organ with six or more filaments 5
4. Filaments short, inflated and saclike with broadly rounded tips, all arising from a common base (fig. 12 herein). Costa Rica .... *salasi* n. sp.
– Filaments longer, swollen but not greatly inflated or saclike, tubular with pointed apices, arranged in two pairs (fig. 22 in Vargas and Díaz Nájera 1948; fig. 9A in Wygodzinsky and Coscarón 1973). Mexico (Veracruz) ... . *grenieri* (Vargas and Díaz Nájera)
5. Respiratory organ with six long, swollen, tubular filaments that are rounded distally, anterior two filaments single, posterior two filaments branching into two petiolate pairs (fig. 4 in Coleman 1953). California *stewarti* (Coleman)
– Respiratory organ with seven or more filaments of varying form 6
6. Respiratory organ with seven or eight filaments 7
– Respiratory organ with 11–15 filaments ... 9
7. Respiratory organ with seven filaments 8
– Respiratory organ with eight filaments (fig. 27 in Currie 1986). Western Canada ....(unnamed species X)
8. Respiratory organ with four swollen, tubular filaments, three of which, in turn, give rise to two slender filaments distally, and the fourth which has a single slender terminal filament (fig. 8A in Wygodzinsky and Coscarón 1973). Highlands of Guatemala ..... *roblesi* (León)
– Respiratory organ with four swollen, tubular, clavate filaments; anteromedial and posteromedial filaments unbranched although the former sometimes with a variably developed thumblike hump on its mesal surface; anterolateral filament branching into two petiolate filaments, and posterolateral filament branching into three filaments (fig. 8 in Petersen 1985). Panama .....*fortunensis* Petersen
9. Respiratory organ with 11–12 filaments ... 10
– Respiratory organ with 14–15 filaments arising from four thickened main trunks (figs. 13–18 in Díaz Nájera 1971). Mexico (Coahuila) ..... *muzquicensis* (Díaz Nájera)
10. Respiratory organ with 11 tubular filaments that are variably swollen basally, some of the filaments are much longer than the others (fig. 9 in Díaz Nájera 1962). Mexico (Morelos) .. *atzompensis* (Díaz Nájera)
– Respiratory organ with 11–12 long, slender, tapering filaments and one short, medial filament, flaments branching fanlike horizontally (fig. 6H in Wygodzinsky and Coscarón 1973). Guatemala, Mexico (Chiapas) *pachecolunai* (León)

Acknowledgments

We thank C. R. Méndez and A. Solano V., field collectors, and W. González, laboratory assistant, Centro de Investigación y Diagnóstico en Parasitología, Universidad de Costa Rica, for field and technical support during our investigations. Financial and logistic support was provided for our studies by the Vicerrectoría de Investigación, Universidad de Costa Rica; and the International Committee of Migrations (CIM) provided financial support to J. Rámirez-Pérez for travel to Costa Rica. We are grateful to P. Malikul, laboratory technician, Systematic Entomology Laboratory, for help in the preparation of the plates that accompany this paper. We thank P. H. Adler, Department of Entomology, Clemson University, Clemson, S.C.; W. N. Mathis, Department of Entomology, Smithsonian Institution, Washington, D.C.; and P. M. Marsh, N. E. Woodley, and F. C. Thompson, Systematic Entomology Laboratory, ARS, USDA, who kindly read our manuscript and made helpful comments.

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SIMULIUM (*HEMICNETHA*) *HIEROGLYPHICUM* (DIPTERA: SIMULIIDAE), A NEW BLACK FLY SPECIES FROM COSTA RICA

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Abstract.—The female, male, pupa and larva of *Simulium* (*Hemicnetha*) *hieroglyphicum*, new species, are described and illustrated. This species occurs in the highlands of Costa Rica, and is most readily differentiated from all other described species of the subgenus *Hemicnetha* by the large number of filaments in the respiratory organ (gill) and the peculiar hieroglyphic-like markings on the thorax and frons of the pupa. A key to the species of *Hemicnetha* known in the pupal stage is provided.

The subgenus *Hemicnetha* Enderlein presently includes about 22 New World species, mostly from the Neotropical Region. The number of species reported by country is as follows: Mexico, 12; Guatemala, seven; Belize, one; El Salvador, one; Costa Rica, two including the new species described here; Panama, six; Colombia, three; Venezuela, six; Trinidad and Tobago, one; Guyana, one; Brazil, two; Bolivia, one; and Argentina with two species (Pinto 1932, Vargas and Díaz Nájera 1951, 1957, Dalmat 1955, Vulcano 1967, Barreto 1969, Field 1969, Ramírez-Pérez 1971, Ramírez-Pérez and Vulcano 1973, Bueno et al. 1979). Two of the species included in the above listing, viz *S. solarii* Stone and *S. virgatum* Coquillett, are known also from the Nearctic Region (Stone 1948). Despite the number of species assigned to this subgenus, there is no comprehensive study of the group. Even so, pupae are known for most of the described species, all of which differ from the distinctive pupa of the new species described below. This new species is described to provide a name to use in work currently being done on the black fly fauna of Costa Rica. This is the second paper in a series describing new species from Costa Rica; for the first paper see Ramírez-Pérez, Peterson, and Vargas (1988). A key to the pupae of the described species of *Hemicnetha*, with distributions and references to published figures, is provided.

Simulium (*Hemicnetha*) *hieroglyphicum*, New Species

Figs. 1–21

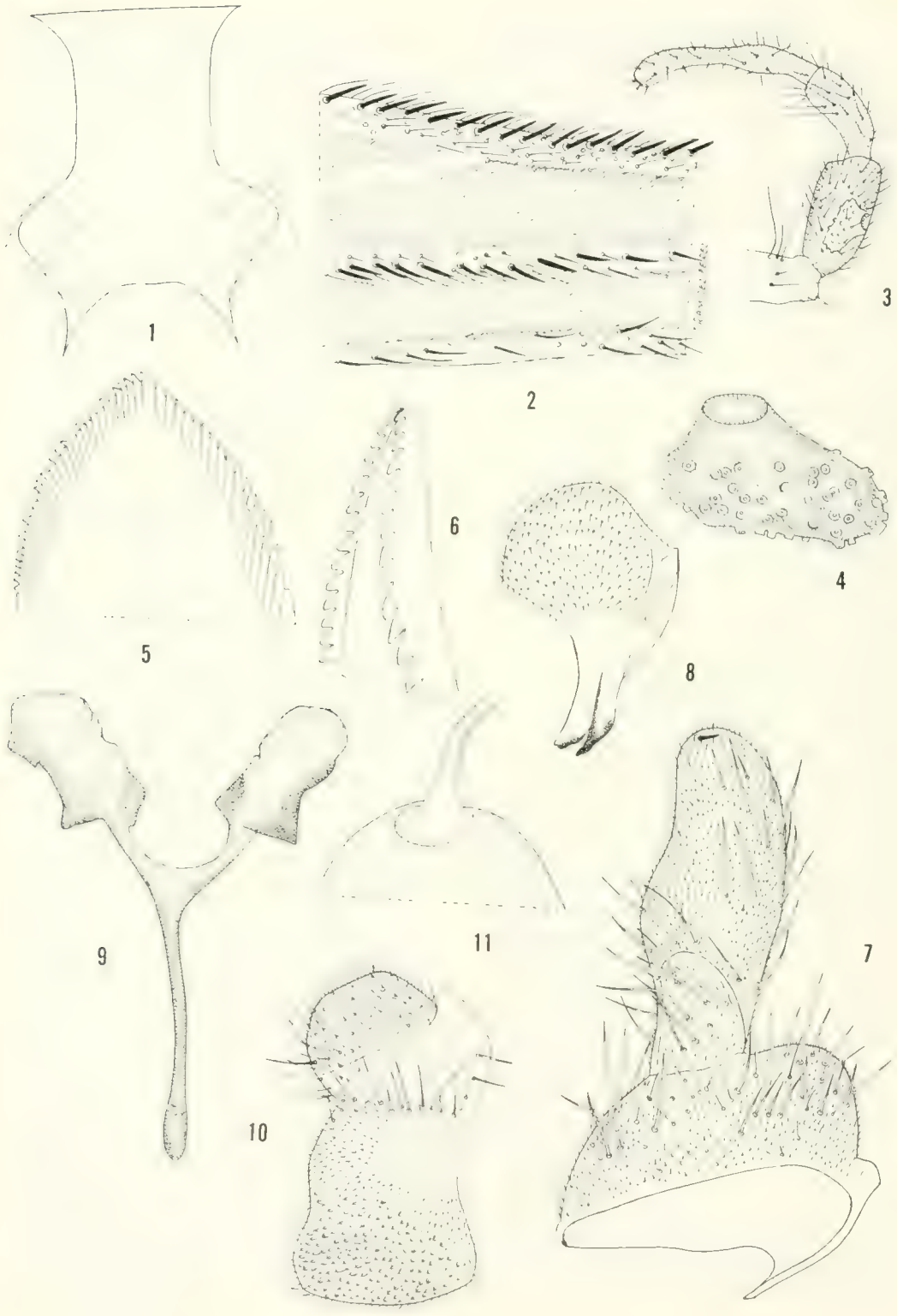
Female (preserved in alcohol).—General body color blackish brown. Length: body, 4.0 mm; wing, 4.08–4.5 mm.

Head: Lightly silvery pollinose. Frons (Fig. 1) moderately broad, at vertex about ¼ wider than at narrowest point, distinctly less than ½ as wide as head, and narrower than long; covered with long, decumbent, black pile. Clypeus concolorous or slightly lighter than frons; slightly longer than wide;

covered with long, ventromedially directed, black pile. Occiput silvery pollinose, densely covered with long, black pile; postocular setae black, closely bending over eye margin. Antenna entirely dark brown to black, with nine flagellomeres; pedicel slightly longer than first flagellomere; fine pubescence black. Mandible (Fig. 5) with 44–51 serrations. Blade of maxilla (Fig. 6) with 23–28 retrorse teeth. Palpus (Fig. 3) with basal two palpomeres and fifth palpomere slightly lighter than palpomere three; palpomere five slightly more than twice as long as palpomere three; all palpomeres with black setae. Sensory vesicle (Fig. 4) about ½ as long as its segment, proximally situated, neck absent or very short with an enlarged, ovoid mouth. Median proximal space of cibarium shallow, broadly U-shaped, and with about 45 minute setulae with rounded bases in membrane medially; dorsolateral arms short, rather broad, sclerotized, inner surfaces of arms with numerous, minute, sensory setulae.

Thorax: Postpronotum small; slightly paler than scutum especially along adjoining margin; covered with long, recumbent, golden yellow pile interspersed with some semi-erect to erect, black setae. Scutum with lateral margins narrowly more pale brownish and with a silvery pollinose border extending around margins, posterior declivity broadly silvery pollinose; anterolateral corners of scutum without distinct silvery spots, but in posterior view, with three slender, dark vittae that extend anteriorly from posterior declivity, median stripe longest, lateral stripes extending about ½ distance to anterior margin; scutum densely covered with short, recumbent, golden yellow setae grouped in small clusters, pile longer along anterior and lateral margins and still longer posteromedially; anterior margin of scutum with a number of long, dark, erect setae, and posterior declivity with more numerous, longer, dark setae. Scutellum yellowish brown; densely covered with short, appressed, golden yellow setae, and numerous long, black setae. Postnotum with dense silvery pollinosity. Pleuron brownish black anteriorly, densely silvery pollinose, becoming paler yellowish brown medially and posteriorly, and often mottled with dark areas; anepisternal membrane brownish yellow, often mottled; mesepimeral tuft of long, black setae. Wing (Fig. 2) membrane hyaline but with a definite brownish tinge; veins brown. Base of costa, stem vein, and remaining veins with black pile; Sc with numerous setae ventrally except for about apical ⅕ which is bare; R_1 with both setae and spinules dorsally; R_{4+5} setose ventrally; stem of wing just basal to MA lightly sclerotized with a conspicuous oval windowlike area present; fringe of anal lobe and calypter with black setae. Knob of halter yellowish white; stem yellowish brown, with pale yellowish setae. Legs with forecoxa, trochanter and femur yellow to brownish yellow especially on distal margins, these segments with short, golden yellow scales plus longer black setae; tibia mostly black with some yellow medially, tarsus black, both tibia and tarsus with black setae mixed with a few yellow setae. Midcoxa, trochanter, basal ⅓ of femur, basal ⅔ of tibia, and about basal ⅔ of basitarsus yellow, remaining portions of midleg black; with mostly black setae. Hind coxa brown; trochanter, basal ⅓ of femur, about basal ½ of tibia, and basal ⅖ to ½ of basitarsus yellow, remainder of hindleg black; with mostly black setae; hind basitarsus swollen, about five times as long as broad; calcipala prominent, stout, broadly rounded apically, reaching to middle of pedisulcus or slightly beyond; pedisulcus moderately deep but not conspicuous. Claw evenly curving from base, with a small but conspicuous subbasal tooth.

Abdomen: Brownish black dorsally, becoming paler laterally and ventrally; basal scale (tergite one) with fringe of long, pale yellow pile; tergites blackish brown, with darker hind margins, covered with short, dark setae; tergite 10 small, subrectangular, wider than long. Pleural membrane paler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brownish yellow, with dark setae. Sternites heavily sclerotized; sternites 2–7 subequal in length, sparsely covered with dark setae; posterior margin of sternite eight with long, black setae. Terminalia as in Figs. 9–11. Anal lobe (Fig. 10) broad, subrectangular, anterior margin slightly concave medially, hind margin nearly straight or slightly bilobed, ventral margin nearly straight, not produced beneath cercus, densely setose. Cercus (Fig. 10) rather small, subrectangular, about two times as high as long, hind margin broadly rounded. Hypogynial valves elongate, ¼ longer than greatest basal width, not reaching hind margins of cerci; outer margin of each valve rather deeply concave, inner margin broadly rounded, apex rounded, with a curved, longitudinal ridge that runs from near apex to near inner basal margin, inner ¼ moderately sclerotized and bare, remaining area densely microsetose. Stem of genital fork (sternite nine) (Fig. 9) long, heavily sclerotized, twice as long as arms; each arm short, expanding into a large, subrectangular plate with outer lateral margin thickened ridgelike and inner proximal corner thickened as a short, rounded process; arms broadly attached to segment nine. Spermatheca (Fig. 11) globular, heavily sclerotized, without a pattern, but with a small circular membranous area at junction with spermathecal duct; inner surface of spermatheca rather evenly covered with numerous, but well separated, minute spicules.

Male.—General body color velvety brown to black. Length: body, 4.6–6.0 mm; wing, 3.9–4.2 mm.

Head: Frons and clypeus densely silvery pollinose, clypeus with erect, black pile. Occiput densely covered with long, black setae. Antenna with scape, pedicel and extreme base of first flagellomere yellow, rest of flagellum black; first flagellomere nearly twice as long as pedicel; scape with tuft of dark setae that are much longer than sparse setae of pedicel especially those of distal margin, fine pubescence of flagellomeres pale yellow, longer setae black. Palpus entirely dark brown to black, with black pile; palpomere four slightly but distinctly longer than three, palpomere five about three times as long as palpomere three. Sensory vesicle small, about ⅓ as long as its segment; neck distinct, enlarging to form a round mouth.

Thorax: Postpronotum small, yellow, with short, recumbent, golden yellow pile interspersed with a few more erect black setae. Scutum brownish black, margins, especially laterally and on notopleuron, slightly paler brown, narrowly silvery pollinose along anterior margin but covering most of posterior declivity; densely covered with short, recumbent, golden yellow pile grouped into small clusters, pile slightly longer laterally and posteromedially, posterior declivity with some long, erect, black setae. Scutellum yellow, densely covered with moderately long, semi-erect, golden yellow setae interspersed with some long, erect, black setae. Extreme anterior margin of postnotum concolorous with scutellum, remainder brownish black, densely silvery pollinose. Pleuron dark blackish brown and densely silvery pollinose anteriorly, becoming paler yellowish brown medially and darker brown posteriorly; anepisternal membrane brownish yellow; mesepimeral tuft of long, black setae. Wing membrane hyaline but with a faint yellowish tinge; veins yellowish brown; base of costa, stem vein, and remaining veins with black setae; Sc with about 12 setae at extreme base ventrally; R_1 with both setae and spinules dorsally; R_{4+5} setose ventrally;

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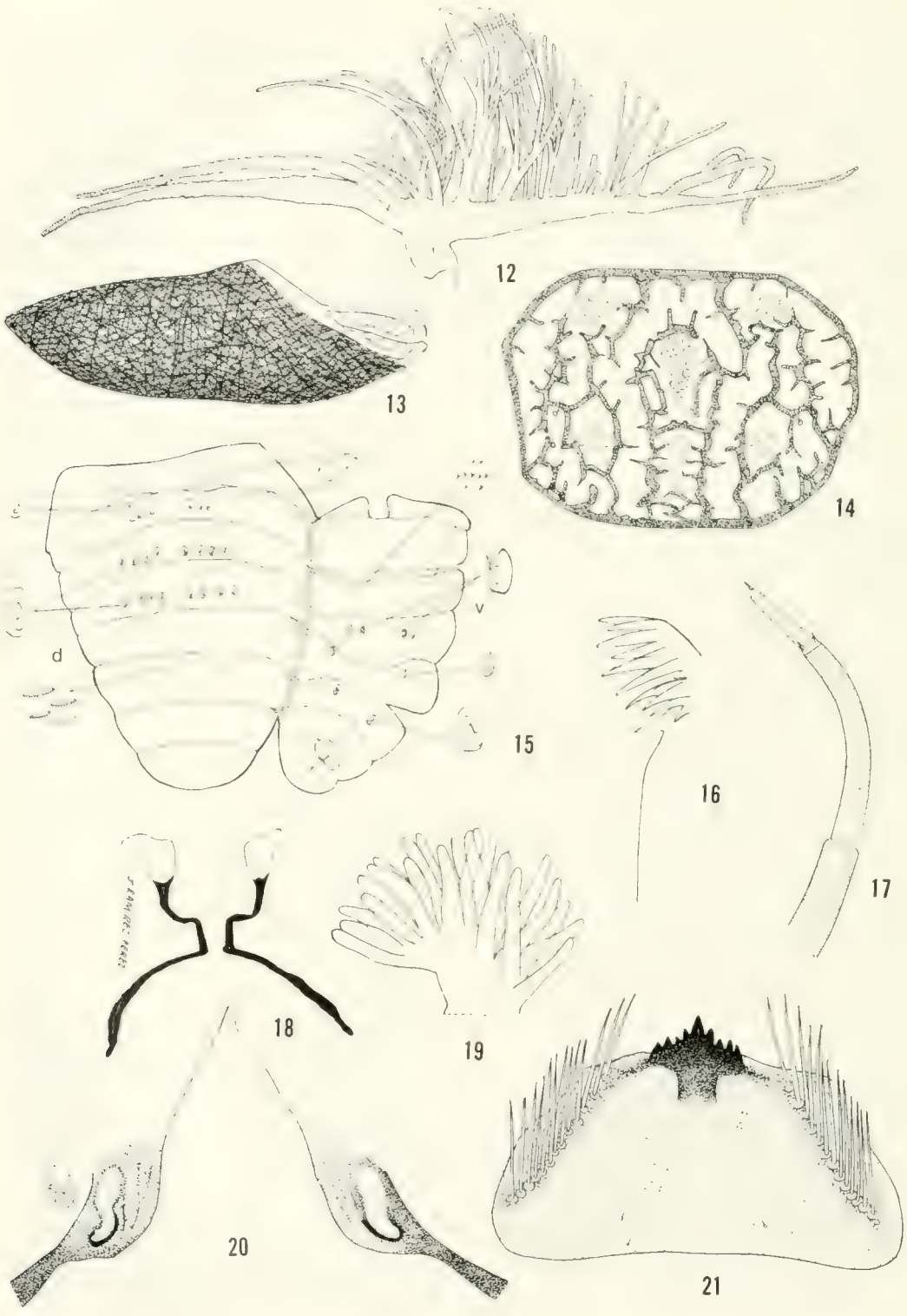
Figs. 1–11. *Simulium* (*H.*) *hieroglyphicum*. Figs. 1–6, female. 1, Front view of frons and ocular notches. 2, Portion of wing showing setation. 3, Maxillary palpus. 4, Enlarged view of sensory organ of third palpomere. 5, Tip of mandible showing serrations. 6, Blade of maxilla showing retrorse teeth. Figs. 7–8, male. 7, Gonocoxite and gonostylus (dorsal (inner) surface). 8, Ventral plate of aedeagus, lateral view. Figs. 9–11, female. 9, Genital fork (sternite 9). 10, Anal lobe and cercus. 11, Spermatheca.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stem of wing just basal to MA lightly sclerotized with a conspicuous oval windowlike area present; fringe of anal lobe and calypter brownish yellow, setae often with black bases. Knob of halter white, stem brownish yellow with pale yellow pile. Fore coxa, trochanter and femur yellow tinged with brown, especially on distal margins, tibia and tarsus black; coxa and trochanter anteriorly with yellow setae plus scattered black setae; tip of femur and anterior surface of tibia with appressed, golden yellow scales, rest of setae black. Mid- and hind coxae dark brown; trochanters dark brown mottled with patches of yellow; mid- and hind femora brownish yellow with dark brown apices; tibiae largely dark brown on anterior face but bases and inner surfaces yellow; about basal ½ of first two tarsal segments yellow, their apices dark brown, remaining portions and rest of tarsomeres dark brown; anterior surfaces of mid- and hind femora, tibiae and basitarsi with appressed, golden yellow scales, rest of setae black; hind basitarsus swollen, about three times as long as broad; calcipala prominent, broadly rounded, nearly obscuring pedisulcus; pedisulcus deep. Claw short, slender, with a short but conspicuous subbasal tooth.

Abdomen: Brownish black dorsally, becoming brownish yellow laterally and ventrally; basal scale with fringe of long, dark setae black at base and distally paler brownish to yellowish; tergites broad, all nearly uniform in width, velvety in texture and with black hind margins, tergites 2–7 each with an oblique, silvery, pollinose patch laterally, covered with short, black setae; tergite 10 small, rectangular, longer than broad. Pleural membrane of segments 3–6 with a dorsal patch of long, black setae just lateral to margin of respective tergites, segment seven with a similar but smaller patch. Sternites 3–8 nearly uniform in width, dark brown on about basal ⅔, paler yellowish on about distal ⅓, with black setae. Terminalia as in Figs. 7–8. Gonocoxite (Fig. 7) subrectangular, about ⅓ wider than long, moderately setose on about distal ½. Gonostylus long, slightly more than three times as long as greatest width at base; margins strongly sinuous, inner margin with distinct bulge at midlength, apical margin rounded, with a single terminal spine. Ventral plate of aedeagus (Fig. 8) with a prominent, broadly rounded ventral lip which, in lateral view, resembles a medieval broadhead ax; in ventral view, body slightly wider than long, lateral and apical margins broadly rounded; basal arms rather slender and straight, obliquely directed outwardly with tips rather strongly curving inwardly. Median sclerite of aedeagus with a slender, straight stem that branches into two broad arms nearly as long as stem, arms tapering distally, narrowly rounded to slightly pointed. Plate of endoparameral organ moderately large, subrectangular, moderately sclerotized; arm only slightly longer than basal plate, twisting, with a series of corrugations and rather poorly defined teeth on outer margin, apical five or six teeth short, stout and better defined than more proximal teeth; aedeagal membrane densely covered with minute spinules arranged in rather regular comblike series of about three to 12 spinules per comb.

Pupa.—Length 6.3–7.0 mm. Respiratory organ (gill) (Fig. 12) 3.0 mm long, often reaching hind margin of thorax; consisting of a short, rather broad base, covered with minute spicules, and with one thick basal branch projecting posteriorly over thorax and dividing apically into two or more slender filaments, and with two similar, thick, closely appressed basal branches, one stouter than the other, which project anteriorly

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Figs. 12–21. *Simulium (H.) hieroglyphicum.* Figs. 12–15, pupa. 12, Respiratory organ (gill) (anterior branch to the left). 13, Cocoon. 14, Portion of frons showing integumental pattern. 15, Abdomen showing chaetotaxy on dorsal (d) and ventral (v) surfaces. Figs. 16–21, larva. 16, Inner distal and subapical margins of mandible showing dentation. 17, Antenna. 18, Anal sclerite. 19, Anal papillae. 20, Hypostomal cleft. 21, Hypostoma.

over head and apparently not dividing into finer filaments apically nor giving rise to other filaments along their dorsal surfaces; dorsal surface of main posterior branch giving rise to about 60–90 relatively short, slender, pale grayish white filaments, some of which are simple, and some dividing at varying distances from their bases into two or more apical filaments. Frons (Fig. 14) with a series of strong, rugosities giving rise to short, spurlike projections; without other granulations; antenna of both female and male reaching only about ½ distance to hind margin of head; a single, short, fine seta present medial to base of each antenna. Dorsum of thorax with strong rugosities, some with short, spurlike projections; these rugosities arranged in a loose reticulate pattern, without other granules dorsally; two long, simple, dorsal trichomes present on each side of thorax. Chaetotaxy of each lateral half of tergites as follows (Fig. 15): tergite one with two fine setae and a closely associated lateral patch of minute spinules; tergite two with three fine setae, and a median patch of minute spinules; tergite three with three small hooklets, three fine setae, and a patch of minute spinules anterolateral to hooklets, and a similar but smaller patch just posterior to hooklets; tergites four and five each with four stout, anteriorly directed hooks near hind margin, 3–4 fine setae, and an anterolateral patch of minute spinules; tergites 6–8 without fine setae but with a small anterolateral patch of minute spinules; tergite nine bare, caudal spines absent. Chaetotaxy of each lateral half of sternites as follows: sternites 1–3 bare; sternites 4–5 each with an anterolateral patch of minute spinules; sternites 6–7 each with two anteriorly directed hooks, and sternite eight with one similar hook, all three of these sternites with a patch of minute spinules just anterior to hooks; sternite nine with an anterior patch of minute spinules across its width. Cocoon (Fig. 13) boot-shaped, densely woven, with floor extending anteriorly about ½ length of flat bottom portion of cocoon; in lateral view, anterior collar of cocoon relatively short, slanting anterodorsally, with one or two small festoons or windowlike openings near anterolateral margin, which, however, are easily broken off and lost.

Larva.—Length 13.0–13.5 mm. Body gradually expanding posteriorly; color grayish dorsally, lighter and more yellowish ventrally; intersegmental lines rather broad, slightly lighter than rest of abdomen dorsally. Head capsule brown, darker laterally and ventrally; head spots darker than rest of frontoclypeal apotome, posteromedian spot broad basally, strongly tapering distally, well separated from anteromedian spot, this paler and not as distinct; first anterolateral spot not discernible, second anterolateral spot large, distinct, well separated from first posterolateral spot, this smaller and less distinct; second posterolateral spot large but pale and diffuse; eye spots large. Antenna (Fig. 17) slightly longer than stalk of labral fan; proportions of segments (basal to apical) 1:2:0.68; dorsal half of basal two antennomeres yellowish brown, ventral half transparent, distal antennomere entirely yellowish brown. Labral fan with 52–59 (av. 55) primary rays. Hypostoma as in Fig. 21; median tooth short but longer than others; lateral teeth small, subequal in length but distal margin convex; lateral margins of hypostoma with 1–3 variable but small, weak serrations; 11–13 hypostomal setae along each margin and with 1–3 much smaller, more medial setae near hind margin. Hypostomal cleft (Fig. 20) moderately deep, extending about ⅔ distance to base of hypostoma, a narrow inverted V-shape. Hypostomal bridge slightly but distinctly longer than hypostoma. Mandible (Fig. 16) with 3–5 apical teeth, 5–8 preapical teeth, and inner subapical ridge with one fine but prominent tooth. Maxillary palpus 2.5 times as long as width at base. Lateral plate of proleg short and broad, heavily sclerotized, extending about ¼ length of apical segment; circlet of apical hooks in about 80 rows of about 20 hooks each. Rectal setulae minute; anal papillae (Fig. 19) complex, arranged in

three main groups of about 22-24-41 short, digitiform papillae. Anal sclerite (Fig. 18) heavily sclerotized, arms slender, narrowly joined; anterodorsal arms about ⅔ as long as posteroventral arms, anterodorsal arms terminating in slightly enlarged, subquadrate to subrectangular, lightly sclerotized plates. Posterior circlet of hooks consisting of 50–55 hooks in 500–550 rows.

Types.—Holotype, ♂ (reared with associated pupal pelt, all preserved in alcohol), stream (#34), upstream from bridge, Río Poasito, Cantón Poás, Provincia Alajuela, Costa Rica, November 4, 1986, A. Solano V. and W. González. The stream is located 23.5 km from Carrizal on the road to Poás Volcano.

Paratypes.—1 ♂ (mounted on 5 slides), same data except January 31, 1970; 1 ♀ (mounted on six slides) (reared with associated pupal pelt mounted on two slides), same data except July 18, 1986; 1 ♀ (mounted on five slides), 2 ♂♂ (one male mounted on four slides and one mounted on three slides) (all reared with associated pupal pelts each mounted on two slides), same data except August 8, 1986; 1 ♀ (reared) (pinned), 1 ♂ (pinned) and 2 ♂♂ (in alcohol), same data except August–September 1986; 1 pupa, same data except August 9, 1968; 19 pupae, same data except January 1, 1970; 10 pupae, same data except March 20, 1970; 5 pupae, same data except August–September 1986; 12 larvae, same data except January 31, 1970; 3 larvae, same data except March 20, 1970; 3 larvae, same data except September 5, 1986 (one larva mounted on six slides; two mounted on five slides each); 58 larvae, same data except August–September 1986.

Holotype deposited in the collection of the U.S. National Museum of Natural History, Washington, D.C. Paratypes are deposited in the U.S. National Museum of Natural History, and the entomology collection of the Department of Parasitology, University of Costa Rica.

Etymology.—The specific name is the singular, neuter form of the Latin adjective hieroglyphicus, and refers to the hieroglyphic-like markings on the dorsum of the head capsule and thorax of the pupa.

Biological notes.—All available specimens of *Simulium* (Hemicnetha) *hieroglyphicum* came from the same stream (#34) of the type locality. The stream arises from nearby slopes, which are covered with abundant vegetation and large trees that shade the area, and then passes through pasture land at about 1940 m in elevation. The stream is about 3 m wide, 0.3 m in depth and has a moderate to fast cascading flow over large boulders and smaller stones. A small amount of trailing vegetation, mostly torch ginger (*Nicolaia elatior* (Jack) Horan), occurs along the stream banks. There is no emergent vegetation in this portion of the stream. The water is unpolluted and ranges in temperature from 13 to 14°C. Larvae and pupae were found on both rocks and trailing vegetation. Adults were neither attracted to nor taken biting humans.

Remarks.—There is not full agreement as to the subgeneric assignments of a number of species of black flies. This is especially true for the Neotropical species, and, in fact, Vulcano (1967) in her catalog of the black fly species of the Americas south of the United States, did not assign species to any subgenera. Based on larval characters and those of the male and female terminalia, as described by Stone (1963), we have selected for inclusion in the key to pupae presented below those species that seemed to us to belong to *Hemicnetha*; even so, there might be some eventual reassignments as the Neotropical species are more thoroughly studied and become better known in all their life history stages.

There currently are no keys that include all the adult and immature stages of all the described species of *Hemicnetha*. Adults of *S. hieroglyphicum* do not satisfactorily run to any species in the keys of Dalmat (1955) or Vargas and Díaz Nájera (1957). Even though they seem to be most similar to *S. smarti* Vargas they differ in many more characters than there are similarities. Fe-

males of *S. hieroglyphicum* can be distinguished from those of all other known species by the Sc being setose ventrally except for about apical ⅓ which is bare, these setae placed in a single row except at the extreme base (four to five setae long) in which they are placed in a double row; anterior marginal area of scutum with numerous clusters of 2–3 golden yellow scalelike setae; the three dark, slender vittae that are visible in posterior view; and by the shape and form of the various genital structures (see Figs. 9–11). The males can be distinguished from all other known males of this group by the following combination of characters: Sc bare except for about 12 setae at extreme base; scutum without distinct dark vittae, but clothed with numerous groups of golden yellow, scalelike setae; broad hind basitarsus; and the distinctive form of the genital structures (see Figs. 7–8).

The respiratory organ, or gill, of the pupa of *S. hieroglyphicum* is distinctly different from those of all other known species as demonstrated by the following key. Two species, viz *muiscorum* Bueno, Moncada, and Muñoz de Hoyos, and *keenani* Field, are included in the key on the basis of published descriptions as we do not have material of these species to check for distinguishing characters. Although we have specimens of *pulverulentum* Knab we lack material of *S. guerrerense* Vargas and Díaz Nájera and so have followed the key of Vargas and Díaz Nájera (1957) to separate the pupae of these two species. Consequently, the key is not complete but it should be useful for separating the pupae of the majority of the species included. In the literature there are only a few other keys to pupae that contain two or more of the species that we include in *Hemicnetha*, and these are included under varying names and in varying combinations of species. None of these keys include all the species that are in the key given below. The pupa of *S.* (*H.*) *dehnei* Field, from Panama, is not known and so does not appear in the key. We are unable, at this time, to prepare a reliable key to the other stages of the species of *Hemicnetha* because of the lack of adequate material.

Key to New World Species *Simulium* (*Hemicnetha*) Pupae

1. Respiratory organ (gill) with six filaments . . 2
– Respiratory organ with eight or more filaments . 4
2. Two of the six filaments much shorter than the other four. Granulations on dorsum of thorax with spinules (Venezuela; fig. 30A, B, J, P in Ramírez-Pérez 1983) . . . . . *oviedoi* Ramírez-Pérez
– All filaments subequal in length. Granulations on dorsum of thorax disk- or buttonlike and without spinules . . 3
3. Cocoon shorter and higher than in following species, anterolateral margin of cocoon nearly straight and set at almost a right-angle to anteroventral surface of collar (Brazil; figs. 23–25 in Pinto 1932) . . *brachycladum* Lutz and Pinto
– Cocoon longer and lower than in above species, anterolateral margin of cocoon sloping and concave, anteroventral portion of cocoon projecting liplike (Venezuela; fig. 42D, E, K in Ramírez-Pérez 1983) . . . . . *rivasi* Ramírez-Pérez
4. Respiratory organ with eight filaments 5
– Respiratory organ with ten or more filaments 9
5. Cocoon boot-shaped, anterodorsal margin with well-developed festoons, these sometimes broken but traces of them usually remain 6
– Cocoon boot-shaped but anterodorsal margin simple, or with poorly-defined festoons 9
6. Frons almost totally covered by small spinules; thorax with small spinules ventral to base of respiratory organ. Caudal spines present but small (Colombia, Guyana, Brazil, Argentina; figs. 33–41 in Vulcano 1958) . . . . . *rubrithorax* Lutz
– Frons smooth, with, at most, a few granulations but without spinules; thorax without spinules. Caudal spines absent 7
7. Filaments arising from stem in two distinct groups of four filaments each (U.S.A., Mexico, Guatemala, Panama; figs. 7, 9 in Stone 1948; and 263, 270 in Vargas and Díaz Nájera 1957) . . . . . *virgatum* Coquillett
– Filaments all arising at about the same level from a common stem 8

8. Filaments slender, about 0.12 mm in width at base; thorax less densely granulose than in following species (Venezuela; figs. 1–4 in Ramírez-Pérez and Vulcano 1973; and 10B, O, P in Ramírez-Pérez 1983) .... *conviti* Ramírez-Pérez and Vulcano
- Filaments broader, about 0.60 mm in width at base; thorax more densely granulose than in above species (Mexico, Guatemala, Costa Rica, Panama, Venezuela; figs. 235, 237 in Vargas and Díaz Nájera 1957) ... *paynei* Vargas

9. Anterodorsal margin of cocoon with poorly developed festoons. Thorax strongly rugose in a somewhat reticulate pattern. All filaments petiolate, branching some distance from base (Mexico; figs. 181, 185, 186 in Vargas and Díaz Nájera 1957) .... *bricenoi* Vargas, Martínez Palacios, and Díaz Nájera
- Anterodorsal margin of cocoon without festoons. Thorax granulose but without reticulate rugosities. All filaments branching close together at or near the base (Mexico; figs. 198, 204 in Vargas and Díaz Nájera 1957) *freemani* Vargas and Díaz Nájera

10. Respiratory organ with ten filaments 11
- Respiratory organ with 12 or more filaments 14

11. Thorax densely covered with black spinules (Mexico; figs. 213, 216, 221 in Vargas and Díaz Nájera 1957) ..... *hinmani* Vargas, Martínez Palacios, and Díaz Nájera
- Thorax may be granulose but without spinules 12

12. Anterior collar of cocoon raised well above level of dorsum of pupal thorax; anterior face of collar almost vertical, its dorsolateral margins curving posteriorly downward in undulating fashion (Mexico, Guatemala; figs. 273, 276 in Vargas and Díaz Nájera 1957) ..... *yepocapense* Dalmat
- Anterior collar of cocoon only raised slightly above level of dorsum of pupal thorax; anterior face of collar distinctly oblique, its dorsolateral margins not undulating downward posteriorly, but simple and at least slightly directed anteroventrally 13

13. Anterodorsal margin of cocoon obliquely slanted anteroventrally. Respiratory organ with filaments somewhat longer and more isolated from each other (Mexico; figs. 210, 211 in Vargas and Díaz Nájera 1957) *guerrerense* Vargas and Díaz Nájera
- Anterodorsal margin of cocoon more horizontal, only slightly slanting anteroventrally. Respiratory organ with filaments somewhat shorter and more closely clumped [no characters are known that reliably separate pupae of this species from pupae of the above species] (Mexico, Guatemala, Belize, El Salvador, Panama, Venezuela; figs. 243, 246 in Vargas and Díaz Nájera 1957) ... *pulverulentum* Knab

14. Respiratory organ with 12 filaments 15
- Respiratory organ with 16 or more filaments 17

15. Anteroventral margin (lip) of cocoon deeply notched medially so that lateral portions are produced anteriorly as two subtriangular or spatulate processes (Mexico, Guatemala, Panama, Trinidad and Tobago, Venezuela, Colombia, Bolivia; figs. 226, 230 in Vargas and Díaz Nájera 1957) ... *mexicanum* Bellardi
- Anteroventral margin (lip) of cocoon simple, without a medial notch and without subtriangular or spatulate processes 16

16. Respiratory organ with relatively short filaments branching antlerlike; filaments without minute tubercles. Thorax without trichomes. Abdomen with two strong caudal spines (Argentina; fig. 6A–I in Wygodzinsky 1949) ..... *lahillei* Paterson and Shannon
- Respiratory organ with relatively short filaments but these not branching antlerlike; filaments covered by minute tubercles. Thorax with branched trichomes. Abdomen without caudal spines (Colombia; figs. 22–26 in Bueno et al. 1979) ..... *muiscorum* Bueno, Moncada, and Muñoz de Hoyos

17. Respiratory organ with 15–16 filaments ... 18
- Respiratory organ with 18 or more filaments 20

18. Anterior collar of cocoon raised well above level of dorsum of pupal thorax; dorsolateral margins of opening of cocoon curving posteriorly downward in undulating fashion. Respiratory organ with 16 filaments (Mexico, Guatemala; figs. 189, 195 in Vargas and Díaz Nájera 1957) ..... *earlei* Vargas, Martínez, Palacios, and Díaz Nájera
- Anterior collar of cocoon only raised slightly above dorsum of pupal thorax; dorsolateral margins of opening of cocoon not curving posteriorly downward in undulating fashion. Respiratory organ with 15–16 filaments ... 19

19. Respiratory organ usually with 15 filaments, 14 in pairs and 1 single filament. Dorsum of thorax smooth. Anterior collar of cocoon short, raised slightly above dorsum of pupal thorax, dorsolateral margins of opening of cocoon straight or slightly concave; (U.S.A., Mexico; figs. 8, 10 in Stone 1948; figs. 255, 261 in Vargas and Díaz Nájera 1957) .... *solarii* Stone
- Respiratory organ with 16 filaments variously

branching near base, some filaments branching in groups of three, some in pairs, and at least three singles. Anterior collar of cocoon longer (Panama; fig. 8 in Field 1969) ..
keenani Field

20. Respiratory organ with 18 filaments. Head and thorax without hieroglyphic-like rugosities (Mexico, Guatemala; figs. 252, 254 in Vargas and Díaz Nájera 1957) ... *smarti* Vargas

– Respiratory organ with two main branches, a posterior branch giving rise to 60–90 short, white filaments, and an anterior branch that divides into two filaments apically. Head and thorax with hieroglyphic-like rugosities (Costa Rica, fig. 11 herein) .....
.....*hieroglyphicum* Peterson, Vargas, and Ramírez-Pérez

Acknowledgments

We thank R. Echeverri, W. González, and the Centro de Investigación y Diagnóstico en Parasitología, Universidad de Costa Rica, for field and technical support in this investigation. Financial and logistic support was provided for our studies by the Vicerrectoría de Investigación, Universidad de Costa Rica; and the International Committee of Migrations (CIM) provided financial support to J. Ramírez-Pérez for travel to Costa Rica. We are grateful to P. Malikul, laboratory technician, Systematic Entomology Laboratory, for help in the preparation of the plates that accompany this paper. We thank J. W. Amrine, Jr., Department of Entomology, West Virginia University, Morgantown, W.V., W. N. Mathis, Department of Entomology, Smithsonian Institution, Washington, D.C., and D. C. Ferguson, A. L. Norrbom and F. C. Thompson, Systematic Entomology Laboratory, ARS, USDA, for reading and commenting on the manuscript.

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90(1), 1988, pp. 87–90

BELASPIDIA LONGICAUDA, NEW SPECIES, THE FIRST NEARCTIC *BELASPIDIA* (HYMENOPTERA: CHALCIDIDAE)

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Abstract.—***Belaspidia longicauda,*** new species, is described from specimens collected in California. Diagnostic characters for the female and male are illustrated. *Belaspidia longicauda* is incorporated into existing keys to world species of *Belaspidia*. The genus *Belaspidia* is recorded for the first time in the Nearctic Region; three other species occur in the Palearctic Region.

Prior to this paper, the genus *Belaspidia* contained only three species, all Palearctic. While examining material for a survey of Chalcididae in California, I found specimens of a Nearctic *Belaspidia*. Further study showed this to be a new species, representing the first record of the genus *Belaspidia* in the Nearctic Region and the fourth species in the genus. I take this opportunity to describe this species as it greatly contributes to the knowledge of the zoogeography and systematics of the family Chalcididae. Host information is known only for *Belaspidia obscura* Masi. This species is a pupal parasitoid of *Aperona crenulella* Brd. (Lepidoptera: Psychidae) (Bouček 1951a, Nikolskaya 1952).

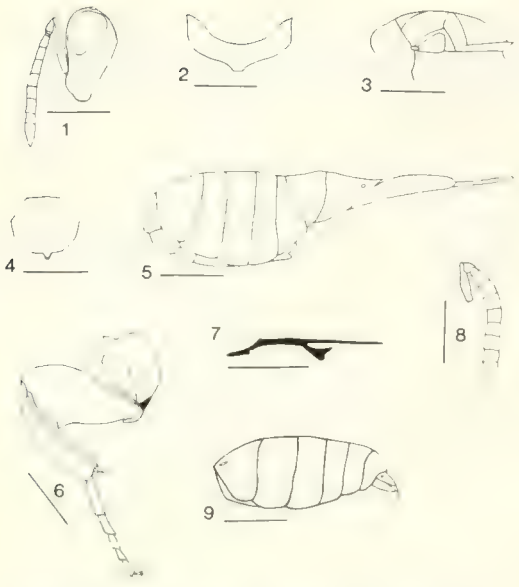
Belaspidia may be distinguished from other Chalcididae in North America by the following characters: Hindtibia truncate distally, two hindtibial spurs present (Haltichellinae); marginal vein on anterior margin of wing, postmarginal and stigmal veins present, distinct (Haltichellini); scutellum with a median tooth on posterior margin, postmarginal vein 1.7× as long as marginal vein, and tergite 1 without longitudinal carinae, coloration never green metallic.

Belaspidia longicauda Halstead, NEW SPECIES

Figs. 1–9

Holotype female.—Length 4.2 mm. Black, with orange markings. The following areas orange: mandibles, joint between scape and frons, joint between femora and tibiae of fore and middle leg, apex of tibiae, tarsi except for brown last tarsomere and claws, sternites, hypopygidium, ventral and lateroposterior margins of tergites, ventral margin of ovipositor sheath where bordered by epipygidium, marginal vein of forewing, and venation of hindwing. Compound eyes and pubescence silver, ocelli tan.

Eyes with short pubescence. Anterior ocellus round, separated from lateral ocelli by 1.7× its diameter. Lateral ocelli oval, separated from margin of compound eye by 0.8× their diameter. Labrum oval, slightly longer than wide, sublaterally with a depression, transversely microridged, ventral margin with a fringe of setae. Mandibles with a few setae on outer margin, left with 2 teeth, right with 3 teeth. Differentiation between clypeus and frons vague. Insertion of antennae ⅓ the distance from the base of



Figs. 1–9. *Belaspidia longicauda*. 1. Head and antenna of female. 2. Pronotum, dorsal view. 3. Thorax of female. 4. Scutellum, dorsal view. 5. Abdomen of female. 6. Hind leg of female, small teeth on ventral margin omitted. 7. Venation (partial) of forewing. 8. Antenna of male. 9. Abdomen of male. Scale lines 0.5 mm.

labrum to imaginary line between ventral margin of compound eyes (Fig. 1). Scape reaching almost to ventral margin of anterior ocellus, widest at ⅓ its length. Pedicel 1.5× longer than wide. Annellus 1 and 2 short, wider than long. Flagellar segments longer than wide. Flagellum and club longer than height of head (lateral view). Scrobe cavity shallowly depressed, coriaceous, without pubescence. Area between antennae flat, distance 1.5× antennal socket width, projecting into scrobe cavity as a raised triangle whose apex lies in the center of frons mediad of ventral margin of compound eyes. Frons at antennal insertions slightly rounded anteriorly (Fig. 1). Occiput medially emarginate for reception of anterior projection of pronotum.

Pronotum with posterior margin broadly emarginate, anterior medial margin slightly projected anteriorly, 5× as wide as long (Fig. 2). Thorax convex dorsally (Fig. 3), coriaceous laterally, dorsally with dense, shallow, small punctures; moderately setose. Posterior margin of scutellum with a median triangular projection that is centrally concave in dorsal view (Fig. 4). Mesopleural acetabulum very shallow, almost flat. Tegula triangular, ventral margin straight. Metapleuron and propodeum laterally with shallow punctures, moderately setose. Mesepisternum coriaceous, without setae. Propodeum with 2 strong, laterally arching submedian longitudinal carinae. Remainder of propodeum with a low areolation of carinae, integument coriaceous. Spiracle crescent shaped, arched anteriorly, wider at each end.

Abdomen sessile, long, 1.7× longer than length of head and thorax, apex accuminate, dorsal margin flat in lateral view (Fig. 5). Tergites with a thin shiny band on margins. T#1–4 dorsally punctate, remainder of abdomen except hypopygidium coriaceous. Hypopygidium smooth, heavily chitinized along median. Tergites (except T#1 and T#2–3 dorsally), epipygidium (except basal ½), and ovipositor sheath with long dense setae. T#1 submedially with a patch of setae. Petiole 3× as high as long, rectangular, anterior margin with a carina, laterally with a few vague longitudinal carinae.

Legs coriaceous, with short dense pubescence. Hindcoxa large, slightly longer than wide; its greatest width equal to that of hindfemur, dorsally with a triangular tooth which fits into posterior margin of metapleuron (Fig. 6). Hindfemur narrowly ovoid, 2× as long as wide, ventral margin with an acute tooth near middle, ventral margin with many minute teeth from large tooth to apex (Fig. 6). Hindtibia anteriorly with an inner and outer carina extending to near apex.

Forewing extending posteriorly to near apex of epipygidium. Forewing and hindwing clear, densely setose. Postmarginal vein long, 1.7× as long as marginal vein (Fig. 7). Stigmal vein ¼ as long as marginal vein. Hindwing with 3 hamuli.

Allotype male.—Length 3.8 mm. Similar to female but differs in compound eye col-

oration being brown, shape of antennae (Fig. 8), and shape of abdomen (Fig. 9).

Variation.—Body length of the female paratypes varies from 3.8 to 4.3 mm. The length and width of the scape in females varies slightly. One paratype with scape slightly longer and thinner than holotype, another with scape slightly shorter and wider. Two paratypes with length of abdomen shorter than holotype, 1.4× as long as head and thorax.

Specimens examined.—Holotype, ♀, United States, California, Tulare Co., Ash Mountain, Kaweah Powerstation #3, VIII-19-1982, R. D. Haines, from Halstead collection, deposited in National Museum of Natural History, Washington, D.C. (USNM). Allotype, ♂, United States, California, Los Angeles Co., Tanbark Flat, VI-23-1950, on *Eriogonum,* from California Insect Survey, University of California, Berkeley (CIS) collection, deposited in USNM. Paratypes.—California, Fresno Co., Coalinga, Coalinga Mineral Springs Road, V-21-1982, R. F. Gill (1 ♀, from Halstead collection to California Academy of Sciences, San Francisco). Sacramento Co., 10 mi. NE Folsom, V-11-1960, on *Eriodictyon californicum,* M. S. Wasbauer (1 ♀, California State Collection of Arthropods, California Department of Food and Agriculture, Sacramento). San Bernardino Co., Cronise Valley, IV-29-1956, on *Prosopis,* M. S. Wasbauer (1 ♀, CIS). San Bernardino Co., Sheep Creek, V-27-1973, E. M. and J. C. Hall (1 ♀, University of California, Riverside (UCR)). Riverside Co., Gavilan, V-8, 12-1950, on *Eriogonum fasciculatum,* Timberlake (2 ♀, UCR).

Habitat.—The holotype was collected from a five mile long hydroelectric flume that runs through foothill woodland and chamise chaparral habitats at an elevation of 660 m (2200 ft). The paratype from Coalinga was collected in chaparral-foothill woodland habitat at an elevation of about 550 m (1800 ft), probably from *Eriogonum fasciculatum* (Gill, pers. comm.).

Etymology.—The species epithet, a noun in apposition, is Latin meaning "long tail." The name refers to the ovipositor sheath of the female.

Discussion and Comparative Comments

The four species in the genus *Belaspidia* are: *obscura* Masi from Central and Southern Europe (Bouček 1951a, Peck et al. 1964), Syria, Turkey (Bouček 1951b, 1956) Crimea, Transcaucasus, Central Asia, and Iran (Nikolskaya 1952 [under the synonym *nigra* Masi]); *masii* Nikolskaya from Central Asia (Nikolskaya 1952); *meridionalis* Steffan from France (Steffan 1951a, 1951b) and *longicauda* n.sp. from California, USA.

The type species of *Belaspidia* (Masi 1916) is *obscura,* described from females. *Belaspidia nigra* was described from a male specimen (Masi 1927). Nikolskaya (1952) treated the *Belaspidia* of the United Soviet Socialist Republic; described *masii* and recognized *obscura* and *nigra.* Steffan (1951a) described *meridionalis* from Toulon, France. He treated the *Belaspidia* of France; recognized *meridionalis, obscura,* and *nigra* (Steffan 1951b). Nikolskaya (1960) recognized three world species: *obscura, masii,* and *meridionalis* with *nigra* synonymized under *obscura* by Bouček (1951b). Bouček (1951b, 1956) indicated that *meridionalis* might be a variety of *obscura.*

In Nikolskaya (1952), *longicauda* differs from *masii* in that the antennae are longer than head height, the funicular segments are longer than wide, the first 2 abdominal tergites have a thin, shiny band on posterior margin; and the ovipositor projects posteriorly from the epipygidium by the same length as T#1 dorsally. As with *masii, longicauda* has the hindfemur ½ as wide as long. In Steffan (1951b), *longicauda* differs from *meridionalis* in that the left mandible is bidentate. The head and antennal characters are similar for both species. In both keys, *longicauda* differs from *obscura* in that the thorax is slightly, not highly convex, the

pronotum is 5 times as wide as long versus 3 times, and the wings are colorless versus slightly darkened.

Acknowledgments

I thank Z. Bouček, Commonwealth Institute of Entomology, London, for material of *Belaspidia obscura* and for examining and confirming the taxonomic placement of *B. longicauda,* D. J. Burdick and K. J. Woodwick, both of California State University Fresno, Fresno, for the use of laboratory facilities and equipment, D. J. Burdick and N. J. Smith, Fresno County Agricultural Commissioner's Office, Fresno, California, R. D. Haines, Tulare County Agricultural Commissioner's Office, Visalia, California, for editorial comments on this paper, L. E. Caltagiorone, University of California, Berkeley, for permission to deposit the allotype male in the USNM; and the several institutions and their personnel for the opportunity to have examined their material.

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PROC. ENTOMOL. SOC. WASH.
90(1), 1988, pp. 91–96

THE *CULTUS DECISUS* COMPLEX OF EASTERN NORTH AMERICA (PLECOPTERA: PERLODIDAE)

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Abstract.—The *Cultus decisus* complex of eastern North America is reviewed, and *C. verticalis* (Banks) and *C. decisus isolatus* (Banks) are removed from synonymy with *C. decisus decisus* (Walker). The three taxa have distinctive eggs, but no differences were observed in adults of *C. decisus decisus* and *C. decisus isolatus*.

Since Ricker's (1952) study, *Cultus decisus* (Walker) has been regarded as a variable species which ranges from southern Canada, along the Appalachians, to northern Georgia. The most recent taxonomic treatment (Hitchcock 1974) includes *Perla verticalis* Banks and *Isoperla isolata* Banks as synonyms, but our study of available types and other specimens suggests these names represent valid taxa. *C. decisus* has also been incorrectly applied to specimens from Great Whale River (Ricker et al. 1968), which are more similar to *C. aestivalis* (Needham and Claassen), and by P. P. Harper (unpub. record) to a similar series collected at James Bay. Careful study of the western Nearctic *Cultus* species is needed to clarify the status of these specimens.

Specimens used in this study are deposited in the British Museum of Natural History (BMNH), the Canadian National Collection (CNC), the Illinois Natural History Survey (INHS), the Museum of Comparative Zoology (MCZ), the Royal Ontario Museum (ROM), the United States National Museum of Natural History (USNM), the Virginia Polytechnic Institute and State University collection (VPI), and in the private collections of R. F. Kirchner (RFK) and the authors (BPS, SWS, BCK).

Cultus decisus decisus (Walker)

Perla decisa Walker (1852). Holotype ♂, St. Martin's Falls, Albany River, Ontario (BMNH).

Diploperla decisa: Ricker (1944).

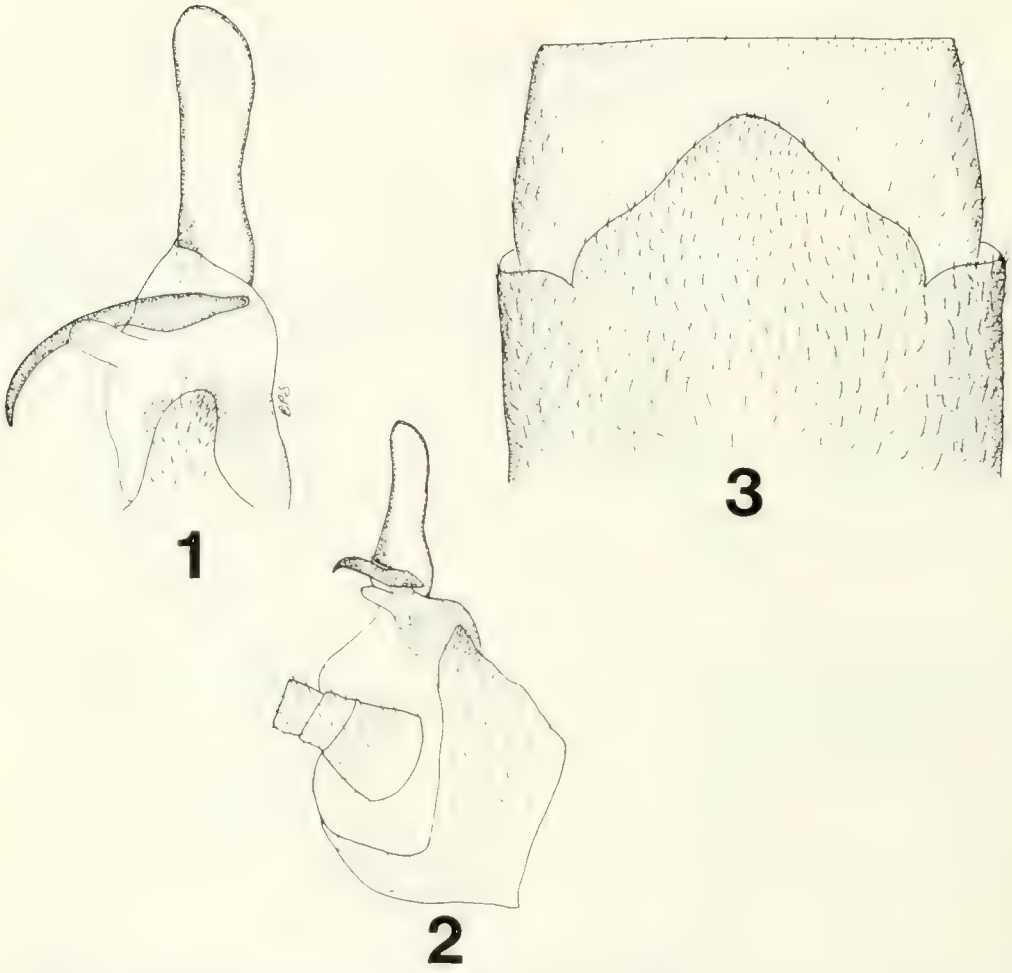
Isogenus (Cultus) decisus: Ricker (1952), in part.

Cultus decisus: Illies (1966), in part.

Male genitalia.—Lobe on sternum 7 well developed, no lobe on sternum 8. Epiproct with weakly sclerotized anterior and posterior bands; mesal section membranous without spinules or setae. Lateral stylets long, slender and slightly curved ventrad. Membranous cowl with a pair of posterolateral spiculate lobes and weakly sclerotized paragenital plates. Hemitergal lobes typical of Diploperlini (Fig. 1).

Female genitalia.—Subgenital plate broadly triangular, reaching beyond midpoint of sternum 9.

Egg.—Dorsal surface and lid covered with irregular, hexagonal follicle cell impressions



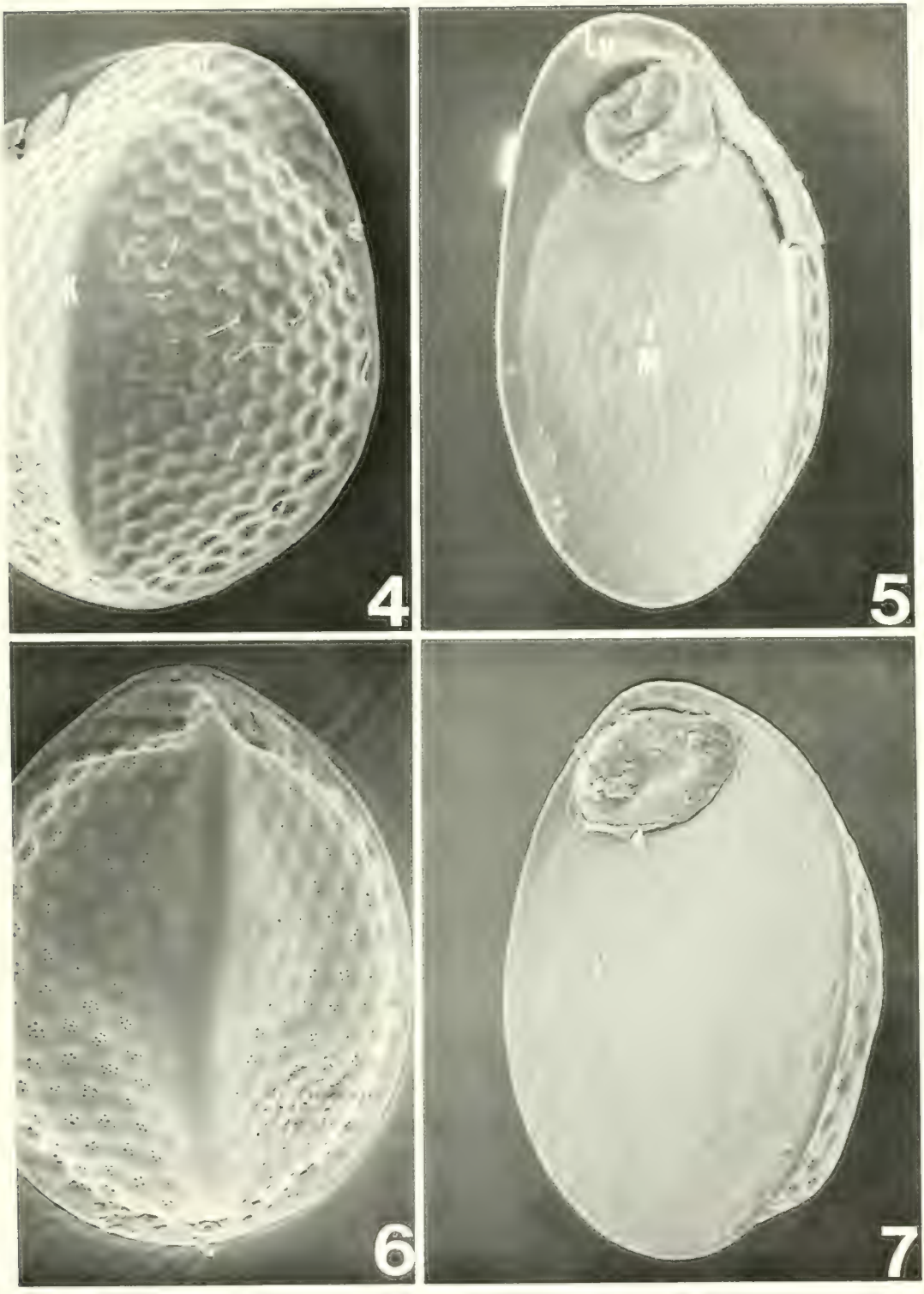
Figs. 1–3. *C. decisus* genitalia. 1. *C. decisus decisus* epiproct complex, lateral. 2. *C. decisus isolatus* male terminalia lateral. 3. *C. decisus isolatus* female sterna 8–9.

(FCIs). FCI walls thick and smooth, concave floors contain ca. 30 minute aeropyles. Sharp, smooth keel extends from posterior third to near lid (Fig. 4). Lid offset by irregular suture which becomes less distinct posteriorly; lateral margins smooth (Fig. 4). Ventral surface flat and covered with FCIs. FCI walls consist of rows of shallow pits. Lip smooth, anchor without specialized superstructure. Micropyles ventral, slightly anterior to equator (Fig. 5).

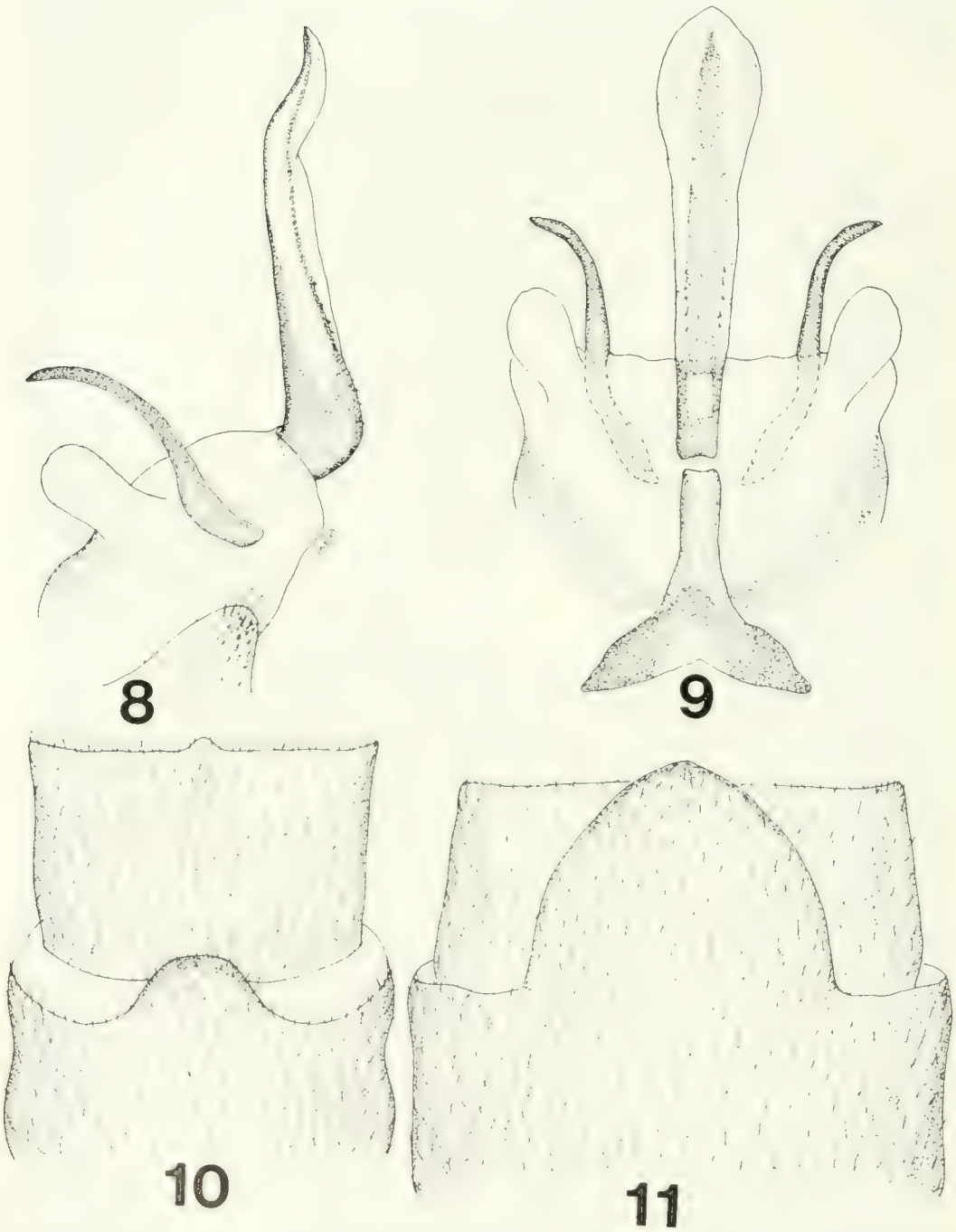
Specimens examined.—MICHIGAN: Benzie Co., Platte River, Honor, 27-V-39, T. H. Frison and H. H. Ross, 2 ♂, 1 ♀ (INHS). Cheboygan Co., Sturgeon River, 3-VII-38, J. W. Leonard, 1 ♀ (USNM). Mecosta Co., Muskegon River, Big Rapids, 22-V-36, T. H. Frison and H. H. Ross, 2 ♂, 5 ♀ (USNM, INHS). Otsego Co., Pigeon River, 23-VI-36, J. W. Leonard, 1 ♂, 2 ♀ (USNM, INHS). ONTARIO: Albany River, St. Martin's Falls, 1 ♂ (Holotype, BMNH).

Cultus decisus isolatus (Banks), New Status

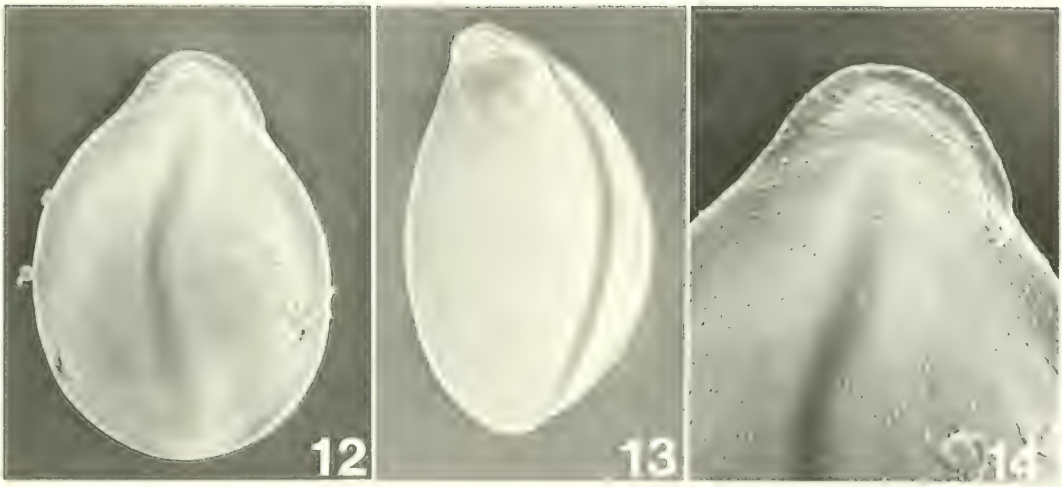
Isoperla isolata Banks (1920). Holotype ♂, Hot Springs, (Madison County) North Carolina (MCZ #10,824).



Figs. 4–7. *C. decisus* eggs. 4. *C. decisus decisus,* Otsego Co., Michigan, dorsal aspect, 380×. 5. *C. decisus decisus* ventral aspect, 300×. 6. *C. decisus isolatus,* Montgomery Co., Virginia, dorsal aspect, 300×. 7. *C. decisus isolatus* ventral aspect, 300× (Ld—Lid, Lp—Lip, K—Keel, M—Micropyle, A—Anchor).



Figs. 8–11. *C. verticalis* genitalia. 8. Epiproct complex, lateral. 9. Epiproct complex, dorsoanterior aspect. 10. Male sterna 7–8. 11. Female sterna 8–9.



Figs. 12–14. *C. verticalis* eggs, Giles Co., Virginia. 12. Dorsal aspect, 270×. 13. Ventrolateral aspect, 270×. 14. Dorsoanterior end, 500×.

Perla decisa: Needham and Claassen (1925), in part.
Cultus decisus: Illies (1966), in part.

Male genitalia.—Indistinguishable from *C. decisus decisus* (Fig. 2).

Female genitalia.—Indistinguishable from *C. decisus decisus* (Fig. 3).

Egg.—Similar to *C. decisus decisus* but dorsal FCIs enclose ca. 10–15 aeropyles, and keel extends from lid to posterior margin (Figs. 6–7).

Specimens examined.—GEORGIA: Fannin Co., Toccoa River, Hwy 60, 19-V-85, B. C. Kondratieff, 1 ♂, 12 ♀ (VPI). NORTH CAROLINA: Madison Co., Hot Springs, 1 ♂ (Holotype, MCZ). VIRGINIA: Carroll Co., New River, Rt. 606, 19-V-80/22-IV-81, B. C. Kondratieff, 2 ♂, 3 ♀ (VPI). Montgomery Co., Little River, Rt. 787, 24-V-83, B. C. Kondratieff, 1 ♀ (VPI).

Comments.—Reliable characters for distinguishing adults of *C. decisus decisus* from *C. decisus isolatus* were not observed. Because of the range disjunction and the distinctive eggs (see Figs. 4 and 6), we are giving these populations subspecific status. Hopefully, gravid females with associated males and nymphs from intermediate localities will soon be available to permit testing of this classification.

Cultus verticalis (Banks), New Status

Perla verticalis Banks (1920). Holotype ♀, Franconia, (Grafton Co.) New Hampshire (MCZ #10,815).
Diploperla verticalis: Frison (1942).
Isogenus (Cultus) decisus: Ricker (1952), in part.
Cultus decisus: Illies (1966), in part.

Male genitalia.—Lobe on sternum 7 well developed, lobe on sternum 8 small (Fig. 10). Epiproct relatively more sclerotized than in *C. decisus*, and with small serrations along anterior sclerite. Lateral stylets, cowl and hemitergal lobes typical of genus (Figs. 8–9).

Female genitalia.—Lateral margins of subgenital plate more convex and plate relatively longer than in *C. decisus* (Fig. 11).

Egg.—Dorsal surface covered with faint FCIs and scattered globular bodies. FCI walls are shallow furrows, floors without aeropyles. Keel smooth with a few globular bodies clustered at either end (Figs. 12, 14). Ventral surface covered with FCIs similar

to those on dorsum. Micropyles ventral, slightly anterior to equator (Fig. 13).

Specimens examined.—NEW HAMPSHIRE: Grafton Co., Franconia, Slosson, 1 ♀ (Holotype, MCZ). NORTH CAROLINA: Haywood Co., Cataloochee Creek, Great Smoky Mountains National Park, 16-V-83/3-V-85, B. C. Kondratieff, 16 ♂, 8 ♀ (BCK). Swain Co., Oconoluftee River, Cherokee, 2-VI-78, B. Stark and K. W. Stewart, 1 ♂ (BPS). Deep Creek, Deep Creek Campground, 19-V-70, G. Wiggins and T. Yamamoto, 1 ♂ (ROM). PENNSYLVANIA: Franklin, 23-VI-67, S. Gilmore, 1 ♂ (USNM). QUEBEC: Brome, 1-VI-36, G. S. Walley, 1 ♂ (CNC). TENNESSEE: Sevier Co., Little River, Great Smoky Mountains National Park, 5-V-79, B. Stark, 2 ♂, 2 ♀ (BPS). VERMONT: Bennington Co., Battenkill, Rt. 313, 25-V-80, A. C. Graham, 1 ♂ (SWS). VIRGINIA: Giles Co., Little Stoney Creek, Rt. 460, 7-17-V-80, B. C. Kondratieff, 7 ♂, 2 ♀ (VPI). Big Stoney Creek, Rt. 635, 26-V-78, D. Gray and D. Minnick, 19 ♂ (VPI). Stony Creek, 28-V-79, E. Bellinger, 1 ♂ (VPI). Patrick Co., Dan River, Rt. 601, 16-V-81, Geivard, 1 ♂ (VPI). Smyth Co., Big Laurel Creek, 28-V-78, G. T. and M. W. Voreh, 1 ♂, 1 ♀ (RFK). WEST VIRGINIA: Pocahontas Co., Williams River, Day Run, 30-VI-82, W. Mathis and O. S. Flint, 2 ♀ (USNM).

Comments.—The pinned female holotype had no eggs, but the subgenital plate is consistent with our figures from a Giles Co., Virginia, specimen (Fig. 11) and the other specimens listed above. Genitalic illustrations given by Needham and Claassen (1925) (as *Perla verticalis*), Hitchcock (1974) (as *C. decisus*) and Kondratieff and Voshell (1982) (as *C. decisus*) are of this species.

Key to *Cultus decisus* Complex Adults

1. Anterior sclerite of epiproct armed basally with small serrations (Figs. 8, 9); sternum 8 with small lobe (Fig. 10); female subgenital plate parabolic, reaching posterior margin of sternum 9 (Fig. 11); chorionic FCIs not enclosing aeropyles (Figs. 12–14) ..... *C. verticalis*
– Anterior sclerite of male epiproct without serrations (Figs. 1, 2); sternum 8 without lobe; female subgenital plate triangular, not reaching posterior margin of sternum 9 (Fig. 3); chorionic FCIs enclose aeropyles (Figs. 4, 6) 2
2. Aeropyles of chorionic FCIs densely packed, small, ca. 30 or more in each FCI (Fig. 4); dorsal keel of egg not extending onto lid (Fig. 4); known from Great Lakes region ..... *C. decisus decisus*
– Aeropyles of chorionic FCIs larger and more widely spaced, ca. 15 or less in each FCI (Fig. 6); dorsal keel extends onto base of lid (Fig. 6); known from southern Appalachians ..... *C. decisus isolatus*

Acknowledgments

We are grateful to O. S. Flint, P. Harper, J. E. H. Martin, R. F. Kirchner, C. Vogt, J. R. Voshell, D. Webb and G. Wiggins for arranging the loan of specimens. D. L. Lentz and S. Faison assisted in SEM micrograph preparation. This study was supported by NSF grant #BSR 840755.

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NOTE

Neotype Designation for *Raptoheptagenia cruentata* (Walsh) (Ephemeroptera: Heptageniidae)

Individuals of predaceous flatheaded mayfly larvae in North America that have been tentatively known as *Anepeorus* McDunnough (Burks, B. D. 1953. Ill. Nat. Hist. Surv. Bull. 26: 1–216) were recently reared through to adults of *Heptagenia cruentata* Walsh by Whiting and Lehmkuhl (1987. Canad. Entomol. 119: 405–407) in Saskatchewan. Those authors, while correctly associating the larvae, erected the genus *Raptoheptagenia* (= *Heptagenia cruentata*), recognizing the highly unusual larvae. These larvae have evidently been referable to either species of *Anepeorus*—the eastern *A. simplex* (Walsh) or the western *A. rusticus* McDunnough—because the range of *R. cruentata* includes both areas, and McCafferty and Provonsha (1985. Gr. Lakes Entomol. 18: 1–6) found that Saskatchewan larvae presumed to be *A. rusticus* and eastern larvae presumed to be *A. simplex* were morphologically identical.

The original types of *Heptagenia cruentata* were destroyed in the Chicago fire of 1871 (Burks 1953). Although the single male adult and single female adult now residing in the Harvard University Museum of Comparative Zoology were identified as *H. cruentata* by Walsh, they are not available as lectotypes because they were collected a year after the published description (Walsh, B. D. 1863. Proc. Entomol. Soc. Phila. 2: 167–272). Thus, the name has remained a nomen dubium, with the descriptions of McDunnough (1924. Canad. Entomol. 56: 90–98) (as *Heptagenia reversalis*), Traver (1935. *In* Needham, J. G., J. R. Traver, and Y. C. Hsu. The Biology of Mayflies. Comstock Publ. Co., Ithaca, NY. 759 pp.), and Burks (1953) providing the bases for identification. I therefore designate a neotype for *Raptoheptagenia cruentata* (Walsh) as follows: Larva: Indiana, Martin County, East Fork White River at Hindustan Falls Public Fishing Site, VII-15-1982, A. V. Provonsha and V. Van Allen; in alcohol with "neotype" label; deposited in the type collection of the Purdue Entomological Research Collection, West Lafayette, Indiana. Since the generic concept is based on the distinctive larval morphology, and in light of the recent reared association, a larva is appropriate as the neotype specimen of the type species of the monospecific *Raptoheptagenia*. Adults of *R. cruentata* have also been taken at the neotype locality.

This paper is Purdue Experiment Station Journal No. 11251.

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PROC. ENTOMOL. SOC. WASH.
90(1), 1988, pp. 98–100

NEW SYNONYMS PERTAINING TO *CHELIFERA* AND GENERIC KEY FOR NORTH AMERICAN HEMERODROMIINAE (DIPTERA: EMPIDIDAE)

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Abstract.—Empididae previously placed in *Thanategia* Melander are shown to be species of *Chelifera* Macquart: *Chelifera defecta* (Loew) n. comb.; *Chelifera recurvata* (Melander) n. comb.; and *Chelifera stuprator* (Melander) n. comb. Males with identical terminalia possessed significant variation in the expression of crossvein dm-cu that renders it invalid as a character of generic importance. Therefore, *Thanategia* is considered here a new junior synonym of *Chelifera*. Also, *Chelifera knutsoni* Lavallee is shown to be a junior synonym of *Chelifera defecta* (= *T. defecta* (Loew)). A revised key to the genera of North American Hemerodromiinae is provided.

Aquatic dance flies (Diptera: Empididae) in the subfamily Hemerodromiinae were last revised by Melander (1947). New revisionary studies of Nearctic Hemerodromiinae now underway reveal that certain genera and species should be placed in synonymy. *Thanategia* was described as a subgenus of *Chelifera* by Melander (1928: 263; type species, *Hemerodromia defecta* Loew, 1862: 210) to accommodate those species that possessed an open cell dm (= "incomplete discal cell" or "discal cell fused with third posterior cell") due to the absence of crossvein dm-cu (= "apical crossvein"). In other respects, the three species placed in that subgenus, *Thanategia defecta* (Loew), *Thanategia recurvata* Melander, and *Thanategia stuprator* Melander, fit the concept of *Chelifera*. Without an explanation, Melander (1947) later elevated *Thanategia* to generic status.

Examination of all specimens labelled as *Thanategia* and *Chelifera* in the Canadian National Collection (CNC), Ottawa, revealed that males of *T. recurvata* were identical to males placed in the CNC and labelled as *Chelifera* "new sp. nr. *scrotifera*." Examination of wing venation revealed that all specimens identified as *Thanategia* either completely or partially lacked crossvein dm-cu in one wing or both wings, whereas those identified as *Chelifera* possessed a complete dm-cu in both wings; thus, all specimens keyed according to Melander (1928, 1947). However, in other morphological features, including all details of male terminalia, males of "*Chelifera* new sp. near *scrotifera*" were identical to males of *Thanategia recurvata*. The same study found a male placed in the CNC as *Chelifera* "new sp. nr. *banksi*" with terminalia exactly fitting the description of *T. defecta* and identical to a paratype male of *Chelifera knutsoni* Lavallee, plus a paratype female of *C. knutsoni* with incomplete expression of dm-cu in one wing resulting in cell dm being "open" apically.

Subsequent examination of holotype males of *T. recurvata* and *T. stuprator* and additional paratype males and females of *Chelifera knutsoni* together with study of two series of specimens obtained in loans from the University of New Hampshire and Washington State University eventually

clarified the males and facilitated association of conspecific males and females.

General analysis of venation of all available males (N = 8) with terminalia matching the very distinctive terminalia of *recurvata* (Melander 1947: 260; fig. 34) revealed that three (including the holotype) possessed "*Thanategia* venation," three possessed "*Chelifera* venation," and two could key to *Thanategia* since cell dm was open in at least one wing. Of the four associated females, two possessed "*Chelifera* venation" and two (including the allotype) possessed an open cell dm in at least one wing. This variation in dm-cu indicates that "*T. recurvata*" simply represents individuals lacking development of dm-cu, and therefore this species is transferred to the genus *Chelifera*: *Chelifera recurvata* (Melander) (= *Thanategia recurvata* Melander), **New Combination.**

Study of a series of males (N = 8) with terminalia matching the description of *T. defecta* (Melander 1947: 259, fig. 32) (collected July–Oct., 1985 by D. S. Chandler near Wonalancet, New Hampshire), together with examination of two paratype males of *C. knutsoni* (collected Macon Co. North Carolina by A. G. Lavallee (1975)) and comparison of the above mentioned two males in the CNC, clarified another question. Every aspect of male terminalia among the above males was identical; however, these males varied significantly in the expression of dm-cu which, based on Melander's 1947 key, would lead to identification of half as *T. defecta* (i.e. dm-cu completely or partially absent) and half as *C. knutsoni* (i.e. dm-cu complete in both wings). A similar result would occur when keying associated females. Examination of *C. knutsoni* paratypes (two males and two females), all possessing a complete dm-cu in both wings, places them in the genus *Chelifera*. The comparison, however, of all males considered above with the general description and specific features of male terminalia of *T. defecta* results in the following nomenclatorial revision: *Chelifera defecta* (Loew) [= *Thanategia defecta* (Loew)] **New Combination** (= *Chelifera knutsoni* Lavallee) **New Synonym.**

The study of *T. stuprator* was puzzling for two reasons. First, all specimens first examined (four males, including the holotype, and six females) fit the description of this species (Melander 1947: 259; fig. 33) and Melander's concept of *Thanategia* based on venation. Second, in addition to lacking crossvein dm-cu diagnostic for *Thanategia*, all specimens possessed a simple R_{4+5} and thus did not possess the branched R_{4+5} typical of *Chelifera*. Melander's (1947) description of the holotype male indicated that R_4 was "vestigial," but my examination revealed that R_4 was completely lacking in the right wing and was expressed as an incomplete, approximately 2 mm, rudimentary crossvein arising from the costa in the left wing. Subsequent acquisition of a series of *T. stuprator* (collected 12-13-VIII-1977 by W. J. Turner in Mt. Ranier National Park) substantiated the suspected variability in venation. All three *stuprator* males and 25/27 associated females lacked dm-cu in both wings, but two females possessed a partial dm-cu in both wings. Variability pertaining to R_4 was as follows: the three males possessed either complete or partially complete R_4 forks in either one or both wings; 11 females expressed no development of R_4 in either wing; one female had a complete R_4 in the right wing (completely lacking in the left wing); and 14 females possessed a partial R_4 in both wings (six females) or only the right wing (four females) or only the left wing (four females). Clearly, R_4 is a trait subject to individual variability. As regards dm-cu, its absence may be typical of *stuprator*, but it is not of generic importance and this species is transferred to the genus *Chelifera*: *Chelifera stuprator* (Melander) (= *Thanategia stuprator* Melander) **New Combination.**

Variation in crossvein dm-cu also exists in other species of *Chelifera*. For example,

occasional specimens of *C. obsoleta* (Loew) from Indiana and Georgia, *C. ensifera* Melander from Oregon, *C. calaga* Lavallee from Utah, and *C. cirrata* Melander from Washington state, either lacked or possessed a partial crossvein dm-cu in one wing or both wings, and would "run to" *Thanategia* in existing keys.

Significant variation in the expression of crossvein dm-cu revealed in the three species formerly placed in the genus *Thanategia*, as well as in several other species of *Chelifera*, is adequate evidence for placing *Thanategia* Melander as a junior synonym of *Chelifera* Macquart, **New Synonym**, as has been shown here by the correct generic placement of the type species and the other two described species of the former genus.

An additional consequence of this study is the revision of the last portion of Melander's (1947) key and the related portion of Steyskal and Knutson's (1981) key to North American genera of Hemerodromiinae, which is here reproduced in its entirety with the needed modifications stemming from this study, as well as a few additional minor changes:

1. Antenna with an arista, more than twice as long as basal flagellomere; mesoscutum with several pairs of well developed setae; laterotergite with setae; male terminalia more or less reflexed over abdomen, with terminal processes projecting anteriorly 2
1'. Antenna with a stylus, shorter than basal flagellomere; mesoscutum without well developed setae (a pair of supra-alars may exist); laterotergite bare; male terminalia erect or projecting posteriorly 3
2. Cell dm closed apically (crossvein dm-cu present) ..... *Chelipoda* (*Chelipoda*) Macquart
2'. Cell dm open apically (crossvein dm-cu absent) ..... *Chelipoda* (*Phyllodromia*) (some authors treat *Phyllodromia* as a separate genus, *Phyllodromia* Zetterstedt)
3. Anal cell absent and CuA_2 not developed; R_1 ending before mid-wing; Sc fused with C close to wing base; crossvein h absent ..... *Hemerodromia* Meigen
3'. Anal cell present, or at least CuA_2 strongly developed; R_1 ending at or beyond mid-wing; Sc distinctly free of C, but evanescent apically; crossvein h present 4
4. Veins M_1 and M_2 not petiolate (i.e. without a common stem); cell dm fused basally with cell bm; front femur relatively slender and typically lacking strong setae beneath ..... *Neoplasta* Coquillett
4'. Veins M_1 and M_2 petiolate (i.e. with a common stem); cell dm variable; front femur swollen and possessing strong setae beneath 5
5. Cells bm and dm fused (i.e. crossvein bm-cu absent) ..... *Metachela* Coquillett
5'. Cells bm and dm separate (i.e. crossvein bm-cu present); crossvein dm-cu usually present, but occasionally partially or totally lacking, opening cell dm apically (the two wings may differ in this regard on the same specimen) *Chelifera* Macquart (Includes *Thanategia defecta*, *T. recurvata*, and *T. stuprator*)

Acknowledgments

The following institutions loaned the material upon which this work is based: D. S. Chandler, University of New Hampshire, Durham; L. Knutson, IIBIII, U.S. Department of Agriculture (U.S. National Museum of Natural History, Washington, D.C.); R. T. Schuh, American Museum of Natural History, New York; H. J. Teskey, Biosystematics Research Centre, Ottawa (Canadian National Collection); and W. J. Turner, Washington State University (James Entomological Collection).

Sincere appreciation is extended to H. J. Teskey and W. J. Turner for their generous assistance during the study, and to W. P. McCafferty for critically reading the manuscript. This paper is Purdue Agricultural Experiment Station journal No. 11,247.

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PROC. ENTOMOL. SOC. WASH.
90(1), 1988, pp. 101–105

A NEW SPECIES OF *DONACEUS* CRESSON (DIPTERA: EPHYDRIDAE) FROM MALAYSIA

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Abstract.—***Donaceus azhari,*** new species, is described from Perak State, Peninsular Malaysia. It is compared to its sole congener, *D. nigronotatus* Cresson.

The shore fly fauna of Malaysia is poorly known, as it is for most of the Oriental Region. Cogan and Wirth (1977) record 16 species from Peninsular Malaysia (Malaya) and only three in Sarawak and Sabah (Malaysian Borneo). The number of species in this area will most likely prove to be much greater. During November of 1986, one of us (RSZ) spent a month in Peninsular and East Malaysia. During that period several new species and material which will expand the distributional ranges of other Oriental ephydrids was discovered. This is the first report concerning the malaysian material. Herein we describe the second species in *Donaceus.*

Genus *Donaceus* Cresson

Donaceus Cresson, 1943: 5 (type species: *Donaceus nigronotatus* Cresson, by original designation and monotypy).

Diagnosis.—Small shore flies (1.50–2.40 mm) similar to *Ilythea* Haliday and *Zeros* Cresson but distinguished by a variety of subtle features.

Head: Microtomentose, produced forward, appearing oversized for body; face flat to facial prominence then with a slight tuberculose development, with 3 large facial setae, equally spaced, uppermost at level just below facial prominence; genal bristle subequal to facials; antennae normal, plumose, with 6–7 aristal hairs; proclinate and reclinate orbital setae well developed; inner and outer vertical setae well developed; ocellar setae large, situated between posterior ocelli; eyes micropubescent.

Thorax: Thoracic chaetotaxy well developed; scutum with 3 pair of dorsocentral setae (1+2), 3–6 pair of acrostichal setae, prescutellar and intra-alar setae strong; scutellum with large lateral and apical setae, lateral margins with or without black, velvety areas; notopleuron with posterior seta 2× diameter of anterior seta and 4× as far from notopleural suture; wing distinctive, with clear rounded spots in a fuscous field, vein R_{2+3} joins costa beyond middle of wing; halter yellow.

Abdomen: Densely microtomentose, ground color black; male genitalia with epandrium not fused dorsally, cerci elongate, surstyli not heavily sclerotized, variously lobed and bristled.

Distribution.—Southeast Asia (Malaysia, Thailand, Japan, Taiwan), Hawaii, Australia, and New Zealand.

Remarks.—Cresson (1943) erected the tribe Ilytheini for three closely related genera including *Ilythea* Haliday, and the new genera *Zeros* and *Donaceus. Donaceus* is separated from *Ilythea* and *Zeros* by a number of subtle characters the most obvious

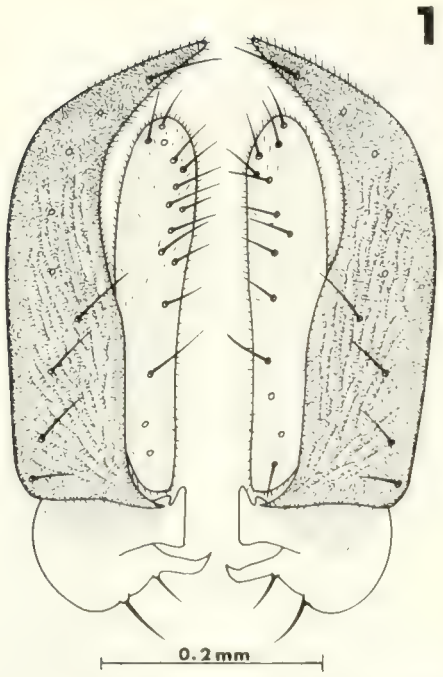

Fig. 1. *Donaceus nigronotatus*. Male external genitalia.

being the presence of 3 dorsocentral bristles (1+2) as opposed to 2 (1+1) in the latter genera. In addition, vein R_{2+3} joins the costa at a point between those found in *Ilythea* and *Zeros*. Facial similarities also seem to suggest a close relationship with *Zeros*. The distribution of *Donaceus* also implies a close relationship with *Zeros* as both are found throughout the Oriental Region, *Donaceus* being limited to this area, while *Ilythea* has an Oriental presence only in Japan.

It is possible that upon closer examination *Donaceus* may not prove to merit a generic ranking and will be considered a subgenus or other grouping within *Ilythea*. However, the question will only be resolved once the tribe is studied on a world basis. Thus, for the present, we have chosen to keep *Donaceus* as a valid genus.

Key to Species of *Donaceus*

1. Coxa and femur pale, golden; scutellum with black, velvety patches on lateral angles; size larger, 1.90–2.40 mm (widespread) .... *D. nigronotatus* Cresson
– Coxa and femur dark, black; scutellum without black, velvety patches on lateral angles; size smaller, 1.50–1.93 mm (Peninsular Malaysia) *D. azhari*, new species

***Donaceus nigronotatus* Cresson**

Fig. 1

Donaceus nigronotatus Cresson, 1943: 5.

Diagnosis.—A small shore fly, length 2.0–2.40 mm.

Description.—*Head:* Microtomentose, subshiny, golden, rarely becoming somewhat dusky; genal area concolorus with face. Second antennal segment pale, golden, contrasting with third segment which is velvety gray to brown. Frons slightly contrasting with face, darker, concolorous in both ground color and microtomentosity with scutum. Mouthparts, including palpi, concolorus with face. Eye height/eye width ratio 1:0.83–1:0.88; eye height/genal height ratio 1:0.30–1:0.34.

Thorax.—Thoracic chaetotaxy well developed. Scutum with 3 pair of dorsocentral setae (1+2), and 3 pair of strong acrostichal setae; microtomentose, dark golden brown, ground color black, with rather diffuse markings at bases of setae but lacking definite blotches and pattern. Scutellum concolorous with scutum, in posterior view, lateral angles with black, velvety patches. Pleural areas golden, contrasting with dark coloration of the scutum, concolorous with face. Legs concolorous with pleural areas, golden. Wing with clear, rounded spots in a fuscous field. Halter yellow.

Abdomen.—Microtomentose, gray with a slight tinge of green, ground color black. Male genitalia as in Fig. 1.

Type material.—The holotype (Academy of Natural Sciences of Philadelphia, type number 6650) was examined. The specimen is a female, minuten mounted and, with the exception of the missing head, is in good condition. It is labeled Takai 1907.V.3/ FORMOSA Sauter/845/Type 6650 Donaceus nigronotatus Cress. A male paratype

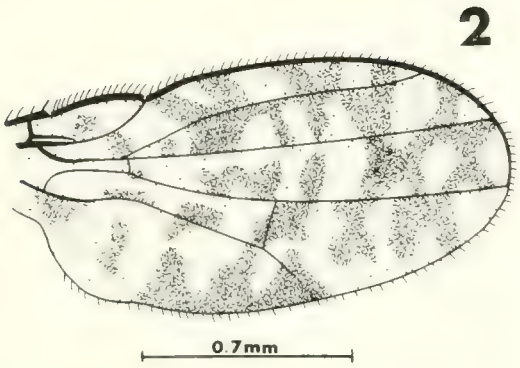

Fig. 2. *Donaceus azhari.* Wing.

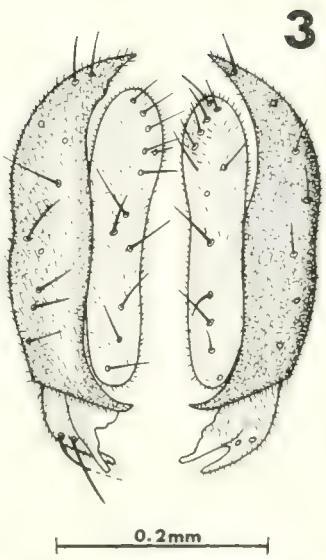

Fig. 3. *Donaceus azhari.* Male external genitalia.

and a female could not be located in the ANSP Collection.

Distribution.—Cresson (1943) described the species from three specimens taken in Formosa (Taiwan, The Republic of China). Since then the species has been recorded from Japan (Miyagi 1977), Hawaii (Hardy and Delfinado 1980), Thailand, Australia, and New Zealand (Cogan and Wirth 1977).

Specimens examined.—The holotype from Formosa and 12 specimens from Oahu, Maui, and Kauai, Hawaii.

Remarks.—Both Miyagi (1977) and Hardy and Delfinado (1980) presented descriptions and figured the genitalia. In Hawaii, Miyagi (1977) found the species to range from sea level to 4000 ft. in elevation and to occur in a variety of aquatic habitats including the margins of ponds, swamps, reservoirs, and streams.

Donaceus azhari Zack and Sites, New Species

Figs. 2–3

Diagnosis.—A small shore fly, length 1.50 to 1.93 mm. It is distinguished from its sole congener *D. nigronotatus* Cresson by the smaller size, overall darker appearance of the thoracic pleura and legs, the lack of lateral velvet patches on the scutellum and the distinctive male terminalia.

Description.—*Head:* Head microtomentose, produced forward. Face light golden brown, in profile straight to facial prominence and then with only a slight tuberculose development, face receding to antennal bases; with 3 large, equally spaced, facial setae, uppermost dorsally inclined and at a level just below facial prominence, bottom 2 mesoventrally inclined, all 3 follow contour of eye in arrangement; 3–4 small, dorsally inclined setae lateral to larger facials. Genal area concolorous with face; genal bristle subequal to larger facials; situated forward, near eye margin; 3–4 small, dark setae situated along posterior genal margin. Antenna with second segment ochraceous to dark golden brown, upper angle with 2 larger setae; flagellum dark, golden brown with numerous fine hairs; arista dark, plumose, 6–7 aristal hairs which are ½–¾ length of main trunk. Frons concolorous with face; proclinate and reclinate orbital setae well developed, with a second, small proclinate orbital seta situated equidistant between the larger setae; inner and outer vertical setae well developed, subequal to facials; ocellar setae larger, subequal to facials, situated between the posterior ocelli; 2 pair of small, postocellar setae; 6–8 dark, small postocular setae. Mouthparts, including palpi, microtomentose, concolorous with face. Eyes mi-

cropubescent. Eye height/eye width ratio 1: 0.83–1:0.86; eye height/genal height ratio 1: 0.30–1:0.33.

Thorax.—Thoracic chaetotaxy well developed. Ground color black; microtomentose, dark golden brown, often with a slight greenish to copper tinge. Scutum with 3 pair of well developed dorsocentral setae, 1+2; 5–6 pair of strong acrostichal setae, irregularly placed in 2 rows, prescutellars strong; intra-alar setae strong, posterior pair especially so, subequal to dorsocentrals; numerous, irregularly-placed setae in the intra-alar and supra-alar areas. Scutum somewhat patterned, blotched with dark brown to black at base of each seta, often with dark brown stripes between the dorsocentral and acrostichal rows of setae. Scutellum concolorous with scutum; large lateral and apical scutellar setae, a pair of small, hair-like subapical scutellar setae; in posterior view, apical, and to some extent lateral margins ochraceous, without black, velvety areas. Pleural areas microtomentose, concolorous with scutum; notopleuron with posterior notopleural seta approximately 2× diameter of anterior seta and 4× as far from notopleural suture; anepisternum with 1 large and 1–2 smaller setae, with numerous hairs throughout; katepisternum with a large, central seta and 3–4 smaller, hair-like setae. Coxa concolorous with pleural areas; femur dark, becoming paler, ochraceous distally (at knee), profemur with a series of strong, ventral setae which become longer and thicker distally; tibia lighter, variegated, mesotibia with a large, dark, apical tibial spine; tarsi ochraceous. Wing distinctive (Fig. 2) with clear rounded spots in a fuscous field. Halter yellow.

Abdomen: Microtomentose, gray with a slight greenish tinge, ground color black; a row of small, dark setae along the posterior margin of each tergite, other setae positioned in rows, more common in lateral areas. Male with ochraceous spot on dorsal tip of abdomen; male genitalia as in Fig. 3.

Type material.—Holotype ♂, allotype ♀, and 5 paratypes (3 ♀♀, 2 ♂♂) labeled-Malaysia: Perak; MARDI-Hilir Perak, 16 mi W Telok Anson. 25 November 1986. R. S. Zack collector. All specimens are paper-point mounted. The holotype and allotype are deposited in the James Entomological Collection at Washington State University. A male and female paratype are deposited in the National Museum of Natural History (USNM). The remaining paratypes are in the senior author's collection.

Distribution.—Known only from the type locality.

Etymology.—The species is named in honor of our friend and colleague, Azhar Ismail, an entomologist with the Cocoa and Coconut Research Division of the Malaysia Agriculture and Development Institute (MARDI). Mr. Azhar served as the senior author's host during his trip to Malaysia.

Remarks.—*Donaceus azhari* is easily separated from its sole congener *D. nigronotatus* by its smaller size (1.50–1.93 mm as opposed to 2.0–2.40 mm), the much darker microtomentosity of the thorax, the darker legs, and the lack of velvety black lateral margins on the scutellum.

The type series of *D. azhari* was collected on the grounds of the Malaysian Agriculture and Development Institute (MARDI), Hilir Perak Station. The flies were taken along the moist soil banks of a small, approximately 2 m wide, rain-fed drainage ditch. The ditch is very susceptible to flooding. Numerous other shore flies were also collected at this site.

Acknowledgments

We thank Donald Azuma and Ruth Griffith of the Academy of Natural Sciences of Philadelphia (ANSP) for making the type specimen of *Donaceus nigronotatus* available to us. E. P. Catts, W. J. Turner, R. D. Akre, L. Chandler, R. T. Ervin, and J. C. Cokendolpher reviewed the manuscript. This is Scientific Paper Number 7801, Agricultural Research Center, College of Agriculture and Home Economics, Washing-

ton State University, Pullman, Washington 99164. The work was conducted under project 9043. TTU Contribution T-10-183, College of Agricultural Sciences, Texas Tech University, Lubbock, Texas 79409.

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Note

A Sesiid Host Record for *Pterocormus chasmodops* (Hymenoptera: Ichneumonidae)

The ichneumonid, *Pterocormus chasmodops* (Heinrich), has not previously been associated with any host. During the summer of 1986, pupae of the raspberry crown borer, *Pennisetia marginata* (Harris) (Lepidoptera: Sesiidae), were collected in Wayne County, Ohio, from the crowns of cultivated *Rubus* spp. as part of biological control research dealing with this bramble pest. From 30 field collected pupae, 22 *P. marginata* adults emerged, 3 died from a disease, and 5 ichneumonids emerged from the remaining five pupae, 1 per pupa. These specimens were subsequently identified as *Pterocormus chasmodops* (Heinrich) (Hymenoptera: Ichneumonidae). The published host range of *Pterocormus chasmodops* is Quebec, Maine, New Hampshire, New York, Ontario, Michigan, Minnesota and Manitoba (Krombein et al. 1979. Catalog of Hymenoptera in America North of Mexico, Vol. I. pg. 521). This is the first record of this species from Ohio. *Bracon bembeciae* (Walley) (Hymenoptera: Braconidae) is the only other species which has been reared from *Pennisetia marginata.*

We thank Dr. Robert W. Carlson of the Systematic Entomology Laboratory, the Biosystematics and Beneficial Insects Institute, USDA, Beltsville, Maryland, for identifying *Pterocormus chasmodops.*

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PROC. ENTOMOL. SOC. WASH.
90(1), 1988, pp. 106–121

STUDIES ON THE SYSTEMATICS OF THE SHORE-FLY TRIBE DAGINI (DIPTERA: EPHYDRIDAE)

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Abstract.—Six new species of the tribe Dagini are described in the genera ***Psilephydra*** Hendel (***kaskiensis, nepalensis, lyneborgi, iridescens***) and ***Dagus*** Cresson (***splanglerorum*** and ***dominicanus***). Revised keys are provided for all known species of both genera and for the genera of the tribe. *Psilephydra* is rediagnosed and divided into two species groups (the *fluvialis* and *cyanoprosopa* groups), and the phylogeny of the taxa treated is discussed. A catalog to all taxa of Dagini is presented, incuding the new species and new distributional data.

The purpose of this paper is to present additional information on the shore-fly tribe Dagini. Mathis (1982) proposed Dagini as a tribe within the subfamily Ephydrinae. Initially the tribe comprised four genera and 11 species as follows (number of species indicated in parenthesis): *Dagus* Cresson (1), *Psilephydra* Hendel (2), *Physemops* Cresson (6), and *Diedrops* (Mathis and Wirth (2). In three subsequent papers, Mathis (1983, 1984) and Mathis and Hogue (1986) described four additional species in the genera *Dagus* and *Diedrops*. In the latter paper, the third-instar larva and puparium of *Diedrops roldanorum* were described, the first immatures known for the tribe. Since publication of these papers, numerous additional specimens of Dagini have been made available to us, including several that represent new species in the genera *Psilephydra* and *Dagus*. Descriptions of these new species are presented here. The addition of new species to *Psilephydra* also necessitates some changes to the characterization of that genus. In addition to the descriptions, we present revised keys to the genera of Dagini and to the species of the genera with new species and a catalog of the tribe.

In this paper we essentially follow the methods and format presented in the above-cited papers. Those works should be consulted for additional details and perspective.

Two head and two venational ratios are used commonly in the descriptions and are defined here for the convenience of the user (ratios are based on measurement of three specimens if available).

Eye-to-cheek ratio: Genal height (immediately below the eye)/eye height.

Eye width-to-face length ratio: Face length (in profile from anterior margin of eye to anterior margin of face)/eye width (greatest horizontal distance along plane of eye).

Costal vein ratio: The straight line distance between the apices of R_{2+3} and R_{4+5}/ distance between the apices of R_1 and R_{2+3}.

M vein ratio: The straight line distance along M basad of crossvein dm-cu/distance distal to crossvein dm-cu.

Acronyms used in the text to indicate depositories of specimens are as follows: BPBM

(Bernice P. Bishop Museum, Honolulu, Hawaii); HNHM (Hungarian Natural History Museum, Budapest, Hungary); ZMC (Zoological Museum, Copenhagen, Denmark); USNM (National Museum of Natural History, Smithsonian Institution, Washington, D.C.).

Key to the Genera and Species Groups of Dagini

1. Pulvilli lacking; postpronotum with 1 to a few setulae ..... *Dagus* Cresson
– Pulvilli present, conspicuous; postpronotum bare 2
2. Distance between apices of veins R_{2+3} and R_{4+5} short, less than half distance between veins R_{4+5} and M; gena high, equal to or greater than eye height; genal seta well developed and conspicuous; prescutellar acrostichal setae well developed; propleuron setulose; 5th tarsomere with dorsoapical process extended beyond base of tarsal claws ..... *Diedrops* Mathis and Wirth
– Distance between apices of veins R_{2+3} and R_{4+5} subequal to that between veins R_{4+5} and M; gena short, usually not more than ½ eye height; genal seta, if present, weakly developed and inconspicuous; prescutellar acrostichal setae not evident; propleuron without setulae; 5th tarsomere not as above 3
3. Two to 3 large, postsutural dorsocentral setae; arista mostly bare, at most with small hairs (their lengths less than aristal width at base) along basal ¼ (*Psilephydra* Hendel) 4
– One large, postsutural dorsocentral seta inserted near scutellum; arista pectinate or macropubescent along at least basal ⅔ (*Physemops* Cresson) 5
4. Anterior notopleural seta weakly developed, much smaller than the posterior seta; fore femur with posteroventral row of short, spine-like setae ..... the *cyanoprosopa* group
– Anterior notopleural seta well developed, subequal in length to posterior seta; fore femur unarmed, lacking spine-like setae ..... the *fluvialis* group
5. Halter capitellum black; ocellar bristles lacking; arista long, over twice combined length of first 3 antennal segments; vein CuA_1 along posterior margin of discal cell bowed posteriorly ..... the *nemorosus* group
– Halter capitellum pale, usually yellowish; ocellar setae present, conspicuous; arista shorter, rarely not over twice combined length of first 3 antennal segments; vein CuA_1 along posterior margin of discal cell straight ... the *panops* group

Genus *Psilephydra* Hendel

Psilephydra Hendel 1914: 99. Type species: *Psilephydra cyanoprosopa* Hendel 1914, by original description (see catalog section, p. 120, for a more complete synonymy).

Diagnosis.—Moderately small to medium-sized shore flies, length 2.0 to 3.4 mm.

Head: Frons wide (width-to-length ratio 2.3–2.7), fronto-orbital setae 2–4, often minute; ocellar setae present; both inner and outer vertical setae present. Arista moderately long, length nearly twice to three times length of 1st flagellomere, apex virtually bare, basal ⅔ with some dorsal, minute setulae or nearly bare; 1st flagellomere longer than pedicel but not twice length of latter; face generally shield-like, either shallowly and uniformly protrudent over entire height or with lower ⅔ slightly but distinctly more protrudent (best seen in profile), sparsely covered by setae and densely microtomentose with coloration metallic silvery to bronzish; eye-to-cheek ratio 0.30–0.66; genal setae usually present. Palpus elongate, dark colored.

Thorax: Mesonotum and pleura subshining to shining; anterior notopleural seta subequal or much smaller than posterior seta; dorsocentral setae 2–5; prescutellar acrostichal setae lacking; postalar seta 1, well developed; scutellar setae with anterior pair usually smaller, although length variable as compared to apical pair; propleuron bare; katepisternal seta subequal or smaller in length than posterior anepisternal seta. Halter whitish to yellowish. Wing hyaline or uniformly lightly darkened; costal vein ratio 0.16–0.23; M vein ratio 0.51–0.73. Distance between veins R_{2+3} and R_{4+5} about equal to that between veins R_{4+5} and M. Legs blackish; fore femur thickened, with or without posteroventral row of short, spine-like setae.

Male genitalia: Epandrium shield-like, forming cercal activity dorsally; surstyli either distinct or apparently fused to ventral

margin; gonite in lateral view with slender, ventral and anterior projections; aedeagal apodeme long and very slender; aedeagus either about as wide as long or longer than wide.

Discussion.—We have divided *Psilephydra* into the *fluvialis* and *cyanoprosopa* groups, as characterized in the above key or following diagnoses. Eventually, each may be recognized as a separate genus because of the many differences between them (see species group diagnoses). Although our key to the species of the genus includes all known species, we are providing descriptions for the new species only.

Key to Species of *Psilephydra* Hendel

1. Anterior notopleural seta weak, much smaller than the posterior seta; fore femur with posteroventral row of short, spine-like setae 2
– Anterior notopleural seta well developed, subequal to posterior seta; fore femur unarmed, lacking spine-like setae 4
2. Mesonotum dark blue; trochanters dark; eye-to-cheek ratio more than 0.5 (India) ..... *P. lyneborgi* Zatwarnicki, new species
– Mesonotum dark brown; trochanters pale, yellowish to orangish; eye-to-cheek ratio less than 0.5 3
3. First flagellomere pale; scutellum flat; wings uniformly darkened; costa not thickened (Thailand) ..... *P. iridescens* Zatwarnicki, new species
– First flagellomere blackish, concolorous with scape and pedicel; scutellum convex; wings hyaline; costa thickened (Taiwan) ..... *P. cyanoprosopa* Hendel
4. Face distinctly bicolored and protrudent on ventral ½, dorsal surface of protrusion metallic blue, ventral portion along oral margin densely microtomentose, whitish gray (Nepal) ..... *P. kaskiensis* Mathis, new species
– Face either unicolorous or with colorational changes gradual, anterior surface of ventral ½ nearly flat 5
5. Dorsocentral setae 5, anterior seta presutural; overall length 2.9 to 3.4 mm (Nepal) ..... *P. nepalensis* Mathis, new species
– Dorsocentral setae 3, all postsutural; overall length 2 to 2.6 mm (Japan and Ryukyu Islands) ..... *P. fluvialis* (Miyagi)

The *fluvialis* Group

Diagnosis.—Genal seta well developed, conspicuous; anterior notopleural seta well developed, subequal to posterior seta, posterior seta inserted at elevated level compared with anterior seta; katepisternal seta well developed, subequal in size to anepisternal seta; fore femur unarmed, lacking spine-like setae.

Species included.—*Psilephydra fluvialis* (Miyagi), *P. kaskiensis* Mathis, and *P. nepalensis* Mathis.

Psilephydra kaskiensis Mathis, New Species

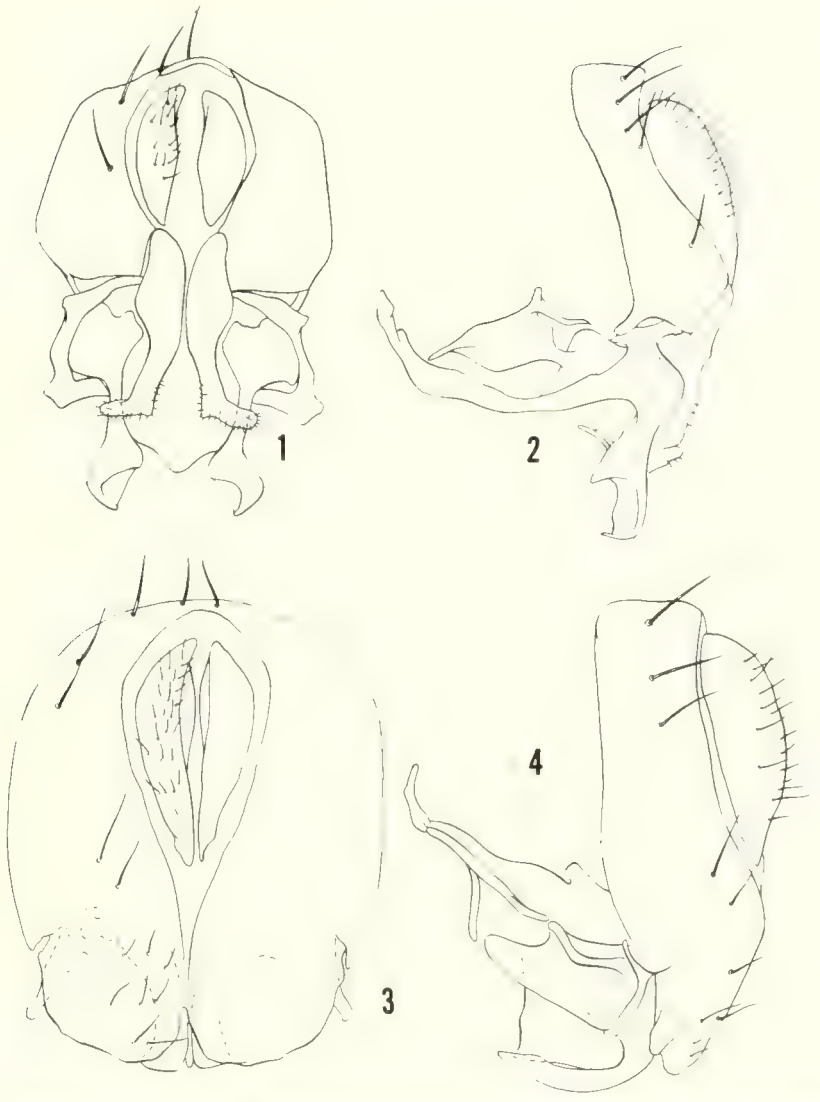
Figs. 1–2

Description.—Moderately small shore flies, length 2.50 to 2.90 mm.

Head: Fronto-orbits and mesofrons bare, shining, with bronzish brown metallic luster; parafrons slightly duller, with sparse microtomentum; fronto-orbital setae 3, posterior 2 larger and subequal in size. Arista with minute hairs, length slightly more than 3× length of 1st flagellomere. Face distinctly bicolored and protrudent on ventral ½, dorsal surface or protrusion metallic blue, ventral portion along oral margin densely microtomentose, whitish gray. Eye-to-cheek ratio 0.30; genal seta well developed and conspicuous.

Thorax: Mesonotum and pleural sclerites mostly shining, with dark brown, metallic luster, only propleuron densely microtomentose, with grayish coloration. Anterior notopleural seta well developed, subequal to posterior seta, posterior seta inserted at distinctly higher level than anterior seta; dorsocentral setae 3, 2 larger posterior setae (including posteriormost, slightly laterally displaced seta) and a smaller anterior seta, anterior seta either sutural or postsutural; basolateral scutellar seta moderately long, about ½ length of apical seta; katepisternal seta well developed, subequal in size to posterior anepisternal seta. Costal vein ratio 0.16; M vein ratio 0.73. Legs, including trochanters, entirely blackish; fore femur unarmed, lacking spine-like setae; setulae on hind coxal strap variable (present on holotype).

Abdomen: Male genitalia as in Figs. 1–2:



Figs. 1–4. *Psilephydra kaskiensis*. 1, Male genitalia, posterior view. 2, Male genitalia, lateral view. *Psilephydra nepalensis*. 3, Male genitalia, posterior view. 4, Male genitalia, lateral view.

epandrium in posterior view about as high as wide, dorsal margin rounded, ventral margin somewhat truncate; surstyli inserted medially at ventral margin of epandrium, each a ventrally projected, linear, more or less sinuate process that is foot-like and setulose apically; gonite in lateral view a 2-pronged process, basal ⅔ of ventral process gradually enlarging from base to apex, thereafter forming a hook-like apex with rounded emargination of anterior surface, anterior process narrowly linear and more or less parallel sided, joined anteriorly with similar process from opposite side; aedeagal apodeme a broadly formed plate-like process lying between anterior gonal processes and base of aedeagus; aedeagus apparently lacking or greatly reduced, mostly membranous; aedeagal apodeme reduced, a well-sclerotized V- to Y-shaped structure that is attached to hypandrium.

Type material.—The holotype male is la-

beled "NEPAL.Kaski Dist[rict] Chomrung, Sinuwa[,] 2250 m, 22 Oct 1985[,] Wayne N. Mathis." The allotype female and three additional paratypes (2♂, 1♀; USNM) bear the same label data as the holotype. The holotype is double mounted (minute nadel in plastic elastomere block), is in good condition (abdomen removed, dissected, preserved in glycerine in an attached microvial), and is deposited in the National Museum of Natural History (USNM), Smithsonian Institution.

Distribution.—This species is known only from the type series from Nepal.

Etymology.—The specific epithet, *kaskiensis*, alludes to the district in Nepal where this species was collected.

Remarks.—This species, although similar to *P. nepalensis* and *P. fluvialis*, is readily distinguished from its congeners by the distinctly bicolored and ventrally protrudent face, shining thorax, especially the pleural area, smaller size, and structures of the male genitalia.

In a few external features, this species is quite similar to those of the genus *Dagus*, the nominate genus of the tribe Dagini (see discussion under that genus below). The protrudent and rounded lower face (best seen in profile) is especially like *Dagus*.

Psilephydra nepalensis Mathis, New Species
Figs. 3–4

Description.—Moderately small to medium-sized shore flies, length 2.90 to 3.40 mm.

Head: Frons subshining, moderately invested with microtomentum; mesofrons undifferentiated; fronto-orbital setae 3, posterior 2 larger and subequal in size. Arista with minute hairs, length slightly more than 3× length of 1st flagellomere. Facial protrusion occupying most of face, protrusion not limited to ventral ½; face generally microtomentose, becoming more densely so ventrally; facial coloration dark gray dorsally to whitish gray ventrally, colorational change gradual. Eye-to-cheek ratio 0.40; genal seta well developed, conspicuous.

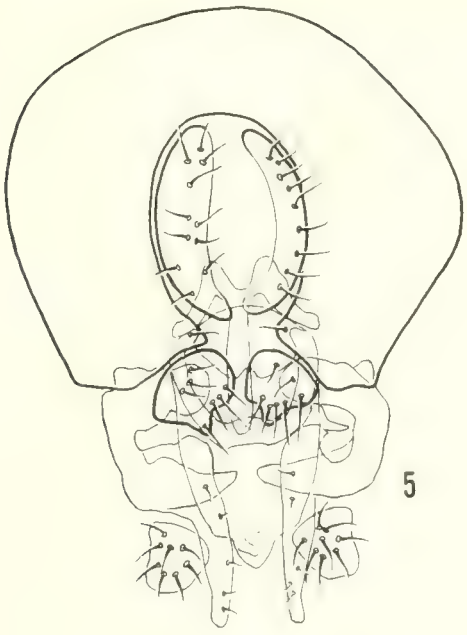
Thorax: Mesonotum moderately invested with microtomentum, subshining, dark brown; pleural sclerites from anepisternum ventrad more densely microtomentose than mesonotum, microtomentum gray. Anterior notopleural seta well developed, subequal to posterior seta, posterior seta inserted at distinctly higher level than anterior seta; dorsocentral setae 5, 3 larger posterior setae (including posteriormost, slightly laterally displaced seta) and 2 smaller anterior setae, anterior setae either sutural or presutural; basolateral scutellar seta moderately long, about ½ length of apical seta; katepisternal seta well developed, subequal in size to posterior anepisternal seta. Costal vein ratio 0.16; M vein ratio 0.58. Legs, including trochanters, entirely dark colored, blackish; fore femur unarmed, lacking spine-like setae; hind coxal strap bearing 1 ventral setula.

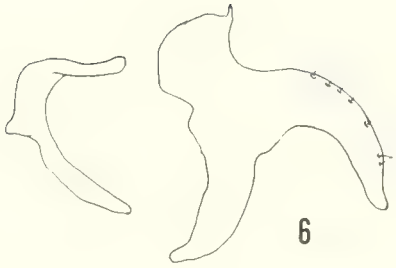
Abdomen: Male genitalia (Figs. 3–4) as follows: epandrium and surstyli in posterior view more or less rectangular; surstyli evident as broadly formed lobes that are fused to the ventral margin of the epandrium; gonite in lateral view a large inverted U-shaped, well-sclerotized process, the anteroventral arm hook-like; aedeagus roughly rectangular, anterior margin concave with pointed angles ventrally; aedeagal apodeme poorly sclerotized, a Y-shaped process.

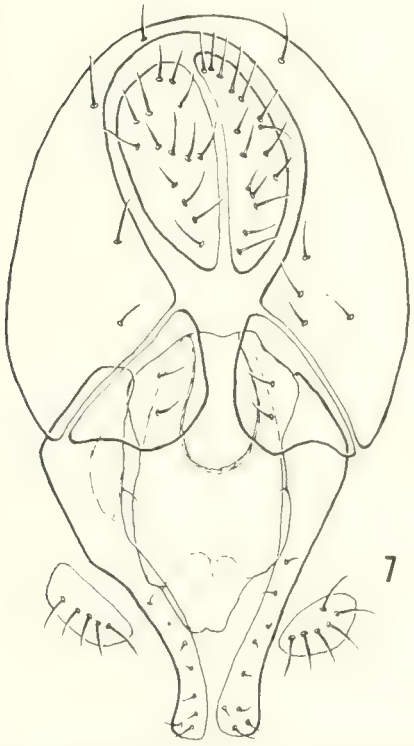
Type material.—The holotype male is labeled "NEPAL.Kaski Dist[rict] Chomrung, Sinuwa[,] 2250 m, 22 Oct 1985[,] Wayne N. Mathis." The allotype female and one male paratype (USNM) bear the same label data as the holotype. The holotype is double mounted (minute nadel in plastic elastomere block), is in good condition, and is deposited in the National Museum of Natural History (USNM), Smithsonian Institution.

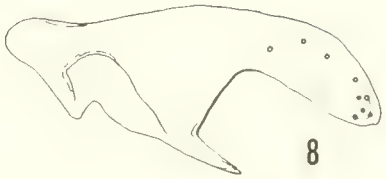
Distribution.—This species is known only from the type series from Nepal.

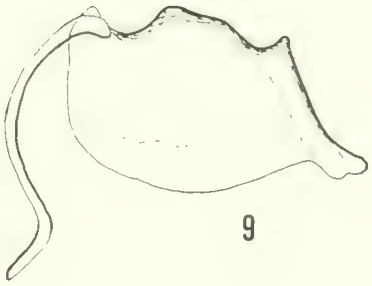
Etymlogy.—The specific epithet, *nepa-*











Figs. 5–9. *Psilephydra iridescens*. 5, Male genitalia, posterior view. 6, Gonite and aedeagal apodeme, lateral view. *Psilephydra lyneborgi*. 7, Male genitalia, posterior view. 8, Gonite, lateral view. 9, Aedeagal apodeme and aedeagus, lateral view.

lensis, alludes to the country where this species was collected.

Remarks.—This species is similar to *P. fluvialis* and to a lesser extent to *P. kaskiensis* but may be distinguished from both and other congeners by its larger size, facial coloration, number of large dorsocentral setae, and structures of the male genitalia.

The *cyanoprosopa* Group

Diagnosis.—Genal seta lacking or reduced; anterior notopleural seta weakly developed, much smaller than posterior seta; fore femur bearing short, spine-like setae along posteroventral margin.

Species included.—*Psilephydra cyanoprosopa* Hendel, *P. lyneborgi* Zatwarnicki, and *P. iridescens* Zatwarnicki.

Psilephydra iridescens Zatwarnicki, New Species

Figs. 5–6

Description.—Medium-sized shore flies, length 3.0 mm.

Head: Frons subshining, dark brown; mesofrons undifferentiated; fronto-orbital setae 2, minute. First flagellomere pale, only darkened above; arista with minute hairs above, length slightly more than 3× length of 1st flagellomere. Facial protrusion occupying most of face, face dull black with generally metallic silvery microtomentum, gradually becoming metallic bronzish medially; eye-to-cheek ratio 0.46; genal setae poorly developed, but evident. Palpus black.

Thorax: Mesonotum moderately invested with microtomentum, subshining, dark brown; pleura from anepisternum ventrad more densely microtomentose than mesonotum, microtomentum silvery gray; anterior notopleural seta minute, posterior seta well developed, subequal to anepisternal seta, posterior seta inserted at same level as anterior seta; dorsocentral setae 2, posteriormost seta slightly displaced laterally, seta well developed, length of anterior seta about ⅕ posterior seta. Scutellum flat, broadly rounded with small projection; basolateral scutellar seta minute, about 1.4× length of apical seta. Halter yellowish. Wing uniformly darkened; costal vein ratio 0.21; M vein ratio 0.57. Legs dark colored, blackish; tarsi pale, darkened apically; trochanters and apices of tibiae brown; fore femur bearing posteroventral row of 4, short, spine-like setae.

Abdomen: Terga concolorous with mesonotum, invested laterally with whitish microtomentum; dorsal surface of terga 2–5 sparsely pitted. Male genitalia (Figs. 5–6) as follows: epandrium in posterior view as an inverted U, anteroventral margin truncate; surstyli evident as lobes with process in the middle of its anterior margin; gonite in posterior view with anterior process elongate, posteroventral process apically rounded, arched anteriorly, and directed ventrally; aedeagal apodeme in posterior view Y-shaped, in lateral view C-shaped, weakly broader centrally; aedeagus in posterior view roughly ovate, rounded posteroapically, anterior apex gradually tapered.

Type material.—The holotype male is labeled "THAILAND: S. Banna. Nakhon[,] 108 m.[,] V-5-10-[19]'58/T. C. Maa Collector[,] Nr. 406." The holotype is glued to a small paper rectangle, is in good condition (apex of abdomen removed, dissected, and in an attached microvial), and is deposited in the Bernice P. Bishop Museum, Honolulu, Hawaii.

Distribution.—This species is only known from the holotype from Thailand.

Etymology.—The specific epithet, *iridescens,* alludes to the shimmering coloration of the face of this species.

Remarks.—This species is similar to *P. cyanoprosopa* but may be distinguished from it and other congeners by its pale 1st flagellomere, darkened wings, and structures of the male genitalia.

Psilephydra lyneborgi Zatwarnicki, New Species

Figs. 7–9

Description.—Medium-sized shore flies, length 3.0 to 3.30 mm.

Head: Frons dark brown; fronto-orbits

and mesofrons bare, shining; parafrons slighty duller, invested with sparse microtomentum. Fronto-orbital setae 3, minute, posterior 2 larger and subequal in size. Arista with minute hairs above, length slightly more than 3× 1st flagellomere. Facial protrusion occupying most of face; face dull black with metallic silvery blue microtomentum, becoming metallic bronzish dorsally; eye-to-cheek ratio 0.66, genal seta poorly developed, but evident. Palpus black.

Thorax: Mesonotum mostly dark, shining, covered with sparse, dark brown microtomentum; pleura with dense, silvery-grayish microtomentum; posterior notopleural seta well developed, its length more than twice length of anterior seta, posterior notopleural bristle inserted at about same level as anterior seta; dorsocentral setae 2, posteriormost seta slightly displaced laterally, well developed, length about twice that of anterior setae. Scutellum flat, broadly rounded with distinct projection; basolateral scutellar seta minute; apical scutellar seta well developed, subequal to posteriormost dorsocentral seta. Length of anepisternal seta about 1.5× length of posterior notopleural seta. Wing hyaline; costal vein ratio 0.17; M vein ratio 0.54. Halter yellowish white. Legs dark colored, blackish, only metatarsus yellowish; fore femur with posteroventral row of 7, short, spine-like setae.

Abdomen: Terga concolorous with mesonotum, invested laterally with whitish microtomentum, dorsal surface of terga 2–5 densely pitted. Male genitalia (Figs. 7–9) as follows: epandrium in posterior view as an inverted U, with arms wider toward anterior margins; surstyli fused to broad anteroventral margin of epandrium, hemispherical in shape, dorsal margin concave; gonite in posterior view weakly S-shaped, apex conspicuously wide and obtuse, anterior process in lateral view with broad and rounded apex, posteroventral margin with sharp process; aedeagal apodeme band-like, bent doubly in lateral view, Y-shaped in posterior view; aedeagus in posterior view longer than broad, basal half with folds laterally, anterior margin tapered gradually with obtuse apex, ventral margin in lateral view rounded, dorsal margin roughly creased, anterior margin truncate, anteroventral apex forming nose-like process.

Type material.—The holotype male is labeled "S. India: Karnataka. Kemmangudi, 1200–1500 m[,] 11–16. xi 1977[,] Zool. Mus. Copenhagen Exp." The allotype female and one additional paratype female (ZMC) are labeled "India (Uttar Pradesh)[,] Dehra Dun Valley, c. 700 m[,] 4.–13. viii 1978[,] Copenhagen Zool. Mus. Exp." The holotype is double mounted (minute nadel in plastic elastomere block), is in good condition (abdomen removed, dissected, and in attached microvial), and is deposited in the Zoological Museum in Copenhagen.

Distribution.—This species is known only from the type series from India.

Etymology.—The specific epithet, *lyneborgi,* is a genitive patronym to honor Dr. L. Lyneborg, who has generously supported our work on shore flies.

Remarks.—This species is similar to *P. cyanoprosopa* but may be distinguished from it and other congeners by the relatively high gena, dark blue mesonotal color, scutellar protrusion, and structures of the male genitalia.

Genus *Dagus* Cresson

Dagus Cresson 1935: 345. Type species: *Ephydra rostrata* Cresson 1918, by original designation.—Wirth 1968: 24 (neotropical catalog).—Mathis 1982: 20–23 (review), 1983:717–726 (revision).

Phylogenetic considerations.—The discovery and study of two new species in *Dagus* and four new species in *Psilephydra* has provided additional information concerning the phylogeny of these taxa. Mathis (1983) suggested previously that *Dagus* was the sister group of *Physemops,* primarily based on the elevated insertion of the posterior notopleural seta. That character state was then known only to species in these two genera. Two of the new species of *Psilephy-*

dra, P. nepalensis and *P. kaskiensis,* also have an elevated insertion of that seta, and, moreover, the face of *P. kaskiensis* is protrudent in a similar way to specimens of *Dagus.* Discovery of these character states casts considerable doubt on the sister-group relationship between *Dagus* and *Physemops* and indicates that such a relationship may exist between *Dagus* and *Psilephydra,* especially between the *fluvialis* group of the latter genus.

Although the sister group to *Dagus* is not clearly demonstrated, the monophyly of *Dagus* is not questioned in view of the evidence. Character evidence to establish this hypothesis was elaborated by Mathis (1983: 718), and we add to the characters he listed the unique condition of the epandrium, which does not extend around the dorsal margins of the cerci. Typically, the dorsal margin of the epandrium forms a connection around the cerci, forming an oval to circular opening in which the cerci and anal opening are situated. We must also note that the third character listed by Mathis, the ventral protrusion of the lower half of the face, is considerably weakened, as that character, which was used to substantiate the monophyly of *Dagus,* also occurs in *Psilephydra* (*P. kaskiensis*).

Among taxa clearly belonging to *Dagus,* the two new species described here are closely related, and together they form a monophyletic lineage, i.e. they are sister species. Character evidence to support this hypothesis is as follows (autapomorphic characters): fore tibia with a preapical, ventral tuft of long setae; and tarsomeres 4 and 5 of foreleg and tarsomere 5 of hind leg with large, ventral, scale-like setae.

Discussion.—The diagnosis of *Dagus* that Mathis (1983) presented remains accurate and is not repeated here. The addition of two new species, however, necessitates a revised key, presented below, to facilitate the identification of species

KEY TO SPECIES OF *DAGUS*

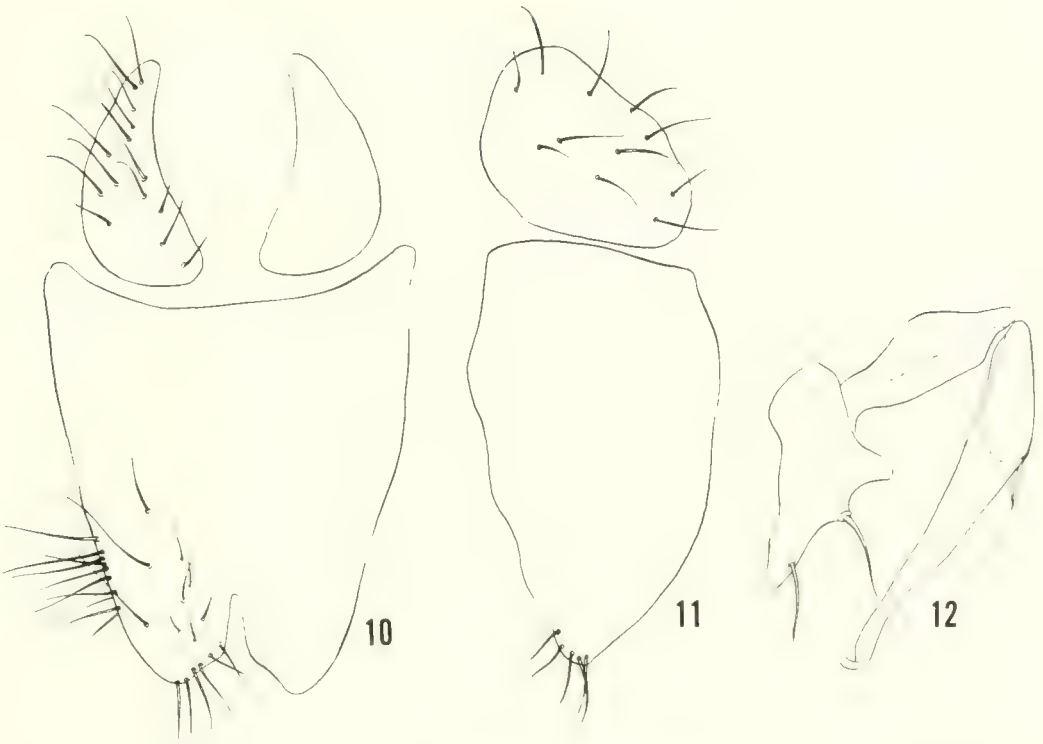
1. Arista long, 3–4× length of 1st flagellomere, conspicuously haired, length of longer hairs much greater than aristal width at base . . . . . *D. trichocerus* Mathis
– Arista shorter, at most 2–3× length of 1st flagellomere, hairs barely evident, length less than aristal width at base 2
2. Posterior notopleural seta inserted at about same level as anterior seta; genal seta well developed, subequal in size to anterior fronto-orbital seta . . *D. dominicanus* Mathis, new species
– Posterior notopleural seta inserted conspicuously above level of anterior seta, usualy 2–3× higher; genal seta weak, usually conspicuously smaller than anterior fronto-orbital seta 3
3. Gena short, about ⅓ eye height; specimens short, less than 2.25 mm . . . . . *D. rostratus* (Williston)
– Gena high, ½ or more of eye height; specimens longer, usually greater than 2.25 mm 4
4. Fore tibia with preapical tuft of long setae ventrally; facial setae generally weak, those along oral margin especially so, usually less than length of anterior fronto-orbital seta . . . . . *D. spanglerorum* Mathis, new species
– Fore tibia lacking preapical tuft of long setae ventrally; facial setae generally well developed, those along oral margin and usually 1–2 setae at lateral margin of facial prominence longer than anterior fronto-orbital seta *D. wirthi* Mathis

Dagus spanglerorum Mathis, NEW SPECIES
Figs. 10–12

Description.—Medium-sized shore flies, length 3.2 to 4.0 mm.

Head: Frons entirely densely microtomentose, appearing velvety, blackish brown to black. Arista bearing minute hairs, barely evident, aristal length nearly 3 times length of 1st flagellomere. Facial protrusion in lateral view with anterodorsal surface less acutely angulate with oral margin; dorsal ½ of facial protrusion with bare, shining areas just below antennae dark, metallic blue, otherwise face micromentose, dark brown; facial setae generally weakly developed, especially setae along oral margin, these smaller than ocellar setae; eye-to-cheek ratio 0.47; eye width-to-face length ratio 0.66; genal seta weakly developed, smaller than anterior fronto-orbital seta.

Thorax: Thoracic chaetotaxy moderately well developed. Dorsocentral setae with 4 larger setae, all postsutural, and 2–3 smaller



Figs. 10–12. *Dagus spanglerorum.* 10, Male genitalia (cerci and epandrium), posterior view. 11, Male genitalia (cerci and epandrium), lateral view. 12, Internal male genitalia, lateral view.

presutural setae; postsutural intra-alar setae with 3–5 generally small setae; posterior notopleural seta inserted at distinctly more elevated position than anterior seta, nearly twice distance from ventral notopleural margin than anterior seta; hind coxal strap bare. Fore tibia with ventral, preapical tuft of well-developed setae; tarsomeres 4 and 5 of foreleg and tarsomere 5 of hind leg bearing large, scale-like setae along ventral surface. Costal vein index 0.13; M vein index 0.70.

Abdomen: Male genitalia (Figs. 10–12) as follows: epandrium, in posterior view, roughly triangular, ventral apex conspicuously cleft, projection on either side of cleft mucronate; lateral view of epandrium nearly bullet shaped with dorsal margin somewhat truncate and remainder tapered gradually to pointed ventral apex; gonite shorter than aedeagus, roughly triangular, longer than wide, dorsal margin uneven, with a shallow projection about ⅓ distance from base.

Type material.—The holotype male is labeled "DOMINICAN REPUBLIC[.] La Vega Province[:] Constanza (3.5 Km S)[,] 9 Nov 1984, sweeping P. & P. Spangler & R. Faitoute." The allotype female and 104 paratypes (32♂, 73♀; USNM) bear the same label data as the holotype. Other paratypes are as follows: DOMINICAN REPUBLIC. La Vega Province: Constanza (8.5 km S), 9 Nov 1984, P. and P. Spangler, R. Faitoute (13♂, 38♀; USNM); Constanza (12 km S) 9 Nov 1984, P. and P. Spangler, R. Faitoute (1♀; USNM). The holotype is double mounted (minute nadel in plastic elastomere block), is in good condition, and is deposited in the National Museum of Natural History (USNM), Smithsonian Institution.

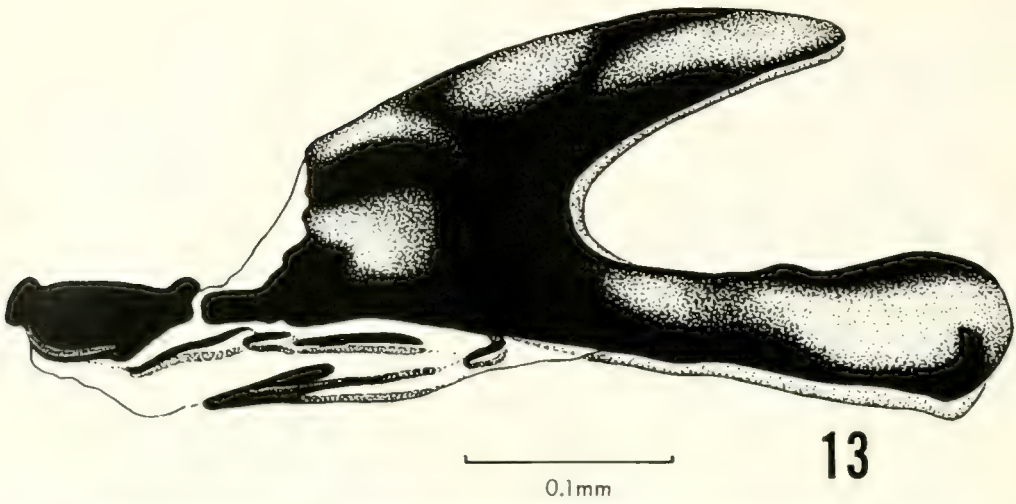


Fig. 13. *Dagus dominicanus.* 13, Cephalopharyngeal skeleton of third-instar larva, lateral view.

Distribution.—This species is known only from the Dominican Republic (Greater Antilles: Hispaniola).

Etymology.—The specific epithet, *spanglerorum,* is a genitive, pleural patronym to recognize the collecting efforts of Paul and Phyllis Spangler, who, along with Robin Faitoute, collected the known specimens of this species as well as numerous other species of Ephydridae.

Remarks.—This species is most easily distinguished from its congeners, especially *D. dominicanus,* by its larger size (smaller than *D. dominicanus* but larger than other congeners), the preapical, ventral tuft of long setae on the fore tibia (also present in *D. dominicanus*), the nearly bare arista, the reduced genal seta, the elevated insertion of the posterior notopleural seta, and the characters of the male genitalia.

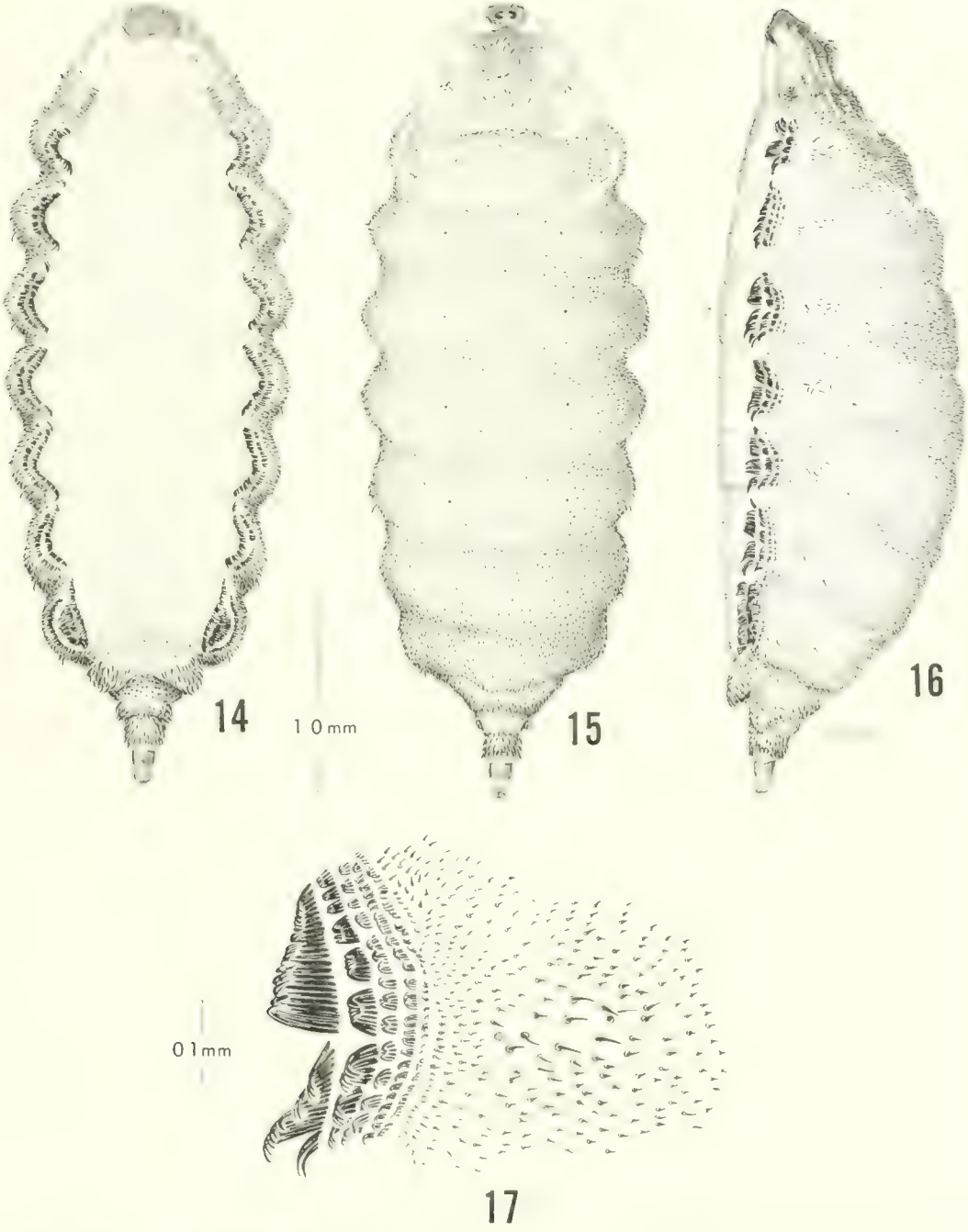
Dagus dominicanus Mathis, New Species
Figs. 13–19

Description.—Medium-sized to large shore flies, length 3.8 to 5.25 mm.

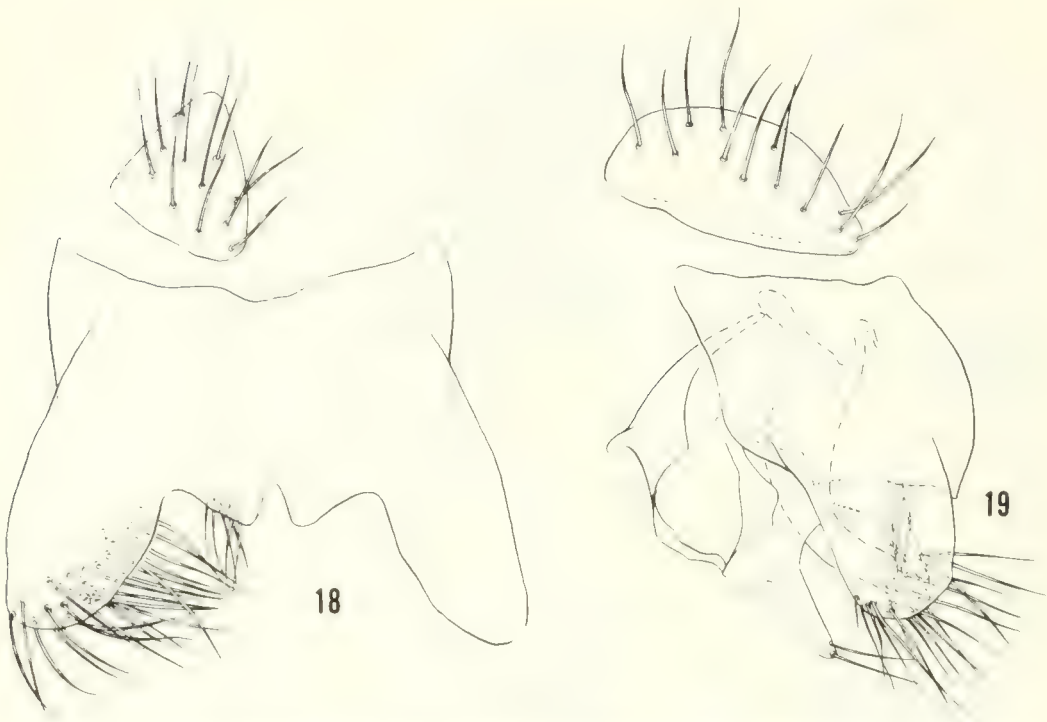
Head: Frons entirely densely microtomentose, appearing velvety, blackish brown to black. Arista bearing minute hairs, barely evident, aristal length nearly 3 times length of 1st flagellomere. Facial protrusion in lateral view with anterodorsal surface less acutely angulate with oral margin; dorsal ½ of facial protrusion with bare, shining area just below antennae dark, metallic blue to brown, becoming microtomentose ventrally, dark brown to gray along oral margin; facial setae generally well developed, especially setae along oral margin, these subequal to ocellar setae; eye-to-cheek ratio 0.55; eye width-to-face length ratio 0.64; genal seta well developed, subequal to anterior fronto-orbital seta.

Thorax: Thoracic chaetotaxy well developed. Dorsocentral setae with 5 larger setae, anterior pair presutural to sutural, and 2–3 smaller presutural setae; postsutural intra-alar setae with 3–5 moderately well-developed setae, all smaller than largest dorsocentral setae; posterior notopleural seta inserted only slightly above level of anterior seta; hind coxal strap bare. Fore tibia with ventral, preapical tuft of well-developed setae; tarsomeres 4 and 5 of foreleg and tarsomere 5 of hind leg bearing large, scale-like setae along ventral surface. Costal vein index 0.09; M vein index 0.88.

Abdomen: Male genitalia (Figs. 18–19) as follows: epandrium, in posterior view, roughly rectangular but with very wide me-



Figs. 14–17. *Dagus dominicanus*, puparium. 14, Ventral view. 15, Dorsal View. 16, Lateral view. 17, Enlargement of 3rd welt (see arrow on Fig. 16).



Figs. 18–19. *Dagus dominicanus*. 18. Male genitalia (cerci and epandrium), posterior view. 19. Male genitalia (cerci, epandrium, and internal genitalia), lateral view.

dian cleft ventrally, producing 2 large, lateral, broadly rounded projections and 2 much smaller, medial, pointed projections within larger cleft, medial margins of larger processes and lateral margin of inner projections densely setulose; lateral view of epandrium somewhat bullet shaped but with ventral margin broadly rounded; gonite about as long as aedeagus, basal portion roughly rectangular and with a long, narrow, digitiform process extended apically; aedeagus gently curved and tapered to rounded tip.

Cephalopharyngeal skeleton of third-instar larva (Fig. 13): Mandible lacking; hypopharynx in lateral view roughly rectangular but with knob-like process anterodorsally and posteroventral angle truncate; ocular depression poorly developed; dorsal cornu evenly tapered to apical point; ventral cornu spatulate.

Puparium (Figs. 14–17): Dimensions: length 4.45–4.70 mm, width 1.65–1.75 mm; height 1.5 mm. Shape: generally oval in ventral or dorsal views (Figs. 14, 15) with 7 ventrolateral, rounded welts forming a crenulate lateral margin, each welt fringed with short setulae (welts probably used for locomotion); retreated margins between welts extended dorsally as shallow furrows that become weaker dorsally; in lateral view dome-shaped (Fig. 16); dorsum gently and evenly rounded, venter nearly flat; anterior spiracle with 4 small papilla-like projections; respiratory tubes essentially fused together externally.

Type material.—The holotype male is labeled "DOMINICAN REPUBLIC[.] La Vega Province[:] Constanza (12Km S) 9 November 1984[,] P. Spangler & R. Faitoute." The allotype female bares the same label data as the holotype. Other paratypes are as follows: DOMINICAN REPUBLIC: La Vega Province: Constanza (10 km S), 10

Nov 1984, P. Spangler, R. Faitoute (4♂, 1♀; USNM); Jarabacoa, 13 Nov 1984, P. and P. Spangler, R. Faitoute (1♀; USNM). The holotype is double mounted (minute nadel in plastic elastomere block), is in good condition, and is deposited in the National Museum of Natural History (USNM), Smithsonian Institution.

Distribution.—All known specimens of this species are from the Dominican Republic (Greater Antilles: Hispaniola).

Etymology.—The specific epithet, *dominicanus,* alludes to the Dominican Republic, the country from which the species was collected.

Remarks.—This species is most easily distinguished from its congeners, especially *D. spanglerorum,* by its larger size (it is the largest species thus far known in the genus), the preapical, ventral tuft of long setae on the fore tibia (also present in *D. spanglerorum*), the nearly bare arista, the well-developed genal seta, the insertion of the posterior notopleural seta at nearly the same level as the anterior seta, and the characters of the male genitalia.

The third-instar larvae and puparia were collected 10 km south of Constanza (9 November 1984) by P. Spangler and R. Faitoute. The habitat was a steep hillside with a seepage area in a shallow, V-shaped depression just above the road cut. Some of the area had a covering of algae.

Catalog of Genera and Species of Dagini

Tribe DAGINI Mathis 1982

Genus DAGUS Cresson

DAGUS Cresson 1935: 345. Type species: *Ephydra rostrata* Cresson 1918, orig. des.—Wirth 1968: 24 [neotropical catalog].—Mathis 1982: 20–23 [review], Mathis 1983: 717–726 [revision].

dominicanus Mathis 1988: 116.

Type locality: DOMINICAN REPUBLIC. La Vega: Constanza (12 km S).

Distribution: Dominican Republic.

rostratus Cresson 1918: 66 (*Ephydra*), 1935: 346 [combination, designated as type species of *Dagus*].—Wirth 1968: 28 [neotropical catalog].—Mathis 1982: 21–23 [review, lectotype designation]; 1983: 720–722 [revision].

pygmaea Williston 1896: 402 (*Ephydra*) [preoccupied, Haliday 1833].

Type locality: WEST INDIES: Saint Vincent: Perseverance Valley.

Distribution: West Indies (Cuba, Dominica, Jamaica, Saint Vincent) and Mexico south through Guatemala and Costa Rica to Venezuela and Brazil.

spanglerorum Mathis 1988: 114.

Type locality: DOMINICAN REPUBLIC. La Vega: Constanza (3.5 km S).

Distribution: Dominican Republic.

trichocerus Mathis 1983: 724–725.

Type locality: CUBA. Pinar del Rio: Soroa.

Distribution: Cuba, Dominican Republic.

wirthi Mathis 1983: 722–724.

Type locality: JAMAICA, Port Parish.

Distribution: Jamaica.

Genus *DIEDROPS* Mathis and Wirth

DIEDROPS Mathis and Wirth 1976: 126. Type species: *Diedrops aenigma* Mathis and Wirth 1976, orig. des.—Mathis 1982: 6–9 [review].—Mathis 1984: 349–353 [key, notes].

aenigma Mathis and Wirth 1976: 129.—Mathis 1982: 7–8[review].

Type locality: MEXICO. Michoacan: Puerto Morillos.

Distribution: Mexico (Michoacan, Sinaloa).

hitchcocki Mathis and Wirth 1976: 129.—Mathis 1982: 8–10 [review].

Type locality: PERU. Moquegua: Yacango.

Distribution: Peru.

roldanorum Mathis and Hogue 1986: 23–26.

Type locality: COLOMBIA. Tolima: Boqueron (3 km W).

Distribution: Colombia.

steineri Mathis 1984: 351–352.

Type locality: PANAMA. Chiriqui: Bambito (Rio Chiriqui Viejo, 1770 m).

Distribution: Central America (Costa Rica to Panama).

Genus *PHYSEMOPS* Cresson

PHYSEMOPS Cresson 1934: 211. Type species: *Psilephydra nemorosa* Cresson 1914, orig. des.—Wirth 1968: 20 [neotropical catalog], 1970: 170–177 [review].—Mathis 1977: 555–556 [generic key and discussion], 1982: 10–20 [review].

The *nemorosus* Group

azul Wirth 1970: 172–173.—Mathis 1982: 14 [review].

Type locality: MEXICO. Oaxaca: Valle Nacional.

Distribution: Mexico (Oaxaca).

nemorosus Cresson 1914: 244 (*Psilephydra*).—1918: 64 [review, figure of head]; 1934: 211 [combination, designated as type species of *Physemops*].—Wirth 1968: 20 [neotropical catalog], 1970: 174–175 [review].—Mathis 1982: 14–15 [review].

Type locality: COSTA RICA. Juan Vinas.

Distribution: Circumcaribbean and South America. Mexico (Oaxaca) and the West Indies (Dominica) south through Central America (El Salvador, Honduras, Nicaragua, Costa Rica, Panama) to Ecuador (Chimborazo) and Brazil (São Paulo).

wheeleri Wirth 1970: 176.—Mathis 1982: 16–18 [review].

Type locality: PANAMA. Canal Zone: Las Cruces Trail.

Distribution: Panama south to Ecuador (Santo Domingo de los Colorados).

The *panops* Group

fairchildi Wirth 1970: 173.—Mathis 1982: 18 [review].

Type locality: PANAMA. Panama: Cerro Capana.

Distribution: Panama south to Colombia (Vicinity of Bogota and Medellin).

maldonadoi Wirth 1970: 173–174.—Mathis 1982: 19–20 [review].

Type locality: PUERTO RICO. Yauco-Lares Road (km 29).

Distribution: Puerto Rico.

panops Wirth 1970: 175–176.—Mathis 1982: 20 [review].

Type locality: HAITI.

Distribution: Haiti.

Genus *PSILEPHYDRA* Hendel

Psilephydra Hendel 1914: 99. Type species: *Psilephydra cyanoprosopa* Hendel 1914, orig. des.—Cresson 1918: 63 [diagnosis, subfamilial placement].—Mathis and Wirth 1976: 128 [comparison with *Diedrops*].—Cogan and Wirth 1977: 338 [Oriental catalog].—Mathis 1982: 24–28 [review].

The *cyanoprosopa* Group

cyanoprosopa Hendel 1914: 100.—Cresson 1934: 211 [list].—Cogan and Wirth 1977: 334 [Oriental catalog].—Mathis 1982: 25–27 [review].

Type locality: TAIWAN. Hoozan.

Distribution: Taiwan.

lyneborgi Zatwarnicki 1988: 112.

Type locality: INDIA. Karnataka: Kemmangudi (1200–1500 m).

Distribution: India.

iridescens Zatwarnicki 1988: 112.

Type locality: THAILAND. S. Banna Nakhon (108 m).

Distribution: Thailand.

The *fluvialis* Group

fluvialis Miyagi 1977: 88 (*Lamproscatella*).—Mathis 1982: 27–28 [review].

Type locality: JAPAN. Shikoku Island: Nametoko, Ehime-ken.

Distribution: Japan (Honshu, Shikoku) and the Ryukyu Islands (Okinawa-honto).

kaskiensis Mathis 1988: 108.

Type locality: NEPAL. Kaski: Chomrung (Sinuwa, 2250 m).
Distribution: Nepal.

nepalensis Mathis 1988: 110.

Type locality: NEPAL. Kaski: Chomrung (Sinuwa, 2250 m).
Distribution: Nepal.

Acknowledgments

We are grateful to the following curators and their respective institutions for making material available to us: N. Evenhius (BPBM) and L. Lyneborg (ZMC). We also thank Elaine R. S. Hodges for rendering the illustrations of the immatures of *Dagus spanglerorum* and George L. Venable for inking the illustrations of *Psilephydra kaskiensis, P. nepalensis, Dagus spanglerorum,* and *D. dominicanus.* For critically reviewing a draft of this paper, we thank Don R. Harris and R. V. Peterson. Support for field work in Nepal was provided through a grant from the Research Opportunity Fund (Smithsonian Institution).

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PROC. ENTOMOL. SOC. WASH.
90(1), 1988, pp. 122–123

Book Review

Historical Perspective and Current World Status of the Tomato Russet Mite (Acari: Eriophyidae). By Thomas M. Perring and Charles A. Farrar. Entomological Society of America, Miscellaneous Publication Number 63, 4603 Calvert Road, College Park, MD 20740. 14 pp. including 1 figure and 5 tables. 1986. $7.50 (non-members) $6.75 (book dealers and subscription agents); $4.50 (ESA members).

Thomas Perring and Charles Farrar have writen an excellent review of the Tomato Russet Mite, *Aculops lycopersici* (Massee), an importrant pest on solanaceous crops throughout many parts of the world. This information was compiled from a review of the existing literature on this mite and presented in the following categories: taxonomy, morphology, life history and biology, host range, host-plant interactions, and control (both biological and chemical).

According to the authors, there was considerable controversy regarding the taxonomy and morphology of this mite until 1966 when *Aculops lycopersici* (Massee) became the accepted name.

A concise review is given on the synonymy and generic names of the species created by Tryon (1917), Massee (1973), Lamb (1953), and Keifer (1940, 1944, 1959, and 1966). Like others, the authors have misspelled Tryon.

The morphology section is documented by references and contains a comparison made by Keifer of specimens described by Massee (1937) and Keifer (1940). To some readers, this comparison may serve as an indication of two distinct species, rather than variations found within a species. It is not clear whether Keifer studied Massee's slide-mounted specimens or if illustrations were used in the study. Keifer and the authors failed to mention that these different observations could be attributed to different optical and measuring equipment, mite clearing agents, and mounting media.

The book contains useful documented references and pertinent information on life history and biology, host range, host-plant interactions, and natural enemies for biological control.

Among the most valuable features in the book are the five tables. The style and information compiled by the authors are commendable. Table 1 presents the worldwide distribution of *A. lycopersici,* with the pertinent dates, locations, authors, and references. The earliest known date for the mite is 1892 where it was first found in Florida and the latest date 1895 where it was reported from Mexico. Although the authors cited the locations from original references, many of the names for countries have changed and the present correct names should have been placed in parentheses beside the old name. Examples of the old and present names are: Ceylon (= Sri Lanka) and Persia (= Iran).

Table 2 gives the distribution of the mite in the United States with the same heading as Table 1.

Table 3 is an excellent adjunct resource that will be useful in identifying the mite. This table lists the common and scientific names, dates, and references for 25 plants known to be hosts of *A. lycopersici.*

Table 4 is a list of 75 materials tested for the control of *A. lycopersici* and includes the common and trade names, efficacy, date, and references for each substance.

Table 5 is composed of citations from the Cooperative Economic Insect Reports and Cooperative Plant Pest Reports that contain information on *A. lycopersici.* The year, volume, number, and pages are included for the years 1952 through 1977.

Unfortunately, the front cover of this book is inappropriate. The cover has a scanning electron micrograph of unidentified setae.

This type of setae has not been reported or illustrated for any member of the eriophyoidea. Surely a picture of any eriophyid mite on the front cover would lend more credence to the book.

This book is an excellent synthesis of the present knowledge on the Tomato Russet Mite and can be used especially by acarologist and biological control and integrated pest management researchers.

Robert L. Smiley, *Systematic Entomology Laboratory, BBII, Agricultural Research Service, USDA, Beltsville, Maryland 20705.*

Book Review

The Bombyliidae of Deep Canyon. Parts I and II. By Ali B. Tabet and Jack C. Hall. Al-Fateh University Publications, Tripoli, S. P. L. A. J. 1984, Part I, A Phenology Study of the Bombyliidae of Deep Canyon, pages [1]–63, figs. 1–17, tabs. I–VI. Part II, pages [1]–176, figs. 1–63 (Key to genus **Bombylius,** pp. 19–21, written by Neil Evenhuis).

This publication on the Bombyliidae of the Philip L. Boyd Deep Canyon Desert Research Center at Palm Desert, California, a facility of the University of California, Riverside, is the sixth major publication resulting from studies at this center. The first, Mammals of Deep Canyon by R. Mark Ryan, 1968, was followed by Ants of Deep Canyon by George C. Wheeler and Jeanette Wheeler, 1973; Deep Canyon, a Desert Wilderness for Science, edited by Irwin P. Ting and Bill Jennings, 1976; Plants of Deep Canyon and the Central Coachella Valley, California by Jan G. Zabriskie, 1979; and Birds of Southern California's Deep Canyon, by W. W. Weathers, 1983.

Published copies of Part I of The Bombyliidae of Deep Canyon were received from Libya by Mr. Hall, at Riverside, California, in 1984, while copies of Part II were received in March of 1987. It has not been possible, as of this writing, to ascertain the exact date of publication of the second part.

Part I, A Phenology Study of the Bombyliidae of Deep Canyon, summarizes an intensive year-long sampling of the Bombyliidae of a localized area within the Colorado Desert of southern California. Seventy percent of the genera and 20 percent of the species of Bombyliidae known from North America are reported from this 13,000 acre (80 square mile) area. Species composition and seasonal distribution of mainly two areas of varying elevation in Deep Canyon, both primarily in the Lower Sonoran Zone, with habitats such as the chaparral and coniferous forest areas occurring at higher elevations in the canyon remain undocumented.

Part II discusses the 186 species of Bombyliidae (in 41 genera) collected in the Deep Canyon study area. A key to the subfamilies and genera of Bombyliidae of California occupies pages 7–17. Fifteen species are new and named as: **Mythicomyia candida** (p. 43), **M. torta** (pp. 49–50), **M. vernalis** (pp. 50–51), **Oligodranes nigricans** (pp. 61–63), **Desmatomyia proboscidea** (pp. 64–66), **Aphoebantus albopilosus** (pp. 83–85), **A. bilineatus** (pp. 85–87), **A. leucospilus** (pp. 89–92), **A. melanomerinyx** (pp. 92–95), **A. nigropilosus** (pp. 95–97), **A. oxypetes** (pp. 98–100), **A. xanthoscelus** (pp. 102–105), **Chrysanthrax albicomus** (pp. 135–136), **C. partita** (pp. 139–141), **C. petalonyx** (pp. 141–143), **Neodiplocampta caliginosa** (pp. 154–156). Primary types are deposited in the collection of the California Academy of Sciences, San Francisco, with the exception of one species, **Aphoebantus xanthocelus**, that is deposited with the University of California, Davis.

Mr. Jack C. Hall has a limited number of copies of this publication that are available for distribution. He may be contacted at the Division of Biological Control, University of California, Riverside, California, 92507, by those so interested.

Paul H. Arnaud, Jr., *California Academy of Sciences, Golden Gate Park, San Francisco, California 94118.*

PROC. ENTOMOL. SOC. WASH.
90(1), 1988, pp. 125–126

Book Review

Manual of Nearctic Diptera, vol. 2. J. F. McAlpine, Ed. Research Branch, Agriculture Canada, Ottawa. 1987, vi + 658 pp. $68.35.

The long-awaited publication of volume 2 of the widely acclaimed Manual of Nearctic Diptera should be cause for celebration by North American Dipterists, as it replaces the long outdated, though memorable, book by C. H. Curran, *Families and Genera of North American Diptera*, published in 1934. As stated in the preface ". . . the main purpose of the Manual of Nearctic Diptera is to provide a modern, well-illustrated, easily interpretable means for identifying the families and genera of two-winged flies of American north of Mexico." This goal has been admirably fulfilled!

Volume 1 of the projected 3 volume work gave background coverage, discussed terminology, presented a key to the Nearctic families, and included keys to the genera of 24 families of Nematocera and 19 families of lower Brachycera. The second volume is largely devoted to the families of Muscomorpha (the so-called higher flies), but also includes corrections and addenda for volume 1 and an index for volume 2. Five families of Aschiza and 60 families of Schizomorpha are recognized, with the taxonomic arrangement of families following the classification scheme presented in volume 1. The coverage for each family includes a synopsis, adult description, larval description (not included for all families), biology and behavior, classification and distribution, key to genera, and references. For a few families descriptions of the egg and puparium are also given. A total of 23 different experts authored the family chapters, thus assuring overall quality. There are 1912 excellent illustrations arranged in 287 plates, with all but 62 of the drawings contributed by Ralph Idema, the same individual who illustrated volume 1. Undoubtedly, one of the most important attributes of volumes of the Manual is the uniformly high quality of the figures, with nearly all of the salient key references being illustrated. I encountered little difficulty with the generic keys for three acalyptrate families poorly known to me (Agromyzidae, Milichidae, Sphaeroceridae) and three families with which I have had considerable experience (Otitidae, Sciomyzidae, Ephydridae) and felt confident that I had correctly identifed the genus involved. I did not test the keys to genera of the calyptrate families. The number of Nearctic species, a summary statement on geographic distribution, and reference to important revisions are given for each genus. Sadly, keys to larvae were included for only 8 of the 65 families.

Although quality varied somewhat from family to family, my overall impression is that the authors have covered the subjects assigned to them in a very satisfactory manner. The habitus sketches that head each family chapter were very well executed. The synopses and descriptions of adults were quite well done, but the coverage of natural history and morphology of the immature stages was a bit weak in places. This latter comment is not meant as a criticism of the authors involved, but is a reflection of our poor knowledge of the immature stages of several families, particularly those of the Acalyptratae. The larval stages were illustrated in volume 1 in connection with the family key. Thus, there are relatively few illustrations of immature stages in this volume. The natural history discussions included summaries of larval feeding habits, comments on habitat distribution, and references to important papers giving information on biology and morphology of the immature stages. Sections dealing with classification and distribution included information on the phylogenetic placement of

the family, its geographic distribution, number of species in the world and Nearctic Region, and comments on fossil species. There were surprisingly few typographical errors in the text, and the figure labels were well done, although a few broken letters were noted. A minor criticism is that some of the figures are so light that patterns are poorly differentiated. Another complaint is that the binding seems surprisingly poor—my copy of volume 1 is already showing deterioration.

It is emotionally exciting and professionally satisfying that dipterists finally have a modern, well-illustrated key to the genera of Nearctic families, as interest in the order undoubtedly will be stimulated now that some of the taxonomic headaches have been overcome. The recent publication of catalogs dealing with various faunal regions, the continual appearance of family and generic revisions, and the publication of this manual all indicate that the world of Diptera is alive and well. Now, attention should be turned to an updating of Hennig's volumes on the larval stages.

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PROC. ENTOMOL. SOC. WASH.
90(1), 1988, pp. 127–128

Book Review

Sphingidae Mundi (Hawkmoths of the World). By Bernard D'Abrera. E. W. Classey Ltd., Faringdon, United Kingdom [1987] 1986, 226 pages, 80 colored plates, large format. Price: £97.50 (approximately $145.00).

More than 1000 sphingid species are illustrated by superb colored photographs and extremely good color separations. Comparison of the plates with several specimens shows the colors to be quite accurate. The greatest contrast in quality is on page 117 where *Sataspes tagalica* is a very good representation of metallic-reflecting scales; however, the numerous species of *Cephonodes* are incorrect. Most species of *Cephonodes* have a pale yellowish-green cast to the wing membrane; these appear bluish gray with yellowish-gray overtones in the photographs. This result may reflect the method used to back light the specimens when the photographs were made. The background has been replaced with a uniform color on all plates. A four-plate appendix has illustrations of 40 species not represented in the British Museum (N.H.).

A more appropriate title might be *Sphingidae of the World as Represented by the Collection of the British Museum (N.H.) and as Arranged by Alan Hayes.* Additional, but not inordinate, time would have been required to obtain specimens of the several species of which the British Museum does not have examples but which Alan Hayes included in his draft checklist provided D'Abrera to form the basis of the arrangement of the illustrations. The very brief introduction includes description of the abbreviations used throughout the text and on the plates, a labeled example of fore- and hindwing venation, a labeled diagram of a pretarsal segment, and a generalized lateral view of the head. The labels for forewing venation (p. 7) are incorrect. Starting with the posterior margin, the basally forked vein is 1A+1B, the first vein arising from the cell is vein 2, then all the numbers should be increased by one until the last numbered vein is 12. A systematic list of valid genera (with the exception of *Neococytius,* which is not treated by name elsewhere in the text) precedes the full work. A general treatment for a genus includes the author and date of publication of the type species; a discussion of distribution, number of species, characters purporting to discriminate the taxon, larvae, and pupae; and host list. Species are briefly treated with the scientific name, author, date, and World List abbreviation of original description, geographic distribution, comments about the species including differentiating features and larval hosts. Throughout, synonyms of species and genera rarely are given. When subspecific names are used, the original publications and dates are not cited.

This book cries for critical editing. Starting on page 12, the family Sphingidae is attributed to Samouelle, 1819; the subfamily Sphinginae to Latreille, ?1805. According to the International Code of Zoological Nomenclature the author of a family-group name is the person who first proposed the name in a higher category sense. Thus, Sphingidae should be attributed to Latreille. In the discussion of *Agrius* (p. 12) the authors of the rearing records are Szent-Ivany and Carver, but in the references section the authors are cited as Carver and Szent Ivany (without hyphen). Under *Coelonia fulvinotata* (p. 14) D'Abrera dismisses Carcasson's synonymy of *fulvinotata* under *C. solani* without explanation. Curious inconsistencies are his treating *Meganoton scribae* as a valid species, yet in the discussion he says "I consider this to be no more than a local race of *analis* Felder." On page 12 proboscis is misspelled as probscis. The citation under *Megacorma obliqua* (p. 12)

should be List Spec. Lep. Ins. BM—not MM. On page 24 for *Manduca kuschei* the place name is Venadio, not Venodio. On page 40 *Sphinx lanceolata* (incorrectly attributed to Boisduval, 1870, instead of R. Felder, 1868) is treated as a valid name with *Sphinx leucophaeta* (correctly *leucophaeata*) Clemens a junior synonym. However, *leucophaeata* was described in 1859 and is the valid name of the species. Also on page 40 the author of *vancouverensis* is Edwards, not Edward. On plate [page 123] *E. damasi* should be *E. adamsi*. On pages 156, 157 the text correctly gives *floridensis* as the valid name, whereas the plate uses *nessus*.

This illustrated, synoptic checklist of Sphingidae should be accompanied by a text with the names, authors, and dates of all taxa. Readers must be warned that many of the species are best determined by genital characters and that the higher classification uses them extensively. Many species are highly variable; attempts to identify many of them without knowledge of their origin and genital characters may result in incorrect identification. D'Abrera treats all specific epithets as nouns in apposition, a practice that will cause some readers concern; and, parentheses are never used for authors' names.

Despite the numerous shortcomings, I know that I will use this work extensively to make preliminary identifications and as a guide to the British Museum (N.H.) collection—the premier collection of world Sphingidae.

Ronald W. Hodges, *Systematic Entomology Laboratory, Agricultural Research Service, USDA, % NHB 168, National Museum of Natural History, Washington, DC 20560.*

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(ISSN 0013-8797)

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of the

ENTOMOLOGICAL SOCIETY

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ORGANIZED MARCH 12, 1884

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STATEMENT OF OWNERSHIP

Title of Publication: Proceedings of the Entomological Society of Washington.

Frequency of Issue: Quarterly (January, April, July, October).

Location of Office of Publication, Business Office of Publisher and Owner: The Entomological Society of Washington, c/o Department of Entomology, Smithsonian Institution, 10th and Constitution NW, Washington, D.C. 20560.

Editor: Hiram G. Larew, B-470, ARS, USDA, Beltsville, MD 20705.

Managing Editor and Known Bondholders or other Security Holders: none.

This issue was mailed 29 April 1988

Second Class Postage Paid at Washington, D.C. and additional mailing office.

PRINTED BY ALLEN PRESS, INC., LAWRENCE, KANSAS 66044, USA

PROC. ENTOMOL. SOC. WASH.
90(2), 1988, pp. 133–154

COMPARATIVE MORPHOLOGY OF THE BUTTERFLY FORELEG COXA AND TROCHANTER (LEPIDOPTERA) AND ITS SYSTEMATIC IMPLICATIONS

ROBERT K. ROBBINS

Department of Entomology, NHB STOP 127, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560.

Abstract.—I describe and illustrate five qualitatively distinct forms of butterfly foreleg coxa, trochanter, and basal femur, and give the distribution of each type by sex for the butterfly families. I code this variation in a character matrix of four characters with 9 character states, from which I derive a most parsimonious cladogram with four monophyletic groups: (1) Styginae (Riodinidae), (2) Hamearinae (in part) + Styginae + Riodininae + Euselasiinae (Riodinidae), (3) Lipteninae + Poritinae + Liphyrinae + Miletinae + Curetinae (Lycaenidae), and (4) Riodinidae + Libytheidae + Nymphalidae. The second and third groups have not been recognized previously as monophyletic. The fourth supports previous results based on other leg characters, but is inconsistent with most published phylogenies to the butterfly families. Contrary to previous reports, the forecoxa of male *Styx infernalis* (Riodinidae: Styginae) extends beyond the trochanter, but this extension is smaller than in most other riodinids. I also show that the male forelegs of *Curetis* (Lycaenidae: Curetinae) and Riodinidae are qualitatively different, a result that does not support the hypothesis that these two taxa are sister groups.

Key Words: leg characters, butterfly, cladogram

For more than 125 years, classification of the butterfly families has relied heavily on foreleg characters, particularly those of the tarsus (Bates 1861, Ford 1945), but morphology of the male foreleg coxa and trochanter has also been used in butterfly higher classification (cf. Borror et al. 1981 for an introduction to insect leg morphology). Godman and Salvin (1879–1901) discovered that the male forecoxa of riodinids extends beyond its articulation with the trochanter, and Stichel (1910–1911) and Ehrlich (1958b) characterized the Riodinidae (Ehrlich's Riodininae), in part, by this structure. Ehrlich also erected a new monobasic "subfamily"—of rank equal to the Lycaenidae (his Lycaeninae) and Riodinidae—for *Styx infernalis* Staudinger because its male forecoxa does not extend spinelike beyond the trochanter and because it differs from riodinids in a few other structures. Scott (1985) proposed that *Curetis* (a genus that Ehrlich had considered to be a lycaenid) and Riodinidae (his Riodininae without *Styx*) are sister groups because both have the male foreleg coxa extending beyond the trochanter.

The few published figures of foreleg coxae and trochanters lack detail (e.g. Ehrlich 1958a, b, Scott 1986), and I propose to solve this problem with the use of a scanning electron microscope (SEM). It is clearly important that the morphology of these structures be well documented if they are to be used in constructing familial classifications of the butterflies. The first purpose of this paper

is to describe and illustrate the foreleg coxa, trochanter, and basal femur of males and females from the different butterfly families.

The second purpose of this paper is to assess the morphologic and phylogenetic hypotheses of Ehrlich (1958b) and Scott (1985). Specifically, I (1) check Ehrlich's statement that the male foreleg coxa of *Styx* does not extend beyond its articulation with the trochanter and (2) assess Scott's proposal that *Curetis* and the Riodinidae are sister groups, based in part on the observation that in both taxa the male forecoxa extends beyond the trochanter.

The third purpose of this paper is to use variation of the foreleg coxa and trochanter among higher taxa to further our understanding of butterfly phylogeny. I code this variation in a character matrix, derive a most parsimonious cladogram, determine whether it is consistent with published phylogenies (Ehrlich 1958b, Kristensen 1976, Scott 1985), and assess the monophyly of some higher taxa.

Materials and Methods

Because foreleg coxae are difficult to remove from dried specimens without breakage, in most cases I wetted the whole body (after removing the wings) in 80% ethanol, soaked it in 10% potassium hydroxide at room temperature for 24–48 hours, and transferred it to 80% ethanol. I then removed both forelegs, and brushed and scraped off as many scales as possible with forceps and a brush with stout bristles. In some cases where scales were particularly hard to remove, I transferred the legs to acetone, which helped to loosen the scales. At this point I examined specimens with a binocular stereomicroscope, which is oftentimes sufficient to determine structures.

For examination with an SEM, I soaked foreleg coxa, trochanter, and femur preparations in absolute ethanol for 5–10 minutes, and mounted them on stubs in various aspects. I mounted some laterally so that they presented either an outside or inside lateral aspect, others as an upright triangle, which provided a posterior aspect in addition to both lateral aspects, and still others as parts of segments to show particular structures. I glued the specimens at the origin of the coxa and/or at the distal end of the femur, and the stubs were coated with carbon and gold.

Results

There are five qualitatively distinct forms of foreleg coxa, trochanter, and femur; all five occur in males while two are found in females. The foreleg coxa, trochanter, and femur in butterflies have a complex three-dimensional morphology that is difficult to communicate on a two-dimensional printed page. I describe the first leg type in detail using pictures from inside lateral, posterior, outside lateral, and anterior aspects, and note some of the major morphological "landmarks" and shapes. I then describe the other leg types by focusing on how they differ from the first one. I illustrate specimens representing diverse taxonomic groups to show some of the quantitative variation within each foreleg type. Under this description, I list genera by family in which I found it. Because distribution of the different foreleg types differs in the sexes, I list distributions in males and females separately. If I examined more than one specimen of one sex in a genus, then I place an asterisk (*) after the generic name.

The familial classification follows Ehrlich (1958b) except for the Lycaenidae and Riodinidae, for which I follow Eliot (1973) and Harvey (1987), respectively. Harvey divided the Riodinidae into the subfamilies Styginae, Corrachiinae, Hamearinae, Euselasiinae, and Riodininae. The Corrachiinae contains a single rare species that I have not had an opportunity to examine.

Type I

Morphology.—*Foreleg coxa:* A tapering tubular structure that is shaped very differently than the midleg or hindleg coxa. Ehrlich (1958a) reported that the coxa is grooved

laterally in the monarch (*Danaus plexippus* Linnaeus), an observation that I believe to be incorrect. I list each morphological structure by letter, and use that letter to designate it in the figures.

The foreleg coxa has a pair of posterior pointing mid- to ventro-lateral processes that articulate with the trochanter. The hinge formed between these processes and the trochanter allows leg movement along the longitudinal plane. (A) One process is on the inner lateral side (Figs. 1–4) and (B) the other on the outer lateral side (Figs. 5–8).

(C) There are two rod-like "tendons" within the coxa that attach distally to the trochanter, one dorsally, the other ventrally (not illustrated). When the coxa and trochanter are separated, the tendons usually remain attached to the trochanter. They are best seen with transmitted light under a binocular stereomicroscope.

Foreleg trochanter: A complexly curved three-dimensional segment.

(D) There are a pair of prongs on the dorsal basal edge of the trochanter (Figs. 9–12). They attach to the dorsal "tendon" of the coxa. The prongs vary considerably in extent, and are reduced to two bumps in some Nymphalidae (Fig. 12).

(E) The outside surface of the trochanter is rounded in posterior aspect (Figs. 9–12), and is indented anteriorly in lateral aspect where the posterior coxa process articulates with it (Figs. 5–8).

(F) The inner surface of the trochanter is slightly concave in posterior aspect (Figs. 9–12), and is slightly indented ventrally where it articulates with the femur process (Figs. 1–4).

(G) There is a slit/groove that extends dorsally from the posterior edge of the indentation for the femur process and that forms the posterior edge of the concave area on the inner surface of the trochanter (Figs. 1–3, 9–10). I presume that this slit/groove allows the leg some lateral flexibility in movement.

There are three clusters of small trichoid sensilla (5 or more sensilla, less than 40 microns in length except in some larger butterflies, such as Papilionidae) on the trochanter. (H) A cluster on the lateral indentation just anterior and ventral to the inside dorsal prong of the trochanter (Figs. 1–4, 9–12). (I) A cluster on the lateral indentation just anterior and ventral to the outside dorsal prong of the trochanter (Figs. 5–8, 9–12). (J) A third cluster just below the articulation of the coxa process on the anterior face of the trochanter. It can be seen from an inside lateral aspect (Figs. 1–4), but is best seen in anterior aspect (Figs. 13–14). I presume that these trichoid sensilla are mechanoreceptors, at least in part, because they occur where movements of the trochanter would cause them to come into contact with the coxa. There are also other trichoid sensilla scattered over the foreleg, but they occur singly or in a cluster of two, and are often longer than 40 microns in length.

Foreleg femur: A simple tubular structure at its basal end, where it connects to the trochanter.

(K) There is a basal process on the posterior inner face of the femur (Figs. 1–4, 9–11). This process may be rounded or somewhat tapered to a point.

Male distribution.—*Hesperiidae: Poanes* Scudder, *Megathymus* Scudder, *Autochton* Hübner, *Epargyreus* Hübner.

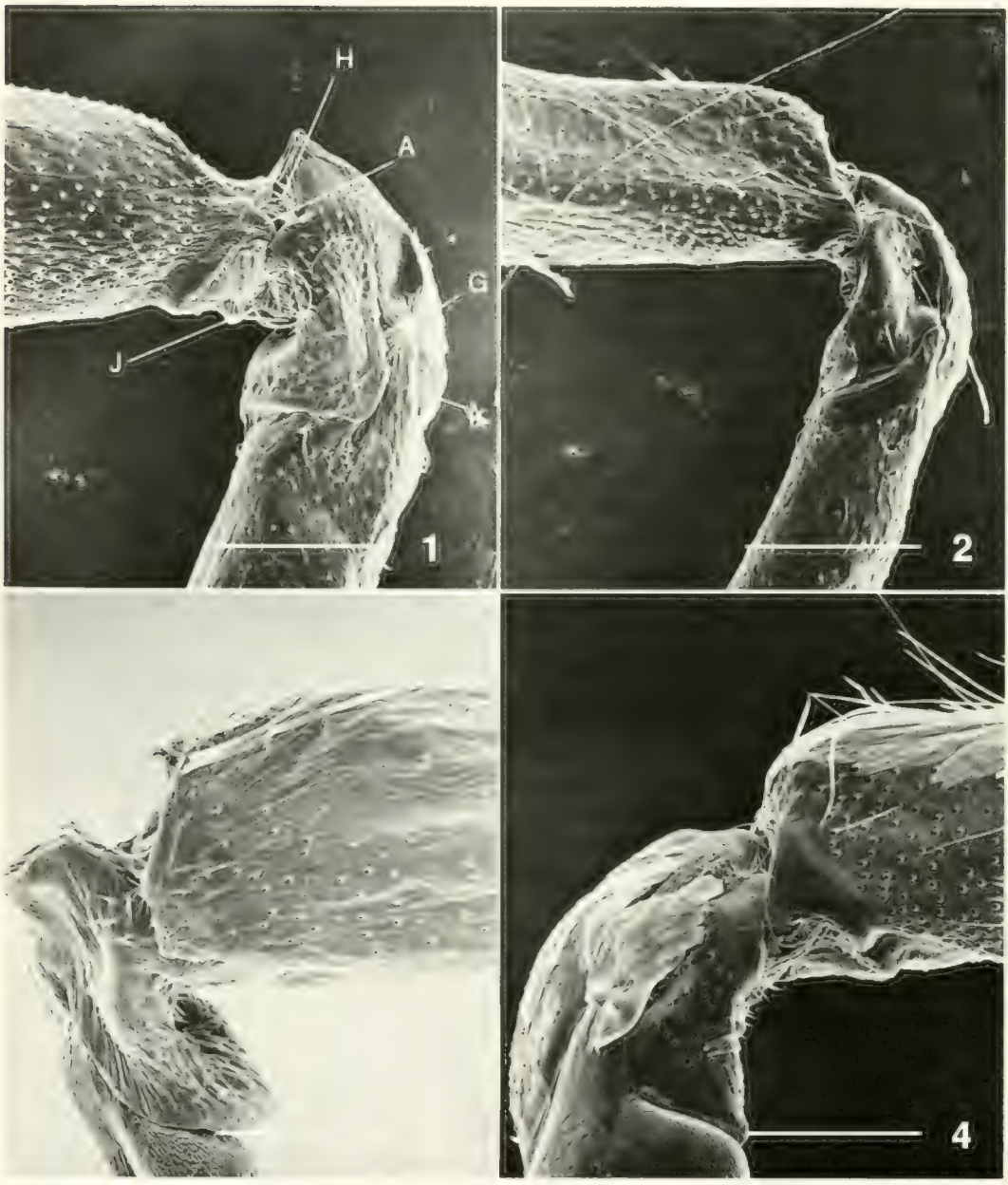
Papilionidae: Papilio Linnaeus, *Battus* Scopoli, *Eurytides* Hübner, *Parnassius* Latreille.

*Pieridae: Eurema** Hübner, *Phoebis* Hübner, *Colotis* Hübner, *Pieris** Schrank, *Euchloe* Hübner, *Dismorphia* Hübner.

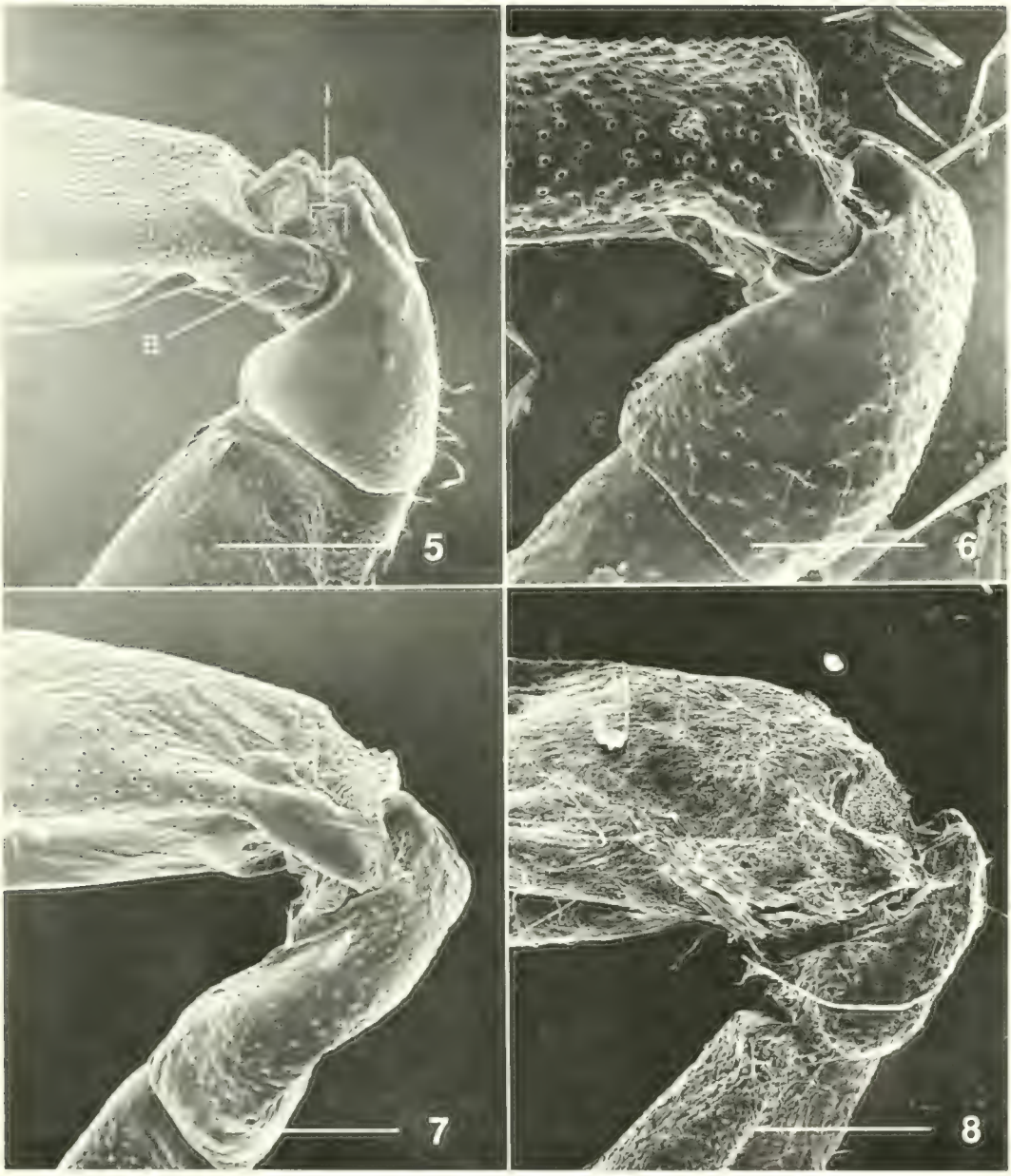
Lycaenidae (Theclinae, Polyommatinae, Lycaeninae): Arawacus Kaye, *Strymon* Hübner, *Calycopis* Scudder, *Evenus* Hübner, *Allosmaitia* Clench, *Hypaurotis* Scudder, *Axiocerses* Hübner, *Everes* Hübner, *Celastrina** Tutt, *Lycaena** Fabricius.

Female distribution.—*Hesperiidae: Hesperia* Fabricius, *Poanes, Thorybes* Scudder, *Erynnis* Schrank.

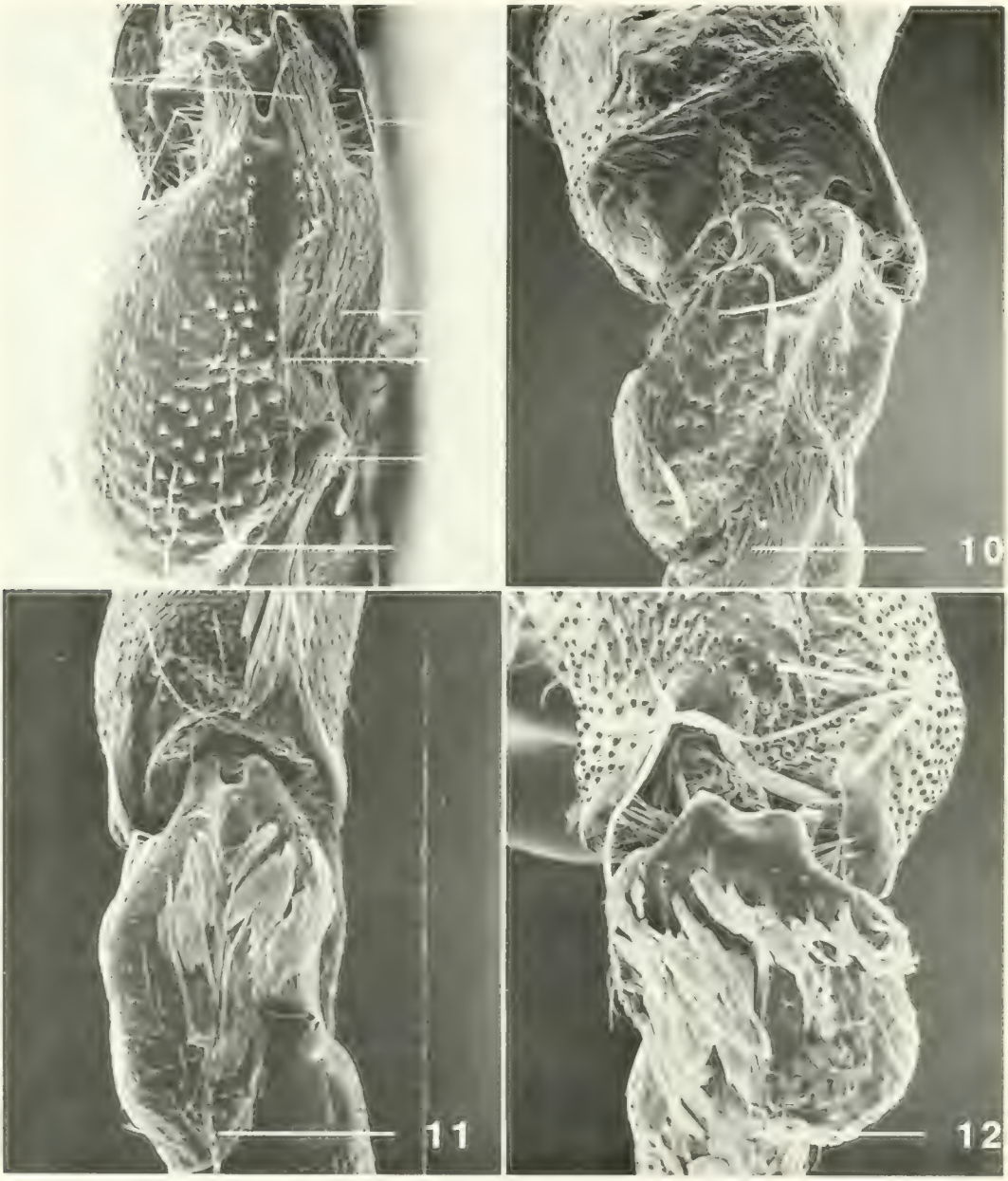
Papilionidae: Papilio, Battus, Eurytides, Parnassius.



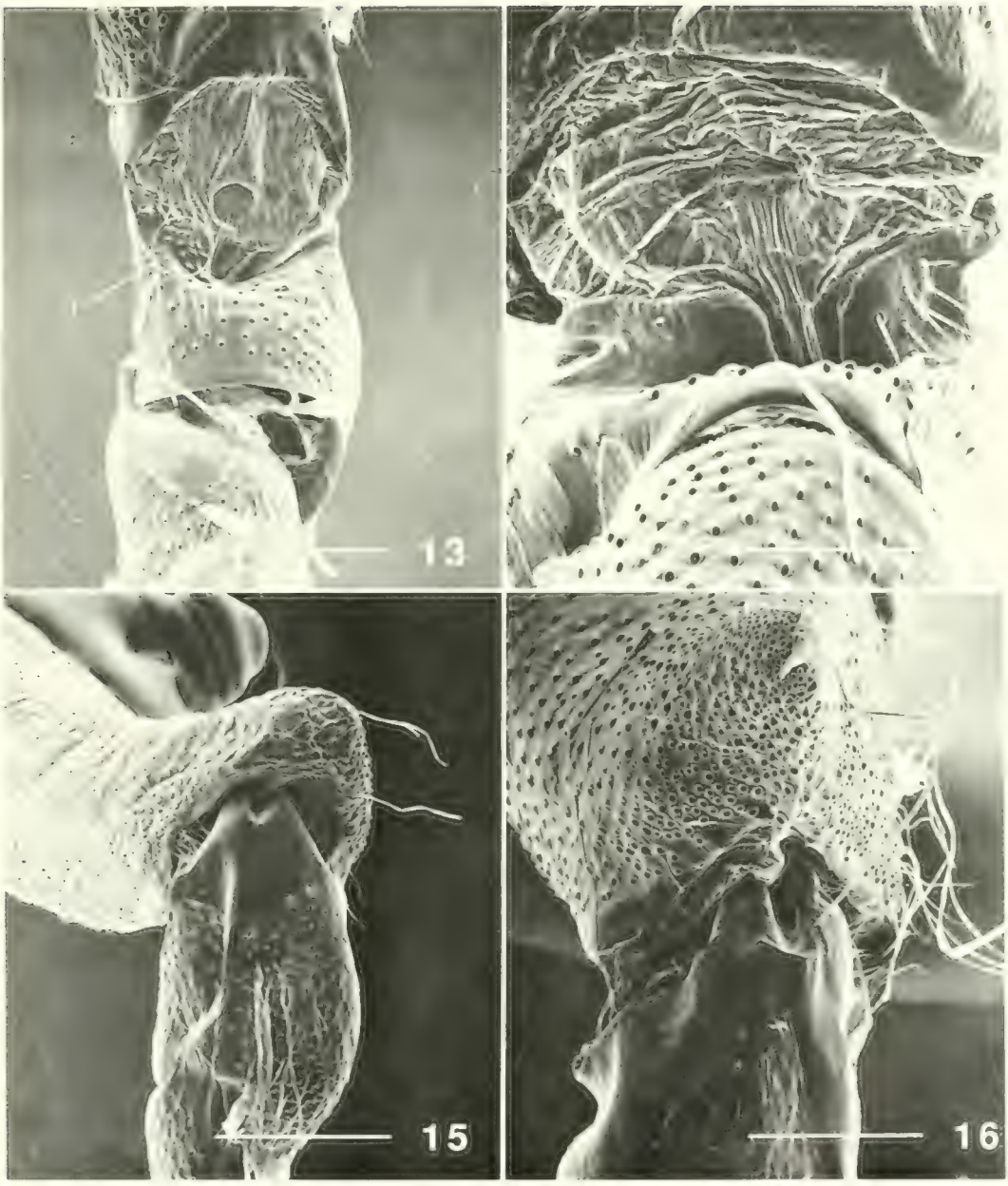
Figs. 1–4. Foreleg coxa, trochanter, and basal femur in lateral inside aspect. Coxa horizontal on top. Letters refer to structures in text. 1, *Eurema* male (Pieridae) (scale line 176 microns). 2, *Celastrina* female (Lycaenidae) (scale line 176 microns). 3, *Styx* female (Riodinidae) (scale line 176 microns). 4, *Libythea* female (Libytheidae) (scale line 150 microns).



Figs. 5–8. Foreleg coxa, trochanter, and basal femur in lateral outside aspect. Coxa horizontal on top. Letters refer to structures in text. 5, *Hesperia* female (Hesperiidae) (scale line 300 microns). 6, *Arawacus* male (Lycaenidae) (scale line 136 microns). 7, *Stalachtis* female (Riodinidae) (scale line 200 microns). 8, *Prepona* female (Nymphalidae) (scale line 380 microns).



Figs. 9–12. Foreleg trochanter in posterior aspect. Outside of leg to left except in *Danaus*. Letters refer to structures in text. 9, *Eurema* male (scale line 100 microns). 10, *Styx* female (scale line 150 microns). 11, *Libythea* female (scale line 150 microns). 12, *Danaus* female (Nymphalidae) (scale line 150 microns).



Figs. 13–16. Foreleg trochanter in anterior and posterior aspects. Letter refers to structure in text. 13, *Strymon* male (Lycaenidae) (scale line 136 microns), anterior aspect, outside of leg to right, coxa on top. 14, *Marpesia* female (Nymphalidae) (scale line 67 microns), anterior aspect, outside of leg to left, coxa on top. 15, *Poritia* male (Lycaenidae) (scale line 200 microns), posterior aspect, outside to right. 16, *Curetis* female (Lycaenidae) (scale line 150 microns), posterior aspect, outside to right.

Pieridae: Eurema, Phoebis, Archonias Hübner, *Pieris.*

Lycaenidae (Theclinae, Polyommatinae, Lycaeninae): Eumaeus Hübner, *Calycopis, Evenus, Axiocerses, Everes, Celastrina,* Lycaena.**

Riodinidae (Styginae, Hamearinae, Euselasiinae, Riodininae): Styx Staudinger, *Laxita* Butler, *Hamearis* Hübner, *Hades* Westwood, *Stalachtis* Hübner, *Ancyluris* Hübner, *Mesosemia* Hübner, *Eurybia* Illiger.

*Libytheidae: Libythea** Fabricius.

*Nymphalidae: Dynamine** Hübner, *Prepona** Boisduval, *Doxocopa* Hübner, *Danaus* Kluk, *Marpesia** Hübner, *Chlosyne* Butler.

Type II

Morphology.—*Foreleg coxa:* This foreleg type retains structures A–K (Figs. 15–24), and its trochanter and femur do not differ from the Type I foreleg. It differs only in the shape of the coxa.

(L) The distal end of the coxa is arched dorsally, but there is a lot of quantitative variation within this character state. In some genera (*Allotinus* Felder & Felder, *Liphyra* Westwood, *Pentila* Westwood, *Ornipholidotos* Bethune-Baker, *Falcuna* Stempffer & Bennett), the dorsal coxa forms a "hump" (Figs. 17, 21). In others (*Feniseca* Grote, *Poritia* Moore), the hump points dorso-posteriorly in a process that extends beyond (by approximately 0.1 mm) the articulation with the trochanter (Fig. 18). And in *Curetis,* the process extends well beyond (by approximately 0.3 mm) the trochanter (Figs. 19, 20, 22). It may be possible to code this variation in character states, but it would entail a more detailed study of the genera that have the Type II foreleg.

Male distribution.—*Lycaenidae (Liptheninae, Poritiinae, Liphyrinae, Miletinae, Curetinae): Pentila, Falcuna, Poritia, Allotinus, Feniseca,* Curetis.**

Female distribution.—*Lycaenidae (Liptheninae, Poritiinae, Liphyrinae, Miletinae, Curetinae): Ornipholidotos, Falcuna, Poritia, Liphyra, Allotinus, Feniseca,* Curetis.*

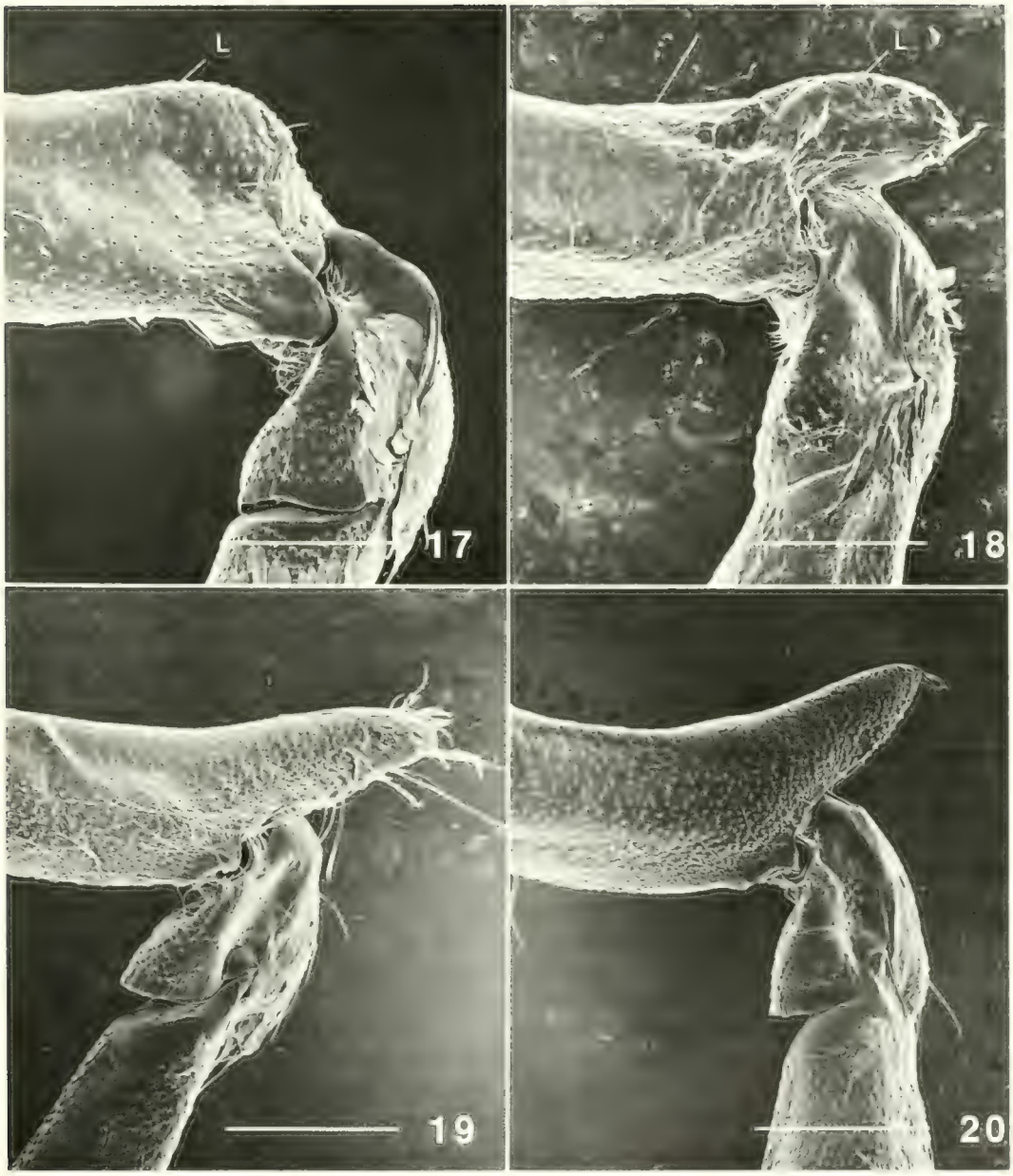
Type III

Morphology.—*Foreleg coxa and trochanter:* This foreleg type retains structures A–I and K (Figs. 25–39), and its femur does not differ from the Type II foreleg. It differs in the structure of the coxa and trochanter, and in that it is restricted to male forelegs.

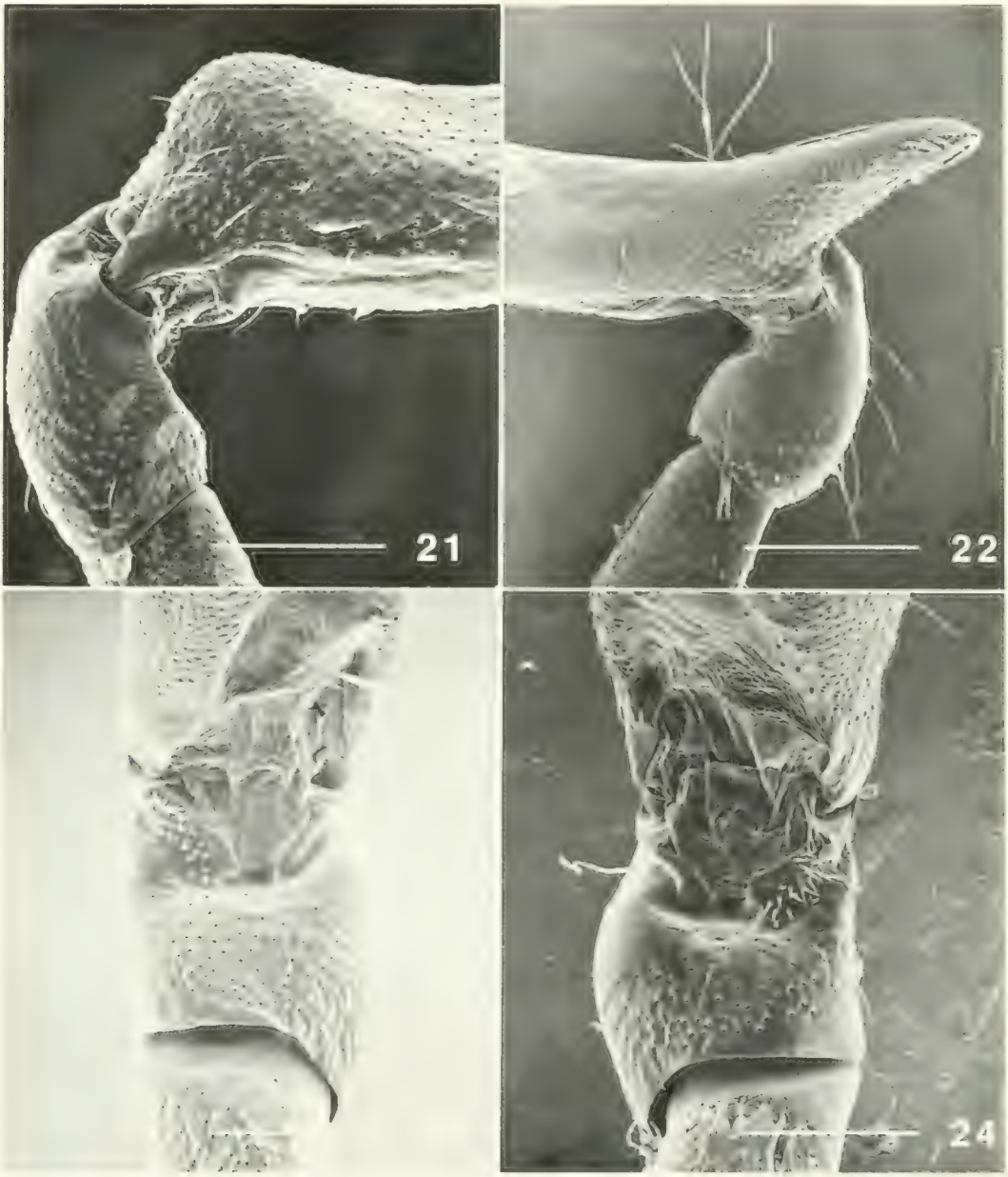
(M) The dorsal, distal end of the foreleg coxa extends beyond the lateral processes of the coxa (structures A and B) and beyond the articulation of the trochanter in a process that is not arched dorsally (Figs. 25–26, 29–30, 33–34, 37–38).

(N) The cluster of trichoid sensilla on the inner anterior face of Type I and II foreleg trochanters (structure J) is lacking (Figs. 25, 28–29, 32–33, 36–37). This group of sensilla is lacking in all male butterflies that do not use their forelegs for walking, including the next two types. It is retained, however, in female nymphalids (Fig. 14), which do not use their forelegs for walking.

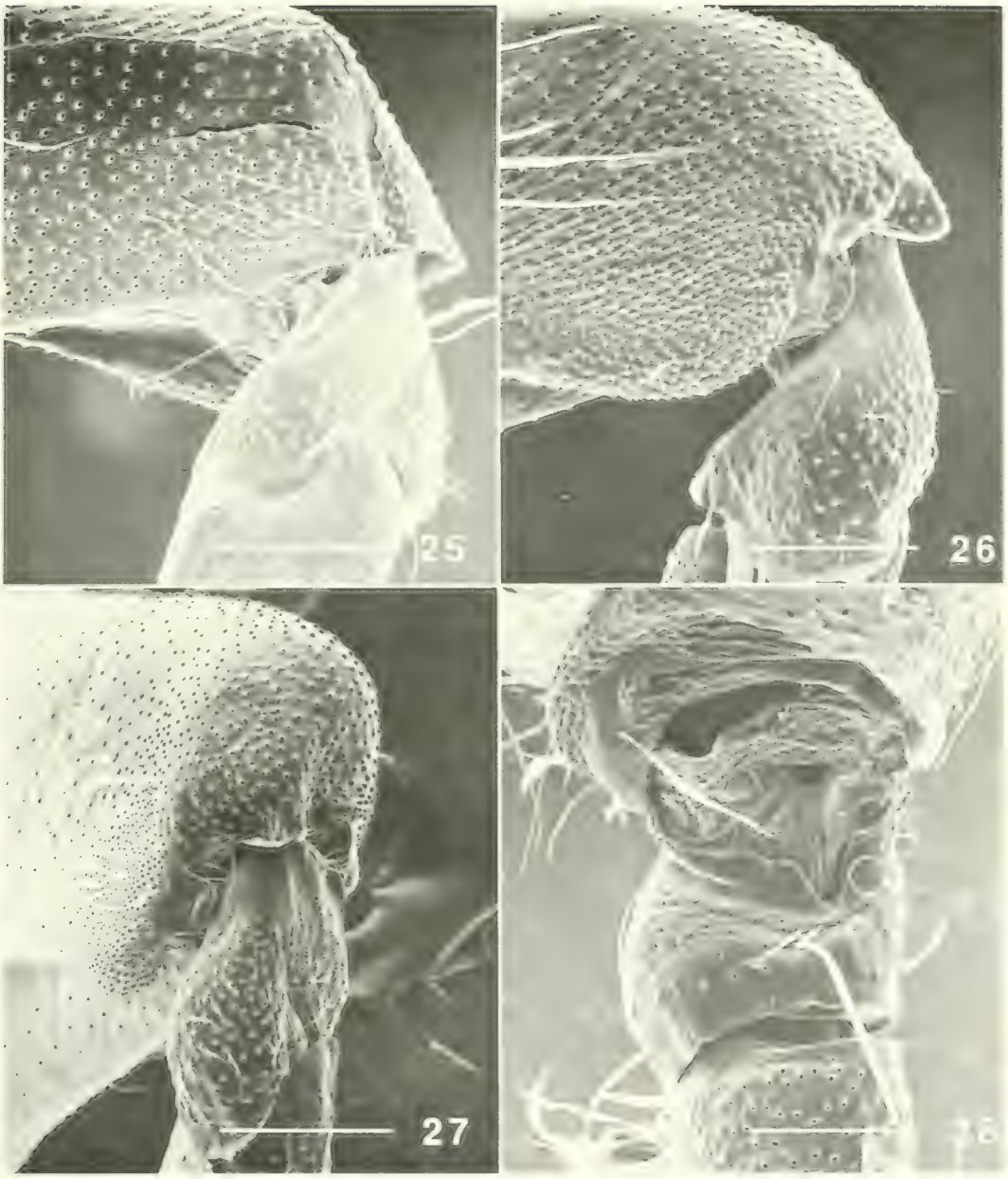
The Type III foreleg coxa shows two kinds of quantitative variation. First, the dorsal process of the coxa varies in length and shape. At one extreme, the dorsal process in *Laxita* and *Libythea* extends beyond the trochanter in a blunt process (approximately 0.10–0.15 mm) (Figs. 33–34, 37–38). At the other extreme in genera such as *Anartia* (Fig. 29), the dorsal process is rounded and barely extends beyond the trochanter (< 0.05 mm). Second, in some genera, such as *Doxocopa, Prepona,* and *Marpesia,* the coxa has a flap on the distal outside lateral side that "covers" the ventro-lateral process (Figs. 26–27). This flap is less well developed in *Dynamine* and *Memphis,* poorly developed in *Danaus,* and is apparently lacking in *Anartia, Libythea,* and *Laxita.* The trochanter is somewhat twisted in species with this flap so that the cluster of sensilla on the outside of the trochanter is more



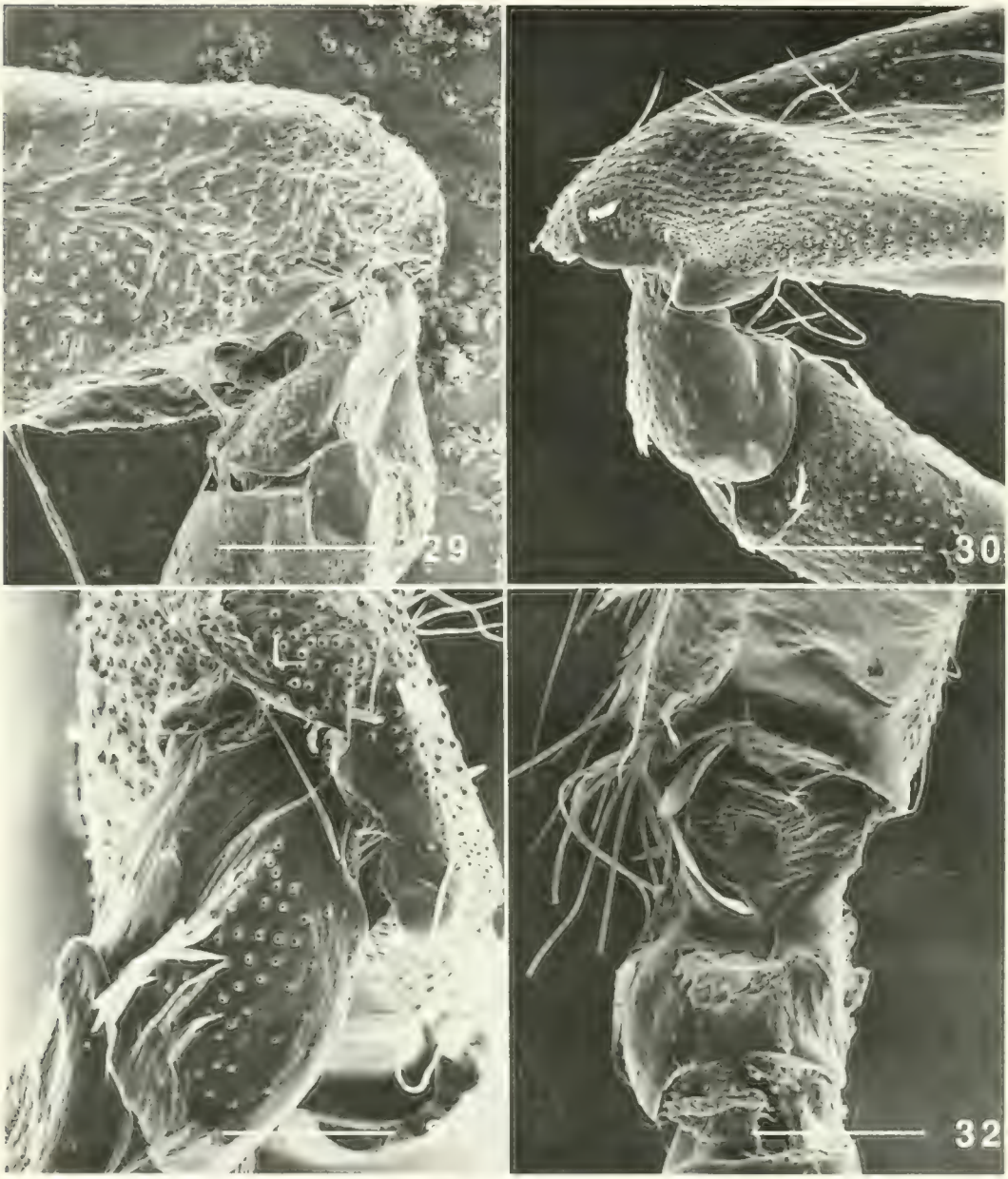
Figs. 17–20. Foreleg coxa and trochanter in inside lateral aspect. Coxa horizontal on top. Letter refers to structure in text. All Lycaenidae. 17, *Allotinus* male (scale line 200 microns). 18, *Feniseca* female (scale line 176 microns). 19, *Curetis* male (scale line 380 microns). 20, *Curetis* female (scale line 380 microns).



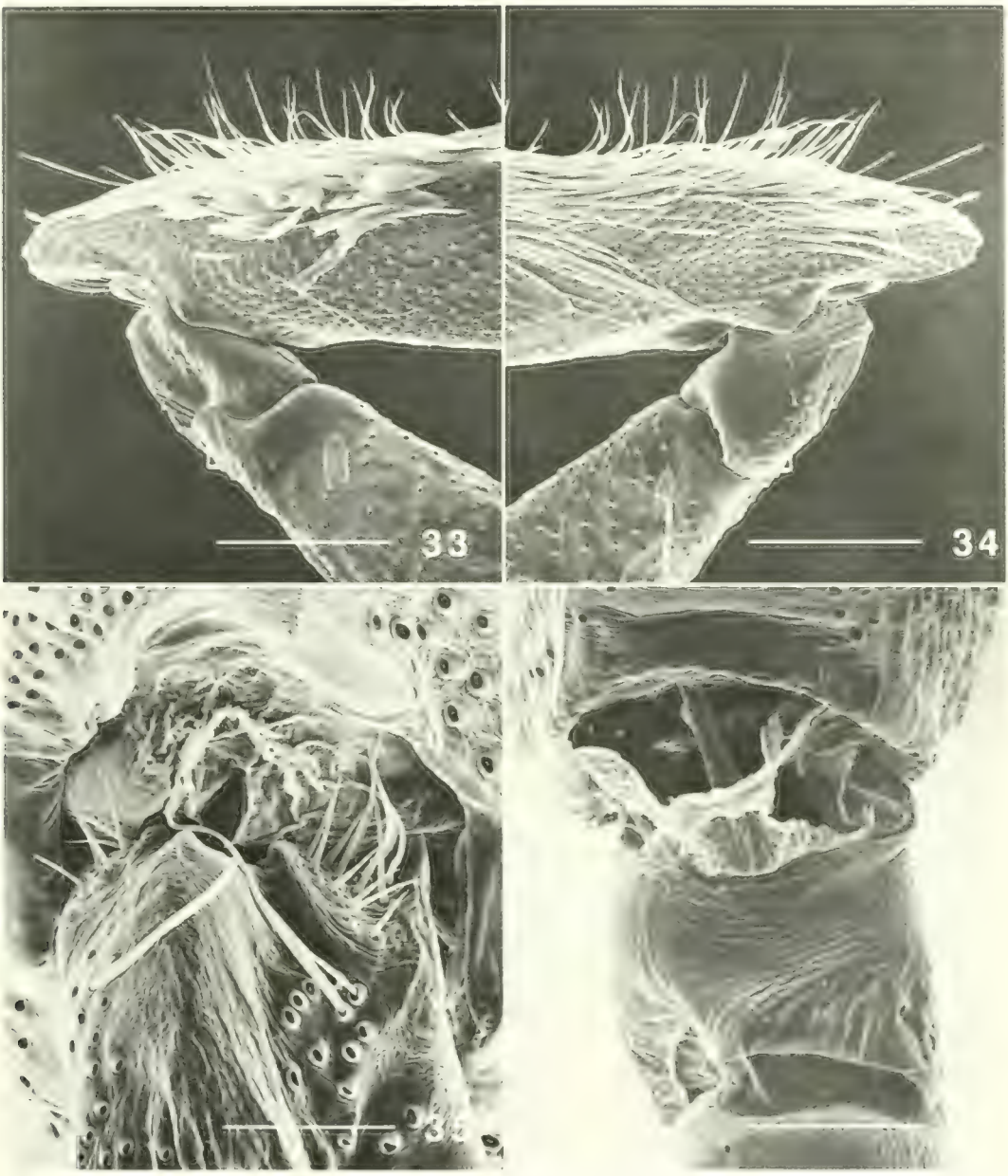
Figs. 21–24. Foreleg coxa and trochanter in outside lateral aspect and trochanter in anterior aspect. All Lycaenidae. 21, *Allotinus* male, coxa horizontal on top, (scale line 200 microns). 22, *Curetis* male, coxa horizontal on top, (scale line 380 microns). 23, *Feniseca* male, outside of leg to right (scale line 136 microns). 24, *Feniseca* female, outside of leg to left (scale line 136 microns).



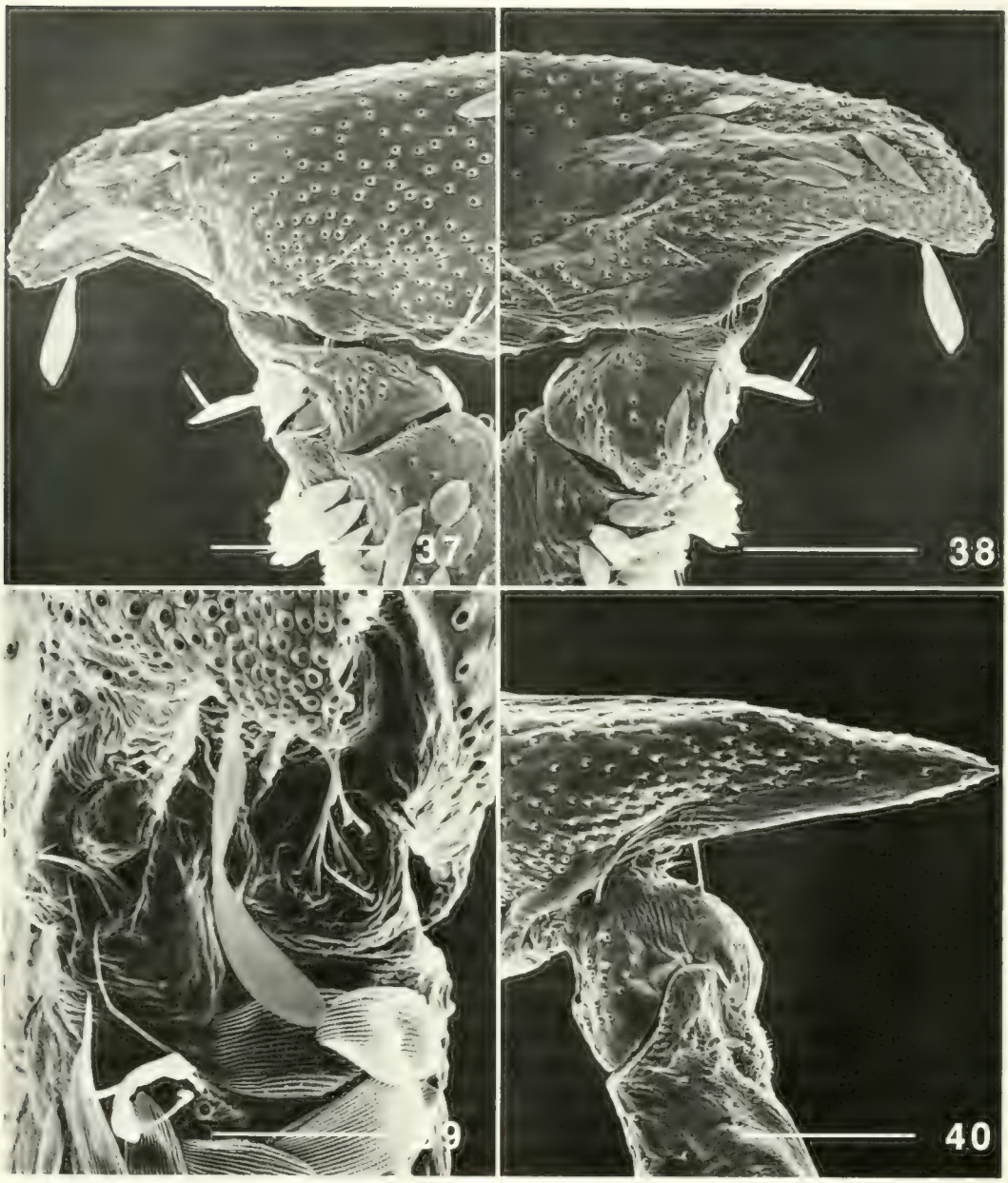
Figs. 25–28. Foreleg coxae and trochanters. Letter refers to structure in text. All Nymphalidae. 25, *Marpesia* male, inside lateral aspect with coxa horizontal on top (scale line 150 microns). 26, *Marpesia* male, outside lateral aspect with coxa horizontal on top (scale line 136 microns). 27, *Marpesia* male, posterior aspect with outside to left (scale line 150 microns). 28. *Memphis* male, anterior aspect with coxa on top and outside to left (scale line 136 microns).



Figs. 29–32. Nymphalid foreleg coxae and trochanters. 29, *Anartia* male, inside lateral aspect with coxa horizontal on top (scale line 150 microns). 30, *Dynamine* male, outside lateral aspect with coxa horizontal on top (scale line 150 microns). 31, *Dynamine* male, posterior aspect with outside to right (scale line 86 microns). 32, *Heliconius* male, anterior aspect with coxa on top and outside to right (scale line 136 microns).



Figs. 33–36. Foreleg coxa and trochanter of male *Libythea*. 33, Inside aspect of coxa and trochanter with coxa horizontal on top (scale line 176 microns). 34, Outside aspect of coxa and trochanter with coxa horizontal on top (scale line 176 microns). 35, Posterior aspect of trochanter (scale line 50 microns). 36, Anterior aspect of trochanter (scale line 60 microns).



Figs. 37–40. Foreleg coxa and trochanter and trochanter in posterior aspect (Riodinidae). 37, *Laxita* male, inside aspect with coxa horizontal on top (scale line 120 microns). 38, *Laxita* male, outside aspect with coxa horizontal on top (scale line 120 microns). 39, *Laxita* male, posterior aspect with outside to left (scale line 43 microns). 40, *Hamearis* male, inside lateral aspect (scale line 120 microns).

ventral than the cluster on the inside (Figs. 27, 31). A more extensive survey of Type III forecoxae might reveal phylogenetically useful qualitative variation within the Nymphalidae or between the Nymphalidae and Libytheidae + Riodinidae (Hamearinae-*Laxita*).

The second source of quantitative variation is the development of the dorsal prongs on the posterior trochanter (structure D). They are reduced to bumps in most genera, and in *Libythea* (Fig. 35), there is a third small bump between the two reduced prongs.

Male distribution.—*Riodinidae (Hamearinae in part): Laxita.*

Libytheidae: *Libythea.**

Nymphalidae: Hypanartia Hübner, *Anartia* Hübner, *Heliconius** Kluk, *Pagyris** Boisduval, *Danaus, Marpesia, Dynamine**, *Callicore* Hübner, *Taygetis* Hübner, *Doxocopa, Prepona, Anaea* Hübner, *Memphis** Hübner.

Type IV

Morphology.—*Foreleg trochanter:* The coxa and femur do not differ qualitatively from the Type III foreleg (Figs. 40–48), but the trochanter does.

(O) The cluster of trichoid sensilla on the inside dorso-lateral posterior trochanter (structure H) is absent (Figs. 40–43, 47) while the Type III leg retains this cluster. Thus, the Type IV male foreleg trochanter is missing both clusters of trichoid sensilla on the inside, but retains the cluster on the outside (Figs. 40, 44, 46, 47).

All the Type IV forelegs that I examined under the SEM lacked the cluster of trichoid sensilla except for male *Ancyluris* and *Hamearis,* which had one sensillum (Figs. 40, 43). In the *Ancyluris* specimen, however, the other leg had no sensilla. I do not know if the presence of a single sensillum is a vestigial condition or if the sensillum is different from those in previous leg types clustered on that part of the trochanter. In either case, there is no cluster of trichoid sensilla.

The extension of the coxa beyond its articulation with the trochanter is highly variable in the Type IV foreleg. The amount that the coxa extends beyond the trochanter varies in the species that I examined from 0.23 mm in *Hamearis* and 0.28 mm in *Stalachtis* to about 0.80 mm in *Thisbe* Hübner. In *Thisbe,* the distal part of the coxa is longer than the basal part, but the opposite is true in *Stalachtis* and *Hamearis.* The male foreleg coxa of *Curetis* (Type II) extends beyond the trochanter more (approximately 0.30 mm) than in *Stalachtis* and *Hamearis,* but it is arched upwards whereas it is bluntly tapered in the riodinids.

The trochanter of the Type IV foreleg is sometimes shaped like a cylinder (Figs. 41–42), with the dorsal prongs completely reduced. In some genera, however, the trochanter is shaped much like that in Type III forelegs.

Male distribution.—*Riodinidae (Euselasiinae, Riodininae, Hamearinae in part): Hades, Emesis** Fabricius, *Thisbe, Stalachtis, Ancyluris, Mesosemia, Hamearis.*

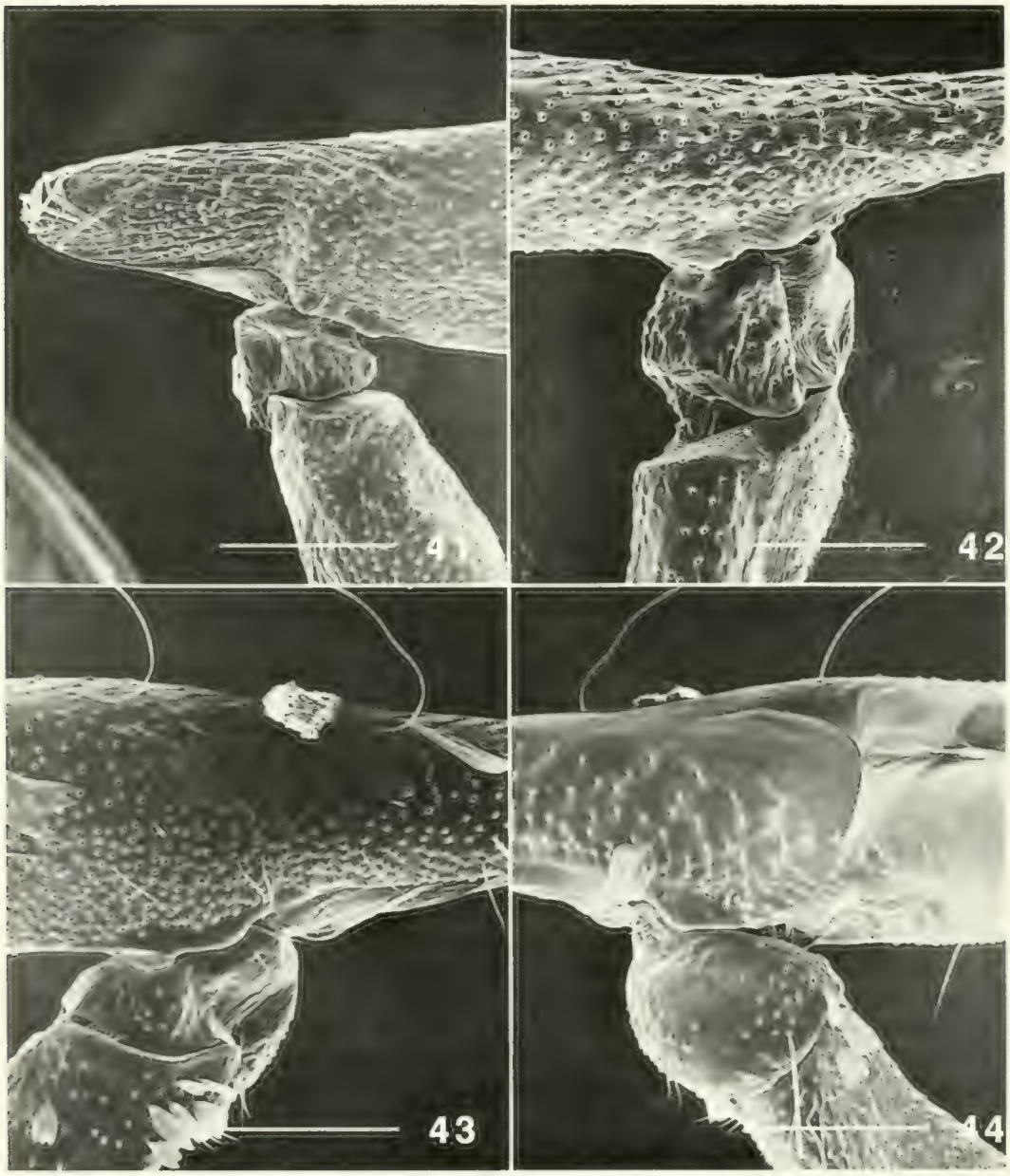
Type V

Morphology.—*Foreleg trochanter:* The foreleg trochanter again differs in the absence of a cluster of trichoid sensilla. Otherwise, the Type V foreleg retains the characters of the Type IV foreleg (Figs. 49–52).

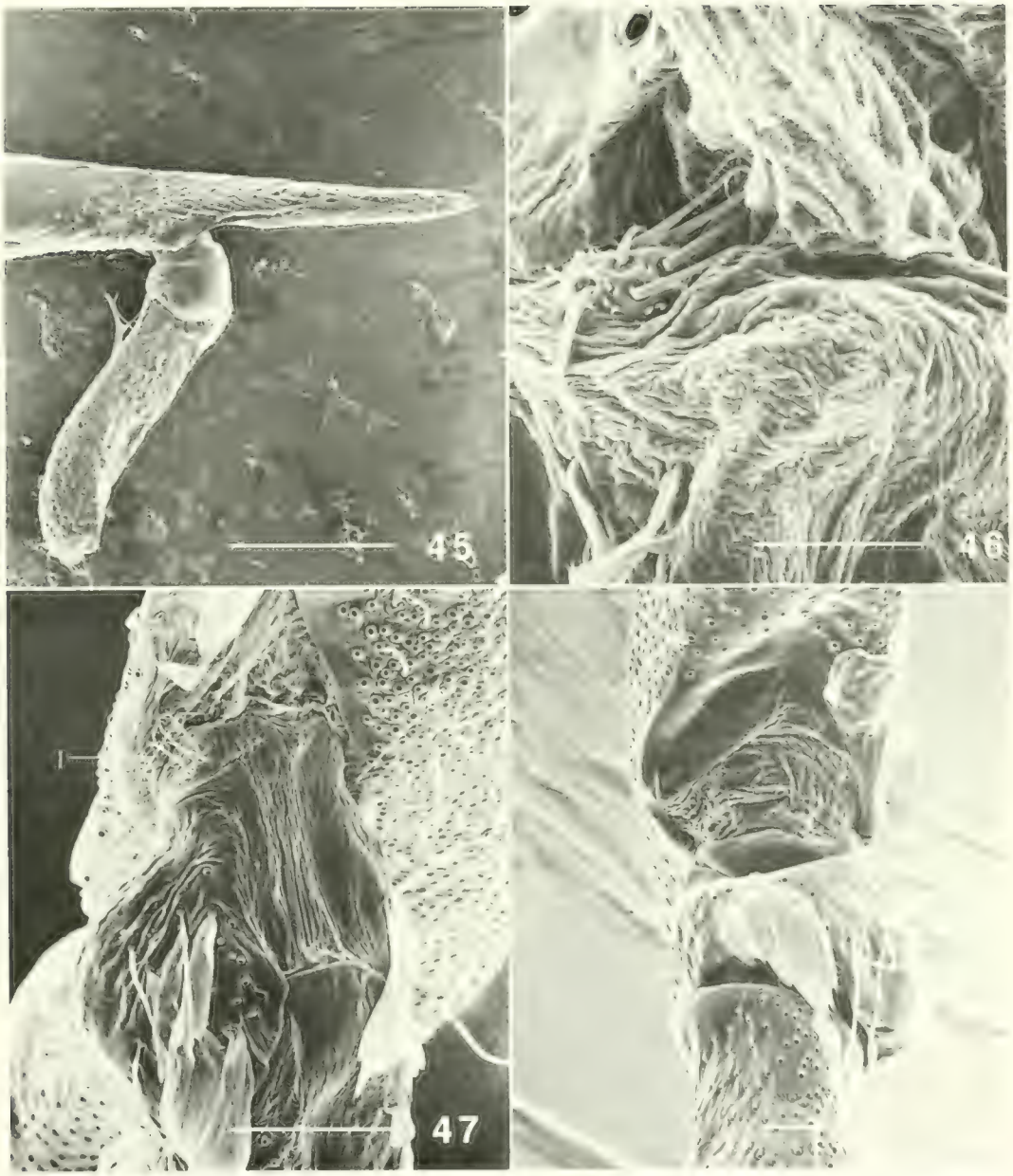
(P) The trochanter lacks the cluster of trichoid sensilla on the outside dorso-lateral posterior surface (structure I) (Fig. 50).

I have examined with the SEM two male forelegs from one male specimen of *Styx.* Both forelegs have one trichoid sensillum on the trochanter in the general area where the outside posterior cluster of the trochanter occurs in other butterflies. It is unclear whether this single sensillum is a remnant of the cluster or a different kind of sensillum. In either case, the lack of a cluster is unique among the butterflies.

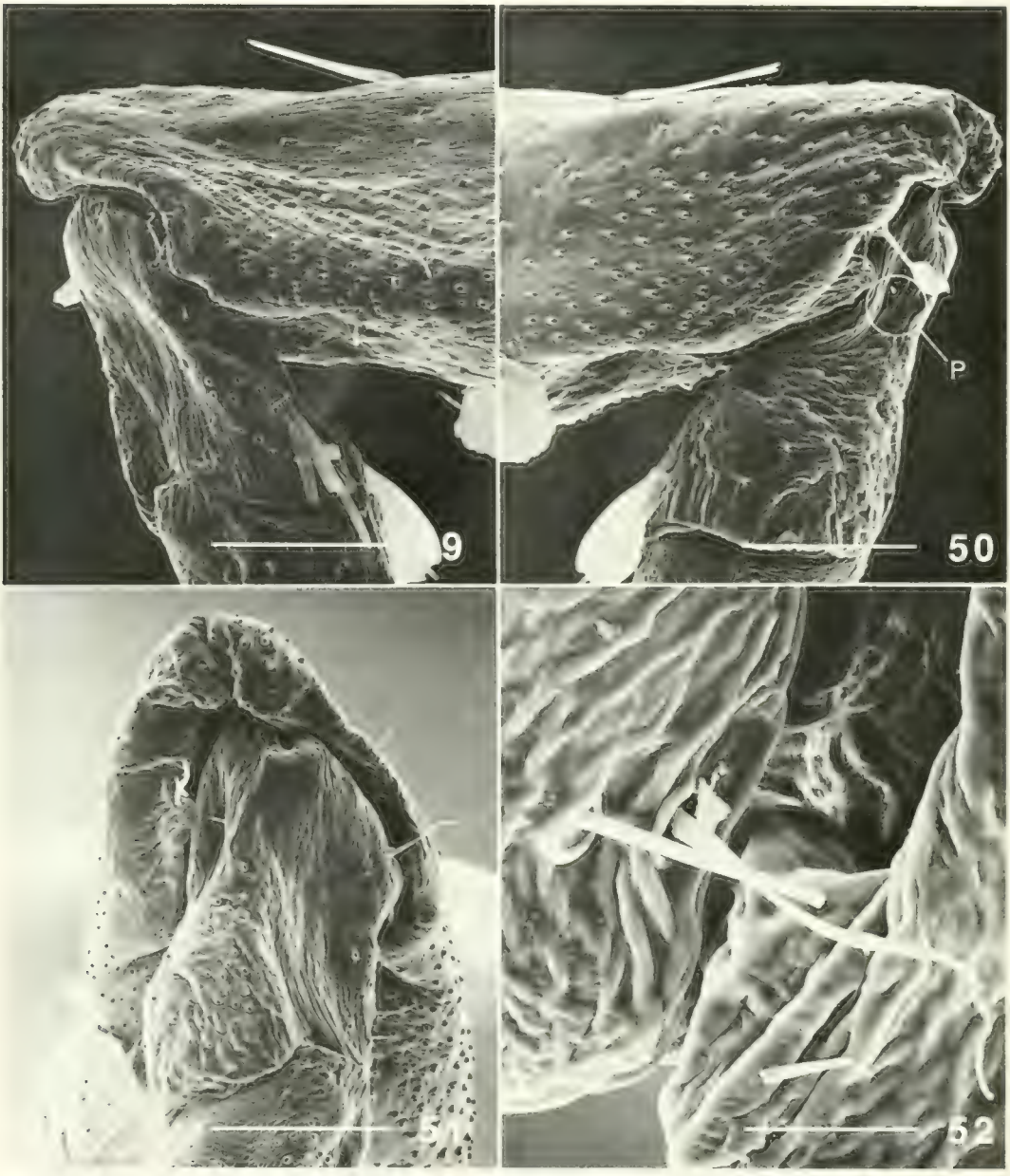
The inside dorsal cluster of the trochanter, which is absent or reduced to one sen-



Figs. 41–44. Lateral aspect of foreleg coxae and trochanters (Rhodinidae). 41, *Stalachtis* male, inside aspect with coxa horizontal on top (scale line 200 microns). 42, *Emesis* male, inside aspect with coxa horizontal on top (scale line 120 microns). 43, *Ancyluris* male, inside aspect with coxa on top (scale line 176 microns). 44, *Ancyluris* male, outside aspect with coxa on top (scale line 176 microns).



Figs. 45–48. Foreleg coxae and trochanters (Riodinidae). Letters refer to structures in text. 45, *Emesis* male, outside lateral aspect with coxa horizontal on top (scale line 300 microns). 46, *Stalachtis* male, posterior aspect of dorsal trocanter showing cluster of trichoid sensilla on outside surface (scale line 30 microns). 47, *Hades* male, posterior aspect of trochanter, outside to left (scale line 100 microns). 48, *Ancyluris* male, anterior aspect with coxa on top, outside to right (scale line 136 microns).



Figs. 49–52. Foreleg coxae and trochanters of *Styx* (Riodinidae). Letter refers to structure in text. 49, Inside lateral aspect with coxa horizontal on top (scale line 120 microns). 50, Outside lateral aspect with coxa horizontal on top (scale line 120 microns). 51, Posterior aspect of trochanter, outside to left (scale line 120 microns). 52, Enlargement of two setae on dorsal outside face of trochanter in Fig. 49 (scale line 15 microns).

sillum in the Type IV foreleg, is similarly reduced in *Styx*. One foreleg has a single trichoid sensillum while the other has two (Figs. 49, 52), but the sensilla are aberrant. On both legs, the sensillum socket is considerably larger than the "stalk" of the sensillum (Fig. 52). The space between the socket walls appears to be solid, and it is unclear whether the stalk goes through the integument. It appears to be a different kind of trichoid sensillum than those with foreleg Types I, II, and III, or it is possible that it is a vestigial structure.

The coxa has a dorsal posterior process that barely extends beyond the articulation of the trochanter (approximately 0.03 mm). In this regard, it is more similar to the Type III than the Type IV foreleg.

Male distribution.—*Riodinidae (Styginae): Styx*.*

Character Matrix

I summarize the information above in a character matrix (Table 1), and derive a most parsimonious cladogram from it (Fig. 53). I use the Hesperiidae as the outgroup for the Papilionoidea (Kristensen 1976, Scott 1985), and put an asterisk (*) next to the primitive character state for the papilionoids.

1. Foreleg coxa (A) in both sexes the dorsal surface is arched upwards at the distal end, may extend beyond the articulation with the trochanter, (B)* in both sexes the coxa tapers distally, but is not arched upwards nor does it extend beyond its articulation with the trochanter, (C) females as in the previous state, but in males the coxa tapers distally in a blunt process that is not arched upwards, but that extends beyond the articulation with the trochanter.

2. In males, the trochanter (A)* has a cluster (≥ 5) of trichoid sensilla on the anterior, inner lateral surface, (B) lacks this cluster of trichoid sensilla.

3. In males, the trochanter (A)* has a cluster of trichoid sensilla on the dorso-posterior inner lateral surface, (B) lacks this cluster of trichoid sensilla.

4. In males, the trochanter (A)* has a cluster of trichoid sensilla on the dorso-posterior outer lateral surface, (B) lacks this cluster of trichoid sensilla.

Of the three possible orders in which the three states of character 1 could have evolved, I chose transformation A-B-C. I provisionally rejected transformation B-A-C because it would require the female coxa to evolve a dorsal arch and then lose it. I provisionally rejected transformation B-C-A because it would require the evolution of sexual dimorphism in the coxa and then its loss. Other characters that provide evidence on the systematic placement of Lycaenidae #2 may also provide a test of my transformation hypothesis.

Table 1. Matrix of foreleg coxa and trochanter characters. Foreleg types and character states are given in the text. Lycaenidae #1: subfamilies Lycaeninae, Theclinae, and Polyommatinae, *sensu* Eliot (1973). Lycaenidae #2: Lipteninae, Poritinae, Liphyrinae, Miletinae, and Curetinae. Riodinidae #1: Hamearinae (*Laxita*), *sensu* Harvey (1987). Riodinidae #2: Hamearinae (*Hamearis*), Euselasiinae, and Riodininae. Riodinidae #3: Styginae.

	Character			
Taxon	1	2	3	4
Type I male and female forelegs				
Hesperiidae	B	A	A	A
Papilionidae	B	A	A	A
Pieridae	B	A	A	A
Lycaenidae #1	B	A	A	A
Type II male and female forelegs				
Lycaenidae #2	A	A	A	A
Type I female and type III male forelegs				
Libytheidae	C	B	A	A
Nymphalidae	C	B	A	A
Riodinidae #1	C	B	A	A
Type I female and type IV male forelegs				
Riodinidae #2	C	B	B	A
Type I female and type V male forelegs				
Riodinidae #3	C	B	B	B

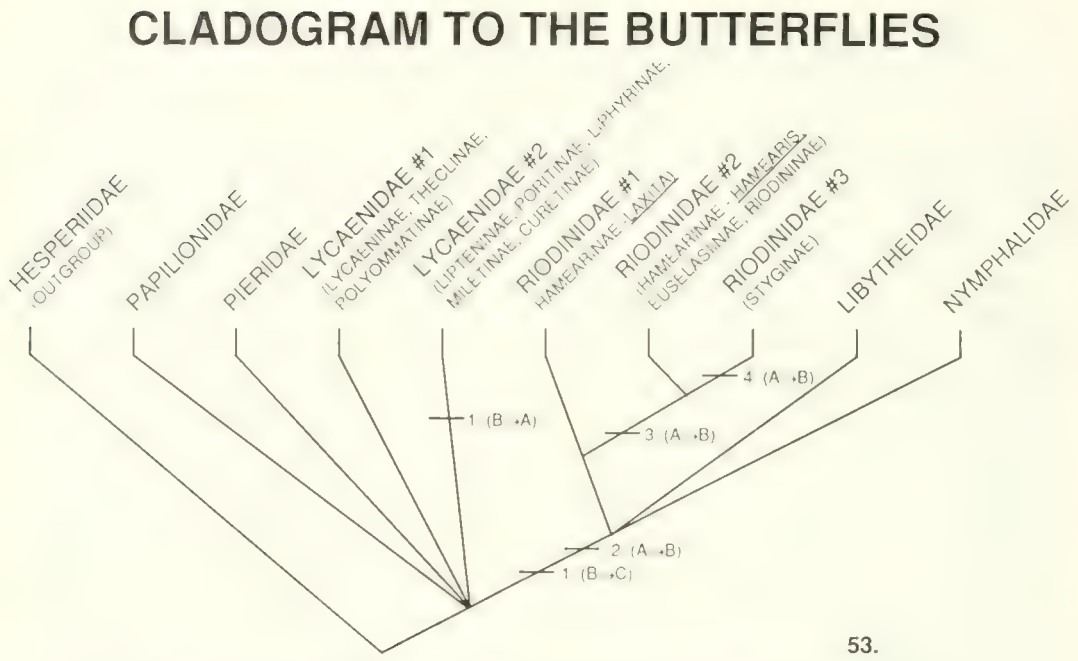


Fig. 53. Cladogram to the butterfly families based on distribution of character states of the foreleg coxa and trochanter (Table 1). The numbers refer to characters and the letters to changes in character state.

Discussion

Foreleg coxa and trochanter character states are qualitatively invariant within previously recognized butterfly families except for the Lycaenidae and Riodinidae, which is significant in two respects. First, the Lycaenidae + Riodinidae are sometimes lumped in a presumably homogeneous and monophyletic taxon (e.g. Kristensen 1976), perhaps because they are rich in species whose morphology is poorly known. The results in this paper and others (Robbins 1987, 1988) indicate that for leg characters, at least, there is a great deal of morphological variation among the Lycaenidae and Riodinidae. Second, the lack of variation within the Hesperiidae, Papilionidae, Pieridae, Libytheidae, and Nymphalidae in the structure of foreleg coxae and trochanters lends credence to their stability as evolutionary characters (Kluge and Farris 1969).

The distribution of foreleg coxae and trochanters—summarized in the character matrix (Table 1)—provides evidence for four presumably monophyletic taxa among the butterflies (Fig. 53). The first taxon is the riodinid subfamily Styginae, which has uniquely evolved state B of character 4 (Fig. 53). I have not yet had the opportunity to examine the legs of the monotypic riodinid genera *Petrocerus* Callaghan and *Corrachia,* but their forecoxae are apparently similar to that of *Styx* (Callaghan 1979, Harvey 1987) in that they do not extend well beyond the articulation with the trochanter.

The second monophyletic taxon is a combination of the riodinid subfamilies Euselasiinae, Riodininae, Styginae, and the genus *Hamearis* of the Hamearinae (Fig. 53). It is characterized by the evolution of state B of character 3. This result has not been proposed previously, and suggests that the New World Riodinidae plus *Hamearis* may be a monophyletic group. The male foreleg

coxa and trochanter of the Old World riodinid *Laxita* (Hamearinae) does not differ qualitatively from those of Libytheidae or Nymphalidae. Harvey (1987) considered the Hamearinae to be monophyletic because they share a posterior pointing beaked uncus in the male genitalia. My results conflict with this classification, but clearly they are preliminary since I have examined only two genera in the Hamearinae.

The third monophyletic taxon is a combination of the lycaenid subfamilies Lipten· inae, Poritinae, Liphyrinae, Miletinae, and Curetinae (Fig. 53). It is characterized by the evolution of state A in males and females (character 1). Again, this combination of subfamilies has not been previously recognized as monophyletic, and is inconsistent with Scott's (1985) phylogeny of the lycaenid subfamilies. If the transformation of character 1 is B-A-C, however, then this group could be paraphyletic. It consists of hundreds of species restricted to the Old World except for a single Nearctic species, *Feniseca tarquinius* Fabricius.

The last monophyletic group is Riodinidae + Libytheidae + Nymphalidae, characterized by the evolution of state C of character 1 and state B of character 2 (Fig. 53). I have gotten the same phylogenetic result using other leg characters (Robbins 1987). Since all other published phylogenies (Ehrlich 1958, Kristensen 1976, Scott 1985) consider the Lycaenidae + Riodinidae to be a monophyletic group—in contradiction to my results—either there has been a great deal of convergence among leg characters or the previous phylogenies have been based on poorly analyzed characters whose distributions are also poorly known.

The results in this paper partly confirm and partly contradict the morphological results of Ehrlich (1958b). They contradict Ehrlich's report that the male foreleg coxa of *Styx* does not extend beyond the trochanter, but its extension is smaller than in most other riodinids, which is probably what Ehrlich observed. Further, similar short extensions apparently occur in some other riodinids, specifically *Corrachia* (Harvey 1987) and *Petrocerus* (Callaghan 1979). Ehrlich's finding that the foreleg coxa extends slightly below the articulation with the trochanter in male *Curetis* (Lycaenidae) is correct, but incomplete. He did not note that the forecoxa also extends beyond the articulation with the trochanter in male Nymphalidae, Libytheidae, and *Styx* as well as both sexes in some lycaenids with a Type II forecoxa (*Curetis, Feniseca, Poritia*).

My results are inconsistent with Scott's (1985) phylogenetic hypothesis that *Curetis* and Riodinidae (his Riodininae) form a monophyletic group. He supported this hypothesis in part by noting that the male forecoxa of these two groups extends beyond the articulation with the trochanter. However, this "character state" occurs in many other butterflies, as I have noted. Further, the forecoxa of *Curetis* is qualitatively distinct from that in riodinids. It is arched dorsally, extends beyond the articulation with the trochanter in both sexes, and its trochanter retains a cluster of sensilla on its inside anterior face. The forecoxa of riodinids is not arched dorsally, extends beyond the trochanter only in males, and its trochanter does not retain the cluster of sensilla on its inside anterior face. Thus, the similarity in shape of the forecoxae of riodinids and *Curetis* is superficial, and Scott's hypothesis would appear to be incorrect.

Acknowledgments

I thank Don Harvey for numerous discussions and exchange of pertinent information. I thank John Eliot, Don Harvey, Gerardo Lamas, James Scott, and an anonymous reviewer for critically reading and commenting on the paper. I thank Brian Kahn and Susann Braden for working with me on the SEM. I thank Gerardo Lamas for loaning me a male specimen of *Styx infernalis*. I thank Phil Ackery and Dick Vane-

Wright for loaning me Ehrlich's dissection of a male *S. infernalis*.

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AEDES (*STEGOMYIA*) *JOSIAHAE*, A NEW SPECIES OF THE *SIMPSONI* SUBGROUP (DIPTERA: CULICIDAE)[1]

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Abstract.—The adult male and female of ***Aedes* (*Stegomyia*) *josiahae*** n. sp. from Tanzania are described and illustrated. Diagnostic characters for distinguishing *Ae. josiahae* from closely allied species are given. The distribution of *Ae. josiahae* is based on examined specimens. *Aedes josiahae* is most closely related to *Ae. kivuensis* Edwards. These two species together with *Ae. bromeliae* (Theobald), *Ae. lilii* (Theobald), *Ae. simpsoni* (Theobald), *Ae. strelitziae* Muspratt, *Ae. subargenteus* Edwards, and *Ae. woodi* Edwards form the *simpsonia* subgroup within the *aegypti* group.

Key Words: Culicidae, mosquitoes, *Aedes*, *simpsoni* subgroup

A new species of *Aedes* (*Stegomyia*), belonging to the *simpsoni* subgroup of the *aegypti* group, was discovered among specimens that were misidentified as *Aedes* (*Stegomyia*) *kivuensis* Edwards from the Division of Vector Borne Diseases (DVBD) collection in Nairobi, Kenya. In view of the medical importance of several species in the *simpsoni* subgroup and the similarity of this new species with *Ae. kivuensis* Edwards, it is desirable to describe the new species here to make its name available and to avoid future confusion between it and *Ae. kivuensis*. As nothing is known about its biting habits and potential as a vector of human pathogens, it is hoped that this paper will stimulate investigations on these subjects.

[1] This work was supported by Grant No. DAMD-17-84-G-4033 from the U.S. Army Medical Research and Development Command, Office of the Surgeon General, Fort Detrick, Frederick, MD 21701, and by the Walter Reed Biosystematic Unit, Museum Support Center, Smithsonian Institution, Washington, D.C. 20560.

MATERIALS AND METHODS

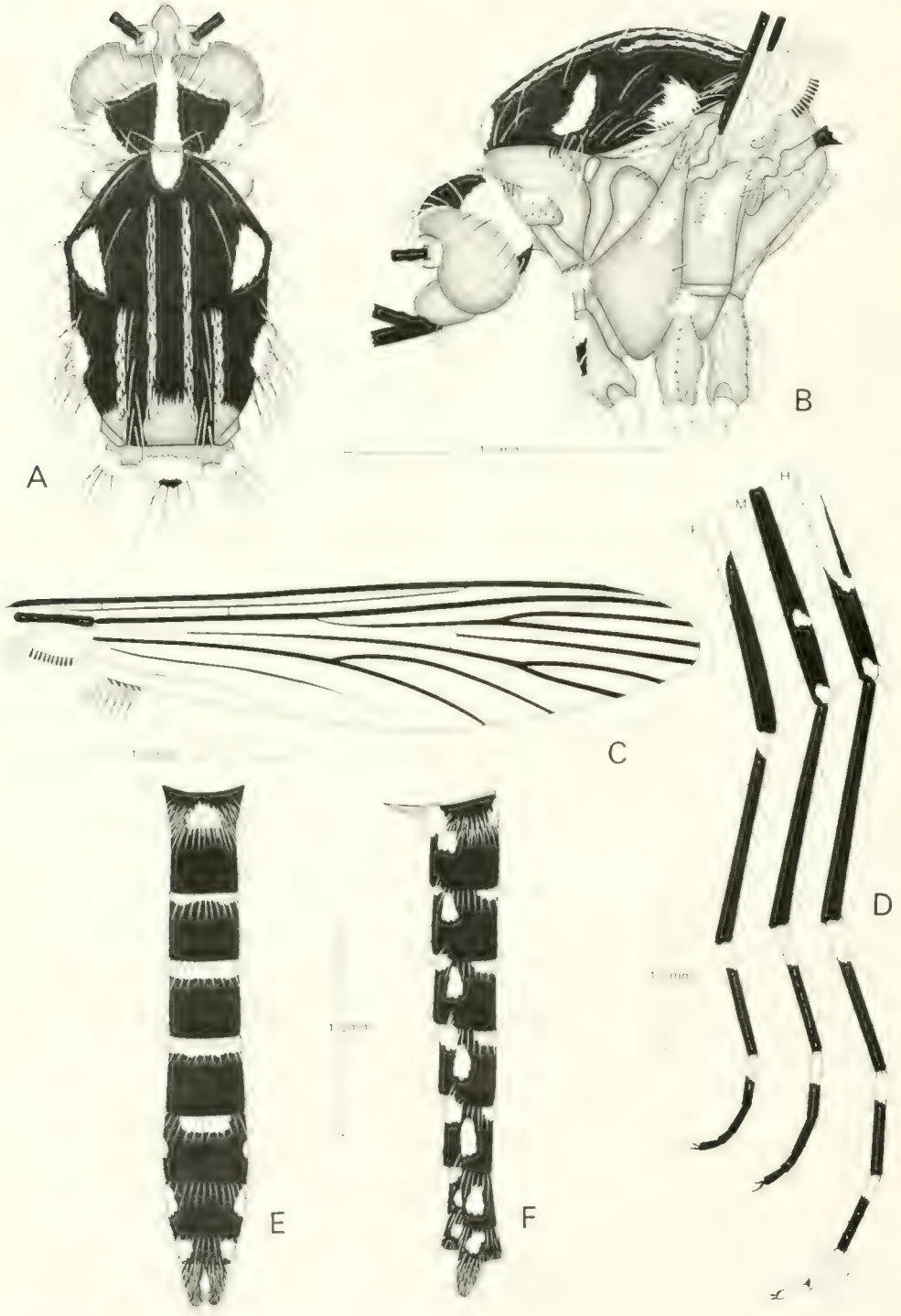
This study is based on specimens that were borrowed from the following institutions: Musee royale de l'Afrique Centrale, Tervuren, Belgium [CMT] and Division of Vector Borne Diseases, Ministry of Health, Nairobi, Kenya [DVBD]. Distributional records are listed in the following order and format: current country names are in capital letters, administrative divisions, where known, are in italics, and place names have the first letter capitalized.

The terminology follows that of Harbach and Knight (1980, 1981), with the exception of "tarsal claws," which is retained for "ungues." The venation terms follow those of Belkin (1962).

***Aedes* (*Stegomyia*) *josiahae* Huang, NEW SPECIES**

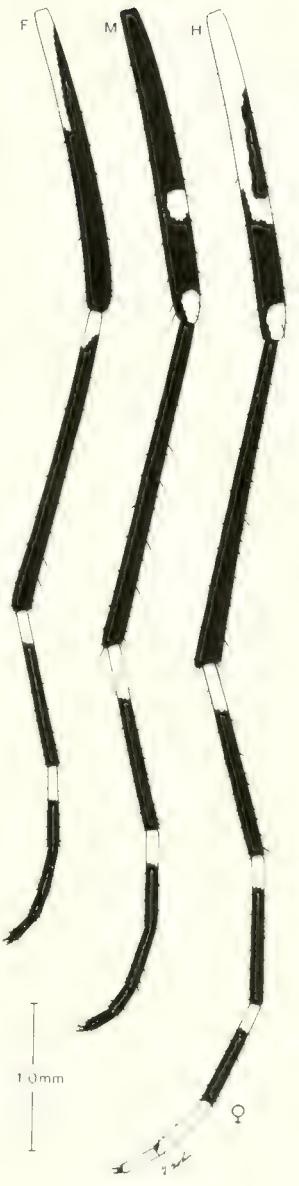
Figs. 1–4

Female.—*Head:* Proboscis bearing dark scales, lacking pale scales on ventral surface, length as long as forefemur; maxillary palpus 0.27 length of proboscis, dark, bearing



Aedes (Stegomyia) josiahae n. sp. ♂

white scales on apical 0.50 of the total length; pedicel covered with white scales except on dorsal and ventral surfaces; clypeus bare; occiput with few erect forked scales; a row of broad white scales around eye margins; vertex with a median stripe of broad white scales, with broad dark scales on each side interrupted by a lateral stripe of broad white scales, followed ventrally by a patch of broad white scales. *Thorax:* Scutum with narrow dark scales and a distinct, median white spot of narrow scales on anterior promontory, followed by a submedian longitudinal stripe of narrow yellowish scales on each side of midline, reaching to prescutellar area and connecting with prescutellar line of narrow yellowish scales; fossal area with a large patch of broader, crescent-shaped white scales; posterior dorsocentral yellowish lines present, reaching posterior 0.50 of scutum; a patch of narrow white scales on lateral margin just in front of wing root; acrostichal setae absent; dorsocentral setae present; scutellum with broad white scales on all lobes and with a few broad dark scales at apex of midlobe; antepronotum with broad white scales; postpronotum with a patch of broad white scales and a few narrow dark scales dorsally; paratergite with broad white scales; postspiracular area without scales; hypostigmal area without scales; patches of broad white scales on propleuron, subspiracular area, upper and lower portions of mesokatepisternum, and on mesepimeron; upper mesokatepisternal scale patch not reaching to anterior corner of mesokatepisternum; upper mesepimeral scale patch connected to lower mesepimeral scale patch; lower mesepimeron without setae; metameron bare. *Wing:* With dark scales on all veins and without a minute basal spot of white scales on costa; cell R_2 2.8 length of



josiahae n. sp.

Fig. 2. *Aedes* (*Stegomyia*) *josiahae* n. sp. Anterior surface of the allotype female legs.

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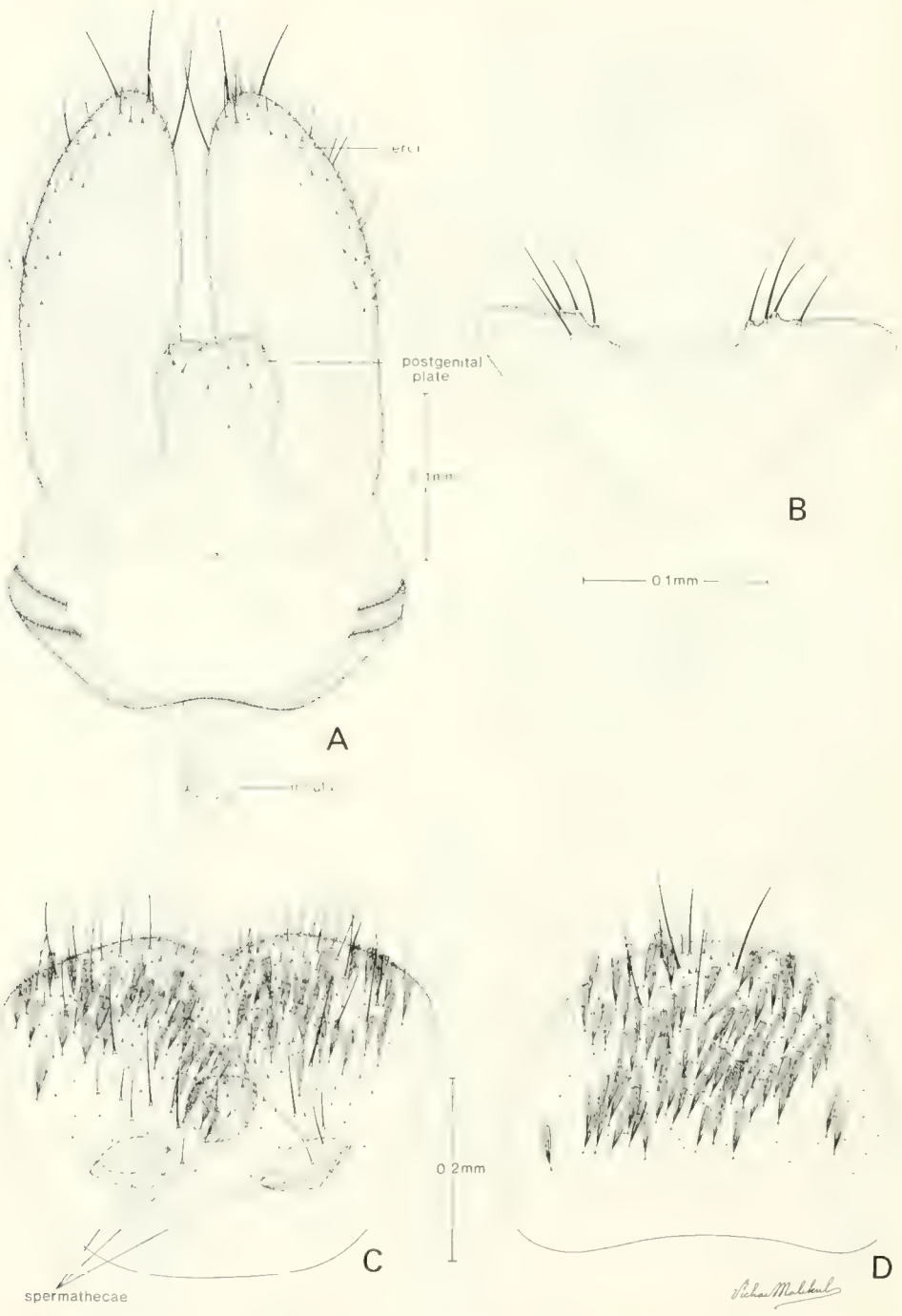
Fig. 1. *Aedes* (*Stegomyia*) *josiahae* n. sp., holotype male. A, Dorsal aspect of the thorax; B, Lateral aspect of the thorax; C, Dorsal aspect of the wing; D, Anterior surface of the legs; E, Dorsal aspect of the abdomen; F, Lateral aspect of the abdomen.



Aedes (Stegomyia) josiahae n. sp.

Fig. 3. *Aedes* (*Stegomyia*) *josiahae* n. sp. A, Sternal aspect of the female genitalia; B, Dorsal aspect of IX-tergum; C, Dorsal aspect of VIII-sternum; D, Dorsal aspect of VIII-tergum.

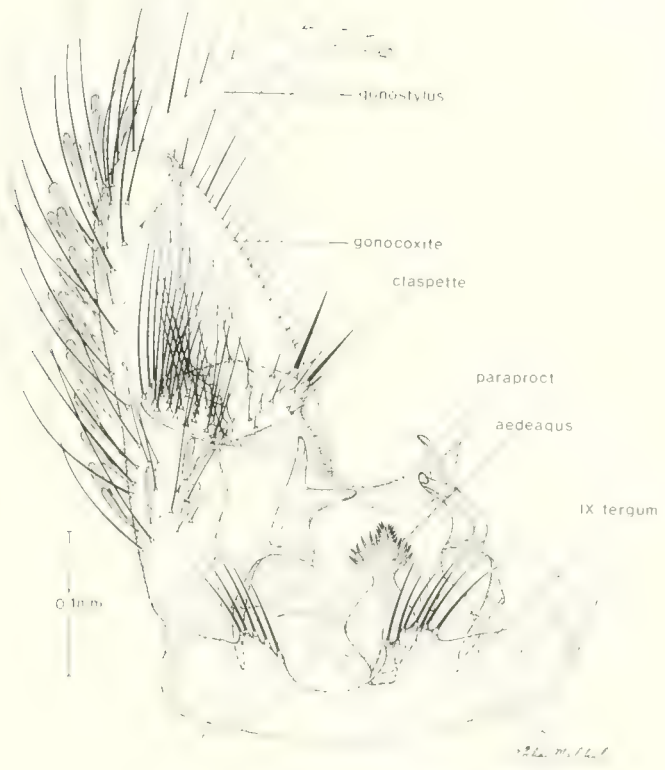
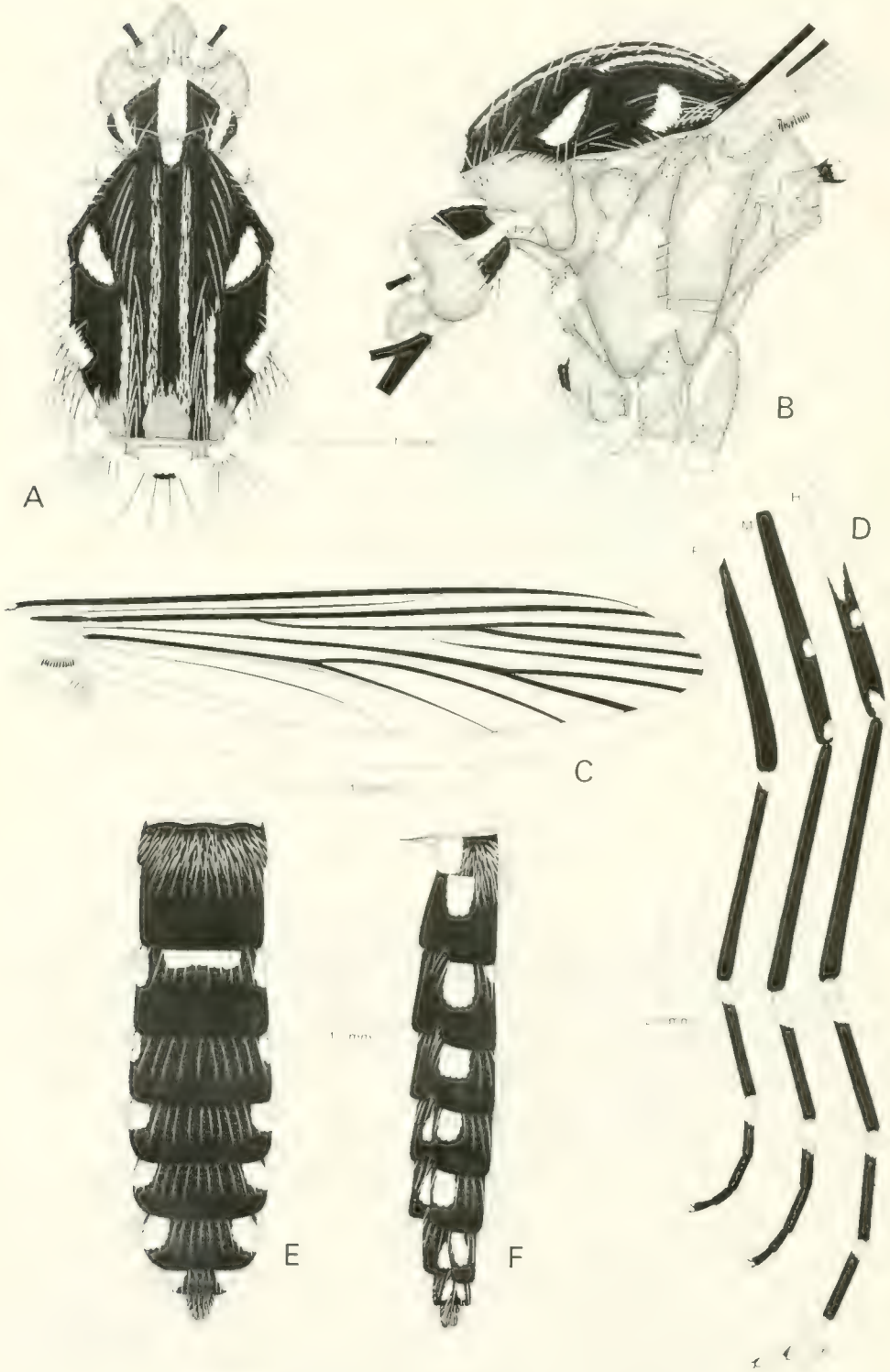


Fig. 4. *Aedes* (*Stegomyia*) *josiahae* n. sp. Tergal aspect of the male genitalia.

R_{2+3}. *Halter:* With dark and pale scales. *Legs* (Fig. 2): Coxae with patches of white scales; white knee-spot absent on forefemur, present on mid- and hindfemora; forefemur anteriorly with a narrow, white longitudinal stripe on ventral surface in basal 0.40; midfemur with a large white spot on anterior surface about 0.67 from base; hindfemur anteriorly with a broad white longitudinal stripe in basal 0.66 that widens 0.25 from base; foretibia anteriorly dark, with a basal white band; mid- and hindtibiae all dark; fore- and midtarsi with a basal white band on tarsomeres 1, 2; foretarsomere 1 with basal 0.20 white on dorsal surface; foretarsomere 2 with basal 0.40–0.50 white on dorsal surface; midtarsomere 1 with basal 0.30–0.33 white on dorsal surface; midtarsomere 2 with basal 0.40 white on dorsal surface; hindtarsus with a basal white band on tarsomeres 1–3, the ratio of length of white band on dorsal surface to the total length of tarsomere is 0.25, 0.20–0.25, and 0.25; hindtarsomere 4 all white, with a few dark scales at apex on ventral surface; hindtarsomere 5 all white, with a few dark scales at apex on ventral surface; fore- and midlegs with tarsal claws equal, all toothed; hindleg with tarsal claws equal, both simple. *Abdomen:* Tergum I with white scales on laterotergite and with a median white spot; terga II–VI each with a basal white band



Aedes (Stegomyia) kivuensis Edwards ♀

and basolateral white spots not connecting with basal white band; terga VII, VIII each with basolateral white spots only; sterna III–VII each with a basal white band; segment VIII largely retracted. *Genitalia* (Fig. 3): Apical margin of sternum VIII with a median notch and with rounded lateral lobes; insula longer than wide, with minute setae and with 9 larger setae on apical 0.25; tergum IX broader than long, apical margin of tergum IX with well developed lateral lobes, each with 4 setae; apical margin of postgenital plate with a shallow median notch; cercus short and broad; 3 spermathecae, one larger than the other 2.

Male (Fig. 1).—Essentially as in the female, differing in the following sexual characters: *Head:* Maxillary palpus 5-segmented, as long as proboscis, predominantly dark, with a white band at base of palpomeres 2–5; those on palpomeres 4, 5 dorsally incomplete; palpomeres 4, 5 subequal, slender, dorsally curved and with only a few short setae; antenna plumose, shorter than proboscis. *Wing* (Fig. 1C). Cell R_2 3.1 length of R_{2+3}. *Legs* (Fig. 1D): Midfemur with a large white spot on anterior surface 0.65–0.67 from base; hindfemur anteriorly with a broad white longitudinal stripe in basal 0.60–0.61 that widens 0.22 from base; foretarsomere I with basal 0.20–0.25 white on dorsal surface; foretarsomere 2 with basal 0.50 white on dorsal surface; midtarsomere 1 with basal 0.33 white on dorsal surface; midtarsomere 2 with basal 0.50 white on dorsal surface; hindtarsus with a basal white band on tarsomeres 1–3, the ratio of length of white band on dorsal surface to the total length of tarsomere is 0.25–0.30, 0.25–0.33, and 0.33; fore- and midlegs with tarsal claws unequal, all simple. *Abdomen* (Fig. 1E, F): Tergum II with basolateral white spots only; sternum VIII with basolateral white spots only. *Genitalia* (Fig. 4): Gonocoxite 2.2–2.4 as long as wide (width measured 0.5 from base), scales restricted to dorsolateral, lateral and ventral surfaces, with setae on dorsomesal surface, mesal surface membranous; claspette large, broad, reaching to 0.54 of gonocoxite, distal expanded portion square in shape in dorsal aspect, with numerous simple setae on the expanded distal portion and bearing 2(1–2) stronger, basally widened spine-like setae on the apicomesal angle; gonostylus simple, elongate, about 0.66 length of gonocoxite, with a short claw process at apex and with a few setae on apical 0.25; aedeagus strongly toothed; paraproct with a sternal arm; cercal setae absent; apical margin of tergum IX deeply concave medially, with 5–7 setae on each lateral lobe; sternum IX without setae.

Pupa and larva.—Unknown.

Type data.—Holotype male (MEP Acc. 808/#157/Tanganyika, 60–70 km. south of Ifakara, Dr. H. Briegel) with genitalia on slide (81/21), Ifakara, TANZANIA (Tanganyika), no date (H. Briegel). Deposited in Division of Vector Borne Diseases, Ministry of Health, Nairobi, Kenya. Allotype female (MEP Acc. 808/#157), same data as holotype [DVBD]. Paratypes: 1 male (MEP Acc. 808/#160) with genitalia on slide (81/22) and 1 female (MEP Acc. 808/#154) with genitalia on slide (81/23), same data as holotype [DVBD].

Other material examined.—TANZANIA (Tanganyika). *Morogoro Region:* Ifakara (8°08′S, 36°41′E), Mselezi (8°46′S, 36°42′E), H. Briegel, 1 F (#146) [DVBD].

Distribution.—This species is presently known only from Tanzania (Tanganyika).

Etymology.—This species is named to honor Mrs. Phoebe A. O. Josiah, Senior Entomologist, Division of Vector Borne Diseases, Ministry of Health, Nairobi, Ke-

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Fig. 5. *Aedes* (*Stegomyia*) *kivuensis* Edwards, holotype female. A, Dorsal aspect of the thorax; B, Lateral aspect of the thorax; C, Dorsal aspect of the wing; D, Anterior surface of the legs; E, Dorsal aspect of the abdomen; F, Lateral aspect of the abdomen.

nya, in recognition and appreciation of her contributions to our knowledge of the mosquito fauna of Africa.

Taxonomic discussion.—*Aedes* (*Stegomyia*) *josiahae* is a member of the *simpsoni* subgroup of the *aegypti* group. The *simpsoni* subgroup presently comprises at least eight species (*Ae. simpsoni* (Theobald) 1905, *Ae. lilii* (Theobald) 1910, *Ae. bromeliae* (Theobald) 1911, *Ae. woodi* Edwards 1922, *Ae. subargenteus* Edwards 1925, *Ae. kivuensis* Edwards 1941, *Ae. strelitziae* Muspratt 1950 and *Ae. josiahae* n. sp.) and is characterized by the following combination of characters: the scutum has a pair of submedian stripes, a white knee-spot is absent on the forefemur but present on the mid- and hindfemora; midfemur has a large, white spot on the anterior surface and the hindtarsus has a basal white band on tarsomeres 1–3. *Aedes josiaehae* differs from all other members of the *simpsoni* subgroup except *Ae. kivuensis,* however, by the following combination of characters: (1) scutum with anterior median white spot of narrow scales; (2) scutellum with broad white scales on all lobes; (3) hindtibia anteriorly dark, without a white stripe in basal area; (4) hindtarsomeres 4 and 5 entirely white.

Aedes josiahae is most closely related and similar to *Ae. kivuensis,* and I consider *josiahae* to be a sister species of *kivuensis.* Adults of *Ae. josiahae* are extremely similar to those of *Ae. kivuensis* with which it has been confused and misidentified. *Aedes joshiahae* can be distinguished easily from *Ae. kivuensis,* however, by the hindfemur, which anteriorly has a broad white stripe in basal 0.60–0.66 and by the presence of a median white spot on tergum I. In *Ae. kivuensis,* the hindfemur anteriorly has a broad white stripe on the basal half, and has a white spot about 0.62 from the base (the white spot does not connect with the basal white stripe) and the tergum I has white scales only on the laterotergite (see Fig. 5).

The male genitalia of *Ae. joshiahae* are easily differentiated from all other species in the *simpsoni* subgroup by the claspette, which has the distal expanded portion square in the dorsal aspect, with numerous simple setae on the expanded distal portion and bearing 2(1–2) stronger, basally widened spine-like setae on the apicomesal angle.

Gerberg and Van Someren (1970: 2) reported that *Ae.* (*Stg.*) *kivuensis* was collected in Tanzania by Dr. H. Briegel of the Swiss Tropical Institute at Ifakara. However, the specimens from Tanzania (Dr. H. Briegel) in the DVBD collection are not *Ae. kivuensis,* but are the new species *joshiahae.*

Aedes josiahae is apparently an East African lowland species. Based on the present collection data, *Ae. josiahae* occurs in habitats with altitudes of 500 m (1500 ft) and yearly rainfall of 88.90 cm (35 in.). *Aedes kivuensis* is presently known only from Zaire (Belgian Congo), where it occurs in habitats with altitudes of 2166 m (6500 ft) and yearly rainfall of 152.40 cm (60 in.).

Medical importance.—Unknown. However, the *simpsoni* subgroup is one of the most important subgroups of *Stegomyia* from the standpoint of transmission of pathogens. *Aedes bromeliae* is an important vector of yellow fever virus in East Africa. *Aedes simpsoni* was incriminated in the transmission of yellow fever virus during an outbreak of yellow fever in Bwamba County, Uganda, in 1941 and yellow fever virus has been isolated from wild caught mosquitoes (*Ae. simpsoni*) from Bwamba, Uganda, (Mahaffy et al. 1942). The yellow fever virus has also been isolated from wild caught mosquitoes (*Ae. simpsoni*) in Uganda by Smithburn and Haddow (1946). However, the species from which Mahaffy et al. (1942) and Smithburn and Haddow (1946) isolated yellow fever virus was *Ae. bromeliae,* not *Ae. simpsoni* (see Huang 1986). *Aedes simpsoni* (probably *Ae. bromeliae*) from Nigeria has been shown to be a laboratory transmitter of yellow fever (Philip, 1929). *Aedes strelitziae* from South Africa can transmit yellow fever virus from one rhesus monkey to another under labo-

ratory conditions, as shown by Gillett and Ross (1953).

Acknowledgments

I express my sincere appreciation to Wayne N. Mathis, Department of Entomology, Smithsonian Institution, and Ronald A. Ward and E. L. Peyton, Walter Reed Biosystematics Unit, for critically reviewing this manuscript and for their valuable comments. I am most grateful to J. Decelle and E. De Coninck, Department of Zoologie, Section d'Entomologie, Musee Royale de l'Afrique Centrale, Tervuren, Belgium, for the loan of the holotype of *kivuensis* Edwards used in this study; to J. M. D. Roberts, Davy K. Koech (formerly of DVBD) and Mrs. Phoebe A. O. Josiah, Division of Vector Borne Diseases (DVBD), Ministry of Health, Nairobi, Kenya, for the loan of the specimens described above, and for their cooperation and kind assistance during the course of the museum and field studies on African *Stegomyia* mosquitoes in Kenya. I also express my gratitude to Young T. Sohn and Vichai Malikul, formerly of the Medical Entomology Project, for preparing the illustrations.

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DESCRIPTION AND BIOLOGY OF *ACROLOPHUS PHOLETER*, (LEPIDOPTERA: TINEIDAE), A NEW MOTH COMMENSAL FROM GOPHER TORTOISE BURROWS IN FLORIDA

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Abstract.—Vacuum sampling of gopher tortoise burrows in Putnam County, Florida, has resulted in the discovery of a new species of tineid moth, *Acrolophus pholeter* Davis. The larva feeds on both the fecal pellets of the gopher tortoise and upon decaying plant debris within the burrow. Supplemented by numerous illustrations, the larval, pupal, and adult stages are described, and the general biology is summarized.

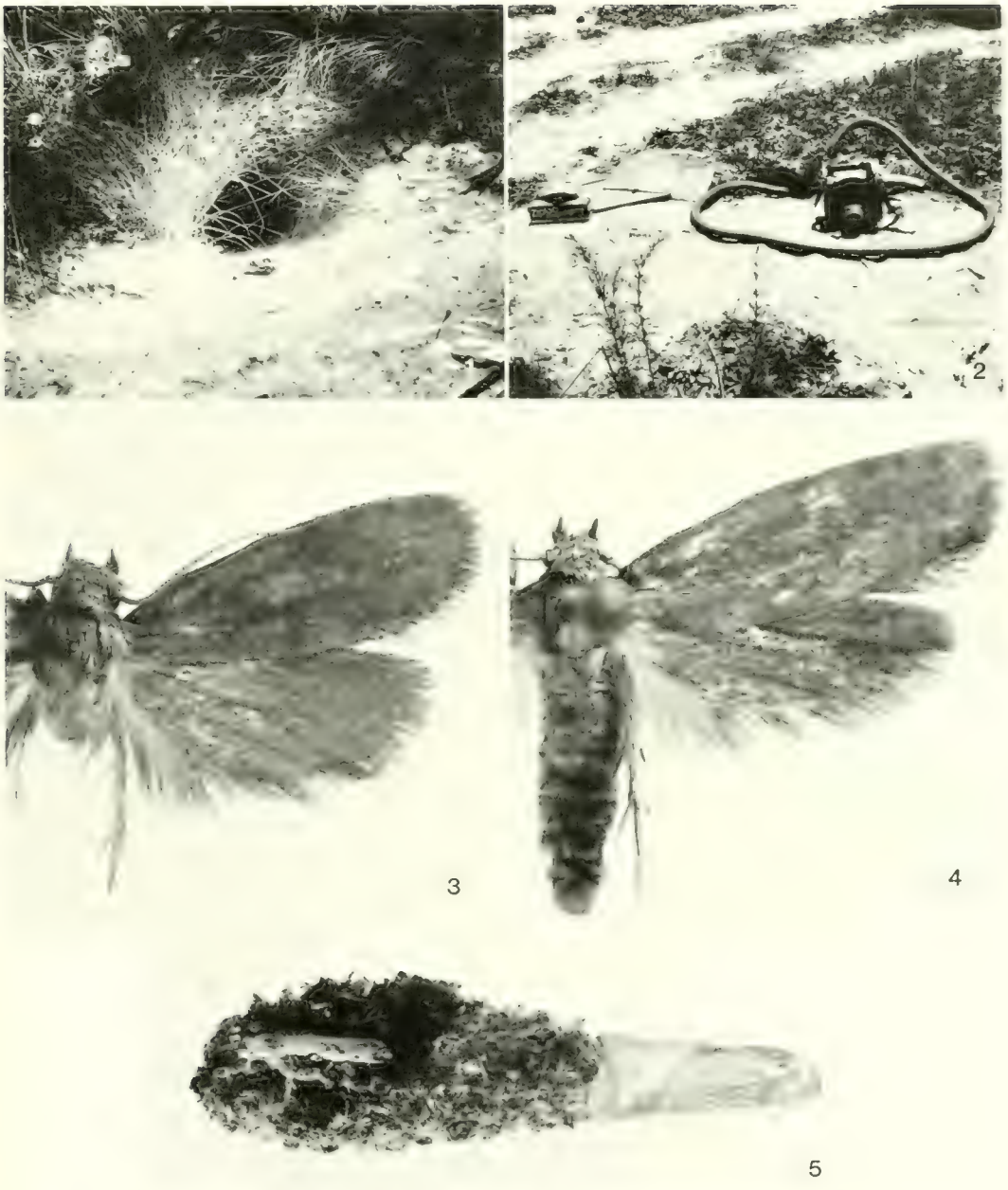
Key Words: Lepidoptera, Tineidae, moth biology, *Gopherus polyphemus*, gopher tortoise

Recent vacuum sampling for invertebrate commensals in the burrows of the gopher tortoise, *Gopherus polyphemus* Daudin, by the junior author has revealed the presence of a few arthropods previously unreported. Among these was a new species of *Acrolophus* that was found in abundance feeding on both tortoise fecal pellets and decaying plant debris within the burrow.

This is the first record of an *Acrolophus* commensal in an animal burrow. The subterranean, tube-constructing habit of the genus, however, is well known. Other Tineidae (all Acrolophinae) have been reported from rodent burrows (Hubbard 1901, Hubbell and Goff 1939, Davis et al. 1986), and at least one other moth, *Idia gopheri* (Smith), is known to inhabit the burrows of the gopher tortoise (Hubbard 1894, 1896, Smith 1899, Woodruff 1982). Hubbell and Goff (1939) reported that some arthropod commensals were true obligates and had not been collected outside gopher tortoise burrows. It is not known to what extent *Acrolophus pholeter* n. sp. is restricted to burrows of this tortoise or if the moth also frequents rodent burrows. The absence of previous *Acrolophus* collecting records suggests that its habitat may be rather restricted.

Since at least the Pleistocene, gopher tortoise burrows have provided a relatively stable habitat for the establishment of a diverse community of organisms. The integrity of individual burrows is normally maintained for five years or more. In terms of numbers of both vertebrate and invertebrate species found using gopher tortoise burrows, the diversity is one of the greatest yet studied in North American animal burrows (Milstrey 1986).

Sampling of organisms from gopher tortoise burrows can be a formidable task. Depending upon soil type and water table, burrows may extend up to 40 feet long and 12 feet deep (Young and Goff 1939). Excavation of such galleries can create a sizeable trench (Hubbard 1894). In recent years the use of vacuum suction devices (Butler et al. 1984) has greatly facilitated collecting from burrows without decimating the landscape



Figs. 1–5. *Acrolophus pholeter*, habitat, adults, and cocoon. 1, Entrance to gopher tortoise burrow, *Gopherus polyphemus*, Putnam Co., Florida. 2, Modified Echo R200 blower used for sampling invertebrate fauna from burrows. 3, Adult male, length of forewing 6.7 mm. 4, Adult female, length of forewing 8.2 mm. 5, Cocoon with pupal exuvium protruding, length of cocoon 13 mm.

(Fig. 2). One disadvantage of this technique is that it does not allow direct observations of the organisms' biology.

All material used in this study was collected by the junior author using a modified Echo R200 (R) blower (Kioritz Corp., Tokyo, Japan). Most adults (all type material) were reared from larvae collected by vacuuming.

Deposition of specimens referred to in this paper are: BMNH for British Museum of Natural History, London, England; FSCA, Florida State Collection of Arthropods, Gainesville, Florida; and USNM, National Museum of Natural History (formerly United States National Museum), Smithsonian Institution, Washington, D.C.

Acrolophus pholeter Davis, New Species

Figs. 3–62

Adult (Figs. 3–4).—Length of forewing: male, 5.5–6.7 mm; female, 7–9.5 mm. A moderately small moth with uniformly brownish gray wings, smooth head, and short labial palpi.

Head: Vestiture smooth over vertex and frons; scales uniformly brownish gray, relatively slender with rounded apices, appearing to arise from lower frons and curving upwards over vertex until they reach flattened, transversely oriented scale patches across occiput. Eye small, interocular index approximately 0.65, cornea relatively smooth with only scattered microsetae (Figs. 10–11); eyelash absent. Antenna about 0.4–0.6 the length of forewing, relatively longer in male, 46–49 segmented; scape uniformly brownish fuscous, smooth, without pecten; flagellomeres of similar color, fully scaled, simple in form with a few sensilla coeloconica along anterior margin (Figs. 12–13). Pilifer reduced, minutely setose (Fig. 7). Mandible absent. Maxillary palpus greatly reduced, 2 segmented; approximately 8–10 elongate sensilla arising from apical pit. Haustellum absent. Labial palpus short; length approximately 2.5× eye diameter, uniformly brownish gray, relatively smooth vestiture with slightly rough scales along venter of second segment.

Thorax: Pronotum and both fore and hindwings uniformly brownish gray. Venter somewhat paler, more light brown. Legs with smooth vestiture, light brownish gray dorsally, lighter buff ventrally; epiphysis greatly reduced (Fig. 14), length only about twice its width. Pretarsus of all legs unspecialized, with symmetrical claws, pulvilli, well developed arolium, and unguitractor plate bearing 5–6 transverse rows of scutes.

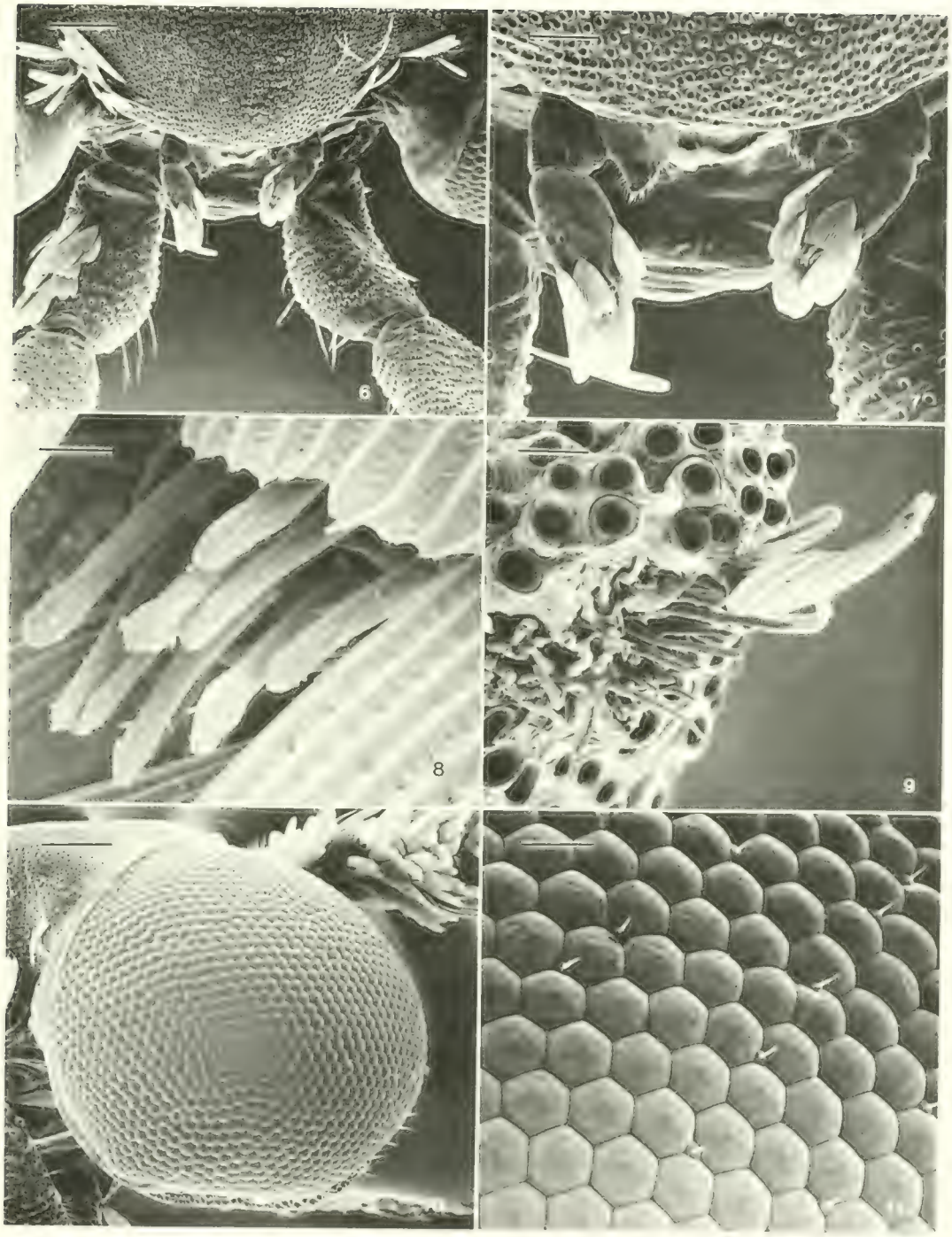
Abdomen: Uniformly light brownish gray.

Male genitalia: As shown in Figs. 18–21. Uncus elongate, slender, and acute. Tegumen relatively broad and elongate. Vinculum slender; anterior margin slightly concave at middle. Gnathos a well developed median lobe with a relatively broad, truncate apex. Valva rather broad over basal half to sharply defined saccular lobe, abruptly narrowing beyond lobe to simple apex. Aedoeagus relatively short, approximately two-thirds the length of valva, and without cornuti; apex with a serrated cleft extending over one-fourth down right side.

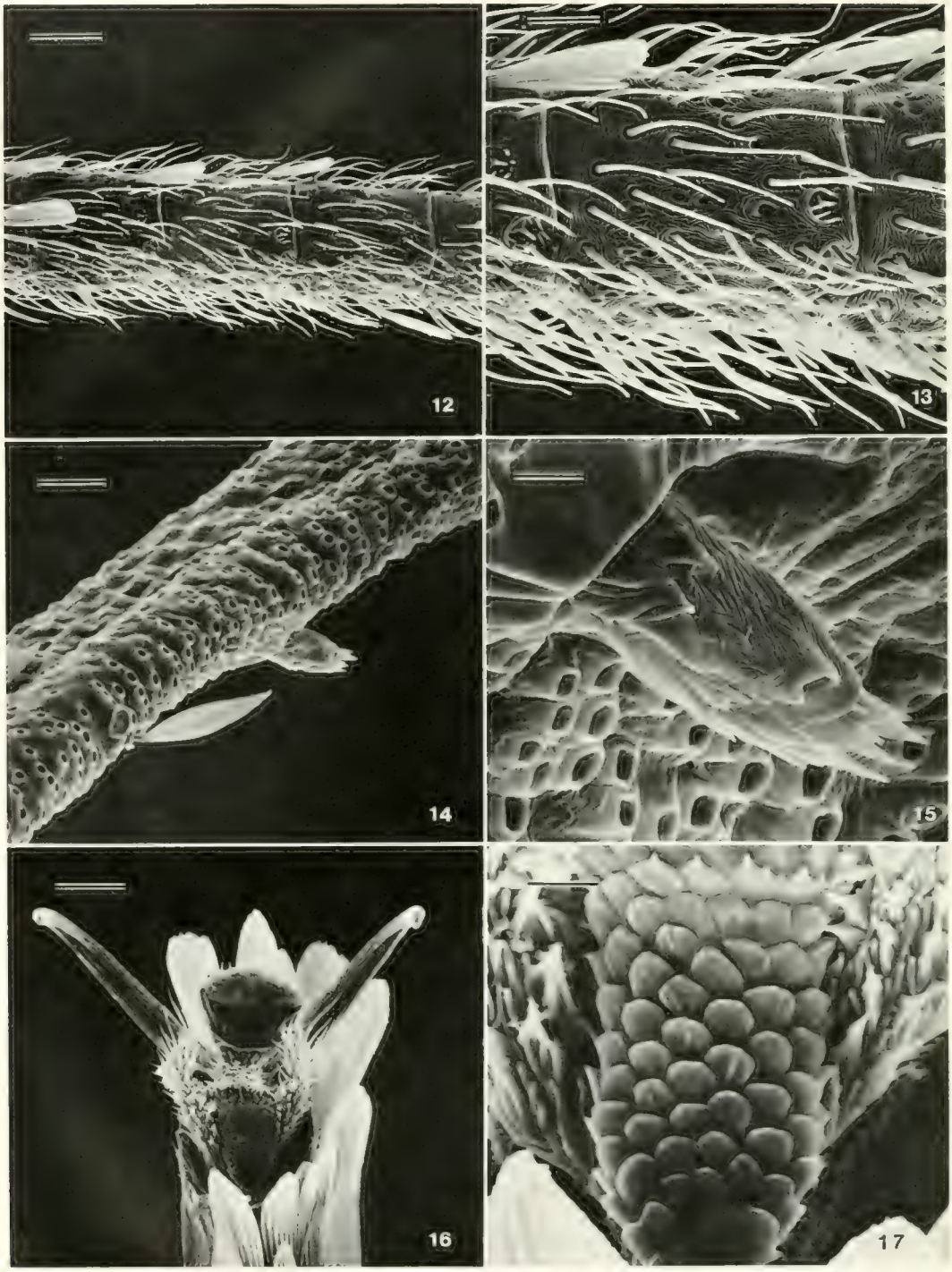
Female genitalia: As shown in Fig. 22. Only a single pair of short, posterior apophyses present. Caudal margin of lamella antevaginalis smoothly curved. Ductus bursae very short, slightly thickened and constricted just before corpus bursae; latter simple, relatively small, membranous sac without spicules.

Larva (Figs. 33–62).—Length of largest larva 18 mm; diameter 2.1 mm. Body translucent, light yellowish brown with light brown thoracic and anal plates.

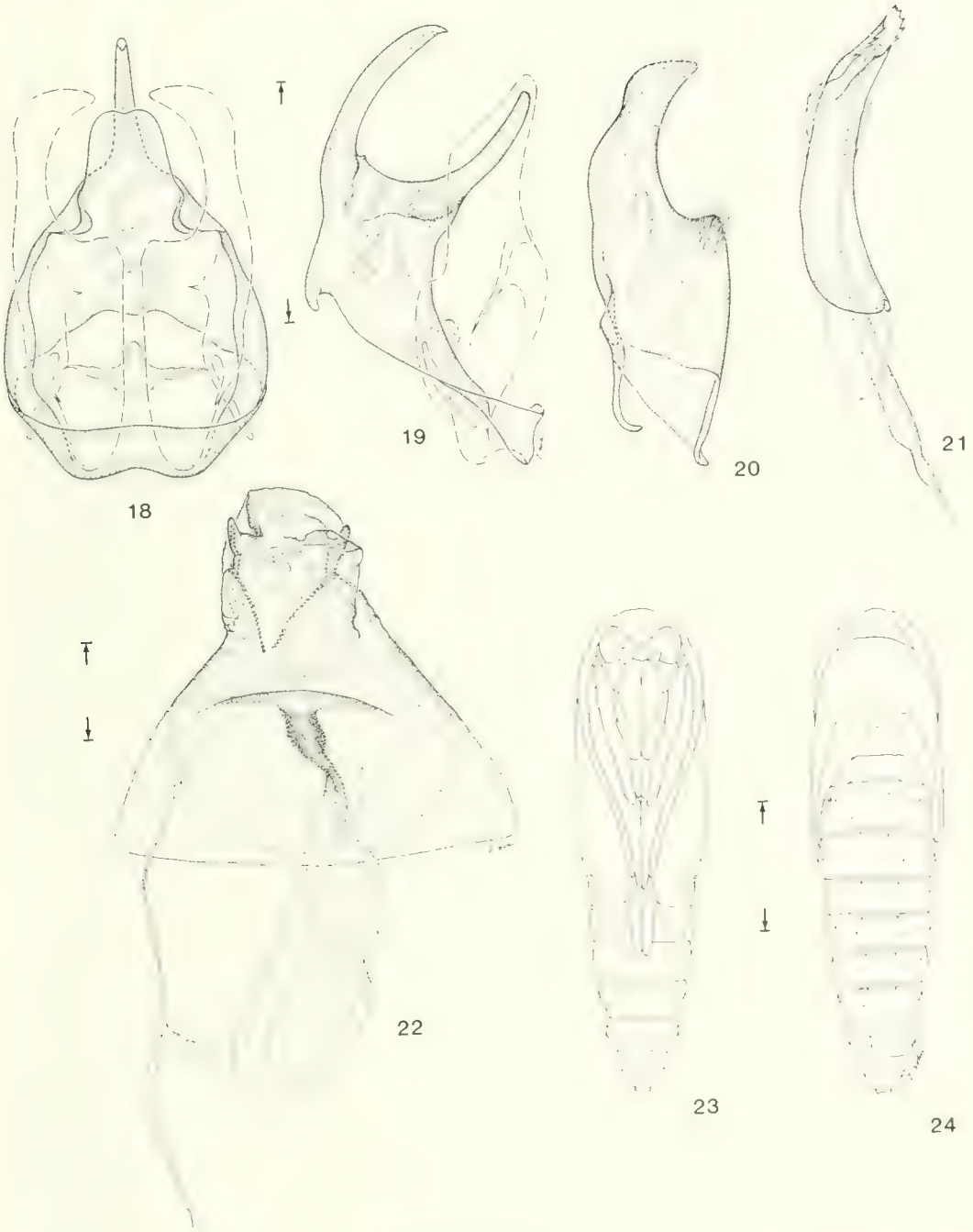
Head: Uniformly light reddish brown, darker around base of mandibles. Greatest width 1.4 mm, length 0.9 mm. AF2 arising well above (caudad) apex of frons. P2 more distant from P1 than P1 is to ecdysial line. Stemmata vestigial, probably non-functional; only three transparent vestiges remaining (Fig. 53); one situated above S2, a very small one well below S2, and an elongate hyaline



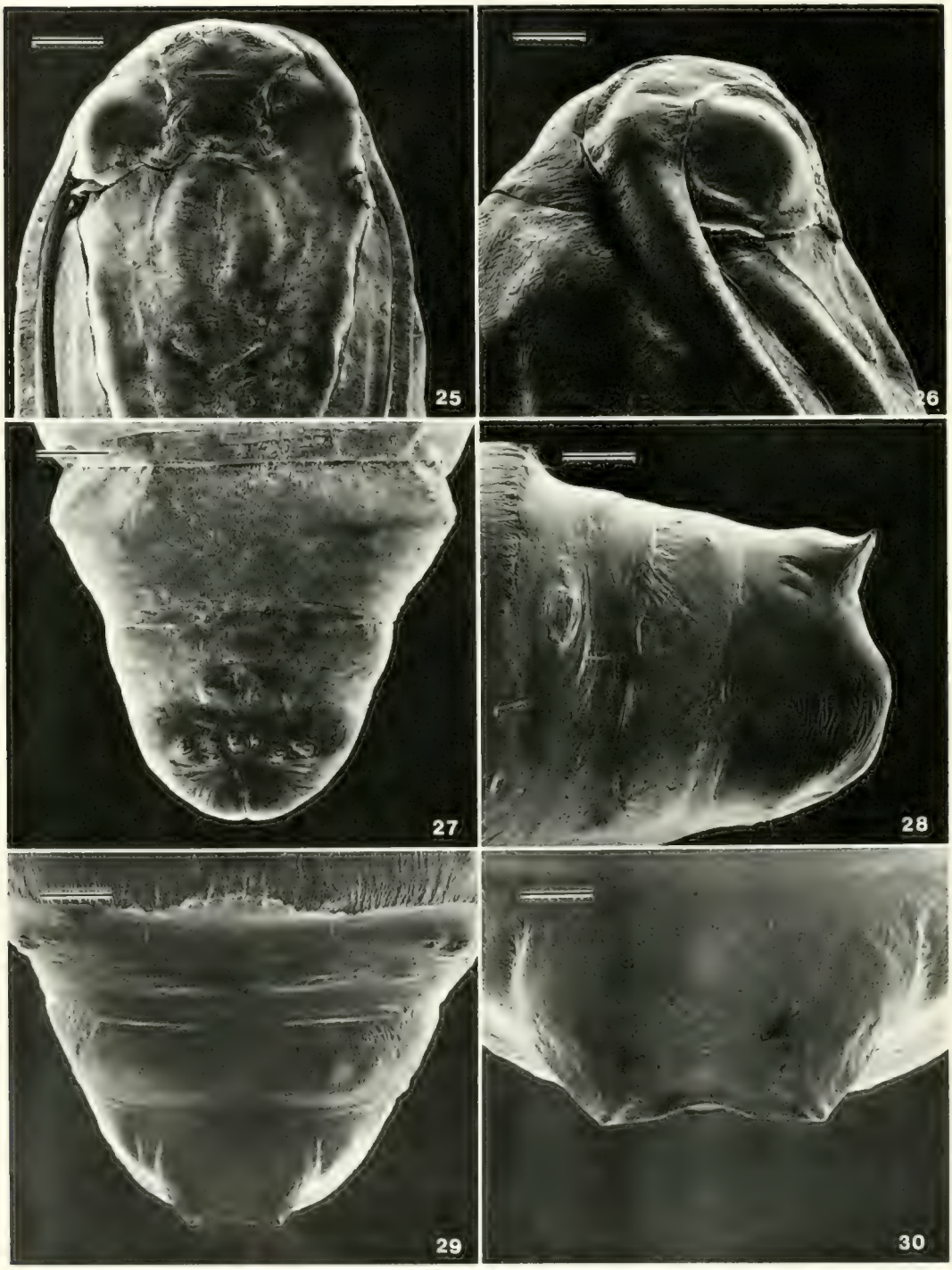
Figs. 6–11. Adult structure, *Acrolophus pholeter*. 6, Partial view of frons and mouthparts (88 μm). 7, Maxillary palpi and pilifers (37.5 μm). 8, Sensilla at apex of maxillary palpus (2.5 μm). 9, Sensilla at apex of labial palpus (8.8 μm). 10, Eye (88 μm). 11, Detail of cornea showing scattered interfacetal microsetae (19 μm). (Scale lengths in parentheses.)



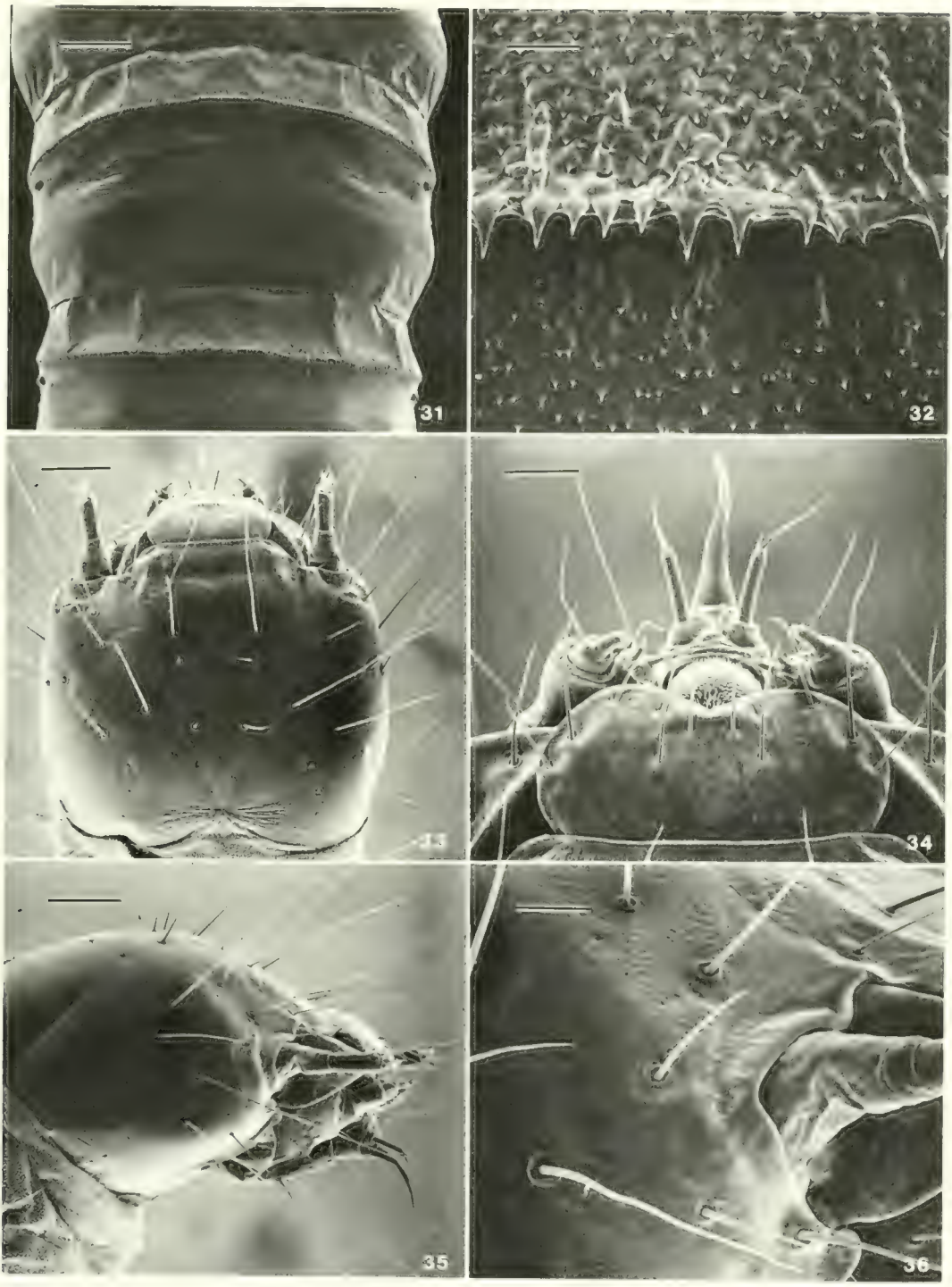
Figs. 12–17. Adult structure, *Acrolophus pholeter*. 12, Antenna near middle of flagellum (37.5 μm). 13, Detail of Fig. 12 showing sensilla coeloconica (16.5 μm). 14, Reduced epiphysis on foretibia (25 μm). 15, Detail of epiphysis (7.5 μm). 16, Pretarsus of hindleg (19 μm). 17, Detail of unguitractor plate (3.75 μm). (Scale lengths in parentheses.)



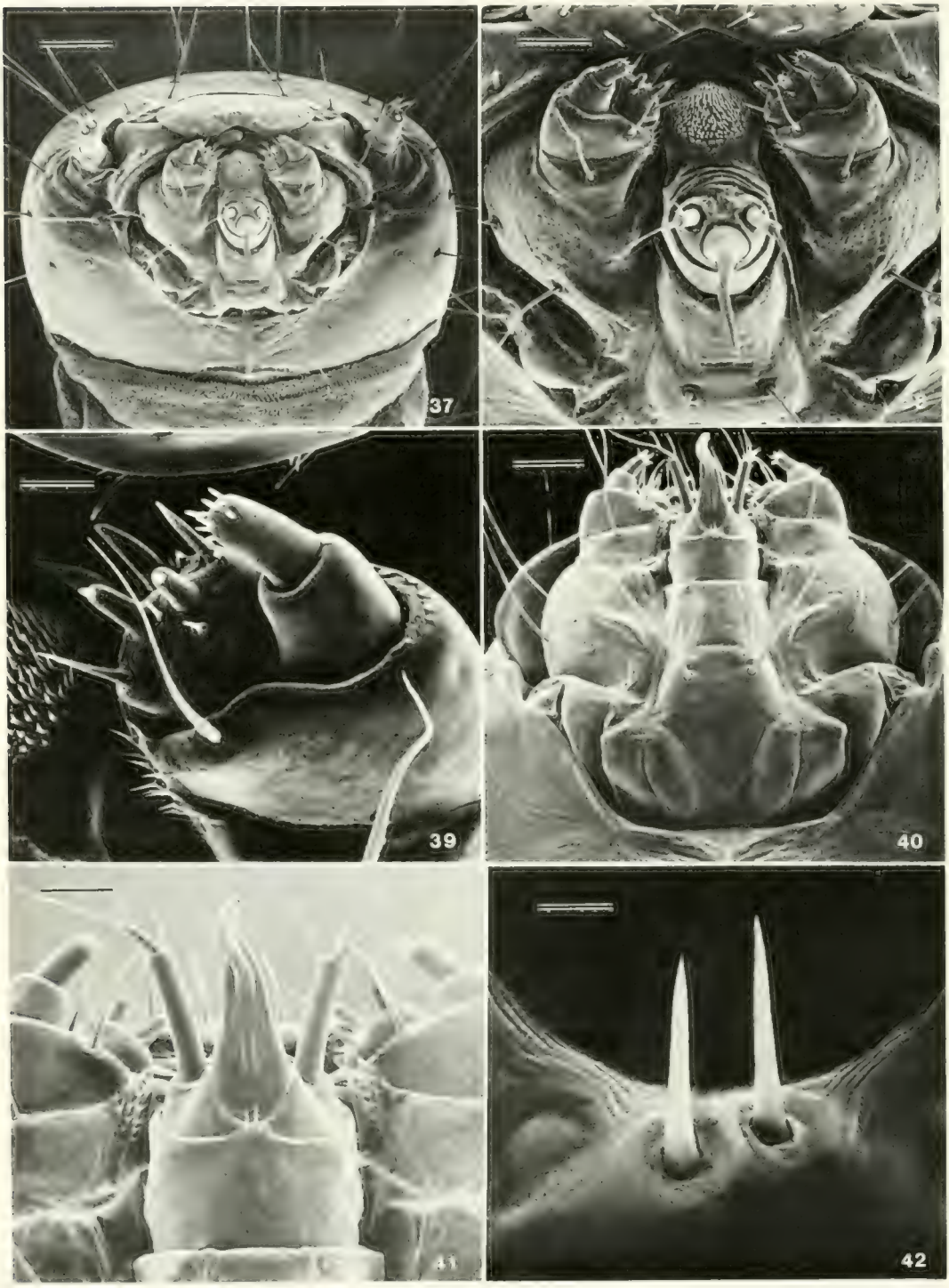
Figs. 18–24. *Acrolophus pholeter*. 18, Male genitalia, ventral view (0.5 mm). 19, Lateral view. 20, Lateral view of valva. 21, Lateral view of aedoeagus. 22, Female genitalia, ventral view (0.5 mm). 23, Pupa, ventral view (2 mm). 24, Dorsal view. (Scale lengths in parentheses.)



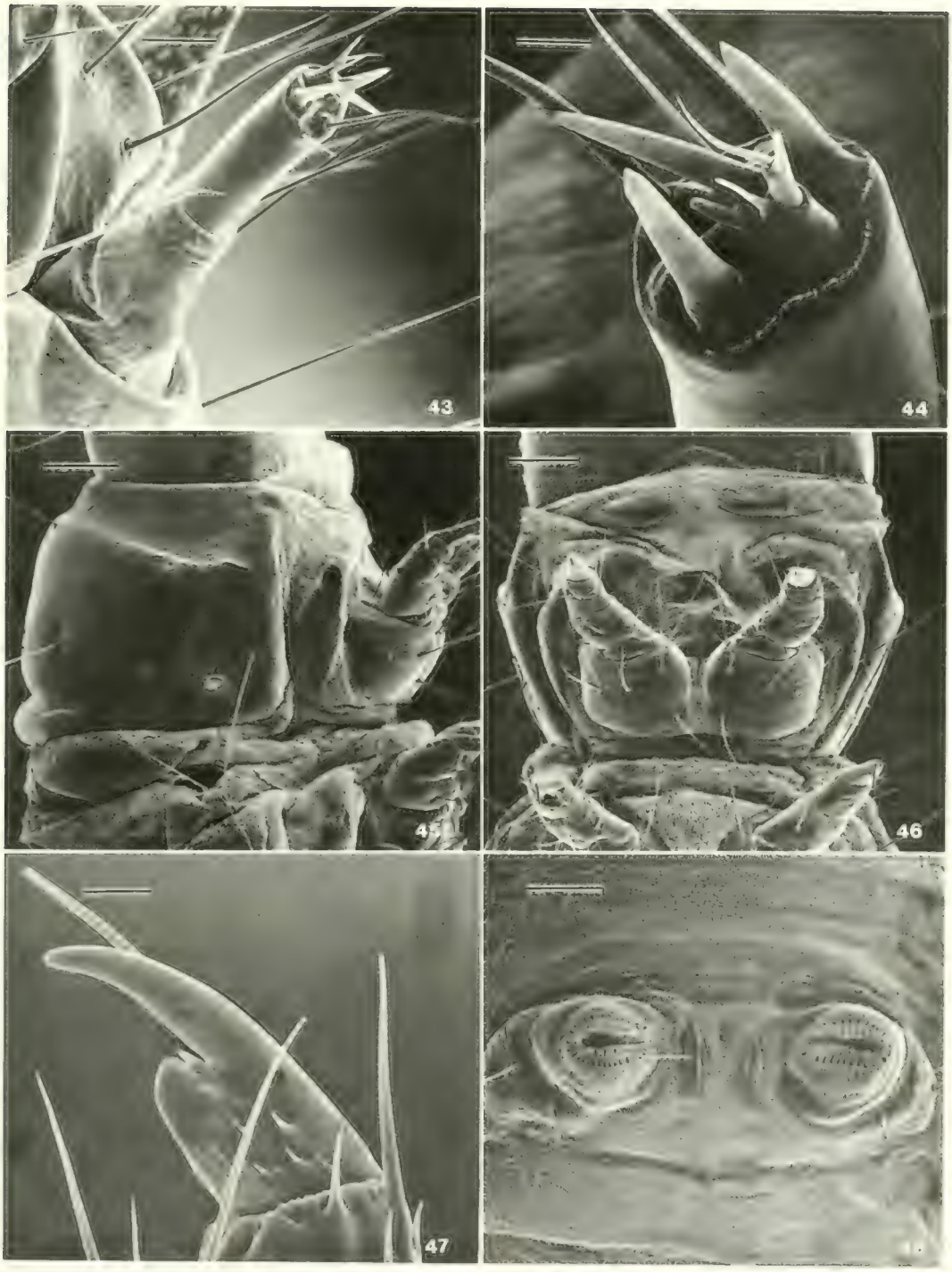
Figs. 25–30. *Acrolophus pholeter*, pupa. 25, Head, ventral view (0.3 mm). 26, Lateral view (0.22 mm). 27, Caudal end (A7–10) of abdomen (0.22 mm). 28, Lateral view, dorsum up (0.19 mm). 29, Dorsal view (0.22 mm). 30, Detail of dorsal cremaster, A10 (88 μm). (Scale lengths in parentheses.)



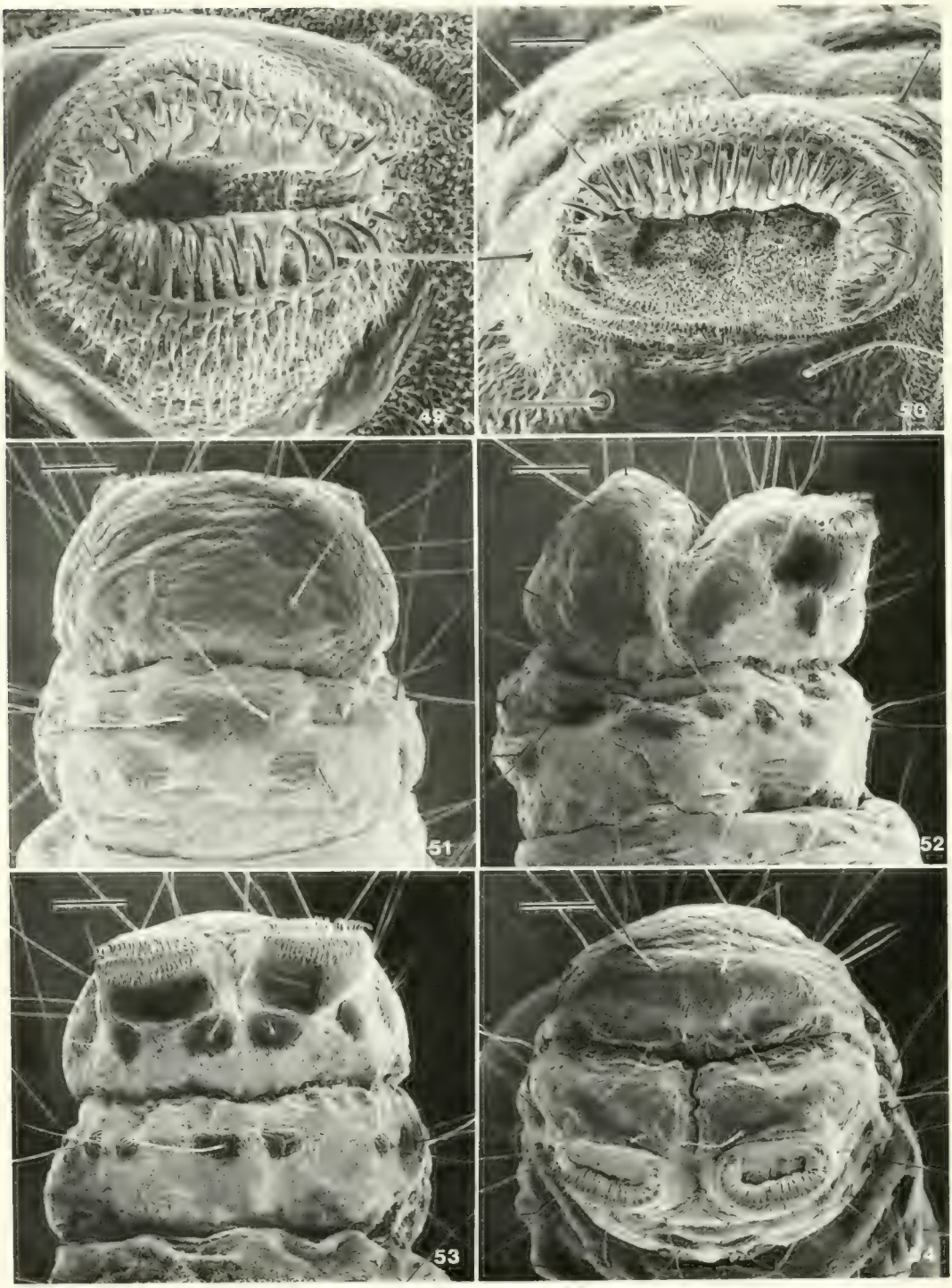
Figs. 31–36. *Acrolophus pholeter*. 31, Pupa, dorsum of A4–5 (0.43 mm). 32, Detail of spine row, A5 (30 μm). 33, Larva, dorsal view of head (0.19 mm). 34, Dorsal view of labrum and mouthparts (68 μm). 35, Lateral view of head (0.17 mm). 36, Lateral view of stemmatal area (60 μm). (Scale lengths in parentheses.)



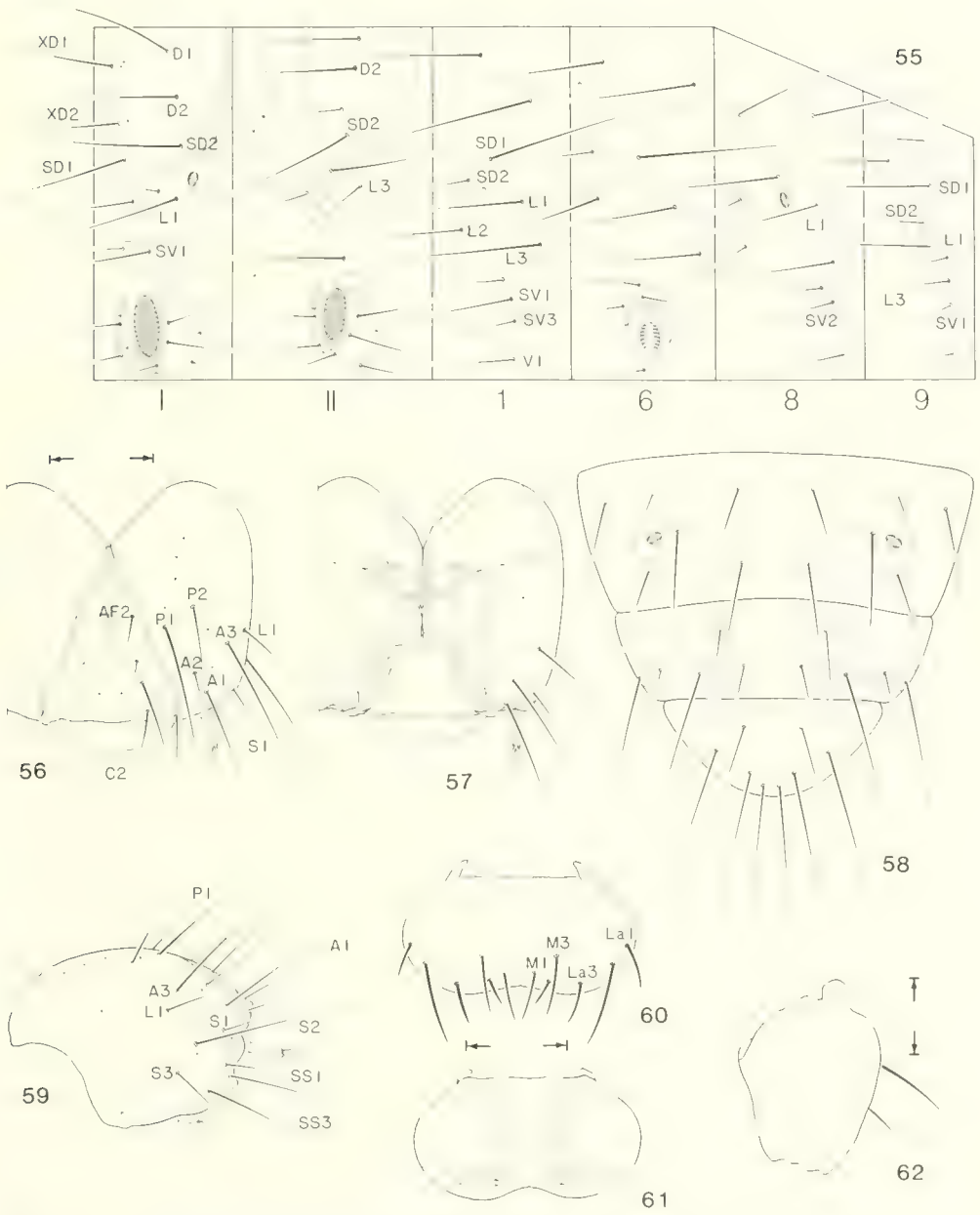
Figs. 37–42. *Acrolophus pholeter*, larva. 37, Head, frontal view (0.15 mm). 38, Maxillae and labium (68 μm). 39, Detail of maxilla (22 μm). 40, Ventral view of maxillae and labium (88 μm). 41, Detail of spinneret and labial palpi (37.5 μm). 42, Detail of secondary labial setae in Fig. 41 (3.75 μm). (Scale lengths in parentheses.)



Figs. 43–48. *Acrolophus pholeter*, larva. 43, Antenna (43 μm). 44, Detail of antennal apex (12 μm). 45, Lateral view of prothorax (0.22 mm). 46, Ventral view of prothorax (0.22 mm). 47, Tarsal claw (11.5 μm). 48, Prolegs, A5 (0.15 mm). (Scale lengths in parentheses.)



Figs. 49–54. *Acrolophus pholeter,* larva. 49, Crochets on proleg 5 (38.5 μm). 50, Anal proleg, A10 (60 μm). 51, Segments A9–10, dorsal view (0.19 mm). 52, Lateral view (0.19 mm). 53, Ventral view (0.19 mm). 54, Caudal view (0.19 mm). (Scale lengths in parentheses.)



Figs. 55–62. *Acrolophus pholeter*, larva. 55, Chaetotaxy of body, segments T1–2, A1, 6, 8–9. 56, Head, dorsal view (0.5 mm). 57, Ventral view. 58, Segments A8–10, dorsal view. 59, Head, lateral view. 60, Labrum, dorsal view (0.2 mm). 61, Ventral view. 62, Mandible (0.2 mm). (Scale lengths in parentheses.)

area anterior to S2; the latter apparently the remnant of three fused stemmata. Apical segment of antenna relatively long; sensilla as in Figs. 43–44. Labrum with M1 and 2 near anterior margin; M3 more remote. Mandible somewhat tapered, with 4 small cusps. Maxilla as in Figs. 38–39. Spinneret elongate, slender; labial palpus 2-segmented, basal segment elongate with a short apical seta; apical segment greatly reduced,

about 0.25 the length of basal segment, with an elongate seta nearly equal in length to both segments; apex of mentum with a pair of minute secondary labial setae (Figs. 41–42).

Thorax: Pronotal and mesonotal plates light brown. Spiracular plate almost completely separated from pronotal plate; all 3 lateral setae together on spiracular plate. Coxal plates separated slightly. Tarsal claw as in Fig. 47.

Abdomen: A1–6 with 11 pairs of primary setae, SV trisetose. Ventral crochets in a uniserial ellipse of approximately 30 hooks; sides of proleg densely covered with small, scattered spines, anal proleg with approximately 21 hooks in a half ellipse open to the rear. A8 with spiracle greatly enlarged, equalling size of prothoracic spiracle; 10 pairs of primary setae, SV bisetose. A9 with 9 setal pairs, SV unisetose. Anal plate light brown, bearing 4 pairs of setae.

Pupa (Figs. 23–32).—Length of largest pupa: male, 7.2 mm; female, 11 mm. Light reddish brown in color. Vertex smooth except for a pair of minute setae. Antenna and labial palpus of relatively equal length in both sexes; antenna extending to caudal margin of A3 and just short of wings which extend to caudal margin of A4; labial palpus short. Mesonotum with two pairs of minute setae clustered together near midline. Dorsum of A3–8 with a transverse ridge like row of minute spines near anterior margin. A9 + 10 relatively smooth except for a cluster of 3 pairs of minute spines ventrally and a large, slightly bilobed ridge dorsally (Figs. 28–30).

Holotype.—Male, (with associated pupal exuvium and cocoon) Roberts' Ranch, ca. 6 km north of Hollister, Putnam Co., Florida; em. 12 May 1985, E. G. Milstrey, (USNM).

Paratypes.—FLORIDA: Same data as holotype except: 2 ♂, 3 ♀, em. Sept. 1984; 5 ♂, 4 ♀, em. Nov. 1984; 3 ♀, em. 8 Dec. 1984; 3 ♂, 1 ♀, em. 19 Dec. 1984; 1 ♂, m. 5 Feb. 1985; 3 ♀, em. 5 May 1985; 1 ♀, 9 May 1985; em. 11 May 1985; 2 ♂, 3 ♀, em. 12 May 1985; 4 ♂, 1 ♀, em. 17 May 1985; 1 ♀, 12 June 1985, em. 30 June 1985; 1 ♀, em. 20 July 1985; 1 ♀, 10 July 1985, em. 23 July 1985; 60 larvae, 26 July 1985; 68 larvae, 9 Sept. 1985. Paratypes deposited in BMNH, FSCA, and USNM.

Host.—Larval substrate consists of both decaying plant debris within burrow of gopher tortoise and fecal pellets of tortoise.

Flight period.—Difficult to assess; adults were collected from burrows through much of the year.

Distribution.—Known only from underground burrows of the gopher tortoise in the sandhill habitat of Putnam County, northeastern Florida.

Etymology.—The specific name is derived from the Greek *pholeter* (one who lurks in a hole), in reference to its subterranean behavior.

Discussion.—*Acrolophus pholeter* does not appear closely allied to any North American *Acrolophus*. In addition to its distinctive male genitalia, this species is unusual in possessing a smooth head and greatly reduced epiphysis. In color pattern, it superficially resembles a nearly unicolorus, undescribed species from southern Florida and Texas.

Even less can be summarized about larval relationships because of the great inadequacy of our knowledge. Compared with the few *Acrolophus* larvae ever studied (e.g. Davis 1987), the chaetotaxy of *A. pholeter* appears little differentiated. However, the atypical stemmatal reduction in this species, particularly the apparent fusion of the three anterior stemmata, is probably characteristic for the species.

Biological observations.—Biology of this species has been determined from laboratory and field observations. Apparently, the species is restricted to burrows of the gopher tortoise, *Gopherus polyphemus,* in sandhill habitats (Fig. 1). Tortoise burrows sampled outside the sandhill biome were found not to contain *A. pholeter.* The sandhills are rel-

ict dunes from the Pleistocene and earlier epochs (Cooke 1945, Laessle 1958). The vegetation of this habitat is characterized by longleaf pines, *Pinus palustris,* several oaks, *Quercus laevis* and *margaretta,* with an understory of wiregrass, *Aristida stricta,* and various herbs. The study site was in Putnam County, 6 km north of Hollister (29°41′40″N–81°48′10″W).

Collections were made every six weeks by vacuum extraction of the burrow using a modified Echo leaf blower similar to that described by Butler et al. (1984). Larvae, pupae and adults were obtained but eggs were not detected. Larval densities ranged up to 30 per burrow. In repeatedly sampled burrows, population estimates, based upon removal sampling estimates (Carle and Maughan 1980), indicated larval numbers commonly were 3 to 16. A few burrows not sampled routinely gave higher estimates, up to as high as 200. First instar larvae were found from May to November. All other stages were present year round. In the later part of the summer and early fall the pupating larvae probably were of two generations; the previous year's and offspring of the spring emergence. Larval development was estimated to require anywhere from 7 to 16 months and most likely around 11 months (± one month) for most individuals. One lab reared larva, field collected in its last larval stage, took 15 months to pupate. The pupation period is relatively short, normally requiring one to two weeks for adult eclosion.

Pupae and adults were infrequently collected in the burrows from May to September. Pupal cocoons (Fig. 5) were constructed of loosely woven silk to which are attached sand grains and larval frass. Apparently, pupation was triggered by unknown narrow microclimatic conditions present in individual burrows, because when pupae were found there were commonly more than one, and in other adjacent burrows none were found. Adults collected from burrows had wings that were badly tattered with few scales remaining on the body and wings. The poor condition of the adults was not due to the sampling method but probably due to abrasion occurring during normal adult activity within the sandy burrows.

As larval size increased in the burrows, density decreased. Larvae were found to be cannibalistic in laboratory studies. Silk lined larval galleries were usually constructed just below the soil surface in the floor of the burrow. Larval galleries could exceed 30 cm in length and were often branched. Larvae traveled forward and backward in these galleries, always facing the same direction. Feeding occurred at the entrance and fecal pellets were deposited on the soil surface at the other end.

Larvae were successfully reared on gopher tortoise fecal pellets. The fecal pellets used were mostly partially disgested wiregrass and some oak leaves. Although fecal material was available in the burrows, its abundance was always low and competition for it was high. The amount of available fecal material was generally too low to support the *Acrolophus* population present. Also, larvae were very common in burrows that no longer had resident tortoises. In active burrows, tortoises frequently re-excavated their burrows, and in those burrows larval populations were significantly decreased if not exterminated. Larval density was positively correlated with burrows that accumulated leaves and other debris. Apparently this rapidly decomposing organic leaf litter was their primary food source. Laboratory studies on limited numbers of larvae found that they would survive on the litter but that growth rates were lower.

The unique humidity situation in the burrow appears to be responsible for restricting the species to this habitat. In the sandhill gopher tortoise burrows studied, relative humidities were in the mid to high 90's but the percent water in the soil was low (0–5%) year round. In the laboratory inside an environmental chamber, larvae were found to survive only within these limits. Mature lar-

vae left their silk galleries and moved to drier conditions to pupate. Pupae in the laboratory could be reared at room temperature and normal humidity levels.

The larvae of the antlion, *Glenurus gratis* (Say), and larvae of an undescribed therivid fly, *Arenagena* sp. were found to prey upon the *Acrolophus* larvae. Lepidoptera larvae were the only prey either would take under laboratory conditions. *Glenurus gratis* was probably the major predator. Its larval population numbers were more strongly correlated with *Acrolophus* larval numbers. Both prefer the same burrows and both are restricted to the drier, looser sand near the entrances where the leaves collect; the therivid was more ubiquitous.

Acknowledgments

The senior author (Davis) is responsible for the systematic and morphological portions of this paper and the biological observations are by the junior author (Milstrey). Thanks are given to Irwin Roberts for allowing his land to be used for this research, Judy Gilmore for adult preparation and Dr. Dale Habeck for recognizing the uniqueness of the species and encouraging its investigation. We are indebted to Young Sohn of the Department of Entomology, Smithsonian Institution, for the line drawings and to Susann Braden and Brian Kahn of the Smithsonian SEM Lab and Victor Kranz of the Smithsonian Photographic Laboratory for photographic assistance. The final draft was prepared by Silver West.

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PROC. ENTOMOL. SOC. WASH.
90(2), 1988, pp. 179–188

NEW SPECIES OF CERAMBYCIDAE FROM TWIN CAYS, BELIZE (COLEOPTERA)

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Abstract.—New species of Cerambycidae (Coleoptera) from Twin Cays, Belize, associated with mangrove, are described along with a description of the male of *Derancistrus fellerae* Chemsak. New taxa are: *Methia rhizophorae, Ataxia cayensis, Leptostylopsis latus, Styloleptus rhizophorae,* and *Urgleptes ozophagus.*

Key Words: Insecta, Coleoptera, Cerambycidae, Belize

The recent interest in and emphasis on Neotropical natural history has resulted in a great increase in biological investigations on insects. The Cerambycidae, because of their larval habits, are directly affected by the well documented loss of tropical forests (Janzen 1986). For this reason, studies dealing with habits and behavior of immatures and adults will attain increasing importance.

One such study, presently being conducted by C. Feller at Twin Cays, Belize, has produced a number of new species. Twin Cays (16°50′N, 18°06′W), locally called Water Range, is a swampy mangrove island within the Belize Barrier Reef. The island is approximately 1 km in diameter and is 22 km SE of Dangriga (Stann Creek), Dangriga District, Belize. The Cerambycidae present appear to be associated with red mangrove, *Rhizophora mangle* L., black mangrove, *Avicennia germinans* (L.) Stearn, white mangrove, *Laguncularia racemosa* (L.) Gaertn. f., and buttonwood, *Conocarpus erectus* (L.). The beetle genera represented are typical West Indian–Central American groups containing numerous species (Chemsak and Linsley 1982).

In 1983, Chemsak described *Derancistrus fellerae* from Twin Cays from two female specimens. Subsequent collections and rearings have produced additional specimens, including the male, which is described below along with five new species. The new taxa are presented to make their names available for current ecological studies. Types are deposited in the United States Museum of Natural History, Washington, D.C. and paratypes in the Essig Museum of Entomology, University of California, Berkeley.

Derancistrus fellerae Chemsak (Prioninae)

Fig. 1

Derancistrus fellerae Chemsak 1983, Proc. Entomol. Soc. Wash., 85: 714.

Male.—Form moderate-sized, rather slender, tapering posteriorly; integument black, elytra black basally, dark reddish toward apex, femora reddish, narrowly black at apices and bases, tibiae reddish toward apical one-half. Head narrow, front short, deeply impressed, impression extending onto vertex; punctures coarse, subconfluent, becoming sparse on neck; pubescence sparse, recurved; antennae serrate, extending to

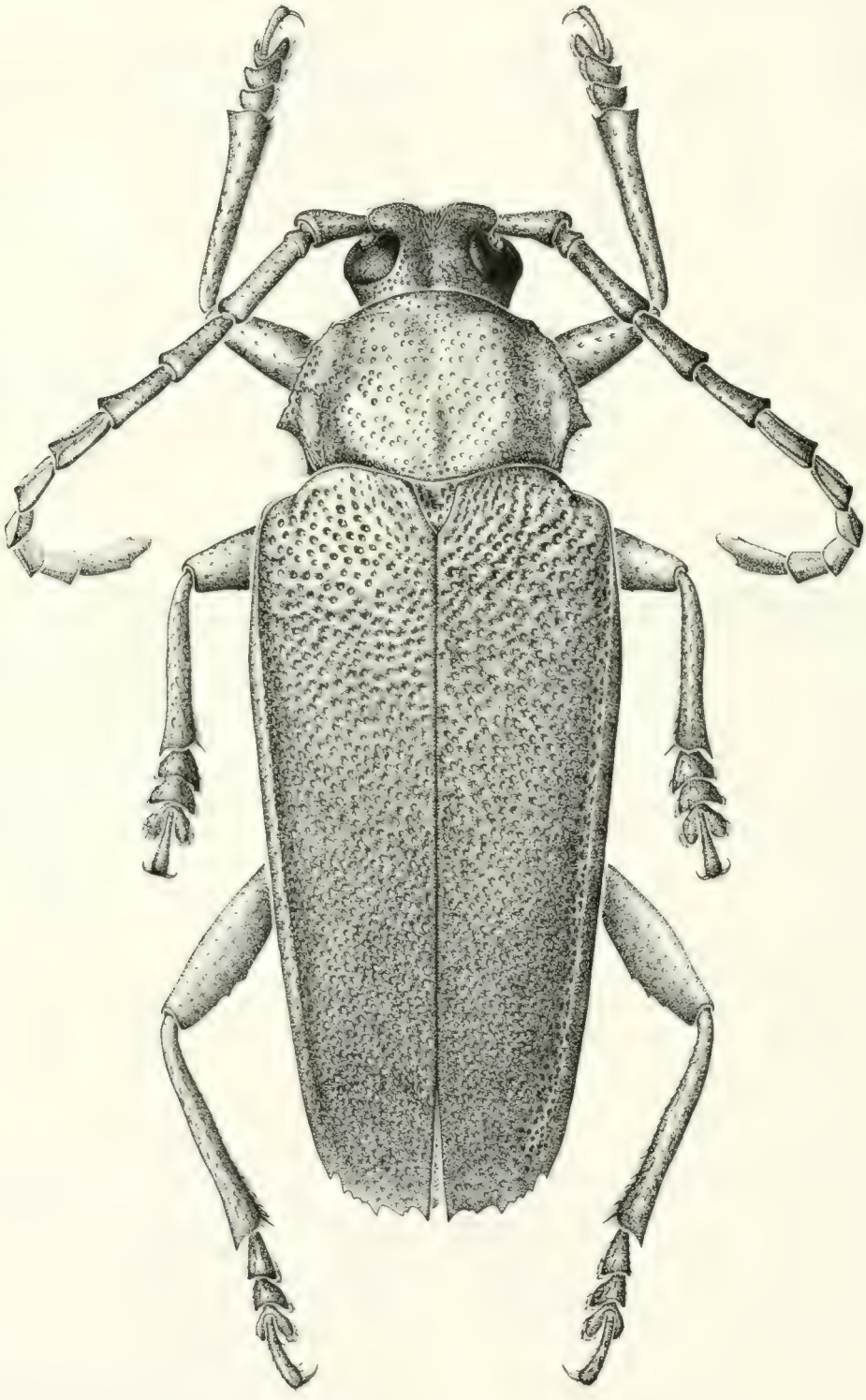

Fig. 1. *Derancistrus fellerae* Chemsak, male.

about third abdominal segment, segments broad, flattened, basal segments sparsely, shallowly punctate, poriferous area small on third segment, areas increasing to sixth segment, segments from seventh entirely opaque, third segment longer than first, fourth subequal to first, eleventh longer than tenth. Pronotum broader than long, sides gradually expanding back from apex to behind middle then narrowing to base, margins crenulate, angles dentate; disk shallowly impressed at middle behind apical margin; punctures irregular, middle with irregular glabrous areas; sides behind dentate angles with a small patch of whitish recumbent pubescence; prosternum sparsely pubescent; meso- and metasternum with patches of white appressed pubescence at sides. Elytra about twice as long as broad; punctures at base coarse, confluent, becoming finer toward apex; apices serrated. Legs slender, sparsely punctate and pubescent. Abdomen with sternites narrowly glabrous on posterior margins; last sternite emarginate at apex. Length, 18 mm.

The male is much smaller and more slender than the female. The antennae are longer with opaque outer segments, and pubescent patches are lacking along the anterior margins and base of the pronotum.

Larvae of this species have been collected from the wood of red mangrove, black mangrove, white mangrove, and buttonwood.

One specimen is deposited in the USNM and the other in the Essig Museum.

Methia rhizophorae Chemsak & Feller, New Species (Methiini)

Female.—Form slender, rather elongate, elytra dehiscent toward apex; color fuscus, head, pronotum and appendages at least partially orange-brown, elytra often paler along suture at basal one-half. Head slightly wider than pronotum; eyes separated on vertex by less than diameter of third antennal segment, separated beneath by more than diameter of scape, lobes of eyes connected by a single row of facets; front finely asperate; antennae extending about four segments beyond body, scape lacking an apical tooth, basal segments dark apically, pubescence rather short, dense, suberect; neck deeply, narrowly impressed medially behind eyes. Pronotum broader than long, sides broadly rounded; apex and base transversely impressed; disk convex, medially impressed before basal margin; punctures finely scabrous; pubescence pale, dense, subdepressed, long; stridulatory plate of mesonotum not grooved; prosternum narrowly impressed at apex, finely plicate. Elytra extending to second abdominal segment; each elytron vaguely bicostate; punctures moderately coarse, shallow, subconfluent; pubescence pale, moderately dense, suberect. Legs moderate; femora finely, transversely plicate; pubescence moderately dense. Abdomen with last sternite deeply v-shaped at apex, margins with a row of setae. Length, 10–11 mm.

Male.—Form small, slender; color brownish, antennae pale orange-brown on basal segments, scape infuscated over apical two-thirds, elytra pale at middle and at apex. Head with front asperate; eyes separated above by less than diameter of third antennal segment, beneath by more than diameter of scape, lobes connected by a single row of facets; antennae extending almost five segments beyond body, segments densely clothed with short erect and suberect pubescence. Elytra brownish basally with vague brownish vittae extending down middle of disk to preapical depressions to form transverse dark spots; punctures fine, dense, confluent basally and contiguous toward apex; pubescence pale, short, subdepressed. Abdomen not modified. Length, 6–7 mm.

Holotype ♀, allotype, from Twin Cays, Belize, 4 June 1985, 21 May 1986, in red mangrove (C. Feller); paratypes, 1 ♂, 21 May 1986; 2 ♀, 2 June 1985, 21 May 1986, from red mangrove.

This species resembles *M. constricticollis* Schaeffer from Texas and Mexico by the

coloration of the antennae. The two differ by the coarsely punctate head, the eye lobes connected by 2–3 facets and by the feebly rugose elytra in *M. constricticollis*.

The female paratypes are slightly paler in color with a pale vitta along the basal half of the suture of the elytra.

Ataxia cayensis Chemsak & Feller, New species (Ataxiini)

Fig. 2

Male.—Form moderate-sized, slightly tapering posteriorly; integument piceous, appendages slightly reddish-piceous; pubescence moderately dense, grayish, fine, appressed. Head with front rather coarsely, deeply punctate, punctures well separated, pubescence appressed, interrupted by punctures, recurved setae arising from each puncture with longer erect hairs around eyes and mouthparts; vertex with a median line, sparsely punctate; antennae about as long as body, segments from fourth paler at bases, segments finely pubescent, long, erect hairs beneath numerous, scape with a fine, apical cicatrix, third segment subequal to first, fourth longer than third. Pronotum slightly broader than long, lateral tubercles small; disk very coarsely, irregularly punctate, medially shallowly impressed behind middle; pubescence mottled, appressed, with recurved setae arising from punctures; prosternum coarsely, sparsely punctate, rather sparsely pubescent; mesosternum with intercoxal process arcuately declivous; metasternum with pubescence interrupted by small glabrous spots. Elytra about twice as long as broad; disk shallowly costate with coarse punctures arranged linearly down intervals, punctures becoming finer toward apex; pubescence fine, mottled, with whitish flecks of denser pubescence interspersed, suberect hairs short; apices subtruncate. Legs moderately densely pubescent, pubescence interrupted by small spots. Abdomen moderately densely pubescent, small glabrous spots numerous; last sternite very shallowly emarginate at apex. Length, 11 mm.

Female.—Form similar to male. Antennae slightly shorter than body. Abdomen with last sternite shallowly impressed, truncate at apex. Length, 10.5–12 mm.

Holotype ♂ and one ♀ paratype from Twin Cays, Dangriga Dist., Belize, 4–5 June 1985. "Fogging Proj. Black Mang." (T. L. Erwin, L. L. Sims, W. N. Mathis); one female paratype, Twin Cays, emerged 29 May 1986, from larva from red mangrove twig terminal (C. Feller); one ♀ paratype, Twin Cays, mudflat nr. Lairchan, 15–19 January 1987 (W. N. Mathis, C. Feller).

This species is distinctive by its small size, dark integument with paler appendages, and fine, dense pubescence of the elytra with small whitish flecks interspersed.

The antennae and legs of the first paratype are paler reddish than those of the type.

Leptostylopsis latus Chemsak & Feller, New Species (Acanthocini)

Fig. 3

Female.—Form moderate-sized, broad; integument reddish brown, underside partially infuscated; pubescence dense, short, fine, appressed, pale and dark brownish. Head with front about as broad as long, micropunctate with larger punctures sparsely interspersed, pubescence fine, pale brownish, interrupted by glabrous spots; genae as long as lower eye lobes; upper eye lobes small, separated by diameter of antennal scape; antennae a little longer than body, segments dark annulate at bases and apices, segments to fifth with small dark spots, third segment slightly longer than first, fourth shorter than first. Pronotum much broader than long, sides tumid, vaguely tuberculate slightly behind middle; disk with five shallow calluses, three median more prominent; punctures around median callus sublinearly arranged between transverse rugosities, punctures at sides finer, scattered; pubescence fine, interrupted by punctures, broadly dark medially, small dark spots interspersed over remaining surface; prosternum finely pubescent, intercoxal process

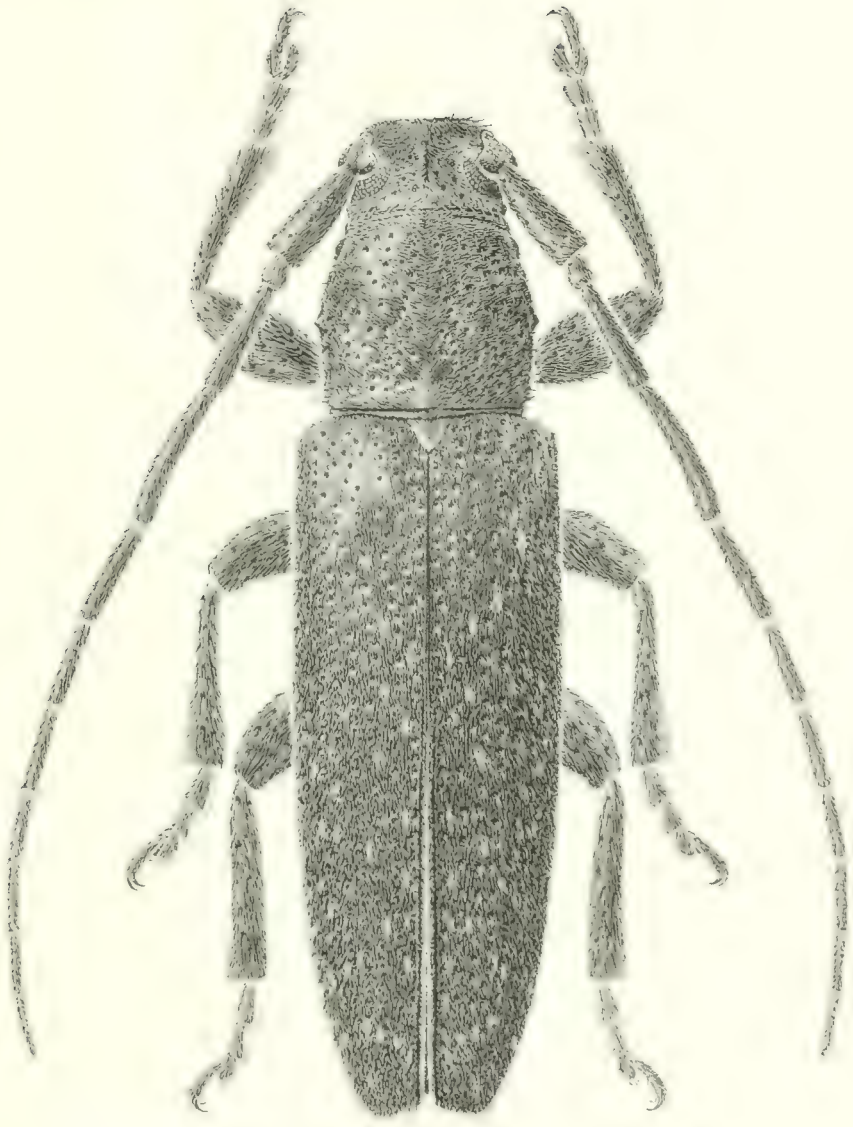

Fig. 2. *Ataxia cayensis* Chemsak & Feller, male.

more than one-half as broad as coxal cavity; meso- and metasternum with darker spots, mesosternal process broader than coxal cavity. Elytra about 1½ times as long as broad, tapering apically; basal gibbosities shallow, impression behind deep; disk with a few tufted tubercles down costae, basal ones elongate; pubescence dense, appressed, brownish, each side with a dark lateral vitta extending from humerus to a little behind middle, basal impressions dark, apical one-half with dark linear markings on suture and on disk before apex, tubercles pale pubescent; apices narrowly, shallowly emarginate truncate. Legs robust, femora with small spots; tibiae dark biannulate; tarsi dark, first segments basally and claws pale. Abdomen thinly pubescent, sternites dark along apical

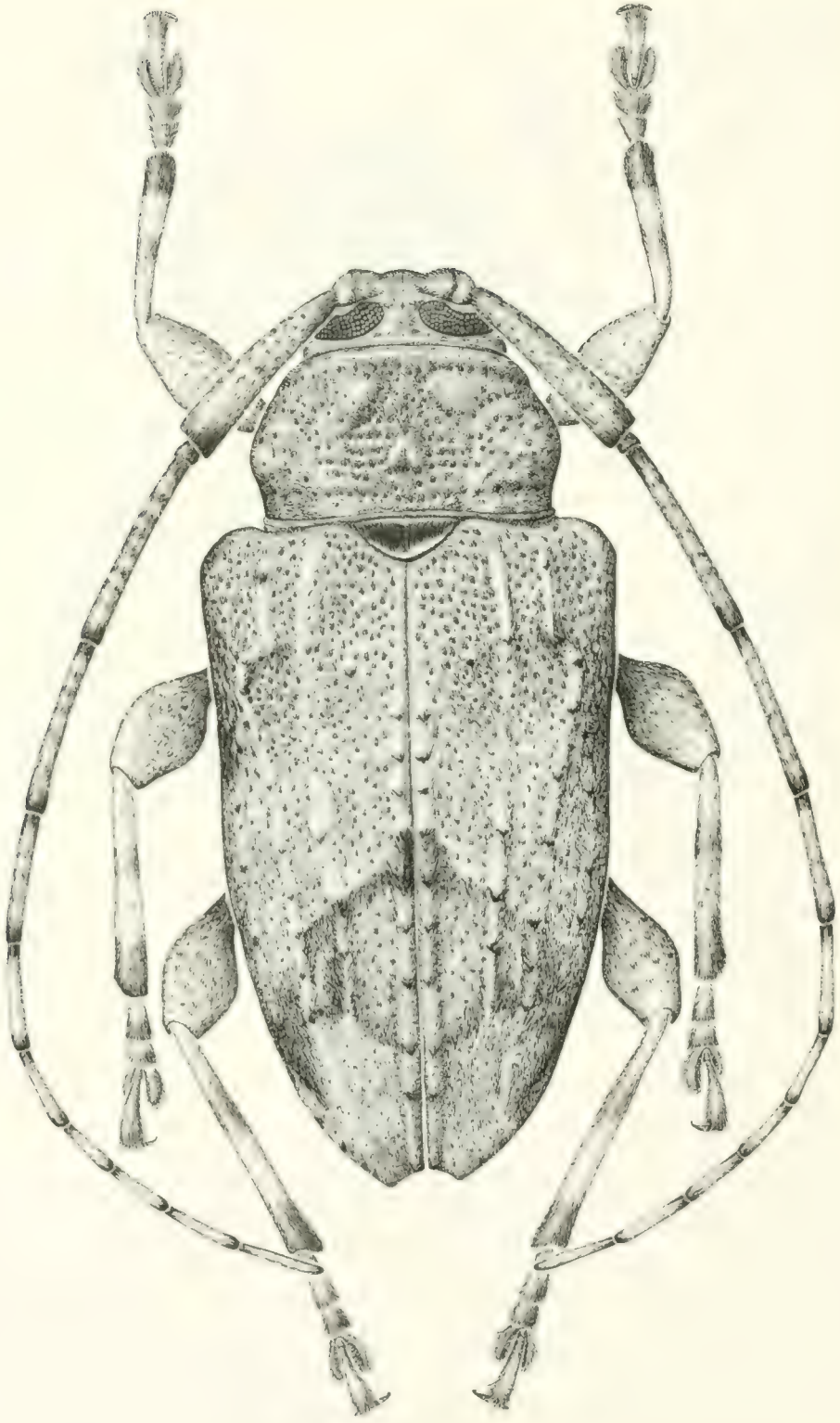

Fig. 3. *Leptostylopsis latus* Chemsak & Feller, female.

margins; last sternite slightly elongate, apex narrowly truncate. Length, 13 mm.

Holotype ♀ from Twin Cays, Belize, 5 May 1985 (26–85), in red mangrove (C. Feller and Canupp).

The broad form and distinctive punctation and rugosities of the pronotum make this species distinctive. The type is slightly teneral, probably making the integumental coloration paler than in fully mature specimens.

Styloleptus rhizophorae Chemsak & Feller, New Species (Acanthocini)

Fig. 4

Male.—Form small, subdepressed; integument pale reddish-brown, head infuscated, antennae with scape dark dorsally, other segments dark annulate at apices, legs with tibiae broadly dark biannulate, femora with clavate portion dark on outside and inside, elytra with dark fasciae and an irregularly margined, oblique whitish fascia on each side at middle; pubescence very short, depressed, grayish and black. Head with front convex, micropunctate, pubescence short, depressed, mouthparts with several erect setae; antennal tubercles moderate, widely divergent; vertex impressed between eyes, convex behind; eyes coarsely faceted, upper lobes separated by more than width of lobes, lower lobes almost twice as long as genae; antennae rather short, extending about four segments beyond elytra, scape barely attaining middle of pronotum, third segment longer than first, fourth equal to first, segments dark mottled, dark annulate at apices, pubescence very fine, depressed. Pronotum almost twice as broad as long, sides with broadly rounded calluses behind middle; disk with three small calluses, one median and one on each side near apical margin; punctures fine, scattered, linear on basal impression; basal transverse impression broad, extending onto sides; pubescence fine, appressed, variegated gray and brownish, sides at base with two long erect setae; prosternum with intercoxal process plane, slightly narrower than coxal cavities; mesosternum with intercoxal process almost plane, as broad as coxal cavities, broader than prosternal process; metasternum finely gray pubescent, pubescence interrupted by small spots. Elytra about 1.75 times longer than basal width, sides slightly expanding behind middle then tapering at about apical one-fourth; basal calluses low, not tufted, basal impression rather small, extending down outside and below calluses; costae vague; punctures moderately coarse basally, becoming finer and sparser toward apex; pubescence fine, depressed, middle with a broad, irregularly margined, oblique, whitish vitta which extends back from suture to lateral margins, sides behind humeri with black vittae, an irregular dark vitta present behind oblique whitish vitta, surface with a few small, black spots particularly along suture; apices narrowly, obliquely truncate. Legs short; femora clavate; pubescence fine, appressed, mottled grayish and brownish; metatibiae with an external sinus. Abdomen finely punctate and pubescent; fifth sternite slightly longer than fourth, subtruncate at apex. Length, 5.5 mm.

Female.—Form similar. Antennae slightly shorter. Abdomen with fifth sternite much longer than fourth, narrowly, shallowly emarginate at apex. Length, 6 mm.

Holotype ♂ from Twin Cays, emerged from red mangrove 14 July 1986 (C. Feller) (twigs collected 26 May 1986). One ♀ paratype, same data, emerged 1 July 1986.

The whitish vitta of the elytra is more pronounced in the male. In the female this band does not extend to the margins and a few narrow pale vittae extend forward and back on the disk. The suture is also narrowly pale.

The previously described species of *Styloleptus* are West Indian with two extending into the United States. This species is the first of this genus from the Central American mainland area. The possibility does exist, of course, that the placement of this species into *Styloleptus* is incorrect. Such

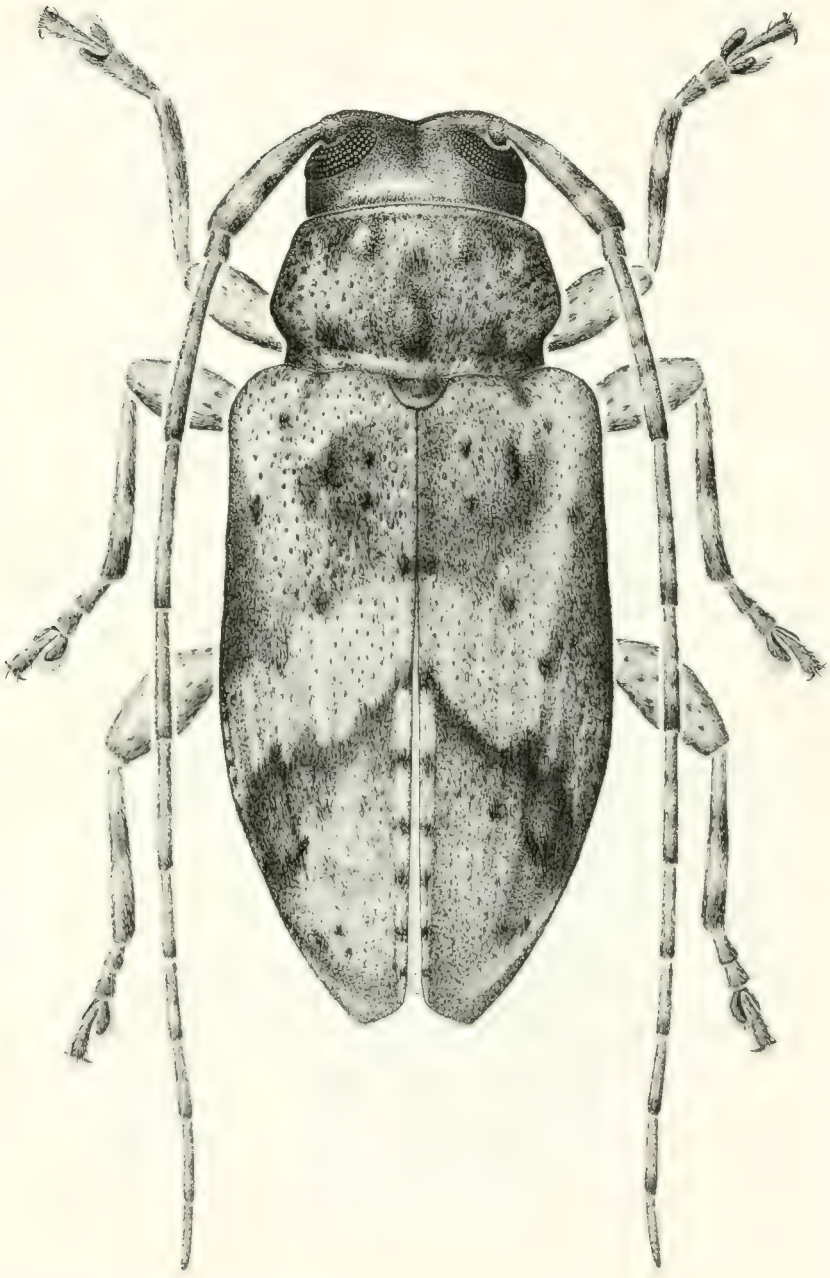

Fig. 4. *Styloleptus rhizophorae* Chemsak & Feller, male.

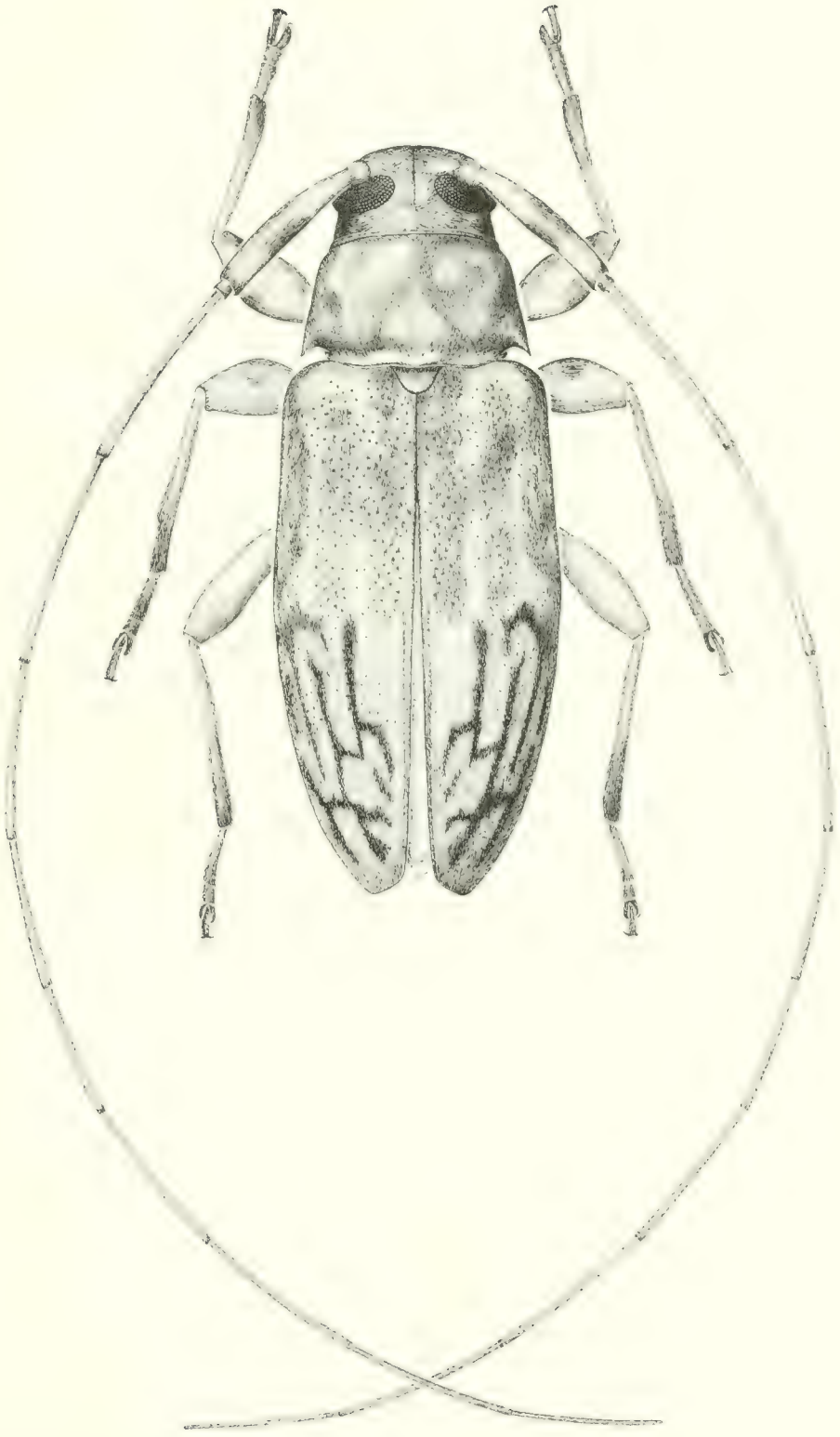

Fig. 5. *Urgleptes ozophagus* Chemsak & Feller, female.

problems must be resolved by a generic revision of the very large and taxonomically difficult tribe Acanthocini.

Urgleptes ozophagus Chemsak & Feller, New Species (Acanthocini)

Fig. 5

Female.—Form small, depressed; integument pale reddish brown, antennae yellowish brown and dark, legs yellow brown, tarsi and most of tibiae dark, elytra dark vittate basally at sides and with narrow, connected, dark vittae on apical one-half; pubescence very fine, appressed, grayish and dark brown. Head with front slightly convex, broad, micropunctate, pubescence short, pale, appressed, margin of frons with several long, suberect setae near sides; vertex convex, medially impressed before inner eye margins; eyes with lower lobes rounded; genae slightly shorter than lower eye lobes; antennae extending about five segments beyond elytra, scape shorter than third segment, fourth longer than third, scape broadly dark annulate, segments very finely pubescent, third segment with several short, subdepressed, dark setae beneath. Pronotum broader than long; disk lightly convex, densely micropunctate, basal impression with a row of fine, deep punctures; pubescence pale, fine, appressed; prosternum with intercoxal process narrow; mesosternum with intercoxal process narrow; metasternum densely clothed with pale, appressed pubescence. Elytra about twice as long as broad, sides tapering behind middle; disk feebly impressed at basal one-fourth; punctures moderately coarse, dense, becoming obsolete near apex; pubescence short, fine, grayish, appressed, sides with broad dark vittae extending from base to about middle, apical one-half with dark, narrow reticulate-like vittae; apices narrowly obliquely truncate. Legs finely pubescent; femora pale with infuscated patches near apices; tibiae pale basally, dark over apical two-thirds; tarsi dark. Abdomen pale, finely densely pubescent; fifth sternite twice as long as fourth, apex narrowly, shallowly emarginate. Length, 5.5 mm.

Holotype ♀ from Twin Cays, emerged 15 July 1986, from twig terminal of red mangrove (C. Feller). Two ♀ paratypes, Twin Cays, N. shore of W. Island, 20 January 1987, on *R. mangle* (W. Mathis) and Weather Station, 21 January 1987, ex *R. mangle*.

The small size and reticulate-like vittae on the apical half of the elytra make this species distinctive.

Acknowledgments

This is contribution no. 196, Caribbean Coral Reef Ecosystems Program (CCRE), Smithsonian Institution, partially funded by a grant from Exxon. Candy Feller prepared the illustrations.

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PROC. ENTOMOL. SOC. WASH.
90(2), 1988, pp. 189–192

CEROPTERA LONGICAUDA, A SECOND NORTH AMERICAN SPECIES IN THE KLEPTOPARASITIC GENUS *CEROPTERA* MACQUART (DIPTERA: SPHAEROCERIDAE)

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Abstract.—***Ceroptera longicauda***, new species, is described from specimens collected in Levy and Leon Counties, Florida. It is compared to *C. sivinskii* Marshall, and new distributional data for the latter species is presented.

Key Words: Sphaeroceridae, Diptera, taxonomy, Kleptoparasite

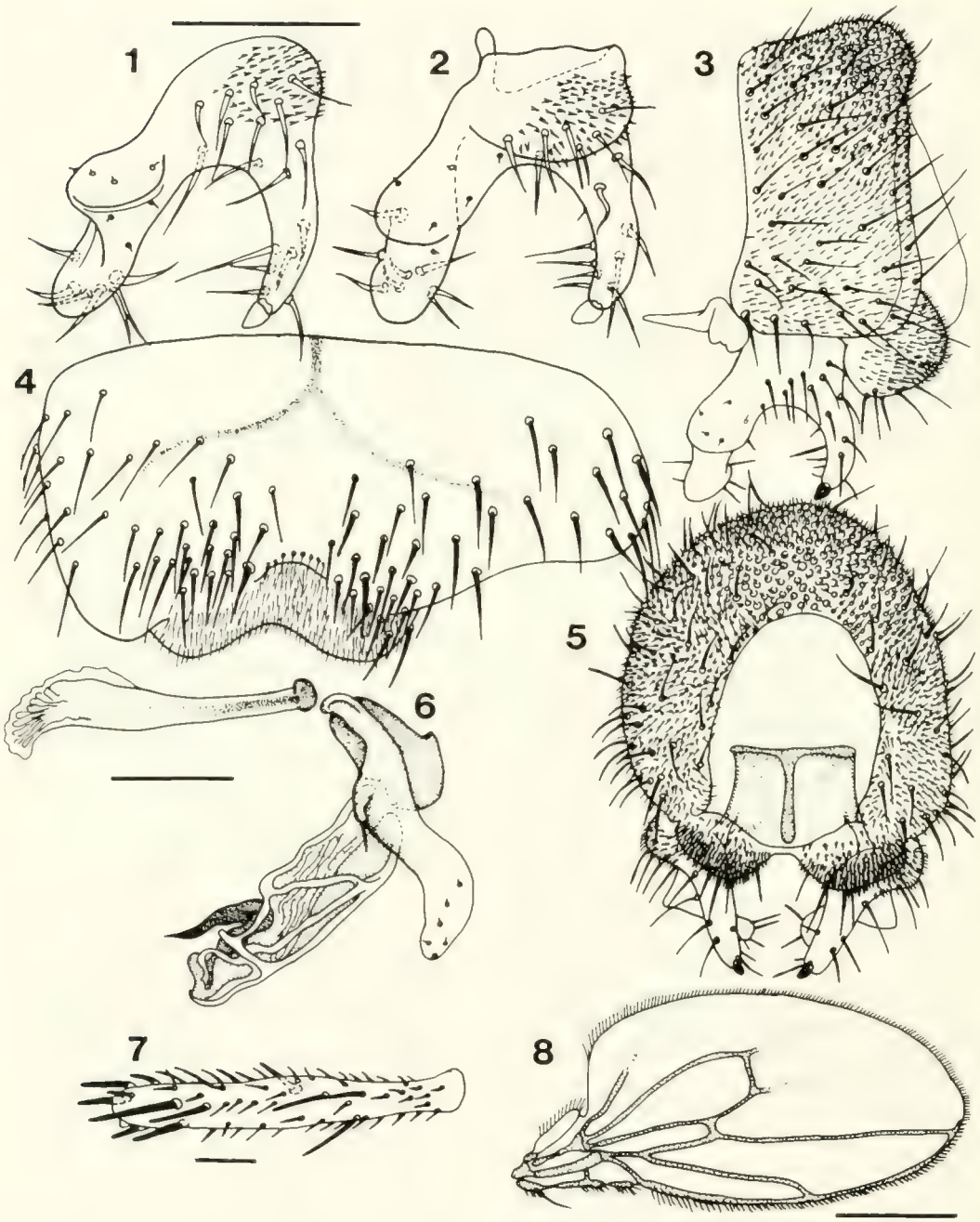
Ceroptera is widespread in the warmer parts of the Old World, with 16 African species, 8 Palaearctic species, and a single species described from Ceylon. This genus was first recorded from the Nearctic region with the description of *Ceroptera sivinskii* Marshall 1983. All species of *Ceroptera* for which biological information is available are associated with dung-rolling scarab beetles. Adult *Ceroptera* have been observed frequently clinging to dung beetles and were first observed to oviposit in scarab dung balls by Roubaud (1916). Sivinski (1983) demonstrated that *Ceroptera sivinskii* is phoretic and kleptoparasitizes dung caches of scarab beetles in north Florida. *Ceroptera sivinskii* has been observed in association with *Phanaeus vindex* MacLeay, *Geotrupes egeriei* Germar, *Copris minutus* (Drury), and *Canthon pilularius* (L.). It has also been reared from the dung cache of *Copris* sp. (Sivinski 1983). *Ceroptera longicauda*, new species, was observed to cling to the elytra of the scarab *Mycotrupes gaigei* Olson and Hubbell. *Ceroptera longicauda* is similar to other *Ceroptera* in possessing strikingly small eyes, a long narrow interfrontal area, 2 long rows of orbital setulae, a small apical spur on the hind tibia, a retractile female abdomen with tubercle-based setae in the membrane, and a deeply bilobed surstylus. Similarities shared between the two Nearctic species include the apparently synapomorphic, strongly modified male sternite 5 and several probably plesiomorphic character states such as the incompletely cleft surstylus and relatively well sclerotized abdomen. Furthermore, the legs of *C. longicauda* are not as strongly modified (for grasping the host) as those of the Old World species. *Ceroptera longicauda* can be differentiated from *C. sivinskii* by the following key:

1. Lunule broadly rounded anteriorly. Wing membrane brown tinted. Two pairs of dorsocentral bristles. Epandrium posterodorsally elongated and tapered, covered with microtubercles (Fig. 3). Anterior surstylar lobe with a large outer lobe (Figs. 1, 2). Female cerci less than twice as long as wide (Fig. 9) ..... *C. longicauda*
– Lunule angulate anteriorly. Wing membrane clear. One pair of dorsocentral bristles. Epandrium simple. Anterior surstylar lobe with a straight outer surface. Female cerci more than twice as long as wide ..... *C. sivinskii*

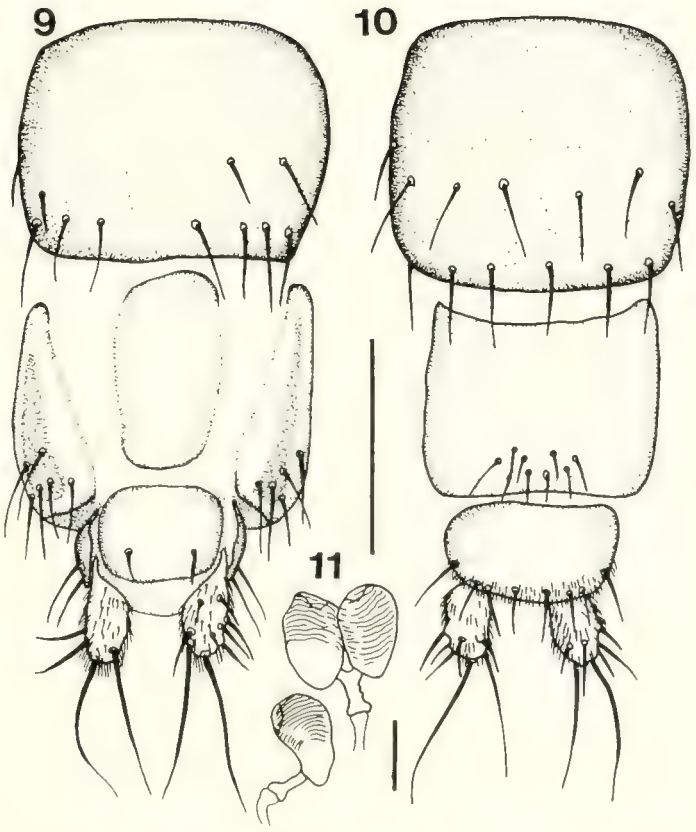
Ceroptera longicauda Marshall

Figs. 1–11

Description.—Body length 2.1–2.7 mm. Color dark brown; tarsi, apices of tibiae, gena, frons and face paler. Interfrontal area



Figs. 1–8. *Ceroptera longicauda*, male. 1, Left surstylus, posteroventral. 2, Left surstylus, lateral. 3, Terminalia, left lateral. 4, Sternite 5. 5, Terminalia, posterior. 6, Aedeagus, aedeagal apodeme and paramere, left lateral. 7, Left tibia, dorsal. 8, Left wing. Scales for Figs. 1–2 as on Fig. 2; for Figs. 3–6 as on Fig. 6. Scale bar for Fig. 8 = 0.5 mm; other scale bars = 0.1 mm.



Figs. 9–11. *Ceroptera longicauda*, female. 9, Terminalia, dorsal. 10, Terminalia, ventral. 11, Spermathecae. Scale bars = 0.1 mm.

long and narrow, 0.2× as wide as frons, 0.4× as wide as high; bordered by 5–6 equal interfrontal bristles. Orbital setulae forming 2 rows; only outer, exclinate row well developed and extending below eye. Face broadly carinate, lunule triangular with a broadly rounded apex. Flagellomere 1 small, 1.5 times as broad as long; arista arising dorsobasally, 2.1× length of rest of antennae. Eye small, 0.8× genal height. Thorax with 2 pairs of dorsocentral bristles, anterior pair slightly longer than acrostichal setulae, posterior pair subequal in length to broad scutellum. Acrostichal setulae in 7–8 rows between dorsocentral areas; prescutellar pair not enlarged. Katepisternum with a large posterodorsal bristle reaching 0.8× distance to wing base, 1 or 2 small anterodorsal setulae, and several ventral setulae. Legs long, all tarsi elongate and curved, distinctly longer than tibiae, with enlarged pulvulli and claws. Mid tibia with 2 anterodorsal and 1 posterodorsal bristle on proximal half; 1 anterodorsal, 1 dorsal and 1 posterodorsal bristle just below middle; 1 very long dorsal bristle in apical quarter; apical part of mid tibia with large anterior and smaller posterior preapical bristles and with a long apicoventral bristle; ventral surface of mid tibia with 1 long bristle near middle. Hind tibia with a weak apicoventral spur and 2 weak distal dorsal bristles, each shorter than tibial width. Hind tarsomeres with short, stout apicoventral bristles. Wing membrane dis-

tinctly brown tinted, second costal sector 1.1× as long as third in male, 1.2× in female (Fig. 8).

Male terminalia: Sternite 5 elongate, posteromedial margin bilobed, setulose, projecting over genital pouch (Fig. 4). Epandrium narrowed and elongated posterodorsally; posterodorsal surface covered with microtubercles (Figs. 3, 5). Cerci bulbous, distinctly differentiated from epandrium. Hypandrium small short, simple (Fig. 3). Surstyli deeply cleft; anterior lobe with a large lateral process; posterior lobe more slender, with a stout apical spine (Figs. 1, 2). Distiphallus elongate, well sclerotized, with a prominent distal ventral medial sclerite. Basiphallus short, simple; ejaculatory apodeme apparently absent. Paramere almost parallel sided, weakly bent anteriorly near apex (Fig. 6).

Female terminalia: Abdomen strongly telescoping; membrane with short, scattered, tubercle-based setae. Tergite 8 with tripartite pigmentation, median part bare (Fig. 9). Epiproct pale medially and posteriorly, with 2 small setae. Hypoproct broad, setulose posteriorly (Fig. 10). Cerci short, less than twice as long as wide, with long apical bristles. Spermathecae ovate, bent, swollen apically, with a small invagination at apex; ducts short, inserted eccentrically (Fig. 11).

Types.—Holotype ♂, Florida, Levy Co., west of Archer, 15.iii.1987, ex. *Mycotrupes gaigei,* Paul Skelley (BRI). Paratypes: Florida, 26 ♂, 43 ♀, same data as holotype; 2 ♂, 5 ♀ same data except i.iii.1987, (GUE, FSC, BRI); Levy Co., 17.iii.1976, pitfall trap, L. R. Davis (3 ♀, FSC); Leon Co., Tall Timbers Research Station, 8–15.x.1969, pitfall, D. L. Harris (2 ♂, 2 ♀, FSC).

Ceroptera sivinskii Marshall

Ceroptera sivinskii Marshall 1983: 139.

Material made available since 1983 has extended the known distribution and allowed two amendments to the original description. The size range is modified to 1.4–2.5 mm, with the majority of specimens less than 2.0 mm (outside the range of the larger *C. longicauda*). The dorsal part of the epiproct, transparent and apparently membranous on the type material, is lightly sclerotized and weakly pigmented at least posteriorly on most other specimens, as in *C. longicauda.*

New records (75 specimens): Florida, Liberty Co., 10 mi. SW. Juniper, Rt. 12, 26.iii.1983, pig dung among Turkey Oaks, Woodruff and Thomas (FSC); Marion Co., Ocala National Forest, Rd. 65, 1.5 mi. W. State Rd. 19, 15–16.iii.1984, dung trap, R. Woodruff (FSC); Alachua Co., Gainesville, Hogtown Creek, 12.x.1976, P. M. Choat & R. E. Woodruff (FSC); Okaloosa Co., 1 mi. N. Holt, Blackwater River Nat. For., 23.x.1978, L. Stange, human dung trap among Turkey Oaks (FSC). Alabama, Covington Co., 1.7 mi. E. jct. Rt. 84 & Rt. 55, pig dung trap, 4–10.iii.1977, Woodruff and Wiley (FSC). Massachusetts, Nonamesset Id., vi.24.23, sheep dung (1 ♂, A. H. Sturtevant Collection, USNM).

Acknowledgments

We thank NSERC for financial support and T. Wheeler for helpful comments. P. Skelley and R. E. Woodruff of the Florida State Collection of Arthropods, Gainesville (FSC) made much of this material available to us. Specimens not deposited at FSC are at the University of Guelph (GUE), the Biosystematics Research Centre in Ottawa, Ontario (BRI) or the United States National Museum, Washington (USNM).

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PROC. ENTOMOL. SOC. WASH.
90(2), 1988, pp. 193–195

A REVIEW OF THE SPECIES OF *ACRITISPA* UHMANN (COLEOPTERA: CHRYSOMELIDAE, HISPINAE)

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Abstract.—The literature on *Acritispa* is reviewed. *Octotoma germaini* Pic is transferred to *Acritispa*. The two included species are redescribed and a key is presented: these species occur in Central and South America.

Key Words: Coleoptera, Chrysomelidae, Hispinae, *Acritispa*

The species of the genus *Acritispa* were examined in connection with ongoing revisionary studies on the subfamily Hispinae (Staines 1986a, b, 1987). The name *Acritispa* was first published by Uhmann (1937); in this genus he placed the species *Physocoryna dilatata* Uhmann. Under Article 13b (Internat. Code Zool. Nomen. 1985) the generic name was a nomem nudem because no type species was designated. Uhmann (1940) designated *Acritispa dilatata* (Uhmann) as the type species of the genus validating the name. Papp (1953) listed five species in *Acritispa*: *dilatata, nigritarsis* (Weise), *triquetra* (Uhmann), *viridiceps* (Pic), and *viridinotata* (Pic). Uhmann (1957) placed all but *dilatata* in the genus *Probaenia* Weise.

Acritispa is in the tribe Uroplatini (Weise 1911) which is characterized by having the last antennal segments very closely united and the antennae appearing as three to eight segmented. The tribe is represented by thirty-two genera. *Acritispa* is distinguished by the following combination of characters: antennae short, not exceeding the base of the pronotum; 8-segmented, segments I and II subequal, VII as wide as VIII and difficult to distinguish as a separate segment; VIII not longer than the four preceeding segments combined. Pronotum with two toothlike projections on lateral margins. Elytra expanded to apex; plications over entire surface.

Acritispa Uhmann

Acritispa Uhmann 1940: 143 (type species: *A. dilatata* (Uhmann)). Uhmann 1937: 336, Blackwelder 1946: 729, Uhmann 1950: 267, Papp 1953: 93, Uhmann 1957: 115, 1964: 11, Gaedike & Dobler 1971: 347, Seeno & Wilcox 1982: 161.

General habitus: Size small (4.0–5.8 mm), with elytra greatly expanded at apex. Head: Vertex micropunctate; median sulcus present; antennae 8-segmented, I–II subequal, III widened apically, VII as wide as VIII and difficult to distinguish as a separate segment, VIII clavate, hirsute. Pronotum: Wider than long; tooth present on anterior margin on each side of head; two toothlike projections on lateral margins; covered with coarse punctures. Elytra: Greatly expanded at apex; translucent at exterior apical angles; plications over entire surface; lateral margins flattened, dentate; apical margins flattened, dentate. Profemur expanded apically.

Measurements were taken with an ocular micrometer. Pronotal length and width were taken along the midlines. Elytral width was measured at the humeri. Elytral length was

measured from the base to apex. Total length was measured from the base of the frontal sulcus to the apex of the elytra.

Key to the Described Species of *Acritispa* Uhmann

1. Vertex of head with median sulcus faint; body color black ..... *dilatata* (Uhmann)
– Vertex of head with median sulcus deep and wide; body color reddish-brown .. *germaini* (Pic)

Acritispa dilatata (Uhmann)

Physocoryna dilatata Uhmann 1932: 266 (type not seen; type locality Brazil, Bahia; holotype deposited in Deutschen Entomologischen Institutes (Gaedike & Dobler 1971)).

Acritispa dilatata (Uhmann): Uhmann 1937: 336, 1940: 143, 1950: 267, Papp 1953: 93, Uhmann 1957: 115, 1964: 11, Gaedike & Dobler 1971: 347.

Body color black. Head: Median sulcus present, faint; three punctures on inner margin of each eye; vertex rugose, micropunctate; antennae reddish; segments I–II transverse, I largest; III–VI compressed, smaller than I or II. Pronotum: Two tubercles present on disc behind midline; covered with coarse punctures; basal margin bisinuate; surface micropunctate; length 0.7–0.8 mm (avg. 0.75, n = 4); width 1.1–1.3 (avg. 1.2). Elytra: Covered with large plicae; lateral margins dentate, more so at base; rows of punctures visible between plicae; length 3.1–3.6 (avg. 3.3); width 1.7–1.9 (avg. 1.75). Legs: Reddish. Venter: Pro- and metasterna alutaceous; mesosternum punctate in middle; abdomen red. Total length: 4.0–4.4 (avg. 4.2).

Discussion: Life history unknown. Immature stages undescribed. This species can be distinguished from *A. germaini* by the less pronounced basal elytral plications, the faint median sulcus on the vertex of the head, and the black body color.

Larval host plant: Unknown.

Distribution: Brazil and Paraguay.

Specimens examined: BRAZIL: Lambary, XI/1926 (USNM); Parahyba, IX/1884 (USNM); Sao Paulo (USNM). PARAGUAY: central, 1885 (USNM). Total: 4.

Acritispa germaini (Pic), New Combination

Octotoma germaini Pic 1925: 1 (Holotype: Cochabamba (Bolivie), Germain/*Octotoma* n. sp./Museum Paris, coll. M. Pic/Type/*germaini* n. sp. (MNHN)). Uhmann 1927: 136, Blackwelder 1946: 729, Papp 1953: 93, Uhmann 1957: 116, Descarpentries & Villiers 1959: 149.

Body color reddish-brown. Head: Median sulcus deep, wide; ledge over base of antennae; antennae reddish-brown, segment I–II punctate; III widened apically, longer than I or II, punctate, IV–VI transverse, punctate, VII wider, fringe of setae on apical margin, VIII hirsute, pointed apically, three whorls of setae. Pronotum: Two tubercles present on disc near midline; areas between punctures micropunctate; callous present near right tubercle; length 0.9–1.4 mm. (avg. 1.1; n = 3); width 1.3–1.5 (avg. 1.4). Scutellum: Light reddish-brown; rounded at apex. Elytra: Apical margin less dentate than lateral margins; puncture rows visible between plications; base explanate, expanded over base of pronotum; plications very large, especially on basal half, less raised on apex; length 3.6–4.4 (avg. 3.9); width 1.9–2.5 (avg. 2.1). Legs: Reddish-brown, except femur which is black; femur with large punctures at apex. Total length: 4.3–5.8 (avg. 4.8).

Discussion: Life history unknown. Immature stages undescribed. This species can be distinguished from *A. dilatata* by the more pronounced basal elytral plications, the deep median sulcus on the vertex of the head, and the reddish-brown body color.

Larval host plant: Unknown.

Distribution: Bolivia and Panama.

Specimens examined: PANAMA: Porto Bello, 11/VIII, 19/III/1911 (USNM); Canal Zone, Fort Kobbe, 20/VI/1976 (EGRC). BOLIVIA: Cochabamba (MNHN). Total: 4.

Acknowledgments

I thank N. Berti, Museum National d'Histoire Naturelle, Paris (MNHN), for the loan of the Pic type; R. E. White, Systematic Entomology Lab, USDA (USNM) for access to that collection and E. G. Riley (EGRC) for the loan of the material from his collection. R. E. White and L. LeSage, Biosystematics Research Institute, Agriculture Canada, commented on an earlier draft of this manuscript.

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PROC. ENTOMOL. SOC. WASH.
90(2), 1988, pp. 196–200

DIGONOGASTRA: THE CORRECT NAME FOR NEARCTIC *IPHIAULAX* OF AUTHORS (HYMENOPTERA, BRACONIDAE)

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Abstract.—The braconine genus *Iphiaulax* Foerster although frequently taken to include Nearctic and Neotropical species, is in fact restricted to the Old World. The correct generic name for most New World *Iphiaulax* of authors is *Digonogastra* Viereck. *Digonogastra* and its type species (*D. epicus* (Cresson)) are redescribed and illustrated. Diagnostic features of *Digonogastra* and *Iphiaulax* are provided. *Monogonogastra* Viereck is a junior synonym of *Digonogastra* Viereck.

Key Words: *Digonogastra, Iphiaulax, Monogonogastra,* Nearctic fauna, Braconidae, Braconinae

The Nearctic fauna of braconine wasps contains a number of described and many undescribed species that have traditionally been treated as species of *Iphiaulax* Foerster. *Iphiaulax* (type-species: *Ichneumon impostor* Scopoli) was originally described from Europe and is distributed throughout the Palearctic, Afrotropical and Indo-Australian regions. However, during the course of a revision of the World genera of Braconinae, it has become apparent that most, if not all, of the New World '*Iphiaulax*' species are not congeneric with those from the Old World despite some superficial resemblance. Viereck (1912) erected two new genera, *Digonogastra* and *Monogonogastra,* to receive a number of species of Nearctic *Iphiaulax* of authors on the basis of small differences in metasomal sculpture, but he still considered that *Iphiaulax* occurred in North America, and subsequently, Muesebeck & Walkley (1951) synonymized both of Viereck's genera with *Iphiaulax. Digonogastra* which is a senior synonym of *Monogonogastra,* appears to be the oldest available name for the Nearctic *Iphiaulax* group. In order to clear up these misunderstandings *Digonogastra* is redescribed below and features are given which enable its separation from *Iphiaulax* Foerster, and from the other New World genera of Braconinae. Many species will be reclassified elsewhere (Quicke, in press a).

Terminology follows that of van Achterberg (1979). The type material is located in the United States National Museum, Washington (USNM).

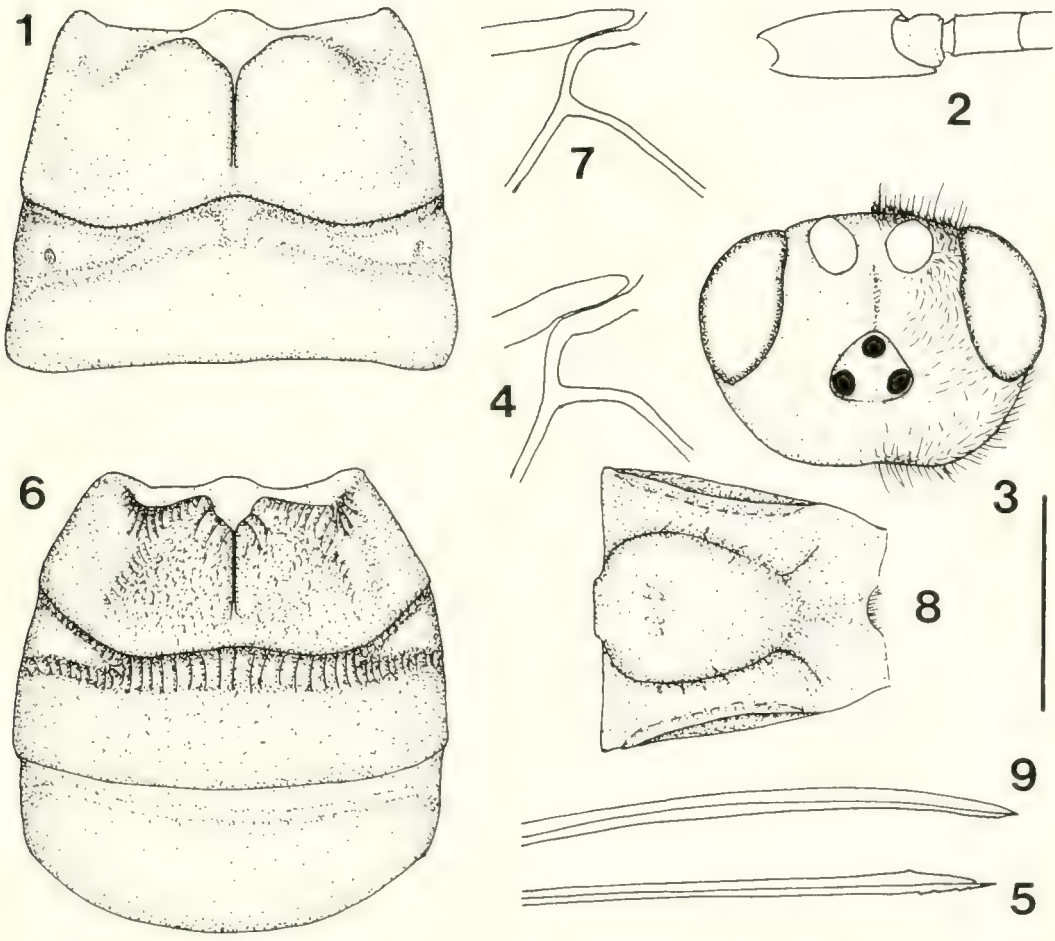
Digonogastra Viereck

Figs. 1–9

Digonogastra Viereck, 1912. Type-species: *Bracon epicus* Cresson, 1872; monobasic and original designation.

Monogonogastra Viereck, 1912. Type-species: *Bracon atripectus* Ashmead, 1889; monobasic and original designation.

Females.—Antennae approximately as long as the forewing. Median flagellomeres wider than long. Scapus sub-cylindrical, longer ventrally than dorsally, apicolaterally and (weakly) apicomedially emarginate (Fig. 2). Labiomaxillary complex not elon-



Figs. 1–9. Features of *Digonogastra* spp. 1–5. *D. epicus* 1, Metasomal tergites 1 & 2, dorsal aspect. 2, Right scapus, pedicellus, and basal flagellomere, lateral aspect. 3, Head, dorsal aspect. 4, Junction of veins 1-SR-M and 1-SR of right forewing. 5, Distal part of ovipositor. 6–9. *Digonogastra* selected species. 6, Metasomal tergites 2–4, dorsal aspect. 7, Junction of veins 1-SR+M and 1-SR of right forewing. 8, 1st metasomal tergite dorsal aspect. 9, Ovipositor. Scale line: Figs. 1–3, 6–7, 1.0 mm; Fig. 4, 0.67 mm; Figs. 5, 9, 1.3 mm; Fig. 8, 0.8 mm.

gate. Lower part of clypeus more or less strongly reflexed into the hypoclypeal depression, separated from the upper part by a carina. Clypeus usually separated from the face by a weak carina though sometimes the two are more or less contiguous. Face usually densely long setose. Eyes virtually glabrous. Frons usually generally, evenly impressed with a mid-longitudinal sulcus; usually extensively densely setose (Fig. 3), the setae often being more or less prostrate and silvery in appearance. Prosoma moderately contracted behind the eyes.

Mesosoma usually extensively setose, especially the scutellum, mesosternum and propodeum, smooth and shiny between the setae. Notauli usually distinctly impressed along most of the length of the mesoscutum. Scutellar sulcus usually narrow and distinctly crenulate. Precoxal suture absent. Pleural suture smooth and almost obliterated. Propodeal spiracle situated at about the middle

of the propodeum, approximately 2 × taller than long.

Forewing: Marginal and 2nd submarginal cells long. Vein 1-SR+M usually distinctly angled posteriorly shortly after arising from 1-SR (Fig. 4), but more or less straight in some species (Fig. 7). Vein cu-a usually interstitial, sometimes marginally postfurcal. Veins 1-SR and C+SC+R forming an angle of more than 55° (often 80°). Vein 1-M straight. Vein 3-CU1 not or hardly expanded posteriorly.

Hindwing: Vein 1r-m at least slightly shorter than SC+R1. Apex of vein C+SC+R with more than 1 especially thickened bristle (hamule), unless the length of the forewing is less than 5 mm. At least with a small glabrous area postero-distal to vein cu-a.

Claws with small, rounded basal lobes. Anterolateral aspect of fore tibia densely setose, without an apical transverse row of thick, peg-like bristles. Hind tibial spurs densely setose.

Metasoma generally depressed; general sculpture variable from largely smooth to rugose or foveate. 1st metasomal tergite with very well-developed dorso-lateral carinae and with a raised medial area which is well-separated from the dorso-lateral carinae. Median area of 1st metasomal tergite usually with at least a trace of a mid-longitudinal carina for a short distance on its posterior third, though sometimes this is only indicated by a pair of sub-medial pits (Fig. 8). 2nd metasomal tergite always with a distinct mid-basal area which is usually produced to form a mid-longitudinal carina (Figs. 1, 6); with a pair of posteriorly diverging furrows running from the anterior corners of the mid-basal area. Posterior margin of 2nd metasomal tergite moderately sinuate. 2nd suture variable, smooth or crenulate. 3rd metasomal tergite with large antero-lateral areas defined by a pair of posteriorly diverging furrows; often with a distinct, sometimes large, mid-basal triangular area (Fig. 1). 4th–6th metasomal tergites only rarely with a distinct transverse, subposterior groove. 4th–6th tergites with a transverse peri-basal groove but this groove not divided laterally to demark anterolateral areas. Ovipositor between 0.25 & 3.0 × length of metasoma; highly variable (Figs. 5, 9), sometimes slender with a pre-apical dorsal nodus and apico-ventral serrations, but sometimes thickened without a pre-apical dorsal nodus and with very reduced apico-ventral serrations.

Males.—Similar to females. Digitus of genitalia with 4 (or sometimes 3) well-developed and widely separated, tooth-like processes dorso-laterally. Basal ring anteriorly pointed but not produced into a spine.

Notes on Digonogastra. Digonogastra species display a remarkable superficial resemblance to *Iphiaulax* species, many also having evolved a thickened ovipositor without a dorsal nodus. *Digonogastra* species may however, be distinguished from those of *Iphiaulax* by a number of features. Perhaps surprisingly, the most consistent feature appears to be the presence of a clearly-defined and often large raised mid-basal triangular area on the 2nd metasomal tergite of *Digonogastra*; such an area is never present in *Iphiaulax*. In addition, most *Digonogastra* species have an extensively, densely setose frons, the setae often being relatively long and lying rather flat, and the 3rd to 5th metasomal tergites lack a transverse subposterior groove (though this is present in *Digonogastra ornatus* (Provancher)). In *Iphiaulax* the frons is always completely glabrous except adjacent to the eye, and the 3rd–5th metasomal tergites nearly always have a transverse, subposterior groove. However, perhaps the most important feature separating *Digonogastra* from *Iphiaulax* is the presence of four (occasionally three) well developed tooth-like processes on the digitus of the male genitalia in *Digonogastra* whereas in *Iphiaulax* there is only one. The presence of four digital teeth

has recently been shown to characterize a group of apparently closely related genera from both the Old and New worlds, (Quicke, in press b) typified by Afrotropical genera *Archibracon* Saussure and *Sororarchibracon* Quicke. Of the Neotropical genera, four digital teeth are also present in *Megabracon* Szepligeti and *Lasiophorus* Haliday, and this may indicate that *Digonogastra* is derived from this Neotropical assemblage of braconine genera.

For practical purposes, *Digonogastra* can be separated from *Iphiaulax* by the presence in the former of a medium sized to large mid–basal triangular area on the 2nd metasomal tergite. In the recent key to the Old World genera of Braconinae provided by Quicke (1987), *Digonogastra* spp. with a preapically smooth ovipositor will key to couplet 95 and some will run out to *Bracomorpha* Papp at couplet 96. *Digonogastra* spp. with a nodus on the ovipositor will run to couplet 125 and most will run (with some difficulty) to *Poecilobracon* Cameron.

Digonogastra epicus (Cresson)
Figs. 1–5

Bracon epicus Cresson, 1872.

Material examined.—Female holotype in USNMW: "Texas Belfrage" & "Type No. 1611 U.S.N.M." One female in the author's collection: "Merivale. Ont. 5.viii. 1980 J. J. de Gryse"; one female in USNM: "Dawson Camp, Salt River Ariz" & "CHT Townsend coll. sep 4" both compared with the holotype.

Females.—Length of body 10–12 mm, of forewing 11–13mm and of ovipositor (exserted part) 7.0–7.5 mm.

Antennae with 51 flagellomeres. Penultimate flagellomere 1.3× longer than wide. 1st flagellomere 1.6 and 1.8× longer than the 2nd and 3rd respectively, the latter being 1.1× longer than wide. Scapus almost cylindrical, approximately 2.2× longer than maximally deep (Fig. 2). Hypoclypeal hairbrushes well developed. Upper part of clypeus finely punctate. Clypeus clearly demarked from face by elevation and by a finely crenulate groove. Height of clypeus: intertentorial distance: tentorio-ocular distance = 10:29:18. Face densely silvery setose and punctate, smooth and shiny between the punctures. Width of face : width of head : height of eye = 29:59:27. Lateral half of frons on either side moderately densely covered with rather prostrate silvery setae. Distance between posterior ocelli : diameter of posterior ocellus : shortest distance between posterior ocellus and eye = 10:9:23. Head rather strongly contracted behind the eyes. Occiput sparsely setose.

Mesosoma 1.6× longer than high. Pronotum largely gabrous laterally; lateral pronotal groove only (weakly) crenulate at the front of the pronotum. Propleuron moderately densely long setose. Middle lobe of mesoscutum rather strongly protruding in front of the lateral lobes. Mesoscutum largely glabrous except along line of notauli. Scutellar sulcus crenulate. Scutellum rather sparsely setose. Mesopleuron sparsely setose posteriorly. Mesosternum moderately densely setose. Median area of metanotum glabrous. Propodeum and metapeuron extensively, densely long setose.

Forewing.—Lengths of SR1:3-SR:r = 80:51:10. Vein 1-SR+M distinctly angled posteriorly shortly after arising from 1-SR. Veins C+SC+R and 1-SR forming an angle of approximately 60°.

Hindwing.—Lengths of veins 1r-m: SC+R1 = 19:27. Apex of vein C+SC+R with 2 to 3 thickened bristles (hamules). Postero-basal part of wing with a moderately large glabrous area.

Length of fore femur : tibia : tarsus = 47: 57:76. Fore basitarsus approximately 5× longer than maximally deep.

Metasoma largely smooth and shiny. Elevated median area of 1st metasomal tergite largely smooth, the mid-longitudinal carina at most only indicated by a pair of small

weak submedial depressions, often absent; bordered antero-laterally by a few rugae. 2nd metasomal tergite approximately 1.9× wider than maximally long; with a clearly-defined though rather small, raised mid-basal area which is produced into a mid-longitudinal carina posteriorly. 2nd metasomal suture and transverse peribasal grooves of the 4th to 6th tergites smooth. Tergites 3 to 6 sparsely setose. Ovipositor (part extending beyond the apex of the metasoma) approximately 0.7× length of forewing; with a pre-apical dorsal nodus and apico-ventral serrations.

Antennae, head, mesosoma, legs and ovipositor sheaths black; metasoma bright red; wings pale brown with dark brown venation.

Acknowledgments

I am indebted to Paul M. Marsh (USNM) for loan of the type specimen of *Digonogastra epicus* and of other specimens relevant to this study.

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PROC. ENTOMOL. SOC. WASH.
90(2), 1988, pp. 201–203

EVIDENCE FOR MULTIVOLTINISM IN *PRODIPLOSIS PLATANI* GAGNÉ (DIPTERA: CECIDOMYIIDAE), A LEAF CURL MIDGE OF AMERICAN SYCAMORE

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Abstract.—Seasonally observed pulses of leaf curls caused by larval feeding suggest a sycamore leaf curl midge, *Prodiplosis platani* Gagné is multivoltine with five to six generations per year. Larvae feed on the abaxial lateral surface of new or expanding leaves and cause the margins to curl tightly, disfiguring the leaf. Frequency of larval activity was measured by periodically counting new leaf curls. In 1983 and 1984, from early June to early October in Maryland, five to six peaks occurred at 16–17 day intervals. Larvae are actively sought as food by adults of many species of coccinellids and the curls serve as retreats for spiders. Pteromalid and eulophid parasites were recovered from the pupae.

Key Words: Sycamore, *Prodipolis platani,* generations, parasites

The recently described leaf curl midge *Prodiplosis platani* Gagné, (Gagné 1986) is a potential pest of American sycamore saplings (*Platanus occidentalis* L.) in eastern North American nurseries. Larvae feed on the surface of abaxial lateral margins of young leaves. These become disfigured as feeding causes the leaf margins to curl tightly during growth. The literature of the nine known species of *Prodiplosis* in N. America includes reports on the biology of *P. citrulli* (Felt) (Wehrle 1946), *P. morrisi* Gagné (Morris 1981), *P. vaccinii* (Felt) (Driggers 1926) and *P. violicola* (Coquillett) (Garman 1922). Each of these reported species has been described as a pest causing economic damage. There are no previous reports on the biology of *P. platani.* Gagné (1986) noted that *P. platani* was first collected in New York [= *Cecidomyia* sp., Felt (1940)] and later from New Jersey, Pennsylvania, and Maryland. Larval feeding damage by *P. platani* was first observed on young American sycamores in research plots at the United States Department of Agriculture, Agricultural Research Center, Beltsville, Maryland throughout the summer of 1982 and has since been observed on sycamores in Prince George's and Howard counties, Maryland. The observed chronic appearance of leaf curls during the growing season prompted our study to determine the frequency of occurrence that would provide data on seasonal activity that could be quantified. Limited observations on the cocoon and predators and parasites are provided.

MATERIALS AND METHODS

In this study six sycamores at the Agricultural Research Center that had been propagated four years earlier by rooted cuttings from a single sycamore were used. The trees had been spring-pruned in the early growth stage to promote sprouting and each plant consisted of several long shoots not exceeding 10 feet in height. Sycamores have

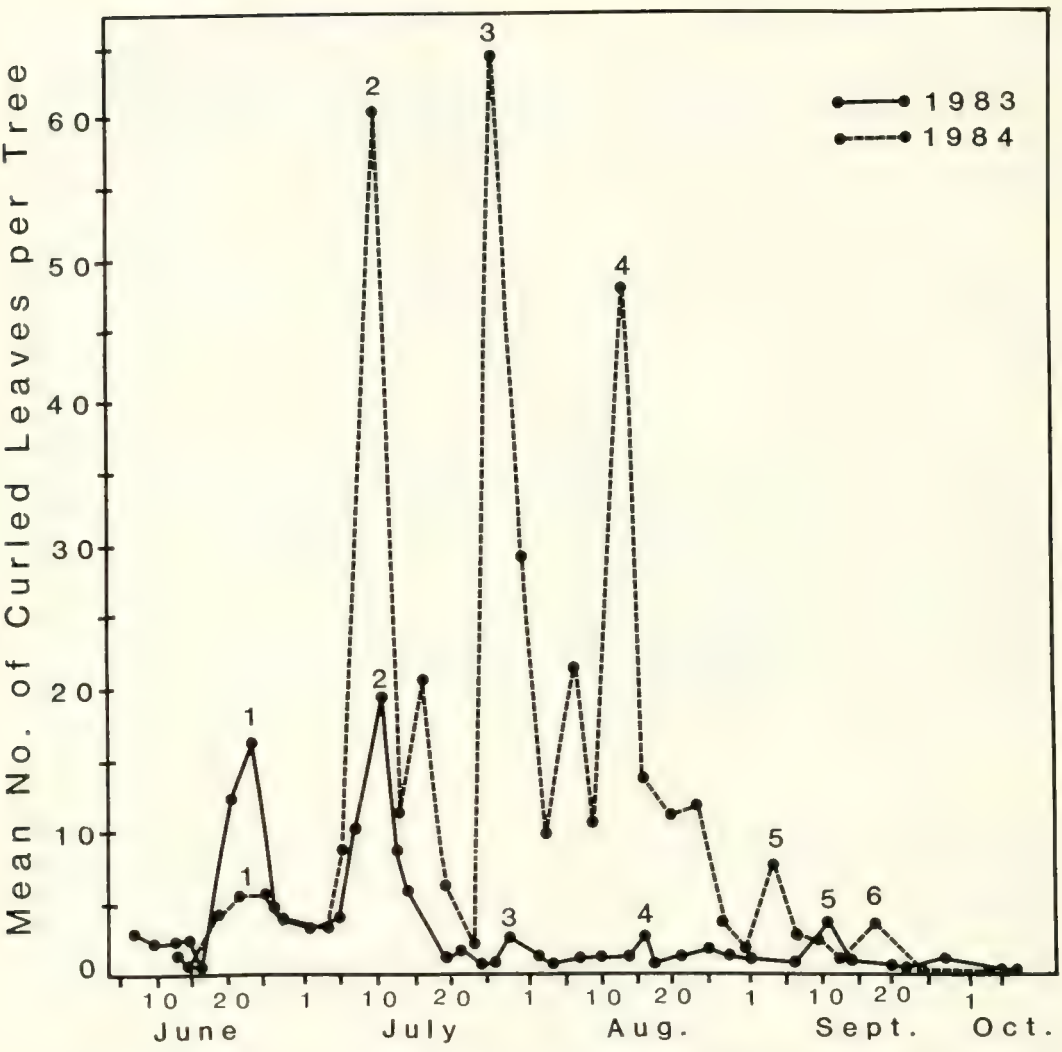

Fig. 1. Mean number of new leaf curls per American sycamore tree in 1983 and 1984. Coincident numbers under peaks represent larval pulses.

indeterminant growth (oaks, *Quercus* have determinate growth and produce two flushes of annual growth) during the growing season and will continue to produce new terminal growth and new leaves as a result of available water. During the first year of study (1983) the sycamores were watered on July 7 and August 22. A repeat study was conducted in 1984 because the first year data suggested several generations. During 1984 trees were watered frequently to promote terminal growth and thus increase the number of new leaves and the potential rate of infestation. The relatively large number of new growth leaves would amplify the larval activity pulses that would occur. The six plants were observed three times a week in 1983 and twice a week in 1984. All leaves on each plant were examined independently by two observers. Each leaf with surface

wrinkling or an incipient curl was marked on the adaxial surface to indicate that it had been observed and recorded.

Results and Discussion

Continuous new leaf production by the sycamores was obtained during the 1984 growing season as a result of frequent watering. The higher number of new leaves resulted in a corresponding higher incidence of infected leaves than in 1983. The mean number of observed new curled leaves by tree per date is presented in Fig. 1. In 1983 a total of 737 curled leaves ($\bar{x}$ = 122.8/tree) was counted and in 1984 2216 ($\bar{x}$ = 369.3/tree) were counted. In 1983 there were five pulses of larval activity. Pulses one and two at 16 and 17 days apart were recorded on the relatively young growth during June and July, three subsequent minor increases of leaf curls with similar temporal spacing followed. In 1984 six pulses of larval activity were observed with peaks 1, 2 and 3 coincident with the first three peaks of 1983. The first pulse, a result of spring-emerged adults, was minor. Activity pulses 2, 3 and 4 were each followed by minor emergences and may result from the sampling intervals. Pulses 5 and 6 in September were minor which may have resulted due to the normal seasonal decline in tree growth. Larval activity for both years commenced in early to mid June and ended in early October. These findings are similar to those seasonal studies of *P. morrisi,* found from June to August on poplar (*Populus deltoides* Bartram) and hybrid poplars (Morris 1981); Morris (1981) reported five generations with an average development period per generation of 16 days based on adult emergences. Larval pulses by *P. platani* suggest a corresponding development time. Our observations suggest that the unsightly feeding damage is accumulative and results in a general ambiguity of the existing 5 to 6 generations without frequent sampling. Because several generations occur on a season's foliage and the damaged leaves do not drop, the cumulative damage can be aesthetically detrimental.

Midge larvae construct white, double convex silken cocoons in the leaf curl. These are formed near the leaf surface or among clots of stellate hairs that form as a result of larval feeding and movement on the surface. Many species of adult coccinellids were observed searching for larvae and pupae in the curl. The curls also provide retreat for hunting spiders such as Salticids. Parasites included Pteromalidae (*Zatropis* sp.) and Eulophidae (*Tetrastichus* sp.) that emerged in the laboratory from pupae collected June 15, 1983. Data from this study indicate that *P. platani* is multivoltine and have established it as a potential pest on rapid growing sycamores.

Acknowledgments

We thank E. E. Grissell Agriculture Research Service, SEL for identification of pupal parasites and Laurie J. Davis, Effie Hawley, Donald C. Johnson and Carol Jo Osiecki of this laboratory for their attentiveness in making leaf counts.

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PROC. ENTOMOL. SOC. WASH.
90(2), 1988, pp. 204–206

NOTES ON THE BIOLOGY OF *CAENOCEPHUS ALDRICHI* BRADLEY (HYMENOPTERA: CEPHIDAE)

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Abstract.—The larva of *Caenocephus aldrichi* Bradley was found boring in stems of *Holodiscus discolor* (Pursh) (Rosaceae). This represents the first host plant record for the genus. The rarity of *C. aldrichi* is demonstrated by the finding of 12 infested stems in 30 hours of searching patches of *H. discolor*. In Oregon, *C. aldrichi* appears to be univoltine, with adults present from early May to early July. Observed mortality factors include parasitism by *Pteromalus* sp. (Hymenoptera: Pteromalidae) and possible predation by birds.

Key Words: *Caenocephus*, Cephidae, *Holodiscus*, host plant.

The host plants of stem sawflies (Hymenoptera: Cephidae) are fairly well known at the generic level. In North America there are six genera in the Cephidae, all in the Cephinae. Species with known hosts in the Cephini (*Calameuta*, 1 sp.; *Cephus*, 2 spp.; and *Trachelus*, 1 sp.) are stem borers in grasses as larvae. Species with known hosts in the Hartigiini (*Caenocephus*, 1 sp.; *Hartigia*, 6 spp.; and *Janus*, 4 spp.) may bore in the stems of various angiosperms (Smith 1979, 1986). Larvae of *Hartigia* species appear to be restricted to the Rosaceae (roses and blackberries) while species of *Janus* utilize various woody dicots (Hanson 1986, Middlekauff 1969). However, the host plant of *Caenocephus aldrichi* Bradley was heretofore unknown. The only other species in this genus is the Palearctic *C. lunulatus* (Strobl) and its host plant is also unknown (Schedl 1981).

Limited data are available on the biology of adults. The species has been recorded from British Columbia, Washington, Idaho, Oregon, and California (Bradley 1905, Middlekauff 1952, 1969), but specimens are very rare in collections (D. R. Smith, pers. comm.). The purpose of this paper is to report the discovery of the host plant of *C. aldrichi* and present brief notes on its biology.

MATERIALS AND METHODS

A search for the larval host plant was begun by limiting field observations to species of Rosaceae, Fagaceae, and Salicaceae where geographic distributions were within the recorded distribution of adult *C. aldrichi*. Because species in the closely related genus *Hartigia* are confined to Rosaceae, special attention was devoted to members of this family.

Field sampling was conducted by looking for severed stems for a set period of time that varied depending on plant density. Typically, several thousand stems were observed in an hour of searching. Stems with severed tips were clipped and set aside until the sampling period was over. The severed stems were then partially dissected to verify

the presence of an insect larva. The "occupied" stems were placed individually in glass tubes (20 cm × 2.5 cm) plugged with cotton. Tubes containing infested stems were kept outside for three months (November–January) and were then brought into the laboratory (22 ± 2°C) for observation of adult emergence.

When cephid larvae were discovered in stems of *Holodiscus discolor* (Pursh), additional field observations and collections were concentrated on this species. Infested stems were collected July–October of 1986 from the following localities in Oregon: Benton County (Corvallis and Mary's Peak); Curry County (15 miles east of Port Orford); and Wasco County (13–16 miles west of Dufur).

Adult stem sawflies, a larva, and parasitoids obtained from this study were deposited in the Systematic Entomology Laboratory, Department of Entomology, Oregon State University.

Results and Discussion

Adult cephids reared from stems of *H. discolor,* ocean spray, were identified as *C. aldrichi* using keys published by Middlekauff (1969) and comparison with specimens identified by D. R. Smith in the Oregon State University insect collection.

The number of infested shoots was extremely low at all sites where *C. aldrichi* were found. Several stands of *H. discolor* were searched for a total of 16 hours without yielding any infested stems. However, in Wasco County (13–16 miles west of Dufur), 8 infested stems were found after a total of 6 hours of searching. Only 4 infested stems were found at the other sites after 10 hours of searching. Thus, a total of 12 infested stems was found from all sites after 30 hours of searching. The difficulty in finding stems of *H. discolor* infested by *C. aldrichi* could be a result of not observing the primary host, which then would remain to be discovered. However, the relative abundance of infested stems at the Wasco Co. site suggests that the association of *C. aldrichi* with *H. discolor* is more than an incidental host record.

Species of Cephidae either sever the stem as an adult at the time of oviposition or as a larva when stem boring is initiated. The stems harboring larvae of *C. aldrichi* were severed in a manner which resulted in a line of girdling that was very smooth and without jagged marks. In comparison, the girdle line on severed shoots containing *Janus rufiventris* (Cresson), in which the adult female girdles the stem with her ovipositor, is rough and exhibits jagged marks around the circumference of the stem (Hanson 1986). In the absence of direct observations this suggests that in *C. aldrichi* the shoot is probably girdled by the larva.

Only the wider stems of *H. discolor* were infested. Stem width of all growing shoots ranged from 0.9 mm to 7.0 mm in diameter. Infested stems ranged from 2.8–7.00 mm in diameter when measured at mid-length of the infested portion.

The pattern of the tunnel in the stem illustrates the behavior of the larva. We noted patterns in tunnelling that suggest the following: the newly hatched larva after girdling the shoot tunnels toward the base in the cambial zone for a short distance (1–3 mm), the larva then turns back (upwards) to the girdled apex, tunnels to the midsection of the shoot, and then bores down the center toward the base of the stem. At the initiation of the downward tunnelling the larva is consuming almost the entire interior of the shoot and packing frass in the vacated tunnel.

Patterns in the length of infested stems suggested that a second severing of the shoot occurs. Stems collected in July had tunnels averaging 5 cm in length (severed apex to location of larval head), whereas stems collected in October had tunnels less than 1 cm in length (newly severed apex to the base of the prepupal chamber). These observations suggested that the last instar severs the stem again, before forming a pupal chamber. Thus, the portion of the stem contain-

ing the initial tunnelling falls off the plant. Similar behavior has been documented in other cephids (Middlekauff 1969).

Observations of emergence in the laboratory indicated that adults exit the shoot by chewing through the apical frass plug, rather than through the stem as in other Hartigiini.

We observed some larval-pupal mortality factors. A larva in one of the 12 infested stems contained larvae of a gregarious *Pteromalus* sp. (Hymenoptera: Pteromalidae; identification by P.E.H.). These parasitoid larvae were reared and produced six females and two males (on July 8) one week after collection. Two of the stems with tunnels had irregular holes in the region of the pupal chamber. The holes exhibited peeled edges and the chamber lacked a cephid larva, suggesting possible mortality by bird predation. In three of the infested stems the cephid larva had already died from unknown causes and in four of the infested stems larvae died after collection (one was preserved), probably because they were collected too early in the season. Thus, we obtained only two adults (both female) out of 12 infested stems.

Data from specimens in the Oregon State University insect collection indicate that adult *C. aldrichi* are active from early May at lower elevations in the Willamette Valley (about 100 m), to early July at higher elevations on Mary's Peak (about 1000 m). Our field observations on the state of larval development in the field indicated that this species is univoltine in Oregon.

The only other species presently placed in *Caenocephus* is the Palearctic *C. lunulatus* (Strobl), formerly known as *C. jakowleffi* Knonow (Schedl 1981). Because *Holodiscus* is absent from the Old World, the host plant of this species must be different from that of *C. aldrichi*.

With the discovery of a host plant containing the larva of *C. aldrichi*, it will be possible to compare the morphology of immature *Caenocephus* with that of other genera of Hartigiini. In a key to the larvae of Cephidae, Middleton (1917) noted that in *Hartigia* the lateral area of the basal anal lobe is setose, whereas in *Janus* this area is bare. In the single preserved specimen of *C. aldrichi* the lateral area of the basal anal lobe is setose as in *Hartigia*. Additional collections of larval *C. aldrichi* are needed for studies on variation in larval morphology.

Based on our limited observations of this rarely collected species it appears that *Caenocephus* is more similar to *Hartigia* than to *Janus*. The following observations suggest this relationship: host plant is in the Rosaceae, initial stem-girdling is likely performed by the larva, and the basal anal lobe is setose in the larva.

Acknowledgments

We are grateful to D. R. Smith, Systematic Entomology Laboratory, USDA, Washington, D.C., for sharing his personal records on *C. aldrichi* with us. This is technical paper no. 8365, Oregon State University Agricultural Experiment Station.

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PROC. ENTOMOL. SOC. WASH.
90(2), 1988, pp. 207–215

PHYTOPHAGOUS INSECT FAUNA OF *BACCHARIS SAROTHROIDES* GRAY (ASTERACEAE) IN ARIZONA AND NEW MEXICO

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Abstract.—Phytophagous insects representing seven orders, 26 families, and 64 species were collected on the unisexual shrub desert broom, *Baccharis sarothroides* Gray, a native plant of the southwestern United States. Twenty-five species fed in two or more plant families, six species fed only within the Asteraceae, and five species fed only on *Baccharis* species. No severe foliage or stem damage due to feeding by the insects was observed.

Key Words: Desert broom, plant-feeding insects, ecology

Desert broom, *Baccharis sarothroides* Gray (Asteraceae: Astereae), is an attractive, erect, unisexual, woody shrub, 1 to 4 m in height with broom-like branches and resinous evergreen leaves and stems. Native to the southwestern United States, desert broom is common in sand or gravel riparian washes, drainage areas, and low hills at elevations of 300–1500 m above sea level (Benson and Darrow 1981, Lee et al. 1984).

The few leaves present on desert broom are simple, linear, alternate, and up to 2 cm long; margins are entire. Flower heads are dioecious, discoid in shape, usually solitary, and occur on elongate leafless twigs. Female heads contain about 10 florets and are 6–8 mm in length; male heads are 3–4 mm in length. Flowering is dependent on rainfall and may occur between August and November. Leaves and stems are not palatable to livestock. The many achenes are about 0.25 mm long, 10-nerved, glabrous, and dispersed by wind. The white pappus is 2–2.5 cm long and conspicuous during bloom (McGinnies 1986, Munz and Keck 1968, Vines 1960).

Desert broom is often seen in the front yards of residential properties and is sold by nurseries in Arizona for landscaping in dry environments because it is drought-resistant and tolerant of temperature extremes and saline water. Recently, a low-growing hybrid, *B. sarothroides* × *B. pilularis* DeCandolle, was developed at the Arizona Agricultural Experiment Station, Tucson, for use in xeriscaping. This new shrub, named "Centennial," is a compact, prostrate, leafy, green bush which survives summer heat of up to 45°C without wilting (Lee et al. 1984, Thompson 1985).

Desert broom was tested on different soil types for use in the reclamation of copper mine waste areas in Arizona. Initially, the plant did poorly, but in the second year, height, vegetation yield, and ground cover compared well with the four other shrubs in the test (Day and Ludeke 1980). Although two years is an insufficient period of time for a proper evaluation, this shrub may be one of several plants which are beneficial for reclaiming disturbed mine soils.

Pellet (1930) considered desert broom to

be locally important for honey production because it blooms in the fall when few other flowers are available.

Insects were previously collected on desert broom in Arizona from July to September by Meyer et al. (1979). Of the 25 species collected, 8 were phytophagous and the remaining species were predators or parasites. Other surveys for insects of *Baccharis* in the United States have been made of *B. halimifolia* L. (Bennett 1963, Palmer 1987) and *B. pilularis* (Tilden 1951).

We investigated the phytophagous insects of *B. sarothroides* as part of a study of insects associated with the genus *Baccharis*. Although this is a beneficial shrub, it is closely related to *B. salicifolia* (R&P) Pers., *B. neglecta* Britt., and *B. halimifolia*, three weedy shrubs that we are studying as potential targets for biological control. This paper is the second in our series; the first paper (Boldt and Robbins 1987) reported the phytophagous insects of *B. neglecta* in Texas.

Materials and Methods

We examined plants of *B. sarothroides* on 33 occasions from June 1985 to September 1987 at sites near Rye, Picacho, Gila Bend, Tucson, Sasabe, and Dragoon, Arizona as well as Rodeo and Lordsburg, New Mexico (Fig. 1). Up to four of the eight sites were visited each month of the year. At each site, insects were handpicked, aspirated, or swept from 10 to 20 plants. Immature insects that were collected were reared to maturity on excised plant material and adults found resting on the plant material were caged on leaf bouquets in the laboratory to confirm their ability to feed on the plant. Male and female flower heads were collected in bulk from near Tucson in October 1986; some were dissected while the remainder were held for emergence. Detailed collection and rearing records were maintained so that we could estimate the relative frequency of each insect species collected and record collection data, plant association, and plant phenology. We deposited voucher insect specimens in the insect collection of the Temple laboratory.

Results and Discussion

The distribution of desert broom is presented in Fig. 1. This shrub is abundant in central and southern Arizona but occurs in the Sonoran Desert and desert grasslands from New Mexico to California, Baja California, and Sonora, Mexico. It is also recorded from Sinaloa, Mexico (Benson and Darrow 1981, Munz and Keck 1968, personal observations).

Desert broom was the host or alternate host for 64 species of phytophagous insects representing seven orders and 26 families excluding those that feed exclusively on pollen (Table 1). At least 38 (59.4%) reproduced and developed to maturity on this plant, and 12 (18.7%) of these were endophagous as immatures.

Three (4.7%) species (Table 1) also feed on two related shrubs, *B. neglecta* and *B. halimifolia* (Boldt and Robbins 1987, Palmer 1987): *Nysius raphanus* Howard, *Lygus lineolaris* (Palisot de Beauvois), and *Neolasioptera lathami* Gagné. In addition, four (6.2%) species: *Frankiniella occidentalis* (Pergande), *Hesperotettix viridis viridis* Thomas, *Brochymena quadripustulata* (F.), and *Clastoptera lineatocollis* Stål (Table 1) were also collected from *B. neglecta* in Texas by Boldt and Robbins (1987). Palmer (1987) listed one (1.6%) species, *Acanthocephala thomasi* (Uhler) from *B. halimifolia*. Only *Chrysobothris bacchari* Van Dyke (Table 1) was also listed by Tilden (1951) on *B. pilularis* in California. The aforementioned insects are polyphagous except for the gall midge, *N. lathami*, and the flatheaded borer, *C. bacchari*.

The following insects on desert broom were listed in the literature but not collected by us: *Dactylotum bicolor variegatum* (Scudder), *Melanoplus desultorius* Rehn, *Aztecacris gloriosa* Hebard, *Poecilotettix pantherina* (F. Walker), and *Poecilotettix sanguineus* Scudder (Ball et al. 1942); *Agri-*

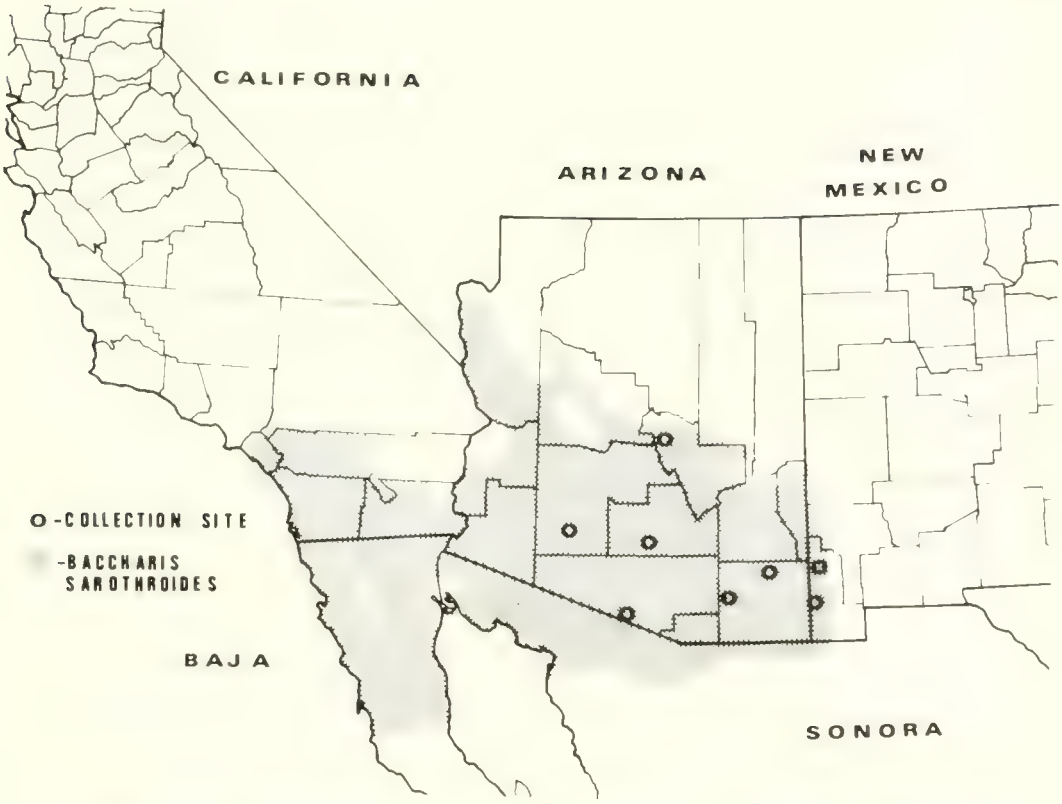

Fig. 1. Insect collection sites and distribution of *Baccharis sarothroides* in the United States and Mexico.

lus aurilatera Waterhouse (Hespenheide 1974), and *Tragidion annulatum* LeConte (Meyer et al. 1979).

In April and May 1987, we collected several larvae of each of two noctuids, *Cucullia laetifica* Lintner and *Platysenta videns* (Guenée), from leaves of desert broom growing in pots in our nursery at Temple, Texas. We reared five *C. laetifica* and one *P. videns* to adults. The only other confirmed host plant of *C. laetifica* is *B. neglecta* (Boldt and Robbins 1987). Other *Cucullia* feed on leaves and flowers of various Asteraceae (R. W. Poole, pers. comm.). *Platysenta videns* occurs east of the Continental Divide (Crumb 1956). We, therefore, concluded that this noctuid does not normally attack desert broom. Crumb (1956), however, collected larvae of another species on this plant in Arizona which he identified as *Platysenta* sp. No. 29 but was unable to rear them to adult for species identification.

According to published literature and available host records for the 51 identified species (Table 1), we determined that 25 (39.1%) were polyphagous because they fed on plants outside the family Asteraceae. Eleven (17.2%) of these are pests of economically important plants and feed on desert broom during the winter or spring when their annual hosts are not available. This percentage is similar to the 18% of identified insects on *B. neglecta* which were listed as pests by Boldt and Robbins (1987) and illustrates the role of these shrubs in harboring pests. We listed six (9.4%) species as oligophagous because they fed on plants within the Asteraceae and six (9.4%) as monophagous because they apparently fed only on the genus *Baccharis*. The gall midge

Table 1. Phytophagous insects collected from *B. sarothroides*.

Insects	Month Collected		Relative Frequency[a]	Associated Plant Part[b]	Host Specificity[c]	References
	Immature	Adult				
Orthoptera						
Acrididae						
Aztecacris gloriosa (Hebard)	Aug.–Oct.	Oct.–Jan.	R	L	O	Ball et al. 1942
Dactylotum bicolor varicegatum (Scudder)	June	June–Oct.	O	L	P	Ball et al. 1942
Hesperotettix viridis viridis (Thomas)		Aug.–Sept.	O	L	O	Ball et al. 1942
Melanoplus desultorius Rehn		July–Nov.	R	L	O	Ball et al. 1942
M. pictus Scudder	Aug.–Oct.	Aug.–Oct.	C	L	PE	Ball et al. 1942
Poecilotettix pantherina (F. Walker)	Apr.–Aug.	Apr.–Nov.	R	L	P	Ball et al. 1942
P. sanguineus Scudder	Mar.–Apr.	Apr.–Aug.	O	L	P	Ball et al. 1942
Schistocerca alutacea shoshone (Thomas)		Sept.–Oct.	R	L	PE	Ball et al. 1942
Thysanoptera						
Thripidae						
Frankliniella minuta (Moulton)		Oct.	R	F	P	
F. occidentalis (Pergande)	Feb.–Oct.	Feb.–Oct.	C	F	PE	Yudin et al. 1986
Heteroptera						
Coreidae						
Acanthocephala femorata (F.)	Aug.–Sept.	July–Sept.	O	F	P	Meyer et al. 1979
A. thomasi (Uhler)	Aug.–Sept.	July–Sept.	O	F	P	Meyer et al. 1979
Lygaeidae						
Lygaeus reclivatus (Say)		Oct.–Dec.	O	L, St, F	P	
Melanopleurus belfragei (Stål)		Aug.–Oct.	R	L, St, F		
Nysius raphanus Howard	Sept.–Jan.	May–Jan.	C	L, F	PE	Ward et al. 1977
Ochrimnus foederatus (van Duzee)		Oct.–Nov.	R			Brailovsky 1982
Miridae						
Lygus desertinus Knight	Oct.–Dec.	May–Dec.	R	L, F	P	
L. hesperus Knight	Oct.–Dec.	May–Dec.	O	L, F	PE	Graham et al. 1986
L. lineolaris (Palisot de Beauvois)	Oct.–Dec.	May–Dec.	O	L, F	PE	Young 1986
Parthenicus baccharidus Knight	Apr.–Sept.	Apr.–Jan.	O	L, F		
Rhinacloa forticornis (Reuter)		Aug.–Nov.	R	L, F, St	P	

Table 1. Continued.

Insects	Month Collected: Immature	Month Collected: Adult	Relative Frequency[a]	Associated Plant Part[b]	Host Specificity[c]	References
Pentatomidae						
Brochymena quadripustulata (F.)		Feb.–May	O	St	P	Gamboa and Alcock 1973
Homoptera						
Acanaloniidae						
Acanalonia clypeata Van Duzee		Aug.–Sept.	O	L, St		
Acanalonia fasciata Metcalf	Aug.–Sept.	Aug.–Sept.	O	L, St		
Aphididae						
Brachycauda helichrysi (Kaltenbach)	Mar.–May	Mar.–May	O	L, St	P	
Cercopidae						
Clastoptera lineatocollis Stål	Mar., Aug.	May, Aug.–Dec.	O	St	P	Doering 1942
Cicadellidae						
Aceratagallia sp. A		Jan., May, July	O	L, St		
Aceratagallia sp. B		July–Aug.	C	L, St		
Empoasca sp.	May	Jan.–Dec.	C	L, St		
Homalodisca lacerta (Fowler)	Aug.–Sept.	Aug.–Nov.	O	L, St		
Idiocerus sp.		Nov.–Mar.	C	L, St		
Stragania robusta (Uhler)		Aug.–Sept.	O	L, St	PE	Fletcher 1937
Cixiidae						
Oecleus productus Metcalf		Apr.–Sept.	C	L, St		
Eriococcidae						
Ovaticoccus californicus McKenzie			R	L		McKenzie 1964
Flatidae						
Mistharnophanita sonorana Kirkaldy		Aug.	O	L, St		
Ormenis prob. *yumana* Ball		May, Aug.–Sept.	O	L, St		
Membracidae						
Hypsoprora neglecta Ball		May–Nov.	C	St		
Spissistilus festinus (Say)		Mar., Aug.–Oct.	O	St	PE	Mueller and Dumas 1987
Psyllidae						
Trioza collaris Crawford	Nov.–Jan.	Aug.–Mar.	C	L, F, G	M	Tuthill 1945
Coleoptera						
Buprestidae						
Agrilus aurilatera Waterhouse			C	St		Hespenheide 1974
Chrysobothris bacchari VanDyke	Sept.–June	June–July	O	St, R	M	Nelson et al. 1981
C. beveri Schaeffer	Sept.–June	June		St, R		Werner (pers. comm.)

Table 1. Continued.

Insects	Month Collected: Immature	Month Collected: Adult	Relative Frequency[a]	Associated Plant Part[b]	Host Specificity[c]	References
Cerambycidae						
Stenodontes lobigenis (Bates)	Sept.–June	July–Sept.	O	R	PE	Werner (pers. comm.), Linsley 1962
Tragidion annulatum LeConte	Oct.–Aug.	July–Sept.	O	St, R	P	Meyer et al. 1979; Linsley 1962
Chrysomelidae						
Exema deserti Pierce	May–Aug.	May–Sept.	O	L	P	
Systena blanda Melsh.		Aug.–Sept.	C	L	PE	
Curculionidae						
Anthonomus stolatus Fall		Aug.–Sept.	R	L, F		
Lixus pervestitus Chittenden		Sept.	R	St		Werner (pers. comm.)
Smicronyx undescribed sp.		Aug.–Sept.	R	F		
Lepidoptera						
Ctenuchidae						
Ctenucha venosa Walker	Aug.	Sept.–Oct.	R	L, F		
Gelechiidae						
Aristotelia argentifera Busck	May–Sept.	May–Oct.	C	L, St		
Gnorimoschema undescribed sp.	Apr.–Nov.	Dec.–Mar.	O	St, G		
Geometridae						
Anavitrinella sp.	Feb.–Mar.	Mar.–Apr.	R	L	P	
Elpiste metanemaria (Hulst)	Mar.–May, Aug.–Sept.	Mar.–June, Sept.–Nov.	O	L		
Lyonetiidae						
Bucculatrix sp. near *seorsa* Braun	Dec., Apr.–May, Aug.	Jan.–Feb. June, Aug.–Sept.	O	L		Braun 1963
Pterophoridae						
genus unknown	Mar.–June		R	St		
Diptera						
Cecidomyiidae						
Neolasioptera lathami Gagné	Mar.–Oct.	Mar.–Oct.	C	St, G	M	Diatloff and Palmer 1986
Tephritidae						
Aciurina mexicana (Aczél)	Feb.–Apr.	Oct.–June	O	St, G	M	Steyskal 1984
A. thoracica Curran	Feb.–Apr.	Feb.–July	O	St, G	M	Steyskal 1984
Euarestoides acutangulus (Thomson)		Oct.–Feb.	O	F	OE	Goeden and Ricker 1986
E. flavus (Adams)	Oct.–Jan.	Aug.–Apr.	O	F		Wasbauer 1972
Tephritis arizonaensis Quisenberry	Oct.–Nov., Mar.–Apr.	Jan.–Dec.	C	F, St, G	M	Foote and Blanc 1963
Trupanea nigricornis (Coquillett)	Oct.–Nov.	Nov.	R	F	O	Goeden 1985
Trupanea wheeleri Curran	Oct.–Nov.	Mar., Aug.–Nov.	C	F	O	Goeden 1985

was tested for host specificity and released in Australia as a biological control agent for *B. halimifolia* (Diatloff and Palmer 1987). The remaining five monophagous species may also be potential biological control agents for *B. halimifolia,* although they were not tested for host specificity and their impact on the plant was not assessed.

The host specificity of 29 (45.3%) species collected on desert broom was not determined because their identification was incomplete or host records were unknown or not available. Based on the host plant record of other species in the genus, some of these may be found at a later date to be monophagous or oligophagous. At least two of the unidentified insects were apparently undescribed.

We collected insects on desert broom during every month of the year. The largest number of adult species, 39 (60.9%), was collected in both August and September when normal daily mean temperatures were 21 and 23°C (Wallis 1977) and the least number, 9 (14.1%), was collected in January when normal daily mean temperature was 10.5°C.

About 40 (62.5%) insect species, most of which were Hemiptera and Homoptera, fed on the leaves and small stems; 21 (32.8%) species fed entirely or partly on the flowers and another 12 (18.7%) fed in the stems or both roots and stems. Various insects, such as bees, ants, syrphids, and beetles were also encountered feeding on the resinous exudate of the stems and leaves but they were not collected.

Seventeen (26.6%) species were recorded as rare because they were encountered at a density of less than one per ten plants. Many of them were identified only to genus, and many are polyphagous insects for which desert broom may not be an important plant. Of the 15 (23.4%) species that were recorded as common because they were encountered at a density of more than one per plant, seven were polyphagous species of sap-feeding Hemiptera and three were species of stem- or flower head-feeding Diptera.

At no time during our collecting did we observe widespread foliage or stem damage due to feeding insects, although we occasionally found isolated areas of shrubs with stem and leaf damage which we attributed to feeding by grasshoppers. No obviously destructive insects were encountered on desert broom such as the chrysomelid leaf feeder, *Trirhabda bacharidis* (Weber), on *B. neglecta* and *B. halimifolia* (Boldt and Robbins 1987), or *T. flavolimbata* (Mannerheim) and the gall midge, *Rhopalomyia californica* (Felt), on *B. pilularis* (Tilden 1951).

Acknowledgments

We gratefully thank Bradford Burk (Parkinsonia Biological Control Laboratory, Western Australian Department of Agriculture, Tucson, Arizona), J. P. Cuda and C. J. DeLoach (Grassland, Soil and Water Research Laboratory, USDA, Agricultural Research Service, Temple, Texas) for their technical assistance and E. W. Baker, D. C. Ferguson, R. C. Froeschner, R. J. Gagné, P. M. Marsh, D. R. Miller, S. Nakahara, A. L. Norrbom, R. W. Poole, R. K. Robbins, T. J. Spilman, M. B. Stoezel, R. E. White and D. R. Whitehead (Systematic Entomology Laboratory, USDA, Agricultural Research Service, Beltsville, Maryland), D. R. Davis (National Museum of Natural History, Washington, D.C.), L. B. O'Brien (Florida A&M University, Tallahassee), and H. R. Burke (Texas A&M University, College Station) for identification of insects mentioned

←

[a] C, common, more than one per plant; O, occasional, less than one per plant but more than one per 10 plants; R, rare, less than one per 10 plants.

[b] L, leaf; St, stem; R, root; F, flower head; Sd, seed (achenes); G, gall on stem.

[c] M, monophagous (apparently restricted to the genus *Baccharis*); O, oligophagous (apparently restricted to the Compositae); P, polyphagous (apparently feeds on various plant families); E, economically important (see Literature Cited).

in this report. Host plant records were furnished by F. W. Werner (University of Arizona, Tucson). We thank C. Mason, Jr., (University of Arizona, Tucson) for access to herbarium records.

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PROC. ENTOMOL. SOC. WASH.
90(2), 1988, pp. 216–228

THE PHYTOPHAGOUS INSECT FAUNA ASSOCIATED WITH *BACCHARIS HALIMIFOLIA* L. IN THE EASTERN UNITED STATES

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Abstract.—A survey of the phytophagous insects found on *Baccharis halimifolia* along the eastern seaboard of the United States was undertaken as part of an extensive program to find biological control agents for this plant in Australia. One hundred and seventy four phytophagous insect species were collected or were recorded in the host records of the Division of Plant Industry, Bureau of Entomology insect collection at Gainesville. Fourteen species were considered to be monophagous and potential biological control agents. Lepidoptera and endophages constituted a high proportion of this group. Fifty five general predators and 51 agricultural pests were also found on *B. halimifolia.*

Key Words: Biological control, survey, weed

Baccharis halimifolia L. (Family Asteraceae: Tribe Astereae: Sub-Tribe Baccharinae) is a North American shrub that has become a noxious weed in Queensland, Australia (Stanley and Ross 1986). As part of its effort to control this weed, the Queensland Department of Lands initiated a program in 1960 to find suitable biological control agents from the New World where the Baccharinae are native.

B. halimifolia is found along the eastern seaboard of the United States from Florida to Massachusetts. It was probably introduced into Australia from Florida which has a subtropical climate most closely approximating that of southeast Queensland where *B. halimifolia* is most troublesome. The eastern seaboard was therefore selected as a very appropriate area in which to survey the insect fauna associated with this plant. From the survey it was hoped that monophagous species suitable for importation and release into Australia could be selected for further study.

Various surveys of insect faunas on *Baccharis* have already been reported. Tilden (1951) listed 221 insects, including 55 primary herbivores, associated with the vegetative parts of *B. pilularis* DC. F. D. Bennett (unpublished) surveyed the fauna on various species of *Baccharis* in Brazil. Kraft and Denno (1982) listed the major foliage-feeding herbivores attacking *B. halimifolia* in Maryland. Palmer (1987) surveyed the insect fauna on *B. halimifolia* and the closely related *B. neglecta* Britton in Louisiana, Texas, and northern Mexico and reported 133 phytophagous species, of which 11 were considered monophagous. Boldt and Robbins (1987) surveyed *B. neglecta* in Texas and reported 91 phytophagous species.

B. halimifolia is a perennial, dioecious woody shrub that grows to a height of 15 feet. It produces new growth in spring, and

the quality of the foliage in terms of nitrogen content, moisture content, secondary chemicals, and toughness declines as the year progresses (Kraft and Denno 1982). It flowers in autumn, producing a prodigious quantity of seed (Panetta 1979). The phenology of this plant is described in more detail by Palmer (1987).

The Area and Methods of Survey

The area between southern Florida and Washington, D.C. was first surveyed on two car trips of 3–4 weeks in 1962. The first trip was made in spring when the *B. halimifolia* was producing new foliage, and the second was undertaken in October when the plants were in full flower. Two to three sites, approximately 50 miles apart, were examined each day on these trips. From 1982–1987 further surveying was undertaken on visits of a few days to Miami and Gainesville, Florida; to Charleston, South Carolina; to Williamsburg, Virginia; and to Toms River, New Jersey. In 1983 a site near Gainesville was also inspected each month.

Collecting procedures were much as described by Palmer (1987). Insects were found by visual inspection and sweeping the foliage. Inflorescences were examined under the microscope. Immatures were reared through to adulthood to enable them to be accurately identified. All insects were sent to expert taxonomists (cf. acknowledgments) for their identification.

A second source of data was the collection and files of the Bureau of Entomology, Division of Plant Industry, Florida Department of Agriculture and Consumer Services (DPI), in Gainesville. This collection maintains a catalogue of host records for all insects submitted for identification. Because the authors had no control over the collection or treatment of these data, information from this collection is clearly marked in the tables to distinguish it from our own collections.

Identified insects were classified as monophagous if restricted to *Baccharis*, oligophagous if the host range was restricted to the tribe Astereae and polyphagous if having a wider host range. Evidence of host range was obtained from observations during the course of the survey, consultations with acknowledged experts, examination of host data attached to specimens in major insect collections, information in texts such as Arnett (1985), Slater and Baranowski (1978), Arnett et al. (1980), Smith and Smith (1978), Baranowski and Slater (1986), and Borror et al. (1981), and, in some instances, formal host testing.

Insects were classified as endophagous if they were found feeding on internal tissues of *Baccharis* and ectophagous if they fed externally on *Baccharis*. They were classified as pest species if mentioned as such in Arnett (1985).

Monophagous species were considered potential agents for biological control of *B. halimifolia* and their potential was rated subjectively by the authors and objectively by applying the formula of Goeden (1983). An insect can score a maximum of 79 points by this formula and is classified as effective, partially effective or ineffective if it scores >50, 20–50, or <20, respectively.

Results

The phytophagous fauna (excluding pollen and nectar gatherers) found on *B. halimifolia* are shown in Table 1. One hundred and eight species were collected and a further 66 species were obtained from the DPI files. The Acari, Hemiptera, Homoptera, Lepidoptera, Coleoptera and Diptera were represented by 5 (3% of total species), 20 (11%), 71 (41%), 22 (13%), 43 (25%) and 13 (7%) species, respectively.

Fourteen species (8% of the total species) were considered to be monophagous. Three species were considered oligophagous, and the remainder were either polyphagous or host range unknown. Of the monophagous species, 7 (50% of the monophagous species) were Lepidoptera and 8 (57%) were endophagous for at least part of their life cycle.

Table 1. Phytophagous species collected on *B. halimifolia* along the eastern seaboard of the United States.

Species[1]	Location (State)	Insect–Host Relationship to *Baccharis*	Specificity[2]	Pest Status[3]
Acari				
Eriophyidae				
**Aceria* nr. *baccharices* Kiefer	Fl	ectophagous	*?	
**Tegonotus acidotus* (Keifer)	Fl	ectophagous	*?	
**Tegonotus* nr. *baccharis* (Keifer)	Fl	ectophagous	*?	
Tegonotus undescribed sp.	Fl	ectophagous	*?	
Tetranychidae				
**Paratetranychus* sp.				
Hemiptera				
Coreidae				
Acanthocephala confraterna (Uhler)	Ga–Fl	ectophagous	*	
Acanthocephala femorata (F.)	SC–Fl	ectophagous	*	
Acanthocephala terminalis (Dallas)	Fl	ectophagous	*	
Catorhintha guttula (F.)	Fl	ectophagous	U	
**Euthochtha galeator* (F.)	Fl	ectophagous	*	
Leptoglossus phyllopus L.	NC–Fl	ectophagous	*	*
Merocoris typhaeus Fab.	Fl	ectophagous	*	
Lygaeidae				
**Ochrimnus lineoloides* Slater	Fl	ectophagous	*	
Ochrimnus mimulus (Stål)	Fl	ectophagous	**	
**Palagonatus divergens* Distant	Fl			
Miridae				
Adelphocoris rapidus (Say)	NC	ectophagous	*	*
Lopidea hesperus (Kirkaldy)	Fl	ectophagous	*	
Slaterocoris pallipes (Knight)	NY–Fl	ectophagous	***	
Taylorilygus pallidulus (Blanchard)	Ga–Fl	ectophagous	*	
Pentatomidae				
**Euschistus crassus* Dallas	Fl	ectophagous	*?	
Euschistus servus Say	SC–Fl	ectophagous	*	*
**Loxa* sp.	Fl	ectophagous		
Mormidea sp.	Fl	ectophagous		
Tingidae				
Corythucha baccharidis Drake	Fl	ectophagous	**	
**Corythucha marmorata* (Uhler)	Fl	ectophagous	*	*
Homoptera				
Acanaloniidae				
**Acanalonia latifrons* Walker	Fl	ectophagous	U	
Aleyrodidae				
**Bemesia berbicola* Cockerell	Fl	ectophagous	*	
**Paraleyrodes naranjae* Dozier	Fl	ectophagous	*	
Aphididae				
Aphis coreopsidis (Thomas)	SC–Fl	ectophagous	*	*
Aphis gossypii Glover	Fl	ectophagous	*	*
Macrosiphum sp.	Fl	ectophagous		
Myzus persicae (Sulzer)	Fl	ectophagous	*	*
Toxoptera aurantii (Fonscolombe)	Fl	ectophagous	*	*
Uroleucon eupatoricolens (Patch)	Fl	ectophagous	*	
Uroleucon gravicornis (Patch)	Fl	ectophagous	**	
Cercopidae				
**Aphrophora* sp.	Fl	ectophagous		
Clastoptera obtusa Say	Fl	ectophagous	*	
Clastoptera xanthocephala Germar	NJ	ectophagous	*	

Table 1. Continued.

Species[1]	Location (State)	Insect–Host Relationship to *Baccharis*	Specificity[2]	Pest Status[3]
Cicadellidae				
**Empoasca kraemeri* Ross & Moore	Fl	ectophagous	*	*
**Empoasca* sp.	Fl	ectophagous		
**Graminella nigrifrons* (Forbes)	Fl	ectophagous	*	*
**Graphocephala coccinea* (Forster)	Fl	ectophagous	*	
**Graphocephala versuta* (Say)	Fl	ectophagous	*	
Gyponana sp.	Fl	ectophagous		
**Paraphlepsius* sp.	Fl	ectophagous		
**Penthimia* nr. *americana* Fitch	Fl	ectophagous	*	
**Ponana* sp.	Fl	ectophagous		
Oncometopia nigrifrons (Walker)	Fl	ectophagous	*	
**Scaphytopius* sp.	Fl	ectophagous		
Cixiidae				
**Bothriocera* sp.	Fl	ectophagous		
**Myndus crudus* Van Duzee	Fl	ectophagous	*	*
Myndus pallidus Caldwell	Fl	ectophagous	*	
Oliarus sp.	NJ	ectophagous		
Coccidae				
Ceroplastes ceriferus (F.)	Fl	ectophagous	*	*
**Ceroplastes cirripediformis* Comstock	Fl	ectophagous	*	*
**Ceroplastes floridensis* Comstock	Fl	ectophagous	*	*
Coccus hesperidum L.	Fl	ectophagous	*	*
**Coccus longulus* (Douglas)	Fl	ectophagous	*	
Coccus viridis (Green)	Fl	ectophagous	*	*
**Eucalymnatus tessellatus* (Signoret)	Fl	ectophagous	*	*
Kilifia acuminata (Signoret)	Fl	ectophagous	*	*
Kilifia elongatus (Signoret)	Fl	ectophagous	*?	
**Parasaissetia nigra* (Nietner)	Fl	ectophagous	*	*
Protopulvinaria pyriformis (Cockerell)	Fl	ectophagous	*	*
**Pulvinaria innumerabilis* (Rathvon)	Fl	ectophagous	*	*
Pulvinaria psidii Maskell	Fl	ectophagous	*	*
Pulvinaria urbicola Cockerell	Fl	ectophagous	*	*
Saissetia coffeae (Walker)	Fl	ectophagous	*	*
**Saissetia miranda* (Cockerell & Parrott)	Fl	ectophagous	*	*
Saissetia neglecta DeLotto	Fl	ectophagous	*	*
Saissetia oleae (Olivier)	Fl	ectophagous	*	*
Delphacidae				
Stobaera pallida Osborn	NJ–Fl	ectophagous	***	
Diaspididae				
Abgrallaspis cyanophylli (Signoret)	Fl	ectophagous	*	*
Aonidomytilus solidaginis (Hoke)	Fl	ectophagous	*	
Hemiberlesia lataniae (Signoret)	Fl	ectophagous	*	*
Melanaspis similacis (Comstock)	Fl	ectophagous	*	
**Pinnaspis strachani* (Cooley)	Fl	ectophagous	*	*
**Pseudaonidia trilobitiformis* (Green)	Fl	ectophagous	*	*
Rhizaspidiotus dearnessi (Cockerell)	Ga	ectophagous	*	*
**Velataspis dentata* (Hoke)	Fl	ectophagous	*	*
Flatidae				
Anormenis septentrionalis (Spinola)	Fl	ectophagous	*	*
Cyarda melichari Van Duzee	Fl	ectophagous	*	*
Fulgoridae				
Cyrpoptus reineckei Van Duzee	SC	ectophagous	*	
Poblicia fuliginosa Olivier	Ga	ectophagous	*	

Table 1. Continued.

Species[1]	Location (State)	Insect–Host Relationship to *Baccharis*	Specificity[2]	Pest Status[3]
Membracidae				
**Acutalis tartaren nigrinervis* Fowler	Fl	ectophagous	*	
Acutalis tartaren semicrema (Say)	Fl	ectophagous	*	
**Campylenchia latipes* (Say)	Fl	ectophagous	*	
**Micrutalis* sp.	Fl	ectophagous		
**Spissistilus festinus* (Say)	Fl	ectophagous	*	
Umbonia crassicornis (A. and S.)	Fl	ectophagous	*	
Vanduzeea arquata Say	Fl	ectophagous	*	
Ortheziidae				
Orthezia insignis Brown	Fl	ectophagous	*	*
Pseudococcidae				
Dysmicoccus sp.	Fl	ectophagous		
**Dysmicoccus bispinosis* Beardsley	Fl	ectophagous	U	
**Planococcus citri* (Risso)	Fl	ectophagous	*	*
Pseudococcus sorghiellus Forbes	Ga–Fl	ectophagous	*	
Lepidoptera				
Arctiidae				
**Estigmene acrea* (Drury)	Fl	ectophagous	*	
Cochylidae				
Lorita baccharivora Pogue	SC–Fl	ectophagous	***	
Coleophoridae				
Coleophora sp.	Va–Fl	ectophagous		
Cossidae				
Prionoxystus piger (Grote)	Fl	endophagous	***	
Prionoxystus robiniae (Peck)	Fl	endophagous	*	*
Gelechiidae				
Aristotelia ivae Busck	SC–Fl	ectophagous	***	
Dichomeris serrativittella Zeller	Fl	ectophagous	U	
Gnorimoschema sp.	Fl	endophagous		
Geometridae				
Anacamptodes defectaria (Guenée)	NC	ectophagous	*	
**Anavitrinella pampinaria* (Guenée)	Fl	ectophagous	*	*
**Eusarca fundaria* (Guenée)	Fl	ectophagous	U	
Itame varadaria (Walker)	SC–Fl	ectophagous	***	
Lyonetiidae				
Bucculatrix ivella Busck	NJ–Fl	endo and ecto	***	
Noctuidae				
Spodoptera ornithogalli (Guenée)	Fl	ectophagous	*	*
Spragueia onagrus (Guenée)	Fl		U	
Psychidae				
**Cryptothelia* sp.	Fl			
Pyralidae				
Glyphodes floridalis (Fernald)	Fl	ectophagous	U	
Pterophoridae				
Oidaematophorus balanotes (Meyrick)	NJ–Fl	endophagous	***	
Tortricidae				
Choristoneura parallela (Robinson)	NC	ectophagous	*	*
Epiblema discretivana (Heinrich)	SC–Fl	endophagous	***	
Epiblema nr. *scudderiana* (Clemens)	NC–Fl	endophagous	*	
Sparganothis sulfureana (Clemens)	Fl	ectophagous	*	
Anthribidae				
**Toxotropis floridanus* Leng	Fl	ectophagous	*	

Table 1. Continued.

Species[1]	Location (State)	Insect–Host Relationship to *Baccharis*	Specificity[2]	Pest Status[3]
Buprestidae				
**Chrysobothris chrysoela* (Illiger)	Fl	endophagous	*	
Chrysobothris femorata (Olivier)	Fl	endophagous	*	*
Cerambycidae				
Amniscus perplexus (Haldeman)	Ga–Fl	endophagous	***	*
**Ancylocera bicolor* (Olivier)	Fl		*	
**Anelaphus inermis* (Newman)	Fl		*	
**Leptura* sp.	Fl			
Sternidius rusticus (LeConte)	NJ		U	
Typocerus zebra Olivier	SC		U	
Chrysomelidae				
**Altica ludoviciana* Fall	Fl	ectophagous	*	
Anomoea laticlavia (Forster)	SC	ectophagous	*?	
**Bassareus brunipes* Olivier	Fl		U	
**Chlamisus* sp.	Fl			
**Chrysomela scripta* F.	Fl		U	
Colaspis recurva Blake	Va		U	
Cryptocephalus pumilis Haldeman	SC–Fl	ectophagous	*	
Diabrotica balteata LeConte	Fl	ectophagous	*	*
Diabrotica undecimpunctata howardii Barber	Ga–Fl	ectophagous	*	*
Diachus auratus (F.)	SC	ectophagous	*	
**Disonychya conjugata* F.	Fl	ectophagous	*	
**Exema gibba* F.	Fl	ectophagous	U	
Exema neglecta Blatchley	SC–Fl	ectophagous	*	
**Pachybrachys* sp.	Fl	ectophagous		
Paria aterrima Olivier	SC–Fl	ectophagous	U	
**Triachus cerinus* LeConte	Fl	ectophagous	U	
Trirhabda bacharidis (Weber)	NJ–Fl	ectophagous	***	
Curculionidae				
Apion metallicum Germar	Fl	ectophagous	*	*
Apion sp.	Fl	ectophagous		
Artipus floridanus Horn	Fl	ectophagous	*	*
**Baris* sp.	Fl			
**Centrinaspis albotectus* Casey	Fl		*	
**Chalcodermus aeneus* Bohemann	Fl		*	*
Curculio sp.	Fl			
**Diaprepes abbreviatus* (L.)	Fl		*	*
Epicaerus formidolosus Boheman	Fl	ectophagous	*	
**Nicentrus grossulus* Casey	Fl		*	
Notolomus basalis LeConte	Fl	ectophagous	*	
Pachnaeus opalus (Olivier)	Fl	ectophagous	*	
Rhodobaenus tredecimpunctatus (Illiger)	Fl	ectophagous	*	
Sitophilus oryzae L.	Fl	ectophagous	*	*
Tanymecus lacaena (Herbst)	Fl	ectophagous	*	
Scarabaeidae				
**Pachystethus marginatus* F.	Fl		*	
Popillia japonica Newman	Va	ectophagous	*	*
Diptera				
Agromyzidae				
**Amauromyza maculosa* (Malloch)	Fl	endophagous	*	
**Liriomyza trifolii* (Burgess)	Fl	endophagous	*	
Melanagromyza sp.	Fl	endophagous		

Table 1. Continued.

Species[1]	Location (State)	Insect–Host Relationship to *Baccharis*	Specificity[2]	Pest Status[3]
Nemorimyza posticata (Meigen)	SC–Fl	endophagous	*	
Phytobia sp.	SC–Fl	endophagous		
Cecidomyiidae				
Contarinia nr. *perfoliata*	Md	ectophagous	U	
Dasineuria undescribed sp.	Md	ectophagous		
Neolasioptera baccharicola Gagné	Va	endophagous	***	
Neolasioptera lathami Gagné	NJ–Fl	endophagous	***	
Neolasioptera undescribed sp.	Md	ectophagous		
Prodiplosis undescribed sp.	Md	ectophagous		
Tephritidae				
Paroxyma sp.	Ga	ectophagous		
Tephritis subpura (Johnson)	NC–Fl	endophagous	***	

[1] * = Record from DPI collection card file.
[2] *** = Monophagous (host-plants apparently restricted to the genus *Baccharis*); ** = oligophagous (host-plants apparently restricted to the tribe Astereae); * = polyphagous (having a wider host range than above two categories); *? = specificity unknown but very likely polyphagous; U = specificity unknown.
[3] * = Pest species.

Conversely, 8 of 18 (44%) endophagous species were monophagous.

Only 2 of the monophagous species, *P. piger* and *N. baccharicola,* had a limited geographic distribution. The other 12 species were found in at least 2 states and 6 species were found throughout the survey area. Ten of the 14 species (72%) were found west of the Mississippi River by Palmer (1987). By contrast only 27 of the total number of species (16%) were common to this survey and that of Palmer (1987).

Nearly one third of the phytophagous species (51 species) were pests of agricultural or ornamemental plants. These included well known pests such as the brown stinkbug, *Euchistus servus* (Say); the green peach aphid, *Myzus persicae* (Sulzer); the black citrus aphid, *Toxoptera aurantii* (Fonscolombe); the green scale, *Coccus viridis* (Green); the green shield scale, *Pulvinaria psidii* Maskell; the carpenterworm, *Prionoxystus robiniae* (Peck), the yellow-striped armyworm, *Spodoptera ornithogalli* (Guenée); and the southern corn rootworm, *Diabrotica undecimpunctata howardi* Barber.

Non-phytophagous insects such as pollinators, predators, parasitoids, nectar gatherers, and casual associates that were collected or reared during the survey are listed in Table 2. This list includes 55 predatory species.

Notes on the More Important Species

The phenologies of *Trirhabda bacharidis* Weber, *Amniscus perplexus* (Haldeman), *Oidaematophorus balanotes* (Meyrick), *Bucculatrix ivella* Busck, *Aristotelia ivae* Busck, *Epiblema discretivana* (Heinrich), *Neolasioptera lathami* Gagné, *Tephritis subpura* (Johnson), *Ochrimnus mimulus* (Stål), and *Stobaera pallida* Osborn were described by Palmer (1987). These species were all commonly encountered along the eastern seaboard. In Florida, however, the phenologies of *T. bacharidis* and *O. balanotes* were different from the previous description (Palmer 1987). Here larvae of *T. bacharidis* were commonly found in the autumn and early spring, suggesting a partial second generation or some populations being asynchronous. Similarly, *O. balanotes* was not discretely univoltine in Florida. A survey in February revealed a range of immature stages from early instars to pupae.

The black mirid, *Slaterocoris pallipes* (Knight), was abundant. It occurs further south, however, than Wheeler (1981) described with the southern limit of its range at Gainesville, Florida.

Table 2. Parasitoids, predators, and incidental visitors recorded, reared or collected on *B. halimifolia* during the course of the survey.

Species[1]	Habit
Acari	
Bdellidae	
**Bdellodes longirostris* (Hermann)	general predator
Phytoseiidae	
**Typhlodromalus peregrinus* (Muma)	general predator
Passalozetidae	
**Passalozetes* sp.	incidental
Tydeidae	
**Lorryia formosa* Cooreman	general predator
**Tydeus* nr. *munsteri* Meyer and Ryke	general predator
Araneae	
Anyphaenidae	
**Aysha* sp.	general predator
Araneidae	
**Araneus mimiatus* (Walckenaer)	general predator
**Argiope* sp.	general predator
**Conepeira mineatus* (Walckenaer)	general predator
**Neoscona* sp.	general predator
Clubionidae	
**Clubiona maritima* L. Koch	general predator
**Trachelas volutus* Gertsch	general predator
Salticidae	
**Hentzia ambigua* (Walckenaer)	general predator
**Hentzia mitrata* Hentz	general predator
Theridiidae	
**Anelosimus studiosus* (Hentz)	general predator
**Anelosimus textrix* (Walckenaer)	general predator
**Theridion flavonotatum* (Becker)	general predator
Thomisidae	
**Misumenops oblongus* (Keyserling)	general predator
Thysanoptera	
**Diceratothrips* sp.	general predator
**Leptothrips mali* (Fitch)	general predator
Hemiptera	
Anthocoridae	
Orius insidiosus (Say)	general predator
Nabidae	
Nabis capsiformis Germar	general predator
Pentatomidae	
Euthyrhynchus floridanus (L.)	general predator
**Podisus maculiventris* (Say)	general predator
Stiretrus anchorago (F.)	general predator
Phymatidae	
Phymata fasciata fasciata (Gray)	general predator
Phymata fasciata mystica Evans	general predator
Reduviidae	
**Apiomerus spissipes* (Say)	general predator
Pselliopus cinctus F.	general predator
Zelus longipes (L.)	general predator
Zelus cervicalis Stål	general predator
Zelus longipes (L.)	general predator

Table 2. Continued.

Species	Habit
Neuroptera	
Chrysopidae	
Chrysopa spp.	aphid predators
Lepidoptera	
Phycitidae	
Laetilea coccidivora Comstock	coccid predator
Coleoptera	
Cantharidae	
Cantharis sp.	pollen feeder
Chauliognathus marginatus (F.)	pollen feeder
Discodon sp.	pollen feeder
Coccinellidae	
Adalia bipunctata (L.)	aphid predator
**Azya orbigera* Mulsant	soft scale predator
Coleomegilla maculata (DeGeer)	aphid predator
**Cryptolaemus montrouzeiri* Mulsant	mealybug predator
Cycloneda sanguinea (L.)	aphid predator
Exochomus childreni Mulsant	soft scale predator
Hippodamia convergens Guerin	aphid predator
Hyperaspis signata Olivier	soft scale predator
**Microweisea* sp.	diaspine scale predator
Olla v-nigrum (Mulsant)	aphid predator
Scymnus creperus Mulsant	aphid predator
Scymnus fraternus LeConte	aphid predator
Elateridae	
Ampedus luteolus (LeConte)	incidental
**Melanotus communis* (Gyllenhal)	incidental
Scarabaeidae	
Trigonopeltastes delta (Forster)	incidental
Diptera	
Asilidae	
Asilus sp.	general predator
**Ommatius tibialis* Say	general predator
Bibionidae	
Plecia nearctica Hardy	incidental
Chamaemyiidae	
Leucopis americana Malloch	aphid predator
Micropezidae	
**Taeniaptera trivatta* Macquart	incidental
Otitidae	
**Euxesta notata* (Wiedemann)	incidental
Platystomatidae	
Rivellia steyskali Namba	incidental
Sciomyzidae	
Dictya sp.	incidental
Syrphidae	
Pseudodoros clavatus (F.)	aphid predator
Tabanidae	
**Chrysops flavidus* Wiedemann	incidental
Tabanus imitans Stone	incidental
Tachinidae	
Lixophaga sp.	incidental

Table 2. Continued.

Species[1]	Habit
Hymenoptera	
Aphelinidae	
Centrodora cercopiphagus (Milliron)	egg parasite of *Clastoptera*
Coccophagus sp. 1	parasite of *Coccus hesperidum*
Coccophagus sp. 2	parasite of *Pulvinaria urbicola*
Aphiidae	
**Diaeretiella* sp.	aphid parasite
Lysiphlebus testaceipes (Cresson)	aphid parasite
Bethylidae	
Parisarola sp.	parasite of *Epiblema discretivana*
Braconidae	
Apanteles undescribed sp.	parasite of *Bucculatrix ivella*
Apanteles epinotiae Viereck	parasite of Lepidoptera defoliator
Apanteles forbesi Viereck	parasite of Lepidoptera defoliator
Agathis texana Cresson	parasite of Lepidoptera
Bucculatriplex sp.	parasite of *Bucculatrix ivella*
Chelona sp.	parasite of *Oidaematophorus balanotes*
Chelonus (*Microchelonus*) sp.	parasite of *Oidaematophorus balanotes*
Macrocentrus cerasivoranae Viereck	parasite of *Oidaematophorus balanotes*
Macrocentrus delicatus Cresson	parasite of Lepidoptera defoliator
Macrocentrus pallister Degant	
Microgaster mediata Cresson	
Mirax texana Muesebeck	parasite of *Bucculatrix ivella*
Opius undescribed sp.	parasite of agromyzid
Opius undescribed sp.	parasite of agromyzid
Ceraphronidae	
Lygocerus sp.	parasite of *Bucculatrix ivella*
Chalcididae	
Spilochalcis sanguineventris (Cresson)	parasite of *Exema neglecta*
Cynipidae	
Gonaspis potentillae Bass	
Eupelmidae	
**Anastatus* sp.	
Eupelmus sp.	parasite of *Exema neglecta*
Eupelmus sp.	parasite of agromyzid
Eupelmus sp.	parasite of *Epiblema discretivana*
Eupelmus sp.	parasite of *Tephritis subpura*
Eupelmus sp.	parasite of *Neolasioptera lathami*
Eulophidae	
Achrysocharella sp.	parasite of agromyzid
Chrysocharis parksi Crawford	parasite of agromyzid
Cirrospilus girualti Peck	parasite of *Bucculatrix ivella*
Derostenus sp.	parasite of agromyzid
Tetrastichus minutus (Howard)	parasite of *Coleomegilla maculata*
Eurytomidae	
Eudecatoma quercilanae (Fitch)	
Eurytoma sp.	
Formicidae	
**Crematogaster ashmeadi* Mayr	
**Crematogaster atkinsoni* Wheeler	
**Dolichocerus pustulatus* Mayr	
**Dorymyrmex pyramicus* (Rogor)	incidental
**Hypoclinea mariae* Forel	general predator

Table 2. Continued.

Species[1]	Habit
**Monomorium floricola* (Jerdon)	
**Pseudomyrma brunnea* F. Smith	general predator
**Pseudomyrma pallida* F. Smith	general predator
**Wasmannia auropunctata* (Rogor)	
Ichneumonidae	
Brachycyrtus pretiosus Cushman	parasite of *Chrysopa*
Eiphosoma mexicana Cresson	
Labena grallator Say	parasite of *Amniscus perplexus*
Temelucha sp.	parasite of *Oidaematophorus balanotes*
Trogomorpha trogiformis (Cresson)	
Mutillidae	
Dasymutilla cypris Bl.	general predator
Platygasteridae	
Platygaster baccharicola (Ashmead)	parasite of *Neolasioptera lathami*
Trichasis sp.	parasite of *Neolasioptera lathami*
Pteromalidae	
Heteroschema sp.	parasite of *Exema neglecta*
Sphecidae	
Sceliphron caementarium Dru.	general predator
Vespidae	
Polistes annularis L.	general predator

[1] * = Record from DPI collection card file.

The cossid, *Prionoxystus piger* (Grote), caused considerable damage to the shrubs by its stem-boring activity. This was a univoltine species, with moth activity in spring and larvae present in the stems throughout the year. It was found only in a very limited, frost-free area to the south of Miami, suggesting that it may be a tropical, immigrant species from the Caribbean Islands. It has been previously reported from Cuba (Grote 1865).

The cochylid, *Lorita baccharivora* Pogue, is a multivoltine species that was commonly encountered from South Carolina to Florida. Larvae tied terminal and surrounding leaves together with silken threads to form tubes in which they lived. This action caused growth to be arrested, and the growing points to die, as reported by Diatloff and Palmer (1988, in press).

The case-bearing chrysomelid *Exema neglecta* Blatchley, was also commonly encountered from South Carolina to Florida. Both larvae and adults fed on the plant.

Prospects for Biological Control

Trirhabda bacharidis (W. Haseler, unpublished), *Oidaematophorus balanotes* (W. Haseler, unpublished), *Aristotelia ivae* (Diatloff and Palmer 1988, in press), *Bucculatrix ivella* (Palmer and Diatloff 1987), *Lorita baccharivora* (Diatloff and Palmer 1988, in press), *Neolasioptera lathami* (Diatloff and Palmer 1987), *Amniscus perplexus* (Palmer, unpublished), *Slaterocoris pallipes* (Palmer, unpublished), *Stobaera pallida* (Palmer, unpublished), and *Itame varadaria* (Palmer, unpublished) have been proven host specific and have been introduced into Australia. *Trirhabda bacharidis* and *A. ivae* have been established in the field in Queensland but they have not contributed to effective control except in localized areas. *Oidaematophorus balanotes* and *L. baccharivora* are at present being released and establishment is anticipated. *Bucculatrix ivella, A. perplexus,* and *I. varadaria* are undergoing final testing in Australia prior to their release. *Neolasioptera lathami, S.*

pallida, and *S. pallipes* have not yet been successfully cultured in the Australian quarantine facilities. The remaining monophagous species will be further tested for host specificity in the future.

The monophagous species were rated by the formula of Goeden (1983) and also subjectively by the authors, based on their North American experience with the insects (Table 3). The two methods of assessment were not in close agreement, although both indicated a number of promising species. *Amniscus perplexus, B. ivella, T. bacharidis,* and *O. balanotes* were given good scores by both methods. All 14 species received a score of >20 by the Goeden formula indicating that they might be at least partially effective agents and worthy of further study.

Table 3. The potential effectiveness for biological control of the monophagous species as predicted by the formula of Goeden (1983) and by the authors' subjective assessment (with a poor candidate scoring 1 and a superior prospect scoring 5).

Species	Goeden's Formula	Authors' Assessment
Amniscus perplexus	47	5
Bucculatrix ivella	45	5
Prionoxystus piger	37	5
Trirhabda bacharidis	45	5
Oidaematophorus balanotes	53	4
Aristotelia ivae	49	3
Lorita baccharivora	51	3
Neolasioptera lathami	47	3
Tephritis subpura	40	3
Itame varadaria	44	2
Slaterocoris pallipes	30	2
Stobaera pallida	41	2
Epiblema discretivana	36	1
Neolasioptera baccharicola	37	1

Discussion

In order to find all the insects on the plant, we found it essential to use both sweeping and visual inspection. *Baccharis halimifolia* is a tall bush growing well above surrounding grasses and herbs and therefore can be swept with little risk that the sample will be contaminated with arthropods from other plants. Sweeping proved to be the best method for capturing small active species and caterpillars present in low numbers. On the other hand, it was essential to inspect the plants visually in order to collect endophages and tightly adhering insects such as coccids.

Despite differences in sampling procedures and time allocated for survey, the size of the insect fauna is similar to that found on *B. pilularis* (Tilden 1951) and on *B. halimifolia* and *B. neglecta* west of the Mississippi by Palmer (1987). However, in one respect, this survey differed from the others; a much larger number of species of scale insects was taken, all in Florida. This may be due in part to Florida's subtropical climate and proximity to the Caribbean Islands from which many tropical species have become established.

The survey emphasized the importance of searching for endophages, as a very high proportion of these were monophagous as indicated also by Palmer (1987). Not only is there a high probability that an endophage will be monophagous, but their endophagous habit may protect them from many general predators and parasites in the country of release.

The survey also indicated that *B. halimifolia* harbours a rich insect fauna occupying a diverse range of niches. As *B. halimifolia* is a common plant along the eastern seaboard, it may be ecologically important to its habitat and to nearby human agricultural endeavours. This is suggested by the number of species of general predators associated with it and by the number of agricultural pests that either feed or seek shelter on it. It may therefore play an important role as an alternate host for these insects.

Acknowledgments

We thank the Systematic Entomology Laboratory (SEL), Agricultural Research Service, USDA, and the Department of Entomology, National Museum of Natural

History (NMNH) for providing such a fine service for us and other collectors.

We thank the following taxonomists for their identifications and advice: R. L. Brown, Mississippi Entomological Museum (Lepidoptera: Tortricidae); E. V. Cashatt, Illinois State Museum (Lepidoptera: Pterophoridae); J. A. Chemsak, UC Berkeley (Coleoptera: Cerambycidae); H. Cromroy, University of Florida (Acari: Eriophyidae); D. R. Davis, NMNH (Lepidoptera: Lyonetiidae); D. C. Ferguson, SEL (Lepidoptera: Geometridae, Pterophoridae, Pyralidae); R. H. Foote, SEL (Diptera: Tephritidae); R. J. Gagné, SEL (Diptera: Cecidomyiidae); R. D. Gordon, SEL (Coleoptera: Scarabaeidae, Coccinellidae); T. J. Henry, SEL (Hemiptera); R. W. Hodges, SEL (Lepidoptera: Gelechoidea); J. P. Kramer, SEL (Homoptera: Fulgoridae, Cicadellidae, Membracidae, Cercopidae); D. R. Miller, SEL (Homoptera: Coccoidea); M. Pogue, NMNH (Lepidoptera: Cochylidae); R. W. Poole, SEL (Lepidoptera: Noctuidae); F. C. Thompson, SEL (Diptera: Syrphidae); T. J. Spilman, SEL (Coleoptera: Cerambycidae, Elateridae); M. B. Stoetzel, SEL (Homoptera: Aphididae); R. E. White, SEL (Coleoptera: Chrysomelidae, Cerambycidae); and D. R. Whitehead, SEL (Coleoptera: Curculionidae).

We also thank the taxonomists at DPI (H. Denmark, H. Weems, F. Mead, and R. Woodruff) for allowing us to use host records from card files in that collection, for identifications and for advice.

We also thank G. Diatloff, D. Green, D. Harbeck, W. Haseler, S. Passoa, and V. Krischick who collected some of the species that we have reported.

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SPECIES OF AUSTRALIAN TELENOMINAE (HYMENOPTERA: SCELIONIDAE) OF A. P. DODD AND A. A. GIRAULT

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Abstract.—The species of Telenominae described by A. P. Dodd and A. A. Girault with types deposited in Australian collections are reviewed. The genera *Dissolcoides, Neoteleia,* and *Platytelenomus* are synonymized with *Telenomus* (new synonymies); *Archiphanurus* is synonymized with *Paratelenomus* (new synonymy). *Telenomus ophiusa* and *T. saccharalis* are transferred to *Paratelenomus* (new combinations); *Telenomus elpenor* and *T. omphale* are transferred to *Pstx* (new combinations); *Dissolcoides exsertus, D. flavinervus, Neoteleia punctata,* and *Platytelenomus planus* are transferred to *Telenomus* (new combinations); *Telenomus biproruli, T. darwinensis, T. eetion, T. egeria, T. ephyra, T. erigone, T. obliteratus, T. oecleoides, T. oecleus, T. oedipus, T. oeneus, T. oenone, T. oenopion, T. ogyges, T. oreas, T. orontes, T. otho,* and *T. wilsoni* are transferred to *Trissolcus* (new combinations); *Telenomus oaxes* is transferred to *Embidobia* (new combination); and *Telenomus orestes* is transferred to *Gryon* (new combination). Lectotypes are designated for *Dissolcus atriscapus, Trissolcus coriaceus, Telenomus darwinensis, Telenomus eetion, Telenomus egeria, Telenomus oecleus, Telenomus oedipus,* and *Telenomus ogyges.* The type material is missing for *Phanurus longicornis, P. depressus, Telenomus diemenensis,* and *Neotelenomus magniclavatus.*

Key Words: types, synonymies, combinations

Our knowledge of the Telenominae (Hymenoptera: Scelionidae) of Australia is based primarily upon the pioneering work of Alan P. Dodd (1895–1981). Several factors, however, make it difficult to use his published works. Generic concepts within the subfamily have substantially changed, and Dodd placed great emphasis upon color and the relative lengths and widths of antennomeres as diagnostic characters. Solely on the basis of the original descriptions (no figures were published), I have found it impossible to determine to which present-day genera Dodd's species belong and to evaluate the genera he described. I thus found it necessary to examine the types of each species to place them in the proper context, at least as it is understood today. I am convinced that the generic concepts within the Telenominae are in need of significant modification. It is premature to offer such a revision, but in the meantime I believe it is important to indicate how Dodd's species fit within the genera presently recognized (see Masner 1980, Kozlov and Kononova 1983, Johnson 1984), so as to indicate which type-specimens are relevant for future revisionary work at the species level.

I discuss below the telenomine types described by Dodd and A. A. Girault that are deposited in Australian institutions (with acronyms used in the text in parentheses):

Australian National Insect Collection, Canberra (ANIC); Department of Primary Industries, Queensland, Indooroopilly (DPIQ); National Museum of Victoria, Melbourne (NMV); Queensland Museum, Brisbane (QM); and the South Australian Museum, Adelaide (SAM). These include several species described from Indonesia and Fiji. A small number of types of Australian species are deposited in the British Museum (Natural History) and the National Museum of Natural History, Washington; the status of these has been discussed by Masner (1961) and Masner and Muesebeck (1968). The species of Australian Scelioninae have already been treated (see Galloway 1976, Austin 1981, and Galloway and Austin 1984). The condition of each specimen or series is briefly summarized. I have cited verbatim the label data accompanying specimens between quotation marks so as to assist recognition of the types. The abbreviation "NQ" in the labels stands for North Queensland, where both Dodd and Girault conducted much of their field work. The town of Nelson is now known as Gordonvale. The fore wings of slide mounts are often quite faded, and in many I was unable to find them although the label stated that they should be present. The type depository is indicated following the citation of the original description for each species. I have designated lectotypes only for those species in the genus *Trissolcus* in which I am conducting revisionary work. Many of Dodd's species were placed in the genera *Baeoneurella, Phanurus,* and *Neotelenomus,* names which were later synonymized with *Eumicrosoma* (the first) and *Telenomus.* In most cases the Australian species were not explicitly transferred to *Telenomus;* I have accepted these transfers as having been made implicitly and have not used the designation "new combination" for them.

Subfamily Telenominae

Archiphanurus Szabó

See *Paratelenomus* Dodd.

Baeoneura Foerster

See *Eumicrosoma* Gahan.

Baeoneurella Dodd

See *Eumicrosoma* Gahan.

Dissolcoides Dodd

See *Telenomus* Haliday.

Dissolcus Ashmead

See *Telenomus* Haliday.

Eumicrosoma Gahan

Eumicrosoma bellum (Dodd)

Baeoneurella bella Dodd, 1913b: 336. QM

Holotype ♀ on slide; "TYPE Hy/1628; Queensland Museum; Baeoneurella bella Dodd ♀." Condition: All tagmata slightly crushed and broken; antennae detached.

Eumicrosoma elongatum (Dodd),

Baeoneura elongata Dodd, 1913a: 166. SAM

Holotype ♀ on slide I11115; "Baeoneurella elongata Dodd ♀ type." Condition: head and mesosoma crushed.

Eumicrosoma girault (Dodd)

Baeoneura girault Dodd, 1913c: 176. SAM

Holotype ♀ on slide I1440; "Baeoneura girault Dodd ♀ type; sweeping in forest, Pentland, NQ, 4th Jun. 13, A. A. Girault." Condition: head and mesosoma crushed.

Eumicrosoma nigrum (Dodd),

Baeoneurella nigra Dodd, 1914b: 124.

Holotype ♀ on slide I2191; "Baeoneurella nigra Dodd ♀ type; 2191." Condition: slide broken in half; cover slip hanging over edge and cracked; head detached, crushed; mesosoma and metasoma slightly crushed.

***Eumicrosoma pulchrum* (Dodd),**

Baeoneurella pulchra Dodd, 1914b: 124. SAM

Holotype ♀ on slide I2190; "Baeoneurella pulchra Dodd ♀ type, B. giraulti Dodd; 2190." Condition: mounted on slide with a ♀ of *E. giraulti;* holotype of *E. pulchrum* is closest to the center of the cover slip; head and mesosoma crushed.

***Neoteleia* Dodd**

See *Telenomus* Haliday.

***Neotelenomus* Dodd**

See *Telenomus* Haliday.

***Paratelenomus* Dodd**

***Paratelenomus bicolor* (Dodd)**

Telenomus bicolor Dodd, 1914c: 251. SAM

Holotype ♀ on slide I11169; "Telenomus bicolor Dodd ♀ type." Condition: head and mesosoma crushed.

This species, although remarkable for its color pattern (black head and golden body), is clearly congeneric with the type species of the genus *Archiphanurus* Szabó, viz. *A. graeffei* (Kieffer). Thus, the last valid telenomine genus described by Szabó (1975) falls as a junior synonym of *Paratelenomus* Dodd (new synonymy).

***Paratelenomus ophiusa* (Dodd),**
New Combination

Telenomus ophiusa Dodd, 1913d: 84. SAM

Holotype ♀ on slide I11176; "Telenomus ophiusa Dodd ♀ type; 11176." Condition: tagmata separated, all badly crushed.

***Paratelenomus saccharalis* (Dodd),**
New Combination

Telenomus saccharalis Dodd, 1914f: 293. QM

Syntype ♂, ♀ on slide; "Telenomus saccharalis Dodd, ♂ ♀ type, From Pentatomid eggs on sugarcane, Java; Hy 2059; TYPE." Condition: ♀ with all tagmata separated, crushed; ♂ has slipped with the balsam over and on top of the edge of the cover slip and is only partially covered by the medium.

***Phanuromyia* Dodd**

***Phanuromyia rufobasalis* Dodd**

Phanuromyia rufobasalis Dodd, 1914g: 121. SAM

Holotype ♀ on slide I11027; "Phanuromyia rufobasalis Dodd ♀ type." Condition: head and mesosoma crushed.

This species clearly represents the same species group as genus *Issidotelenomus* Pélov, and possibly both *Aradoctonus* Masner and *Phlebiaporus* Kozlov. A short time ago I would have freely synonymized all under the name *Telenomus.* I now believe that this species group will warrant generic recognition and therefore I have elected not to transfer *P. rufobasalis.*

***Platytelenomus* Dodd**

See *Telenomus* Haliday.

***Psix* Kozlov and Lê**

***Psix elpenor* (Dodd),**
New Combination

Telenomus elpenor Dodd, 1914h: 4. SAM

Holotype ♀ with mesosoma and metasoma on point; "Telenomus elpenor Dodd ♀ type." Condition: good. Head, antennae, fore wing on slide I11095; "Telenomus elpenor Dodd ♀ type; I11095." Condition: head badly crushed, cover slip cracked over head.

***Psix glabriscrobus* (Girault)**

Telenomus glabriscrobus Girault, 1926b: 138. ANIC

See Johnson and Masner, 1985: 46–47.

***Psix olympus* (Dodd)**

Telenomus olympus Dodd, 1913c: 166. SAM

Holotype ♀ on slide I1418; "Telenomus

olympus Dodd ♀ type, sweeping on edge of jungle, Nelson, NQ, 5.iv.13 (A. P. Dodd)." Condition: badly crushed. Also under the cover slip is a specimen of *Telenomus*. The recognition of the specimen of *Psix* as representing *T. olympus* is based upon another specimen in ANIC identified by Dodd (see Johnson and Masner 1985: 49).

Psix omphale (Dodd), New Combination

Telenomus omphale Dodd, 1913c: 166. SAM

Holotype ♀ on point, "Telenomus omphale Dodd, ♀ type." Condition: good; antennae, both without radicle, forewing on slide I1419, "Telenomus omphale Dodd, ♀ type, antennae, forewings, From Pentatomid eggs in forest, Nelson, NQ, Apr. 13, A. P. Dodd."

Telenomus Haliday

Telenomus acares Johnson

Neotelenomus minimus Dodd, 1913c: 172, [preoccupied by *minimus* Ashmead, 1893]. SAM

Telenomus acares Johnson, 1984: 6 (replacement name).

Holotype ♀ on slide I1433; "Neotelenomus minimus Dodd ♀ type; On window, Nelson, NQ, 2nd.xii.12, A. P. Dodd." Condition: crushed.

Telenomus aegeus Dodd

Telenomus aegeus Dodd, 1914g: 124. SAM

Holotype ♀ on slide I11031; "Telenomus aegeus Dodd ♀ type." Condition: head and mesosoma crushed.

Telenomus aegicerophilus (Dodd)

Neotelenomus aegicerophilus Dodd, 1914h: 11. SAM

Holotype ♀ on slide I11141; "Neotelenomus aegicerophilus Dodd ♀ type; 11141." Condition: crushed, especially mesosoma.

Telenomus ajax Dodd

Telenomus ajax Dodd, 1914g: 125. SAM

Holotype ♀ on slide I11032; "Telenomus ajax Dodd ♀ type." Condition: head and mesosoma badly crushed.

Telenomus anthereae (Dodd)

Neotelenomus anthereae Dodd, 1913c: 171. SAM

One ♂, two ♀ syntypes on slide I1429; "Neotelenomus anthereae Dodd ♂, ♀ types; From egg of Antherea janetta, Nelson, NQ, May, 13, A P Dodd." Condition: all crushed; male genitalia exserted and clearly visible.

Nixon (1937) synonymized *Neotelenomus* with *Telenomus* on the basis of his conviction that the characters defining a genus should be applicable to both sexes. In this case, the only character used to distinguish *Neotelenomus* was the 10-merous female antenna. Nixon's interpretation that, aside from this character, *Neotelenomus* was indistinguishable from *Telenomus* was based not on an examination of the type species, *N. anthereae*, but on Dodd's original description and his knowledge of other species with the same reduction in antennomeres. I can now confirm that Nixon's synonymization is correct.

Telenomus atratus Johnson

Neotelenomus niger Dodd, 1913c: 172 [preoccupied by *niger* (Dodd), 1913c: 158]. SAM

Telenomus atratus Johnson, 1984: 12 (replacement name).

Twelve syntype ♀ on card (with 3 chalcidoids); "Kuranda, Qld., Mch 04, F. P. Dodd; Neotelenomus niger Dodd ♀ types." Condition: generally good, but very dirty. One ♀ syntype on slide I1432; "Neotelenomus niger Dodd ♀ type; Kuranda, NQ, March, 04, F. P. Dodd." Condition: crushed.

Telenomus australis (Dodd)

Neotelenomus australis Dodd, 1913d: 86. SAM

Holotype ♀ on slide I11140; "Neotelenomus australis Dodd ♀ type." Condition: mesosoma and head crushed and broken.

Telenomus beatus (Dodd)

Neotelenomus beatus Dodd, 1913d: 85. SAM

Holotype ♀ on slide I11142; "Neotelenomus beatus Dodd ♀ type." Condition: end of slide broken off; specimen badly crushed.

Telenomus caesaris (Girault)

Neotelenomus caesaris Girault, 1939: 149. ANIC

Syntypes on card; "♂, ♀ *Neotelenomus caesaris* Gir, Types." Condition: four ♀, one ♂ in good condition; also with bits and pieces of several broken specimens. There is also a second unlabelled pin with five ♀ and one ♂ that appear to belong to the same series.

Telenomus carnifex Johnson

Neotelenomus ovivorus Dodd, 1913c: 172 [preoccupied by *ovivorus* (Rondani), 1870]. SAM

Telenomus carnifex Johnson, 1984: 7 (replacement name).

Syntype ♂, ♀ on slide I1430; "Neotelenomus ovivorus Dodd, ♂ and ♀ types, Nelson, May, 13, Dodd." Condition: ♂ with head and mesosoma crushed; ♀ entirely crushed.

Telenomus corniger Johnson

Phanurus longicornis Dodd, 1913c: 160, [preoccupied by *longicornis* Ashmead, 1901].

Telenomus corniger Johnson, 1984: 8 (replacement name).

Type missing from SAM. The unit tray refers to slide I1409, but it is missing from the slide collection.

Telenomus depressus (Dodd)

Phanurus depressus Dodd, 1914h: 8.

Type missing from SAM.

Telenomus diemenensis Dodd

Telenomus diemenensis Dodd, 1914g: 123.

Type missing from SAM. Unit tray refers to slide I11030; this is missing from the slide collection and the label on the inside of the box's lid questions whether the slide was ever received.

Telenomus doddi Johnson

Telenomus giraulti Dodd, 1914d: 161. [preoccupied by *giraulti* (Dodd), 1913c]. QM

Telenomus doddi Johnson, 1984: 9 (replacement name).

Holotype ♀ on slide; "TYPE Hy/2057; Queensland Museum; Scelionid, Telenomus giraulti Dodd ♀." Condition: head detached; mesosoma on its side, slightly crushed laterally.

Telenomus eleleus Dodd

Telenomus eleleus Dodd, 1914h: 5. SAM

Holotype ♀ on slide I11170; "Telenomus eleleus Dodd ♀ type; I11170." Condition: crushed, tagmata separated.

Telenomus emersoni Girault

See *Telenomus olsenni* Johnson.

Telenomus endymion Dodd

Telenomus endymion Dodd, 1914h: 6. SAM

Holotype ♀ on point; "Telenomus endymion Dodd ♀ type." Condition: good. Antennae (and possibly also the fore wings) on slide I11096; "I11096; Telenomus endymion Dodd ♀ type." Condition: good; radicles still attached to head.

Telenomus eteocles Dodd

Telenomus eteocles Dodd, 1914h: 5. SAM

Holotype ♀ on slide I11171; "Telenomus eteocles Dodd ♀ type; I11171." Condition: tagmata separated, head and mesosoma crushed.

Telenomus exsertus (Dodd), New Combination

Dissolcoides exsertus Dodd, 1913a: 179. SAM

Holotype ♀ with mesosoma and metasoma on point; "Dissolcoides exsertus Dodd ♀ type; Pentland, Queensland." Condition: deeply embedded in glue, barely visible. Head on slide I11059; "Dissolcoides exsertus Dodd ♀ type; head, antennae, forewings; sweeping grass in forest, Pentland, NQ, 15th [?] Jan 13, A. A. Girault." Condition: head crushed, A10–A11 of right antenna missing; left antenna detached, near edge of cover slip.

Dodd apparently erected the genus *Dissolcoides* to accommodate what he perceived was a species that combined important characters of several of Ashmead's genera (1893). With the head detached it is now difficult to visualize the habitus of this wasp that so struck his attention, but it appears to me to be a fairly typical species of *Telenomus* (new synonymy).

Telenomus eximius (Dodd)

Neotelenomus eximius Dodd, 1914b: 121. SAM

Holotype ♀ on point; "Neotelenomus eximius Dodd ♀ type; I2186." Condition: body deeply embedded in glue. Antennae and possibly fore wings on slide I2186; "Neotelenomus eximius Dodd ♀ type; forewings, antennae." Condition: one antenna crushed.

Telenomus flavescens Dodd

Telenomus flavescens Dodd, 1914h: 4. SAM

Holotype ♂ on slide I11172; "Telenomus flavescens Dodd ♂ type." Condition: head separated from body; mesosoma and head crushed.

Telenomus flavinervus (Dodd) New Combination

Dissolcoides flavinervus Dodd, 1914c: 253. SAM

Holotype ♀ on point; "Dissolcoides flavinervus Dodd ♀ type; Herbert R." Condition: deeply embedded in glue, otherwise good. Antennae (and possibly fore wings) on slide I11060; "Dissolcoides flavinervus Dodd ♀ type; antennae forewings." Condition: antennae broken off from head beyond radicles, one clava slightly crushed.

Telenomus giraulti (Dodd)

Phanurus giraulti Dodd, 1913c: 159. SAM

Two syntypes, ♂ and ♀ on separate slides, both coded I1403; "Phanurus giraulti Dodd ♂ type, Nelson, NQ, 13.iii.13, A P Dodd"; "Phanurus giraulti Dodd ♀ type, Forest Nelson, NQ, 10.viii.12, A A Girault." Condition: both with head and mesosoma crushed.

Telenomus giraulti Dodd, 1914d

See *Telenomus doddi* Johnson.

Telenomus gloriosus Dodd

Telenomus gloriosus Dodd, 1913d: 84. SAM

Holotype ♀ on slide I11173; "Telenomus gloriosus Dodd ♀ type; 11173." Condition: head and mesosoma crushed; A8–A11 of both antennae missing.

Telenomus hackeri (Dodd)

Phanurus hackeri Dodd, 1913b: 337. QM

Holotype ♀ on slide; "TYPE Hy/1629; Queensland Museum; Phanurus hackeri Dodd ♀." Condition: tagmata separated, all badly crushed.

Telenomus hilli (Dodd)

Phanurus hilli Dodd, 1914b: 119. SAM

One ♂, 3 ♀ syntypes on slide I2180; "Phanurus hilli Dodd ♂ + ♀ types, 2180." Condition: all badly crushed.

Telenomus javensis Dodd

Telenomus javensis Dodd, 1914e: 163. QM

Syntype ♀ on point; "TYPE Hy/2060; Telenomus javensis Dodd ♀ type." Condition: deeply embedded in glue. Syntype ♀ on slide

[together with the holotype of *Telenomus vandergooti* Dodd]; "TYPE/2060 2061; Scelionid, Queensland Museum, ♀ Telenomus javensis D. 2060 T. vandergooti D. ♀ 2061." Condition: mesosoma crushed; head is separated and has slipped to the edge of the cover slip beneath a drop of balsam.

***Telenomus laticeps* (Dodd)**

Neotelenomus laticeps Dodd, 1914h: 10. SAM

Holotype ♀ on slide I11143; "Neotelenomus laticeps Dodd ♀ type; I11143." Condition: mesosoma and metasoma badly crushed; head has slipped beyond the edge of the cover slip; one antenna, with A2–A9 is beyond the head, along the edge of the slide; second antenna not found.

***Telenomus leai* (Dodd)**

Neotelenomus leai Dodd, 1913c: 172. SAM

Holotype ♀ on slide I1431; "Neotelenomus leai Dodd ♀ type; King Island, Bass Strait, Tasmania, A. M. Lea." Condition: head and apex of metasoma broken off; all badly crushed.

***Telenomus longicornis* (Dodd)**

See *Telenomus corniger* Johnson.

***Telenomus longicorpus* (Dodd)**

Phanurus longicorpus Dodd, 1913c: 160. SAM

Two syntype ♀ mounted on separate slides both coded I1406. "Phanurus longicorpus Dodd ♀ type, sweeping forest, Nelson, Feb [other handwriting indistinct]." Condition: head detached, crushed; mesosoma crushed. "Phanurus longicorpus Dodd ♀ type, sweeping forest, Nelson, NQ, 13.II.12, A A Girault." Condition: head detached, all tagmata crushed.

***Telenomus longipennis* (Dodd)**

Phanurus longipennis Dodd, 1913c: 160. SAM

Holotype ♀ on slide I1407; "Phanurus longipennis Dodd ♀ type, sweeping in forest, Ingham, 14.i.13, A. P. Dodd." Condition: head detached, mesosoma crushed.

***Telenomus magniclavatus* (Dodd)**

Neotelenomus magniclavatus Dodd, 1914b: 122.

Type missing from SAM. It should be mounted on slide I2187, but this is missing from the slide collection.

***Telenomus minimus* (Dodd)**

See *Telenomus acares* Johnson.

***Telenomus montanus* (Dodd)**

Phanurus montanus Dodd, 1913c: 159. SAM

Holotype ♀ on slide I1404, "Phanurus montanus Dodd ♀ type [with specific name fumipennis crossed out], on window, Herberton, NQ (3000 feet), 28.xii.11, A. A. Girault." Condition: mesosoma crushed.

***Telenomus necopinatus* (Dodd)**

Phanuromyia necopinata Dodd, 1916: 32.

Holotype ♀, mesosoma and metasoma on point; "Phanuromyia necopinata Dodd ♀ type." Condition: head missing. Antennae, fore wing on slide I11158; "Phanuromyia necopinata Dodd ♀ type." Condition: radicles missing.

***Telenomus nelsonensis* (Dodd)**

Phanurus nelsonensis Dodd, 1913c: 160. SAM

Holotype ♀ on slide I1405; "Phanurus nelsonensis Dodd ♀ type, sweeping in forest, Nelson, NQ, 14.vi.12, A A Girault." Condition: good.

***Telenomus niger* (Dodd)**

Phanurus niger Dodd, 1913c: 158. SAM

Holotype ♀ on slide I1402; "Phanurus niger Dodd ♀ type, Nelson, NQ, 24th Dec, 12,

on window of laboratory porch." Condition: head and mesosoma crushed.

***Telenomus niger* (Dodd), 1913c**

See *Telenomus atratus* Johnson.

***Telenomus nigricorpus* (Dodd)**

Phanurus nigricorpus Dodd, 1913c: 160. SAM

Holotype ♀ on slide I1408; "Phanurus nigricorpus Dodd ♀ type, Nelson, Jan 12, A A Girault." Condition: crushed, barely covered by balsam.

***Telenomus ocnus* (Dodd)**

Telenomus ocnus Dodd, 1914b: 120. SAM

Holotype ♀ on slide I2183; "Telenomus ocnus Dodd ♀ type, head, antennae, forewings, 2183." Condition: head crushed; mesosoma and metasoma missing.

***Telenomus odyssea* (Dodd)**

Telenomus odyssea Dodd, 1913c: 162. SAM

Holotype ♀ on slide I1410; "Telenomus odyssea Dodd ♀ type, sweeping in forest, Nelson, 3.ix.12, A. A. Girault." Condition: head detached, mesosoma crushed.

***Telenomus oeagrus* Dodd**

Telenomus oeagrus Dodd, 1913c: 163. SAM

Holotype ♀ on slide I1411: "Telenomus oeagrus Dodd, ♀ type, sweeping jungle along streamlet, Babinda, NQ, 26.x.11, A. A. Girault." Condition: mesosoma crushed.

***Telenomus oechalia* Dodd**

Telenomus oechalia Dodd, 1913d: 83. SAM

Holotype ♀ on slide I11175; "Telenomus oechalia Dodd ♀ type." Condition: badly crushed.

***Telenomus oeta* Dodd**

Telenomus oeta Dodd, 1914c: 252. SAM

Holotype ♀ on slide I11174; "Telenomus oeta Dodd ♀ type." Condition: head detached, all tagmata crushed, mesosoma especially so; balsam barely covers specimen.

***Telenomus olsenni* Johnson**

Telenomus emersoni Girault, 1932: 6 [in Gordh et al., 1979: 298; preoccupied by *emersoni* (Girault), 1916]. QM

Telenomus olsenni Johnson, 1984: 12 (replacement name).

One wing, one antenna on slide; "Telenomus emersoni Gir. Type ♀." Condition: good; remainder of specimen missing.

***Telenomus ophion* Dodd**

Telenomus ophion Dodd, 1913c: 167. SAM

One syntype specimen on card, sex uncertain; "Telenomus ophion Dodd ♂ type." Condition: fair, antennae, forewings missing. Slide I1420 with head of ♀, one antenna attached, complete; left antenna with radicle, A10–A11 missing; head of ♂ with one antenna attached, second detached; propleuron, fore legs, a fore wing and hind wing present; "Telenomus ophion Dodd, ♂, ♀ types; From Pentatomid eggs, Nelson, NQ, May, 12, A. A. Girault."

***Telenomus opis* Dodd**

Telenomus opis Dodd, 1913d: 84. SAM

Holotype ♀ on slide I11177; "Telenomus opis Dodd ♀ type; 11177." Condition: head, propleura, prosternum and fore legs separated; entire body crushed.

***Telenomus orithyia* Dodd**

Telenomus orithyia Dodd, 1913c: 180. SAM

Holotype ♀ on slide I1451; "Telenomus orithyia Dodd ♀ type; sweeping in jungle, Nelson, NQ, 15.v.13, A. P. Dodd." Condition: head and mesosoma badly crushed.

***Telenomus ormenis* Dodd**

Telenomus ormenis Dodd, 1913c: 181. SAM

Holotype ♀ on slide I1452; "Telenomus ormenis Dodd ♀ type; sweeping on edge of jungle, Kuranda, NQ, 18.v.13, A P Dodd."

Condition: head detached, mesosoma crushed.

Telenomus orodes Dodd

Telenomus orodes Dodd, 1913c: 181. SAM

Holotype ♀ on slide I1453; "Telenomus orodes Dodd ♀ type; sweeping on edge of jungle, Kuranda, NQ, 18.v.13 (A P Dodd)." Condition: crushed.

Telenomus orpheus Dodd

Telenomus orpheus Dodd, 1913c: 181. SAM

Holotype ♀ on slide I1454; "Telenomus orpheus Dodd ♀ type; sweeping foliage of lantana, Mackay, NQ, 11.x.11 (A A Girault)." Condition: crushed.

Telenomus osiris Dodd

Telenomus osiris Dodd, 1913c: 180. SAM

Holotype ♀ on slide I1450; "Telenomus osiris Dodd ♀ type; sweeping forest and jungle, Nelson, NQ, 3.ix.12, A. A. Girault." Condition: tagmata detached, mesosoma broken, head and anterior part of mesosoma have slipped beyond the edge of the cover slip.

Telenomus ossa Dodd

Telenomus ossa Dodd, 1914b: 119. SAM

Holotype ♀ on slide I2181; "Telenomus ossa Dodd ♀ type; 2181." Condition: crushed.

Telenomus ovivorus (Dodd)

See *Telenomus carnifex* Johnson.

Telenomus oxycareni Girault

Telenomus oxycareni Girault, 1934: 2 [Gordh et al. 1979: 307]. QM

Two syntype ♀ (with identical labels); "Telenomus oxycareni Gir., ♀, Type." Condition: one ♀ in good condition; second with head missing and mesosoma crushed.

Telenomus pallidicornis (Dodd)

Neotelenomus pallidicornis Dodd, 1913d: 86. SAM

Holotype ♀, mesosoma and metasoma on point; "Neotelenomus pallidicornis Dodd ♀ type; Cairns." Condition: deeply embedded in glue. Head, fore wing on slide I11147; "Neotelenomus pallidicornis Dodd ♀ type head, forewings." Condition: head crushed, fore wings not visible.

Telenomus pallidithorax (Dodd)

Neotelenomus pallidithorax Dodd, 1914h: 10. SAM

Holotype ♀ on slide I11149; "Neotelenomus pallidithorax Dodd ♀ type; I11149." Condition: crushed.

Telenomus pallidiventris (Dodd)

Neotelenomus pallidiventris Dodd, 1913d: 86. SAM

Holotype ♀ on slide I11146; "Neotelenomus pallidiventris Dodd ♀ type." Condition: head and mesosoma crushed; specimen very pale.

Telenomus parvulus (Dodd)

Neotelenomus parvulus Dodd, 1914h: 12. SAM

Holotype ♀ on slide I11144; "Neotelenomus parvulus Dodd ♀ type; I11144." Condition: head detached; it and mesosoma crushed; right antenna missing.

Telenomus planus (Dodd), New Combination

Platytelenomus planus Dodd, 1914a: 126. SAM

Holotype ♀: mesosoma and metasoma on point; "Platytelenomus planus Dodd ♀ type; Cairns." Condition: good. Head, fore wing on slide I11072; "Platytelenomus planus Dodd ♀ type, head, forewings." Condition: head slightly crushed, fore wing not visible.

After having examined the type species, I consider the genus *Platytelenomus* Dodd to be a junior synonym of *Telenomus* (new synonymy). *Telenomus planus* is closely related to the species I have grouped together

in the *floridanus* species group as indicated by the elongate, depressed body and, more importantly, the elongate clavomeres (Johnson 1984). All species in these group, so far as is now known, are parasites of the eggs of lygaeids. *Platytelenomus,* when correctly understood, is not closely related to the depressed species of *Telenomus* that parasitize the flattened eggs of various moths (see Fergusson 1983). If at some time in the future it is thought appropriate to recognize the *floridanus* group as a genus, the names *Hemisius* Westwood and *Dissolcus* Ashmead have priority.

***Telenomus pseudoclavatus* (Dodd)**

Neotelenomus pseudoclavatus Dodd: 1913d: 87. SAM

Holotype ♀ on slide I11145; "Neotelenomus pseudoclavatus Dodd ♀ type." Condition: head detached; all tagmata crushed.

***Telenomus pulcherrimus* Dodd**

Telenomus pulcherrimus Dodd, 1914b: 121. SAM

Holotype ♀ on slide I2185; "Telenomus pulcherrimus Dodd ♀ type 2185." Condition: mesosoma, head broken.

***Telenomus pulchricornis* (Dodd)**

Neotelenomus pulchricornis Dodd, 1914h: 9. SAM

Holotype ♀ on slide I11148; "Neotelenomus pulchricornis Dodd ♀ type; I11148." Condition: head detached; all tagmata, especially mesosoma, crushed.

***Telenomus punctatus* (Dodd), New Combination**

Neoteleia punctata Dodd, 1913a: 169. SAM

Holotype ♂, mesosoma and metasoma on point; "Neoteleia punctata Dodd ♂ type; Cairns." Condition: good. Head on slide I11070; "Neoteleia punctata Dodd ♂ type, head, forewings." Condition: head crushed; fore wings not visible.

This is a fairly large species that may be most closely related to *Phanuromyia.* However, until freshly collected material is identified and the cephalic characters can be carefully examined, it falls within the, admittedly, very broad definition of *Telenomus.* I prefer to synonymize *Neoteleia* under that name (new synonymy) than to maintain it as a distinct genus. This species can probably be identified by its large size, sculptured frons, presence of episternal foveae, very elongate T2, and the elongate basal flagellomeres.

***Telenomus sidneyi* Girault**

Telenomus sidneyi Girault, 1932: 5 [Gordh et al. 1979: 297]. QM

One leg, two fore wings on slide; "Scelionid, Type ♀, Telenomus sidneyi Gir. wing [remaining handwriting unclear]." The rest of the specimen is missing.

***Telenomus simulans* (Dodd)**

Neotelenomus simulans Dodd, 1914h: 11. SAM

Holotype ♀ on slide I11150; "Neotelenomus simulans Dodd ♀ type; I11150." Condition: head detached, slightly broken; mesosoma crushed.

***Telenomus spodopterae* Dodd**

Telenomus spodopterae Dodd, 1914e: 164. QM

Four syntype ♀ on slide; "TYPE Hy/2062; Queensland Museum; Telenomus spodopterae Dodd ♀." Condition: two ♀ with mesosoma broken, otherwise good; one ♀ with head widely separated from mesosoma, metasoma also detached but close to mesosoma, mesosoma broken; one ♀ with mesosoma crushed, head and metasoma widely separated from mesosoma; clavomeres of all specimens distorted.

***Telenomus vandergooti* Dodd**

Telenomus vandergooti Dodd, 1914e: 164. QM

Holotype ♀ on slide [together with syntype of *Telenomus javensis* Dodd]; "TYPE/2060 2061; Scelionid, Queensland Museum, ♀ Telenomus javensis D. 2060 T. vandergooti D. ♀ 2061." Condition: tagmata detached, head and mesosoma crushed.

Trissolcus Ashmead

Trissolcus atriscapus (Girault)

Dissolcus atriscapus Girault, 1926a: 1 [Gordh et al. 1979: 200]. DPIQ

Lectotype (here designated) ♀ on point; "*Dissolcus atriscapus* Gir. Type ♂♀." Condition: head missing; most of the second specimen on the point has been lost, only legs remain glued to the tip.

Trissolcus beenleighi (Girault)

Dissolcus beenleighi Girault, 1932: 5 [in Gordh et al. 1979: 297]. QM

Holotype ♀ on point; "*Dissolcus beenleighi* Gir., ♀, *Type;* 29.xii.1925, Beenleigh, Forest." Condition: metasoma detached; antennae and wings from left side of body missing.

Trissolcus biproruli (Girault), New Combination

Telenomus biproruli Girault, 1926b: 137. QM

Holotype ♀ on point; "*Telenomus biproruli* Gir., ♀, *Type.*" Condition: good.

Trissolcus coriaceus Dodd

Trissolcus coriaceus Dodd, 1915: 451. SAM

Lectotype ♀ (here designated) and paralectotype ♀ on point; "Trissolcus coriaceus Dodd ♀ types." Condition: lectotype at apex of point with head and anterior half of mesosoma embedded in glue; paralectotype with mesosoma broken between mesothorax and metathorax; otherwise both in good condition. Two antennae on slide I5177; "Trissolcus coriaceus ♀ type."

Trissolcus darwinensis (Dodd), New Combination

Telenomus darwinensis Dodd, 1914h: 7. SAM

Lectotype ♂, paralectotype ♀ on point; "Telenomus darwinensis ♀, ♂ types." Condition: good. Male antennae, female head and antennae on slide I11099; "Telenomus darwinensis Dodd ♂, ♀ types." Condition: head badly crushed, male antennae with scape broken, still attached to head.

Trissolcus eetion (Dodd), New Combination

Telenomus eetion Dodd, 1914h: 3. SAM

Lectotype ♀ on point; "Telenomus eetion Dodd ♀ type." Condition: dirty, otherwise good; both antennae present. Paralectotype male, female antennae, fore wing on slide I11093; "I11093, Telenomus eetion Dodd ♂♀ types." Condition: female antenna good; male antenna broken.

Trissolcus egeria (Dodd), New Combination

Telenomus egeria Dodd, 1914h: 4. SAM

Lectotype ♀ "Telenomus egeria Dodd ♀ type." Condition: head missing. Paralectotype ♀ on slide I11094; "Telenomus egeria Dodd ♀ type." Condition: head crushed and broken, mesosoma crushed, A6–A11 of right antenna, A8–A11 of left antenna missing.

Trissolcus ephyra (Dodd), New Combination

Telenomus ephyra Dodd, 1914h: 7. SAM

Holotype ♀ on point; "Telenomus ephyra Dodd ♀ type." Condition: body deeply embedded in glue. Antennae, fore wings on slide I11097; "Telenomus ephyra Dodd ♀ type; I11097." Condition: antennae crushed, without radicles.

Trissolcus erigone (Dodd), New Combination

Telenomus erigone Dodd, 1914h: 8. SAM

Holotype ♀ on point; "Telenomus erigone Dodd ♀ type." Condition: body deeply embedded in glue. Antennae (and possibly the fore wings) on slide I11098; "Telenomus erigone Dodd ♀ type; I11098." Condition: radicles missing (still attached to head), antennae slightly crushed.

Trissolcus euander (Dodd)

Telenomus euander Dodd, 1914h: 7. SAM

Holotype ♀ mesosoma and metasoma on point; "Telenomus euander Dodd ♀ type." Condition: good. Head, antennae (and possibly fore wings) on slide I11092; "Telenomus euander Dodd ♀ type; I11092." Condition: head crushed.

Trissolcus flaviscapus Dodd

Trissolcus flaviscapus Dodd, 1916: 32. SAM

Holotype ♀ on point; "Trissolcus flaviscapus Dodd ♀ type." Condition: fore wings missing, otherwise good. Antenna on slide I11180; "Trissolcus flaviscapus Dodd ♀ type; 11180." Condition: broken off from head above radicle.

Trissolcus obliteratus (Dodd), New Combination

Telenomus obliteratus Dodd, 1914g: 122. SAM

Holotype ♀ on point; "Telenomus obliteratus Dodd ♀ type." Condition: only one hind wing remaining, left antenna broken off just above radicle, right antenna with A2–A11 missing, otherwise good. Slide 11029 with nothing visible (it may hold the wings, but I could not find them). The label in the unit tray states that the type of this species was not received. I found the specimen in the tray with *Trissolcus oecleoides*.

Trissolcus oecleoides (Dodd), New Combination

Telenomus oecleoides Dodd, 1914g: 122. SAM

Holotype ♀ on point, "Telenomus oecloides [sic] Dodd ♀ type." Condition: good. Antennae (without radicles) on slide I11028, "Telenomus oecloides [sic] Dodd ♀ type."

Trissolcus oecleus (Dodd), New Combination

Telenomus oecleus Dodd, 1913c: 163. SAM

Lectotype ♂ (here designated): "Telenomus oecleus Dodd type." Condition: mounted on point, A7–A12 of left antennae, A10–A12 of right antenna missing; lower half of body, most of head embedded in glue. One paralectotype ♀; "Telenomus oecleus Dodd type." Condition: mounted on point, antennae, wings missing; deeply embedded in glue. The paralectotype, although clearly labelled as a type by Dodd, is not conspecific with the male. The choice of the lectotype is based upon a series of specimens in DPIQ identified by Dodd as *T. oecleus* that are conspecific with the male. There are also two slides with the code I1412 in SAM that bear labels identifying them as types. One has a fore wing and two complete male antennae and bears the label "Telenomus oecleus Dodd, ♂ type, forewing, antenna, reared from Pentatomid eggs, Kuranda, NQ, 3/ix/04, F P Dodd"; the second has the label "Telenomus oecleus Dodd, ♀ type, forewings and antennae, sweeping edge of jungle, Kuranda, NQ, 20.xii.12, A P Dodd," presumably from the point-made female.

Trissolcus oedipus (Dodd), New Combination

Telenomus oedipus Dodd, 1913c: 164. SAM

Three specimens glued to a card; "Hobart, Tas: Lea; Hobart, Tas: Lea; Telenomus oedipus Dodd ♀ types." Condition: 1 ♀ lectotype (here designated) on left (viewed from above with pin at bottom) with line beneath, in good condition; two paralectotypes: 1 ♀ in middle, metasoma missing; 1 specimen on right, probably a ♀, head miss-

ing. One ♀ paralectotype on slide I1413: "Telenomus oedipus Dodd ♀ type, Hobart, Tasmania, A M Lea." Condition: head and mesosoma badly crushed.

***Trissolcus oeneus* (Dodd),**
New Combination

Telenomus oeneus Dodd, 1913c: 164. SAM

Holotype ♀ on card; "King I, Tas: Lea, Telenomus oeneus Dodd, ♀ type." Condition: body almost completely covered by glue; mesosoma broken, mesonotum covering head; foretibia and tarsus, A2–A9 of one antenna, A7–A11 of another on slide I1414: "Telenomus oeneus Dodd, ♀ type, antenna, forewings, King Is., Bass Strait, A. M. Lea."

***Trissolcus oenone* (Dodd),**
New Combination

Telenomus oenone Dodd, 1913c: 165. SAM

Holotype ♀ on card, "Cairns district, A. M. Lea, Telenomus oenone Dodd, ♀ type." Condition: covered in glue, antennae, forewing on slide I1415, label: "Telenomus oenone Dodd, ♀ type, forewing antennae, Cairns district, NQ, A M Lea."

***Trissolcus oenopion* (Dodd),**
New Combination

Telenomus oenopion Dodd, 1913c: 165. SAM

Holotype ♀ on slide I1416; "Telenomus oenopion Dodd ♀ type forewing, antenna, From foliage of a lemon tree, Roma, Q., 6.x.11, A. A. Girault." Condition: one antennae, broken, and distal half of fore wing only on slide, no body present.

***Trissolcus ogyges* (Dodd),**
New Combination

Telenomus ogyges Dodd, 1913c: 166. SAM

Lectotype ♀ and 2 paralectotype ♀ on slide I1417; "Telenomus ogyges Dodd ♀ type, sweeping Cape River, Pentland, NQ, Jan. 13, A. A. Girault." Condition: lectotype (here designated) near edge of cover slip, head attached to mesosoma, mesosoma crushed.

***Trissolcus oreas* (Dodd),**
New Combination

Telenomus oreas Dodd, 1913c: 180. SAM

Holotype ♀ on slide I1449; "Telenomus oreas Dodd ♀ type; Sweeping in jungle, Nelson, NQ, 15.v.13, A P Dodd." Condition: head and mesosoma badly crushed.

***Trissolcus orontes* (Dodd),**
New Combination

Telenomus orontes Dodd, 1914b: 120. SAM

Holotype ♀ on slide I2181; "Telenomus orontes Dodd ♀ type; 2182." Condition: crushed.

***Trissolcus otho* (Dodd),**
New Combination

Telenomus otho Dodd, 1914c: 252. SAM

Holotype ♀ on point, "Telenomus otho Dodd ♀ type; Cairns." Condition: tagmata detached, otherwise good. Fore wing, antennae on slide I11100, "Telenomus otho Dodd ♀ type, forewing antennae"; antennae crushed.

***Trissolcus wilsoni* (Dodd),**
New Combination

Telenomus wilsoni Dodd, 1930: 28. NMV

Holotype ♀; "Eltham, V., F. E. Wilson, May, 1927; HOLOTYPE T-1420 Telenomus wilsoni Dodd [red museum label]; Telenomus wilsoni Dodd, ♀, Holotype [Dodd's handwritten label]; F. E. Wilson Collection." Condition: good; right mid leg beyond coxa, hind leg beyond femur missing; left legs hidden beneath body.

Subfamily Scelioninae

***Embidobia* Ashmead**

Embidobia oaxes (Dodd), New Combination

Telenomus oaxes Dodd, 1914b: 120. SAM

Holotype ♀ on card, "Telenomus oaxes Dodd ♀ type; I2184." Condition: good. Head on slide I2184, "Telenomus oaxes Dodd, ♀ type, head, forewings, 2184." Condition: head badly crushed; fore wings not found.

Gryon Haliday

Gryon orestes (Dodd), New Combination

Telenomus orestes Dodd, 1913c: 167. SAM

Holotype ♂ on slide I1421; "Telenomus orestes Dodd ♂ type, on window, Herberton (3000 ft) NQ, 28.iii.11, A A Girault." Condition: head and mesosoma crushed.

Acknowledgments

I gratefully acknowledge the help and hospitality of I. D. Naumann (Canberra), J. Cardale (Canberra), G. Gross (Adelaide), A. D. Austin (Adelaide), I. D. Galloway (Indooroopilly), E. C. Dahms (Brisbane) and G. Monteith (Brisbane) during my trip to Australia; to K. Walker (Melbourne) for the loan of material; and to L. Masner (Ottawa) and J. B. Whitfield (Columbus) for review of the manuscript. This material is based upon work supported by the National Science Foundation under Grant No. BSR-8516579.

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PROC. ENTOMOL. SOC. WASH.
90(2), 1988, pp. 244–247

TELENOMUS SPECIES (HYMENOPTERA: SCELIONIDAE) ASSOCIATED WITH THE EGGS OF ZYGAENIDAE (LEPIDOPTERA)

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Abstract.—Two species of *Telenomus* are known to parasitize the eggs of Zygaenidae. ***Telenomus argus*** n. sp. has been reared from the eggs of the vineyard pest *Theresimima ampelophaga* Bayle-Barelle in Israel. *Telenomus zygaenae* Kieffer was reported to attack the eggs of *Zygaena lonicerae* (Scheven); it is compared with *T. argus* and its host relationships discussed.

Key Words: Parasitoid, biological control

The new species of *Telenomus* (Hymenoptera: Scelionidae) described below has been reared from the eggs of *Theresimima* (*Ino*) *ampelophaga* Bayle-Barelle (Lepidoptera: Zygaenidae) in Israel. This moth is one of the few zygaenids of any economic importance: it feeds on *Vitis* spp. in countries around the Mediterranean Basin and in other warm areas of the western Palearctic (Balachowsky 1972). We therefore present this description in order to provide biological control workers with a name for the parasitoid. In addition, we discuss *T. zygaenae* Kieffer, the only other *Telenomus* recorded from this family of moths. The morphological terminology used follows that discussed in Johnson (1984).

Telenomus argus, NEW SPECIES
Fig. 1

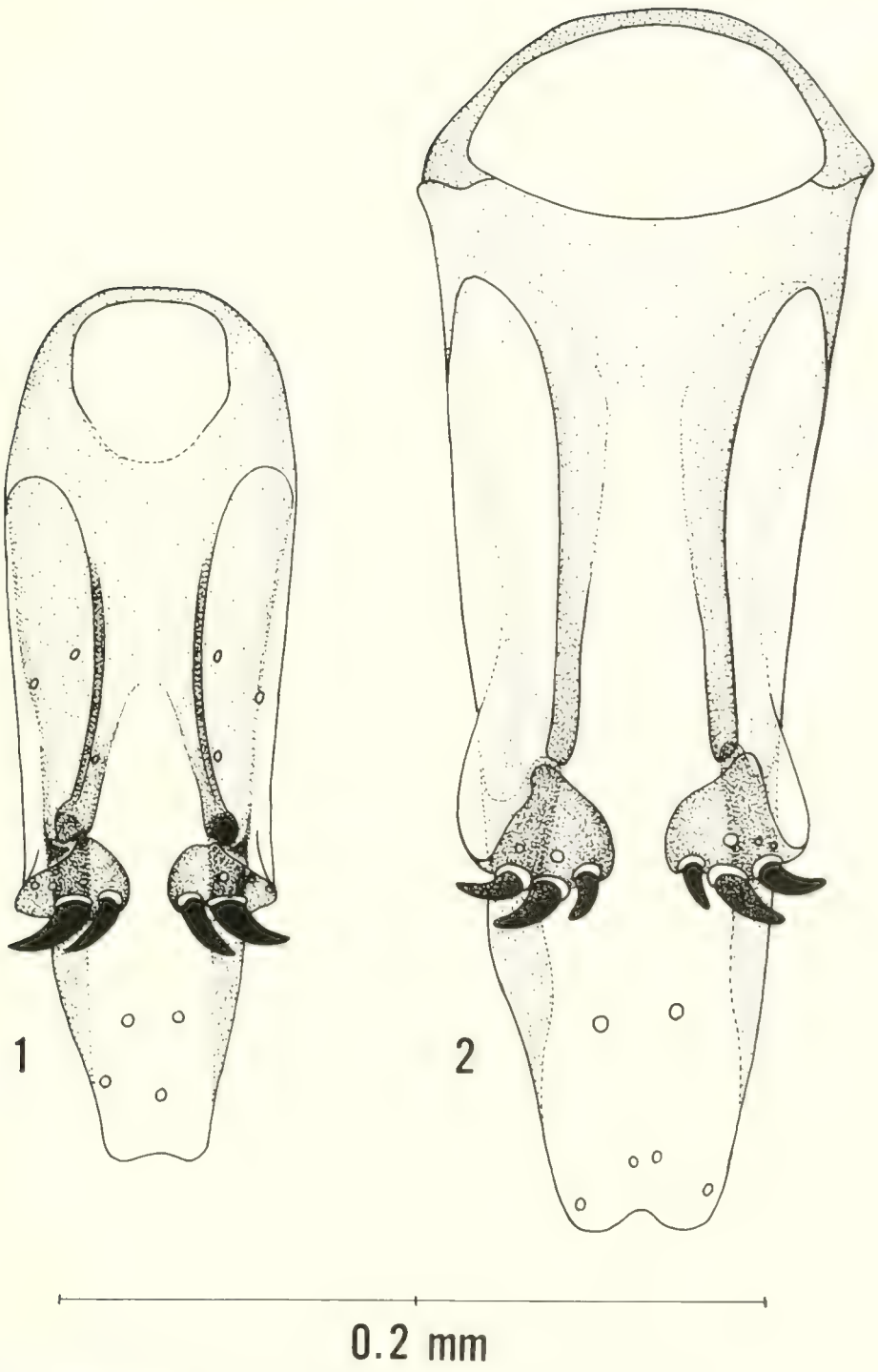
Length 0.47–0.54 mm (n = 20 males, 20 females). Small, but typical species of the *T. californicus* complex (see Johnson 1984 for characters of that taxon).

Head: hyperoccipital carina absent, vertex broadly rounded onto occiput; preocellar pit (Bin and Dessart 1983) absent; frons smooth medially, orbital bands present ventrally, effaced dorsally; frons width > eye height; lower frons with curved wrinkles flanking clypeal range and antennal insertions; labrum articulated with clypeus, not fused, mandibles tridentate, teeth subequal in size.

Mesosoma: notauli absent; disk of scutellum smooth; dorsellum as long laterally as medially, rugulose above, striate below; episternal foveae, metapleural carina absent; mesopleural carina absent, mesopleural scrobe not sharply defined anteriorly; acetabular field small; acetabular carina simple, not crenulate.

Metasoma: T1 with one pair of sublateral setae; T2 transverse, smooth beyond basal foveae; male genitalia (Fig. 1) with laminae volsellares distinctly separated, strongly melanized; aedeagal lobe moderately elongate, slightly narrowed apically, apex truncate or weakly excised; penis valves not well differentiated; digiti each with two large digital teeth, teeth subequal in length.

Diagnosis: Telenomus argus is most eas-



Figs. 1–2. Male genitalia, ventral view. 1, *Telenomus argus*. 2, *Telenomus zygaenae*

ily recognized by the characters of the male genitalia, in particular the possession of two equally large teeth on each digitus and the well-developed, but distinctly separated laminae volsellares. Other species with only a single pair of teeth on each digitus may be easily separated by other genitalic characters. *Telenomus lobatus* Johnson & Bin has an extremely long aedeagal lobe, longer than the remainder of the aedeago-volsellar shaft (Johnson and Bin 1982). In both *T. ampullaceus* Johnson & Bin and *T. turbatae* Nixon the aedeago-volsellar shaft is distinctly wider than the aedeagal lobe (Johnson and Bin 1982, Nixon 1937). *Telenomus sciron* Nixon has small, delicate digital teeth, in contrast to the long, thick structures in *T. argus* (Nixon 1935). *Telenomus guangdongensis* Chen & Liao appears to have a very broad aedeago-volsellar shaft and to have the laminae volsellares closely approximated medially (Wu et al. 1979).

The genitalia of *T. zygaenae* (Fig. 2), also reportedly reared from the eggs of a zygaenid, are very similar to *T. argus*, but may be distinguished by the presence of three teeth per digitus, with the mesal tooth distinctly smaller than the other two (Fig. 2). We have found the number of these structures to be variable only in those species with small teeth; among those with long, stout digital teeth (the *californicus* group, *arzamae* group, *dalmanni* group, see Johnson 1984) the number seems to be constant within a species.

The species described here keys out to *T. etiellae* Kozlov in Kozlov and Kononova (1983). The latter, however, is known from only four female specimens from the lower Volga region of the Soviet Union. Its distinguishing features, viz, short funicular segments, long fringe of setae along the posterior margin of the hind wing, and short striae at the base of T2, characterize a number of small species that parasitize the eggs of Lepidoptera. *Telenomous argus* may be conspecific with *T. etiellae*, but this determination must await the discovery of either males of the latter or useful diagnostic characters in the females.

Material.—Holotype male: Israel: Jerusalem; 5.vii.1978; Y. Eisenstein; ex *Theresimima ampelophaga*; deposited in the Canadian National Collection of Insects, Arachnids and Nematodes (Ottawa, Ontario). Paratypes: 12 males, 18 females with same data as holotype; 20 males with same locality data, collected 9.vii.1981, deposited in the authors' collections, CNC, and British Museum (Natural History).

Discussion.—This tiny species, like many other *Telenomus* that parasitize the eggs of Lepidoptera, is difficult or impossible to identify on the basis of external morphology. The male genitalia provide by far the best characters for separating it from others. Unfortunately, the male genitalia of very few Palearctic *Telenomus* have been described or figured; many species, in fact, are known only from females. Thus it has been impossible for us to be completely assured that this species has not already been described. We present it as a new species anticipating that when the identities of the many *Telenomus* described in the last 150 years are finally established, its proper status can be clearly and easily recognized.

Comments on Host Associations.—*Telenomus argus* was reared from its host in two years, 1979 and 1981, but its economic importance has yet to be assessed (D. Gerling, in litt.). The parasite may be confined to Israel or the eastern Mediterranean Basin as no other rearings have been reported despite the relatively wide distribution and food-plant specificity of its host.

Telenomus zygaenae was reportedly reared from *Zygaena lonicerae* (Scheven) in Denmark (Kieffer 1913), but this needs to be confirmed. The host name written on the labels of the type material of *T. zygaenae* is "Zygaena filip.", standing for *fillipendulae* (L.). Neither the egg mass nor a description of it is available, so this conflict between the published information and the label data cannot be directly resolved.

Acknowledgments

We thank Dr. D. Gerling (Tel Aviv University) for offering us these *Telenomus* and to Dr. B. Petersen (Zoologisk Museum, Copenhagen) for making the type material of *T. zygaenae* available; and to J. B. Whitfield for comments on the manuscript.

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PROC. ENTOMOL. SOC. WASH.
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EFFECTS OF MALATHION AND DIAZINON EXPOSURE ON FEMALE GERMAN COCKROACHES (DICTYOPTERA: BLATTELLIDAE) AND THEIR OOTHECAE

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Abstract.—Female German cockroaches, *Blattella germanica* (L.), were exposed to malathion and diazonon by tarsal contact. The effects of exposure on hatch of oothecae and on newly-emerged nymphs are compared in resistant and susceptible strains. Insecticide exposure increased the frequency of oothecal drop over that which occurred naturally in the susceptible but not in the malathion or diazinon-resistant strains. The time from exposure to hatch was decreased when oothecae hatched on a treated surface in all except oothecae of the diazinon-resistant strain. Exposure to diazinon, but not malathion, decreased nymphal emergence. Nymphs of the susceptible strain that emerged on treated surfaces were unable to shed the embryonic cuticle, whereas 18 to 23% of resistant strain nymphs were upright and moving freely. Results are compared to similar experiments with propoxur.

Key Words: Insecticides, behavior

Many studies of the German cockroach, *Blattella germanica* (L.), have dealt with insecticide resistance. Behavioral responses to insecticides have received less attention. German cockroaches are repelled by certain insecticides (Ebeling et al. 1967, 1968, Ebeling et al. 1966), but little is known concerning possible modifications of the repellency response following several decades of selection pressure from insecticides. Bret and Ross (1985, 1986) reported evidence that behavioral modifications have indeed accompanied the development of insecticide resistance. Dispersal and grooming behavior in adults of a susceptible strain exposed to propoxur vapors differed from that of adults in a propoxur-resistant field strain.

Irritability and repellency are widely recognized responses to insecticides (Lockwood et al. 1984), but in *B. germanica*, a third response has been reported. Insecticide exposure may cause a female to drop her ootheca prematurely (Woodbury 1938, Parker and Campbell 1940, Russell and Frishman 1965, van den Heuvel and Shenker 1965, Chadwick and Evans 1973, Muller and Coch 1975, Barson and Renn 1983, Harmon and Ross 1987). In two of the foregoing studies, comparisons were made between resistant and susceptible strains. Russell and Frishman (1965) reported a higher frequency of premature drop among susceptible than chlordane-resistant females when exposed to vapors from dichlorvos resin strips. The ages of the oothecae were unknown. Harmon and Ross (1987) also found a higher retention of oothecae by resistant than susceptible females. They used females of a propoxur-resistant field strain and a laboratory susceptible strain (VPI) that

carried oothecae in Stage XII of embryonic development (Tanaka 1976), that is, oothecae that were due to hatch within 48 to 72 h after selection.

When oothecae are within 2 to 3 days of hatch and conditions approximate those typical of German cockroach infestations (room temperature; r.h. usually above 30%), hatch and nymphal survival depend primarily on whether the ootheca falls on a treated or untreated surface. Van den Heuvel and Shenker (1965), Barson and Renn (1983) and Harmon and Ross (1987) found treatment of females bearing mature oothecae had little effect on hatch or productivity of the ootheca unless it dropped on a treated surface. On the other hand, when oothecae hatched on a treated surface, nymphal emergence and survival, when studied, were affected. Decreases in the latter effects due to hatch on a propoxur-treated surface were less in a propoxur-resistant than in a susceptible strain (Harmon and Ross 1987).

Reported here are experiments on the effects of malathion and diazinon on females carrying mature oothecae. The purpose was two-fold: first, to compare the effects on females of resistant strains to those of susceptible strains; secondly, to compare the effects of two organophosphates (malathion and diazinon) to those of propoxur, a carbamate.

Materials and Methods

Ootheca-bearing females were from three strains: the VPI strain, our standard susceptible laboratory strain; the Carver strain, a field strain resistant to malathion, propoxur, and pyrethrins, collected in Gainesville, Fla., in 1983 (Cochran, pers. commun.); and the Lynn Haven strain, a diazinon-resistant strain collected in Lynn Haven, Va., in 1983 (Cochran, pers. commun.).

Cockroach rearing conditions and test procedures were like those of the propoxur experiments (Harmon and Ross 1987). In brief, females carrying 20–24 day-old first oothecae were lightly anesthetized with CO_2 and examined under low power of a binocular microscope to determine the stage of egg development, using Tanaka's (1976) developmental table. Females carrying Stage XII oothecae were selected for test purposes, that is, females carrying oothecae due to hatch within 48 to 72 h. Only those oothecae with normal-appearing embryos in each compartment or, at most, no more than three undeveloped eggs, were used. The females were held for 24 h and then exposed by tarsal contact to filter paper treated with either malathion or diazinon (Cochran 1973). The filter paper (Whatman #1) was cut in 15 × 15 cm squares, placed on a glass plate, and impregnated evenly with a 3 ml mixture of risella oil and trichloroethylene (1:2 v/v) and either 0.08 ml of technical grade malathion (0.356 $\mu l/cm^2$) or 0.015 ml of technical grade diazinon (0.067 $\mu l/cm^2$). Dosages were selected by preliminary experimentation so as to give an approximate mortality of 65% among VPI strain females following an exposure period of 100 min. The purpose was to make the results comparable to prior work with propoxur, where 65% of the VPI strain females died as a result of a 100 min exposure to propoxur-treated filter paper (Harmon and Ross) 1987).

Groups of 10 to 12 ootheca-bearing females were confined by a glass chimney on the treated papers or on unused filter paper (controls) after the papers had dried for 1 h. Initial tests with the TCE/risella oil mixture showed that, as expected, neither lethality nor oothecal drop were affected. TCE evaporates rapidly and the possibility that risella oil, basically a mineral oil, would affect the cockroaches was highly unlikely. The experiments were begun between 9:00 and 11:00 h. Oothecal drop during exposure was recorded. Following exposure, females that dropped oothecae were separated from those that retained oothecae. The latter were placed in separate jars for subsequent observations, as follow: retention of oothecae

at 24 h after exposure; hatch of oothecae; time from the end of the exposure period to hatch; number of embryos remaining in the ootheca; number of nymphs that emerged; and the number that were alive and whether they were upright and/or fully pigmented 24 h after hatch. Like observations were made on oothecae that dropped during the exposure period. They were kept on the treated papers but were placed in individual jars with a water source 5 to 7 cm above the bottom of the jar that maintained a high humidity (85–90% r.h.) within the jar, ensuring the oothecae did not dry out. The purpose was to assess the effects of a treated surface on hatch and nymphal survival. Additional data were obtained by manually detaching oothecae of like stage to those carried by females at the time of exposure and placing them in individual jars on treated papers as described above or, in the case of the controls, on clean filter paper. Female mortality was recorded at 72 h after exposure. At that time, mortality was complete and could be compared to that in the propoxur experiment.

Percentages of oothecal hatch, nymphal emergence, nymphal survival, and freely-moving nymphs were calculated. Nymphs were counted as live if pulsation was occurring in the dorsal blood vessel. This included nymphs that were alive, but that were unable to free themselves from the embryonic cuticle. Percentage survival was based on the number of live nymphs among those that emerged successfully in order to distinguish between death that occurred within the oothecae (reduced emergence) from that due to emergence on a treated surface.

Data were analyzed using the Statistical Analysis Service (SAS) and the Bio-medical Data Processing (BMDP) statistical software available on the VPI & SU IBM mainframe computer. The best statistical model to analyze each type of data was determined by loglinear models (BMDP). Percentage premature drop of oothecae was analyzed by a least significant differences (LSD) pairwise comparison procedure. The association between mortality and premature drop was analyzed by establishing two-way frequency tables. The null hypothesis was that post treatment mortality among females that retained their oothecae did not differ significantly from that of females that dropped their oothecae. Percentage hatch was analyzed using a one-way ANOVA ($F = 19.79$; $df = 1075$; and $P > 0.0001$) followed by a LSD comparison test. Times from exposure to hatch were analyzed using a general linear models procedure ($F = 134.55$; $df = 893$; and $P > 0.0001$) followed by a LSD comparison test. Means were calculated for each treatment group and sorted in ascending order. Significance groupings were assigned from LSD tests. Estimates of percentage nymphal emergence, survival, and freedom of movement were arc-sine transformed and then analyzed as above with a general linear models procedure and LSD pairwise comparison.

Results

None of the VPI strain females died during exposure to untreated filter paper and, in the two resistant field strains, only one (3%) died in each strain (Table 1). Mortality due to malathion exposure of VPI strain females did not differ significantly from that due to diazinon exposure, as expected due to pre-selection of dosages. Resistance in the Carver strain reduced mortality from malathion to approximately half that of the VPI strain. No mortality occurred following exposure of Lynn Haven strain females to diazinon.

Premature drop of oothecae during the exposure period occurred only in the malathion experiment. It was limited to 3 oothecae in one strain and 4 in the other (Table 1). No oothecae were dropped by the control females or those in the experiment with diazinon. A tendency towards higher mortality of females that dropped oothecae than of those that retained oothecae was evident. Mortality was significantly higher among the

Table 1. Effects of malathion and diazinon on mortality and oothecal drop in female *B. germanica* carrying Stage XII: oothecae (oot).[a]

	Control Data[b]							
		% Mortality[c]			oot Drop during Exposure		oot Drop 24 h after Exposure	
Strain	No. of ♀♀	All ♀♀	♀♀ Dropped oot during Exposure	Retained oot	No.	%	No.	%
VPI	27	0 a	—	0 a	0	0 a	4	15 bc
Carver	34	3 a	—	3 a	0	0 a	7	21 c
Lynn Haven	30	3 a	—	3 a	0	0 a	5	17 bc
				Malathion Treatment				
VPI	100	56 c	66 b	55 c	3	3 a	28	28 c
Carver	102	24 b	50 a[d]	23 b	4	4 a	17	17 bc
				Diazinon Treatment				
VPI	100	63 c	—	63 c	0	0	26	26 c
Lynn Haven	48	0 a	—	0 a	0	0	4	8 a

[a] Means within a column followed by the same letter are not significantly different ($P > 0.05$).
[b] Control females were exposed to untreated filter paper.
[c] 72 h after exposure to untreated or treated filter paper.
[d] Significantly higher than mortality of females that retained their oothecae (23%) ($P > 0.05$).

former when results from the two strains were pooled ($P > 0.05$).

Normal drop and hatch of oothecae was expected to occur in the period from 48 to 72 h after selection. Oothecae 24 h after exposure were aged 48 h plus 100 min (time of exposure of females to malathion, diazinon, or clean filter paper). At this time, control females had begun to drop their oothecae. The frequency of drop by control females ranged from 15 to 21% in the three strains (Table 1). Percentage drop by VPI strain females was increased significantly over that of unexposed females when the females had been exposed to either malathion or diazinon. The difference between naturally occurring drop and that found among insecticide-exposed VPI strain females gives a rough estimate of drop due to the insecticide, i.e. 13% were dropped prematurely due to malathion and 11% due to diazinon. In the Carver strain, drop following exposure to malathion did not differ significantly from that in the controls. Retention of oothecae by Lynn Haven strain females exposed to diazinon was significantly longer than that by control females.

Table 2 summarizes the effects of malathion and diazinon on hatch of oothecae and on the newly-hatched nymphs. "Days to hatch" refers to the time between the end of the exposure period and hatch (opening) of the ootheca. In the control data, results were closely similar. The only notable variations were that detached oothecae of VPI strain females took longer to hatch than those that hatched naturally (attached) and hatch time of the latter was significantly less than in the Carver and Lynn Haven strains.

In the malathion experiment, VPI and Carver strain oothecae hatched more quickly on the treated surface (oothecae dropped or detached) than on an isecticide free surface (Table 1, control data and oothecae attached to malathion-exposed females). Hatch time was also decreased when VPI strain oothecae hatched on a diazinon treated surface.In one instance only, the time required for hatch on a treated surface was not decreased over that in the control data. That was among detached Lynn Haven strain oothecae.

In general, the number of oothecae that hatched (opened to permit nymphal emer-

Table 2. Effects of malathion and diazinon on hatch of Stage XII *B. germanica* oothecae (oot) and on nymphal emergence and survival.[a]

Strain	oot	Days to Hatch[b]	oot Hatched n	oot Hatched %	Nymphs from Hatched oot % Emergence	Nymphs from Hatched oot % Survival[c]	Nymphs from Hatched oot % Freely Moving[d]
			Control Data				
VPI	attached	1.9 b	27	100 a	96 a	100 a	100 a
	detached	2.1 c	36	92 a	95 a	100 a	100 a
Carver	attached	2.7 cd	32	100 a	96 a	100 a	100 a
	detached	2.3 c	29	85 b	90 b	100 a	100 a
Lynn Haven	attached	2.5 c	30	100 a	95 a	99 a	100 a
	detached	2.2 c	30	100 a	89 b	100 a	100 a
			Malathion Treatment				
VPI	attached	1.9 b	84	86 b	94 a	100 a	100 a
	dropped	0.3 a	3	100 a	92 a	97 a	2 d
	detached	1.5 b	101	98 a	90 b	94 b	0 d
Carver	attached	2.3 c	95	94 a	91 ab	100 a	100 a
	dropped	1.0 a	1	100 a	93 a	100 a	54 b
	detached	1.8 b	89	94 a	83 c	95 ab	23 c
			Diazinon Treatment				
VPI	attached	3.1 d	80	80 b	83 c	100 a	100 a
	dropped	—	0	—	—	—	—
	detached	1.5 b	102	97 a	83 c	87 b	0 d
Lynn Haven	attached	2.5 c	40	85 b	80 c	100 a	100 a
	dropped	—	1				
	detached	2.3 c	46	93 a	89 bc	99 a	18 c

[a] Means within a column followed by the same letter are not significantly different ($P > 0.05$).
[b] Days from end of exposure period (24 h and 100 min after oot stage identification) to hatch.
[c] % of emerged nymphs that were alive 24 h after emergence.
[d] % of emerged nymphs that were free of the embryonic cuticle and moving about freely 24 h after emergence.

gence) was not decreased due to manual detachment, except for possible injury to a few in the Carver strain (Table 2). In the experimental groups, small but significant reductions occurred among oothecae retained by malation-treated VPI strain females and by diazinon-treated VPI and Lynn Haven strain females (attached oothecae). Some of the VPI and a few of the Carver strain oothecae were from dead females, but death had no perceptible effect on hatch. Once the nymphs had forced open the oothecae at the time of hatch, most emerged successfully. At least 95% emerged from oothecae of the untreated control females, except for 90 and 89% from detached Carver and Lynn Haven oothecae, respectively. Handling of the latter may have injured a few of the eggs. A tendency towards reduced emergence was evident in the malathion experiment, but it was only in the diazinon experiment that treatment had a clear effect on emergence. It was reduced among attached and detached oothecae of both the VPI and Lynn Haven strains.

Nymphs were scored as living at 24 h after exposure of the parent females to untreated or treated filter paper if pulsation was observed in the dorsal blood vessel. On this basis, survival was below 99% only in situations where nymphs emerged on a treated surface (Table 2, dropped or detached). Slight but significant reductions occurred among detached oothecae of VPI and Carver strain females exposed to malathion, although the results were similar for the two

strains (94 and 95% survival, respectively). The greatest decrease (87% survival) was among VPI strain nymphs that hatched on a diazinon-treated surface. Survival of Lynn Haven strain nymphs was not affected. Dead nymphs, as well as survivors, were fully pigmented.

The main difference between the effects of malathion and diazinon on newly-hatched nymphs of susceptible and resistant strains was in the ability of nymphs that hatched on a treated surface to free themselves from the embryonic cuticle (Table 2). These nymphs were still alive at 24 h after emergence. Entanglement of VPI strain nymphs on the malathion and diazinon treated surfaces was complete except for 2% of those that emerged from oothecae that dropped on a malathion-treated surface. The percentage of Carver strain and Lynn Haven strain nymphs that freed themselves was significantly higher than in the VPI strain. The nymphs of the resistant strains were upright and could have escaped the treated surface if permitted to do so.

Discussion

Estimates of times between exposure of females to untreated filter paper and hatch may have been affected by slight differences in oothecal development at the time of selection. Nevertheless, it was apparent that oothecae carried by field strain females took longer to hatch than those of the VPI strain. This difference may have been related to either laboratory culture or modifications of resistant field strains. Although Muller and Coch (1975) found that manual detachment increased hatch time, a similar phenomenon was observed here only in the VPI strain.

Hatch on a treated surface decreased hatch time in all experiments except that with the Lynn Haven strain. Another difference in this strain was that diazinon treatment caused a longer-than-normal retention of oothecae. More extensive studies on field strains are needed before it can be determined whether these special characteristics are related to the development of diazinon resistance.

The only effect of insecticide exposure that could be attributed to exposing females rather than to hatch on a treated surface was a slight reduction in the number of oothecae that hatched. Only the Carver strain females did not show this effect. Perhaps it was only when oothecae were retained that there was sufficient time for toxic substances to be passed from the females to the developing embryos.

Emergence was reduced slightly when oothecae hatched on a treated surface. Diazinon had a stronger effect than malathion, especially in the susceptible strain. Possibly vapors from diazinon penetrated the ootheca more deeply than those of malathion, both during exposure of ootheca-bearing females and when oothecae were dropped or placed on a diazinon-treated surface. Lawson (1949) found that diazinon was the only one of several insecticides tested that caused a reduction in emergence.

A basis was laid for comparing the effects of propoxur (Harmon and Ross 1987) to those of two organophosphates, malathion and diazinon, by selecting dosages that caused similar mortality in VPI strain females during the same period (100 min). The primary difference was that premature drop of oothecae due to propoxur was more immediate than that due to the two organophosphates. Delay may have been due to the slower action of malathion and diazinon than of propoxur (Matsumura 1985). Oothecae dropped due to exposure to propoxur would be more likely to fall on a treated surface, as observed in shipboard experiments (Ross and Bret 1986). Whether oothecae would indeed be dropped prematurely depends on whether or not the strain was resistant. A second difference between the effects of propoxur and those reported here was that nymphs that hatched on a propoxur-treated surface died before pigmentation was complete, whereas dead nymphs in the present experiments were

fully pigmented. This difference may also be attributed to a slower action of the two organophosphates than of propoxur.

The results of the experiments with malathion and diazinon, considered in conjunction with the earlier study on propoxur, indicate clearly that premature drop of oothecae is a phenomenon associated with susceptibility. It is decreased or, indeed, may disappear entirely among females resistant to chlordane (Russell and Frishman 1965), propoxur, malathion, and diazinon. In addition, Lawson (1949) found a higher mortality among females that dropped oothecae prematurely than among those that retained them and Muller and Coch (1975) reported that premature drop only occurred when the dosage of an insecticide was sufficient to cause the knock-down condition. Mortality and knockdown are, of course, indications of susceptibility. The relative frequency of premature drop by females of a resistant strain compared to those of a susceptible strain may well provide an indication of the frequency of genetically-susceptible females present in the resisistant strain, providing it is not completely homozygous for resistance-conferring genes. Perhaps most insecticides, regardless of differences in mechanisms of resistance, affect the nervous system of susceptible females in a way that leads to premature drop. In any case, the ability of resistant strain females to retain their oothecae following insecticide exposure is clearly an advantageous characteristic. When females bearing mature oothecae are dispersed due to an insecticide treatment, they have more opportunity to find a situation (harborage) favorable to oothecal hatch and survival of newly-hatched nymphs. When immature oothecae are retained, the likelihood of their maturing successfully is enhanced.

The only oothecae that could be distinguished on an individual basis as being dropped prematurely were those aborted during the exposure period. Although only seven were dropped, mortality of their parent females was higher than that of females that retained oothecae—a finding that can be attributed to the association of premature drop with suceptibility noted above.

Many of the nymphs that emerged on diazinon or malathion treated surfaces were unable to shed the embryonic cuticle–a phenomenon that was reported previously following exposure to a variety of insecticides (Lawson 1949, Killough 1958, Harmon and Ross 1987). The present study supports Killough (1958) who concluded that entanglement would not occur unless an insecticide came in contact with nymphs during emergence. Entanglement was nearly complete in the susceptible strain but not the malathion or diazinon resistant strains. On the basis that entanglement would eventually have resulted in death, mortality of susceptible strains nymphs exceeded that of the resistant nymphs. The frequency of susceptible nymphs that were dead at the time of observation (24 h after hatch) did not differ markedly from that of resistant strain nymphs, although a tendency towards higher mortality of susceptible nymphs occurred in the malathion experiment and, in the diazinon experiment, the difference was significant.

Whether drop would be sufficiently rapid to cause oothecae to fall on a treated surface would depend on both resistance characteristics of the target population and on the choice of insecticides. If oothecae did happen to hatch on a treated surface, the effects of malathion or diazinon on resistant strain nymphs would probably be less severe than those of propoxur (Harmon and Ross 1987). At least some of the nymphs that survived for 24 h on the treated surfaces were free of the embryonic cuticle and could have left the treated surface if permitted to do so. Nymphs that were still alive after a similar exposure to propoxur were either entangled in the cuticle or were in the knockdown condition. We conclude that oothecal retention by resistant females, as well as decreased mortality, adds to the difficulty of control-

ling insecticide resistant populations of the German cockroach.

Acknowledgments

We are grateful to D. G. Cochran for helpful criticism of the manuscript and to the National Pest Control Association for partial support of the research.

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NOTE

Hyadaphis tataricae (Homoptera: Aphididae): 10 Years After its Introduction into North America

The arrival of alien species of insects on the North American continent is a common phenomenon, whether occurring accidentally or purposefully. The aphid *Hyadaphis tataricae* (Aizenberg) is one such recently, accidentally-introduced immigrant (Voegtlin. 1981. Proc. Entomol. Soc. Wash. 83(2): 361–362); it has not only established itself but also has rapidly expanded its geographical range. This aphid has a fairly narrow host range within the honeysuckles, feeding only on those within the *Lonicera tatarica* complex (Voegtlin. 1982. Great Lakes Entomol. 15(3): 147–152). Species and cultivars of this complex of honeysuckles have been planted extensively across Canada and the northern United States, and there have probably been few insects that found a more favorable environment waiting for them on this continent.

Over the past 10 years, as *H. tataricae* has continued to expand its range, we have re-

Fig. 1. Distribution of *Hyadaphis tataricae* in North America. Years indicated on the map represent first verification of the collection of the aphid in the region, state or province.

ceived many samples for identification and verification. As can be seen from Fig. 1, there has been a continual expansion westward, and the aphid has now crossed the Rocky Mountains, at least into Idaho (S. E. Halbert, pers. commun.). The aphid probably can be found in Montana,Utah and several of the north-eastern states as well, but to date we have no positive records from them. An interesting aspect of the spread has been the apparent limit in the expansion of the aphid's range southward. This could be a function of the distribution of its host plants, which are not widely planted in the middle to southern regions of the United States, or of unfavorable climate. Grigorov (1965. Gradinor. Lozar. Nauk. Sofia 2(4): 493–501) noted that *H. tataricae* did poorly in hot weather in Bulgaria.

The impact of this aphid has been felt most keenly in the north central areas of the United States and adjacent parts of Canada where honeysuckles have been widely used as ornamentals and in shelterbelts. Nurseries, which catered to the demand for honeysuckles and grew, almost exclusively, cultivars related to *L. tatarica*, have suffered severe losses with the result that these cultivars have pretty much disappeared from the horticultural trade. The Landscape Arboretum of the University of Minnesota has developed and released a cultivar that appears to be resistant to *H. tataricae* but has retained most of the desirable horticultural characteristics of the species in the *L. tatarica* complex (Pellet et al. 1985. J. Environ. Hort. 3(2): 79–81).

The invasion by this newly introduced aphid species has not been considered a problem by everyone. It is well known that the species in the *L. tatarica* complex escape cultivation and become problems in native landscapes. Initially it was hoped that *H. tataricae* might effect some natural control of these escaped, weedy honeysuckles. Unfortunately, this has not happened. However the intensity of attack, the dwarfing and folding of terminal leaves, and the resulting witches' broom undoubtedly influences growth rate and seed set and thus may slow the plant's proliferation.

We would like to acknowledge and thank those who sent in samples for verification and provided distributional information.

David Voegtlin, *Illinois Natural History Survey, 607 E. Peabody, Champaign, Illinois 61820;* Manya B. Stoetzel, *Systematic Entomology Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Maryland 20705.*

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NOTE

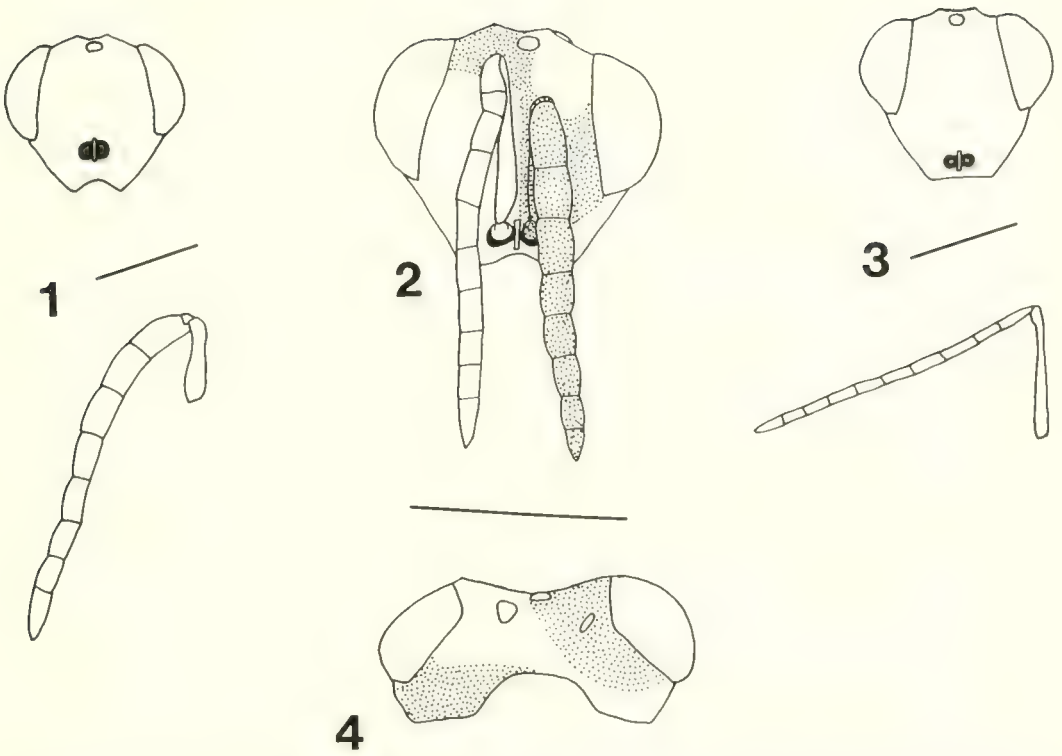
A Gynandromorph of *Hockeria rubra* (Ashmead) (Hymenoptera: Chalcididae)

A gynandromorph is an individual which has both male and female characters. This condition is often reported in the literature and occurs in many insect orders. Gynandromorphism is commonplace in *Drosophila* and ants. In ants, a specialized terminology has been developed to denote particular types of gynandromorphs (Donisthorpe. 1929. Zool. Anz. 52: 92–96; Berndt and Kremer. 1982. Experientia 38: 798–799). Gynandromorphism is believed to be caused by fertilization anomalies and meiotic abnormalities during embryogensis though the definitive causes, at least in ants, remain unknown (Jenkins. 1979. Genetics, Second edition, Houghton Mifflin Co., Boston, MS; Jones and Phillips. 1985. Proc. Entomol. Soc. Wash. 87(3): 583–586; ibid., 1982).

While examining specimens at the United States National Museum of Natural History (USNM) for a revision of the genus *Hockeria* Ashmead in North America, I found a gynandromorph of *Hockeria rubra* (Ashmead). I take this opportunity to describe this gynandromorph because the condition is believed to be rare in this family and may be the first such record.

Typically, females of *H. rubra* are red or orange with slender filiform antennae, patterned wings, and are about 7 mm long (4–10 mm). Males are black, have robust filiform antennae, clear wings, and are about 5 mm long (3–6 mm). The gynandromorph was reared from the Western Grapeleaf Skeletonizer, *Harrisina brillians* B & McD. (Lepidoptera: Zygaenidae), a pest in which the larvae defoliate grapes (*Vitis* spp.) and two ornamental vines, Virginia Creeper (*Parthenocissus quinquefolia*) and Boston Ivy (*P. tricuspidata*) in the southwestern United States and Mexico (Stern et al. 1981. Western Grapeleaf Skeletonizer, pp, 140–146. In Flaherty et al. [eds.]. Grape Pest Management. Univ. Calif. Publ., Berkeley, CA). *Hockeria rubra* ranges throughout the United States and Mexico (Burks. 1979. Chalcididae, pp. 860–879. In Krombein et al. [eds.]. Catalog of Hymenoptera in America North of Mexico. Vol I. Smithson. Inst. Press., Wash., D.C.; Halstead, in prep.).

The gynandromorph "EX. *Harrisina brillians* pupa, coll. Chihuahua, Mexico, 10/10/51, O. J. Smith, #A," is as follows (see Figs. 1–4): 3 mm. Right antenna (♀), scape long and thin, 12× as long as wide, flagellum slender and filiform, flagella 2× as long as wide; scape, pedicel and flagella 1–2 orange, remainder black. Left antenna (♂), scape short and stout, 7× as long as wide, flagellum robust and filiform, flagella 1.7× as long as wide; antenna black except for scape which is dark orange-brown. Right half of occiput (dorsal view) black anteriorly (♂), orange posteriorly (♀); left half of occiput orange anteriorly (♀), black posteriorly (♂). Right lateral ocellus elliptical, situated slightly posterior to vertex (♂); left lateral ocellus round, situated on vertex (♀). Right gena orange (♀), left gena black (♂) with central area orange (♀). Right frons black dorsally (♂), remainder orange (♀); left frons orange ventrally and dorsally (♀), black centrally (♂). Pubescence on eyes similar to that of females, less pubescent than on males. Right eye situated more dorsad, giving a tilted assymetry to the face in frontal view. Pronotum, forelegs, and right hindleg orange (♀). Left hindleg black except for apex of tibia and tarsus which are orange-brown (♂). Right hindfemur narrowly ovoid (♀); left hindfemur broadly ovoid (♂). Forewings clear (♂). Remainder of thorax and abdomen black (♂).



Figs. 1–4. *Hockeria rubra* (Ashmead). 1, Head, frontal view, of male; side view of antenna. 2, Head, frontal view, of gynandromorph (stipuled = male, black color; nonstipuled = female, orange color). 3, Head, frontal view, of female; side view of antenna. 4, Head, dorsal view, of gynandromorph (stipuled = male, black color; nonstipuled = female, orange color). Scale lines 1.0 mm.

I thank D. J. Burdick, Department of Biology, California State University Fresno, Fresno; N. J. Smith, Fresno County Agricultural Commissioner's Office, Fresno, California; and R. D. Haines, Tulare County Agricultural Commissioner's/Sealer's Office, Visalia, California for comments on earlier drafts of this manuscript. I thank an anonymous reviewer for comments on a later draft of this manuscript. I thank also E. E. Grissell, Systematic Entomology Laboratory USDA-ARS, % USNM, Washington, D.C. for loaning the specimen, and the Kings River Conservation District, Fresno, California for the use of word processing equipment.

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NOTE

Note on the Habitat of *Pterostichus* (*Pseudomaseus*) *tenuis* (Casey) (Coleoptera: Carabidae) with Six New State Records

The carabid species *Pterostichus* (*Pseudomaseus*) *tenuis* (Casey) was recently redescribed and removed from synonymy with *P. luctuosus* (Dejean) (Bousquet, Y. and J. G. Pilon. 1983. Redescription of *Pterostichus* (*Pseudomaseus*) *tenuis* (Casey), a valid species (Coleoptera: Carabidae). Coleopterists Bulletin 37: 389–396). The authors included range maps and listed the states and provinces from which they had seen specimens (in Canada: Alberta, Manitoba, Ontario, Quebec, Nova Scotia, Newfoundland; in the United States: Colorado, Illinois, Michigan, New York, New Hampshire, Maine, Massachusetts, Rhode Island, New Jersey). They were not, however, aware of any differences in habitat between the two species. They noted that *P. luctuosus* is a marsh species and speculated that the habitat of *P. tenuis* might be the same. Most of the specimens of the latter collected by the authors were taken in hibernation under rocks and logs in a deciduous forest near a large marsh. In a later paper (Bousquet Y. 1985. Morphologie comparée des larves de Pterostichini (Coleoptera: Carabidae): descriptions et tables de déterminations des espèces du Nord-est de l'Amérique du Nord. Le Naturaliste Canadien 112: 191–251), Bousquet repeated these observations and stated that the precise habitat of *P. tenuis* remained to be discovered.

Although diagnostic differences between *P. tenuis* and *P. luctuosus* were not widely known until recently (Bousquet and Pilon 1983), I had been aware of them for many years through conversations with Yves Bousquet. Specimens from different localities and habitats were therefore kept carefully segregated and labelled. These specimens verify that *Pterostichus luctuosus* is a marsh species occurring in a variety of wetland habitats, a fact also noted by Larochelle (Larochelle, A. 1975. Les Carabidae du Québec et du Labrador. Bulletin de la Département de Biologie du Collège Bourget, Rigaud 1: 1–155). The sixty or so specimens of *P. tenuis* (collected at thirteen localities in six states) indicate that this species has a much more limited habitat and is probably found exclusively in *Sphagnum*.

All of the specimens of *Pterostichus tenuis* listed below were taken by treading *Sphagnum*, both in large bogs and in smaller, more isolated patches. In Pine Swamp on the Maryland-West Virginia border, beetles were taken from several small (ten square feet) patches of *Sphagnum* on the wet grassy shores of a pond. Other carabid species abundant in the *Sphagnum* were *Agonum mutatum* G. & H. and *Pterostichus patruelis* (Dejean). At the Linn Run State Park in Pennsylvania, *Pterostichus tenuis* was taken in a large open bog with sundews (*Drosera*) and pitcher plants (*Sarracenia purpurea*), again in the company of *Agonum mutatum* and *Pterostichus patruelis*. The specimens of *P. tenuis* from Shelburne Pond, Vermont, were taken in a similar large open bog, along with specimens of *Agonum darlingtoni* Lindroth (a bog species). In no instances were *Pterostichus tenuis* and *P. luctuosus* taken together, though this should be expected to occur occasionally. The areas of *Sphagnum* preferred by *P. tenuis* are often very close to marsh habitats preferred by *P. luctuosus*.

There follows a detailed list of new localities and dates of collection of *Pterostichus tenuis*. Specimens were collected by me unless otherwise indicated. They are deposited in the Carnegie Museum of Natural History, except the Ohio specimens (Harry J. Lee private collection) and the Wisconsin specimens collected by Walter Suter (Rob-

ert C. Graves private collection). Collector and number of specimens are listed in parentheses after each date. All specimens were collected by treading *Sphagnum*. These localities represent six new state records not included in Bousquet and Pilon (1983). Canaan Mountain at Canaan Heights, West Virginia, is the southernmost locality in the eastern United States from which *P. tenuis* has thus far been collected. I thank Dr. Robert E. Acciavatti for his efforts in collecting the West Virginia specimens and Dr. John E. Rawlins for suggestions and improvements on this paper.

MARYLAND. Garrett Co.: Pine Swamp, 2 km. SE Cranesville (West Virginia), July 6, 1986 (Acciavatti & Davidson, 8).

OHIO. Ashtabula Co.: Grand River Terraces, Morgan Township, September 27, 1987 (Lee, 2).

PENNSYLVANIA. Westmoreland Co.: Linn Run State Park, 10 km. SE Rector, July 27, 1981 (11), May 13, 1984 (1), July 24, 1986 (2).

VERMONT. Addison Co.: 2 km. N. Starksboro, July 19, 1977 (1). Chittenden Co.: Colchester Bog, May 30, 1976 (1); Shelburne Pond, Shelburne, April 14, 1974 (4), April 12, 1975 (3), April 22, 1975 (2), July 4, 1975 (2). Franklin Co.: Fletcher, June 22, 1975 (1). Grand Isle Co.: Isle la Motte, June 18, 1975 (1).

WEST VIRGINIA. Tucker Co.: Backbone Mountain, 6 km. N. Hendricks, 975 m, August 15, 1986 (Acciavatti, 5); 1.5 km. NW Canaan Heights, 1130 m, August 11, 1986 (Acciavatti, 1); Canaan Mountain at Canaan Heights, 1130 m, July 29, 1986 (Acciavatti, 6).

WISCONSIN. Kenosha Co.: Van Halter Bog, Silver Lake, Salem, September 9, 1972 (Suter, 1), June 20, 1974 (Suter, 2), June 21, 1975 (Suter, 1). Racine Co.: Kneeland Bog, April 23, 1966 (Suter, 1); King Bog, 5 km. SW Dover, October 23, 1970 (Suter, 1), August 11, 1971 (Suter, 1).

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Book Review

Bees and Their Keepers. Richard F. Trump, 1987. Iowa State University Press, Ames, Iowa. 171 pp. $17.95 Hardcover.

Bees and Their Keepers is a delightful book presenting the science of beekeeping in a novel manner: from the perspective of the bee as well as the beekeeper. The book is written in a simple, clear style, and is easily readable by both the novice and the expert. The book is illustrated by 69 excellent black and white photographs, most apparently by the author (absence of photo credits and figure numbers are weaknesses).

The twenty chapter headings are thought-provoking, eye catching "come-ons" such as "Those Wild Bees," "How to Tell a Bee From the Keeper," "A Sampling of Nectars" and "Gum Robbers" to name a few. Despite the "down-home" jargon, each chapter is carefully organized to logically present a major beekeeping topic to a novice, or to entertain as well as educate the more experienced beekeeper. In most chapters he begins with a historical introduction to the development of a method or practice, which is usually accompanied by anecdote, commentary and personal or classroom experience.

Being a native of the midwest (Missouri, Illinois), Richard Trump has made the book strongly oriented to beekeeping in that region, especially Iowa and Iowa State University. Many comments are made about Walter Rothenbuhler, Vic Thompson, Frank Pellett, and others who are familiar to most beekeepers as well as to many established, professional beekeepers such as Glen and Lloyd Stanley, Henry Hansen, and to several hobbyists, such as Ann Garber, Paul Goossen and many others—names that will not be noticed outside Iowa, but by anecdote become recognized perhaps as the people who make beekeeping such an important part of agriculture in the U.S. today.

Of particular interest are anecdotes referring to the development of the American foulbrood-resistant, "Brown" strain of honey bees in Iowa by Dr. Rothenbuhler. Mr. Trump comments on observations on the behavior of the bees of this and susceptible strains (some based on research by Mr. Trump) and the eventual loss of the strain. Other interesting and noteworthy comments are made on honey plants of the region (and elsewhere), importation of exotic plants and weeds and their comparison as nectar sources to native prairie plants, and many comments on ecology throughout the book.

The value of this book is its potential for many uses: it can be an introduction to beekeeping for almost any novice from high school to retirement; it can serve as a "motivating reference" for college students; established beekeepers can read it for a source of information and popular reading; and experts can use it as a reference, especially to historical notes, but also to some of Mr. Trump's novel ideas and different perspective.

As a teacher of apiculture I greatly appreciate Mr. Trump's numerous classroom anecdotes and even the use of student questions and replies as chapter introductions. Mr. Trump's experience and excellence as a biology teacher are obvious throughout the book. I believe other educators may benefit from some of his ideas as I have.

A major drawback of the book is the incomplete reference list: Mr. Trump presented many interesting points in the text that led me to want to read more but some citations were missing. Also I would have liked a little more information on bee diseases, and bee mites, etc., especially with the coming of Africanized Bees and Varroa

mite to the U.S. Some modern key references, such as Morse and Cooper's "Encyclopedia of Beekeeping," and Morse's "Diseases and Pests of the Honey Bees" were absent from the list of selected books.

One error in biology on page 62 implies that all adult bee protein is derived directly from the food glands; actually, most adult protein is derived directly from digested pollen and the protein secreted from food glands is passed on mostly to the larvae and the queen (this may have been an error of syntax). A few other minor errors in usage were noted, such as the use of the term grub for larvae (I personally prefer the use of "grub" for the larvae of Coleoptera), and an occasional incomplete sentence or misspelling.

But despite these few minor errors, I thoroughly enjoyed reading the book: I learned several new facts, the change in style and point of view were refreshing, and Mr. Trump is obviously well acquainted with the literature of beekeeping. For the modest price of $17.95 I believe that every serious beekeeper should have a copy.

James W. Amrine Jr., *Div. Plant Sci.-Entomol., West Virginia Univ., Morgantown, WV.*

New Members for 1987

Nezha Aouad
Gerald T. Baker
Vitor Osmar Becker
Paul E. Boldt
Jeffrey R. Brushwein
John A. Chemsak
Stephen L. Clement
James C. Cokendolpher
Márcia Souto Couri
Gary Dodson
Lance A. Durden
Lester E. Ehler
Sonia Maria Lopes Fraga
J. Kenneth Grace
Harlan J. Hendricks
Aileen Nien-Hwa Hsu
Herb Jacobi
John Jenkins
James B. Johnson
Joseph W. Kamp
Scott F. Larcher
Ted C. MacRae
Donald D. Miller
Charles Mitter
John D. Oswald
Analia C. Paggi
Robert R. Parmenter
Daniel M. Pavuk
Foster Forbes Purrington
Donald Lambert Jesse Quicke
Jay Aaron Rosenheim
John Schulte
Cristopher K. Starr
Daniel Strickman
Michael Joseph Sharley
Robert B. Trumbule
David B. Wahl
D. M. Wood
Gregory Zolnerowich

Total new members for 1987: 39

Total membership as of 8 December 1987: 580

Submitted by Geoffrey B. White, Membership Chairman, 10 December 1987.

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Society Meetings

934th Regular Meeting—October 1, 1987

The 934th Regular Meeting of the Entomological Society of Washington was called to order by President Thomas E. Wallenmaier in the Naturalist Center, National Museum of Natural History, at 8 p.m. on October 1, 1987. Twenty-nine members and eleven guests were present. Corresponding Secretary R. G. Robbins read the minutes of the May meeting. R. J. Gagné distributed reprints of the Society's revised Bylaws, published in Proc. Entomol. Soc. Wash. 89: 625–631. Membership Chairman G. B. White read the names of the following applicants for membership: Vitor Osmar Becker, Planaltina, Brazil; Lester E. Ehler, University of California, Davis; John Jenkins, Michigan State University; Charles Mitter, University of Maryland, College Park; John D. Oswald, Cornell University; Daniel M. Pavuk, Ohio State University, Wooster; Donald Lambert Jesse Quicke, University of Sheffield, England; John Schulte, Imlay City, Michigan; Christopher K. Starr, Department of Entomology, Smithsonian Institution, Washington, D.C.; Márcia Souto Couri, Museu Nacional, Rio de Janeiro, Brazil; and Sonia Maria Lopes Fraga, also of the Museu Nacional, Rio de Janeiro.

President Wallenmaier noted that the cost of the annual banquet was still under study. He also asked that ESW's final meeting of this year be held on the 10th of December so as not to conflict with the national meeting of the Entomological Society of America.

R. J. Gagné announced the death of Honorary Member Frederick W. Poos. President Wallenmaier called for nominations for a new Honorary Member, who must be unanimously approved by the Executive Committee and by two-thirds vote of members present at a regular meeting, in accordance with Article III, Section 6, of the Bylaws. T. J. Spilman suggested that someone write an obituary for Dr. Poos.

R. J. Gagné reminded the membership that a nominating committee for a new slate of officers should be formed as soon as possible. Any member who regularly attends meetings or has a little spare time to devote to the Society should feel free to volunteer for a position as an officer. President Wallenmaier also called for volunteers to bring refreshments to Society meetings.

President Wallenmaier displayed a newly published manual, *Microlepidoptera from the Sandy Creek and Illinois River Region*, by George L. Godfrey, Everett D. Cashatt, and Murray O. Glenn, Illinois Natural History Survey Special Publication 7. J. M. Kingsolver exhibited a new reference for coleopterists, *The Insects and Arachnids of Canada. Part 15. The Metallic Wood-Boring Beetles of Canada and Alaska. Coleoptera: Buprestidae*, by Donald E. Bright, Publication 1810, Biosystematics Research Centre, Ottawa, Ontario. Corresponding Secretary R. G. Robbins distributed copies of a revised manual on Lyme disease published by Pfizer Central Research, Groton, Connecticut.

The speaker for the evening was David W. Inouye, Department of Zoology, University of Maryland. His talk was entitled "Mutualistic Relationships between Ants and Plants: Examples from the Rocky Mountains, Europe, and Australia."

Visitors and guests were introduced and the meeting was adjourned at 9:05 p.m., after which refreshments were served.

Richard G. Robbins, *Corresponding Secretary*

935th Regular meeting—November 5, 1987

The 935th Regular Meeting of the Entomological Society of Washington was called to order by President T. E. Wallenmaier in the Naturalist Center, National Museum of Natural History, at 8 p.m. on November 5, 1987. Twenty-three members and four guests were present. Minutes of the October meeting were read and approved. Membership Chairman G. B. White noted that the Executive Committee approved the election of Dale Parrish to emeritus status.

President Wallenmaier discussed a few items from the recent Executive Committee meeting. The recent death of F. W. Poos left a vacancy in the group of three honorary members allowed by the Bylaws. The Executive Committee voted unanimously to elect another honorary member and selected C. W. Sabrosky, who has been active in the Society and is a regular attendee at the meetings. R. J. Gagné presented a brief review of Dr. Sabrosky's career and moved that he be selected as an honorary member. The motion was seconded and passed. President Wallenmaier presented to the members a proposed change in the Bylaws to delete the word "June" in Art. VIII, Sec. 1, which will allow a more accurate numbering of the regular society meetings. The proposed change will be voted upon at the next meeting.

D. R. Smith presented the following slate of officers for next year selected by the Nominating Committee: President-Elect, F. C. Thompson; Treasurer, N. E. Woodley; Editor, H. G. Larew; Recording Secretary, R. G. Robbins; Corresponding Secretary, J. M. Kingsolver; Custodian, A. M. Wieber; Program Chairman, W. E. Steiner, Jr.; Membership Chairman, G. B. White.

A brief discussion was held concerning the banquet expenses and lost checks. G. Wood said that all expenses have been covered from his personal funds and that any who wish to may send replacement checks to him.

R. J. Gagné displayed a copy of the recent issue of the Proceedings which includes a colored plate accompanying an article on ticks.

J. H. Fales reported on the current heavy northward flight into Maryland of the pierid butterfly *Phoebis sennae eubule,* the cloudless sulfur, which is the first major migration of this butterfly since 1975. It was first observed on July 8 at Plum Point, Calvert County, and Fales noted that there appear to be two color forms, one perhaps being a migratory form.

R. G. Robbins reported on the Hoogstraal Fund to support the tick collection and research at the Smithsonian's Museum Support Center, pointing out errors in the announcement in the Bulletin of the Entomological Society of America. He also displayed a new text, *The Ixodid Ticks of Uganda,* by Matthysse and Colbo, published by the Entomological Society of America.

W. E. Bickley noted that the Asian tiger mosquito, *Aedes albopictus,* has recently been found in Maryland.

The speaker for the evening was Melanie Odlum, University of Maryland. Her talk was entitled "An update on the Africanized bee."

Visitors and guests were introduced and the meeting was adjourned at 9:45 pm, after which refreshments were served.

Paul M. Marsh, *Recording Secretary*

936th Regular Meeting—December 10, 1987

The 936th Regular Meeting of the Entomological Society of Washington was called to order by President Wallenmaier in the Naturalist Center, National Museum of Natural History, at 8:10 p.m. on December 10, 1987. Twenty-five members and five guests were present. Minutes of the previous meeting were read and approved.

Annual reports of officers were given by the Treasurer, Editor, Membership Com-

mittee, Corresponding Secretary, Program Chairman, and Custodian. President Wallenmaier thanked the officers for a job well done during this year.

D. R. Smith presented the slate of nominees for new officers for 1988. President Wallenmaier called for further nominations of which there were none. A motion was made and seconded that the slate be accepted as presented. The motion was unanimously passed.

President Wallenmaier again discussed the proposed Bylaw change to delete the word "June" from Art. VIII, Sec. 1. It was moved, seconded, and passed to approve the change.

R. G. Robbins displayed a mosaic tick wall plaque given as a gift to H. Hoogstraal by an Egyptian colleague.

The speaker for the evening was Dr. George K. Roderick, Department of Entomology, University of Maryland. His talk was entitled "Stocks, bonds, and commodities: avoidance of risk for planthoppers."

D. W. S. Sutherland reported on the Entomological Society of America program to establish a national insect. Final results of a survey show that the monarch butterfly was the preferred insect. A brochure will be prepared to support a bill to be put before Congress in the near future.

P. M. Marsh announced the recent death of long-time member and honorary president C. F. W. Muesebeck.

President Wallenmaier thanked Mignon Davis and the Hospitality Committee for their efforts this year and asked for more volunteers to bring refreshments during the coming year. President Wallenmaier then passed the gavel to incoming President G. Wood. Following the introduction of visitors, the meeting was adjourned at 9:20 pm.

Paul M. Marsh, *Recording Secretary*

Reports of Officers

Treasurer's Report

SUMMARY FINANCIAL STATEMENT FOR 1987

	General Fund	Special Publications Fund	Total Assets
Assets: November 1, 1986	$15,551.71	$64,909.43	$80,461.14
Total Receipts for 1987	62,389.06	7,139.32	69,528.38
Total Disbursements for 1986	64,101.50	5,997.62	70,099.12
Assets: October 31, 1987	13,839.27	66,051.13	79,890.40
Net Changes in Funds	$ 1,712.44−	1,141.70	570.74−

Norman E. Woodley, *Treasurer*

Corresponding Secretary's Summary of Major Activities for Calendar Year 1987

Letters of welcome were mailed to 32 new members. Our computerized membership list tonight stands at 580 (for the record, the figure was 592 at this time last year). In response to changes in the tax code, seven individuals purchased life memberships, raising to 20 the number of members in this category. Three of our members were welcomed to Emeritus status: Victor E. Adler of Laurel, Maryland; Roger O. Drummond of Kerrville, Texas; and Dale W. Parrish of Camp Springs, Maryland. Eight letters were written thanking our guest speakers. Some two dozen thank-you letters were sent to members who contributed to our Special Publication Fund when paying their dues. An equal number of letters were written to members and other persons who had requested information about the organization, functions, or publications of our Society. The postage costs of this Office totaled $25.00.

Richard G. Robbins, *Corresponding Secretary*

Editor's Report

This report is my fourth and final one as Editor of the Entomological Society of Washington. Much worth noting happened to the Proceedings in these last four years, and taking leave is a good occasion for a review.

Regional journals such as ours compete for members with a quality journal. To compete favorably, a journal has to look good, appear on schedule, carry a large enough assortment of articles to interest the readership, have a negligible backlog to encourage submission of good manuscripts, and maintain a respectable scientific quality.

As to appearance, we are fortunate that our printer, Allen Press, prints scientific journals as a large part of its business, so we enjoy the benefits of that company's considerable expertise. We pay for quality paper, through which one cannot read print on the reverse side of the page. My first issue as Editor was the Centennial issue, and I took Manya Stoetzel's suggestion that the color of the cover be changed to mark the occasion. I ordered blue, which turned out to be so handsome that I kept it to the present. I encouraged authors who wrote well to send more articles. I was usually successful in getting authors to lead a manuscript with a topical paragraph to interest the general reader. The journal is not only a permanent record; it should be topical enough so that an intelligent, well-rounded entomologist will want to read at least the first paragraph of every article.

In the not so remote past, an energetic editor convinced the Executive Committee to budget for 200 pages per number. That number of pages makes possible a large number of articles in a wide range of subjects and may be the major reason for our continuing growth in membership. With the 1987 volume we made another change, suggested to us by Allen Press: we began a two-column per page format, in large part to be able to get more print into the same 200 pages.

For many years we have had a written policy of not accepting manuscripts that would print to more than 15 pages; however, the rule was set aside when editors found they needed the longer manuscripts to fill an issue. When I became Editor, though, we had a backlog of 12–15 months, so I refused overlong manuscripts unless they were of a general nature. I feared we would lose those papers of immediate interest that make a journal interesting to read. I refused two other categories of papers also: mere lists of insects found in a very restricted area and some descriptions of new species, of which more later. The backlog became reduced in due course to 5–7 months. That is the lower limit of a backlog. A manuscript usually requires one month for review and revision and then has to be

sent to press four months before it is published. The new policy did not by itself reduce the backlog; some of the reduction was certainly due to competition from journals that have resumed timely publication during the last several years.

The Proceedings is a refereed journal, but I did not send out manuscripts for the pro forma two reviews when I was confident one would do. Some manuscripts were sent out to three reviewers, when that was deemed necessary. Reviewers were almost always willing to review a paper on request and were generally supportive and sympathetic to the authors. Authors were mostly happy for the criticisms. I should mention some author services that are not widely known. Each member-author is subsidized by members' dues for one-third the cost of an article. Approximately 10% of an issue is made up of fully-subsidized papers because the authors are students or retired members without funds, or authors who are not paid to do research. Manuscripts are published according to date of receipt, not acceptance. In that way, an author is not unduly penalized for a slow review.

Each editor invests the office with some individuality, especially in our Society, where the editor probably enjoys more independence than do editors of any other regional North American journal. An editor who does all the work should not have it any other way. I did not worry about uniformity of format among papers for such items as collection dates of specimens, so long as data were uniform within an article. But I did attempt to achieve uniformity of some terminology, especially in anatomical terms used in Diptera, for which there is now a lingua franca. I am averse to "humorous" scientific names, so refused manuscripts in which they were coined. Some such names are clever, but most are silly, and I think the practice lends taxonomy to ridicule. I refused manuscripts that featured one or more new species descriptions that did not enlarge the generic concept and were based on one or a few specimens of one sex caught in flight. I believe such descriptions add nothing essential to our sum of knowledge.

Several titles were suggested for our Memoir series. The topics of only two were general enough to consider seriously, and one was eventually accepted. It became Memoir No. 13 by Marsh, Shaw, and Wharton, a generic key to adult North American Braconidae.

I still have in my possession the original drawings for papers whose authors did not request return. I will discard them on June 1, 1988, unless an author requests them by then.

I take this opportunity to thank individuals and institutions for help in producing the Proceedings: Arly Allen and the competent, helpful, and courteous staff of Allen Press; the Publications Committee, composed of D. R. Smith, T. J. Spilman, and G. C. Steyskal, for their support and good counsel; I thank G. C. Steyskal additionally for checking the scientific names for each issue; my fellow Society Officers, particularly V. Blackburn, R. Robbins, G. White, and N. Woodley, who happily and competently provided information under their purview; the Systematic Entomology Laboratory for its support of this volunteer, unpaid work with some secretarial help in typing letters, dispensation from reviewing in-house manuscripts, and use of the copy machine and telephone; the U.S. Postal Service and the Smithsonian Institution mailroom staff for generally speedy delivery and for never having lost a piece of mail of which I am aware. Finally, I thank the authors for submitting manuscripts and the reviewers for their invaluable help. My communications with the authors and reviewers were the most gratifying part of the editorship. And I enjoyed keeping abreast of general entomology.

Respectfully submitted, Raymond J. Gagné, *Editor*

PUBLICATIONS FOR SALE BY THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

Miscellaneous Publications

Cynipid Galls of the Eastern United States, by Lewis H. Weld	$ 5.00
Cynipid Galls of the Southwest, by Lewis H. Weld	3.00
Both papers on cynipid galls	6.00
Identification of Alaskan Black Fly Larvae, by Kathryn M. Sommerman	1.00
Unusual Scalp Dermatitis in Humans Caused by the Mite *Dermatophagoides*, by Jay R. Traver	1.00
A Short History of the Entomological Society of Washington, by Ashley B. Gurney	1.00
Pictorial Key to Species of the Genus *Anastrepha* (Diptera: Tephritidae), by George C. Steyskal	1.50
Taxonomic Studies on Fruit Flies of the Genus *Urophora* (Diptera: Tephritidae), by George C. Steyskal	2.00

Memoirs of the Entomological Society of Washington

No. 1.	The North American Bees of the Genus *Osmia*, by Grace Sandhouse. 167 pp. 1939	$15.00
No. 2.	A Classification of Larvae and Adults of the Genus *Phyllophaga*, by Adam G. Boving. 95 pp. 1942	(out of print)
No. 3.	The Nearctic Leafhoppers, a Generic Classification and Check List, by Paul Wilson Oman. 253 pp. 1949	15.00
No. 4.	A Manual of the Chiggers, by G. W. Wharton and H. S. Fuller. 185 pp. 1952	15.00
No. 5.	A Classification of the Siphonaptera of South America, by Phyllis T. Johnson. 298 pp. 1957	15.00
No. 6.	The Female Tabanidae of Japan, Korea and Manchuria, by Wallace P. Murdoch and Hirosi Takahasi. 230 pp. 1969	15.00
No. 7.	Ant Larvae: Review and Synthesis, by George C. Wheeler and Jeanette Wheeler. 108 pp. 1976	11.00
No. 8.	The North American Predaceous Midges of the Genus *Palpomyia* Meigen (Diptera: Ceratopogonidae), by W. L. Grogan, Jr. and W. W. Wirth. 125 pp. 1979	12.00
No. 9.	The Flower Flies of the West Indies (Diptera: Syrphidae), by F. Christian Thompson. 200 pp. 1981	10.00
No. 10.	Recent Advances in Dipteran Systematics: Commemorative Volume in Honor of Curtis W. Sabrosky. Edited by Wayne N. Mathis and F. Christian Thompson. 227 pp. 1982	11.00
No. 11.	A Systematic Study of the Japanese Chloropidae (Diptera), by Kenkichi Kanmiya. 370 pp. 1983	18.00
No. 12.	The Holarctic Genera of Mymaridae (Hymenoptera: Chalcidoidae), by Michael E. Schauff. 67 pp. 1984	5.00
No. 13.	An Identification Manual for the North American Genera of the Family Braconidae (Hymenoptera), by Paul M. Marsh, Scott R. Shaw, and Robert A. Wharton. 98 pp. 1987	18.00

Back issues of the Proceedings of the Entomological Society of Washington are available at $25.00 per volume to non-members and $13.00 per volume to members of the Society.

Prices quoted are U.S. currency. Postage extra except on prepaid orders. Dealers are allowed a discount of 10 per cent on all items, including annual subscriptions, that are paid in advance. All orders should be placed with the Custodian, Entomological Society of Washington, c/o Department of Entomology, NHB 168, Smithsonian Institution, Washington, D.C. 20560.

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(ISSN 0013-8797)

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of the

ENTOMOLOGICAL SOCIETY of WASHINGTON

PUBLISHED
QUARTERLY

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THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

ORGANIZED MARCH 12, 1884

All correspondence concerning Society business should be mailed to the appropriate officer at the following address: Entomological Society of Washington, c/o Department of Entomology, NHB 168, Smithsonian Institution, Washington, D.C. 20560.

MEETINGS.—Regular meetings of the Society are held in the Natural History Building, Smithsonian Institution, on the first Thursday of each month from October to June, inclusive, at 8 P.M. Minutes of meetings are published regularly in the *Proceedings*.

MEMBERSHIP.—Members shall be persons who have demonstrated interest in the science of entomology. Annual dues for members are $20.00 (U.S. currency) of which $18.00 is for a subscription to the Proceedings of the Entomological Society of Washington for one year.

PROCEEDINGS.—The *Proceedings* are published quarterly beginning in January by The Entomological Society of Washington, % Department of Entomology, NHB-168, Smithsonian Institution, Washington, D.C. Members in good standing receive the Proceedings of the Entomological Society of Washington. Nonmember subscriptions are $35.00 per year, domestic, and $40.00 per year, foreign (U.S. currency), payable in advance. Foreign delivery cannot be guaranteed. All remittances should be made payable to *The Entomological Society of Washington*.

The Society does not exchange its publications for those of other societies.

PLEASE SEE P. 129 OF VOL. 90(1) FOR INFORMATION REGARDING PREPARATION OF MANUSCRIPTS.

STATEMENT OF OWNERSHIP

Title of Publication: Proceedings of the Entomological Society of Washington.

Frequency of Issue: Quarterly (January, April, July, October).

Location of Office of Publication, Business Office of Publisher and Owner: The Entomological Society of Washington, c/o Department of Entomology, Smithsonian Institution, 10th and Constitution NW, Washington, D.C. 20560.

Editor: Hiram G. Larew, B-470, ARS, USDA, Beltsville, MD 20705.

Managing Editor and Known Bondholders or other Security Holders: none.

This issue was mailed 20 July 1988

Second Class Postage Paid at Washington, D.C. and additional mailing office.

PRINTED BY ALLEN PRESS, INC., LAWRENCE, KANSAS 66044, USA

PROC. ENTOMOL. SOC. WASH.
90(3), 1988, pp. 269–287

SENSILLA ON THE LARVAE OF FOUR *HYPERA* SPECIES (COLEOPTERA: CURCULIONIDAE)

WAI P. CHAN, GERALD T. BAKER, AND MICHAEL M. ELLSBURY

(WPC, GTB) Department of Entomology, P.O. Drawer EM, Mississippi State University, Mississippi State, Mississippi 39762; (MME) USDA-ARS, Crop Science Research Laboratory, Forage Research Unit, P.O. Box 5367, Mississippi State, Mississippi 39762.

Abstract.—The morphology, number and distribution of the antennal, mouthpart and body sensilla of the fourth instar larva of *Hypera meles* (F.) are described and compared to those of *H. nigrirostris* (F.), *H. postica* (Gyllenhal) and *H. punctata* (F.); comparisons also are made among the first, second and third instar larvae of *H. meles*. The number and distribution of the antennal and mouthpart sensilla are very similar for the four species, and they are the same for the different larval instars of *H. meles*. Only *H. punctata* exhibits some morphological differences. The antenna has two sensilla auricillica, three sensilla basiconica and one sensillum campaniformium. Sensilla campaniformia and sensilla chaetica are found on the clypeus, labrum, mandible, stipes and prementum. Six scolopophorous sensilla are found on the mandible. Only sensilla chaetica are found on the postmentum. The epipharynx has six sensilla basiconica on the anterior edge, and 12 sensilla basiconica and two sensilla chaetica deeper in the buccal cavity. The adoral surface of the mala has 11 sensilla basiconica. Ten sensilla basiconica and two sensilla campaniformia are found on the apex of the maxillary palpus whereas eight and two of the respective sensilla are found on the apex of the labial palpus; both palpi have one sensillum digitiformium on the side of the apical segment. Two types of setae are found on the body. The first type is hair-like, resembling a sensillum chaeticum, and the second type is capitate on the first instar larva of *H. meles* but clavate on the other instars of *H. meles* and the fourth instar larvae of the other three species. The second type can be found on the prodorsum, postdorsum, and spiracular area of all segments except the prothorax. *Hypera punctata* has thinner sensilla aurillica and no trifurcate sensillum basiconicum on the antenna, a different arrangement of epipharyngeal sensilla basiconica, and eight scolopophorous sensilla in the mandible. Also, *H. punctata* has a short bifurcate sensillum chaeticum on the stipes, a shorter and thinner sensillum digitiformium on the maxillary palpus, emarginated dorsal sensilla of mala without scythe-like projections, and smooth-walled clavate body setae.

Key Words: Curculionidae, *Hypera* spp., larvae, morphology, sensilla, setae

Larvae of North American species of the genus *Hypera* feed mostly on plants in the legume (Fabaceae) and buckwheat (Polygonaceae) families (Titus 1911, Kissinger 1964). In the southeastern United States there are four introduced species of *Hypera* which feed on clover, *Trifolium* sp., alfalfa, *Medicago sativa* L. and sweet clover, *Melilotus* sp.: (1) clover-head weevil, *H. meles* (F.); (2) lesser clover-leaf weevil, *H. nigrirostris* (F.); (3) alfalfa weevil, *H. postica* (Gyllenhal); and (4) clover-leaf weevil, *H.*

punctata (F.). *Hypera meles* and *H. postica* are known to be serious pests on alfalfa and clover. The life history, biology and feeding preferences of these four *Hypera* species are summarized by Chapin and Oliver (1981 and references cited within). The larvae have distinct feeding preferences: larvae of *H. meles* and *H. nigrirostris* feed on the flowers and developing seeds, larval *H. postica* feed inside leaf buds and on leaves, and larval *H. punctata* feed on leaves. To understand their feeding preferences, we need to know the various types of cephalic sensilla that are involved in the feeding behavior and physiology. However, the morphology, number and distribution of the antennal and mouthpart sensilla which play an integral role in feeding behavior are documented only for the alfalfa weevil, *H. postica* (Bland 1983).

It is common for more than one of the four above-mentioned species to infest the same field together. The ability to differentiate the four species and their different life stages is critical for decision making in pest management. A key to the fourth instar larvae of 14 *Hypera* spp. which includes these four introduced species is available (Anderson 1948). However, the couplet that separates *H. meles* from *H. nigrirostris* depends on the color of the head capsule and the relative length of the abdominal postdorsal setae (Anderson 1948: couplet 4). These characters are hard to determine in preserved specimens.

Dyar's rule (1890) often is applied to reliably differentiate the different larval instars of these weevils (Detwiler 1923, Mailloux and Pilon 1975, Tower and Fenton 1920). The different larval instars of the four above-mentioned species have been described (Detwiler 1923, Titus 1911, Tower and Fenton 1920). However, no other definite characters are reported that would enable the differentiation of the different larval instars of the same species, except in alfalfa weevil (Gurrea-Sanz and Cano 1983).

This study provides information on (1) the morphology, number, and distribution of the antennal and mouthpart sensilla on the fourth instar larvae of the lesser clover-leaf weevil, alfalfa weevil, and clover-leaf weevil and also those of the four larval instars of the clover-head weevil; and (2) the morphology of their body setae.

Materials and Methods

Laboratory-reared fourth instar larvae of *H. meles, H. nigrirostris, H. postica,* and *H. punctata* were placed in boiling water for 30 s, transferred to Perfix® overnight, rinsed five times with distilled water, sonicated in a dilute detergent solution for 2 s, and rinsed three times with distilled water; or, they were fixed in Poly/LEM with 4% Triton® X-100, sonicated in the fixative for 2 s, and rinsed five times in distilled water. The mouthparts were dissected from the head and placed in a flow-through cell that was made from size 00 BEEM® capsules and embedding bag material. Specimens were osmicated 24–48 h in 4% aqueous OsO_4, rinsed in distilled water, dehydrated in a graded ethanol series, and either critical point dried in CO_2 or air dried from pentane. Specimens were attached to aluminum stubs with double stick tape or conducting silver paint and sputter-coated with gold/palladium. They were examined with a Hitachi HHS-2R or JEOL JSM-35CF scanning electron microscope at 20 kV.

The reduced silver staining method of Schafer and Sanchez (1976) was used to demonstrate porous sensilla. Stained larval mouthparts were dehydrated in graded ethanol series, then cleared in clove oil for 3 days and rinsed for 5 min in xylene. The specimens were mounted in Permount® for examination with a compound microscope.

A modified Essig's technique (Essig 1948) was used to study body setae. Decapitated fourth instar larvae were cut open either along the horizontal or sagittal plane. They were cleared in Essig's fluid for 25 min at 50°C and then overnight at room temperature. The clearing procedure was repeated

until a clear specimen was obtained. Larval skins were rinsed ten times in distilled water, dehydrated in a graded ethanol series, cleared in clove oil for 3 days and rinsed for 5 min in xylene, then mounted in Permount® and examined with a compound microscope. The nomenclature of the setae is based on the terminology of Anderson (1947) and that of the sensilla on Schneider (1964) and Snodgrass (1935). Descriptions, figures and measurements given are those of the fourth instar larva of *H. meles* unless otherwise stated.

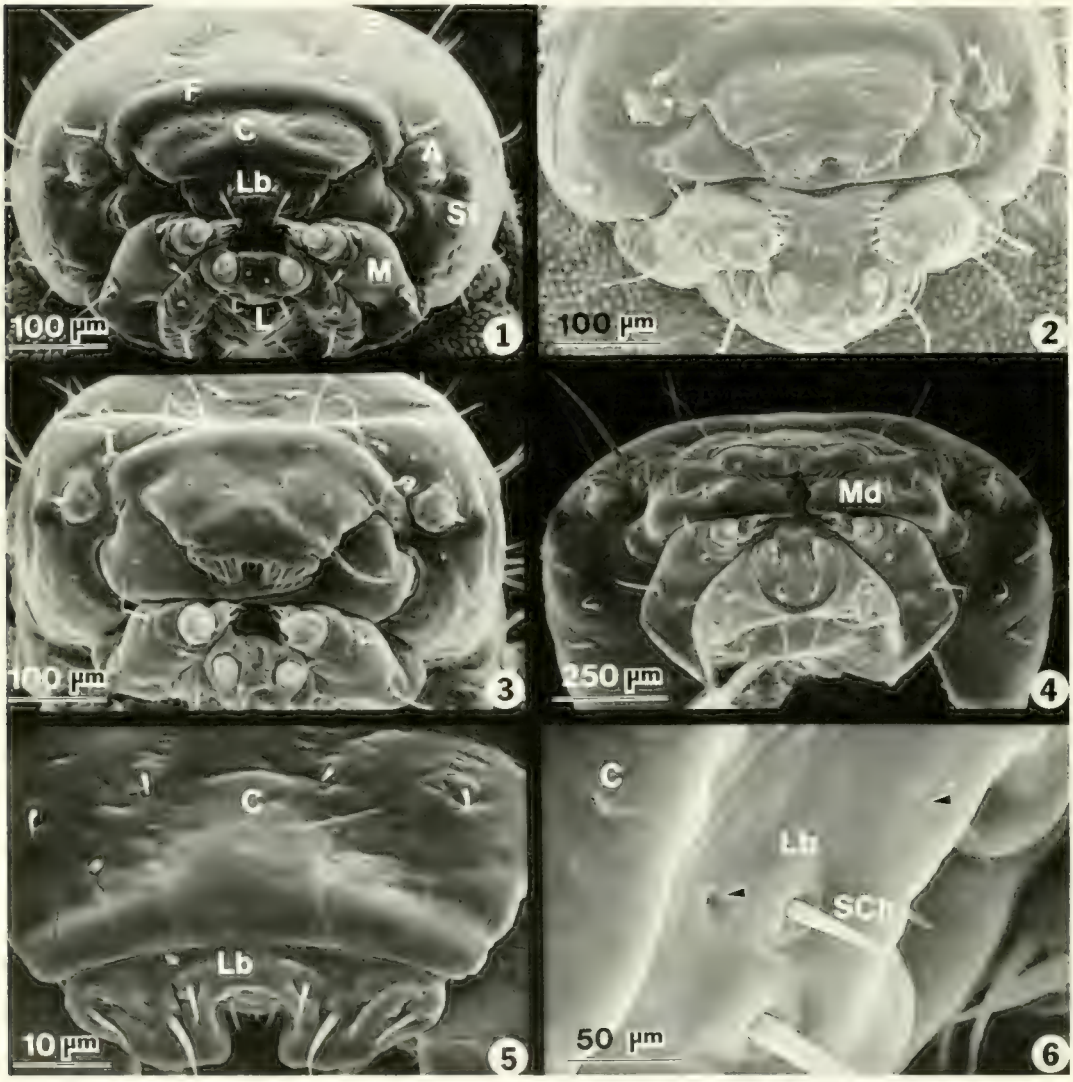
Results

The antenna and mouthparts did not differ from the published description (Anderson 1948). The former is located on the side of the epicranium between the anterior stemma and the base of the mandible. Larvae of the four *Hypera* spp. have hypognathous mouthparts, but usually the labrum is treated as the most dorsal mouthpart and the labium the most ventral. The labrum joins to the clypeus which is connected to the frons and underneath is the epipharynx. A pair of mandibles is situated behind the labrum. The ventral mouthparts consist of the labium and a pair of maxillae.

The average head capsule widths for the fourth instar larvae used in this study were 0.47 mm (n = 18) for *H. meles,* 0.39 mm (n = 3) for *H. nigrirostris,* 0.56 mm (n = 2) for *H. postica,* and 1.2 mm (n = 28) for *H. punctata* (Figs. 1–4). The average head capsule widths for the various instar larvae of *H. meles* are 0.2 mm (n = 5) for the first instar, 0.25 mm (n = 5) for the second instar and 0.33 mm (n = 5) for the third instar.

Antenna.—The antenna has seven sensilla on a short segment (Figs. 7, 8, 13, 16). The anteriorly located sensillum basiconicum is surrounded partially by three smaller sensilla basiconica, two sensilla auricillica and one sensillum campaniformium. The larger sensillum basiconicum is ca. 17 μm long, and 8 μm wide at the base where some plugged pores with diameters of ca. 400 to 600 nm are situated (Fig. 12). The outer surface of this sensillum is pitted as seen in the SEM micrographs (Fig. 9) and silver staining preparations (Fig. 7 insert). Fractured sensillum has a reticulated inner surface and the wall is ca. 0.75 to 1 μm thick (Fig. 11). Terminal pores are apparent on two of the three smaller sensilla basiconica which are ca. 2 to 3 μm long and 1 to 1.5 μm wide at the base (Fig. 10). The sensillum basiconicum between the sensilla auricillica is trifurcate and does not have a terminal pore (Fig. 14). The sensillum auricillicum is leaf-like, ca. 8 to 10 μm long, 2 μm wide at the base and constricted to ca. 1 μm halfway up the sensillum where a pore of ca. 250 nm in diameter is located (Fig. 15). It widens again towards the tip to form a blade and the widest part measures ca. 2.5 μm. On the other side of the blade there is a midrib-like structure and in some specimens the blade is emarginated. All of these sensilla lack a socket. A sensillum campaniformium, an oval depression with a raised rim of ca. 1.5 μm in diameter, is located near one of the sensillum auricillicum (Fig. 7). It often is not discernible when the cuticle is distorted during preparation. In *H. punctata* the sensillum auricillicum appears to have a narrower blade and the sensillum basiconicum between the sensilla auricillica is not trifurcate (Fig. 16).

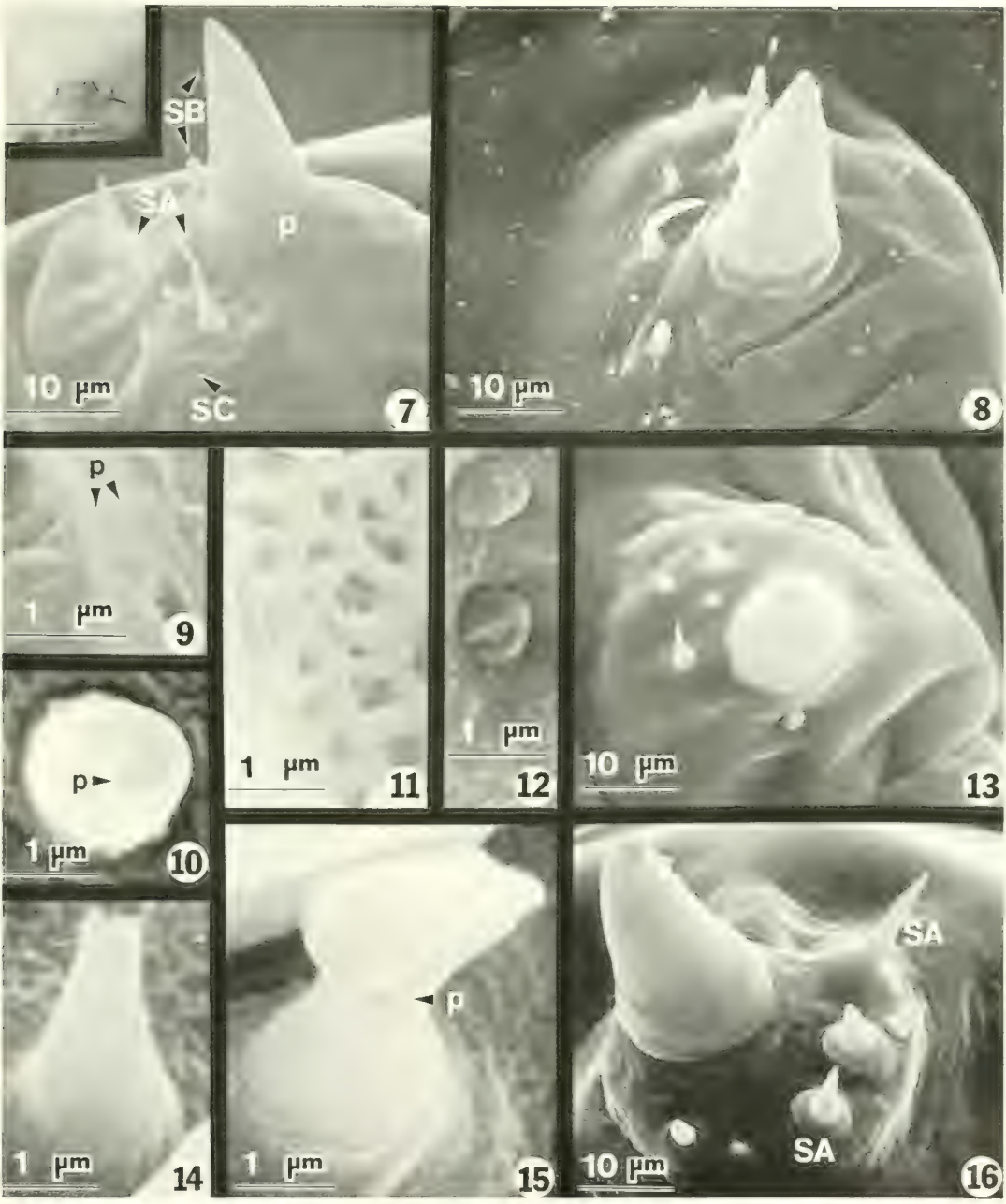
Labrum, clypeus and epipharynx.—There are three sensilla chaetica, ca. 14 to 50 μm long and 2 to 3 μm wide at the base, and one sensillum campaniformium on each side of the bilobed labrum (Figs. 1–6). Four sensilla chaetica, ca. 4 to 9 μm long and 1 to 2 μm wide at the base, are situated in the medial notch. A median sensillum campaniformium is located above the notch. Two sensilla chaetica, ca. 10 to 15 μm long and 2 to 3 μm wide at the base, are located on each side of the clypeus near the epistomal suture. One sensillum campaniformium is located between them. The sensilla chaetica are smooth-walled, attenuated, straight or slightly curved, and each has a socket. Some



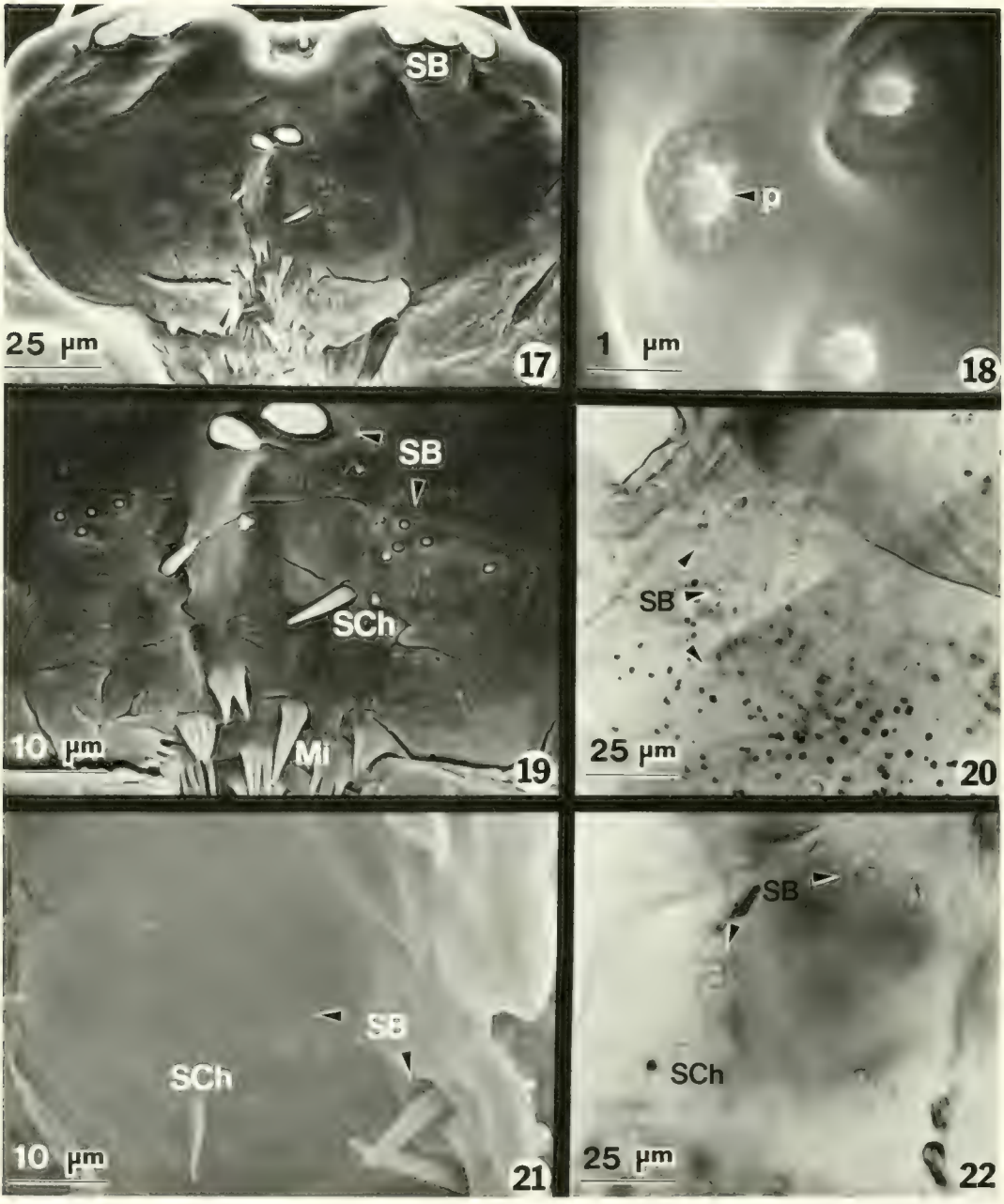
Figs. 1–6. 1–4, Head. 1, *H. meles* (frontal view). 2, *H. nigrirostris* (frontal view). 3, *H. postica* (frontal view). 4, *H. punctata* (frontal view). 5, Clypeus and labrum, *H. postica*. 6, Labrum, *H. meles*. Arrows = sensilla campaniformia.

sensilla campaniformia possess a depression of ca. 200 nm in diameter in the center.

On each side of the outer edge of the epipharynx there are three sensilla basiconica (Fig. 17). They are ca. 10 to 21 µm long and 4 to 5 µm across the widest part. These sensilla are slightly flattened, sunken and constricted at the base, and directed mesad. Deeper in the buccal cavity are 12 sensilla basiconica and two sensilla chaetica. Microtrichia are present and they are directed toward the pharynx. The two larger sensilla basiconica are ca. 10 to 12 µm long, 2 to 3 µm wide at the base and sit in a cavity (Figs. 19, 21). Their tips may be blunt or sharp. The other ten sensilla basiconica are arranged in two fields of five on each side of the midline (Fig. 17). In each field, four of the sensilla are grouped together and the other one is further away from the midline.



Figs. 7–16. Antenna. 7, *H. meles* (insert shows pitted surface of the larger sensillum basiconicum, silver staining, scale bar = 25 µm). 8, *H. nigrirostris*. 9–11, *H. meles*. 9, Larger sensillum basiconicum with pitted outer surface. 10, Sensillum basiconicum with terminal pore. 11, Fractured larger sensillum basiconicum shows reticulate inner surface. 12, Plugged pores at the base of the larger sensillum basiconicum, *H. punctata*. 13, *H. postica*. 14, Trifurcate sensillum basiconicum, *H. meles*. 15, Sensillum auricillicum shows a pore, *H. meles*. 16, *H. punctata*.



Figs. 17–22. Epipharynx. 17–19, *H. meles*. 17, Low magnification. 18, High magnification of the small sensilla basiconica. 19, Central region. 20, *H. nigrirostris*. 21, *H. postica*. 22, *H. punctata*.

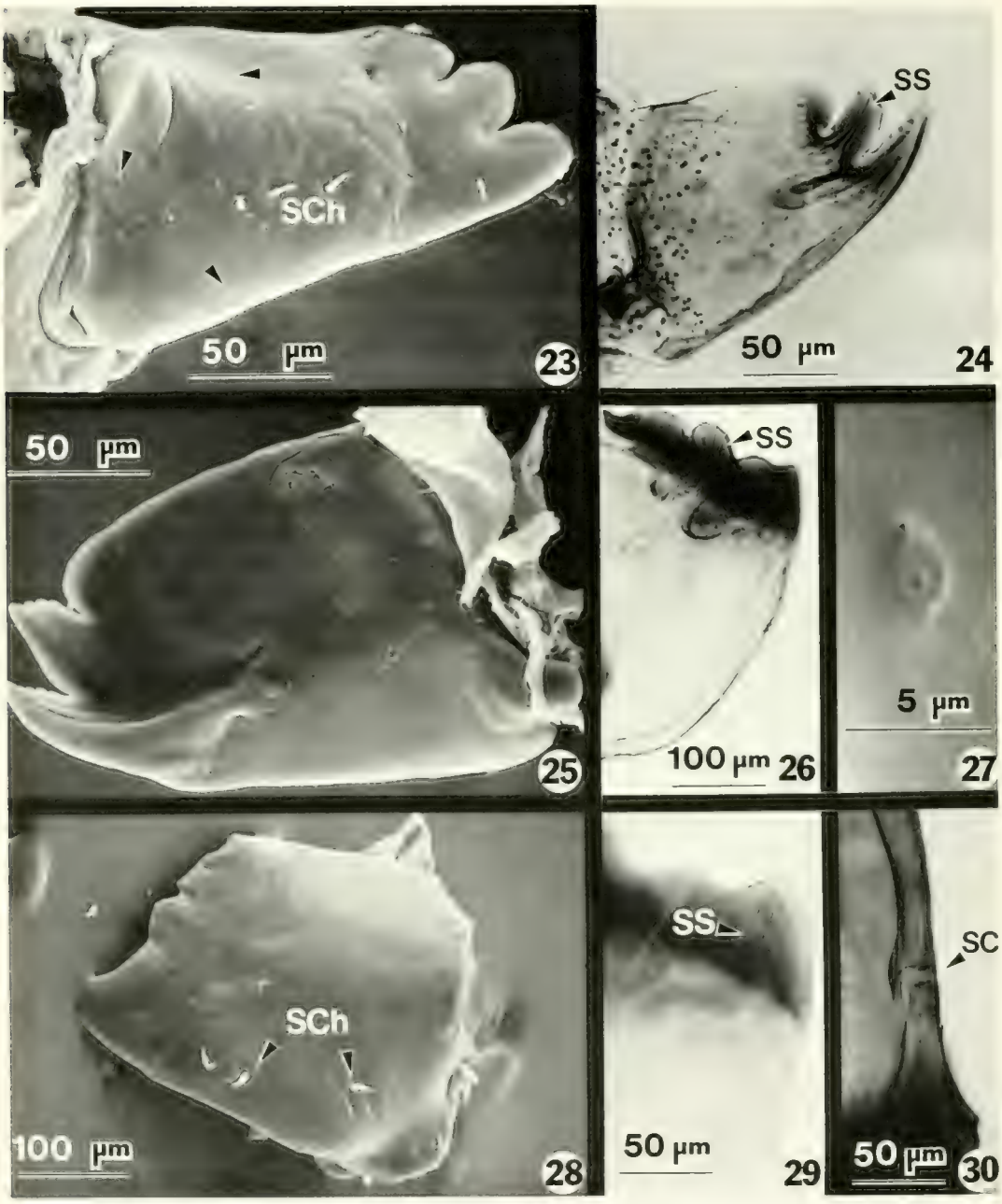
The same are found in *H. nigrirostris* (Fig. 20) and *H. postica* (Fig. 21) but in *H. punctata* the five sensilla are grouped together (Fig. 22). These sensilla are short, nipple-like, ca. 300 to 400 nm wide, and sit inside an oval depression of ca. 1 µm in diameter. A pore about 100 nm in diameter, which appears plugged, is located at the tip of these

sensilla basiconica (Fig. 18). Two sensilla chaetica ca. 7 μm long and 1.5 μm wide at the base, are located between these sensilla basiconica and the microtrichia (Figs. 17, 19). They are similar to the sensilla chaetica on the labrum.

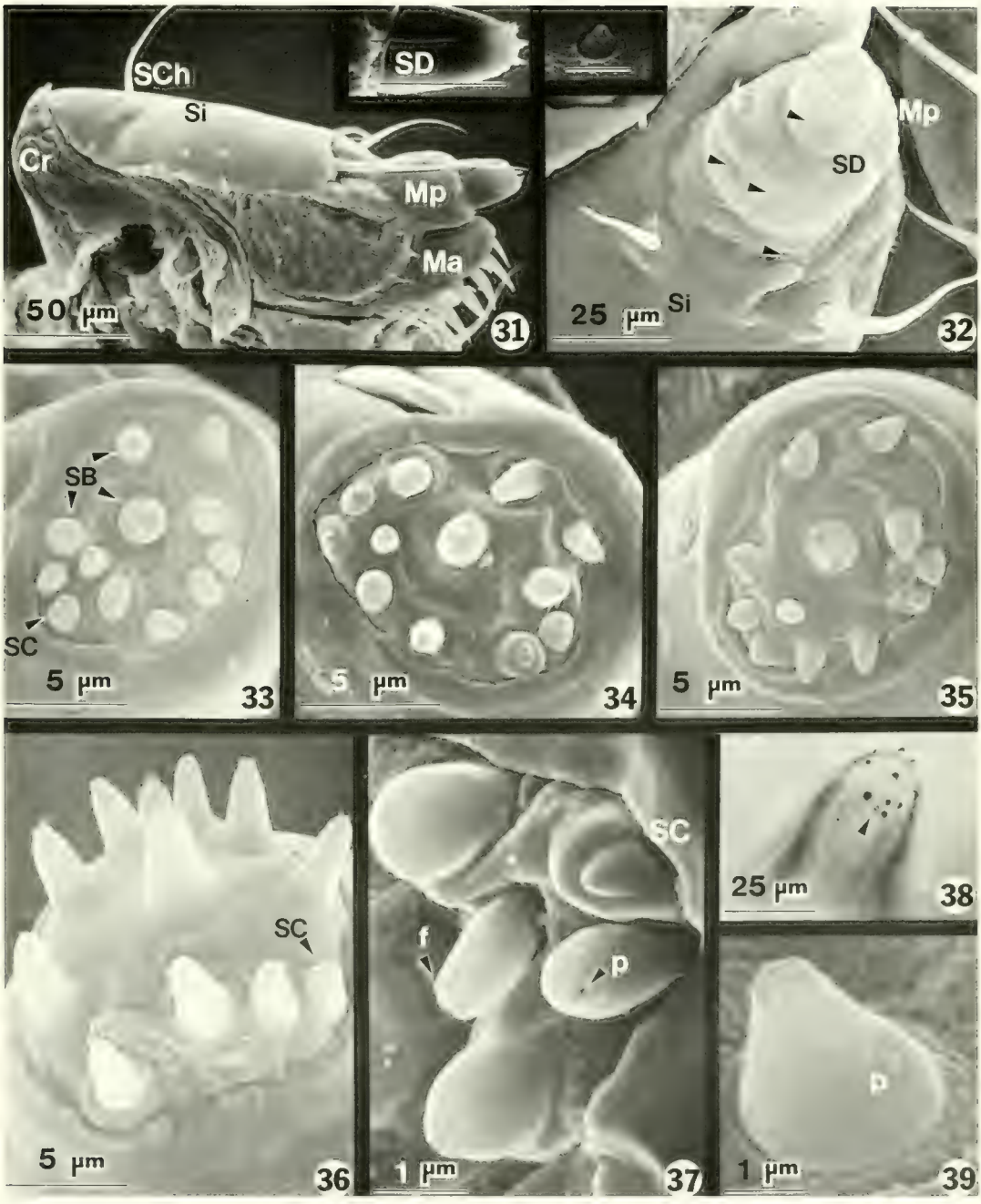
Mandible.—The anterior surface bears two sensilla chaetica which are ca. 10 μm long and 1.5 μm wide at the base (Figs. 23, 28). There are three sensilla campaniformia: one is located on the center of the dorsal surface, one on the anterior surface near the dorsal articulation and one at the boundary between the anterior and posterior surface (Fig. 23). In silver-stained preparations, the sensillum campaniformium appears as a canal in the heavily sclerotized cuticle (Fig. 30). Each mandible of *H. meles, H. nigrirostris* and *H. postica* has two apical teeth. Inside each tooth there are three scolopophorous sensilla (Fig. 24). Each mandible of *H. punctata* has four apical teeth (Fig. 28). Inside the fourth (ventral most) tooth are five scolopophorous sensilla (Fig. 29) whereas inside the second tooth there are only three (Fig. 26). The scolopophorous sensillum appears as a long canal extending from the internal cavity of the mandible into the teeth.

Maxilla.—Each maxilla consists of a fused cardo and stipes with the mala on the adoral side, and bears a two-segmented palpus on the other side (Figs. 31, 32). No sensilla are found on the cardo. The stipes has four sensilla chaetica, ca. 5 to 75 μm long and 3 to 5 μm wide at the base, and four to five sensilla campaniformia. Two longer sensilla chaetica, each accompanied by a sensillum campaniformium, are found on the aboral side of the stipes: one near the cardo and one near the palpus. Two shorter sensilla chaetica are found on the ventral surface near the palpus and the shortest one, accompanied by a sensillum campaniformium, is closer to the mala. In *H. punctata* the shortest sensillum chaeticum is bifurcate. Another sensillum campaniformium is situated on the aboral side of the articulating membrane between the palpus and the stipes. It is a short cone or dome situated in an oval depression of ca. 2 μm in diameter (Fig. 32 insert). The sensillum campaniformium located on the dorsal surface of the stipes where it joins the epicranium is found only in *H. meles* and *H. nigrirostris* but not in the other two species.

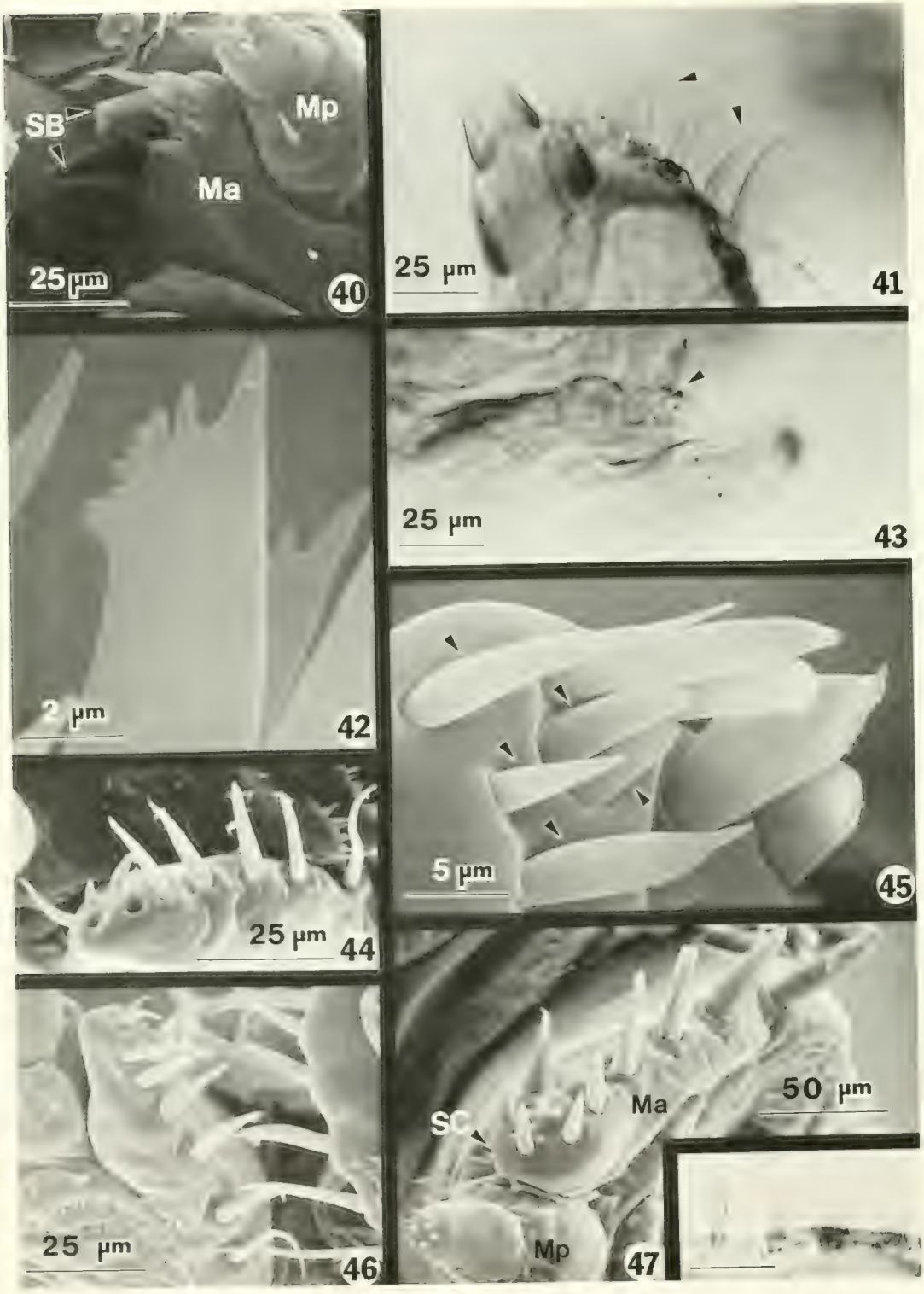
The basal segment of the palpus has one short sensillum chaeticum, ca. 3 μm long and 1.5 μm wide at the base, and two sensilla campaniformia on the ventral surface (Fig. 32). The second segment has one sensillum digitiformium on the aboral surface, one sensillum campaniformium on the ventral surface adjacent to the sensillum digitiformium and a group of 12 sensilla on the apex (Figs. 32–36). The sensillum digitiformium is ca. 12 μm long, 3 μm wide, rod-shaped, smooth-walled, socketed and lies in a groove. In some preparations a pore can be found on the distal tip. In *H. punctata*, the sensillum digitiformium is much shorter and thinner when compared to the size of the second palpal segment (Fig. 31 insert) whereas in the other three species it is almost as long as the second palpal segment (Fig. 32). The 12 sensilla on the apex consist of two sensilla campaniformia and ten sensilla basiconica. The sensillum campaniformium is a short cone ca. 500 nm in diameter and sits in an oval depression of ca. 700 nm in diameter on an elevated base. The rim of the depression is lower on the outer edge thus exposing the cone. One sensillum campaniformium is found facing the ventral surface and the other facing the adoral surface (Figs. 33–36). The sensilla basiconica are ca. 1.5 to 2 μm high and 0.5 to 2 μm wide at the base, cone to peg-like, and without a socket. In some of the sensilla basiconica, the terminal pore is surrounded by a lip and in the others by finger-like projections (Fig. 37). The centrally located sensillum basiconicum is larger than the rest and only lightly stained by silver just below the tip, whereas the other sensilla basiconica were deeply stained (Fig. 38). It does not



Figs. 23–30. Mandible. 23, Anterior and dorsal surface, *H. meles*. Arrows = sensilla campaniformia. 24, Scolopophorous sensilla, *H. nigrirostris*. 25, Posterior surface, *H. postica*. 26, Scolopophorous sensilla, *H. punctata*. 27, Sensillum campaniformium, *H. meles*. 28, Anterior surface, *H. punctata*. 29, High magnification of scolopophorous sensilla, *H. punctata*. Note only four of the five sensilla are visible. 30, Sensillum campaniformium at the boundary between the anterior and posterior surface, silver staining, *H. punctata*.



Figs. 31–39. Maxilla. 31, Dorsal view, *H. meles* (insert shows the distal palpal segment, *H. punctata*, scale bar = 50 µm). 32, Anterior-ventral view of the palpus, *H. meles* (insert shows sensillum campaniformium at the junction of the palpus and stipes, scale bar = 2.5 µm). 33–39, Apex of the palpus. 33, *H. meles*. 34, *H. nigrirostris*. 35, *H. postica*. 36, *H. punctata*. 37, High magnification of sensilla basiconica and sensillum campaniformium on the ventral region, *H. meles*. 38, Sensilla basiconica stained at the tips, silver staining, *H. punctata*. Note sensillum campaniformium is not stained (arrow). 39, Larger sensillum basiconicum with a plugged pore near the base, *H. postica*.


SB
Mp
Ma
25 µm
40
25 µm
41
25 µm
43
2 µm
42
5 µm
45
25 µm
44
50 µm
Ma
SC
Mp
25 µm
46
47

appear to have a terminal pore. However, a plugged pore which is ca. 300 nm in diameter, is found at the base of this sensillum (Fig. 39). It may be the ecdysial pore.

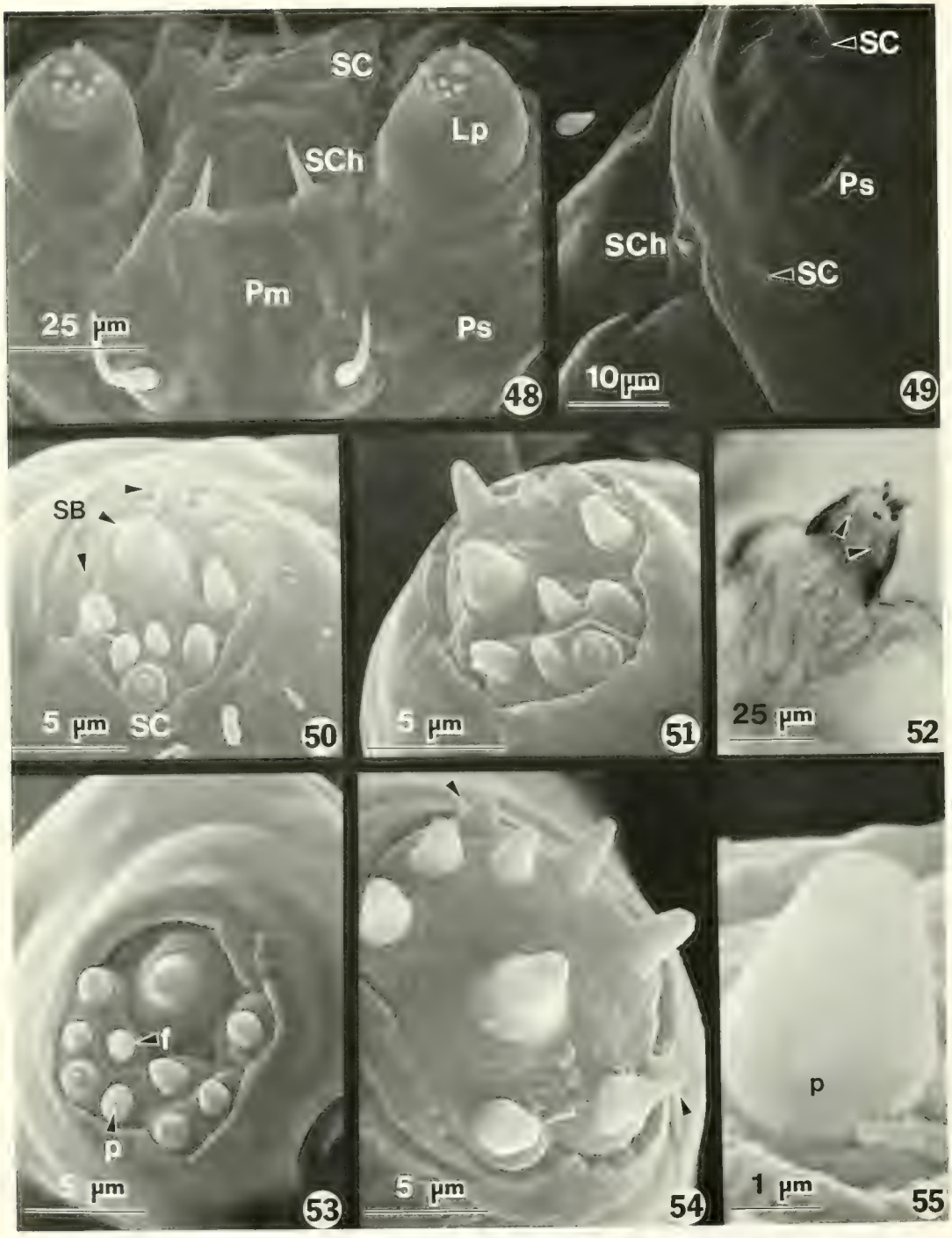
The adoral surface of the mala bears 11 sensilla and the ventral surface bears only one sensillum campaniformium near the apex (Fig. 47). Along the dorsal margin of the adoral surface extending into the buccal cavity are six sensilla basiconica, whereas in the central region and along the ventral margin of the distal adoral surface, there are five sensilla basiconica (Figs. 40–47). These 11 sensilla project mesad. Anderson (1947) called them the dorsal and ventral setae of mala, respectively. These sensilla range from ca. 6 to 37 μm long, and ca. 2 to 3 μm wide at the base. In *H. meles, H. nigrirostris* and *H. postica,* they have a smooth wall and some of the dorsal sensilla of mala bear irregular scythe-like projections at the tip (Fig. 42). In *H. punctata,* these sensilla measure ca. 6 to 48 μm long, and ca. 3 to 11 μm wide at the base and possess emarginated walls. Their tips are rough and have no scythe-like projections (Fig. 47). In optical sections of the silver staining preparation these sensilla appear to have a thick wall (Fig. 47 insert). In all four species these malar sensilla have sockets. A terminal pore is apparent on the two shorter medial ventral sensilla of mala (Fig. 45) and they were stained by silver at the tips (Fig. 43).

Labium.—The labium consists of the prementum and the postmentum separated by the premental sclerite. A pair of one-segmented labial palpi is situated on each side of the prementum. There are one pair of sensilla chaetica, ca. 10 μm long and 2.5 μm wide at the base, and one pair of sensilla campaniformia, ca. 2.5 μm in diameter, on the prementum near the edge of the buccal cavity (Figs. 48, 49). Another pair of similar sensilla chaetica and sensilla campaniformia are located between the palpi, and a third pair of sensilla chaetica which are approximately three times as long are near the premental sclerite. One sensillum campaniformium is found on the base of the aboral side of the palpus (Fig. 49). Posterior to this, on each side of the premental sclerite one short sensillum chaeticum which is ca. 2.5 μm long and 1.5 μm wide at the base, is found adjacent to the postmentum and also accompanied by a sensillum campaniformium (Fig. 49). Both sensilla campaniformia are ca. 1 to 1.5 μm in diameter. The former is dome-shaped, whereas the latter is crateriform. The palpus has one sensillum digitiformium on the dorsal surface (Fig. 56), two sensilla campaniformia on the ventral surface (Fig. 52), and a group of ten sensilla on the apex (Fig. 48). Unlike the sensillum digitiformium on the maxillary palpus, this one is wider than long, measures ca. 2 μm long and 3 μm wide, and does not seem to have a socket (Fig. 57). Although the number of sensilla is different from the apex of the maxillary palpus, the spatial arrangement and morphology of the sensilla are very similar. Seven sensilla basiconica and two sensilla campaniformia partially surround a central larger sensillum basiconicum (Figs. 50, 51, 53, 54, 55).

There are three pairs of sensilla chaetica on the postmentum. Two of these are situated laterally and one pair medially. The anterior-most pair is the shortest, ca. 15 μm long and 2 μm wide at the base. The pair adjacent to them is the longest, ca. 40 μm long and 6 μm wide at the base. The medial pair are ca. 24 μm long and 4 μm wide at

←

Figs. 40–47. Mala. 40–43, *H. meles.* 40, Mala (ventral view). 41, Dorsal sensilla of mala (arrows), silver staining. 42, High magnification of dorsal sensilla of mala. 43, Medial ventral sensilla of mala, silver staining. Arrow indicates stained tip. 44, *H. nigrirostris.* 45, Ventral sensilla of mala (arrows), *H. meles.* Note the position of the two medial sensilla as compared with Fig. 43. 46, *H. postica.* 47, *H. punctata* (insert shows the thick-walled dorsal sensilla of mala, silver staining, scale bar = 50 μm).



Figs. 48–55. 48, Prementum, *H. meles*. 49, Premental sclerite, *H. meles*. 50–55, Labial palpus. 50, Apex, *H. meles*. 51, Apex, *H. nigrirostris*. 52, Sensilla campaniformia on the ventral surface (arrows), silver staining, *H. meles*. 53, Apex, *H. postica*. 54, Apex, *H. punctata*. Arrows = sensilla campaniformia. 55, Larger sensillum basiconicum on the apex with a plugged pore near the base, *H. meles*.

the base. The base of the postmentum is covered with asperites similar to those found on the body.

Body.—The number and distribution of setae on the body are the same for the fourth instar larvae of *H. meles, H. postica,* and *H. punctata.* They are similar to the description on *Pissodes strobi* (Peck) (Anderson 1947) but have more setae, ca. 10 μm long and 2 μm wide at the base (Fig. 59), in the following regions:

1. Two setae on the side between the pronotum and the epicranium.
2. Three setae on the side between the pedal area and epicranium adjacent to the postmentum.
3. Two setae on the spiracular area and one seta anterior to the pedal area of the meso- and metathorax.
4. One seta on the spiracular area of the first to the seventh abdominal segment.

Moreover, the anal lobe (tenth abdominal segment) has no setae. The differences in the relative sizes of the setae are similar to those previously reported by Anderson (1948) except that the postdorsal seta 2 of *H. postica* on the fifth and sixth abdominal segments is clavate instead of attenuate (Anderson 1948: figs. 20, 21).

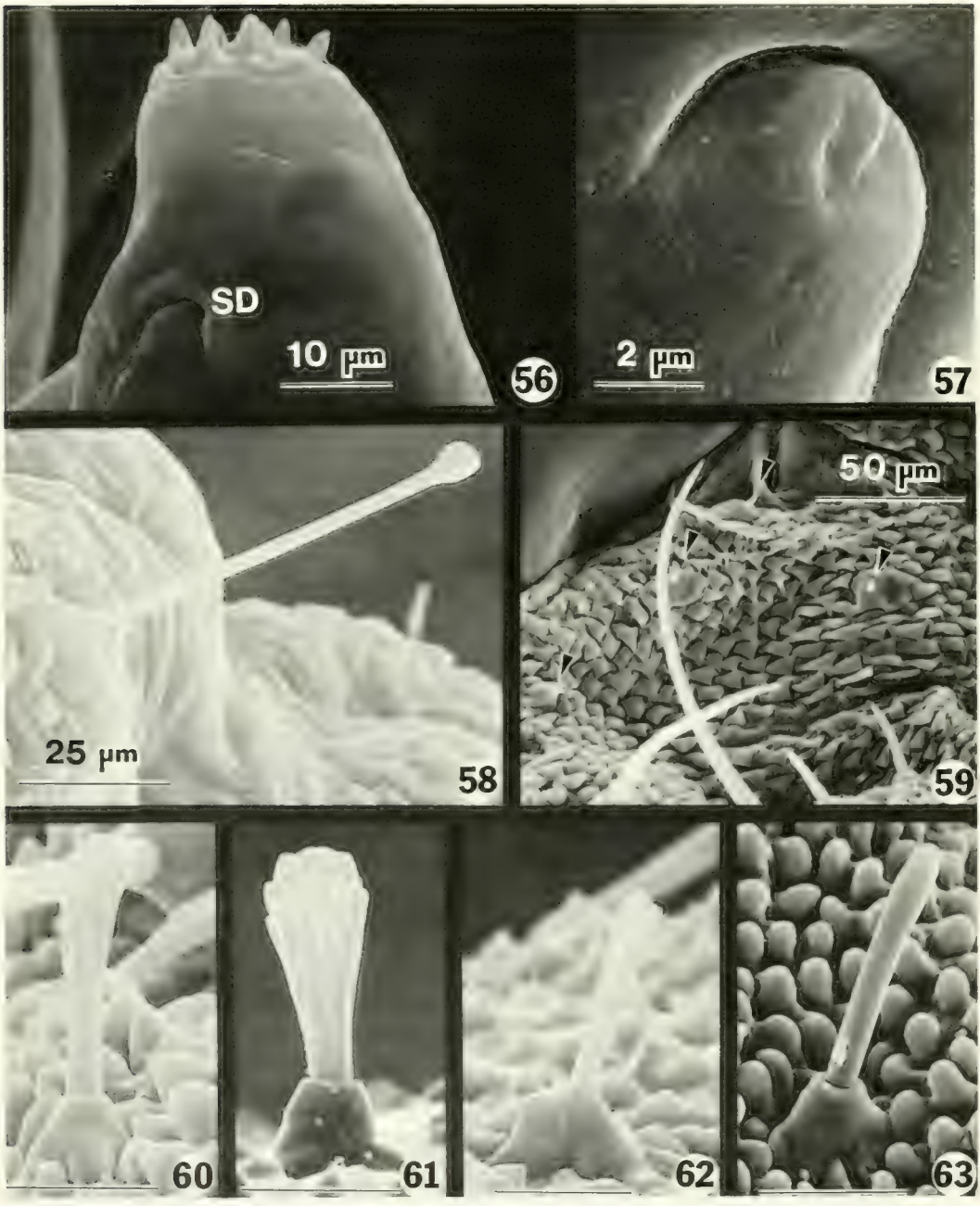
In *H. meles* two morphological types of setae are present on the body. The first type is smooth-walled and resembles a sensillum chaeticum. It is straight or slightly curved and varies from ca. 10 to 200 μm long and 2 to 7 μm wide at the base (Fig. 59). The second type is clavate and can be found on the prodorsum, postdorsum and spiracular area of all segments except the prothorax. Both types of setae have sockets. A unique variation of the second type is found in the first instar larva. It is capitate, smooth-walled, ca. 70 to 230 μm long, 3 to 8 μm wide at the base and the distal bulb is ca. 7 to 10 μm in diameter (Fig. 58). The longer ones are found on the last three abdominal segments. In later instars, clavate setae have overlapping plates on the distal end and a smooth middle piece (Figs. 60–62). On the last three abdominal segments, some of the clavate setae are replaced by long sensilla chaetica-like setae which are ca. 160 μm long and 8 μm wide at the base.

The first type of setae is found on all four *Hypera* spp. The clavate seta has the same appearance in *H. nigrirostris* and *H. postica,* but in *H. punctata* it does not have overlapping plates and the whole seta appears smooth (Fig. 63).

Discussion

The number and distribution of the antennal and mouthpart sensilla are very similar for the four species, and they are the same for the different larval instars of *H. meles.* Only *H. punctata* exhibits some morphological differences.

The morphology, number and distribution of the antennal and mouthpart sensilla of *H. postica* reported here are different from those previously reported by Bland (1983) in the following aspects. Bland (1983) did not mention that the sensillum basiconicum (sensillum 4—Bland 1983) between the sensilla auricillica is trifurcate. In both the maxillary and labial palpi he did not mention the sensilla digitiformia and sensilla campaniformia found on the side, and called all sensilla on the apex of both palpi, sensilla basiconica. But, I suggest that the two sensilla campaniformia be named as such because they resemble those in the wireworms (Bellamy 1973, Doane and Klingler 1978), adult *Dendroctonus ponderosae* Hopkins (Whitehead 1981) and adult *Ips typographus* L. (Hallberg 1982). In the last two species tubular bodies are present in the sensilla, which suggests that they are mechanoreceptors. On some of the ventral sensilla of the mala (galea—Bland 1983) the shape of the tip is variable rather than trifurcate as reported by Bland (1983). The sensilla found in these four *Hypera* spp. also resemble those on the rice weevil larvae, *Sitophilus oryzae* (L.) in their distribution pattern. However, the latter has three to four more



Figs. 56–63. 56, Sensillum digitiformium on the dorsal surface of the labial palpus, *H. punctata*. 57, High magnification of the sensillum digitiformium similar to Fig. 56. 58, Capitate seta, first instar larva, *H. meles*. 59, Short sensilla chaetica-like setae (arrows) on the prothorax near the epicranium, *H. meles*. 60–63, Clavate seta. 60, *H. meles*. 61, *H. nigrirostris*. 62, *H. postica*. Scale bar for Figs. 61–62 = 25 µm. 63, *H. punctata*. Scale bar = 50 µm.

sensilla on the antenna, and sensilla aurillica are absent. It also has three less sensilla basiconica on both the mala and apex of the labial palp (Speirs et al. 1986).

Sensilla auricillica are common on the antennae of adult Lepidoptera. They are reported to be chemoreceptors (Flower and Helson 1974, Faucheux 1984), temperature and humidity receptors (Subchev 1980), or receptors for selecting oviposition sites (Flower and Helson 1976). These sensilla are quite variable in shape (Subchev 1980). They are perforated and different from those found in this study. On the antenna of the adult cave beetle, *Aphaenops cryticola* Linder, the sensilla auricillica which are called "sensilla basiconica inflata" are considered to be chemoreceptors (Juberthie and Mazzoud 1977). Bland (1983), however, suggested that the sensillum auricillicum in *H. postica* may be simply flattened mechanoreceptors.

The pitted surface and the reticulate inner wall structure suggest that the larger sensillum basiconicum of the antenna is a single-walled, multiporous sensillum. This is similar to the "lobe membraneux" of *Speophyes lucidulus* Delar larva (Corbiere 1969) and the antennal sensory appendix of *Ctenicera destructor* (Brown) larva (Scott and Zacharuk 1971). Plugged pores on the base of the antennal sensory cone of *Aedes aegypti* (L.) larva, which serve as attachments of dendritic sheath (Zacharuk et al. 1971), are also found on these four *Hypera* spp.

The sensilla basiconica on the apex of the maxillary and labial palpi are believed to be multiporous because they are only stained slightly on the tip by the silver stain and a terminal pore is not apparent. The presence of plugged (ecdysial) pores at the base may indicate the possibility of absence of a terminal pore (Zacharuk 1980). In adult *Ips typographus,* single-walled sensilla that occur on the maxillary and labial palpi which have a system of pores penetrating the apex, are considered to be both gustatory and olfactory in function (Hallberg 1982). Thermoreceptor cells are known to bind to multiporous double-walled chemoreceptors in *Periplaneta americana* (L.) (Altner et al. 1977). The function of these sensilla basiconica found in this study may be primarily olfactory.

The sensilla basiconica on the antenna, epipharynx, mala, maxillary and labial palpi, which possess a terminal pore (uniporous) may serve as gustatory receptors (Zacharuk 1980). They can also be bimodal, both mechanoreceptor and gustatory receptor, like the lateral sensillum of the galea in larval *Entomoscelis americana* Brown (Mitchell 1978, Mitchell et al. 1979), uniporous pegs of the maxilla and labium in adult *Dendroctonus ponderosae* (Whitehead 1981) and the terminal pore sensilla in adult *Ips typographus* (Hallberg 1982). The lip and finger-like projections around the pore may regulate the pore opening to expose the dendrites to or conceal them from stimulants (Blaney and Chapman 1969). The nipple-like sensilla basiconica on the epipharynx of *Ctenicera destructor* larva are also found as two groups of five sensilla in which Zacharuk (1962) termed the 'oral plate organ' and suggested that they were gustatory receptors.

The trifurcate sensillum basiconicum found on the antenna, the six sensilla basiconica found on the anterior edge of the epipharynx, the pair of sensilla basiconica found in front of the nipple-like sensilla basiconica on the epipharynx, and the dorsal sensilla of mala, exept the medial two, do not possess a terminal pore and their lumens do not pick up the silver stain. In the colorado potato beetle larvae, *Leptinotarsa decemlineata* (Say) the longer sensilla on the edge of the galea are believed to be mechanoreceptors protecting the two central contact chemoreceptors (Mitchell and Schoonhoven 1974). Some non-porous sensilla with inflexible sockets found on the antenna of *Locusta migratoria* (L.) (Altner et al. 1981)

and *Drosophila* spp. (Altner et al. 1983), and also on the maxillary palpus of *Periplaneta americana* (Altner and Stetter 1982) are known to be thermo- and hygroreceptive. The information gathered for these sensilla basiconica in this study is not enough to ascribe a particular function.

Sensilla campaniformia and sensilla chaetica are believed to be mechanoreceptors (McIver 1975). The form of sensilla campaniformia vary from simple depressions (Fig. 27) to elaborate dome-shaped organs (Figs. 32 insert, 37). Pringle (1961) proposed that specialization of arthropod proprioceptors arose by slowly increasing restriction of conditions, such as their orientation and the thickness of their cuticle, producing the strain. This is illustrated by the sensilla campaniformia on the halteres of the muscid flies (Pringle 1948) and *Drosophila melanogaster* Meigen (Chevalier 1969). Zill and Moran (1981) found that the responses of the tibial sensilla campaniformia in *Periplaneta americana* are related to their position and cap orientation. Thus, it is possible that the simple-structured sensillum campaniformium like those on the prementum may respond to one form of cuticular stress while the more elaborate ones that are situated between the palpus and stipes may respond to another form.

In larval *Ctenicera destructor*, the sensillum digitiformium on the labial palpus is found to be responsive to mechanical stimulations (Zacharuk et al. 1977). In the maxillary palpi of *Agabas bipustulatus* (L.) and *Hydrobius fuscipes* (L.), the sensilla digitiformia are reported to be hygro- and thermoreceptor because they do not possess a special socket and tubular body, and the outer dendritic segment divides into several branches in the shaft (Guse and Honomichl 1980). However, these two kinds of sensilla only differ in morphology by the possession of a socket. It is possible that the sensilla digitiformia found in this study are mechanoreceptors.

The scolopophorous sensilla are similar to those found in larval *Speophyes* sp. (Corbiere-Tichane 1971). Zacharuk and Albert (1978) found that in elaterid larva, the scolopophorous sensillum responds electrophysiologically to an outward deformation or bending of the mandibular teeth, therefore they serve as proprioceptors monitoring the stress and deformation in biting and chewing. In *Hypera* spp. these scolopophorous sensilla probably also function similarly while the sensilla campaniformia and sensilla chaetica on the surface serve as proprioceptors and exteroceptors, respectively.

In these four *Hypera* spp. a general pattern, in which a larger sensillum basiconicum is surrounded by a group of other sensilla, is found on the antenna, and apexes of the maxillary and labial palpi, but the number of surrounding sensilla varies. The number of sensilla on the apex of the maxillary palpus is greater than the number on the apex of the labial palpus. Both conditions are true in larval *Sitophilus oryzae* (Speirs et al. 1986) and larval *Lyctus brunneus* (Stephens) (Iwata and Nishimoto 1981). In *Tribolium* spp. larvae, the apex of the maxillary palpus has one more sensillum than that of the labial palpus (Ryan and Behan 1973). The same conditions are also found in the adult *Dendroctonus ponderosae* (Whitehead 1981) and *Ips typographus* (Hallberg 1982). The functional implication of such a pattern, if there is any, is unknown.

Zacharuk (1962) reported that the number, distribution and structure of the cephalic sensilla among different genera and species of larval elaterids are very similar, and the minor differences may be related to differences in habitat. In *Tribolium* spp. larvae, Ryan and Behan (1973) found that there is no difference in number and distribution of sensilla on the last instar of two species. In this study, a similar situation is found. *Hypera punctata* is the only species among the four to show some morphological differences. The similarity in the number and distribution of antennal and mouthpart sen-

silla among the four *Hypera* spp. indicates that the difference in feeding preferences among the fourth instar larvae is probably due to physiological differences either at the receptor level or at the central nervous system integration level. The exact function of the sensilla can only be determined by extensive electrophysiological and ultrastructural studies. The findings of this study provide the basis for such experiments.

The capitate sensillum is also found in the first instar of *H. postica* (Bland 1983). The body setae or sensilla, including the capitate and the clavate sensilla, are believed to be mechanoreceptors. Studies on the function of larval body sensilla are scarce. Chapman (1982) in his review mentioned that Henig (1930) showed that sensilla on the thoracic tarsi of the caterpillar, *Agrochola lota* (Clerck) is equipped with a single neuron which suggests their role in mechanoreception.

In exopterygota, the number of antennal and mouthpart sensilla of different nymphal instars varies considerably as illustrated by *Periplaneta americana* (Schafer and Sanchez 1973) and *Locusta migratoria* (Chapman 1982 and references cited within). In endopterygota, these characters are not highly variable. In Coleoptera, the carnivorus larvae of *Macrodytes* spp. have more sensilla basiconica in the third instar than the first (Hamon 1961). Different instar larvae of the powder-post beetle, *Lyctus brunneus*, a xylophagous species, exhibit a difference in the shape of the apical sensilla of the maxillary palpus and in the length of the antennal segments, but there is no mention of the number of sensilla found in each larval instar (Iwata and Nishimoto 1981). Our study shows that the number of sensilla on the antenna and mouthparts of *H. meles*, a phytophagous insect, remain the same throughout larval development. This is in agreement with the similar feeding preference of the different larval instars. All larval instars feed on flowers, ovaries and developing seeds of the host (Tippins 1957).

No additional diagnostic characters were found that would enable differentiation of the fourth instar larvae of *H. meles*, *H. nigrirostris* and *H. postica*. *Hypera punctata* can be identified easily because of the larger size and number of mandibular teeth (Anderson 1948: couplet 2). Revision cannot be made at this stage. The distribution of body setae of the different larval instars may provide an alternative to using measurements of head capsule width, to differentiate the instars as was proposed for alfalfa weevil larva by Gurrea-Sanz and Cano (1983).

Acknowledgments

This paper is assigned No. 6784 of the Mississippi Agriculture and Forestry Experiment Station. We thank B. Perrigin for typing the manuscript. Mention of trademark or proprietory products does not constitute a guarantee or warranty of the products by the U.S. Department of Agriculture and does not imply approval to the exclusion of other products.

List of Abbreviations

(A) = Antenna. (C) = Clypeus. (Cr) = Cardo. (E) = Epicranium. (f) = Finger-like projections. (F) = Frons. (L) = Labium. (Lb) = Labrum. (Lp) = Labial palpus. (M) = Maxilla. (Ma) = Mala. (Md) = Mandible. (Mp) = Maxillary palpus. (p) = Pore. (Pm) = Prementum. (Ps) = Premental sclerite. (SA) = Sensillum auricillicum. (SB) = Sensillum basiconicum. (SC) = Sensillum campaniformium. (SCh) = Sensillum chaeticum. (SD) = Sensillum digitiformium. (Si) = Stipes. (SS) = Scolopophorous sensillum. (St) = Stemma.

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PROC. ENTOMOL. SOC. WASH.
90(3), 1988, pp. 288–293

A NEW SPECIES OF *BRACON* (HYMENOPTERA: BRACONIDAE) PARASITIC ON *EOREUMA LOFTINI* (DYAR) (LEPIDOPTERA: PYRALIDAE)

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Abstract.—A new species of *Bracon* (Hymenoptera, Braconidae) is described. This species is parasitic on stem-boring Pyralidae (Lepidoptera) in grasses, and has been reared during biological control programs directed against *Eoreuma loftini* (Dyar). Unusual features, not previously associated with the genus *Bracon*, are described.

Key Words: *Bracon*, Braconidae, Biocontrol, stem borer, Pyralidae

An undescribed species of *Bracon* was reared during the course of a biological control program directed against the Mexican rice borer, *Eoreuma loftini* (Dyar). It is described here to provide a name for researchers working on stem borers, and to identify several unusual features not previously reported for Nearctic *Bracon* species. This species has been reared only from *E. loftini* in grasses of the genera *Setaria, Cynodon,* and *Sorghum.*

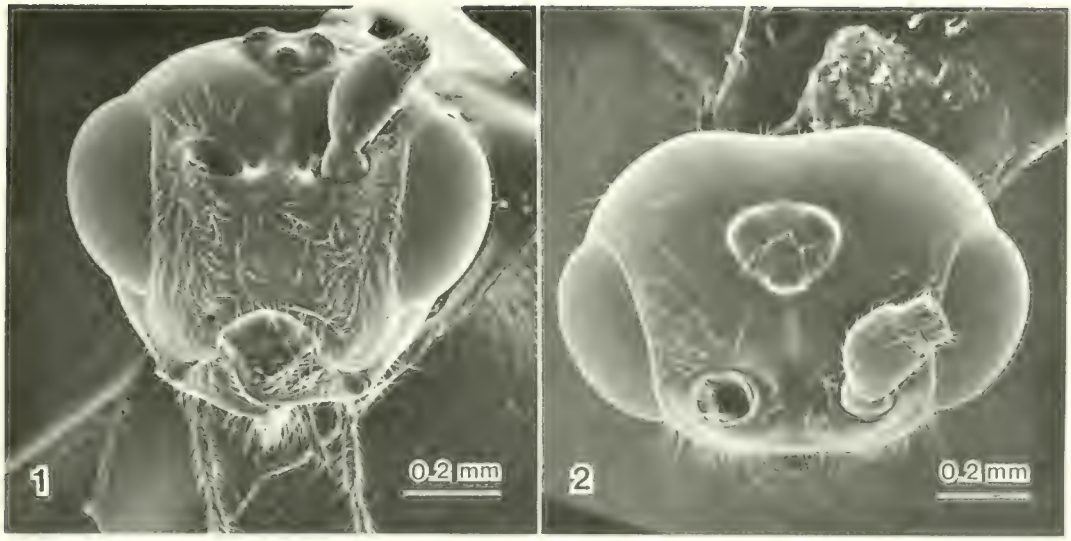
Terminology for the description follows van Achterberg (1979) and Quicke (1987), except that the total length of the ovipositor has been measured rather than just the portion extending beyond the metasoma. Measurements presented only as ratios or ranges are based on five individuals, with ratios representing median values. Ranges followed by a mean and standard deviation in parentheses are based on 10 individuals.

Bracon rhyssaliformis Quicke & Wharton, New Species

Figs. 1–11

Males.—Length of body 2.5–5.0 mm and of fore wing 2.1–4.0 mm.

Antennae with 38–45 flagellomeres. Terminal flagellomere strongly acuminate (Fig. 3), 3.0 times longer than maximally wide. Penultimate flagellomere 1.8–2.4 times longer than wide. Median flagellomeres 1.7–2.0 times longer than wide. First flagellomere 1.05–1.20 times and 1.10–1.25 times longer than the 2nd and 3rd respectively, the latter being 2.0–2.3 times longer than wide. Hypoclypeal depression dorsally strongly rounded, bordered dorsally by a distinct lamelliform carina. Clypeus separated from face dorsally by a narrow shallow sulcus. Height of clypeus : inter-tentorial distance : tentorio-ocular distance = 1:2.6:1.7. Face moderately densely short setose laterally, more or less glabrous medially; smooth and shiny between the punctures at the bases of the setae except for the malar space which is broadly imbricate. Width of head : shortest distance between eyes : height of eye = 1:0.55:0.46. Eyes moderately densely short-setose medially, glabrous laterally (Fig. 1). Frons hardly impressed behind the antennal sockets, with a well-developed mid-longitudinal sulcus. Vertex, temples and occiput sparsely setose. Ocelli



Figs. 1–2. Scanning electron micrographs of head, *Bracon rhyssaliformis*. 1, facial view. 2, dorsal view.

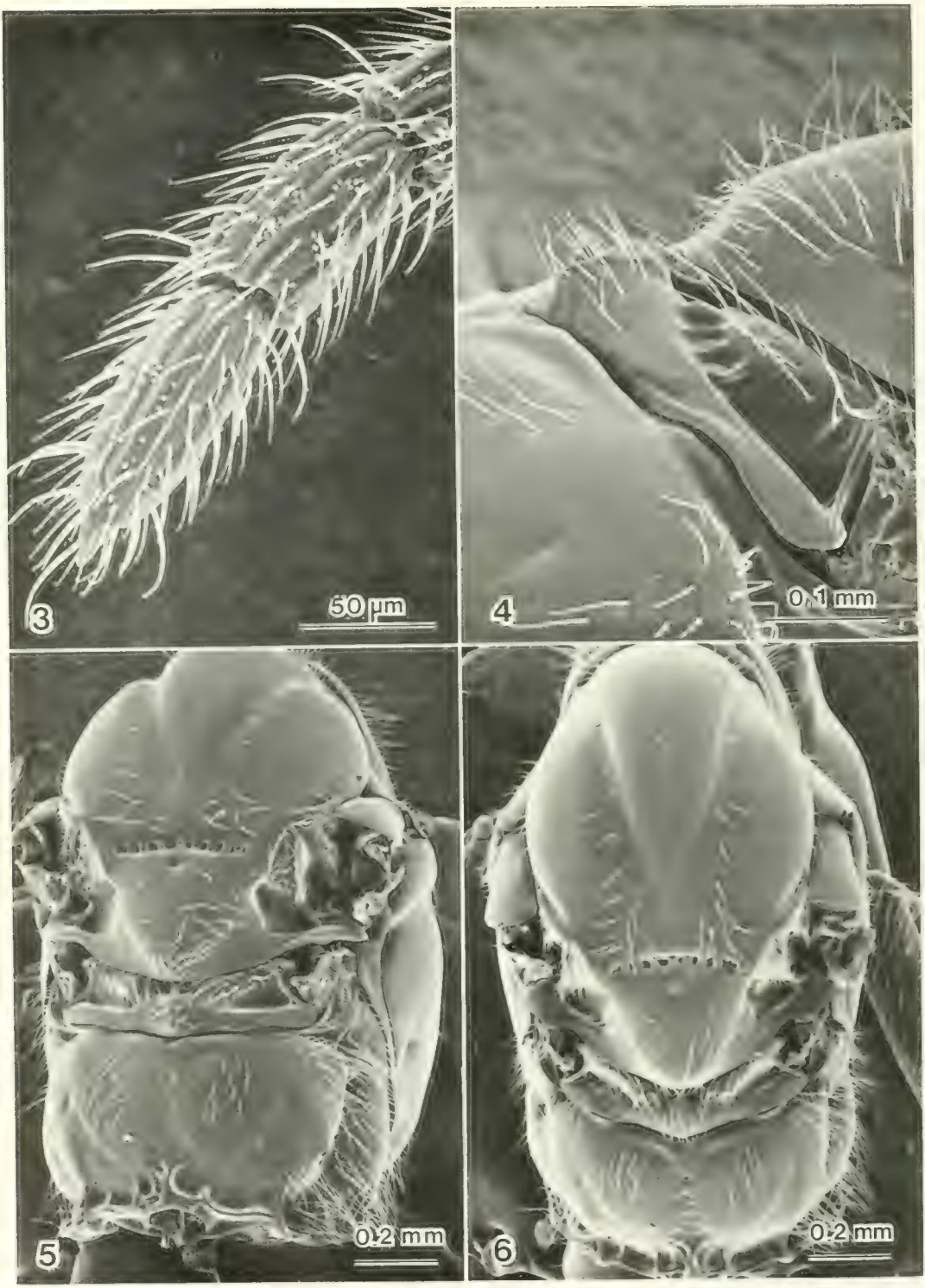
small, shortest distance between posterior ocelli : narrower diameter of elliptical posterior ocellus :shortest distance between posterior ocellus and eye = 1:0.7:2.1. Head subparallel immediately behind eyes (Fig. 2).

Fore wing (Fig. 11). Veins C + SC + R and 1-SR forming an angle of approximately 65°. Vein 1-SR + M straight. Length of veins r:3-SR:SR1 = 1:2.4:6.2; SR1 2.13–3.08 (2.54 ± 0.32) times longer than 3-SR; 3-SR 1.13–1.43 (1.27 ± 0.10) times longer than 2-SR. Vein r-m straight; vein 2-M distinctly curved. Vein 2-SR + M usually rather long, 0.60–1.04 (0.82 ± 0.12) times length of m-cu. Veins 2-CU and 3-CU forming an angle of approximately 75°. Vein cu-a often (50% of specimens) interstitial, otherwise antefurcal.

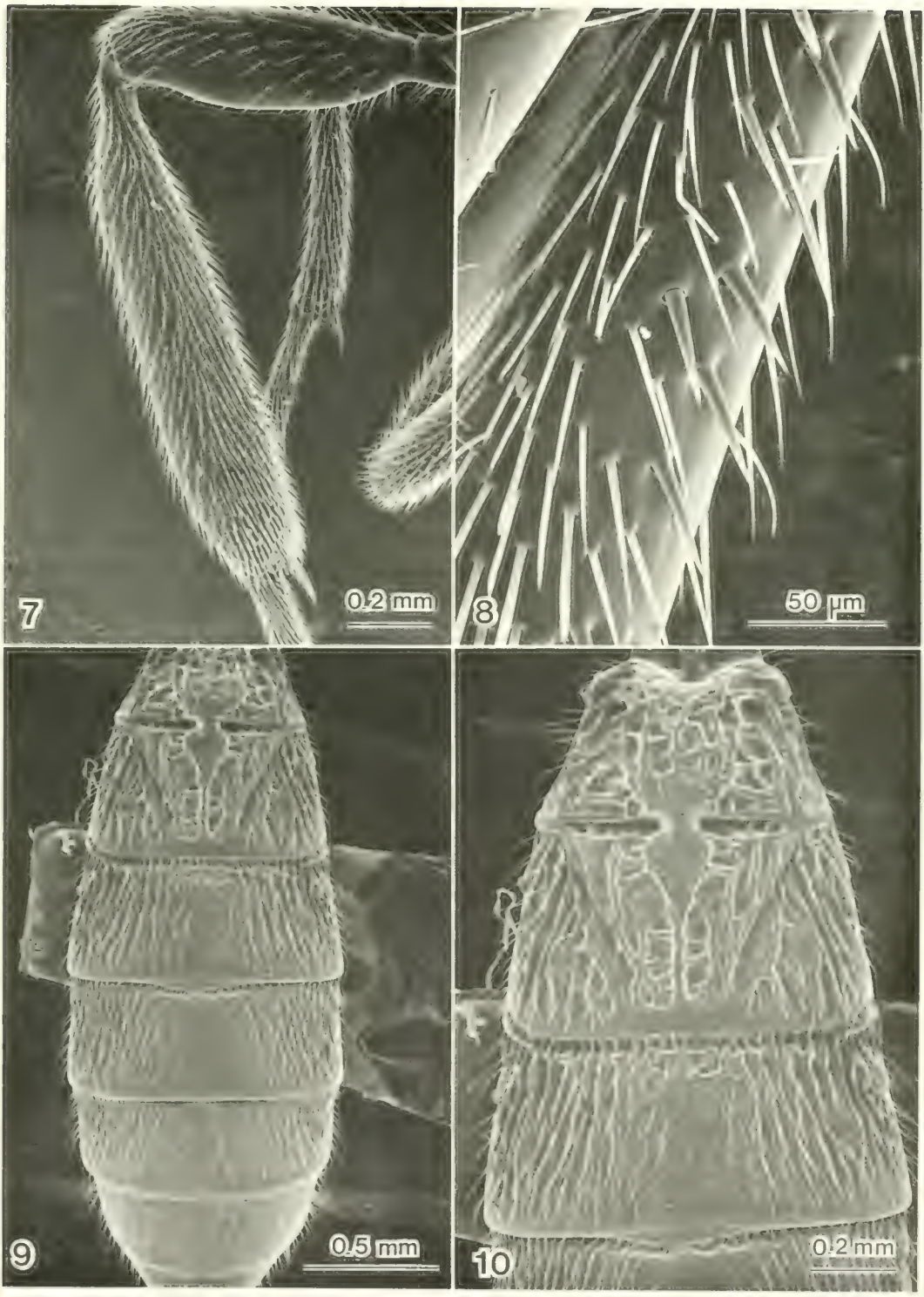
Hind wing (Fig. 11). Apex of vein C + SC + R with 1 thickened bristle (hamule). Vein 1r-m short, SC + R1 1.76–3.14 (2.29 ± 0.43) times longer than 1r-m. Vein 2-SC + R distinctly longitudinal. Base of wing evenly densely setose.

Claws with acutely pointed basal lobes. Length of fore femur : tibia : tarsus = 1:1.2:1.5. Length of hind femur : tibia : basitarsus = 1:1.9:0.6. Hind tibia (Fig. 7) extraordinarily swollen for its whole length, 5.3–6.5 times longer than maximally deep, without a distinct longitudinal, lateral furrow. Hind basitarsus 5.1–6.6 times longer than deep. Fore tibia with a longitudinal row of stout setae interspersed with finer ones (Fig. 8).

Mesosoma (Figs. 4–6) smooth and polished. Pronotum in dorsal view long, bisected by a deep, usually smooth, transverse sulcus; this sulcus usually connected to anterior margin by a short, median longitudinal groove. Mesonotum weakly declivous, nearly bare, with patch of 5–10 setae near base of notaulus and less than 15 setae extending along each notaulus to the posterior margin. Notauli unsculptured, deep anteriorly, evanescent posteriorly. Prescutellar pit narrow, containing 3–9 short, longitudinal ridges. Scutellum usually (70% of specimens) with small median pit anteriorly. Metanotum (Fig. 4) often (40% of specimens) with complete median longitudinal carina. Propodeum usually (60% of specimens) with rugae or carinae along midline, forming an irregular longitudinal ridge, but propodeum completely smooth in 30% of specimens.



Figs. 3–6. Scanning electron micrographs, *Bracon rhyssaliformis*. 3, terminal flagellomere with acuminate tip. 4, dorso-lateral, oblique view of metanotum showing median carina. 5 & 6, dorsal view of mesosoma showing effect of angle of view on appearance of certain sculptural features.



Figs. 7–10. Scanning electron micrographs, *Bracon rhyssaliformis*. 7, hind femur and swollen hind tibia of male. 8, spinose setae of fore tibia. 9 & 10, metasoma of male.

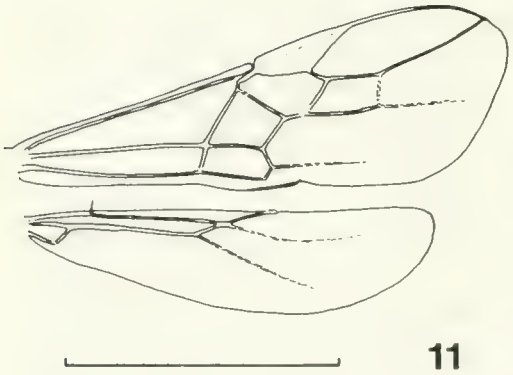


Fig. 11. Fore and hind wing; scale = 2.0 mm.

First metasomal tergum approximately as long as posteriorly wide, with distinct though sub-lamelliform dorso-lateral carinae; posterior 0.6–0.7 of 1st tergum rugose and distinctly elevated medially. Second and 3rd metasomal terga (Fig. 10) separated by a broad, carinate suture. Second tergum with narrow, relatively smooth, triangular plate baso-medially, apex of triangle extending as a carina to or nearly to the posterior margin; median triangle centered within a larger, raised, triangular area usually delimited laterally by distinct, weakly converging, lateral grooves; entire tergum rugoso-striate. Terga 3–5 (Fig. 9) completely rugose to rugoso-striate, with metasomal sculpture weaker posteriorly. Remaining terga often finely or only incompletely sculptured.

Color: orange; gena, palps and fore wing stigma often yellow; pedicel, flagellum, hind tibia, and 5th tarsus of mid, hind, and sometimes fore leg dark brown to black; wings usually uniformly infumate; 60% of specimens with small dark spot on temple adjacent eye, and varying amount of dark markings around ocellar field.

Females.—Similar to males except as follows:

Length of fore wing 2.5–4.3 mm. Antennae with 36–48 flagellomeres. Median flagellomeres 1.4–1.6 times longer than wide. Clypeus short, inter-tentorial distance approximately 3.4–4.0 times height of clypeus. Ocellar triangle even smaller than in male, with shortest distance between posterior ocellus and eye approximately 2.5 times shortest distance between posterior ocelli (ocellar measurements highly variable). Length of fore wing veins r:3-SR:SR1 = 1:2.2:5.6; SR1 2.30–2.88 (2.53 ± 0.17) times longer than 3-SR; 3-SR 1.20–1.29 (1.23 ± 0.03) times longer than 2-SR, these ratios thus less variable than in males. Length of hind femur : tibia : basitarsus = 1:1.7:0.5. Hind tibia not swollen, 10.5–12.1 times longer than deep. Hind basitarsus 4.2–5.3 times longer than deep. Scutellum usually (70%) without small median pit. Metanotum with median carina nearly always well developed. Propodeum with at least some sculpture along midline in 90% of specimens. Metasomal sculpture variable, often (40% of specimens) considerably reduced posteriorad 3rd segment. Second metasomal segment with median triangle often weakly defined due to absence of distinct longitudinal depression on either side of median triangle; larger median triangular area usually set off laterally by a pair of strongly converging grooves. Ovipositor (total length) 1.7–1.9 times longer than mesosoma, with small, sharp subapical node dorsally and well-defined serrations ventrally at tip; ovipositor sheath 1.1–1.2 times longer than mesosoma. Color as in male, but only 2 of the specimens examined with a black spot on the temple; ovipositor sheath black, ovipositor red.

Holotype ♂.—U.S.A.: Texas, Hidalgo County, TAES Annex, 2 miles north of Mercedes, ex. *Setaria* (Poaceae), 19.ix.1984, H. W. Browning, in U.S. National Museum of Natural History (= USNM).

Paratypes.—MEXICO: Nuevo Leon, Monterrey (Marin), 2–3.vii.1982, J. W. Smith, Jr. & F. Bennett, Texas A&M University (= TAMU) Quarantine Number 82015, TAMU Voucher Number 208 (6 ♂, 4 ♀) reared from *E. loftini* ex. *Sorghum halapense.* U.S.A.: Texas, same data as holotype (6 ♂, 8 ♀); Hoblitzelle Farm, 5 miles

north of Mercedes, reared from *Eoreuma loftini* (Dyar) on Bermuda grass (*Cynodon*), 15.viii.1984, H. W. Browning (2 ♂, 4 ♀); 4 miles north of Mercedes, ex. *Eoreuma loftini* in Bermuda grass, 29.v.1985, R. Pfannenstiel (2 ♀); 5 miles northwest of Weslaco, 1.vi.1983, C. W. Melton (1 ♀). Paratypes deposited in TAMU Collection, USNM, Canadian National Collection, and British Museum (Natural History).

Diagnosis.—The enlarged hind tibia of the male readily separates *rhyssaliformis* from all previously described species of *Bracon*. This species runs to *oenotherae* Muesebeck in the latest revision of the Nearctic species of *Bracon* (Muesebeck 1925). It is also somewhat similar to *mellitor* (Say). As in *oenotherae* and *mellitor*, the metasoma is extensively sculptured, the propodeum is unsculptured except along the midline, and the fore wing stigma tends to be yellow. However, females of both *oenotherae* and *mellitor* have more extensive dark markings on the hind legs and the petiolar sculpture in both sexes is less rugose than in *rhyssaliformis*. *Bracon mellitor* also has a longer ovipositor and *oenotherae* a relatively shorter second tergum.

Discussion.–The enlarged hind tibia of the male, fore tibial spines, and petiolar morphology place *rhyssaliformis* in a somewhat isolated position amongst the species of *Bracon* known from the Nearctic Region. Since this region has not been well-studied, and several species are as yet undescribed, further discussion regarding the relationships of *rhyssaliformis* would be premature.

Despite the presence of some doryctine characteristics (notably the fore tibial spines), *rhyssaliformis* is clearly a braconine, and readily fits the characterization of *Bracon* given by Quicke (1987). Diagnostic features for the genus include the 5-segmented maxillary palps; upper margin of mandible abutting lower margin of face without formation of a groove; scape longer dorsally than ventrally; fore and hind wing as in Fig. 11; and absence of an occipital carina, a prepectal carina, and a sculptured sternaulus.

Acknowledgments

We wish to thank F. Bennett, J. W. Smith, Jr., and H. W. Browning for making this material available for study, and for providing the rearing records. Approved as TA#23276 by the Texas Agricultural Experiment Station. This work was supported in part by the Rio Grande Valley Sugar Growers, Inc.

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PROC. ENTOMOL. SOC. WASH.
90(3), 1988, pp. 294–306

NESTING BEHAVIOR OF *APORINELLUS WHEELERI* BEQUAERT AND *A. TAENIOLATUS* (DALLA TORRE) (HYMENOPTERA: POMPILIDAE)

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Abstract.—The ecology and nesting behavior of *Aporinellus wheeleri* were studied from late May through early October 1979–1987 in a field containing small hills of gravel and shale and an abandoned gravel pit, both SE of Erie, Erie County, PA, and in a patch of gravelly soil at the edge of an active quarry E of Auburn, Cayuga County, NY. Nests in sand or gravel comprised short cylindrical burrows with terminal cells, whereas those in gravel or crushed shale were simple conical depressions. Wasps provisioned their nests with various Salticidae, predominantly immature *Pellenes borealis*, and, rarely, Thomisidae (*Xysticus* spp.).

Additional observations were made on *A. taeniolatus* nesting in bare sand behind a beach at Presque Isle State Park, Erie County, PA during July–September 1969–1978. This species constructed relatively long, cylindrical burrows with terminal cells and provisioned with *P. borealis*. Behavioral similarities between *A. wheeleri* and *A. taeniolatus* included searching for prey, paralysis, cachement, transport, position of prey in the cell, and oviposition site. Manner of burrow excavation and closure was dictated by the kind of soil in which the wasps nested. The two species often differed in these behavioral activities.

A comparison of the geographic distribution, altitude, habitat (soil type), flight period, adult external morphology, and nesting behavior of *A. wheeleri* and *A. taeniolatus* suggests that the two taxa have separate gene pools in the eastern United States.

Key Words: Nesting behavior, Pompilidae, spider wasps, *Aporinellus*, Salticidae, prey, sibling species, biosystematics

The genus *Aporinellus* contains eight species in North America. The six species in the *Fasciatus* and *Apicatus* groups are easily recognized in the male sex, using genitalic characters. Females belonging to these groups are very similar and in some cases cannot be separated reliably. Slight differences in head shapes appear to separate the females of some species in the *Fasciatus* group, but this character is difficult to use without prior experience. In the *Apicatus* group the females of some species may be separated by small differences in the lengths of antennal segments (Evans 1951, 1966).

In the *Taeniolatus* group the reverse is true. Males of *A. taeniolatus* (Dalla Torre), the correct name for *A. taeniatus* (Kohl) (A. S. Menke 1980, pers. comm., see Kurczewski and Kurczewski 1987), and *A. wheeleri* Bequaert are indistinguishable by the criteria of external morphology and terminalia. However, females of the two taxa are

separated readily in the eastern United States by body coloration, pubescence, and foretarsal comb length (Evans 1951, Kurczewski and Kurczewski 1987). In the extreme southern and western U.S. and Mexico the situation is complicated by much intraspecific variation in *A. taeniolatus*, specifically coloration of body and pubescence, width of temples, and number of comb-spines on the forebasitarsus (Evans 1951, 1966). Two and three distinct color forms of *A. taeniolatus* females have been collected at a single locality in Mexico (Evans 1966). In the eastern United States only *A. wheeleri* exhibits a black and red body with mostly rufous legs, but in the western U.S. several forms of *A. taeniolatus* demonstrate varying amounts of rufous coloration on the body and legs (Evans 1951, Wasbauer and Kimsey 1985).

Species of *Aporinellus* occur in sandy or gravelly areas, feed as adults on honeydew and flowers, and store paralyzed Salticidae, less often Oxyopidae or Thomisidae, as food for their larvae (Krombein 1979). Studies on the biology of the Nearctic species are limited. Prey records exist for *A. basalis* Banks, *A. completus* Banks, *A. medianus* Banks, *A. taeniolatus* (Dalla Torre), and *A. yucatanensis* (Cameron) (Evans 1951, 1959, Evans and Yoshimoto 1962, Krombein 1959, 1961, 1964, Kurczewski and Kurczewski 1968a, b, 1973, Peckham and Peckham 1898). Information on nesting is scant and available for only *A. basalis* (Evans 1959), *A. completus* (Krombein 1961), *A. medianus* (Peckham and Peckham 1898, Krombein 1959, Kurczewski and Kurczewski 1968a), *A. taeniolatus* (Kurczewski and Kurczewski 1973) and *A. yucatanensis* (Krombein 1959).

Nothing is known about the nesting behavior of *A. wheeleri* (Krombein 1979). Despite the relative abundance of *A. taeniolatus* (Evans 1951, 1966), little is known about its nesting behavior. Evans (1951) collected a female with the salticid *Pellenes* (*Habronattus*) *calcaratus* (Banks) near Jacksonville FL. Krombein (1964) noted cache and prey (*Pellenes* sp.) of a female near Lake Annie FL. Kurczewski and Kurczewski (1973) recorded cache, tumulus size, entrance and burrow dimensions of one nest, and prey type and prey weight ratios of two females at Weymouth, NJ. They reported a ♀ *Pellenes* (*H.*) *agilis* (Banks) and an imm. *P.* (*H.*) *viridipes* (Hentz) as prey from this locality. The following observations on the ecology, nesting behavior, and prey preference of *A. wheeleri* and *A. taeniolatus* expand considerably the amount of biological information about this genus and emphasize the ecological and behavioral differences between the two species (see Kurczewski and Kurczewski 1987). Related species of Pompilidae are often readily separated by habitat and prey type rather than specific sequencing of behavioral components (Evans and Yoshimoto 1962).

Aporinellus wheeleri Bequaert

Observations on *A. wheeleri* were made during nine field seasons: 21 July–2 Oct. 1979, 9 July–27 Sept. 1980, 15 June–14 Sept. 1981, 1 June–14 Sept. 1982, 6 July–6 Sept. 1983, 11 June–19 Sept. 1984, 19 June–20 Sept. 1985, 26 May–27 July 1986, and 28–31 July 1987, in a field containing small hills of gravel and shale in Wintergreen Gorge Cemetery, 1.6 km SE of Erie, Erie County, PA (site I), and in a large, abandoned, overgrown gravel pit containing fine and coarse gravel mixed with sand, 2.4 km SE of Erie (site II) (Figs. 1, 2), and during 4–19 Sept. 1985 in a gravelly area at the edge of an active quarry 2.3 km E of Auburn, Cayuga County, NY (site III) (Fig. 3). Approximately 50 wasps nested annually at site II during 1979–1982 in flat areas of gravel and in gravelly hills, both nearly devoid of vegetation (Fig. 2), but their numbers decreased to just a few individuals during 1984–1987.

Twelve males of *A. wheeleri* were collected in Erie County, PA during 21 July–14 Aug. 1979, 7 Sept. 1980, 21 July–3 Sept. 1981, 18–28 June 1982, 11 June–28 Aug.

Fig. 1. Habitat of *Aporinellus wheeleri* and various other species of ground-nesting Pompilidae and Sphecidae, 2.4 km SE of Erie, Erie County, PA.

Fig. 2. Nesting site of *Aporinellus wheeleri* in Erie County, PA. Females excavated and provisioned nests in the bare gravel in foreground.

Fig. 3. Nesting site of *Aporinellus wheeleri* in Cayuga County, NY. Females dug and provisioned nests in the gravel in foreground but avoided the peripheral sandy areas.

1984, 24 May–24 July 1985, and 29 May 1986 while attempting to mate with nesting females of *A. wheeleri*. The males trailed the females on the ground and in flight as the latter searched for prey and prospective nesting sites.

Females of *A. wheeleri* searched for spiders from 0950 to 1805 h (EDT) among the sparse vegetation within and at the peripheries of the nesting areas. Wasps flushed spiders from upright and decumbent vegetation and pursued them rapidly on the ground, either by running or in flight. The wasps caught and stung spiders once or a few times in rapid succession in the underside of the cephalothorax after which they cleaned and malaxated the prey. Some large prey were stung, examined, malaxated, and then stung again. Using their mandibles, the wasps then grasped the spiders by the face or pedipalps, dragged them backwards to a position on an upright plant, grass blade, dead twig, raised stone or soil ridge, and released them dorsal side upward. Most prey were placed on the leaves of low, upright plants up to 8.3 cm above ground level. One paralyzed spider was cached vertically on the side of a stone. Wasps often cleaned their antennae with the strigilis following cachement. The entire stinging-cleaning-malaxation-cachement-cleaning sequence often took less than 1 min.

One wasp was observed searching for jumping spiders in their silken retreats beneath stones. She flushed a relatively large female salticid from underneath a stone, pursued it on the pebbles, caught it, stung it in the underside of the cephalothorax, examined it with her antennae for 15 s, malaxated it, and then stung it again. She pulled it to a small *Melilotus alba* Desr. plant, placed it 2 cm above the ground, and began a burrow 67 cm away. She abandoned this burrow, rebuffed the advances of a male,

and then a few minutes later, stung a second prey and cached it similarly. She began and abandoned a second burrow. Unlike the first spider, this prey recovered from the effects of the sting in less than 15 min. The wasp repeated the process of capturing and stinging a third, fourth, and fifth salticid, each time caching the prey 2–4 cm above ground on a white sweet clover plant, and beginning and abandoning a burrow. These prey recovered rapidly from the effects of the sting, the last one taking only 2 min. This suggests that the wasp's venom became less effective with subsequent captures. All five spiders were adult females of *Pellenes* (*Habronattus*) *borealis*. They weighed (wet) 38, 54, 42, 39, and 40 mg (wasp wt. 7 mg). Why the wasp did not use these prey for provisioning nests is unknown. Perhaps she was unmated, which seems unlikely in view of the above-mentioned rebuff of a male, or the spiders were too heavy to transport to a nest. She had little difficulty in transporting them the short distances to their caches. The spiders were not used for adult feeding.

Selection of a nesting site often required 15 min and some females searched for over 30 min. In Erie County PA females sampled many gravelly and sandy areas, usually dug in gravel, but frequently abandoned such burrows. The wasps often selected tiny patches of compacted sand between gravel particles, and, although these sites were often abandoned, most females eventually dug burrows in such areas. Wasps near Auburn, NY invariably nested in gravel even though loose sand was only 50–75 cm away (Fig. 3).

Females excavating burrows used their mandibles in unison to loosen the soil and forelegs alternately to throw the loosened sand and gravel underneath and behind the abdomen. One female weighing 9 mg, when beginning to dig, pulled backward with her mandibles pebbles weighing 117–182 mg to a distance of 25 mm from the opening. Between periods of digging some wasps examined their prey by walking or flying to the cache 11 cm–5 m away, and a few females moved the spider closer to the excavation at this time. Such periodic examinations may have been related to the rather light paralysis and rapid recovery of some of the prey. Nest excavation usually took 4–28 ($\bar{x}$ = 13.8, n = 24) min except for one wasp that spent 43 min constructing a nest in gravel. Much of this time was spent in dragging various-sized pebbles backwards with the mandibles onto a crescent-shaped tumulus.

Upon finishing their burrows females exited headfirst, turned 1–3 circles in front of the opening—possibly a form of orientation—interspersed with antennal cleaning, or entered and exited 1–3 times, and then walked in a mostly straight line toward the cached prey. Such females occasionally paused and cleaned their antennae *en route* to the prey. One of 31 wasps apparently became disoriented while *en route* and alternated short, quick, circular flights with walking.

Provisioning females paused at the cache, examined the spider with their antennae, grasped it dorsal side upward with the mandibles by the face, or pedipalps in the case of one male spider, and flew to the ground. Transport to the nest then involved walking rapidly backwards in a rather straight line, interspersed with occasional turns and flights forward, in either case retaining the grasp of the prey. Some wasps released their prey one to several times on the gravel, dorsal side upward, walked to the nest, flew or walked back to the spider, and resumed transporting it toward the nest. Eventually the wasps released the spiders directly in front of the entrances, then went inside, turned around, came out headfirst, repositioned the spiders, and, using the mandibles, pulled in the prey by its spinnerets. If prey recovered from the effects of the sting while cached or during transport, they were stung again in the cephalothorax and sometimes malaxated.

One to 7 min later, females reappeared

Fig. 4. Closed nest of *Aporinellus wheeleri* showing circular mound of pebbles (center) covering entrance.

in the openings, throwing sand and gravel backwards with the forelegs which moved alternately, and tamping the soil in the burrows with the end of the abdomen. Some wasps periodically turned 180° and checked the amount of fill. After 4–15 min of closing, a female began retrieving small pebbles with her mandibles and placed these in the burrow and on the filled entrance. She intermittently cleaned her antennae, threw small pebbles or sand onto the area with the forelegs, and spent much time rearranging the surface by placing pebbles atop bare sand near the entrance. After 5.5–22 ($\bar{x}$ = 11.8, n = 28) min of such closing activity females paused, cleaned their antennae, and flew away. The resulting closure comprised a circular mound of fine gravel and pebbles, 15–30 mm in diameter (Fig. 4). Such a closure prevented the lightly paralyzed spider from escaping from the cell.

In Erie County, PA the burrow structure reflected the substrate in which the nest was built. Nests in mixed sand and gravel had cylindrical burrows, 20–28 mm ($\bar{x}$ = 25, n = 23) long, that terminated in cells 14–23 mm ($\bar{x}$ = 19, n = 23) beneath the ground surface, including cell height (Fig. 5). The entrances and burrows were 2.5–4.0 mm and 2.5–3.5 mm in diameter, respectively. Nests in gravel comprised conical depressions, 9–22 mm ($\bar{x}$ = 17, n = 40) deep (Fig. 5). Near Auburn, NY, on the other hand, nests in gravel contained cylindrical burrows, 18–26 mm ($\bar{x}$ = 22, n = 6) long, which ended in cells 15–23 mm ($\bar{x}$ = 17, n = 6) beneath the surface. Three cells were 6–7 mm wide and 10–12 mm long. In either substrate at all localities the paralyzed spider was placed in the crude cell dorsal side upward, either sideways or head toward the entrance. The eggs of *A. wheeleri* were 1.25–2.00 mm long and placed on the undersides of the spiders' abdomens near the base, perpendicular to the longitudinal axis of the body (Fig. 6), but two eggs were attached

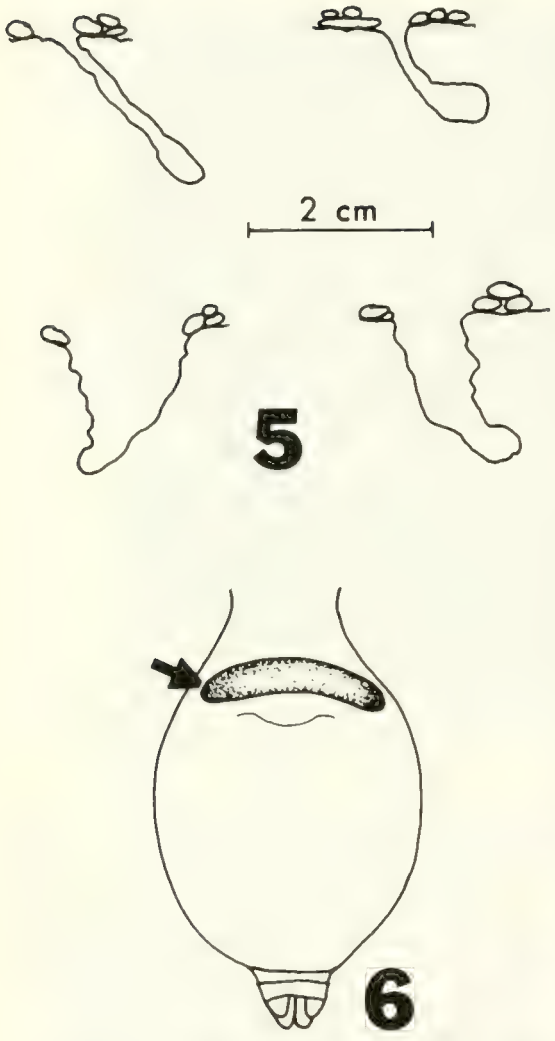

Fig. 5. Longitudinal sections of nests of *Aporinellus wheeleri* in sand (top) and gravel (bottom), as viewed from the side.

Fig. 6. Egg (arrow) of *Aporinelllus wheeleri* attached to base of abdomen of *Pellenes borealis*, ventral view.

about midway from the abdominal base, obliquely and lateroventrally.

Prey taken from provisioning females of *A. wheeleri* or their nests in Erie County, PA comprised the following species of Salticidae: *Pellenes* (*Habronattus*) *borealis*, 8 ad. ♂♂, 43 imm. ♂♂, 14 ad. ♀♀, 81 imm. ♀♀, 12 imm.; *P.* (*H.*) *decorus* (Blackwall), 4 ad. ♂♂, 5 imm. ♂♂, 3 ad. ♀♀, 10 imm. ♀♀, 3 imm.; *Eris* sp., 2 imm. ♀♀; *Tutelina elegans* (Hentz), 1 ad. ♀; *Metaphidippus protervus* (Walckenaer), 1 ad. ♂, 5 ad. ♀♀; and *Metaphidippus* sp., 1 imm. The capture of 1 ♂ *Xysticus ferox* (Hentz) (Thomisidae) is noteworthy because it is the first record of a crab spider taken as prey by this species of pompilid. Spiders taken from *A. wheeleri* cells near Auburn, NY included *P.* (*H.*) *borealis*, 3 ♀♀; *P.* (*H.*) *decorus*, 1 ♀, 1 imm. ♀; and, *X.* sp., 1 imm. Prey were larger in late summer and late spring (overwintering?) and comprised relatively more adults, and were smaller in midsummer and included a high proportion of immatures.

Many of the spiders recovered from the paralysis of the wasp's sting shortly after being removed from the cells. Wasps weighing (wet) 8–11 mg ($\bar{x}$ = 8.8, n = 5) were particularly ineffective in paralyzing larger salticid spiders weighing (wet) 22–34 mg ($\bar{x}$ = 27.0, n = 5), whereas one small wasp (7 mg) completely and permanently paralyzed an immature crab-spider weighing only 12 mg. Larger prey had to be restung periodically by the wasps to effect partial paralysis and acquiescence. The spider weighing 34 mg recovered quickly from repeated wasp stings, was placed in a vial, spun a silken retreat, and fed on a small fly introduced thereto. In several nests excavated 48 h after closure, adult spiders bearing wasp eggs were found enclosed in silken retreats and were extremely lively. Smaller, immature spiders with wasp eggs had no such surrounding retreats, were lethargic, and appeared to be partly paralyzed. The construction of silken retreats by the larger, adult spiders may be related to the ineffectiveness of the wasps' stings (relative amount of venom?), which enabled the spiders to behave normally as if not stung at all.

After feeding on the spider in the cell the wasp larva spun a cocoon of saliva, silk and sand and gravel particles (Fig. 7). Some wasps emerged by chewing through their own cocoon and then the surrounding spider retreat (Fig. 8). Two nests from Auburn,

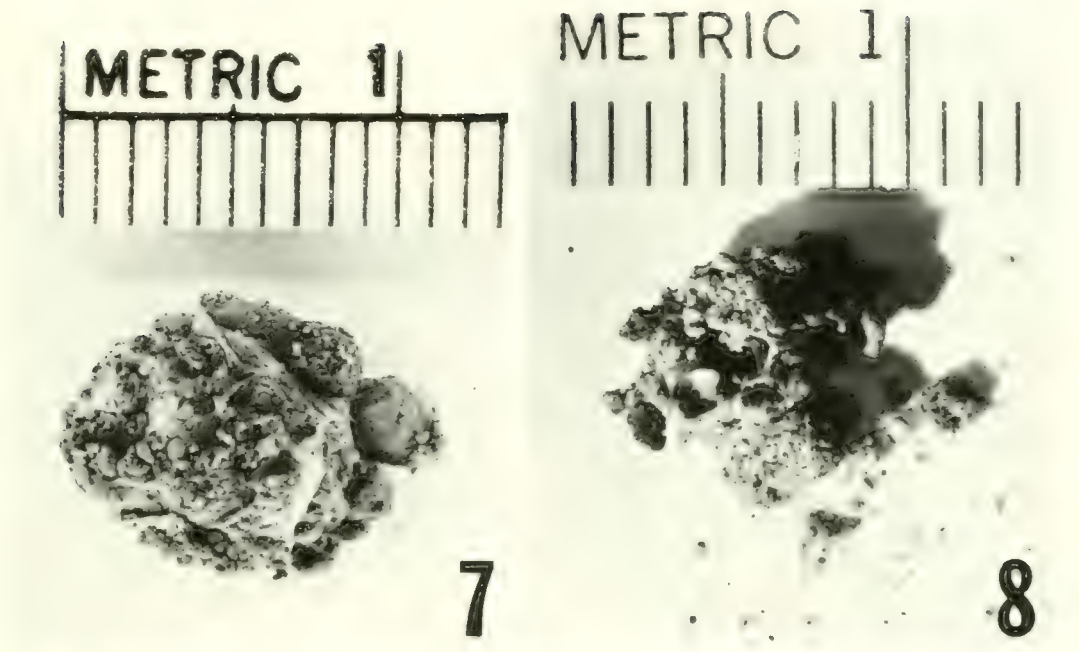

Fig. 7. Completed cocoon of *Aporinellus wheeleri* showing construction of silk, saliva and soil particles. Units are in mm.

Fig. 8. Emergence hole in cocoon of *Aporinellus wheeleri* showing inner wasp cocoon and surrounding silken spider retreat. Units are in mm.

NY provisioned on 17 Sept. 1985 and excavated on 19 Sept. 1985 gave rise to two males on 26 May 1986, leaving ample time for the production of another, mid- or late summer generation of *A. wheeleri* at this latitude.

A few provisioning females of *A. wheeleri* were trailed by females of the cleptoparasites *Sphenometopa tergata* (Coquillett) and *Hilarella hilarella* (Zetterstedt) (Sarcophagidae: Miltogramminae). The flies also pursued wasps searching for places to dig and paused nearby on raised stones or other perches during burrow construction. Despite this activity, none of the cells or prey examined contained maggots. Several spiders were stolen from the wasps' caches by workers of the ant *Formica subsericea* Say. The completed nest of one female was excavated partly by a female of *Evagetes parvus* (Cresson) (Pompilidae), but this cleptoparasite could not penetrate fully the stone-filled closure and abandoned the excavation.

Aporinellus taeniolatus (Dalla Torre)

Five females of *A. taeniolatus* were observed nesting at Presque Isle State Park, Erie County, PA on 7 July 1969, 7, 12 Sept. 1976, and 23 Aug. 1978, in bare sand behind Beach 10 (Fig. 9). These wasps searched for spiders on the sparse beach vegetation, pursued them on the sand, and captured and stung them in a manner similar to *A. wheeleri*. The paralyzed spiders were dragged backwards on the sand and cached above ground on vegetation.

The wasps sampled many areas of sand before beginning to dig. Females used the mandibles to loosen the sand crust and forelegs alternately to remove loosened sand from the burrow, backing out periodically to deposit the load in a crescent-shaped tumulus partly surrounding the entrance. Two

Fig. 9. Nesting site of *Aporinellus taeniolatus*, Beach 10, Presque Isle State Park, Erie County, PA. Females excavated and provisioned nests in the bare sand in foreground.

such tumuli were 25–45 mm long and 40–55 mm wide. One burrow took 27 min to dig. Exiting females made orientation turns on the sand near their entrances. Removal of the spider from the cache and transport of it to the nest occurred as in *A. wheeleri*.

Nests of *A. taeniolatus* comprised cylindrical burrows, 55–70 mm ($\bar{x}$ = 59, n = 5) long which terminated in roughly ovoidal cells, 44–57 mm ($\bar{x}$ = 48, n = 5) beneath the sand surface. The paralyzed spider was placed in the cell dorsal side upward and head toward the entrance. Wasp eggs were ca. 1.8 mm long and attached to the undersides of the spiders' abdomens perpendicularly near the base. Prey taken from *A. taeniolatus* nests comprised the salticid *Pellenes* (*H.*) *borealis* (2 ♀♀, 2 imm. ♀♀, 1 imm.). One spider weighed (wet) 24 mg.

Discussion

In *A. wheeleri* a black-red-black body pattern coupled with red and black legs is obviously disruptive yet highly cryptic against a gravelly substrate and reminiscent of the body coloration of *Tachysphex pechumani* Krombein which is also associated with a gravelly habitat (see Kurczewski and Elliott 1978). Aside from theories expounding cryptic or aposematic coloration, one explanation for the relatively large amount of erythrization in *A. wheeleri* is that the developing adult may be melanized less in gravelly than in sandy soil. Water percolates readily through the larger gravel particles and is not intimately bound to the wasp's cell, thus approximating soil conditions in some arid regions of the western U.S. and possibly enhancing erythrization of the adult exoskeleton. In sandy soil water adsorbs tightly to the numerous small particles and may keep the cell confines evenly humid, thus resulting in more melanization of the adult exoskeleton.

The dark pubescence exhibited by *A. wheeleri* might enhance the absorption of

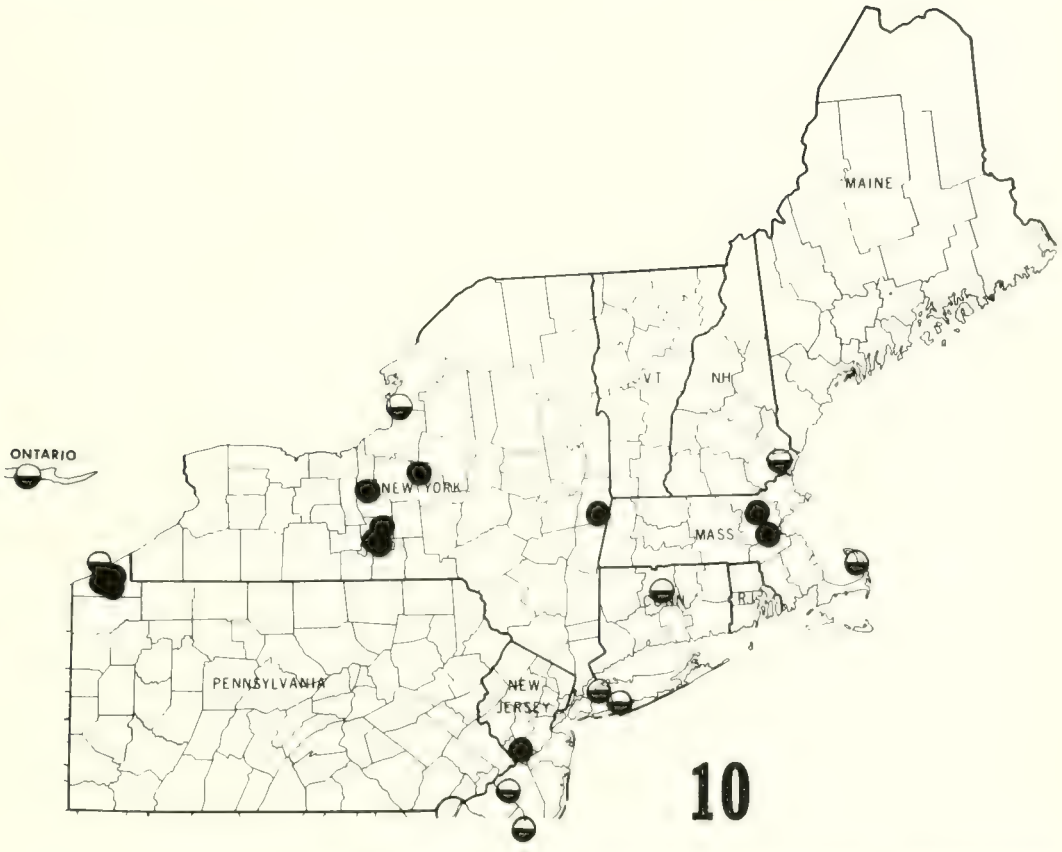

Fig. 10. Distribution of *Aporinellus taeniolatus* (◒) and *A. wheeleri* (●) in the northeastern United States and Canada.

radiant energy at higher altitudes and cooler temperatures; however, males of *A. wheeleri* have silvery pubescence which, according to G. C. Eickwort (personal communication) is genetically unusual. Some females of *A. taeniolatus* from the extreme southern U.S. and Mexico also have dark pubescence. *Aporinellus completus* Banks females show geographic variation in the amount of grey pubescence on the body with some specimens appearing essentially entirely grey and others mostly black. Females of *A. completus* from Presque Isle State Park and Erie County, PA were, however, identical in body coloration.

A. taeniolatus has a broad geographic range, occurring throughout southern Canada and the United States and extending into Mexico and Central America (Evans 1951, 1966, Krombein 1979). In the northeastern U.S. *A. taeniolatus* has a coastal distribution, whereas *A. wheeleri* exhibits an upland distribution (Fig. 10). In the Northeast, *A. taeniolatus* has been collected at altitudes ranging from near sea level (Wellfleet, MA, Bayville, NY, Manumuskin, NJ) to 580′ (Presque Isle St. Pk., PA, Long Point Prov. Pk., ONT). Altitudes for *A. wheeleri* range from ±900′ (nr. Ithaca, NY) to 1985′ (Asheville, NC), except for specimens from Bridgeport, NY, Princeton, NJ (det. K. W. Cooper), and Stonybrook Res., Middlesex Co., MA (det. J. Bequaert). In Erie County, PA, where the two taxa are virtually sympatric, *A. taeniolatus* has been collected at elevations of 575–580′ (Presque Isle St. Pk.) and *A. wheeleri*, only 9–11 km away, at elevations of 1050–1200′ (Wintergreen Gorge

Table 1. Major ecological and behavioral characteristics of females of *Aporinellus wheeleri* and *A. taeniolatus*.

Characteristic	*A. wheeleri*	*A. taeniolatus*
Flight season (PA)	May–October	June–September
Habitat (NE U.S.)	Upland gravel pits, roadways, paths	Lowland soils near bodies of water
Soil type (NE U.S.)	Gravel, loam, shale	Sand
Prey search	On plants, under stones	On plants
Sting	Underside of cephalothorax	Underside of cephalothorax
Cache	Upright plant, stone	Upright plant
Burrow excavation	Mandibles and forelegs	Mostly forelegs
Excavation time	4–43 min ($\bar{x}$ = 15.0)	27 min
Orientation form	Circles near entrance	Circles near entrance
Prey transport type	Mandibles; ground/flight	Mandibles; ground/flight
Closure type	Pile of pebbles on entrance (mandibles)	Sand fill (forelegs)
Burrow length	18–28 mm (mixed sand and gravel)	55–70 mm (sand)
Cell depth	14–23 mm (mixed sand and gravel); 9–22 mm (gravel)	44–57 mm (sand)
Prey placement	Cephalothorax toward entrance, dorsum up	Cephalothorax toward entrance, dorsum up
Oviposition site	Underside of abdomen, near base	Underside of abdomen, near base
Egg length	1.25–2.00 mm	Ca. 1.8 mm
Prey type (PA)	Mostly Salticidae (*Pellenes borealis*)	Salticidae (*Pellenes borealis*)
Prey sex or stage	♂, ♀, immature	♀, immature
Prey weight (wet)	12*–34 mg	24 mg

* Thomisidae (*Xysticus* sp., immature).

Cemetery, Four Mile Creek nr. route I-90). Although there is some overlap in altitude when one compares their ranges in the Northeast, *A. wheeleri* occurs mostly at the higher and *A. taeniolatus*, mostly at the lower elevations.

Habitat (soil type) is a better indicator of distribution of the two taxa in the eastern U.S. than altitude (Table 1). *A. taeniolatus* is restricted to mostly sandy soils near bodies of water (Fig. 9) whereas *A. wheeleri* occurs on heavier, often gravelly, soils away from water (Figs. 1–3). Bequaert's (1919) type specimen (♀) of *A. wheeleri* was collected on a "stony woodroad" in Massachusetts. Krombein (1958) reported *A. wheeleri* in association with gravelly soil in West Virginia. Near Bridgeport, Madison County, NY, an area characterized by sandy-loamy soils, one female of *A. wheeleri* was collected on a pile of gravel near the base of a utility pole connecting a power line crossing a road. This gravel was not the typical soil of the area but had been trucked in from elsewhere and dumped to support the pole. In the western U.S. and Mexico, *A. taeniolatus* inhabits gravelly as well as sandy soils (Evans 1951, 1966), thus filling the niches of both species. One can envision the evolution of *A. wheeleri* from *A. taeniolatus* in the eastern U.S. by progressively farther movements inland away from the sandy beaches near water (Great Lakes, Atlantic Ocean) to higher altitudes and gravelly soil. Such movements would obviously have been influenced by the most recent period of glaciation.

The inclusive flight periods for both taxa in Erie County, PA (*A. wheeleri*, 24 May–2 October; *A. taeniolatus*, 28 June–22 September) suggest more than one generation per year (Table 1). In New York we reared males of *A. wheeleri* in May from the previous September's nests, extending the opportunity for a second generation in mid- or late summer. Both *A. taeniolatus* and *A.*

wheeleri exhibit peak abundance in Erie County, PA and Cayuga County, NY in late summer (Aug.–Sept.), and occur only sparingly throughout June and July. Evans (1951) collected *A. taeniolatus* at East Hartford, CT from 13 June to 19 Sept. but could not ascertain the number of generations per year.

In comparing the nesting behaviors of *A. taeniolatus* and *A. wheeleri* we found essentially identical components to be the manner of prey searching, method of paralysis, cachement, transport, position of prey in the cell, oviposition site, and kind of prey, predominantly *Pellenes borealis* (Salticidae) (Table 1).

Two major behavioral activities, burrow excavation and closure, and the result thereof, nest structure, are linked to the habitat in which the wasp nests (Table 1). Thus, *A. taeniolatus* females dig and close nests in a fashion typical of sand inhabiting pompilids, i.e. they back out of the burrow while throwing sand backward with the forelegs which move alternately, and close the burrow while backing in, using the forelegs alternately along with the abdominal apex for tamping the sand into place. Females of *A. wheeleri* which nest in patches of compacted sand in gravelly soil dig their burrows similarly. However, females of *A. wheeleri* nesting in broken shale or gravel use the mandibles considerably and forelegs less frequently during burrow construction and closure. As is typical of females in the family Pompilidae, species inhabiting sand have more elaborate foretarsal digging rakes, i.e. longer spines and more of them, than species inhabiting heavier soils such as gravel, loam and clay (Evans 1950). Thus, females of *A. taeniolatus* collected on sand in the Northeast have a more extensive foretarsal rake with longer spines than females of *A. wheeleri*; however, females of *A. taeniolatus* collected in the extreme southern U.S. and Mexico on gravel have a short foretarsal rake similar to that of *A. wheeleri*.

In both taxa the architecture of the burrow reflects the soil in which the nest is excavated (Table 1). Nests of *A. taeniolatus* in loose sand comprise elongate (55–70 mm) cylindrical burrows, those of *A. wheeleri* in compacted sand and gravel, short (20–28 mm) cylindrical burrows, and those of *A. wheeleri* in gravel, short cylindrical burrows or shallow conical depressions (Fig. 5). Closed burrows of *A. taeniolatus* are indistinguishable from the surrounding sand. For *A. wheeleri* the burrow closure is clearly visible as a characteristic circular mound of small pebbles covering the filled nest entrance (Fig. 4).

In conclusion, although Evans (1951) considered *A. wheeleri* to be nothing more than a subspecies of *A. taeniatus* (= *taeniolatus*) based upon its localized geographic distribution in the Alleghenian Fauna and distinctive body coloration, the available morphological, distributional, ecological and behavioral data suggest that the two taxa have separate gene pools in the eastern United States (Kurczewski and Kurczewski 1987). *Aporinellus wheeleri* and *A. taeniolatus* are distinguished by a combination of geographic, altitudinal, soil, behavioral and morphological (♀) criteria; the two taxa are similar in their inclusive flight periods, ♂ morphology (including genitalia), prey preferences and many behavioral features. In the western U.S. and Mexico, *A. taeniolatus* inhabits heavy, somewhat gravelly, as well as sandy soil (Evans 1951, 1966), thus occurring in areas similar to those inhabited by *A. wheeleri* in the Northeast. The distinctive ecology and morphology exhibited by these two taxa in the northeastern U.S. may reflect character divergence now compounded by human disturbance.

Acknowledgments

We thank R. A. Norton, SUNY-CESF, for identifying the species of Salticidae used as prey and reviewing the manuscript, and M. S. Wasbauer, Calif. Dept. of Food and Agric., for reviewing the manuscript and addressing the biosystematics problem of the

Taeniolatus group. We appreciate the input of G. C. Eickwort, Cornell University, on the specific statuses of the two species of *Aporinellus*. We also thank R. J. Gagné and D. R. Smith, both of BBII, ARS, USDA, for determining Sarcophagidae and Formicidae, respectively. E. Tucker, Jr., Behrend College of The Pennsylvania State University, provided information on the elevations in Erie County, PA. A. F. Newton, Jr., Museum of Comparative Zoology, Harvard University, L. L. Pechuman, Cornell University, Marjorie Favreau, American Museum of Natural History, and A. S. Menke, BBII, ARS, USDA, furnished distributional data for *A. wheeleri* and *A. taeniolatus*.

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PROC. ENTOMOL. SOC. WASH.
90(3), 1988, pp. 307–309

ESTABLISHMENT OF *CYBOCEPHALUS* SP. (COLEOPTERA: NITIDULIDAE) FROM KOREA ON *UNASPIS EUONYMI* (HOMOPTERA: DIASPIDIDAE) IN THE EASTERN UNITED STATES

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Abstract.—In 1983, a species of *Cybocephalus*, tentatively identified as *C.* prob. *nipponicus* Endrody-Younga, was imported from the Republic of Korea and released on euonymus trees and shrubs infested with the euonymus scale, *Unaspis euonymi* (Comstock). The predaceous nitidulid is well established at three release sites in the metropolitan Washington, D.C. area and has reduced the scale populations on the host plants. Distribution is in progress to establish this beneficial beetle at other locations in the eastern United States.

Key Words: Biological control; armored scales; predator; Diaspididae; Nitidulidae.

In 1980 the Agricultural Research Service, United States Department of Agriculture, initiated a Small Farm Research project to study the biological control of several species of armored scale pests. Among the targeted insects was the euonymous scale, *Unaspis euonymi* (Comstock), an exotic pest of Asian origin that is devastating to many species of ornamental plants of the genus *Euonymus* (Gill et al. 1982).

Because *U. euonymi* is common in Korea, the USDA Asian Parasite Laboratory, Seoul, Republic of Korea (ROK), was assigned the task of obtaining natural enemies of the scale as a part of its research effort. Among the many biotic agents found was a species of *Cybocephalus* that preyed on all stages of the euonymus scale. We have tentatively identified this nitidulid as *C.* prob. *nipponicus* Endrody-Younga through comparison with paratypes of *C. nipponicus* in the collection of the United States National Museum of Natural History, Washington, D.C.

Species of *Cybocephalus* are important predators of diaspine scales. They may rank second to the Coccinellidae as predators of armored scales but nitidulids and their impact on scale populations have received relatively little study. However, several species have been introduced into various parts of the world for scale control (Drea 1988). Limited introductions of *Cybocephalus* spp. have been made into North America but with little success. A species of Japanese origin, referred to as *C.* probably *gibbulus* Erichson, was introduced and established in California in 1932–1933 for the control of the California red scale, *Aonidiella aurantii* (Maskell), (Rosen and DeBach 1978). Although the predator expanded its host range to include two other species of scale, it has not proven to be effective (Bumgardner 1945). In 1956–1957, a *Cybocephalus* sp. from India was introduced into California but did not become established (Rosen and DeBach 1978).

Our introductions of *C.* prob. *nipponicus* began in 1984. Three sites were selected in the metropolitan Washington area for releases of the beetle. On April 5, 1984, a total of 29 adults (24 ♀, 5 ♂), from Namhansanseong, Kyeonggi Province and Seoul, ROK, were released at the Chadwick Overlook at the National Arboretum on *Euonymus fortunei* (Turcz.) Hand.-Mazz., a shrub heavily infested with *U. euonymi*. A colony was established and living individuals were regularly collected at this site through 1986.

A second site in the National Arboretum was a grove of euonymus trees near the Administrative Center. In August, 1984, 15 adults (11 ♀, 4 ♂) from Sacheon, Kyeongsangnam Province, ROK, were released on *E. europaeus* L. heavily infested with the euonymus scale. Within several weeks the colony expanded and the beetles spread to neighboring euonymus trees, *E. hamiltonianus* var. *nikoensis* (Nakai) Blakelock and *E. kiautshovicus* Loes., also heavily infested with the scale. The scale population on the release tree had been reduced to an insignificant level by late summer, 1986, and the tree has shown increased growth.

The third release site was an unidentified euonymus tree at the USDA Beltsville Agricultural Research Center in Maryland. In May, 1984, a total of 32 adults (25 ♀, 7 ♂) were released on the tree and quickly increased in number. Individuals were recovered from the tree in 1985 and 1986.

Because a laboratory colony of the beetle was not established, it was necessary to utilize field collected insects for the releases. However, before any beetles were released, samples from the Korean material were dissected and examined for parasites, but none were found. Furthermore, Williams et al. (1984) report that there are no known parasites of adult *Cybocephalus,* although larvae of the genus are recorded as hosts of *Zeteticontus* (Encyrtidae), *Aphanogmus* (Ceraphronidae), and *Zatropis* (Pteromalidae).

Once a field colony was established, no additional releases were made with Korean specimens. Consequently, a total of 76 adults (60 ♀, 16 ♂) were liberated in the three sites of the metropolitan Washington area. Using the trees in the National Arboretum as a natural insectary, more than 4000 *Cybocephalus* adults were collected and shipped during 1985 and 1986 for release by cooperators in Pennsylvania, New Jersey, Delaware, North Carolina, and Ohio.

Blumberg and Swirski (1982) present a comprehensive study of the biologies of *C. micans* Reitter and *C. nigriceps nigriceps* (Sahlberg) that prey on diaspine scales in Israel. Our observations suggest that *C.* prob. *nipponicus* has a life cycle similar to these two nitidulid species.

At the National Arboretum the beetles had 3, and possibly 4, generations per year. The greyish-white eggs, 0.5 × 0.2 mm, were laid in or under empty scale coverings and in other protected areas. According to Blumberg and Swirski (1982), eggs of the species they studied hatched in about one week, and the larvae completed 3 instars in one or more weeks. Pupation reportedly occurs on the plant, in debris near or on the plant, or in the soil (Clausen 1956, Kartman 1946). Pupae of *C.* prob. *nipponicus* were found on leaves of the plant.

Adults of *C.* prob. *nipponicus* are small, about 1.0 mm in length, hemispherical in appearance. The female is entirely black, the male has a yellow head and pronotum. The adults can live 1 month or more depending upon the season. Overwintering beetles at the Arboretum survived at least 5 months, from November to April. During the winter beetles were active on the trees when the temperature was about 10°C.

There appears to be a degree of host specificity in species of *Cybocephalus*. Blumberg and Swirski (1974) noted a difference in the effect of the species of scale on the development of the species of *Cybocephalus*. They observed that *C. micans* preyed mainly on the nymphal stages of *A. aurantii* and other diaspine scales and that younger instars of

the predator were not able to feed on mature female scales. Our laboratory and field observations with *C.* prob. *nipponicus* indicated that the small male scales are the chief prey of the adults. More beetles were found on leaves infested with the males of *U. euonymi* than on branches where the female scales were more abundant. Microscopic examination indicated that more male than female scales were damaged by the beetles.

The sex ratio, was 1:1 determined from 756 individuals of 7 field samples, collected from May through September, 1986.

At present, *C.* prob. *nipponicus* is well established at 3 sites in the metropolitan Washington area. The beetle has had an impact on the populations of euonymus scales at these sites. The predator has increased to a level that has permitted the collection and shipment of the beetle to other states in the eastern United States. However, the population of the host at the original release sites has been reduced to a very low level, because of the predation by *C.* prob. *nipponicus* and by a coccinellid, *Chilocorus kuwanae* (Silvestri), also introduced from Korea and established at the same study sites (Drea and Carlson 1987).

Acknowledgments

We wish to thank Ho-Yeon Han and Jang-Hoon Lee, personnel of the Asian Parasite Laboratory, who assisted in the original collections in the ROK; S. G. March, U.S. National Arboretum, Washington, D.C. for assistance in locating scale populations; and L. R. Ertle and R. M. Hendrickson, Jr., Beneficial Insects Research Laboratory, Agricultural Research Service, USDA, Newark, Delaware for assistance in quarantine clearance and release of the beetle in northern areas.

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PROC. ENTOMOL. SOC. WASH.
90(3), 1988, pp. 310–322

A REVIEW OF NEARCTIC *MERISMUS* WALKER AND *TOXEUMA* WALKER (HYMENOPTERA: CHALCIDOIDEA: PTEROMALIDAE)

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Abstract.—The genus *Toxeuma* Walker, herein reported for the first time from the Nearctic region, is represented by four new species: ***aciculare*** Heydon, ***aquilonium*** Heydon, ***gerra*** Heydon, and ***inopinum*** Heydon. The specimen from which *Toxeuma gerra* is described was reported as *Merismus rufipes* Walker in the Nearctic, but this is a misidentification and the record should be eliminated. However, the Palearctic species *Merismus megapterus* Walker and *M. lasthenes* (Walker) are reported for the first time from the northern Nearctic region. A key to females of Nearctic *Toxeuma* is given.

Key Words: Chalcidoidea, Pteromalidae, *Merismus*, *Toxeuma*, Agromyzidae, Gramineae

The Palearctic species *Merismus rufipes* Walker was first reported in the Nearctic region by Burks (1979). The specimen upon which this record was based is in the collection of the U.S. National Museum of Natural History and represents an undescribed species of *Toxeuma*, a genus not previously known from North America. In this paper we report *Toxeuma* from the Nearctic for the first time and describe four new species. Additionally, we report *Merismus megapterus* Walker and *M. lasthenes* (Walker) for the first time from North America. Both species were previously thought to be restricted to the Palearctic, but the former is widespread in the Nearctic and the latter has been found in Alaska.

This paper is part of a series by the senior author reviewing the Nearctic fauna of the miscogasterine Pteromalidae (Heydon 1988a, b, Heydon and LaBerge 1988). *Toxeuma* and *Merismus* are phenetically similar genera and belong with *Cryptoprymna* Foerster in a group of miscogasterine genera characterized by the following synapomorphies: 1. The genal concavities extending around one-third of the malar distance. 2. A tendency for the female club to have a large patch of micropilosity. 3. A propodeum which is usually rather elongate (except in *Merimus megapterus*), arched front to back, and with plicae that tend to curve regularly till they converge posteriorly. The plicae in most other closely related genera are initially parallel, and then there is a sharp angle at the point where they begin to converge. *Cryptoprymna* is distinct from *Merismus* and *Toxeuma* by its loss of metallic coloration, its smooth frenum, and elongate hypopygium which extends to the tip of the gaster. *Merismus* and *Toxeuma* retain metallic coloration, a reticulate frenum, and a hypopygium extending less than three-fourths the gastral length. Nearctic *Cryptoprymna* is treated by Heydon (1988a).

The following abbreviations are used for

institutions in the text: BMNH = British Museum (Natural History), London, England; USNM = U.S. National Museum of Natural History, Washington, D.C., U.S.A.; CNC = Canadian National Collection, Ottawa, Canada; SEC = Snow Entomological Collection, University of Kansas, Lawrence, Kansas, U.S.A.; INHS = Illinois Natural History Survey, Champaign, Illinois, U.S.A. Abbreviations used in the descriptions are: LOD = lateral ocellar diameter; OOL = ocelocular line; POL = posterior ocellar line; LOL = lateral ocellar line; F = funicular segment; T = tergal segment (apparent gastral terga, excluding petiole). Body sizes are given as thoracic lengths measured from anterior of pronotal neck to posterior of propodeal nucha; the long petiole of the gaster allows so much flexion that total body length often cannot be measured accurately. Measurements given are units from a Wild 120 unit reticle at 50× and can be converted to millimeters by multiplying by 0.02.

Toxeuma Walker

Toxeuma Walker, 1833: 371, 378. Type species: *Toxeuma fusicornis* Walker. Desig. by Westwood, 1839: 68.

This genus is known from the Palearctic, Neotropical, and Australian regions and was revised in the Palearctic by Graham (1959, 1969) and Dzhanokmen (1978). The distribution of world species by regions is as follows (the generic placement of these names was not confirmed and we cite them as currently recognized without attempt at correction): Palearctic: *acilius* (Walker), *discretum* Graham, *fuscicorne* Walker, *mucronatum* Graham, *paludum* Graham, *subtruncatum* Graham; Neotropical: *aphareus* (Walker), *faceta* Girault, *orobia* (Walker); Oriental: *affinis* Ashmead, *ferrugineipes* Ashmead, *hawaiiensis* Ashmead, *nigrocyanea* Ashmead, *nubilipennis* Ashmead, *tarsata* Ashmead; Australian: *pax* Girault. To this list we add the four new Nearctic species described below.

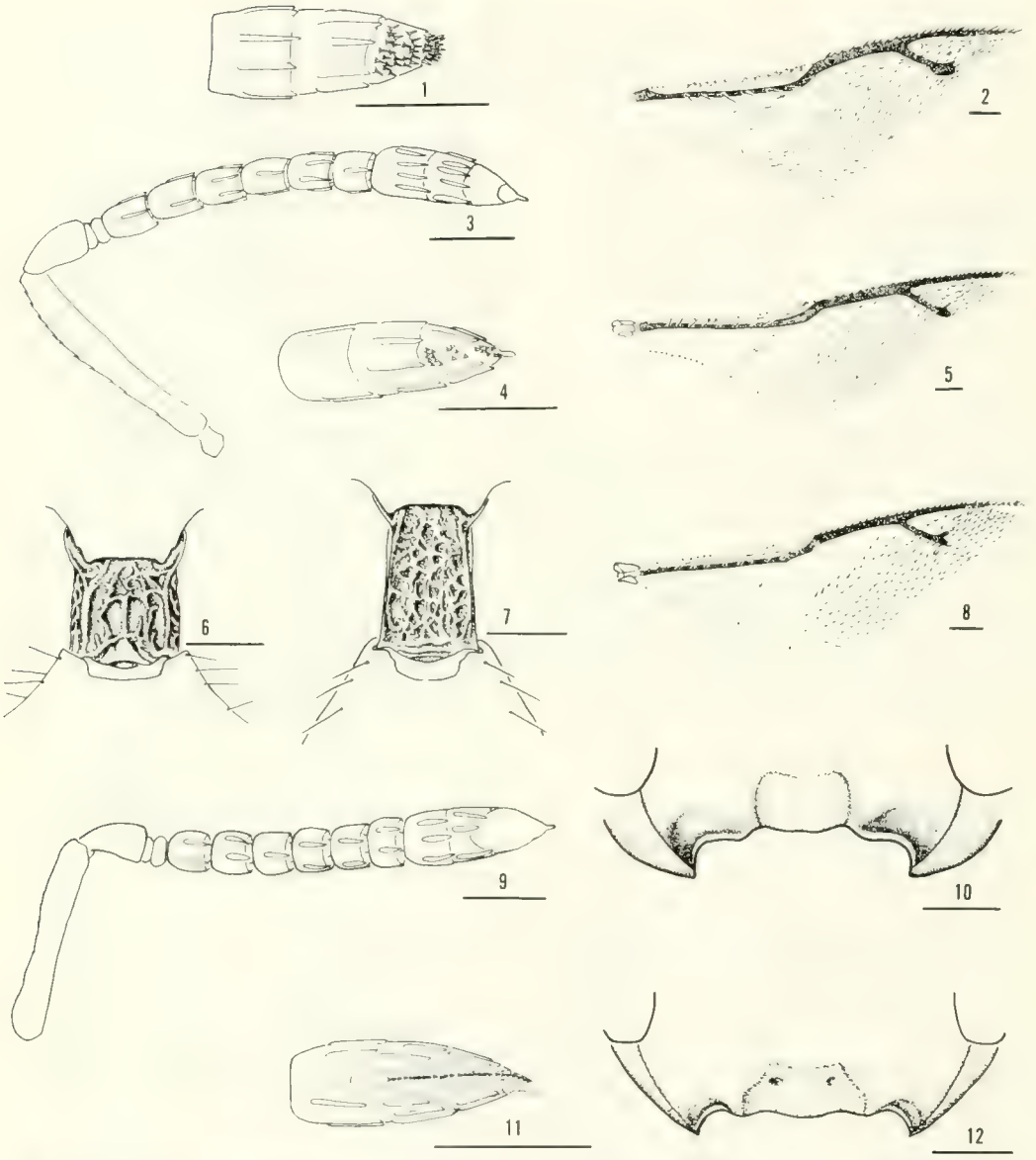
The only biological record is for *T. fuscicorne*, which was reared from seeds of *Avena* (Graham 1969); the actual insect host within the seeds is unknown.

The genus *Toxeuma* may be recognized as follows: body metallic green or blue; clypeus with anterior margin straight, lacking denticles (Figs. 10, 12); gena with distinct hollow above mandible (Fig. 10) except in *T. gerra* (Fig. 12); antennal formula 1:1:2:6:3, female club with (Fig. 11) or without large ventral patch of micropilosity and apical spine sometimes present (Figs. 4, 11); pronotum with collar with sharp anterior transverse carina; notauli complete, furrow-like; prepectus reticulate, without carinae; scutellum with 2 or 3 pairs of lateral setae, frenum set off by punctate sulcus; propodeum with median carina and plicae, usually also with weak rugae; gastral petiole reticulate, transverse to elongate, with basal flange laterally and ventrally, lateral longitudinal carinae present (Figs. 6, 7) except in *T. mucronatum*; gaster fusiform or lanceolate; T1 often nearly covering dorsum of gaster, hind margin straight mesally and laterally. Characters to differentiate *Merismus* from *Toxeuma* are listed under the former genus.

Key to Female Nearctic *Toxeuma*

The following key will separate females of the Nearctic species of *Toxeuma*. Males of *T. gerra* are unknown. Because males have a simple apical club segment (no spine or micropilosity) and vary in color and wing setation patterns, it is not possible to provide reliable characters to identify unassociated males at this time.

1. Antennal club with terminal spine (Figs. 4, 9, 11) 2
– Antennal club rounded apically, lacking terminal spine (Fig. 1) .... *aquilonium* Heydon, new species
2. Club with needle-like spine at apex (Figs. 4, 9); basal vein with 1–7 setae (rarely bare) (Figs. 5, 8); gena with distinct hollow extending ¼ to ⅓ malar length (Fig. 10) 3
– Club with conical spine at apex (Fig. 11); basal vein bare; genal hollow obscure, extending ⅓ malar length (Fig. 12) ..... *gerra* Heydon, new species



Figs. 1–12. 1–2, *Toxeuma aquilonium* n. sp., female. 1, Club. 2, Forewing. 3–6, *Toxeuma inopinum* n. sp., female. 3, Antenna. 4, Club. 5, Forewing. 6, Petiole. 7–10, *Toxeuma aciculare* n. sp., female. 7, Petiole. 8, Forewing. 9, Antenna. 10, Clypeus and lower face. 11–12, *Toxeuma gerra* n. sp., female. 11, Club. 12, Clypeus and lower face. Scale bar = 0.1 mm.

3. Funicular segments 1–3 elongate (Fig. 3); gastral petiole as long as wide (Fig. 6) . . . . . *inopinum* Heydon, new species
– Funicular segments 1–3 quadrate (Fig. 9); gastral petiole 1.5–2.0× as long as wide (Fig. 7) . . . . . *aciculare* Heydon, new species

Toxeuma aciculare Heydon, New Species
Figs. 7–10

Holotype female.—Thoracic length 0.90 mm. Body and coxae dark green except: oc-

ciput, neck of pronotum, and gastral terga after T1 darker, almost black; mandibles dark reddish brown with teeth reddish; legs beyond coxae yellow-brown, mid- and hind tarsi cream, pretarsi dark; antenna brown with basal ⅔ of scape yellow-brown; wing veins translucent brown. Head subreticulate with clypeus microalutaceous; thorax reticulate except pronotum with smooth band along hind margin (length equal to median length of collar), and frenum subreticulate; propodeum with region between plicae reticulate with some rugae, nucha subreticulate; petiole rugulose between irregular longitudinal carinae; gastral terga smooth. Head ovate in anterior view, 1.2× as wide as high (29.5:25), 2.0× as wide as long (29.5:15); occiput moderately concave; clypeus with anterior margin produced, anterior tentorial pits obscure; anterior margins of face laterad of clypeus produced (Fig. 10); gena with hollow extending almost ⅓ malar length (1.5:5.5); toruli 1 diameter above lower eye margin (2:2); intermalar distance 3.1× malar length (17:5.5); eye height 2.7× malar length (15:5.5); ratio of LOD:OOL:POL:LOL as 3:4:7:4; antenna with pedicel plus flagellum 1.0× head width (30:29.5), ratio of lengths of scape : pedicel : annelli 1 + 2 : funicular segments 1–6 : club as 13:4:1:2.5:2.5:2.5:3:2.5:2.5:8.5, funicular segments 1 and 6 both 0.91× as long as wide (2.5:2.75) (Fig. 9), apical segment of club with subterminal needle-like spine and patch of micropilosity ventrally, ratio of ventral lengths of basal : second club segments 1.25 (2.5:2). Thorax with propodeum shorter than scutellum (11:14), nucha set-off by low carina anteriorly. Forewing with ratio of submarginal : marginal : postmarginal : stigmal veins as 38:15:12:7; basal vein with 2 setae on right wing and 1 on left; basal cell bare; costal cell with 1 complete ventral row of setae (Fig. 8). Petiole 1.8× as long as wide (9:5) (Fig. 7), median and sublateral carinae weakly developed. Gaster ovate, 1.6× as long as wide (32:20), basal tergum 0.75× median length (24:32), a row of 3 setae distal to each posterolateral corner of basal fovea; T3–6 retracted beneath T2.

Allotype male.—Thoracic length 0.90 mm. Similar to female except generally light green; thorax with strong golden reflections; mid- and hind femora darkly pigmented over most of length, mid-tibia with dark band on basal third; antenna with pedicel plus flagellum 1.2× head width (35:28), ratio scape : pedicel : annelli 1 + 2 : funicular segments 1–6 : club as 11:4:1:3.5:3.5:3.5:3.5:3:3:10, funicular segments decreasing from longer than wide (F1 1.4× as long as wide, 3.5:2.5) to as wide as long (F6 3:3); ratio of gaster length : width as 26:16, T1 0.80× median length (20:25).

Type material.—Holotype ♀, Illinois, Champaign Co., Champaign (from railroad siding at the end of Gerty Street on the South Farms of the University of Illinois), 26-V-1985, S. L. Heydon. Allotype ♂, 2 ♀ and 17 ♂ paratypes with same data. Additional 24 paratypes as follows.—CANADA: *New Brunswick:* Fredricton (Acadia Field Station), 13-VII-1970, 1 ♀: Kouchibouguac National Park, 5-VIII-1977, 2 ♀; 16-VII-1977, 2 ♂. *Ontario:* Innisville, 16-VII-1963, 2 ♀, 18-VII-1962, 1 ♀. *Quebec:* Cap Rouge, 4-VII-1956, 1 ♀; 7-VII-1953, 1 ♀. UNITED STATES: *Illinois:* same data as holotype except 19-V-1985, 2 ♀, 1 ♂; 8-VI-1985, 4 ♀, 1 ♂; 19-VI-1985, 3 ♀; 21-VI-1985, 1 ♂; 22-VI-1985, 5 ♀; 24-VI-1985, 1 ♀; 21-VIII-1981, 1 ♀. *Michigan,* Iron Co., 27-VIII-1952, 1 ♀. Holotype female, allotype male, and paratypes in USNM. Additional paratypes in BMNH, CNC, and INHS.

Etymology.—The species name is derived from the Latin *acicularis*—like a needle—referring to the needle-like process on the tip of the female antenna.

Variation.—In females, the body varies from green to dark green to blue-green. The topotypic females nearly all have dark green bodies, only a couple being more blue-green. However, about half the females from Canada are blue-green. The scape varies from completely pale to brownish with a trace of

metallic coloration over the apical half. Femora are always pale. The thoracic length varies between 0.62 and 0.90 mm. The basal funicular segments are rarely slightly longer than wide (2.5:2) but F3 is always quadrate. The petiole varies from 1.4× to 2.0× as long as wide ($\bar{x}$ = 1.56, n = 10). One specimen does not have gastral terga 3–6 retracted beneath T1 and T2. In males, which were all collected from the type-locality, the dark bands on the femora and tibiae may be strongly or only faintly developed, the scape may be entirely dark or pale, the gold reflections of the thorax may not be visible and there may be some setae in the basal cell. The thoracic length varies between 0.70 and 0.86 mm. In most specimens, all funicular segments are longer than wide. In both sexes, the number of setae on the basal vein varies from 0–5 but 84% of female wings examined had between 1 and 3 setae (n = 20).

Discussion.—*Toxeuma aciculare* closely resembles *inopinum* in having the nucha set off anteriorly by a fine carina and having a small area of micropilosity ventrally and needle-like subterminal spine on the apical club segment of the female antenna. These species are readily separated by characters given in the key and also because *aciculare* almost never has setae in the basal cell while *inopinum* almost always does. The eye height is generally more than 2.5× the malar length in *aciculare* while the eye height is less than this in *inopinum*. The scape of *T. aquilonium* is always strongly metallic, and though the scape of *T. aciculare* is rarely brown for half its length, even then, it has only a trace of metallic coloration. The Palearctic species, *T. mucronatum* Graham has a terminal spine on the antennal club, but differs from all such Nearctic *Toxeuma* species in having no rugae on the propodeum, and the petiole uniformly cylindrical and reticulate. In Nearctic *Toxeuma* species, the petiole always has a pair of distinct lateral carinae and it usually has rugae dorsally.

Toxeuma aquilonium Heydon, New Species

Figs. 1–2

Holotype female.—Thoracic length 1.0 mm. Body and coxae blue-green except: frons and discs of mesoscutum and scutellum which are green, occiput and neck of pronotum dark; mandible yellowish brown; legs yellow with fore and hind tibiae with brown bands basally, pretarsi brown; antenna brown with scape metallic blue-green; wing veins translucent brown; setae of body reddish brown. Sculpture similar to *T. aciculare* except face and frenum alutaceous. Head 1.2× as wide as high (28:22.5), 2.0× as wide as long (28:14); clypeus with anterior margin truncate, tentorial pits obscure; anterior margin of face laterad of clypeus not produced; genal hollow extending ⅕ malar length (1:5); toruli a little over 1 diameter above lower eye margin (2:1.5); intermalar distance 3.2× malar length (17:5); eye height 2.7× malar length (14.5:5); ratio of LOD: OOL:POL:LOL as 2.5:3.75:6.25:3; antenna with pedicel plus flagellum 1.1× head width (30.5:28), ratio of lengths of scape : pedicel : annelli 1 + 2 : funicular segments 1–6 : club as 13.5:4:1:2.5:3:3:3:3:2.5:8.5, F1 1.1× as long as wide (2.5:2.25), F6 0.71× as long as wide (2.5:3.5), apical segment of club without spine but with patch of micropilosity on ventral surface, ratio of ventral lengths of basal : second club segments 1.7 (5:3) (Fig. 1). Thorax having propodeum almost as long as scutellum (11:12), costulae distinct, nucha acarinate anteriorly. Forewing with ratio of submarginal : marginal : postmarginal : stigmal veins as 27:16:15:8, basal vein with 3 setae on left wing and 5 on right, basal cell with 2 setae, costal cell with 1 complete row of setae and partial second row apically (Fig. 2). Petiole 1.5× as long as wide (6:4), with complete median carina, a pair of lateral carinae basally which converge with the median carina basally, and a pair of short sublateral carinae apically. Gaster fusiliform, 1.7× as long as wide

(32.5:19), T1 extending 0.6× median length, 2 setae present distal to each posterolateral corner of basal fovea, all terga visible, T2–6 with 1 transverse row of setae.

Allotype male.—Thoracic length 0.94 mm. Body blue. Sculpture similar to female. Antenna with pedicel plus flagellum 1.2× head width (35:28), ratio of scape : pedicel : annelli 1 + 2 : funicular segments 1–6: club as 11:4:1:4:3.5:3.5:3.5:3.75:3.5:3.25:9, all funicular segments elongate (F1 1.6× as long as wide (4:2.5), F6 1.3× as long as wide (3.25:2.5); basal vein with 2 complete but irregular rows of setae.

Type material.—Holotype female, Alaska, Matanuska Susitna Borough, Matanuska, 12-15-VII-1945, J. C. Chamberlin (Soil emergence cage 118–119, series II, Lot No. 45-19986). Allotype and 1 paratype male same locality, 20-VI-1945, A. Linn (with thrips swept from grass; Lot No. 45-19986). Additional 23 paratypes as follows.—CANADA. *Alberta:* Bilby, 1-VI-1924, 1 ♀. *British Columbia:* Hixon, 11-29-VII-1965, 7 ♀; Kaslo, 1943, 1 ♀. *Ontario:* Ottawa, 27-VI-1982, 1 ♀, 1 ♂; One Sided Lake, 16-VII-1960, 1 ♀. *Quebec:* Laniel, 14-VI-1942, 1 ♀; 8-VII-1944, 1 ♀. *Saskatchewan:* White Fox, 7-VII-1944, 1 ♀. UNITED STATES *Alaska:* Kenai-Cook Inlet, Kenai Peninsula, 1 mi. S Jct. Hwy. #4 and Homer Road, 30-VI-1957, F. W. Preston, 5 ♂. *Colorado:* Doolittle Ranch (Near Mt. Evans), 23-VIII-1961, 1 ♀. *New Mexico:* Lincoln National Forest, 26-30-VII-1977, 3 ♀, 2 ♂. Holotype, allotype, and paratypes in USNM. Additional paratypes in CNC, INHS, and SEC.

Etymology.—The species name is derived from the Latin *aquilonium,* meaning northerly.

Variation.—The females from Kaslo, British Columbia; Colorado; and Saskatchewan lack the dark bands on the legs, but still have the scape nearly totally metallic. The number of setae in the basal cell varies between 0 and 6, with 17 of 23 wings having at least 1 and 10 having at least 2. The petiole varies from as long as wide to 1.4 times as long as wide ($\bar{x}$ = 1.24, n = 10). The amount of telescoping of the gastral terga depends on the method of drying. Most terga are retracted beneath T1 in air-dried specimens. The allotype male has a quadrate petiole while the other male paratypes have elongate petioles. The other male from Matanuska has broken antennae and therefore was not selected as the allotype.

Discussion.—Females of *aquilonium* are distinct from those of the other three Nearctic species of *Toxeuma* because they lack the apical spine on the clava. Males and females resemble *inopinum* in the pattern of wing setae and closely resemble those *inopinum* from western Canada in color pattern. However, in *aquilonium* the petiole averages longer than wide and the basal flagellar segments are usually transverse or quadrate, whereas the petiole in *inopinum* is as long as wide and the funicular segments are always elongate. The scape is nearly wholly metallic throughout the range of *aquilonium,* while outside western Canada and montane western U.S.A., the scape of *inopinum* is light over at least the basal third. *Toxeuma inopinum* also has setae in the basal cell, but in this species the setae are almost invariably inserted adjacent to those on the basal vein while in *aquilonium* the setae are often inserted at some distance from the basal vein. *Toxeuma aquilonium* would key out to *subtruncatum* in Graham (1969) but differs from this species in having the sides of the pronotal collar distinctly convergent anteriorly in dorsal view.

Toxeuma gerra Heydon, New Species
Figs. 11–12

Merismus rufipes, Burks, 1979: 789; *nec* Walker, 1833: 378. (Misidentification)

Holotype female.—Thoracic length 0.79 mm. Body and coxae blue-green except: occiput and neck of pronotum dark blue, mesoscutum and scutellum green; mandible brown; legs yellow, pretarsi brown; wing

veins translucent brown. Sculpture like *T. aciculare* except face and frenum alutaceous and gastral tergum 7 microalutaceous. Head 1.1× as wide as high (21:19), 1.8× as wide as long (19:12); clypeus with anterior margin produced medially, anterior tentorial pits distinct (Fig. 12); genal hollow narrow, extending 0.14× malar length (1:7) (Fig. 12); face with subantennal tubercle ventrally curving abruptly to meet dorsal edge of clypeus; toruli 1 diameter above lower eye margin (2:2); intermalar distance 3.0× malar length (15:5); eye 2.2× malar length (11.5); ratio of LOD:OOL:POL:LOL as 1.5:4:6:3; antenna with pedicel plus flagellum 1.1× head width (24:21), ratio of lengths of scape : pedicel : annelli 1 + 2 : funicular segments 1–6 : club as 10:3.5:1:2:2:2:2:2:2:8, F1 1.1× as long as wide (2:1.75) and F6 0.8× as long as wide (2:2.5), ratio of flagellar length to head width 1.1 (24:21); apical segment of club with conical terminal spine and ventral patch of micropilosity extending more than halfway to club base, sutures between the club segments strongly oblique (ratio of ventral lengths of second : basal club segments 0.5 (1:2) although dorsal lengths subequal (4:4) (Fig. 11)). Thorax with propodeum shorter than scutellum (7:10), with plicae and medina carina complete and distinct and with irregular rugae posteriorly, basal fovae smooth and bordered on all sides by carinae, spiracular sulci shallow, nucha collar-like, transversely rugulose with traces of carina anteriorly. Forewing with ratio of submarginal : marginal : postmarginal : stigmal veins as 24:13:8:5, basal cell and vein bare, costal cell with single complete row of setae ventrally. Petiole 1.3× as long as wide (6:4.5), median and sublateral carinae present anteriorly. Gaster ovate; 2.1× as long as wide (29:14); T1 extending 0.75× median length, 2 setae present distal to each posterolateral corner of basal fovea; only posterior margin of T2 and all of T7 visible.

Male.—Unknown.

Type material.—Holotype female, Virginia, Montgomery Co., 21-VIII-1973, J. M. Beisler (on sedge). One additional paratype female from Nova Scotia, Bridgetown, 17-VIII-1912. Holotype in USNM, paratype in CNC.

Etymology.—The name is from the Latin *gerra*—trifle—referring to the smallness and rareness of this species.

Discussion.—Females of *gerra* have a terminal spine and patch of micropilosity on the club like those of *aciculare* and *inopinum* but the terminal spine is conical not lanceolate and the patch of micropilosity extends more than halfway to the base of the club (Fig. 11). In females of *aciculare* and *inopinum* the patch extends less than halfway to base of the club (Figs. 4, 9). Unique characteristics of females, and possibly males, of this species are the lack of setae on the basal cell and basal vein, the distinct anterior tentorial pits, and narrow genal hollows which extend only 1/7 genal length.

Toxeuma inopinum Heydon, New Species
Figs. 3–6

Holotype female.—Thoracic length 0.88 mm. Head with face blue-green, frons green, vertex from lateral ocellus and occiput dark blue; thorax with pronotum black except smooth posterior hind margin dark yellow-green, remainder, including coxae, blue-green, propodeum with yellowish reflections; gastral petiole dark blue-green, gaster blue-green with yellowish reflections; mandibles yellow-brown with teeth brownish; legs beyond coxae yellow except pretarsi black and mid- and hind tarsi cream; antenna with scape yellow, remainder dark brown; wing veins pale brown. Sculpture similar to *aciculare;* T2–7 coriarious except for smooth band along hind margin. Head ovate in anterior view, 1.2× as wide as high (29:23.5), 1.9× as wide as long (29:15); occiput concave; clypeus with anterior margin produced, anterior tentorial pits obscure; anterior margins of face just laterad of clyp-

eus not produced; gena with hollow extending ⅓ malar length (2:6); toruli 1 diameter above lower eye margin (2:2); intermalar distance 3.0× malar length (18:6); eye height 2.3× malar length (14:6); ratio of LOD: OOL:POL:LOL as 2:5:7.5:3.5; antenna with pedicel plus flagellum 1.1× head width (31.5:29), ratio of lengths of scape : pedicel : annelli 1 + 2 : funicular segments 1–6 : club as 14:4:1.5:3:3:3:2.5:2.5:2.5:9.5, F1 1.5× as long as wide (3:2), F6 0.83× as long as wide (2.5:3) (Fig. 3), apical segment of club with subterminal needle-like spine and patch of micropilosity ventrally (Fig. 4), club sutures perpendicular, ratio of ventral lengths of basal : second club segments 1.8 (3.5:2). Thorax with smooth strip along hind margin of pronotal collar extending just over halfway to anterior transverse carina; propodeum as long as scutellum (13:13), nucha bordered anteriorly by fine but sharp carina. Forewing (Fig. 5) with ratio of submarginal : marginal : postmarginal : stigmal veins as 29: 17:13:8; basal vein with 3 setae; basal cell with setae near basal vein—2 on right wing, 1 on left; costal cell with 1 complete ventral row of setae. Gastral petiole 1.0× as long as wide (5.5:5.5) (Fig. 6), median and sublateral carinae weakly developed; gaster ovate, 1.5× as long as wide (34:22); T1 extending 0.5× median length of gaster (17: 34), slightly produced medially, 2 setae present distal to each posterolateral corner of basal fovae; all terga visible dorsally (specimen prepared in critical point dryer so less telescoping of gastral terga relative to that in air-dried specimens).

Allotype male.—Thoracic length 0.80 mm. Similar to female except face and mesoscutum green, pedicel and flagellum pale brown; antenna with pedicel plus flagellum 1.4× head width (35:25), ratio scape : pedicel : annelli 1 + 2 : funicular segments 1–6; club as 12:3.5:1:4:4:3.5:3.5:3.5:3.5:10, F1 2.0× as long as wide (4:2), F6 1.8× as long (3.5:2); gaster 1.7× as long as wide (29: 17.5), T1 0.55× median length of gaster (16: 29).

Type material.—Holotype female, Oregon, Benton Co., Mary's Peak (near Corvallis), 15-VIII-1984, M. E. Schauff, E. E. Grissell, roadside meadow. Allotype male and 32 female and 1 male paratypes with same data. Fifteen additional paratypes as follows.—CANADA: *Alberta:* Lethbridge, 26-VI-1956, 1 ♀; McMurray 8-VIII-1943, 1 ♀; 30-VII-1953, 3 ♀. *British Columbia,* Hatzic Lake, 22-20-VII-1953, 4 ♀; Mission City, 26-VII-1953, 1 ♀. *New York:* Whiteface Mountain, 19-VII-1962, 1 ♀, 1 ♂. *New Mexico:* Lincoln National Forest, 28-VII-1977, 1 ♀. *Utah:* Cache Co., Logan, 7-XI-1954 (alfalfa), 1 ♀; *Washington:* San Juan Island Co., Carter's Point on San Juan Island, 23-VII-1944, 1 ♀. Holotype, allotype, and paratypes in USNM. Additional paratypes in BMNH, CNC, and INHS.

Etymology.—The species name is derived from the Latin *inopinus*—unexpected, unlooked for—referring to the discovery of this species after several drafts of this paper had been completed.

Variation.—In females, body color varies from a basic dark blue to dull green with yellowish tints; the scape is sometimes darker in the apical fifth. Females from Alberta, British Columbia, Washington, and Utah have the scape metallic over most of its length, and dark bands on the femora like female *T. aquilonium.* The thoracic length varies between 0.82–0.96 mm. The basal vein has 2–7 setae with 15 of 20 wings examined having 4–6. The basal cell has 0–5 setae with 11 of 20 wings examined having 2 or 3. Generally, in those individuals having 4 or more setae along the basal vein, there is a partial row of setae apically in the cubital cell. The male paratype is a little paler than the allotype and it has strong yellow reflections on the propodeum and gaster.

Discussion.—Females of this species closely resemble those of *aciculare* in structure of club and both sexes in structure of the nucha but can be distinguished by the characters given in the discussion section of

the latter species. Specimens of *inopinum* from western Canada and montane western United States resemble *aquilonium* closely in color. Additional characters to separate these two species are given in the discussion section for the latter species. *Toxeuma inopinum* is unique in generally having the smooth strip along the hind margin of the collar narrow, extending medially only a little more than halfway to the anterior carina.

Merismus Walker

Merismus Walker, 1833: 371, 375. Type species: *Merismus rufipes* Walker. Desig. by Westwood, 1839: 68.

Kentema Delucchi, 1953: 218. Type species: "*Lamprotatus ovatum* Walker" (= *Miscogaster ovata* Walker). Orig. Desig.

Stylomerismus Graham, 1969: 171. Type species: *Merismus* (*Stylomerismus*) *rufipes* Walker. Orig. Desig. **New Synonymy.**

Kentema Delucchi was synonymized with *Merismus* by Graham, 1956. The subgenus *Stylomerismus* was created by Graham (1969) to characterize members of the group of species to which *rufipes* belongs, but unfortunately *rufipes* is the type of the genus (and thus subgenus) *Merismus*. Therefore the name *Stylomerismus* is invalid. Boucek (*in litt.*) pointed out to us that *Kentema* would be the valid subgeneric name if one were used, but we believe it is sufficient to recognize the two species-groups proposed by Graham.

With the findings of this paper, the genus *Merismus* is now represented by the following world species (the generic placement of these names is not confirmed and we cite them as they are currently recognized without attempt at correction): Holarctic: *lasthenes* (Walker), *megapterus* Walker; Palearctic: *nitidus* (Walker), *rufipes* Walker, *splendens* Graham; Australian: *scutellaris* Dodd and Girault, *squamosus* Girault. Revisions of Palearctic species have been written by Graham (1969), Hedqvist (1974) and Dzhanokmen (1978).

Host records are known only for two Palearctic species, both reared from Agromyzidae: *M. splendens* from *Agromyza albipennis* Meigen (Graham 1969) and *M. megapterus* from *Cerodontha* (*Poemyza*) *pygmaea* (Meigen) (Graham 1969), *C.* (*P.*) *incisa* (Meigen) (Graham 1969), *C.* (*P.*) *pygmaea* on *Deschampsia caespitosa* (Hansson, 1987), and *Cerodontha* (*Dizigomyza*) *ireos* Robineau-Devoidy on *Iris pseudacorus* (Hansson 1987). The U.S. National Museum of Natural History houses specimens of *rufipes* reared from "wheat stubble" in France.

Merismus differs from *Toxeuma* in having 3 asymmetrically arranged anterior denticles on the clypeus (Fig. 14); female club with a linear patch of micropilosity (Figs. 19–20); notauli sometimes shallow posteriorly; prepectus smooth, with oblique carina delimiting posterior triangular area; propodeum with median carina and plicae less well developed, usually more rugose; gastral petiole sometimes also with dorsal basal flange (Fig. 20), well developed lateral longitudinal carina absent (Figs. 20, 22); T1 never nearly covering dorsum of gaster.

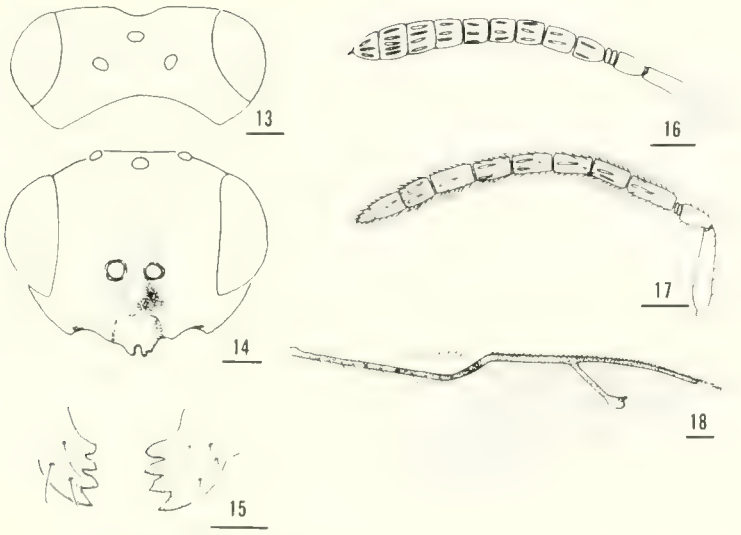
Merismus lasthenes (Walker)

Figs. 13–20

Sphegigaster Lasthenes Walker, 1848: 108, 165–166, ♀. Lectotype, BMNH, examined.

This species was described apparently from one female collected in England and now housed in the British Museum. The only other known specimen of this species was reported by Graham (1969) as a female collected in Scotland. We have discovered a series of 4 female and 7 male specimens collected 30 miles north of Fairbanks, Alaska, 30-VII-13-VIII-1984, by S. and J. Peck from a mixed birchwood forest. These are in the collection of the CNC (except 1 ♀, 2 ♂, USNM).

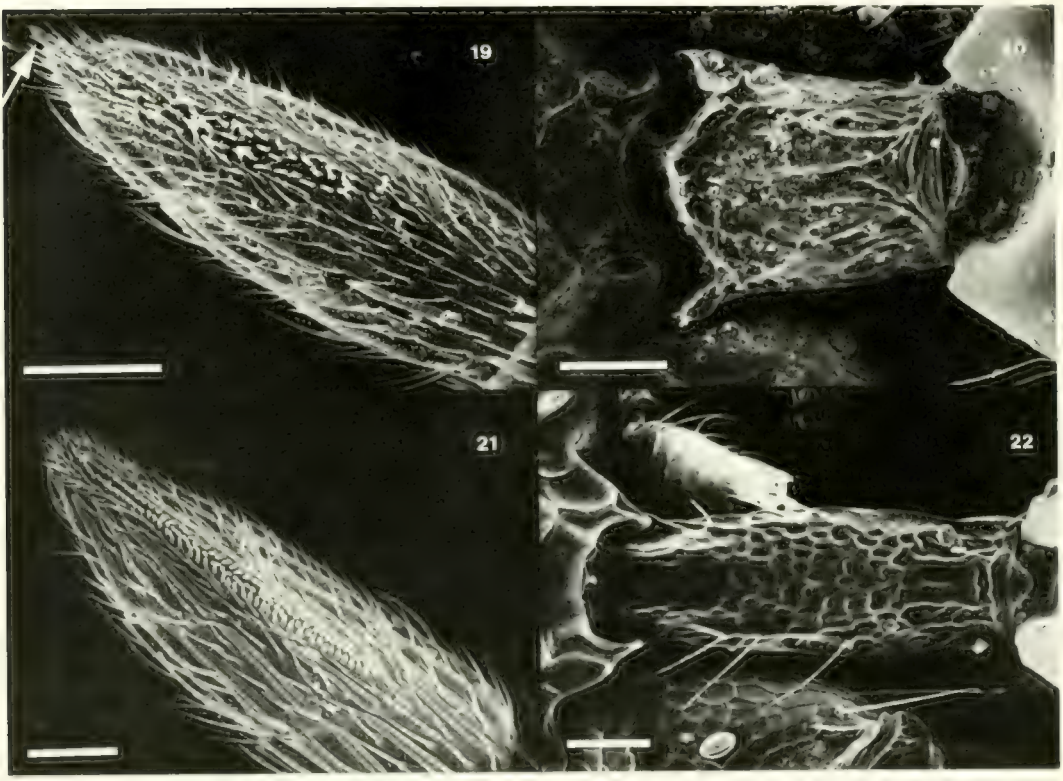
Although it seems unlikely that the Alas-



Figs. 13–18. *Merismus lasthenes*. 13, Head, dorsal view, female. 14, Head, anterior view, female. 15, Mandibles, dorsal view, female. 16, Antenna, lateral view, female. 17, Antenna, lateral view, male. 18, Forewing, dorsal view, female. Scale bar = 0.1 mm.

kan specimens would be the same species as the apparently rare British *lasthenes*, we have been unable to find any morphological structures to distinguish the specimens. Measurements as well as superposition of drawings and specimens have given no indication that more than one species is involved. Because the male of this species has never been described and we now can contribute some information on variation in females, we take this opportunity to redescribe the species as follows (the main descriptive sections are based upon the Alaskan specimens; measurements, ratios, and differences for the lectotype female are given in brackets):

Female.—Thoracic length 0.9–1.0 mm [0.9]. Body and coxae blackish metallic green; smoky yellow [to orange] are: basal ¾ of scape, tibiae, and tarsi 1–4; mandibles mahogany; wing veins dark brown. Reticulate sculpture fairly uniform on head, thorax, and coxae; gastral petiole faintly reticulate (compared to thorax) and with irregular wrinkles; smooth are: clypeus, posterior margin of pronotum, prepectus, upper mesepimeron, metapleuron, lateral sides of propodeum, dorsellum, and dorsum of nucha; propodeum with irregular median and lateral carinae [no distinct median carina] in addition to reticulation; gastral terga alutaceous. Head in anterior view with interocular distance 1.3–1.4× eye height [1.3], in dorsal view 2.1–2.2× [2.2] as long as broad, temples converging only slightly and about ⅓ length of eye (Fig. 13), POL 1.3–1.7× length of OOL [1.3], genal hollow *ca.* ¼ distance to eye, clypeal apex as in Fig. 14, both mandibles with 4 teeth (Fig. 15), scape barely reaching ventral margin of midocellus, antennal proportions as in Fig. 16, club with ventral area of micropilosity and rows of sensillae on last 2 segments [unknown for lectotype because antenna glued flat to card], apex of club with spine (Fig. 19, arrow). Notauli weakly delimited over posterior third, frenum evenly sculptured much like rest of scutellum, propodeum ⅔ length of scutellum. Forewing (Fig. 18) with marginal vein 0.9–1.1× postmarginal [0.9], apical margin of costal cell with complete setal row on ventral surface but dorsal surface with setal row only in distal half, ventrally also are a few scattered setae distally, basal vein



Figs. 19–22. 19–20, *Merismus lasthenes*, scanning electron micrographs. 19, Club of antenna, ventral view, female (arrow points to apical spine). 20, Gastral petiole, dorsal view, male. 21–22, *Merismus megapterus*, scanning electron micrographs. 21, Club of antenna, ventral view, female. 20, Gastral petiole, dorsal view, male. Scale bar = 0.05 mm.

setose, basal cell with 0 to 1 seta, cubital vein with basal ⅔ bare and 3 or 4 setae distally, speculum open below, wing surface evenly setose from speculum to apex. Gastral petiole 1.0–1.2× as long as wide [1.0], flanged dorsally, slightly shorter than propodeum; gaster ovate in outline, 1.4–1.7× longer than wide [1.5], T1 *ca.* ¼ length of gaster and 0.5–0.7× as long as wide [0.7], T2–7 subequal in length.

Male.—Generally similar to female except as follows: thoracic length 0.8–0.9 mm; legs except for coxae entirely straw-yellow; interocular distance 1.2–1.5× eye height; POL 1.5–1.8× OOL; antennal proportions as in Fig. 17, no area of micropilosity on venter of club, club without spine at tip but last segment conical and sharply pointed; marginal vein 0.8–1.0× postmarginal vein, 0 to 4 setae in basal cell; propodeum varies from nearly completely reticulate with faint rugulosity, to irregularly rugulose with interrupted median carina as in Alaska females, to irregularly rugulose with no median carina as in lectotype female; gastral petiole 1.1–1.5× as long as broad (Fig. 20), carinate dorsally on distal half; gaster 1.7–3.0× longer than wide, tending to telescope greatly, T1 *ca.* ⅓ length of gaster and 0.7–0.8× as long as wide, T2–7 subequal in length.

Discussion.—Based upon Graham's 1969 key to European *Merismus* and an examination of *rufipes* Walker (lectotype ♀, BMNH), *lasthenes* (Walker) (lectotype ♀, BMNH), and *nitidus* (Walker) (paralecto-

type ♂, 2 additional ♀ and 2 ♂, England, BMNH), *lasthenes* may be separated from other species in the *rufipes* species-group by the 4-toothed mandibles (left 3, right 4 in other species) and the short gastral petiole (1.0 to 1.5× as long as wide and shorter than the propodeum, versus 1.5 to 2.0× as long as wide and equal to the propodeum in other species).

In the Nearctic region, *lasthenes* may be distinguished from *megapterus* by the species-group characters, namely *lasthenes* with gastral petiole flanged (Fig. 20; absent in *megapterus*, Fig. 22), notauli superficial posteriorly (complete in *megapterus*), scutellar frenum evenly reticulate (longitudinally wrinkled with smooth interspaces in *megapterus*), and female with spine on apical tip of club (Fig. 19; absent in *megapterus*, Fig. 21).

Merismus megapterus Walker
Figs. 21–22

Merismus megapterus Walker, 1833: 377, ♂, ♀. Lectotype ♂, paralectotypes, BMNH, examined.
Merismus clavicornis Walker, 1833: 377, ♀.
?*Miscogaster tenuicornis* Walker, 1833: 462, ♀.
Miscogaster ovata Walker, 1833: 462, ♀.
Sphegigaster Agriope Walker, 1848: 108, 165, ♂.
Merismus megalopterus Schulz, 1906: 143 (emendation).
?*Kentema viride* Delucchi, 1955: 94, 96, ♂, ♀.

The above synonymy is taken from Graham (1969) and has not been changed since his work. *Merismus megapterus* has been reported throughout western and central Europe (Boucek 1977). One of us (EEG) first discovered specimens of *megapterus* in material reared and submitted for identification to the Systematic Entomology Laboratory by Dr. Chris Maier (The Connecticut Agricultural Experiment Station, New Haven). Four females and six males emerged in April 1980 from "grass plants" collected in March. These were identified initially using Graham's key (1969) to European *Merismus*, then compared to specimens identified by Dr. Z. Boucek (Commonwealth Institute of Entomology, London), and finally compared with the type material in 1982. Subsequently a large number of specimens were collected and accumulated by the senior author as part of a study on the miscogasterine pteromalids.

We have seen a total of 38 females and 48 males of this species from eastern Canada and the northern United States (USNM, CNC, INHS, Cornell University, Ithaca, NY). Records from Canada include Quebec, New Brunswick, and Nova Scotia. United States records include (from west to east) California, Washington, North Dakota, Colorado, Texas, Nebraska, Minnesota, Wisconsin, Michigan, Missouri, Illinois, Indiana, New York, Massachusetts, Connecticut, Washington, D.C., Virginia, and West Virginia.

Acknowledgments

We thank the following individuals for the loan of specimens: Z. Boucek and J. Noyes, British Museum (Natural History), London, England; Chris Maier, The Connecticut Agricultural Experiment Station, New Haven, U.S.A.; G. A. P. Gibson, Biosystematics Research Centre, Ottawa, Canada. For reviewing this paper and offering substantial improvements we thank G. Gibson, Tom Henry (Systematic Entomology Laboratory, Washington, D.C.), and W. E. LaBerge and G. L. Godfrey (Illinois Natural History Survey, Champaign, IL).

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PROC. ENTOMOL. SOC. WASH.
90(3), 1988, pp. 323–328

NOMENCLATURAL NOTES ON POLISTINAE (HYMENOPTERA: VESPIDAE)

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Abstract.—Correct nomenclature is supplied for certain genus-group names of paper wasps. The infrasubgeneric names of Saussure (1852–58) were made available in 1985 from the original dates of publication. *Alpha* Saussure, 1854, is thus a senior synonym of *Hypopolybia* Richards, 1978; *Phi* Saussure, 1854, is a senior synonym of *Monocyttarus* Richards, 1978. *Trichinothorax* is newly proposed as a replacement name for *Trichothorax* Richards, 1978, *non* Montrouzier, 1860. *Agelaia* Lepeletier, 1836, is a senior synonym of *Stelopolybia* Ducke, 1910.

Key Words: Nomenclature, Polistinae, social wasps

During the course of various studies on the paper wasps, certain nomenclatural problems became apparent to both authors. The purpose of this note is to correct the nomenclature of the genus-group names.

GREEK LETTERS

The difficulties stem in large part from the infrasubgeneric names proposed by Saussure. In Volume 2 of his great work, Études sur la Famille des Vespides (1852–58), Saussure recognized 13 genera in the tribe "Vespiens" (a taxon equivalent to the Vespidae of Richards 1962). He divided the genus *Polybia* Lepeletier into two subgenera, *Clypearia* and *Polybia* "proprement dites," and subdivided the latter into seven "divisions." These divisions were *Alpha, Iota, Phi, My, Kappa, Omega* and *Parapolybia*. Subsequently, Saussure (1863) recognized *Pseudopolybia* as a division of the genus *Polybia*.

Volume 2 of "Études" was published between 1853 and 1858; the divisions were proposed in 1854 (see Griffin 1939). Shortly thereafter, both *Alpha* and *Phi* were used again by Saussure in Volume 3 of "Études" (1854–1856; the part mentioning these names appeared in 1855). The names were applied to divisions of the eumenine genus *Eumenes* (p. 137 and 145, respectively), and *Alpha* was further used for a division of *Montezumia* (p. 160). Other names derived from Greek letters were used for divisions of genera in this work. *Delta, Epsilon, Omicron* and *Zeta* are currently applied to eumenine genera, and *Beta* was also used in both *Eumenes* and *Montezumia* (see Carpenter 1986). Saussure applied these names to divisions first delineated in Volume 1 of "Études" (1852–1853), where they had been referred to by Roman numerals. In Volume 1, Saussure also delineated sections of some of these divisions. These were referred to typically by capital letters or arabic numerals, but in *Zethus* he also used the letters "α" and "β." This practice was continued throughout the "Études." From this it is plain that Saussure was merely hierarchically partitioning his genera according to the prin-

ciples of Aristotelean division, and did not consider these names to be validly proposed. As explained in a footnote on p. 167 of Volume 2, he began applying "arbitrary" names instead of numerals in order to facilitate interpolation of new taxa into his classification, without the necessity of renumbering. Nevertheless, the criteria of availability now in the International Code of Zoological Nomenclature make it clear that these names, even if proposed unintentionally, are available.

Subsequent to Saussure, Dalla Torre (1894: 161) treated *Pseudopolybia* as a genus, and Bingham (1897: 382) did the same for *Parapolybia*. Dalla Torre (1904: 76) listed the other polistine secondary names as divisions of his subgenus *Eupolybia*, but otherwise these names were generally ignored. Then Bequaert (1933: 112) transferred *Kappa* and *Omega* to the synonymy of *Mischocyttarus* Saussure, and designated a type species for the former. Richards (1941) subsequently raised them to subgenera. Later, Bequaert (1944a: 99) fixed the identity of *Alpha* by designating a type species, and Bequaert (1944b: 292) did the same for *My* (as *Mu*) and *Phi* by designating type species for them. Finally, Richards (1978: 33) selected a type species for *Iota*. However, it was Richards' monograph which crystallized the present problem.

The International Code of Zoological Nomenclature in force prior to 1985 did not treat infrasubgeneric names as available. As mentioned above, Saussure described numerous "divisions" of subgenera in his Études, especially in the eumenine genus *Odynerus*. When the present trend of splitting this genus was begun 50 years ago by Blüthgen (1938), these divisions gradually came to be treated as genera (see Carpenter and Cumming 1985, and Carpenter 1986). In order to fix their status, van der Vecht (1967) sought an Opinion ruling these names as available from their original dates of publication, with original authorship. Opinion 893 (ICZN 1970) so ruled.

Richards (1978) did not follow this course in Polistinae. While stating correctly that infrasubgeneric names had no nomenclatural status under the Code in force at that time, he misunderstood van der Vecht's treatment of the analogous case in Eumeninae, which Richards erroneously stated as pertaining to *primary* divisions of genera. Of course, van der Vecht's proposal would have been unnecessary if this were true! Following the Code, Richards treated the names as first made available when they were given nomenclatural standing by subsequent authors, either as subgenera or by designation of type species, with these later workers as authors of the names. Thus he attributed *Parapolybia* to Bingham (1897), *Pseudopolybia* to Dalla Torre (1894), and *Kappa*, *Omega* and *Alpha* to Bequaert (1933) [*Alpha* should have been cited as dating from Bequaert 1944a]. Under this procedure Richards treated *Omega* as a junior objective synonym of *Monacanthocnemis* Ducke, 1905 in his subgeneric arrangement of *Mischocyttarus*. Richards' classification was therefore inconsistent with the precedent established in Vespidae by van der Vecht.

It is unfortunate that Richards misconstrued the situation, although to have followed van der Vecht's precedent would have required submission of another case to the Commission. However, no argument on the point is now required. Under Art. 10(e) of the revised International Code of Zoological Nomenclature, secondary divisions are valid as genus-group names from their original date of publication, with original authorship. Richards' classification must therefore be amended. Richards himself, in a list of errata and addenda to his monograph published in 1983, reversed his stance in part, accepting Saussure's authorship of *Pseudopolybia* and *Omega*. In addition, Richards (1978), although citing Bequaert (1944b), overlooked that that author had designated type species for *Phi* and *My*, and as a result Richards' subgenus *Monocyttarus* is a junior subjective synonym. Thus,

Alpha and *Phi* become valid names for current subgenera of Polistinae and preoccupy the use of these names in the Eumeninae (Carpenter 1986). The corrected synonymies of the relevant taxa are listed below. But first two unrelated matters must be addressed.

Homonymy

Richards proposed a subgeneric classification of *Polybia* in his monograph. The naturalness of his arrangement remains to be investigated, but that aside, one of his subgenera is a junior homonym. As pointed out by Day (1979), *Trichothorax* Richards, 1978 is preoccupied in Coleoptera (by Montrouzier 1860). A replacement name is herewith proposed. This name is the replacement intended by Richards, as shown by an unpublished manuscript at the British Museum.

The Identity of *Agelaia* Lepeletier

The final matter concerns *Agelaia fuscicornis* Lepeletier, 1836. Since its proposal this taxon has been unrecognized. Saussure (1854: 210) placed it in *Polybia,* while pointing out the similarity in color of its description to that of *Apoica pallida* and *Polybia testacea* (now in *Stelopolybia*). Following him Dalla Torre (1894: 161) placed *Agelaia* in the synonymy of *Polybia.* However, Bequaert (1944b: 254) suggested that it may have been a *Polistes.* After success in identifying *Aphanilopterus* Meunier from its description (see Richards 1978: 437), J. van der Vecht inquired whether one of us (MCD) might also be able to identify *Agelaia.* It was determined that the description almost certainly applies to *Stelopolybia testacea* (F.). The evidence for this is outlined next.

Lepeletier (1836: 535) described *Agelaia* as a member of his fourth family, "Les Polistides." He mentioned (p. 536) that nothing was known of its habits, nevertheless the name was derived from the Greek for "Vivant en société." The placement of *Agelaia,* in between *Polybia* and *Apoica,* and the similarities in the details of the descriptions of these taxa, indicate that *Agelaia* must be a social wasp. Lepeletier stated that the collecting locality was unknown, but the color pattern he described, largely ferruginous with the posterior part of the metasoma blackish, is that of a well known South American mimicry complex and does not occur elsewhere. Three South American social wasps with this color pattern and of the right size (10 lines, or approximately 21 mm, *cf.* Mayr 1969) are known to us: *Stelopolybia testacea, Mischocyttarus flavicans* and *Polistes testaceicolor.* Two solitary vespids of similar color pattern and size (*Pachymenes orellanae* and *Montezumia analis*) may be dismissed because the clypeus is not angular below. Only the *Stelopolybia* matches the description of the metasomal petiole. The petiole is described as almost conical and tuberculate laterally. The metasoma of *Polistes testaceicolor* is as in other species of this genus described by Lepeletier: ". . . sans pédicule distinct; son premier segment se dilatant en cloche dès sa base." The petiole in *Mischocyttarus flavicans* is elongate, as in the species of *Apoica* described by Lepeletier. The second submarginal cell ("cubitale") in *Agelaia* is described as scarcely narrowed towards the marginal ("radiale") cell and little dilated towards the discal cell. Saussure (1854: 210) considered this feature the main obstacle in identifying *Agelaia fuscicornis* as *Stelopolybia testacea.* Saussure characterized the latter species as having this cell strongly ("entièrement") narrowed, as in other paper wasps. Lepeletier was possibly in error, however the cell in *S. testacea* is narrower posteriorly relative to the other two species, and so it appears less narrowed anteriorly. If this interpretation is correct, the only discrepancies concern the color pattern. The antennae are described as blackish above, and the second metasomal segment as blackish on the posterior third. Most specimens of *Stelopolybia testacea* which we have seen have the joints

between the flagellomeres slightly darkened, but the antennae are otherwise ferruginous, and the second metasomal tergum has a ferruginous band apically. However the antennae do appear blackish if viewed with the naked eye, and the extent of black and ferruginous on the second tergum varies greatly. We regard these discrepancies as minor compared to the general correspondence to the description. In the absence of the original material there can be no absolute certainty, but the description appears adequate to recognize this taxon. *Agelaia fuscicornis* Lepeletier, 1836 is thus considered here a junior synonym of *Stelopolybia testacea* (F., 1804).

This resolution of the identity of *Agelaia* creates another problem. *Agelaia* Lepeletier, 1836 is a senior synonym of *Stelopolybia* Ducke, 1910. We regard replacement of the name *Stelopolybia* by *Agelaia* with equanimity, since we believe that stability is best served through strict application of the Principle of Priority. We do not think this replacement will cause more than temporary confusion, and the situation will henceforth be stable. However, other workers may disagree, in which case an appeal to the Commission for suppression of *Agelaia* under the plenary powers should be made. Were adoption of *Agelaia* the only change required in an othewise stable nomenclature, more force might accrue to an argument for suspension of the rules. In particular, we note with interest that the majority of changes necessitated here arise from the Commission's recent adoption of revised criteria of availability with respect to infrasubgeneric names. It would have been so easy to make these criteria dependent on previous accepted usage for extant names!

Correct Synonymy

Polybia Lepeletier, 1836: 533. Type species *Polistes liliacea* F., 1804. By subsequent designation of Ashmead, 1902: 166.

subgenus *Polybia*

Iota Saussure, 1854: 174, explanations to plates 22 and 24 (as division of subgenus *Polybia*). Type species "*Polybia liliacea* (F.)." By subsequent designation (Richards 1978: 33) under Art. 67(f).

Jota Dalla Torre, 1894: 161. Unjustified emendation of *Iota*.* **New synonymy**.

Eupolybia Dalla Torre, 1904: 76. New name for *Polybia*. Type species "*Polybia liliacea* (F.) (= *Polistes liliacea* Fabricius, 1804)." By subsequent designation of Richards, 1978: 33.

Iota Richards, 1978: 33, 46; *non Iota* Saussure, 1854. Unjustified emendation of *Jota*. Unavailable under Art. IIe.

subgenus *Alpha* Saussure, 1854: 167, explanations to plates 21 and 22 (as division of subgenus *Polybia*). Type species *Polybia bifasciata* Saussure, 1854. By subsequent designation of Bequaert, 1944a: 99. **New status**.

Hypopolybia Richards, 1978: v, 35, 52 (subgenus of *Polybia*). Type species *Polybia bifasciata* Saussure, 1854. Original designation. **New synonymy**.

subgenus *Myrapetra* White, 1841: 320. Type species *Myrapetra scutellaris* White, 1841. By indication (monotypic).

Myraptera Saussure, 1854: 192, 194, 211, 249. Incorrect subsequent spelling of *Myrapetra*.

My Saussure, 1854: 191, explanation to plate 23 (as division of subgenus *Polybia*). Type species *Myrapetra scutellaris* White, 1841. By subsequent designation (Bequaert 1944b: 292) under Art. 67(f).

Mi Dalla Torre, 1904: 76. Unjustified emendation of *My*. **New synonymy**.

Mu Bequaert, 1944b: 292. Unjustified emendation of *My*. **New synonymy**.

* Note that unjustified emendations are available names (Art. 33b(iii)).

subgenus *Trichinothorax* **new name** for *Trichothorax* Richards, 1978, q. v.

Pseudopolybia Ihering, 1896: 452, junior homonym of *Pseudopolybia* Saussure, 1863. Type species *Polistes ignobilis* Haliday, 1836. By subsequent designation of Bequaert, 1933: 112.

Trichothorax Richards, 1978: v, 35, 101 (subgenus of *Polybia*); *non* Montrouzier, 1860: 235. Type species *Vespa chrysothorax* Lichtenstein, 1796. Original designation.

Trichthorax Snelling, 1981: 416. Incorrect subsequent spelling of *Trichothorax*.

Mischocyttarus Saussure, 1853: 19. Type species *Zethus labiatus* Fabricius, 1804. By subsequent designation of Ashmead, 1902: 166.

Mischocytharus Saussure, 1853: viii, footnote in Introduction to Vol. 1. Incorrect original spelling of *Mischocyttarus*.

Mischocittarus Saussure, 1857: xi. Incorrect original spelling of *Mischocyttarus*.

Mischocythorus Krombein, 1979: 1516. Incorrect subsequent spelling of *Mischocytharus*.

subgenus *Kappa* Saurssure, 1854: 200 (as division of subgenus *Polybia*). Type species *Polybia injucunda* Saussure, 1854. By subsequent designation of Bequaert, 1933: 112.

subgenus *Phi* Saussure, 1854: 183, explanations to plates 23 and 24 (as division of subgenus *Polybia*). Type species *Vespa phthisica* Fabricius, 1793. By subsequent designation of Bequaert, 1944b: 292. **New status**.

Monocyttarus Richards, 1978: vi, 18, 273, 307. Type species *Polybia flavitarsis* Saussure, 1854. Original designation. **New synonymy**.

subgenus *Omega* Saussure, 1854: 206 (as division of subgenus *Polybia*). Type species *Polybia filiformis* Saussure, 1854. By indication (monotypic).

Monacanthocnemis Ducke, 1905: 6, 8, 21. Type species *Polybia filiformis* Saussure, 1854. By indication (monotypic).

Parapolybia Saussure, 1854: 207 (as division of subgenus *Polybia*). Type species *Polybia indica* Saussure, 1854. By subsequent designation of Bingham, 1897: 382.

Pseudopolybia Saussure, 1863: 237 (as division of genus *Polybia*). Type species *Polybia vespiceps* Saussure, 1863. By indication (monotypic).

Agelaia Lepeletier, 1836: 535. Type species *Agelaia fuscicornis* Lepeletier, 1836 (= *Polistes testacea* F., 1804). By indication (monotypic).

Aglaia Dalla Torre, 1904: 75. Incorrect subsequent spelling of *Agelaia*.

Stelopolybia Ducke, 1910: 452, 464, 517. Type species *Polistes angulata* F., 1804. By subsequent designation of Lucas, 1912: 210. **New synonymy**.

Gymnopolybia Ducke, 1914: 316, 317, 327. Type species *Polybia vulgaris* Ducke, 1904 (= *Vespa fulvofasciata* DeGeer, 1773). By subsequent designation of Richards, 1943: 45. **New synonymy**.

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PROC. ENTOMOL. SOC. WASH.
90(3), 1988, pp. 329–333

FIRST RECORD OF THE GENUS *PROCANACE* HENDEL FROM NORTH AMERICA, WITH THE DESCRIPTION OF A NEW SPECIES (DIPTERA: CANACIDAE)

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Abstract.—The genus *Procanace*, previously known only from the Indopacific, Hendel is reported from North America for the first time, and a new species, ***P. dianneae***, is described and illustrated from specimens collected in Virginia. A revised key to the genera occurring in North America is presented, as well as one to the species groups of *Procanace*.

Key Words: Diptera, Canacidae, *Procanace*, species groups, new species

Beach flies of the genus *Procanace* Hendel were previously known from littoral habitats, both marine and freshwater, within the basins of the Pacific and Indian oceans (Afrotropical, Oriental, eastern Palaearctic, and Oceanian regions). No species were known from the Western Hemisphere, and it was an unexpected surprise to discover a new species of *Procanace* on the tidal shores of the Potomac River in peninsular Virginia, thousands of kilometers from its nearest congener and within a drainage system of the Atlantic Ocean.

A further anomaly of this discovery concerns the climate of the area. Although a few species of *Procanace* occur in temperate regions (Japan), greater species diversity occurs in the tropics and subtropics. Thus, the discovery of a new species in temperate Virginia was again unanticipated.

The purpose of this paper is to describe the new species, provide a diagnosis to the genus and an annotated key to its species groups, and to present a revised key to the genera of the family Canacidae that occur in North America. The key to genera will essentially be an updating of Wirth's key (1987) that was recently published in the *Manual of Nearctic Diptera*, Volume 2. In addition to *Procanace*, the generic key also includes *Paracanace* Mathis and Wirth even though that genus has not yet been recorded from the United States. *Paracanace* has been found in Cuba and Mexico, however, and I would expect it to occur along the Gulf Coast in the southeastern United States. The chapter on the family Canacidae in the *Manual* should be consulted for additional details on the family, its biology, and characterization.

It is timely that this species be described now so that its record, including that of the genus, can be incorporated in a checklist of Nearctic Diptera that is being prepared.

Methods.—The descriptive format used in this paper essentially adheres to that which I have published elsewhere in the family Canacidae (Mathis 1988). The terminology used for anatomical structures follows McAlpine (1981) with the exceptions that have been noted previously (Mathis 1986). For the convenience of the user, the definition of M vein ratio of the wing is: the straight line distance along M between crossveins rm and dm-cu/distance apical of crossvein dm-cu.

Key to Genera of Canacidae in North America

1. Lateroclinate fronto-orbital setae 4. Presutural acrostichal setae present; acrostichal setulae numerous, in four irregular rows. Female cercus with 1 large apical seta that is usually acutely pointed (subfamily Canacinae) ..... *Canacea* Cresson
– Lateroclinate fronto-orbital setae 3. Presutural acrostichal setae absent; acrostichal setulae sparse or absent. Female cercus with 2 large setae, 1 apical and 1 subapical, each usually rather broadly rounded (subfamily Nocticanacinae) 2
2. Interfrontal setae absent, although anterior ⅓ of frons occasionally with scattered setulae ..... *Procanace* Hendel
– Interfrontal setae present, 1 or more pairs in additional to any setulae 3
3. Two interfrontal setae present; postocellar setae well developed, proclinate and slightly divergent ..... *Paracanace* Mathis and Wirth
– One interfrontal seta present; postocellar setae either much reduced or absent 4
4. Disc of scutellum with setae; 3 large anaclinate genal setae ..... *Canaceoides* Cresson
– Disc of scutellum lacking setae; 2 anaclinate genal setae ..... *Nocticanace* Malloch

Genus *Procanace* Hendel

Procanace Hendel 1913: 93. Type species: *Procanace grisescens* Hendel, by original designation.

Diagnosis.—General coloration whitish gray, olivaceous, to blackish brown.

Head: Interfrontal setae absent, but with a few setulae inserted anteriorly; fronto-orbital setae 3; ocelli arranged to form equilateral or isosceles triangle, if isosceles, the greater distance is between posterior ocelli. Arista pubescent over entire length. Two large anaclinate genal setae; anteroclinate genal seta moderately well developed. Palpus not bearing long setae. Epistomal margin, in lateral view, more or less horizontal.

Thorax: Acrostichal setae, especially a prescutellar pair of large setae, usually lacking (setulae present in species of the *williamsi* group); scutellar disc lacking setae (1–2 pairs of scutellar disc setulae occur in *P. nakazatoi* Miyagi of the *williamsi* group); 2 pairs of marginal scutellar setae, apical pair not anaclinate; anterior and posterior notopleural setae present, length of both subequal; anepisternum with scattered setulae. Katepisternal setal usually present (lacking in species of the *grisescens* group). Hind tibia lacking spine-like setae apically.

Abdomen: Male genitalia as follows: Epandrium in posterior view wider than high; cerci reduced, poorly sclerotized; surstylus with an anterior and posterior lobe, the latter larger, sometimes markedly so and shape unique to species.

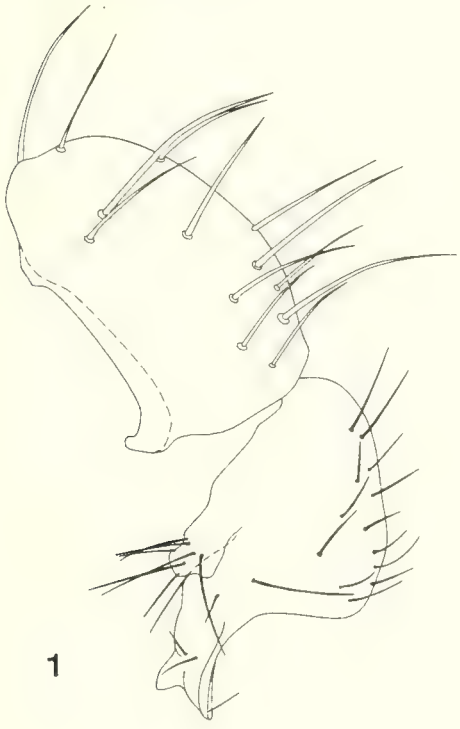
Discussion.—*Procanace* is probably a monophyletic taxon, although the evidence is weak, i.e. the lack of interfrontal setae and the more or less horizontal epistomal margin. The possibility remains that the genus is paraphyletic, which is a common condition for groups that include disjunct species.

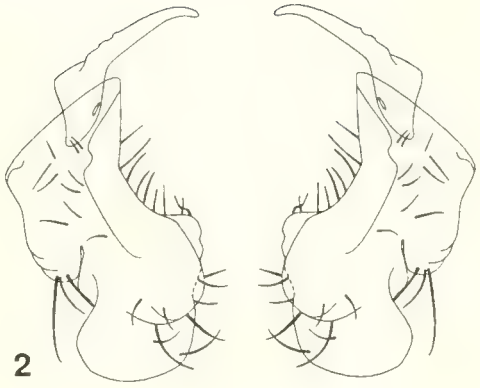
Annotated Key to Species Groups of *Procanace* Hendel

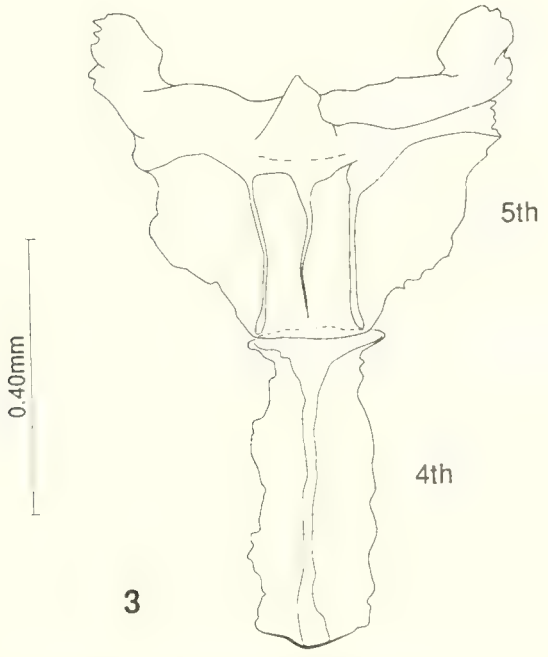
1. Katepisternal seta absent .... the *grisescens* group 4 species; Oriental, eastern Palaearctic, Oceanian, Malagasy, Seychelles
– Katepisternal seta present 2
2. Clypeus high, width about twice the height; palpus blackish brown; proepisternal seta absent ..... the *nigroviridis* group 7 species; Hawaiian Islands
– Clypeus low, width at least 4 times the height; palpus yellowish; proepisternal seta(e) present 3
3. Acrostichal setulae present, in 2 irregular rows ..... the *williamsi* group 4 species; Hawaiian and Ryukyu Islands
– Acrostichal setulae absent 4
4. Postocellar setae either absent or much reduced ..... the *fulva* group 9 species; Oriental and eastern Palaearctic
– Postocellar setae present, subequal to length of ocellar seta ..... the *cressoni* group 3 species; Oriental, Nearctic

Procanace dianneae Mathis, New Species
Fig. 1–3

Diagnosis.—Extenally this species is very similar to those of the *cressoni* group, and







Figs. 1–3. *Procanace dianneae*. 1, Epandrium and surstylus, lateral view. 2, Surstyli, posterior view. 3, Sterna 4–5 of male, ventral view.

I am tentatively placing it in that group. It differs from the two species of that group, *P. cressoni* Wirth and *P. taiwanensis* Delfinado, as well as other congeners by the following combination of characters: Postocellar setae well developed, subequal in length to ocellar setae; clypeus low, height ¼ width; palpus yellowish. Scutum mostly bluish black, sparsely microtomentose, scutum densely microtomentose, brown; proepisternal seta present, pale; katepisternal seta present; acrostichal setae absent. Shape of the male genitalia unique (see figs. and description below).

Description.—Moderately small to medium-sized beach flies, length 2.0 to 3.1 mm; general coloration whitish gray, olivaceous to brown, scutum darker.

Head: Frons with ocellar triangle and fronto-orbits mostly grayish but usually with some golden coloration, especially on anterior half of fronto-orbits, mesofrons mostly golden brown but with some rust to reddish coloration toward base of ocellar triangle; anterior half of mesofrons bearing about 10 setulae; postocellar setae well developed, length subequal to that of ocellar setae; middle fronto-orbital seta inserted slightly closer to posterior fronto-orbital seta than to anterior seta. First and 2nd antennal segments and arista dark colored, grayish black; 1st flatellomere reddish brown to brown; palpus yellow; face mostly white but with faint bluish to olivaceous coloration; gena mostly concolorous with face, posterior portion slightly more olivaceous. Gena bearing 1 anteroclinate and 2 anaclinate, well-developed setae and 2 setulae between them. Clypeus low, height about ¼ width.

Thorax: Scutum mostly subshining, bluish black, sparsely microtomentose but microtomentum becoming denser laterally, whitish or olivaceous gray to brown; scutellum densely microtomentose, brown; pleural areas densely microtomentose, mostly gray but with some olivaceous and light brown coloration. Acrostichal setulae absent; 3rd dorsocentral seta inserted at level of or anterior to supra-alar seta; anterior notopleural seta present, well developed, size subequal to posterior seta; proepisternal setae present but pale colored; anepisternum with few scattered setulae, mostly in more or less vertical arrangement in middle and along posterior margin; katepisternal seta present, well developed, katepisternum with several setulae anterior to large seta. Femora, tibiae, and most tarsomeres of male yellowish with light dusting of whitish gray microtomentum on dorsal surface, females with microtomentum on legs more extensive and darker; tarsomeres becoming darker apically, apical 1–2 tarsomeres blackish; fore femur bearing 5–6 moderately long and evenly spaced setae along posteroventral margin, basal 1–2 pale; mid femur bearing row of setae, these more evident and closely set on apical ⅓. Wing with length of apical section of vein CuA_1 moderately long, subequal to length of crossvein dm-cu; M vein ratio 0.6.

Abdomen: Unicolorous, olivaceous gray with some faint brownish coloration. Male abdomen as follows: 4th sternum (Fig. 3) narrowly rectangular, over 2× as long as wide; 5th sternum (Fig. 3) wider than long, width of anterior margin subequal to that of 4th sternum, becoming wider posteriorly, lateral margins irregular, widest at posterior margin, bearing a short process posterolaterally; epandrium wider than high in posterior view, bearing numerous setae, in lateral view (Fig. 1) posterodorsal margin broadly rounded, ventral margin nearly flat, anterior margin nearly straight except for anteroventral prong and irregular dorsal ⅓; surstylus (Figs. 1, 2) as 2 processes, anterior one much smaller, digitiform, bearing several setulae preapically and apically, posterior process much larger, length nearly equal to that of epandrium and equally as wide, in lateral view with posterior margin irregularly arched, anteroventral process very angulate in lateral view and spatulate in posterior view.

Type material.—The holotype male is labeled "USA. VIRGINIA[:] Westmoreland

Co. & Park (bank Potomac River)[,] 9 Oct 1987[,] W. N. & D. Mathis." Allotype female and 87 paratypes (65 ♂, 22 ♀; USNM) bear the same label data as the holotype. The holotype is double mounted (minute nadel in a plastic elastomer block), is in excellent condition, and is deposited in the National Museum of Natural History, Smithsonian Institution.

Etymology.—It is a pleasure to name this species after my wife, Dianne, in recognition of her many contributions to my studies of Diptera. Dianne was also a collector of the type series.

Natural history.—All specimens of the type series were collected from the shoreline of the tidal portion of the Potomac River at Westmoreland State Park. At the park, the river is over a mile wide, due largely to the tidal influence, and the water is slightly brackish. The shore is either almost entirely sand, the bathing area of the beach, or a combination of sand, considerable gravel, and some cobble and large rocks. In the latter habitat, the shore is quite narrow, at most two to three meters, and immediately adjacent to the shore is a cliff. In the sandy area, specimens occurred along the protected sides of narrow, wooden jetties that were installed perpendicular to the shoreline to break up the action of waves and prevent erosion of the beach. In the sand/cobble/rock habitat, specimens were found only on the rocks and were easily collected by sweeping immediately over and between the rocks. Most of the rocks and jetties were covered in part with algae, and I suspect that the larvae of this species were feeding on them.

Remarks.—The Chesapeake Bay is one of the busiest commercial waterways in the world, and I do not dismiss the possibility that this species, albeit previously unknown, was introduced in conjunction with the large volume of traffic on these waters.

Acknowledgments

The illustrations were skillfully prepared by George Venable on a MacIntosh II computer, and a draft of this paper was critically reviewed by Oliver S. Flint, Jr. and Norman E. Woodley. I thank these individuals for their contributions to this paper.

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PROC. ENTOMOL. SOC. WASH.
90(3), 1988, pp. 334–337

FIRST RECORD OF THE SHORE-FLY GENUS *PLACOPSIDELLA* KERTÉSZ FROM NORTH AMERICA (DIPTERA: EPHYDRIDAE)

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Abstract.—The shore-fly genus *Placopsidella* Kertész is reported from North America for the first time. The species, *P. grandis* (Cresson), was previously known from littoral habitats within the Pacific and Indian Ocean basins, with probable introductions into the eastern Mediterranean (Israel). This introduction apparently follows a similar pattern for other recent ephydrid introductions into North America, and these are apparently abetted by the large volume of commerce on the lower Chesapeake Bay and the natural history of the flies.

Key Words: Diptera, Ephydridae, *Placopsidella grandis* (Cresson), introduction

Peninsular Virginia and the Eastern Shore of Maryland and Virginia, especially their seashores and tidal rivers, appear to be focal points for the introduction of new taxa into North America. During the last two years alone, we have reported the introduction of two other shore and beach flies (Mathis and Steiner 1986, Mathis 1988) to these areas, and the purpose of this paper is to report yet another. The introduced shore fly, *Placopsidella grandis* (Cresson), is the first occurrence of that genus and species in North America, although previously it was reported from Panama, the first record from the Western Hemisphere (Mathis 1986).

I have adopted a taxonomic format to present the published history of the introduced species, chiefly to save space, and have attempted to provide all references to the species. Inasmuch as *Placopsidella* was recently revised (Mathis 1986), I have not repeated the charcterizations of the genus and species. A brief diagnosis for the genus and species, however, plus figures of distinguishing characters are provided to facilitate identification. Consult Mathis (1986) for further information on the genus and its included species.

Placopsidella grandis (Cresson)

Figs. 1–5

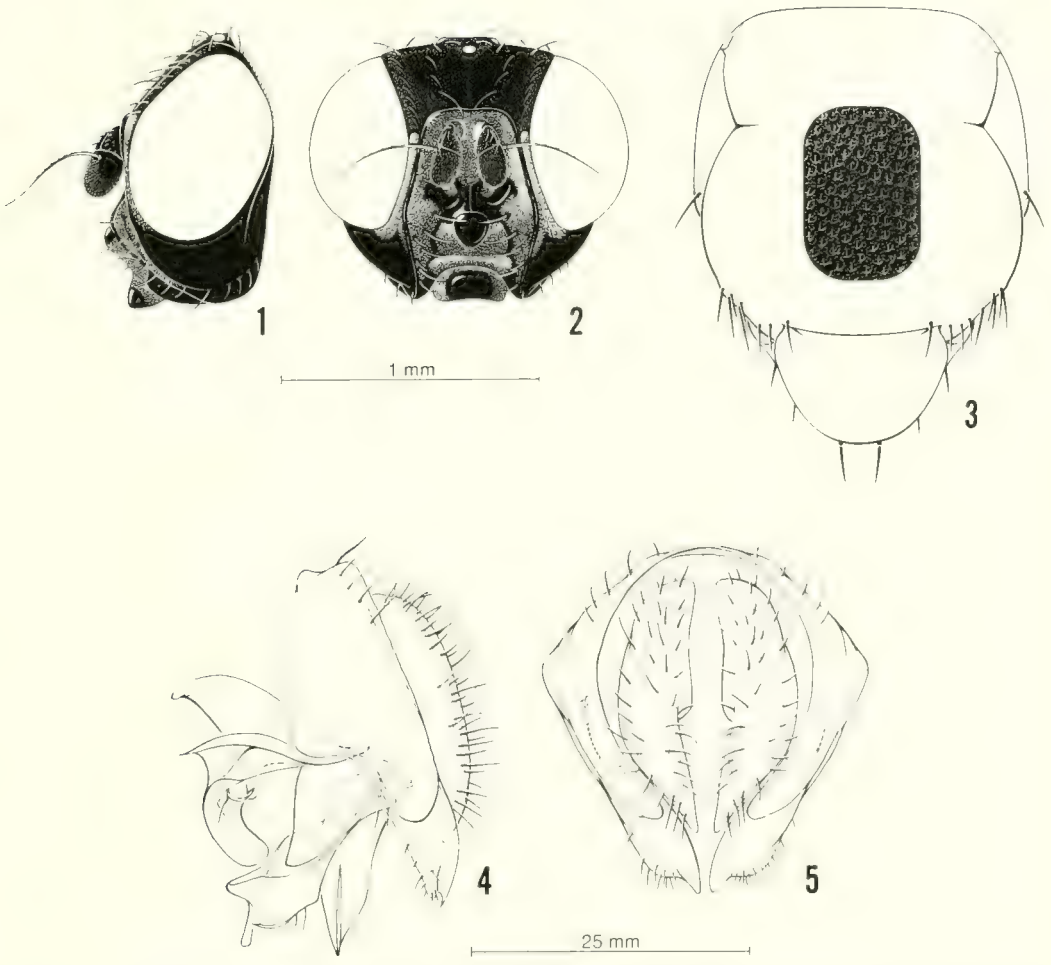
Gymnopa grandis Cresson 1925: 232; 1945: 54 [review].

Placopsidella grandis.—Cogan and Wirth 1977: 323 [comb.; Oriental cat.].—Mathis 1986: 22–25 [revision].

Placopsidella opaca Miyagi 1977: 30–31.—Cogan 1984: 129 [Palearctic cat.].—Mathis 1986: 23 [syn. with *P. grandis*].

Mosillus grandis.—Tenorio 1980: 268 [comb.; review of Hawaiian species].

Diagnosis.—*Placopsidella* belongs to the tribe Gymnopini and is closely related in the North American fauna only to *Mosillus* Latreille. Like the latter, the ocellar and pseudopostocellar setae are either much reduced or absent, there is a single notopleural seta that is inserted in the posterior angle of the notopleuron, and the arista is bare or nearly so. *Placopsidella* is distinguished from *Mosillus* and other genera of Gymnopini by



Figs. 1–5. *Placopsidella grandis*. 1, Head, lateral view. 2, Head, anterior view. 3, Thorax, dorsal view. 4, Male genitalia, lateral view. 5, Male genitalia, posterior view.

its grayish brown to brown microtomentose vestiture, the absence of an outer vertical seta (the inner seta is present, although only moderately well developed), and the presence of four to six large setae between the postalar seta and the base of the scutellum. Other genera of Gymnopini are mostly shining black, nearly bare of microtomentum, and there are no large setae between the postalar seta and the base of the scutellum. In Wirth et al.'s key (1987) to the genera of North American Ephydridae, *Placopsidella* keys to the first half of couplet 39 (*Mosillus*) but is distinguished by the characters just outlined. *Placopsidella* is strictly coastal in distribution, mostly intertidal, whereas *Mosillus* occurs inland.

Within *Placopsidella,* this species belongs to the *liparoides* species group and is distinguished from congeners by its smaller size (length 2.7 to 3.7 mm), silvery white facial microtomentum, pattern of shining areas on face, conically prominent face, the anteriormost aspect of the facial prominence shining, darker antenna, number of scutellar bristles (two), and the unique conformation of the male genitalia (see figs.).

Canzoneri (1986) recently described *P.*

rossii from a specimen collected in West Africa (Sierra Leone). That species is apparently very similar to *P. grandis* and is reported to differ from the latter only by charcters of the male genitalia. I have not examined the holotype male of this species, but would not be surprised to learn that it is conspecific with *P. grandis*.

Materials examined.—VIRGINIA. Northampton Co., Kiptopeke, 2–5 Oct 1987, on flowers of *Solidago sempervirens*, W. E. Steiner, J. M. Swearingen, J. M. Hill, J. J. Marshall (1 ♂, 1 ♀; USNM). This site is at the tip of the Eastern Shore of the Chesapeake Bay and is located directly across the Bay from Norfolk and Virginia Beach.

Distribution.—Widespread throughout the Pacific basin (Hawaiian Islands, Japan, Panama, Taiwan); from there disjunct, presumably by introduction to the Mediterranean (Israel), and Virginia.

Natural history.—In Hawaii, specimens were collected from salt bush (*Atriplex semibaccata*), a plant introduced from Australia in the early part of this century. The specimens collected in Virginia were swept from goldenrod (*Solidago sempervirens*). Other species of the genus are predators, perhaps scavengers, on various molluscs, especially small mussels, and barnacles.

Remarks.—Mathis (1988) has suggested elsewhere that the lower Chesapeake Bay and ajoining land are the recipients of many introductions because of the large volume of commerce on these waterways. The lower Chesapeake Bay, the principal waterway associated with this portion of Virginia, is one of the busiest in the world, serving the large metropolitan areas of Baltimore and Washington, and housing a principal base for the U.S. Navy on the East Coast. With a high level of traffic, the possibility of an introduction, as "extra baggage," is much greater.

Other factors contributing to the introduction of species concern their natural history (Lewin 1987). All species reported recently, including this one, frequent the littoral zone where they are scavengers on molluscs or feed on algae and/or seaweed that has accumulated on the shore. These food sources are plentiful in the littoral zones of Virginia. Furthermore, these habitats are not particularly rich in insect species, which may contribute to the success of an insect invader. The widespread distribution of *P. grandis* has undoubtedly further abetted the possibilities of invasion but has probably had little or no influence on the stability of the invasion afterwards.

Clearly much remains to be studied about the immigration of insects and of this species in particular, whose natural history and ecology are largely unknown. Also, basic survey work and general collecting are valuable tools in and prerequisites for the detection of exotic organisms.

Acknowledgments

The collecting efforts of Warren E. Steiner, particularly in littoral habitats, are appreciated. I also thank Allen L. Norrbom for critically reviewing a draft of this paper. The illustrations were rendered by George Venable. I thank them all for their contributions to this paper.

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PROC. ENTOMOL. SOC. WASH.
90(3), 1988, pp. 338–342

A NEW SPECIES OF *HAEMATOMYZUS* (MALLOPHAGA: HAEMATOMYZIDAE) OFF THE BUSH PIG, *POTAMOCHOERUS PORCUS*, FROM ETHIOPIA, WITH COMMENTS ON LICE FOUND ON PIGS

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Abstract.—A new species, ***Haematomyzus porci***, is described and illustrated for specimens taken off the Bush Pig, *Potamochoerus porcus*, in Ethiopia; this represents the third species described in this genus. The known data of lice found on the eight species of pigs are also summarized.

Key Words: Mallophaga, *Haematomyzus*, *Haematopinus*, Suidae

Only two species of *Haematomyzus* Piaget have been described to date: *H. elephantis* Piaget from the African Elephant, *Loxodonta africana* (Blumenbach), and the Asiatic Elephant, *Elephas maximus* Linnaeus, and *H. hopkinsi* Clay from the Wart Hog, *Phacochoerus aethiopicus* (Pallas), in Kenya and Uganda. When Piaget (1869) described *H. elephantis*, he established *Haematomyzus* as a genus of Anoplura. Subsequently, Enderlein (1904) erected the family Haematomyzidae in the order Anoplura for this species. Ferris (1931) published results of a detailed study of the anatomy of *H. elephantis*, concluding that it had "biting mouth-parts" and should be in the order Mallophaga; he, therefore, described the suborder Rhynchophthirina for the family Haematomyzidae. External morphology features found only in the genus *Haematomyzus* are illustrated in Figs. 1–3; these include the prolonged mouthparts which are mandibulate and have no piercing mechanism, the thorax which is different in shape from any known in the Anoplura or other Mallophaga genera, and the legs which are distinct from those found on any Anoplura or other Mallophaga species. Clay (1963) examined four hypotheses as to the host for the original ancestral stock which resulted in the genus *Haematomyzus* and could not conclude which was most probable, the Wart Hog or the African Elephant.

We recently received a series of *Haematomyzus* collected from the Bush Pig in Ethiopia; these lice represent a third species of this group of Mallophaga. All measurements are in millimeters. Details common to *Haematomyzus* species will not be repeated here, since Ferris (1931) and Clay (1963) have adequately treated them.

Haematomyzus porci **Emerson and Price, New Species**

Figs. 1–3

Type host: Potamochoerus porcus (Linnaeus) [Artiodactyla: Suidae].

Male.—As in Fig. 1. Each abdominal pleuron II with 2 dorsal medial setae consisting of short fine seta and longer thicker seta; dorsal posterior seta on pleuron III 0.03 mm long. Dorsal abdomen with 5 clear circular areas on each side encompassing medium seta in each; additional minute setae

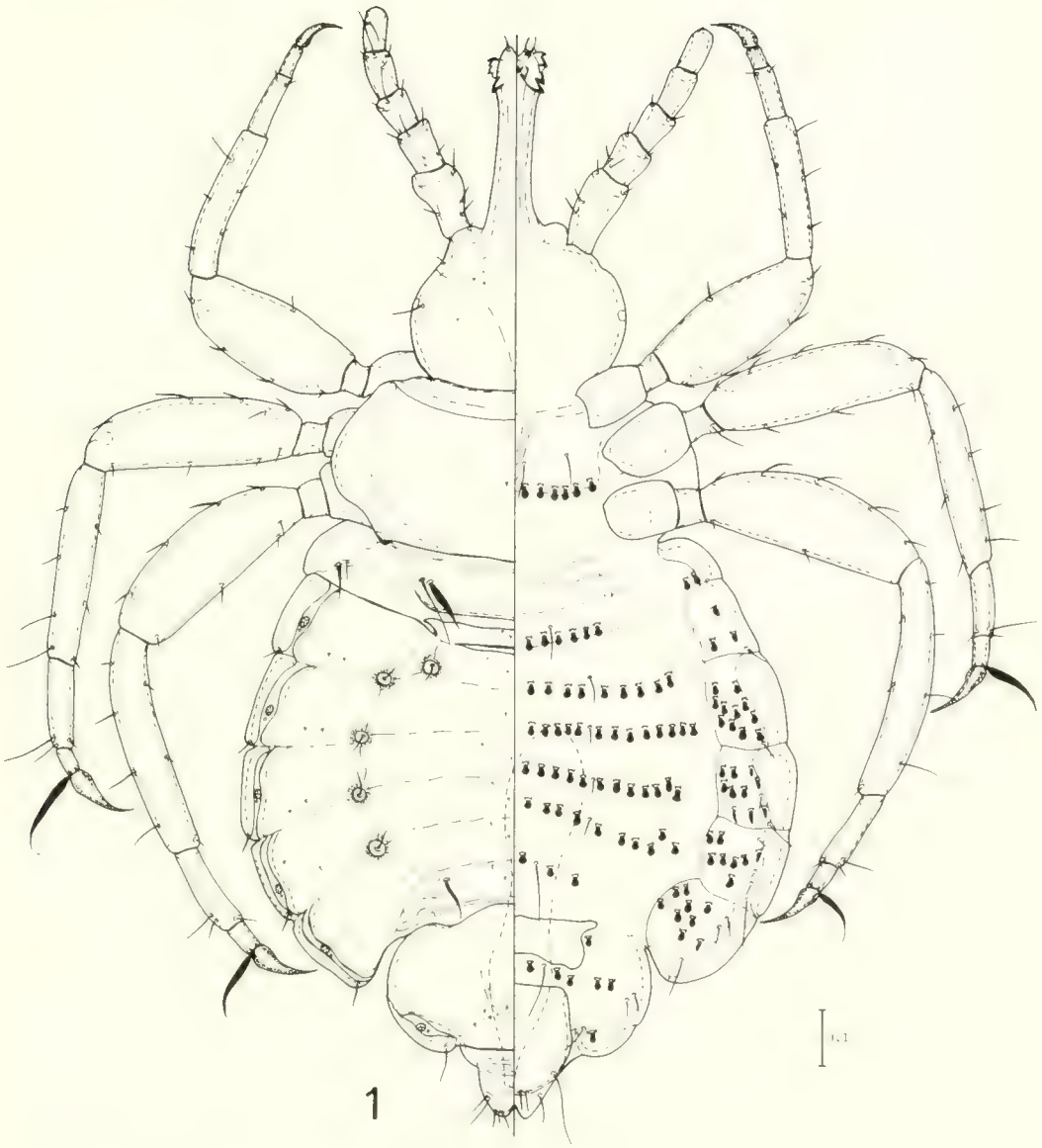
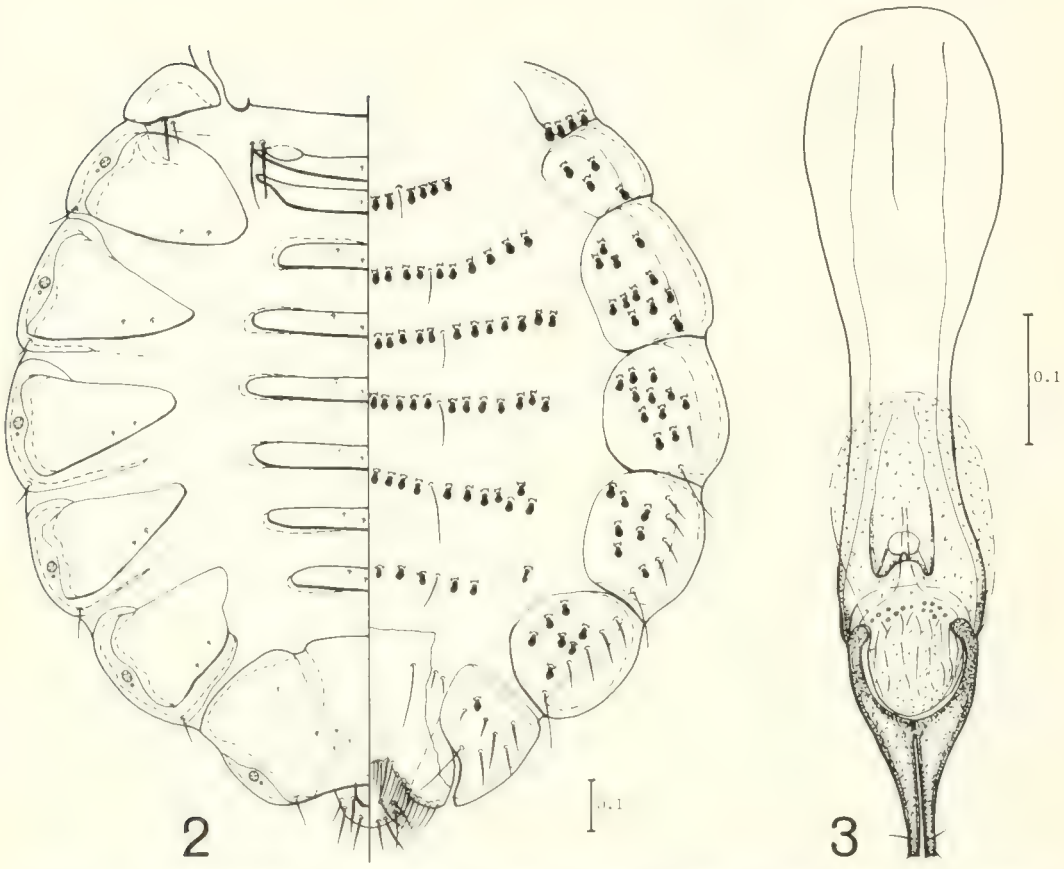


Fig. 1. *Haematomyzus porci*, male, dorsal (left)–ventral (right) view. Scale line = 0.1 mm.

lateral and medial to these. Abdominal sterna II–VII each with 2 unmodified setae and following number of stout modified setae: II, 12; III, 20; IV–V, 25; VI, 20; VII, 7. Genitalia (Fig. 3) with long prominent rounded basal plate, closely apposed parameres with truncate apices each bearing 2 setae, and with spinose sac and associated structures as shown. Dimensions: head width, 0.43 mm; head length (including proboscis), 0.65 mm; proboscis length, 0.38 mm; pterothorax width, 0.68 mm; abdomen width (at V), 1.02 mm; total length, 1.95 mm; genitalia length, 0.65 mm; genitalia width, 0.11 mm.

Female.—Head and thorax as for male (Fig. 1). Abdomen as in Fig. 2. Width of 8 median tergal plates, respectively, from an-



Figs. 2–3. *Haematomyzus porci.* 2, Female abdomen, dorsal (left)–ventral (right) view. 3, Male genitalia, dorsal view. Scale lines = 0.1 mm.

terior to posterior: 0.31–0.33 mm, 0.39–0.40 mm, 0.35–0.36 mm, 0.46 mm, 0.47–0.49 mm, 0.44–0.47 mm, 0.36–0.41 mm, and 0.28–0.31 mm. Abdominal sterna II-VII each with 2 unmodified setae and following number of stout modified setae: II, 12–13; III, 20–22; IV, 25; V, 22–26; VI, 22; VII, 11. Dimensions: head width, 0.40–0.43 mm; head length (including proboscis), 0.66–0.71 mm; proboscis length, 0.42–0.43 mm; pterothorax width, 0.68 mm; abdomen width (at V), 1.37–1.40 mm; total length, 2.30–2.34 mm.

Discussion.—Clay (1963) provides excellent features for distinguishing *H. hopkinsi* from *H. elephantis. Haematomyzus porci* is morphologically closer to the former, differing from *H. elephantis* in many of the same ways as does *H. hopkinsi.* The principal feature separating *H. porci* from *H. hopkinsi* is the presence of 5 pairs of clear circular areas, each surrounding a medium seta, on the male dorsal abdomen as opposed to only 4 pairs of such areas on *H. hopkinsi* (lacking the medioanterior pair) and none on *H. elephantis.* The separation of *H. porci* is further supported by the dorsal posterior seta on male pleuron III only a third the length of that of *H. hopkinsi,* the female with a tendency for 1–5 fewer modified setae on each of abdominal sternites II–VII, and smaller female dimensions for

the pterothorax width (0.68 mm vs 0.73–0.76 mm) and total length (2.30–2.34 mm vs 2.42–2.52 mm).

Material examined.—Holotype ♂ from *Potamochoerus porcus* collected on July 16, 1964, near Addis Ababa, Ethiopia, by C. T. O'Connor; in the collection of Oklahoma State University, Stillwater. Paratypes: 7 ♀, same data as holotype; distributed among Oklahoma State University, University of Minnesota, Field Museum of Natural History, and U.S. National Museum of Natural History.

Lice Found on Pigs

Most mammalogists place the eight species of living pigs into five genera (Nowak and Paradiso 1983). The known data of the lice on these eight species of pigs are summarized here.

The genus *Sus* contains *S. scrofa* Linnaeus, the Wild Boar, found originally in Europe, parts of Asia, and North Africa, but now widely introduced by man. The louse found on this host is *Haematopinus apri* Goureau, a species of sucking louse in the order Anoplura which has been reviewed by Ferris (1951). The domestic pig is also included in *S. scrofa*; domestic pigs, however, have a different anopluran louse, *Haematopinus suis* (Linnaeus). We have not been able to obtain lice off *S. salvanius* (Hodgson), the Pigmy Hog, *S. barbatus* Muller, the Bearded Pig, or *S. verrucosus* Muller and Schlegel, the Javan Pig, but we suspect that the lice of these south Asian pigs will also be species of *Haematopinus*.

The remaining four genera of pigs each contains a single species: *Babyrousa babyrussa* (Linnaeus), the Babirusa, is found in the Celebes and probably has a species of sucking louse; *Phacochoerus aethiopicus*, the Wart Hog, is found in Africa and has *Haematomyzus hopkinsi*, a species of chewing louse, as well as a sucking louse, *Haematopinus phacochoeri* Enderlein; *Potamochoerus porcus*, the Bush Pig, is found in Africa and Madagascar and has both *Haematomyzus porci*, the new species of chewing louse described here, and *Haematopinus latus* Neumann, a sucking louse; *Hylochoerus meinertzhageni* Thomas, the Giant Forest Hog, is found in Liberia, southwestern Ethiopia, and northern Tanzania and has the sucking louse *Haematopinus meinertzhageni* Werneck, described by Werneck (1952) subsequent to the review by Ferris (1951).

A key to separate these three species of *Haematomyzus* is as follows:

1. Male dorsal abdomen lacking clear circular areas each surrounding medium seta; female dorsal last abdominal segment with both short and medium setae ..... *elephantis*
– Male dorsal abdomen with 4–5 pairs of clear circular areas each surrounding medium seta (Fig. 1); female dorsal last abdominal segment with all setae similar, of medium length (Fig. 2) 2
2. Male dorsal abdomen with 4 pairs of clear circular areas each surrounding medium seta and posterior seta of pleurite III over 0.08 long; female with pterothorax width over 0.72 ..... *hopkinsi*
– Male dorsal abdomen with 5 pairs of clear circular areas each surrounding medium seta and posterior seta of pleurite III less than 0.06 long; female with pterothorax width less than 0.70 *porci*

Acknowledgments

We thank J. S. Ashe for the loan of critical specimens from the Field Museum of Natural History, Chicago. This research was partially supported by Project No. Min-17-015, Minnesota Agricultural Experiment Station, St. Paul, Minnesota 55108, and has been assigned Paper No. 15,703, Scientific Journal Series.

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BIOLOGY AND IMMATURE STAGES OF THE RHODODENDRON GALL MIDGE, *CLINODIPLOSIS RHODODENDRI* FELT (DIPTERA: CECIDOMYIIDAE)

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Abstract.—*Clinodiplosis rhododendri* (Felt) is an occasionally serious pest of *Rhododendron catawbiense* hybrids grown in nurseries in the Northeast. Biological and ecological information is presented for the first time. Immature stages are described and illustrated. The larva was examined via scanning electron microscopy. The species is multivoltine, passes through 3 instars, and overwinters both in the soil and in flower buds as mature larvae. Larval aestivation and natural enemies are reported. Damage is described.

Key Words: Insecta, rhododendron gall midge, *Clinodiplosis rhododendri*, insect pest

Cecidomyiids, or gall midges, are a diverse group biologically and ecologically and are represented by more than 1200 species in North America. Although a few members of the family, such as the Hessian fly and alfalfa gall midge, are serious agricultural pests and well studied, most species have received very little attention.

White (1933) described damage caused by an unidentified gall midge on rhododendron. It was reported to cause considerable deformation of the leaves of *Rhododendron ponticum* L., *R. maximum* L., and hybrid varieties in nurseries. White also reported finding it on wild *R. maximum* in the Pocono mountains of Pennsylvania. Felt (1939) described the gall midge as a new species, *Giardomyia rhododendri*. Gagné (1973) placed *G. rhododendri* in the genus *Clinodiplosis* Kieffer. By our petition, the Entomological Society of America has approved the common name rhododendron gall midge. The gall midge is recognized in various books dealing with insect pests of ornamental plants, including those by Pirone (1978) and Westcott (1973). It is also recognized as a pest in several books on rhododendron culture such as those by Leach (1961), Bowers (1960), and Van Veen (1969).

MATERIALS AND METHODS

Site 1—a commercial nursery, East Hampton, NY; Site 2—a commercial nursery, Melville, NY. Emergence of adults from overwintering larvae was monitored with the aid of traps. Traps consisted of standard 6-in.-diameter white plastic flowerpots coated on the inside with Tanglefoot®. Traps were placed in an inverted position on the soil beneath branches of plants showing damage from the previous year. Twenty-eight traps were placed throughout two fields at Site 2 on 10 May 1980. Traps were checked by removing them and recording the number and sex of all gall midges present. Traps were checked nine times at intervals of 3–5 days from 19 May to 15 June.

Above-ground plant parts were examined with a 10× hand lens to ascertain oviposition sites. Eggs were collected with a moistened camel-hair brush and placed in

70% ethanol. Plant parts bearing eggs were removed and brought to the laboratory for further observation. Foliage bearing evidence of damage was removed and examined for larvae by carefully pulling it apart. The number of larvae, their size, color, location in the damaged tissue, and activity were noted. Larvae were transferred to 70% ethanol or a KAAD mixture with a moistened camel-hair brush. Infested foliage was removed and placed in paper bags for transport to the laboratory. Petioles of 10 infested leaves were sprayed with Tanglefoot® on 26 June 1979 at Site 1 to determine if mature larvae crawl down the plant to reach the soil for pupation. These petioles were checked on 2 July.

A random sample of 21 flower buds of the cultivar 'Nova Zembla', and 32 flower buds of 'Roseum Elegans', were taken on 10 April 1980 at Site 2 to ascertain whether mature larvae had overwintered in them, and whether there was a varietal preference. The buds were dissected on 17 April 1980 and the number and condition of mature larvae in them noted. Soil samples were taken on 10 May 1981 at Site 2 to determine the stage of development of overwintering larvae and their distribution within the soil. Fifteen saples were taken with an Oakfield® soil sampler from beneath plants that were heavily damaged the previous summer. Samples were divided into five depth intervals: 1–2 cm, 2–4 cm, 4–6 cm, 6–8 cm, and 8–10 cm.

Eggs on plant parts were observed with a dissecting microscope to determine color changes associated with development; location, orientation, and distribution on the host plant; and to aid in illustration. Eggs were placed directly in Euparal® on microscope slides for detailed observation and measurement. This was advantageous in that the minute, translucent eggs were difficult to recover from ethanol. An ocular micrometer was used to determine egg dimensions. A small camel-hair brush was used to manipulate and transfer eggs.

Larvae were easily removed from leaves by placing infested foliage in plastic bags; in a few hours the larvae vacated the leaves. Larvae crawling on the inner surface of the bags were then collected with a moistened camel-hair brush.

Larvae killed in KAAD were transferred to 95% ethanol after ½ hour. Some larvae were dehydrated in an alcohol series, cleared in a terpineol solution (Hood 1953), and mounted in Canada balsam on microscope slides for detailed observation. Other larvae were treated in cold 5% NaOH for 24 hours, dehydrated, cleared as above, and mounted in Canada balsam. Larval dimensions, including head capsuls widths, were determined with the aid of an ocular micrometer.

Larvae to be viewed with the scanning electron microscope were dehydrated in an alcohol series, washed twice in pure acetone, then transferred to small plastic capsules that had been perforated with a No. 00 insect pin. The larvae were critical-point dried using pure acetone. Each capsule was then gently opened and inverted over a mounting stub covered with double-sided tape. Larvae were positioned on the tape with the aid of a small camel-hair brush and then coated with 200–250 å of gold-palladium. All micrographs were made at 10 kV with an AMRAY 1000® SEM.

An estimate of the time required for mature larvae to complete development and emerge as adults was made by placing 20 mature larvae in a Syracuse watch glass containing moist sand and checking it daily for adult emergence. To more precisely determine the length of this period, mature larvae were placed in Thunderbird® No. 111 clear plastic cups of about 30 ml capacity containing sand moistened with distilled water. A single larva was placed in each cup after being examined for ectoparasites or any readily visible pathological condition. Each cup was covered with a plastic lid and placed in a rearing room (25°C, 75% RH). Cups were checked each morning and night starting on the ninth day. Forty cups were

Table 1. Dimensions (mm) of immature stages of *C. rhododendri*.

	Egg		Larva						Pupa	
			1st Instar		2nd Instar		3rd Instar			
	L	W	L	W	L	W	L	W	L	W
Mean	0.29	0.08	0.64	0.17	1.32	0.35	2.27	0.56	1.80	0.62
Maximum	0.30	0.09	1.17	0.47	2.10	0.51	3.03	0.76	2.10	0.76
Minimum	0.28	0.06	0.27	0.07	0.75	0.17	1.72	0.46	1.51	0.53
SD	0.01	0.01	0.27	0.08	0.29	0.08	0.29	0.08	0.21	0.08
n	25		24		47		37		7	

set up on 25 August 1979 with larvae collected at Site 1 the day before. Fifty larvae collected on 26 August 1980 at Site 2 were set up on 2 September 1980.

Cocoons were recovered from thoroughly dried soil samples with the aid of a No. 18 USA Standard Testing Sieve® (1.0 mm opening, Tyler equivalent = 16 mesh). Soil aggregates not passing the sieve were carefully broken apart under a dissecting microscope.

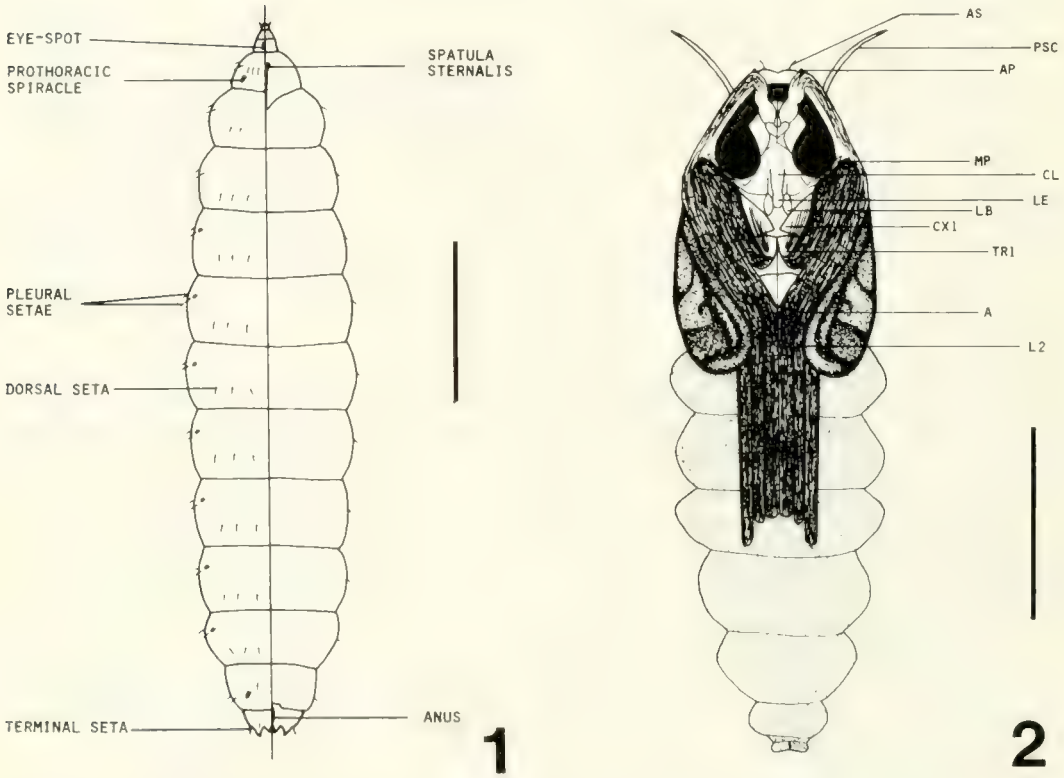
The longevity of adults was estimated by recording mortality for individuals emerging in the plastic cups. Sex was determined after death. Fecundity was measured by dissecting the ovaries of newly emerged gall midges and counting the number of eggs per female with the aid of a dissecting microscope. Cecidomyiids emerge from the pupal stage with their full complement of ova matured and ready for oviposition (Barnes 1946). Pairs of newly emerged adults were confined on swollen vegetative buds in the laboratory with the aid of small plastic cages (10 cm tall, 8 cm diam.). Unfortunately, all adults placed in cages on plants died within a few hours without having oviposited.

Description of Immature Stages

Felt (1939) published a description of the adult. Immature stages have not been previously described.

Egg ellipsoidal, nearly round in cross section, anterior end slightly wider than posterior; ca. 3 times longer than wide, 0.29 × 0.08 mm (Fig. 9; Table 1). Chorion smooth, shiny, transparent and unsculptured; sticky and resilient. Vitelline membrane visible, especially at posterior end. Newly deposited egg nearly colorless. As egg develops it becomes reddish-orange. A large, diffuse, reddish area appears slightly posteriad of center. Vitelline membrane becomes constricted at both ends of egg. Incipient segmentation evident as white patches appear along sides. A dark-red eyespot appears in the anterior eighth of egg during late stages of development.

Larva spindle-shaped with a distinct but minute head; ca. 3¾ times longer than wide, length varies from ca. 0.5 mm in first instar to ca. 2 mm at maturity (Figs. 1, 3, 4; Table 1). Larva creamy white throughout most of its development, becoming orange-yellow at maturity. Head capsule weakly sclerotized, with prognathous mouthparts (Fig. 5). Mouthparts consist of mandibles, maxillae, a labrum and labium (Fig. 6). Mandibles inserted internally. Papillae present on maxillae and labium; pits present on labrum. Antennae two-segmented, conical, conspicuous. Head separated from thorax by well-developed cervix. Dark-red eyespot present within cervix in all instars. Spiracles present on prothoracic segment and abdominal segments 1–8 of third-instar larva; those on prothoracic segment and eighth abdominal segment prominent. Spatula present on prothoracic venter of third-instar larva. Integument rugose (Figs. 3, 4). Rows of spinules prominent on venter of meso- and metathoracic segments and abdominal seg-



Figs. 1–2. *Clinodiplosis rhododendri*. 1, third-instar larva (dorsal and ventral views). 2, Pupa (A = antenna, AP = antennal process, AS = apical seta, CL = clypeus, CX1 = prothoracic coxa, LB = labella, LE = labrum-epipharynx, L2 = mesothoracic leg, MP = maxillary palp, PSC = prothoracic spiracular cornicle, TR1 = prothoracic trochanter). Scale bar represents 0.5 mm.

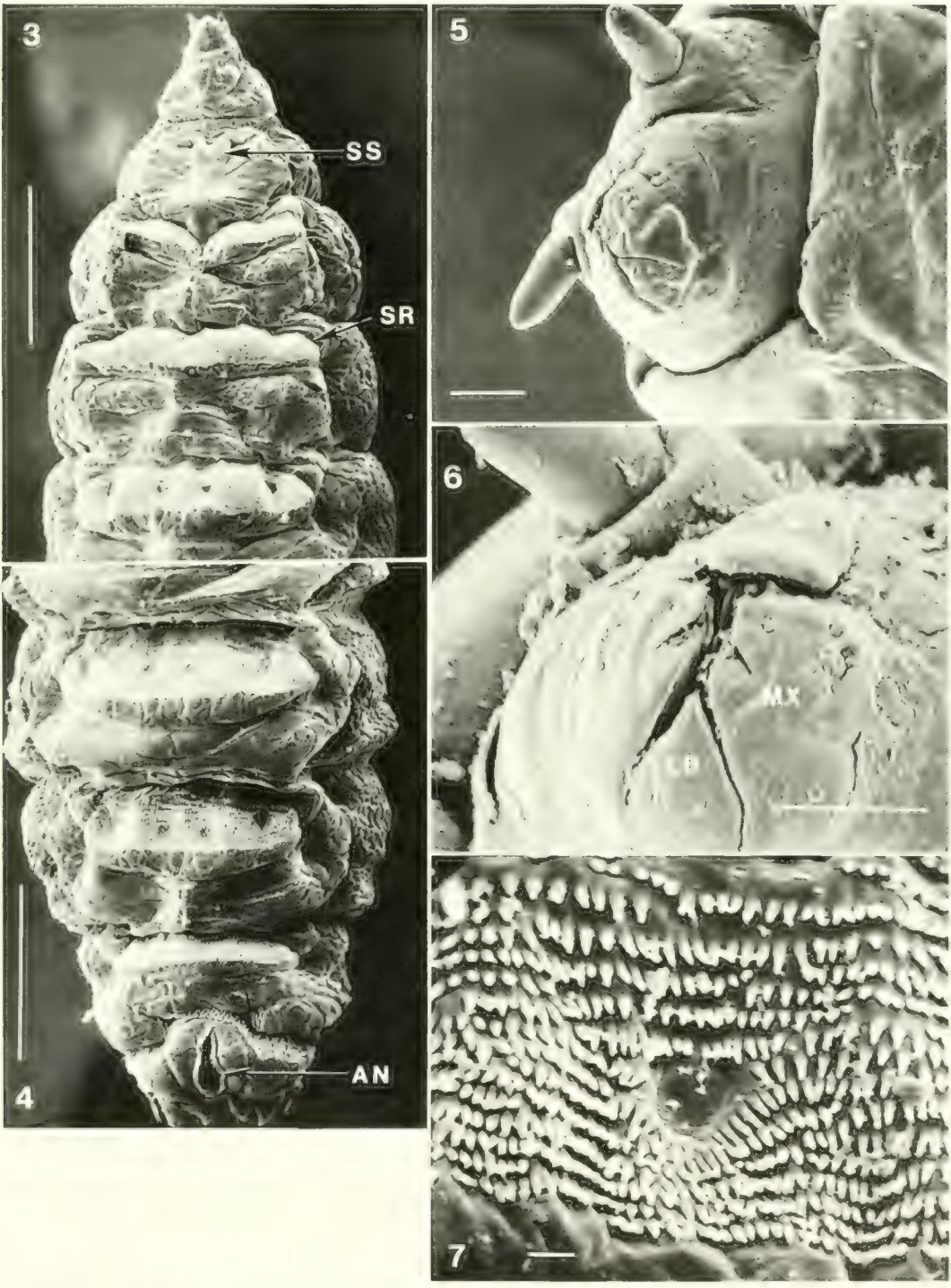
ments 1–9. Barren patches within spinule rows present on abdominal segments 1–7 (Fig. 7). Spinules surround anus. Six dorsal and 4 pleural setae present on each thoracic segment and on abdominal segments 1–7. Terminal segment with 8 papillae; 4 with setiform setae, 4 with corniform setae.

Pupa spindle-shaped, exarate (Fig. 2; Table 1). Teneral pupa orange-yellow. In mature pupa (pharate adult) eyes black, wings dark brown to black, legs and antennae dark yellow-brown, legs lighter distally. Abdomen retains larval color. Sclerotized process located on base of each antennal sheath. Apical seta situated mediad and posteriad to each process. Prothoracic spiracular cornicles prominent, curved outward, tapering. Abdomen 8-segmented; minute spiracles on segments 2–6. Prominent setulae present dorsally along anterior margins of segments 2–8.

Adult yellowish (Fig. 10).

Life History

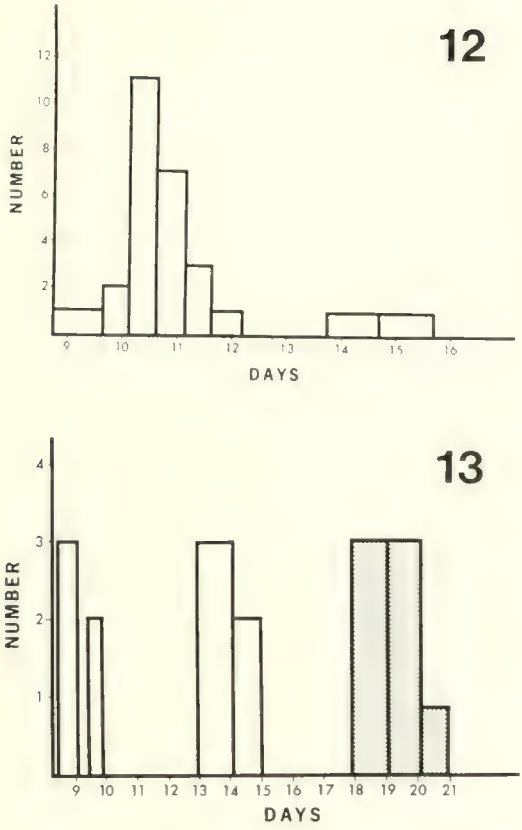
Eggs may be deposited on swollen, partly opened, or fully opened vegetative buds throughout most of the growing season but may also be placed on dormant flower buds in early autumn. Clutch size is variable (mean = 6.66, SD = 5.51, range = 1–29, n = 35). Eggs are most often deposited on the undersurfaces or rolled edges of leaves as soon as they are free from the bud but before they have fully separated from each other. Eggs are not deposited in a specific orientation but may adhere to a leaf along their lengths, on end, or obliquely, and are often attached to each other in irregular clumps.



Figs. 3–7. *Clinodiplosis rhododendri* (mature larva). 3, Anterior segments, ventral view (SS = spatula, SR = spinule rows). 4, Posterior segments, ventral view (AN = anus). 5, Head. 6, Mouthparts (LM = labrum, MX = maxilla, LB = labium). 7, Rows of spinules. The barren area within the rows shows the location of an asetose, anterior ventral papilla. Scale bars for Figs. 3, 4 represent 0.25 mm; all others represent 10.0 μm.

Figs. 8–11. *Clinodiplosis rhododendri*. 8, Damage to very young leaves of a *Rhododendron catawbiense* hybrid. Larvae are present in the rolled leaf margins. Note swollen, necrotic areas and necrotic lesions. 9, Eggs on undersurface of an expanding leaf. 10, Adult female. 11, Mature pupa with broken cocoon. Scale bars for Figs. 8, 9 represent 10.0 mm, 0.5 mm, respectively; those for Figs. 10, 11 represent 1.0 mm.

A female may deposit several clutches on the same developing leaf, distribute them among other leaves in the same whorl, or deposit them on different plants. Females readily oviposit on leaves and buds already bearing clutches from other females. In an outbreak situation 272 eggs were found on one swollen vegetative bud. Oviposition was



Figs. 12–13. *Clinodiplosis rhododendri.* 12, Adult emergence following placement of mature larvae in moist sand on day 0. 13, Emergence of *C. rhododendri* (white bars) and *Platygaster* sp. (shaded bars) following placement of mature larvae in moist sand on day 0.

never witnessed during frequent trips to Site 2 between 10:00 AM and 7:00 PM. Eggs hatch in ca. 3 days.

Upon hatching a larva crawls into a loosely inrolled margin of a developing leaf and begins feeding on the abaxial surface; this feeding usually induces a strong inrolling of the leaf margin. Most leaf rolls are moist to wet inside. Larvae that have hatched on swollen vegetative buds crawl into the bud to feed on all surfaces of developing leaves. Larvae infesting flower buds usually feed on the outer bud scales. Larvae do not move from leaf to leaf but are restricted to feeding on the leaf on which they hatched.

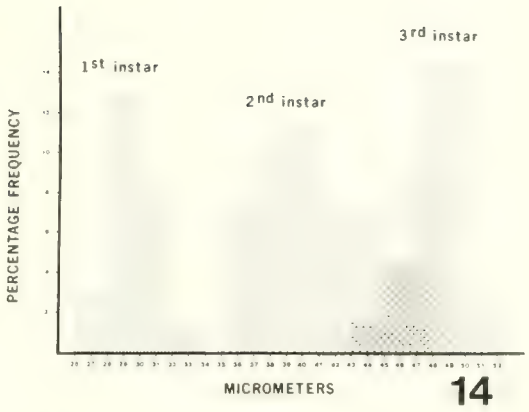


Fig. 14. *Clinodiplosis rhododendri.* 14, Frequency distribution of larval head capsule widths. Note overlap between second and third instars.

Larvae pass through three instars (Fig. 14). Head capsule widths of the second and third instars overlap. The third-instar larva is distinctive, however, due to the presence of the spatula.

All larval stages are motile but require a film of water for sustained locomotion. Larval development takes ca. 7 days. Mature larvae crawl out of damaged leaves or buds and either drop to the ground or descend from the leaves on silken threads (pers. observation). They burrow into the top 2 cm of soil and construct a flimsy, silken cocoon (Fig. 11). Cocoons, which were not found at depths exceeding 2 cm, are covered with soil particles that adhere tightly; in sandy soils cocoons and adhering particles are approximately ellipsoidal, ca. 2.5 mm in length. Larvae moult into pupae ca. 7 days after burrowing into the soil. The mature pupa breaks out of the larval cocoon, probably with the aid of its antennal processes, and wriggles to the soil surface where ecdysis to the adult occurs. Laboratory rearings suggest that ca. 11 days elapse from the time mature larvae drop to the soil until adults emerge (Fig. 12). A few adults emerged at 14–15 days.

Adults emerge during the night or early morning; peak emergence of 27 laboratory-reared adults occurred between 9:00 PM and

8:00 AM. Five adults were observed in the field between 4:50 AM and 6:20 AM on 25 August 1979 at Site 2, but none were seen during frequent visits between 10:00 AM and 7:00 PM. Adults were observed to walk upon plant surfaces with quick, jerky movements. They frequently flew from plant part to plant part. The longevity of adults in the laboratory was ca. 3 days for females and 1 day for males. The sex ratio is female-predominant; 76% of 25 laboratory-reared adults were female. A binomial proportion test (Snedecor and Cochran 1967) indicated that the observed proportions were significantly different from a 1:1 ratio ($\chi^2 = 5.76$, df = 1, $P < 0.025$). Fecundity was variable (mean = 34.5 eggs/female, SD = 11.5, range = 10–51, n = 10).

Throughout this study the only nursery-grown plants observed to be hosts of *C. rhododendri* were hybrids of the Catawba rhododendron, *R. catawbiense* Michaux. All such hybrids observed in the field served as host plants. The two most widely grown hybrids, 'Nova Zembla', and 'Roseum Elegans', appeared to be equally susceptible to attack; a binomial proportion test (Snedecor and Cochran 1967) indicated that the proportion of damaged flower buds was not significantly different for these two hybrids ($\chi^2 = 0.153$, df = 1, $P = 0.70$). *Clinodiplosis rhododendri* was found on wild *R. maximum* at Livingston Manor, Sullivan County, NY during the summer of 1982.

Seasonal History

On 10 May 1980, plants at Site 2 exhibited slight swelling of vegetative buds. Adults, eggs, or larvae of *C. rhododendri* could not be found on any plant part. On 19 May most vegetative buds were swollen (a small number had opened) while flower buds were beginning to swell. A female of *C. rhododendri* was found stuck to a swollen flower bud and a male and female were found stuck to a partly opened vegetative bud. By 24 May many plants were beginning to flower. Although no evidence of *C. rhododendri* was found in a random sample of 25 swollen and opened vegetative buds, an adult was found in an emergence trap for the first time. By 27 May most vegetative buds had opened and leaves were enlarging. Most plants were in full bloom. The number of adults caught in emergence traps peaked at this time (n = 6). Leaves damaged by *C. rhododendri* were first found on 2 June. These contained mostly first-instar larvae but also second and third instars, and in some cases leaves had already been vacated. The last adults from the overwintering generation were found in an emergence trap on 5 June.

Eggs were first observed on 29 May 1980 at Site 2. A single clutch of 16 eggs was found in a random sample of 40 expanding vegetative buds. On 2 June, two buds (of 20 randomly sampled) bore small clutches. Three days later six of 20 buds yielded a total of 120 eggs. Oviposition during this period increased logarithmically (For log % of vegetative buds bearing eggs vs. time, r = 0.993). The observed increase in the magnitude of the infestation could have been due to two phenomena: 1) a prolonged, increasing emergence of overwintering adults, or 2) oviposition by a subsequent, larger generation of gall midges.

On 19 June 1980, a much greater number of mature, brightly colored larvae were noted than had been found previously. Many of these larvae were present in severely damaged leaves that had become necrotic and dry and which thus provided little or no food. On 25 June, only mature larvae occupied the leaves. During this period the weather was dry, the last rain having occurred on 10 June. On 28 June, 10 damaged leaf whorls were randomly sampled for larvae; nine of these had 48 brightly colored mature larvae distributed among them. Eggs or immature larvae were not found. Heavy rain fell on 29 June. The next day a random sample of 10 damaged leaf whorls yielded no larvae of any age. The larvae had apparently been in aestivation in the leaves for at least 10 days. Dry necrotic leaves con-

taining mature larvae were brought into the laboratory and stored in a paper bag under dry conditions for 16 days. At the end of this period larvae were removed from the dried leaves and observed with a dissecting microscope. The larvae were motionless and appeared dead, but with the addition of water began moving. A number of these larvae developed into adults. It appears that free water, such as is supplied by rain, is required for larvae to vacate the leaves. In the prolonged absence of rain, larvae aestivate.

The early seasonal history of *C. rhododendri* is characterized by a close synchrony with the development of its host plant. Adults of the overwintering generation begin to emerge as vegetative buds swell, and peak emergence appears to occur during full bloom. During this time there is no intraspecific competition for the many enlarging vegetative buds as very few insects are present. Subsequent generations of the gall midge more fully utilize the large number of enlarging buds. Intraspecific competition for oviposition sites begins at this time and may continue for the remainder of the season. *R. catawbiense* hybrids usually produce two flushes of growth per season but only the spring flush is seasonally synchronized; the second flush may occur at any time between July and September. The gall midge population, which increases greatly during the spring flush, is faced with a reduced and temporally discontinuous resource for the remainder of the season, resulting in a loss of synchrony between insect and host plant. For example, on 28 June, 272 eggs were found on one of the few remaining vegetative buds present in the nursery.

As autumn approaches, an increasing percentage of the larval population does not pupate following cocoon construction but instead enters diapause until following seasons. Twelve percent of 50 last-instar larvae collected at Site 2 on 25 August 1980 did not pupate. In contrast, all of 20 last instar larvae collected at Site 1 on 26 June 1979 developed into adults within 12 days. On 20 September, almost every plant had completed growth for the season although a few enlarging vegetative buds could still be found. Surprisingly, eggs occurred on these buds. Based on field observations and laboratory rearings, by this time five generations of the gall midge may have developed. On 14 October 1979, mature and penultimate-instar larvae were found although most of these were in necrotic, dry leaves and probably were not feeding. An examination of dormant flower buds revealed small necrotic lesions in the outer tissues of some buds. A few of these damaged buds contained mature larvae. Oviposition had apparently occurred on these flower buds in the absence of suitable vegetative buds, and some of the larvae had matured and dropped to the soil to overwinter. Mature larvae remaining in flower buds would be expected to overwinter there because of the time of year and their marked inactivity. A random sample of 53 flower buds taken on 10 April the following spring contained a total of 12 larvae, five of which were alive. Seventeen buds showed evidence of damage. Four of the living larvae were found in one bud.

Natural Enemies

No natural enemies of *C. rhododendri* have been previously identified. Field and laboratory observations suggest that natural enemies are relatively insignificant as control agents during most of the seasonal history of the insect. A random sample of 40 mature larvae collected at Site 1 on 25 August 1979 yielded only two parasitized individuals. No other incidences of parasitism or predation were observed at Site 1. The effect of natural enemies was greater at Site 2, but appeared to be confined to the late seasonal history of the insect.

A male pteromalid, possibly of the genus *Callitula* Spinola, was reared from an ectoparasitic larva found on a mature gall midge larva collected on 25 August 1979 at Site 1. The adult parasitoid eclosed ca. 9

days after the gall midge larva was placed in moist sand, or ca. 1 day before the peak emergence of the gall midge cohort. The parasitized larva failed to construct a cocoon or pupate.

Two male parasitic wasps of the genus *Platygaster* Latreille were reared from a mature gall midge larva collected on 25 August 1979 at Site 1. The platygasterids were endoparasitic, and pupated in a head-to-head position within the cuticle of their host. The parasitized larva successfully constructed a cocoon. The parasitoids emerged ca. 8 days after the peak emergence of the gall midge cohort.

A single encyrtid wasp, probably of the genus *Copidosoma* Ratzeburg, emerged from a sample of infested leaves collected on 26 August 1980 at Site 2. A pteromalid, possibly of the genus *Mesopolobus* Westwood, was also recovered from the same sample.

A species of *Platygaster* was commonly recovered from mature larvae collected on 26 August 1980 at Site 2. Ten of 30 gall midge larvae in one sample and 15 of 50 in another were parasitized by this wasp. In all cases one individual pupated per host, in contrast to the *Platygaster* sp. reared from Site 1, where two individuals pupated within one larva.

Sixteen of 25 parasitized larvae successfully constructed cocoons, although all died shortly thereafter. All of the parasitoids emerged after the peak emergence of the gall midge cohort (Fig. 13).

The anthocorid bug *Orius insidiosus* (Say) was abundant in infested leaves collected on 26 August 1980 at Site 2. It was probably feeding on mature larvae present in the leaves, although feeding was not observed. No other predators were observed.

Infestation and Damage

The rhododendron gall midge is an occasionally serious, but not commonly encountered pest in nurseries on Long Island. It has not been reported to be a pest in home plantings.

The distribution of this insect at both study sites was strongly clumped. At Site 2, groups of non-infested and very lightly infested plants could be found within 10 m of heavily infested ones. Five emergence traps were placed 2–3 m apart in a 72 m^2 bed of 4-yr old plants on 25 June 1980. Three days later the number of adults in each trap was as follows: 4, 0, 1, 0, 156. Barriers such as woods, fence rows, and non-host plantings seem to limit infestations. The infestation at Site 1 was limited to a 2-ha field of stock plants. A large number of container-grown plants, separated from the infested field by ca. 275 m of wooded fence-rows and non-host plantings, were not infested. It appears that the active dispersal capability of this insect is small.

Infestations usually remain at a low level, but under favorable conditions can increase dramatically. A 72 m^2 bed of 2-yr old plants growing in a screen house at Site 2 was infested so severely that no growth occurred, resulting in the destruction of the plants by the nurseryman.

Serious infestations of the rhododendron gall midge tend to be short-lived. This may be a function of variables such as rapid turnover of nursery-grown plants, use of insecticides, adverse environmental conditions caused by weather and cultural practices, and natural enemies. The owner of the nursery at Site 1 first noticed gall midge damage in 1976. The severity of damage increased each year until 1980, when it was markedly diminished. Various insecticides were applied to the plants during this period. The owner of the nursery at Site 2 first noticed damage in 1979. Severity increased greatly in 1980. The insecticide diazinon, applied as a soil-drench in the spring of 1981, reportedly gave good control of the pest. Whitman Wholesale Nurseries, Suffolk Co., NY, sustained damage by this pest on container-grown plants in 1978. The insecticide lindane was applied to the plants three times during the year. The gall midge could not be found at this nursery in 1979.

Various types of damage may result from the feeding of *C. rhododendri* depending on the number of larvae present and the development stages of affected parts. Leaves that are heavily attacked while still in the bud are severely damaged and normally die before attaining a length of 6 cm. Leaves thus affected exhibit swollen, chlorotic areas and necrotic lesions (Fig. 8). Leaves attacked while free of the bud may reach full size but become deformed. On these leaves small (ca. 1 mm^2), chlorotic lesions are produced in affected areas. All infested leaves develop an inrolling of one or both margins and become contorted. Damaged areas of leaves become necrotic with time. Larvae feeding within flower buds produce necrotic lesions in the outer bud tissues.

Discussion

Bionomics: The biology of *C. rhododendri* is similar to that of the leaf-curling pear midge, *Dasineura pyri* (Bouche). Both species are multivoltine, oviposit on newly expanding leaves, cause leaf margins to roll on woody plants, and overwinter as mature larvae in the soil (Barnes 1935). The tendency toward restriction of emergence, mating, and oviposition activities of gall midges to the night and early morning hours has been reported by many workers, including Weigel and Sanford (1920), Walter (1941), and Coutin and Harris (1968). This restriction of adult activities is advantageous for at least two reasons: 1) it minimizes the disruptive effects of wind, the primary dispersal agent for the higher gall midges (Mamaev 1968), and 2) it minimizes the potential for desiccation, especially during emergence. The short adult life of *C. rhododendri* is common to other cecidomyiids (Weigel and Sanford 1920, Walter 1941, Azab et al. 1965, Brewer 1971, Ranasinghe 1977). Another aspect of the biology of *C. rhododendri* that is shared by other cecidomyiids is a female-predominant sex ratio (Sasscer and Borden 1919, Barnes 1935, Walter 1941, Redfern 1975, Ranasinghe 1977). *Clinodiplosis rhododendri* appears to be native to the northeastern United States as it has been found on wild *R. maximum* in both the Catskill mountains of New York and the Pocono mountains of Pennsylvania. It has not been recorded to occur outside of this area on a wild host, nor has it been recorded from any other wild host. It has been found on cultivated hosts in nurseries from Maryland north to Massachusetts. *R. maximum, R. catawbiense, R. ponticum, R. caucasicum* Pallas, *R. arboreum* Smith, and *R. smirnowii* Trautvetter are all reported to be parent species of *R. catawbiense* hybrids. *C. rhododendri* has been reported to occur on *R. ponticum* in nurseries (White 1933).

Phenology: The seasonal history of *C. rhododendri* is similar to that of other cecidomyiids. The emergence of adults in spring coincides closely with the development of their host plant. Synchrony between gall midges and host plants has been reported by Bishop (1954), Gable et al. (1959), and Coutin and Harris (1968). Coutin (1964) reported that for many species the behavior of ovipositing females and the duration of oviposition are governed by the floral biology of the host. The seasonal buildup of large populations of *C. rhododendri* is common to other gall midges as well. Barnes (1940) reported that over 2000 individuals of *Diarthronomyia chrysanthemi* Ahlberg may develop in one chrysanthemum plant. The number of larvae of *Contarinia pseudotsugae* Condrashoff developing in a single Douglas-fir shoot is usually over 2000 (Condrashoff 1962). The aestivation of mature larvae of *C. rhododendri* during dry weather also resembles the behavior of other gall midges. Bishop (1954) reported that mature larvae of *Dasineura gentneri* Pritchard remain in clover florets for variable intervals, dependent on weather conditions. During damp or rainy weather there is a tendency for the larvae to vacate the florets shortly after reaching maturity. During dry weather some larvae may remain in the florets for a week or more. Barnes (1952b) showed that

fully fed larvae of *Contarinia tritici* (Kirby) need moist conditions in order to descend from damaged wheat plants to the soil. Dry weather during the maturation of larvae results in an assemblage of larvae in damaged plants that vacate the plants en masse when rain comes. These same conditions are required by *C. rhododendri.* Diapause of mature larvae during autumn and winter is a common aspect in the seasonal history of many gall midge species, including *C. rhododendri.* Barnes (1935) noted that in the multivoltine species *D. pyri,* varying proportions of the larvae of the second, third, and fourth generations entered diapause until the following spring. He also demonstrated that larvae of *C. tritici* could spend two winters in diapause, those of *Sitodiplosis mosellana* (Gehin) three winters (Barnes 1943), and later (Barnes 1952a) showed that *S. mosellana* may diapause for up to 12 years. The late season utilization of flower buds as an alternate resource by *C. rhododendri* appears to be unrecorded for other cecidomyiids.

Natural enemies: Species of *Platygaster* have been recorded from other cecidomyiids by a number of workers (Brewer 1971, Coutin and Harris 1968, Houseweart and Brewer 1972, and Ranasinghe 1977). Most platygasterids are parasitoids of cecidomyiid larvae (Borror et al. 1976). Both Coutin and Harris (1968) and Barnes (1935) observed predation of gall midge larvae by Anthocoridae.

Acknowledgments

We thank Richard Vrana, Springs Nursery, L.I., and Kenneth Graham, Graham's Nursery, L.I., for granting permission to use their nurseries as study sites. Raymond J. Gagné (Systematic Entomology Laboratory, USDA) identified *C. rhododendri* and Norman F. Johnson (Ohio State University) its parasitoids. Donald Steinkraus (Cornell University) was of valuable assistance in preparing the plates and in microscopy. Robert G. Mower (Cornell University) provided information on cultivated host plants. We especially are indebted to Donald B. Zepp (Rhone-Poulene, Inc.) for his constant assistance in carrying out this study. We thank E. Richard Hoebeke (Cornell University) for reviewing the manuscript.

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MALE FORETARSAL VARIATION IN LYCAENIDAE AND RIODINIDAE, AND THE SYSTEMATIC PLACEMENT OF *STYX INFERNALIS* (LEPIDOPTERA)

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Abstract.—I describe and illustrate male forelegs, particularly the tarsus, of Lycaenidae, Riodinidae, and *Styx infernalis*, and note seven characters: (1) whether the male foreleg is used for walking, (2) presence or absence of pretarsal claws, (3) number of tarsomeres, (4) distribution of scales on the tarsus, (5) whether scales lie flat on the tarsus, (6) presence or absence of tarsal spines (A-Type trichoid sensilla) and (7) distribution of B-Type trichoid sensilla on the tarsus when present. Previous descriptions of the male foretarsus and pretarsus of riodinids and *Styx* were inaccurate, including a reported pretarsal claw in *Styx*. Characters of the *Styx* male foreleg are either shared with riodinids or are unique. This conclusion supports Harvey's classification of *Styx* as a riodinid, and is inconsistent with Ehrlich's and Scott's phylogenies to the butterfly families.

Key Words: leg characters, butterfly classification, Lycaenidae, Riodinidae, *Styx*

Morphology of the male foretarsus and pretarsus in the butterfly, *Styx infernalis* Staudinger, has been disputed. Ehrlich (1958) distinguished the male foretarsus and pretarsus of *Styx* from those of Riodinidae. He reported that male *Styx*, a monobasic genus from the eastern Andes of Peru, has a segmented foretarsus whereas riodinids have a fused male foretarsus. He noted a pretarsal claw (and possibly a second one that had been broken in the one foreleg that he had available for study) in *Styx* but not in riodinids (with rare exceptions). Forbes (1960:138), on the other hand, stated, "It is said that the South American *Styx infernalis* has developed legs in both sexes; in fact . . . the true male . . . has the proper reduced legs" of a riodinid. Harvey (1987) partially resolved this controversy by reporting that male riodinids may have a segmented tarsus and that male *Styx* lacks pretarsal claws.

The systematic position of *Styx* has likewise engendered controversy. Ehrlich (1958) erected a monobasic subfamily for *Styx* of rank equal to the Riodinidae (his Riodininae) and Lycaenidae (his Lycaeninae) on the basis of differences in the male forelegs and some other characters. This classification has been followed by many subsequent authors (e.g. Common and Waterhouse 1982, Ackery 1984). Further, using some of Ehrlich's results, Scott (1985) proposed a cladogram in which *Styx* is the first taxon to split off from a lineage leading to the Lycaenidae and Riodinidae.

The classification and phylogenies of Ehrlich (1958) and Scott (1985) have been questioned. Harvey (1987) placed *Styx* in the Riodinidae on the basis of two shared, derived character states: female foretarsal trichoid sensilla clustered centrally, not laterally, and lack of apophyses posteriores on the female genitalia. I (Robbins 1988) reported that *Styx* and Riodinidae (with the

exception of the Old World genus *Laxita* Butler) are the only butterflies that share the loss of a cluster of trichoid sensilla on the dorsal posterior inner face of the male foreleg trochanter, which supports Harvey's placement of *Styx* in the Riodinidae. Scott and Wright (1988) placed *Styx* in the Riodinidae (their Riodininae) "for the moment." I (Robbins 1987b) reported that Scott (1985) did not analyze the distribution of male lycaenid and riodinid foretarsal character states parsimoniously, casting doubt on his phylogeny.

The purposes of this paper are (1) to describe and illustrate the male foretarsal morphology of the Lycaenidae (*sensu* Eliot 1973), Riodinidae (*sensu* Stichel 1910–1911), and *Styx*, (2) to resolve the differing results of Ehrlich, Forbes, and Harvey, (3) to detail the qualitative differences in male foreleg morphology of Riodinidae and Lycaenidae, and (4) to use this information to assess the classifications and phylogenies of Ehrlich, Scott, and Harvey.

The scanning electron microscope (SEM) provides an opportunity to study leg structures in a detail not available to many previous authors, and I have made extensive use of it. I describe morphology of the male lycaenid and riodinid foretarsi by citing previous results and adding my new findings. I then report the morphology of the male foretarsus of *S. infernalis*.

Materials and Methods

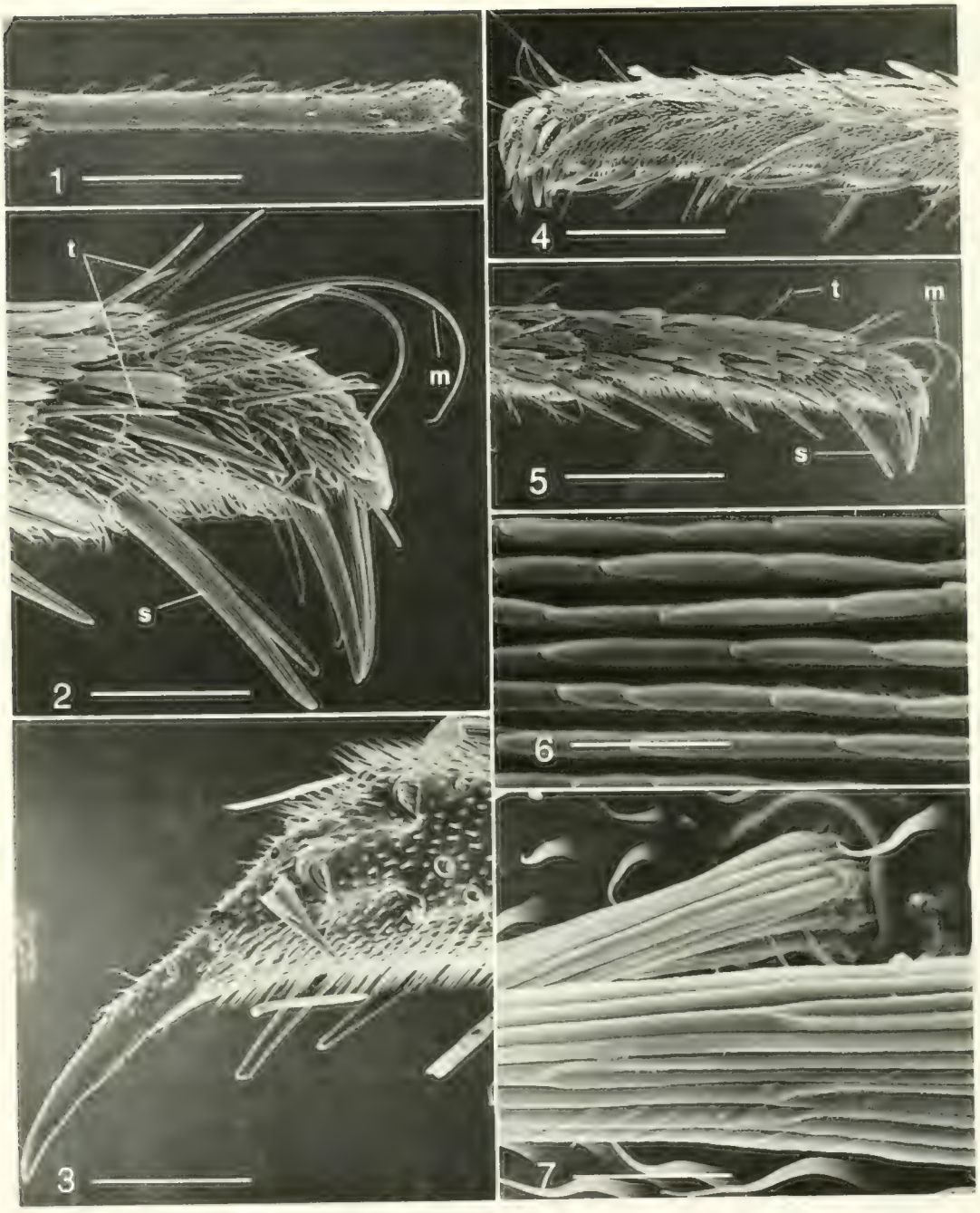
I used specimens in the collection of the National Museum of Natural History for study except for males of *Styx infernalis*. Gerardo Lamas (Lima, Peru) loaned me a male specimen with both forelegs intact, and Phil Ackery (British Museum of Natural History) sent me Ehrlich's dissection of a male with one unbroken foreleg.

I prepared forelegs for study by briefly wetting them in 80% ethanol, soaking them in 10% potassium hydroxide for 24–48 hours, and rinsing them in water or ethanol. In some cases, I removed some or all scales using fine watchmaker forceps and a brush with stout bristles. Specimens for the SEM were soaked for 10 minutes in absolute ethanol before being mounted on stubs, which were coated with carbon and gold.

Male Foretarsus and Pretarsus

Lycaenidae (*sensu* Eliot 1973).—The lycaenid male foreleg is unique among the butterflies. With few exceptions (see below), it lacks pretarsal claws (Bates 1861) (Figs. 2, 3), and its tarsus is fused (Bates 1861) (Fig. 1), ends in a stubby (Fig. 2) or down-curved point (Clench 1955, Eliot 1973) (Fig. 3), and possesses A-Type and B-Type trichoid sensilla (terminology from Ma and Schoonhoven 1973). A number of authors (Sibatani 1974, Higgins 1975, Miller and Brown 1979) reported a single pretarsal claw, but I found no structure that fits Snodgrass's (1935) description of a pretarsal claw, and believe that these authors misconstrued the down-curved point at the tarsal tip reported by Clench and Eliot in some lycaenids (Fig. 3). Scales cover the dorsal and lateral surfaces of the lycaenid male foretarsus, but not the distal ventral surface, where many trichoid sensilla occur (Fig. 4). Further, scales lie relatively flat on the tarsus surface so that B-Type trichoid sensilla are not covered by scales (Fig. 5). Lycaenid forelegs are used for walking (Bates 1861, Ford 1945) although a number of popular books mistakenly state the opposite (Howe 1975, Pyle 1981). Scales usually have longitudinal ridges with shingled and distally tapered scutes (Downey and Allyn 1975) (Fig. 6). These structures are not reported in trichoid sensilla, and in lieu of better evidence, I use them to distinguish scales from trichoid sensilla. I describe below the A-Type and B-Type trichoid sensilla on lycaenid male forelegs as well as distinctive setae that also may be trichoid sensilla.

(1) A-Type trichoid sensilla (spines).—Spines are stout trichoid sensilla, sometimes called "bristles," that have fluted sides and occur primarily on the ventral surface



Figs. 1–7. Male lycaenid foretarsus. 1. "*Theritas*" *augustinula* Strand, dorsum, scales removed to show lack of segmentation. Scale line 600 microns. 2. *Calycopis cecrops* Fabricius, lateral view, stubby tip, spine (A-Type trichoid sensillum, labelled s), "macrotrichion" (m), B-Type trichoid sensilla (t), and lack of pretarsal claws. Scale line 60 microns. 3. *Lycaena editha* Mead, lateral view, down-curved point at tip. Scale line 75 microns. 4. "*Theritas*" *theocritus* Fabricius, ventro-lateral aspect, no scales on ventral surface, empty sockets of removed scales on lateral surface. Scale line 200 microns. 5. *C. cecrops*, lateral view, spine (A-Type trichoid sensillum, s), "macrotrichion" (m), and B-Type trichoid sensillum (t), which extends beyond scales that lie flat on the tarsus. Scale line 176 microns. 6. "*T.*" *theocritus*, scale showing scutes of longitudinal ridges, base of scale to right. Scale line 3 microns. 7. "*T.*" *Theocritus*, fine structure spines. Scale line 12 microns.

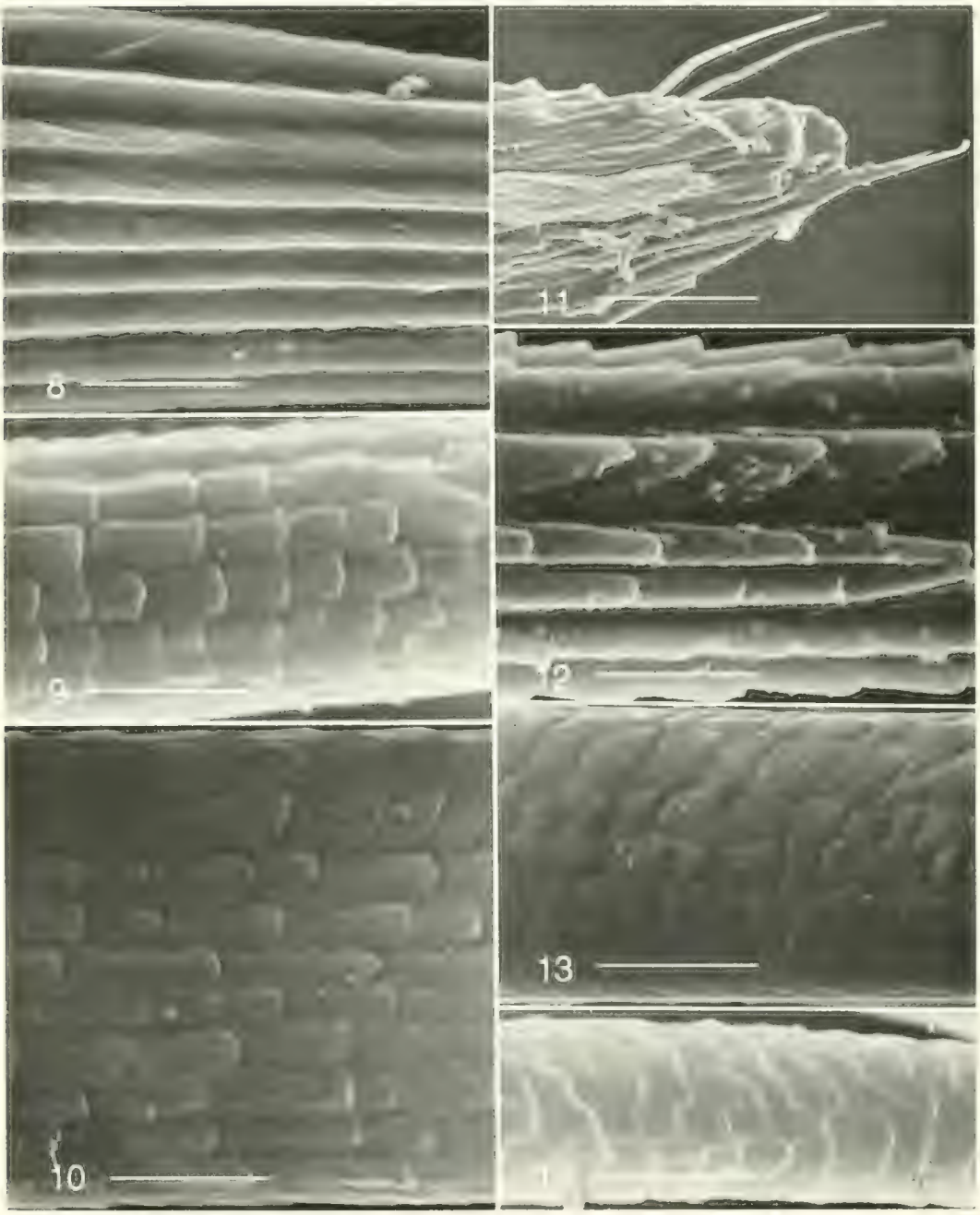
of the lycaenid foretarsus (Bates 1861) (Figs. 1–5, 7, 8) and other legs. Histology of spines in nymphalids (Eltringham 1933) and neurophysiology from nymphalids and pierids indicate that they are mechanoreceptors (Morita et al. 1957, Ma and Schoonhoven 1973). Those on female butterfly foretarsi are associated with clustered B-Type trichoid sensilla, and are apparently used to abrade leaves (reviewed in Chew and Robbins 1984), but may also be mechanoreceptors. Superficially similar spines occur on the ventral abdomen of some lycaenids and riodinids (Clench 1955, Inoue and Kawazoe 1966, Eliot 1973, Harvey 1987) and on butterfly antennae (Myers 1968, Grula and Taylor 1980), where they are presumed to be mechanoreceptors (Odendaal et al. 1985). Spines on legs and antennae always seem to occur in association with B-Type trichoid sensilla, as they do on the venter of the female abdomen in the lycaenid, *Curetis* Hübner (Robbins unpubl.).

(2) B-Type trichoid sensilla.—These sensilla are scattered over the dorsal, lateral, and ventral sides of the lycaenid male foretarsus (Figs. 1, 2, 4, 5). At magnifications below about 1000 times, B-Type trichoid sensilla on male lycaenid foretarsi appear to be smooth-walled (Robbins 1987a) (Fig. 2), but at magnifications above about 8000 times, they have a variable fine structure (Figs. 13, 14). It is unclear in the absence of histological and neurophysiological data whether there is one kind of B-Type trichoid sensillum on male lycaenid foretarsi with variable surface structure or if there are several morphologically and functionally different types. Another fine structure, in which there are ringed indentations (Fig. 15), occurs on female lycaenid foretarsi, but I have not found them on male lycaenid foretarsi. Undoubtedly, histological and neurophysiological techniques will be needed to establish homologies.

B-Type trichoid sensilla on butterfly legs are chemosensory and mechanosensory. Lycaenids extend their proboscis when their tarsi are exposed to water or sugar water (Anderson 1932), and Hodgson (1958) showed that trichoid sensilla respond neurophysiologically to sodium chloride, sucrose, and tactile stimulation. It has not been specifically demonstrated, however, that the B-Type trichoid sensilla on the lycaenid male foreleg are chemosensory, although this is a reasonable inference. Similar sensitivity among B-Type trichoid sensilla to water, sugars, sodium chloride, and tactile stimulation has been shown for a variety of butterflies (reviewed in Fox 1967), and Eltringham (1933) presented a histological description of these sensilla. Ma and Schoonhoven (1973) described the histology of a clustered B-Type sensillum on the female pierid foretarsus, and demonstrated that these clusters are sensitive to plant secondary compounds, water, sodium chloride, and tactile stimulation.

(3) "Macrotrichia."— Clench (1955) noted that a pair of long setae, which he termed "macrotrichia," occurs on the dorsal surface of the male lycaenid foretarsus just basal to the tip (Figs. 2, 5). Their surface structure at higher magnifications is distinctive (Figs. 9, 10), and these markings are often more pronounced towards their distal end. Whether these setae are scales or sensilla is currently unknown. Superficially similar structures are found in most other butterflies, even male Ithomiinae (Nymphalidae) that have the tibia and tarsus fused into a short segment (Fig. 11). In *Phoebis* Hübner (Pieridae), the analagous structures have scale-like longitudinal ridges and scutes (Fig. 12), similar to some piliform scales (Brown & Miller 1983). Kuznetsov (1967) illustrated similar structures in a sphingid and arctiid, termed them "setae" or "ungal bristles," and reported that their number varies in Lepidoptera from 2–10 and is "of definite taxonomic importance."

Some male lycaenids have a five-segmented foretarsus and pretarsal claws, which apparently have evolved at least four times in the Theclinae and perhaps once in the



Figs. 8–14. Male foretarsi. Socketed base of sensillum to left in figures of their fine structure. 8. *Atlides halesus* Cramer (Lycaenidae), fine structure spine (A-Type trichoid sensillum). Scale line 6 microns. 9. *C. cecrops* (Lycaenidae), fine structure "macrotrichion." Scale line 2 microns. 10. *A. halesus* (Lycaenidae), fine structure "macrotrichion." Scale line 2 microns. 11. *Pagyris cymothoe* Hewitson (Nymphalidae: Ithomiinae), apex of fused foretarsus and tibia with "macrotrichia." Scale line 33 microns. 12. *Phoebis sennae* Linnaeus (Pieridae), fine structure "macrotrichion." Scale line 2.5 microns. 13. *A. halesus* (Lycaenidae), surface structure B-Type trichoid sensillum. Scale line 2 microns. 14. *C. cecrops* (Lycaenidae), surface structure B-Type trichoid sensillum. Scale line 2 microns.

Liphyrinae + Miletinae (Eliot 1973). Eliot (1973) suggested that if the "genes" for a segmented foretarsus and clawed pretarsus were on the Y chromosome, then crossing over with the X chromosome might account for its repeated evolution in males. However, the segmented male foretarsus lacks the clusters of B-Type trichoid sensilla found on female foretarsi, at least in *Theclopsis* Godman and Salvin (Figs. 16, 17), casting some doubt on this hypothesis.

Riodinidae (*sensu* Stichel 1910–1911).—Unlike the male lycaenid foretarsus, the male riodinid foretarsus is not used for walking (Bates 1861, Ford 1945), and is covered dorsally, laterally, and ventrally with elongate scales (the so-called "brush foot") (Figs. 18–21). It has from 1 to 4 tarsomeres (Godman and Salvin 1879–1886, Scott 1985) (Figs. 18–21), contrary to Ehrlich's findings, but segment partitions are sometimes incomplete (Godman and Salvin 1879–1886, Powell 1975), making a count of the number of tarsomeres somewhat arbitrary. The male riodinid pretarsus is like that of lycaenids in that it lacks claws (Figs. 18–21). Godman and Salvin (1879–1886) reported male pretarsal claws in *Apodemia nais* Edwards, but the three specimens that I examined lacked them. I have not seen any riodinid with male foreleg pretarsal claws, but remnant ones may occur in some species.

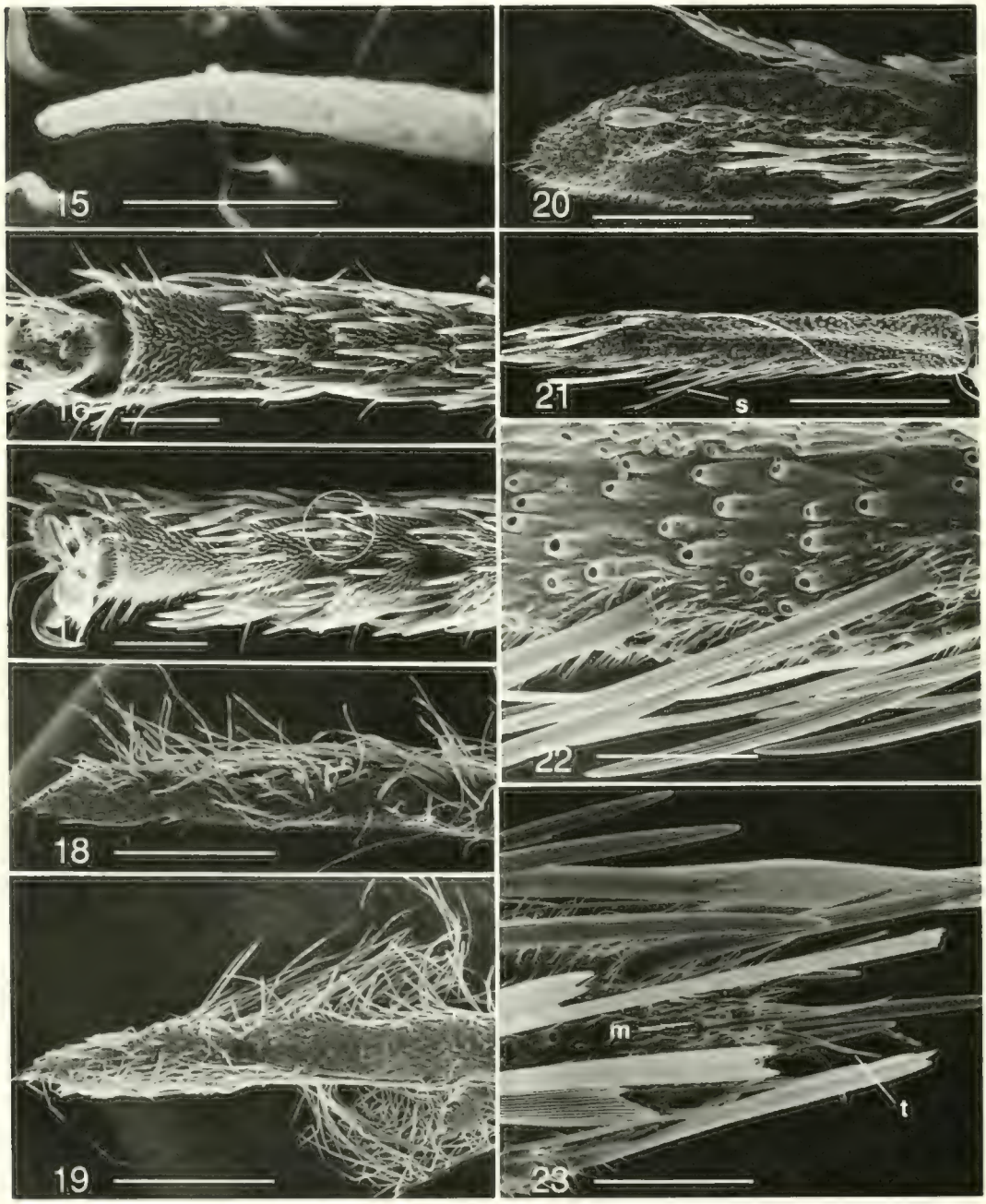
The occurrence of spines (A-Type trichoid sensilla) on male foretarsi differs between lycaenids and riodinids. Male riodinids lack foreleg spines (Bates 1861) (Figs. 18–20) although I examined one male of *Emesis* with a spine on one foretibia and none on the other. A striking exception is males of *Sarota* Westwood (Harvey 1987), which have many foretarsal spines (Figs. 21, 22).

The distribution of B-Type trichoid sensilla differs markedly between lycaenid and riodinid male foretarsi. B-Type trichoid sensilla are absent from the male riodinid foretarsus except at the distal end of the tarsus where "macrotrichia" also occur. These sensilla are difficult to discern because they do not extend beyond the scales covering the tarsus as they do in lycaenids. I usually find one or two "macrotrichia" at the tarsal tip (Figs. 23, 25–27), and sometimes a few B-Type trichoid sensilla (Figs. 23, 24). Many setae on the tarsus resemble B-Type trichoid sensilla at lower magnifications, but at higher magnifications appear to be scales with longitudinal ridges and scutes (Fig. 28). It is not known whether the B-Type trichoid sensilla on the riodinid foretarsus are neurophysiologically active.

All riodinid male foretarsi may have B-Type trichoid sensilla and "macrotrichia" at the tip even though I could not find them in all preparations. Some scales have to be removed to see them, and in these cases, I may have removed them with the scales. However, the restricted occurrence of B-Type trichoid sensilla on the distal tarsus where they are intermixed with elongate scales, whether or not these sensilla are present in all riodinid species, is quite different from their distribution in lycaenids, as described above. Further, even though male *Sarota* have spines similar to lycaenids, their B-Type trichoid sensilla are distributed according to the riodinid pattern (Figs. 22–24).

Styx infernalis.—The structure of the male *S. infernalis* foretarsus and pretarsus is similar to those of riodinids in some respects, and is unique in others. The *Styx* male foreleg pretarsus lacks claws (Harvey 1987) (Figs. 29, 30), and in that respect, is the same as riodinids and most lycaenids. There is a lightly sclerotized structure at the tip of the tarsus that may be a remnant of the pretarsus (Figs. 29, 30), perhaps homologous with the arolium. No riodinids have such a structure. The distal edge of the lightly sclerotized structure at the tip of the tarsus appears dark under a light microscope, and may account for Ehrlich's report of a single pretarsal claw.

The male riodinid foretarsus segmentation is unusual. One specimen (the Ehrlich dissection) has two tarsomeres with an indication of two other partitions while the



Figs. 15–23. Foretarsi. 15. female *Liptena libyassa* Hewitson (Lycaenidae), fine structure clustered B-Type trichoid sensillum. Scale line 10 microns. 16. male *Theclopsis murex* Druce (Lycaenidae), ventral aspect, segmented, but no clustered B-Type trichoid sensilla. Scale line 100 microns. 17. female *T. murex* Druce (Lycaenidae), ventral aspect with lateral cluster of B-Type trichoid sensilla (circled). Scale line 100 microns. 18. male *Melanis pixe* Boisduval (Riodinidae), lateral aspect with most elongate scales on lateral and ventral surfaces removed (sockets visible), four tarsomeres. Scale line 380 microns. 19. male *Emesis mandana* Cramer (Riodinidae), lateral view with most elongate scales on lateral surface removed (sockets visible), three tarsomeres. Scale line 430 microns. 20. male *Stalachtis magdalenae* Westwood (Riodinidae), lateral aspect with most elongate

second specimen has four complete tarsomeres on both forelegs (Figs. 31, 32). Powell (1975) reported similar intraspecific variation in the number of tarsomeres in the male foretarsus of the riodinid *A. nais*. Segmentation in *Styx* appears to be more complete and to allow more intersegmental movement than in riodinids, but like riodinids and lycaenids, it has less than 5 tarsomeres.

The distribution of setae on the male foretarsus of *S. infernalis* is similar to that of riodinids. It has a sparse covering of elongate scales on all sides (Figs. 31, 32) with two "macrotrichia" on the dorsal end of the tarsus (Figs. 31, 32). One foreleg had no spines (A-Type trichoid sensilla) on the tarsus (Fig. 31), whereas the other foreleg from the same specimen had a spine on the second tarsomere (Fig. 33). B-Type trichoid sensilla occur on the last tarsomere, primarily on the ventral surface (Figs. 34, 35) except that one leg had one trichoid sensillum on the third tarsomere. The fine structure of these trichoid sensilla is superficially more similar to that of "macrotrichia" (Fig. 36) than to that of lycaenid and riodinid B-Type trichoid sensilla.

It is not known whether male *S. infernalis* use their forelegs for walking. Ehrlich (1958) noted that its male foretarsus is less than half the size of the pterothoracic legs and is doubtfully functional. Because other butterflies with "brush feet" do not use their forelegs for walking, I agree that the same is probably true for *Styx*.

Discussion

The male foreleg of Lycaenidae differs from that of Riodinidae in a number of characters. (1) The foreleg is used for walking in lycaenids, but not in riodinids. (2) The distal, ventral surface of the tarsus lacks scales in lycaenids but not in riodinids. (3) Scales lie flat on the tarsus in lycaenids but not in riodinids. (4) The tarsus is wholly fused in lycaenids (with some five-segmented exceptions) whereas it is partially or wholly fused in riodinids with 1–4 tarsomeres. (5) The lycaenid tarsus possesses spines (A-Type trichoid sensilla) over much of the ventral surface whereas the riodinid tarsus does not, with the notable exception of *Sarota*. (6) The lycaenid tarsus has scattered B-Type trichoid sensilla that protrude beyond the scales while the riodinid tarsus has B-Type trichoid sensilla restricted to the tip where they are intermixed with elongate scales. (7) The foreleg is more than half the length of the pterothoracic legs in lycaenids and less than half this length in riodinids (Ehrlich 1958). (8) The coxa does not extend beyond its articulation with the trochanter, or if it does, it is arched upwards in lycaenids whereas it extends beyond the trochanter in a blunt process without being arched upwards in riodinids (Robbins 1988). (9) The trochanter has a cluster of small trichoid sensilla on its anterior inner surface whereas this cluster is lacking in riodinids (Robbins 1988).

The male foreleg of *Styx* is structurally that of a riodinid. It shares the riodinid character state for each of the 9 characters above except that data for the first character are lacking. Ehrlich (1958) was mistaken in finding similarity between the male foreleg of *Styx* and that of male lycaenids with a five-segmented foretarsus and clawed pretarsus.

The *Styx* male foreleg differs from that of riodinids in several characters. (1) The lightly sclerotized structure at the tarsus tip is

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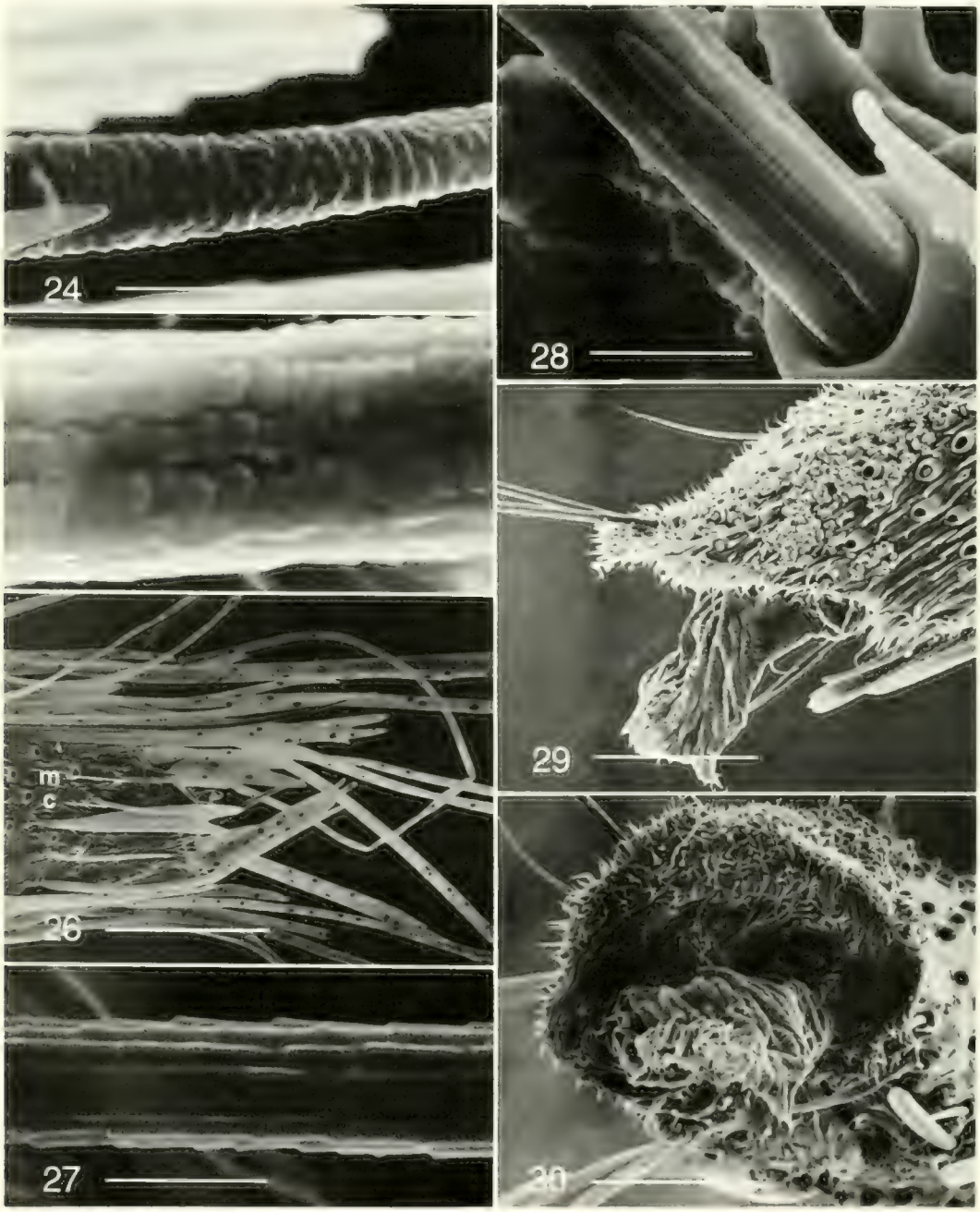
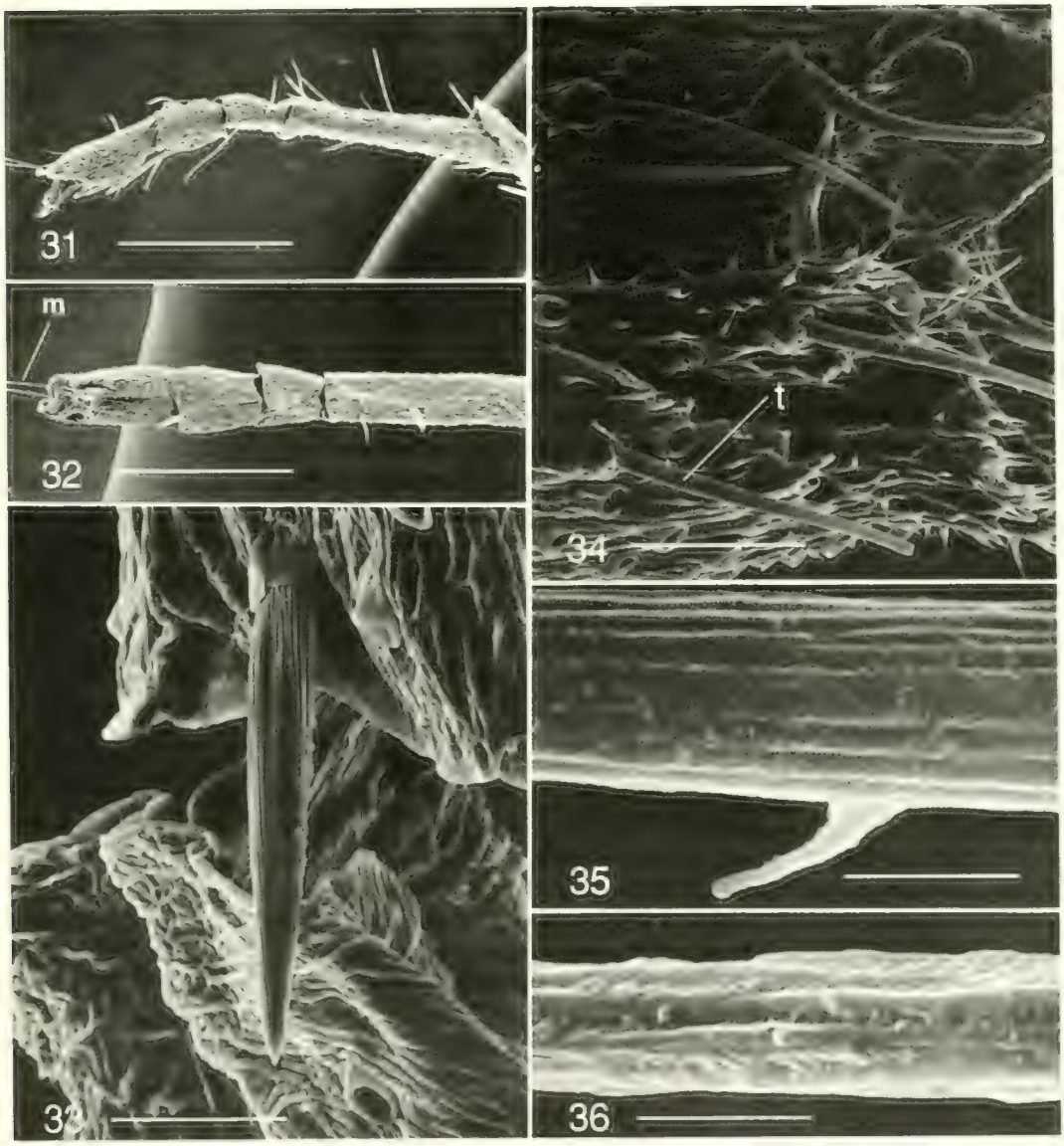
←

scales removed (sockets visible) to show lack of segmentation. Scale line 200 microns. 21. male *Sarota dematria* Westwood (Riodinidae), lateral view with most elongate scales removed (sockets visible), spine (A-Type trichoid sensillum, s) on ventral surface. Scale line 430 microns. 22. male *S. dematria* (Riodinidae), detail of ventral surface showing spines with fluted walls. Scale line 60 microns. 23. male *S. dematria* (Riodinidae), tip showing position of "macrotrichion" (m) and B-Type trichoid sensillum (t). Scale line 60 microns.



Figs. 24–30. Male foretarsi. 24. *Sarota dematria* (Riodinidae), fine structure B-Type trichoid sensillum at apex. Scale line 3 microns. 25. *S. dematria* (Riodinidae), fine structure "macrotrichion" at apex. Scale line 2 microns. 26. *Hades noctula* Staudinger (Riodinidae), apex showing position of "macrotrichion" (m) and piliform scale (c). Scale line 87 microns. 27. *H. noctula* (Riodinidae), fine structure "macrotrichion" at apex. Scale line 2.5 microns. 28. *M. pixe* (Riodinidae), fine structure piliform scale at apex. Scale line 3 microns. 29. *Styx infernalis*, lateral aspect, lightly sclerotized structure at tip, no pretarsal claws. Scale line 60 microns. 30. *S. infernalis*, posterior aspect of 29. Scale line 50 microns.



Figs. 31–36. Male foretarsus of *Styx infernalis* 31. Lateral view, four tarsomeres, "macrotrichia." Scale line 400 microns. 32. Ventral view, four tarsomeres, "macrotrichion" (m). Scale line 380 microns. 33. Spine (A-Type trichoid sensillum) on ventral surface of second tarsomere. Scale line 20 microns. 34. B-Type trichoid sensillum (t) on ventral surface last tarsomere. Scale line 38 microns. 35. Fine structure B-Type trichoid sensillum on ventral surface of last tarsomere. Note longitudinal lines instead of broken latitudinal lines in Lycaenidae and Riodinidae. Scale line 2.5 microns. 36. Fine structure "macrotrichion" dorsal surface of last tarsomere. Scale line 2.5 microns.

unique to *Styx*. (2) The tarsomere partitions in *Styx* appear to allow greater intersegmental movement. (3) The forecoxa extends a shorter distance beyond the trochanter in *Styx* than in most riodinids (Robbins 1988). (4) The trochanter of *Styx* lacks a cluster of trichoid sensilla on the dorsal, outer posterior surface whereas it is

present in riodinids (Robbins 1988). These four differences show that Forbes's description of the male *Styx* foreleg as typically riodinid was partially incorrect.

Systematic Position of *Styx*

Ehrlich (1958) placed *Styx* in its own subfamily (Styginae) of rank equal to the Riodinidae (his Riodininae) and Lycaenidae (his Lycaeninae). His evidence was (1) the occurrence of two recurrent veins in the forewing cell, (2) the form of the labial sclerite, (3) a strongly convex mesothoracic anepisternum, and (4) the morphology of the male foreleg. Ehrlich remarked that the first two character states are unique to *Styx* and the third is also "unique but close to the riodinines." These unique character states by themselves provide no evidence on the systematic placement of *Styx*. Either they evolved on the lineage leading to *Styx* only or they are part of a transformation series for which information from other characters is necessary to show the order of transformation.

Ehrlich noted that the male foreleg of *Styx* is close to lycaenids whose males have a five-segmented foretarsus with pretarsal claws. This comparison was incorrect because *Styx* lacks pretarsal claws and has less than five tarsomeres. Further, lycaenids, whose males possess a five-segmented tarsus and clawed pretarsus, have the lycaenid pattern of scales, spines, and B-Type trichoid sensilla (Fig. 16), not the one shared by riodinids and *Styx*. Thus, Ehrlich's evidence did not justify giving the Styginae rank equal to the Lycaenidae and Riodinidae.

Scott (1985) proposed that *Styx* branched from the lineage that then evolved into the Lycaenidae and Riodinidae. His evidence is that *Styx* possesses (1) a large anepisternum that became "slightly smaller" in the remainder of the lineage, and (2) eyes that are not notched at the antennae whereas the remainder of the lycaenids and riodinids have notched eyes.

While Ehrlich noted that the shape of the mesothoracic anepisternum is unique to *Styx* (but close to the riodinids), Scott considered its size to be a "primitive" character state, but did not indicate his evidence for this hypothesis. He did not measure the anepisternum nor indicate whether its size is allometrically correlated with body size. Further, the mesothoracic anepisternum is not a separate sclerite in Libytheidae and Pieridae, and is present in only some species of Papilionidae and Nymphalidae (Ehrlich 1958). Since this sclerite may be present or absent in potential outgroups and its size unmeasured when present, there is no evidence that a large anepisternum is "primitive" on the lineage leading to the Lycaenidae and Riodinidae.

Scott's statement that the Lycaenidae and Riodinidae (exclusive of *Styx*) have eyes notched at the antennae is inaccurate. Although it is true for many Lycaenidae and Riodinidae, some (*Hades* Westwood, *Euselasia* Hübner) have the same arrangement of compound eyes and antennae as *Styx*. In short, Scott provides no evidence for his systematic placement of *Styx*.

Harvey (1987) put *Styx* in the Riodinidae. He characterized the Riodinidae as those butterflies (1) with B-Type trichoid sensilla on the female foretarsus clustered centrally and (2) lacking apophyses posteriores on the female genitalia. *Styx* and riodinids (with the exception of *Laxita*) also share the loss of a trichoid sensillum cluster, which is present in all other butterfly families, on the male foretrochanter (Robbins 1988).

My results in this paper are consistent with Harvey's placement of *Styx* in the Riodinidae. The differences between *Styx* and other riodinids in male foretarsus structure are character states that are unique to *Styx* (such as the slightly sclerotized structure at the tip of the tarsus) and that provide no evidence on its systematic position. On the other hand, riodinids and *Styx* share 8

character states of the male forelegs. These results are consistent with Harvey's classification of *Styx* as a riodinid.

Acknowledgments

I am grateful to Gerardo Lamas for loaning me the only male specimen of *Styx* in the Museo de Historia Natural (Lima) and for allowing me to examine its forelegs with the SEM. I thank Phil Ackery for loaning me Ehrlich's dissection of a male *Styx* and for trying to find another male in the British Museum collection. For sharing information on butterfly phylogeny with me over the years, I thank Don Harvey. For allowing me to read an advance copy of his co-authored paper on butterfly phylogeny, I thank James Scott. For reading and commenting upon the manuscript, I am grateful to Don Harvey, Gerardo Lamas, James Scott, and Adrienne Venables. I particularly thank an anonymous referee whose comments greatly improved the manuscript. For technical help with the SEM, I thank Brian Kahn, Susann Braden, and Heidi Wolff.

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OBSERVATIONS ON THE TRUE BUGS *EMESA TENERRIMA*, A POSSIBLE SPIDER MIMIC, AND *GHILIANELLA BORINCANA* (HEMIPTERA: REDUVIIDAE: EMESINAE) FROM PUERTO RICO

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Abstract.—*Emesa tenerrima* and *Ghilianella borincana* were observed in a semi-evergreen forest of northern Puerto Rico during day hours for eleven months. *Emesa tenerrima* lives on the webs of the pholcid spider *Modisimus signatus* with which it shares the elongated body form and banded coloration pattern of its legs. Mild disturbances induce mantid-like displays; stronger disturbances produce easy movement over the web or flight escape. Live pholcids were not observed coinhabiting the webs occupied by *E. tenerrima*. *Ghilianella borincana* is not a web inhabitant, shows no interest in offered pholcids but seems to eat spiders. It intermingles with dark vegetation debris and, with the aid of catalepsis, is highly cryptic. Disturbed individuals drop from the substrate.

Key Words: Emesinae, Pholcidae, spider mimicry, mimicry

Hinton (1973, 1976) noted that while numerous spiders mimic insects, no insects indisputably mimic spiders. Only recently has the occurrence of spider mimicry been confirmed (Greene et al. 1987, Mather and Roitberg 1987, Whitman et al., in press). Emesine true bugs (Hemiptera: Reduviidae: Emesinae) are frequently associated with spiders (Gagné and Howarth 1975, Hickman 1971, Wygodzinsky 1966).

One of us (JASB) noticed a "stick-like spider" inhabiting a pholcid web in the understory of a semi-evergreen forest of northern Puerto Rico. Upon manipulation with forceps, the arthropod disclosed its true identity: *Emesa tenerrima*, an emesine (Fig. 1). Several specimens, including a second emesine, *Ghilianella borincana* (Fig. 2), were observed in dark vegetation debris suspended in the forest. This paper documents some biological features of *Emesa tenerrima* and *Ghilianella borincana*, and suggests their possible biological significance.

METHODS

The study site, a semi-evergreen, subtropical moist, premontane forest (Ewel and Whitmore 1973, Holdridge 1982), is located in a limestone hill, a short walk off road 2, km. 21.4 (near junction road 165), Toa Baja. Observations were done, usually during the mornings of 12 different days, from September 1983 to August 1984. Each observation period lasted a minimum of ten minutes. Observations were made on different individuals of each species. Six observation periods were devoted to *E. tenerrima*, seven to *G. borincana*. Detection of *G. borincana* was facilitated by placing a white background behind possible residence places. Simple manipulations were performed to observe the reactions of the eme-

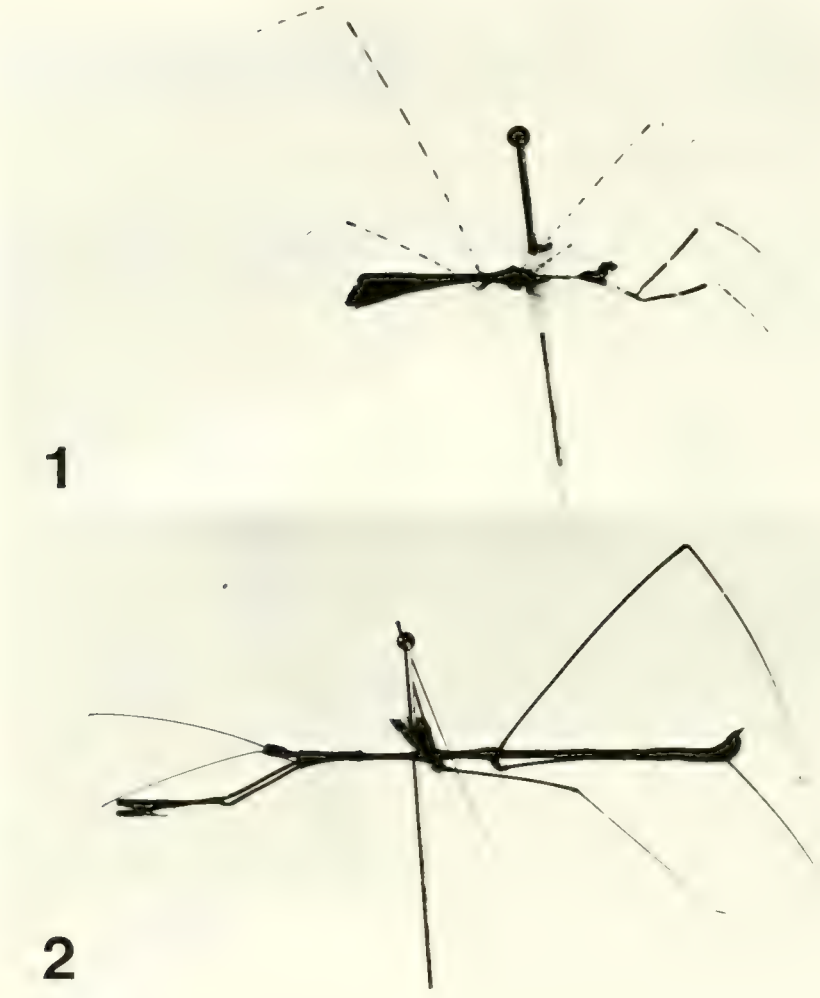

Fig. 1. *Emesa tenerrima*. Pin length about 40 mm.
Fig. 2. *Ghilianella borincana*. Pin length about 35 mm.

sines to artificial stimuli. Voucher specimens are deposited in the Entomology Museum, Agricultural Experiment Station, Univ. Puerto Rico, Mayagüez Campus (at Río Piedras), Puerto Rico.

Results

Emesa tenerrima (Dohrn, 1860)

(Fig. 1)

This winged, silvery grayish-black emesinine was always collected on webs of *Modisimus signatus* (Banks) (Pholcidae). Webs of this spider were found on the branches of *Quararibaea turbinata* (Bombacaceae), a common shrub on the study site. The webs were located 0.25–2.00 m above ground in shady areas (50–75% leaf cover). As noted for other emesines, *E. tenerrima* was usually observed on the web, hanging upside down, and did not entangle, even if suddenly forced to move. *Emesa tenerrima* resembles *M. signatus* in its overall elongate body form

and silver/black transverse banded legs. However, the body, excluding the legs, of *E. tenerrima* is much longer and more robust than that of *M. signatus*. Remnants of dead spiders, including a *Modisimus signatus*, were found twice in the emesine inhabited web, but *E. tenerrima* and *M. signatus* were not observed coinhabiting a web.

When warm air was blown directly toward *E. tenerrima*, or when the branch supporting the web was repeatedly touched, adduction of the meso- and metathoraxic legs followed. However, the forelegs adducted only when they were touched, then the femora and tibiae apposed in a mantid-like posture. Gentle touch with forceps of the antennae, the meso- and metathoraxic femora, or tibiae prompted quick walking and escape from the web to surrounding vegetation. Subsequent manipulation was followed by escape to the ground where the insect was extremely difficult to detect. Escape was also achieved by flight (speed ≅ 3 m in 10 s, n = 1).

Ghilianella borincana (Maldonado, 1960)

(Fig. 2)

This wingless, dark-brown metapterinine lives on vegetation debris in very shady areas that hangs vertically from *Coffea arabica* (Rubiaceae) or *Q. turbinata*. There it hangs by four legs, with the fore legs adducted and apposed, as in *E. tenerrima*, but with the head directed downwards. At times, remnants of other spider species were noticed on the debris. *Ghilianella borincana* was observed once on the border of a pitfall trap with a small unidentified spider held between a fore femur and tibia.

Ghilianella borincana exhibited catalepsis. When a branch with *G. borincana* was touched over 30 times, only the antennae moved, becoming perpendicular to the longitudinal axis of the body. At times specimens were left unattended for more than 10 min, either on vegetation debris or on a white piece of paper, and no change in position was noted. However, rubbing a pencil in front of an emesine placed on a piece of paper made the insect move away. Escape occurred by dropping from the substrate. When living pholcids were brought close to a *G. borincana*, no reaction was observed.

Discussion

Reports of emesine/spider associations are summarized by Wygodzinsky (1966). *Nesidiolestes ana* and *Empicoris rubromaculatus* have been observed using webs as a place to feed (Gagné and Howarth 1975, Hickman 1971), whereas *Stenolaemus edwardsii* is known to feed on its host spiderlings (Hickman 1971, Maldonado-Capriles and van Doesburg 1966).

Twelve emesines are known for Puerto Rico, but their biology is unknown (Maldonado-Capriles 1986). Our data are insufficient to indicate the nature of the biological association between *E. tenerrima* and *M. signatus*. One possibility is that the resemblance of the emesine leg pattern to that of the spider short-circuits intraspecific communication (Greene et al. 1987, Mather and Roitberg 1987, Whitman et al., in press), thus, possibly representing a case of aggressive mimicry. The fact that we did not see live pholcids coinhabiting the web with *E. tenerrima* questions this hypothesis, unless spiders actually were eaten at the time of observation. Another possibility is that *E. tenerrima* simply uses the web as a place to live, at least during the day hours.

Ghilianella borincana, in contrast, may find protection by remaining on vegetation debris, at least during the day hours. Resemblance to other objects has been reported for a predatory ant-mimic mirid (Wheeler and Henry 1980), a termite-eating (McMahan 1983) and medically important reduviids (Harwood and James 1979), and an asopine pentatomid nymph that mimics its chrysomelid prey (Bourdouxhe and Jolivet 1981). We have not found comments concerning similarity of emesines to a substrate habitat.

Acknowledgments

We wish to thank L. Orsak (Scientific Methods, Inc.; Chico, CA), Dr. S. Medina (Univ. Puerto Rico, Mayagüez) and two anonymous reviewers for their careful review of an earlier version of this paper. Drs. G. O. Poinar, Jr. and G. M. Thomas (Univ. California, Berkeley) provided materials and instructions, respectively, to JASB toward completion of the photographic process. Dr. Willis Gertsch (Portal, AZ), Dr. M. J. Vélez, Jr. and Mr. R. Rodríguez (Univ. Puerto Rico, Río Piedras) loaned specimens of *M. signatus*.

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DISTRIBUTION AND HABITAT COMPARISONS FOR *CARABODES* COLLECTED FROM CONIFER BRANCHES WITH DESCRIPTIONS OF *BREVIS* BANKS AND *HIGGINSI* N. SP. (ACARI: ORIBATIDA: CARABODIDAE)

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Abstract.—Seven species of *Carabodes* (*brevis* Banks, *dendroetus* Reeves, ***higginsi*** n. sp., *willmanni* Bernini, *granulatus* Banks, *niger* Banks and *labrynthicus* (Michael)) were collected from spruce and fir branches using the caustic soda wash technique. A redescription of *C. brevis*, a description of ***C. higginsi*** and distribution within North America for each species is included. Comparisons of branch samples with leaf litter/rotten wood samples from the forest floor clearly show that *C. brevis* and *C. dendroetus* prefer arboreal habitats. Additional evidence from literature and other collections indicate that *C. granulatus*, *C. labrynthicus* and *C. niger* may be arboreal depending on the presence of lichens, moss or fungi but *C. willmanni* may be arboreal only where lichens are present. Habitat preferences for ***C. higginsi*** could not be determined except that most specimens were collected in association with conifers.

Key Words: Oribatid mites, *Carabodes brevis*, *C. dendroetus*, *C. higginsi*, *C. willmanni*, *C. granulatus*, *C. niger*, *C. labrynthicus*

Oribatid mites are difficult to remove from arboreal habitats, especially evergreens with needles, with the conventional method of searching bark, branches or foliage. Often lichens, moss or various other organic accumulations adhere to branch surfaces obscuring vision. Fungi and lichens on the trunks of trees offer an easier habitat from which to collect. In Europe *C. labrynthicus* (Michael) has sometimes been collected from dry plants on rock surfaces (Seyd and Seaward 1984) and Bellido (1979) found all stages of *C. willmanni* Bernini burrowing into lichens. Travé (1963) found *C. labrynthicus* and *minusculus* Berlese more common in moss and lichens on rock and tree surfaces than in soil. The presence of certain species of *Carabodes* on the bark surfaces of trees or in lichens, fungi, moss, etc. attached to these surfaces is thus known, yet the extent of their distribution into the forest canopy has not been documented.

The caustic soda wash technique that resulted in the mite collections reported in this paper is used for second instar larval surveys of spruce budworm (*Choristoneura fumiferana* (Clemens)) (Miller and McDougal 1968). Briefly this technique requires clipping branches from the midcrowns of host trees and immersing the branches in a 1% hot caustic soda solution for several hours to free larvae from their hibernacula. Much of the organic debris (needles, bark, etc.) is removed through sieving before the eventual sample is filtered in a Büchner funnel. Large numbers of mites on filter papers from branch samples subjected to the above process were brought to

my attention. I proceeded to remove mites as the samples were processed and time permitted. These samples were clipped on September 3/4 or 9/11, 1983 from red spruce (*Picea rubens* Sarg.) and balsam fir (*Abies balsamea* (L.) Mill.) at 10 different locations all within approximately 13 miles of Errol, Coos Co., New Hampshire. The amount of branch surface and whether lichens, fungi or moss were present on the branches is unknown.

Among the mites collected from the branch samples were varying numbers of seven species of *Carabodes*. I had rarely encountered the two most abundant species, *C. brevis* Banks and *C. dendroetus* Reeves, in leaf litter/rotten wood collections indicating that they may prefer an arboreal habitat. Thus a comparison of species present in both habitats was appropriate even though differences in sampling methods did not allow statistical comparisons. Descriptions of *C. brevis* Banks and *C. higginsi* n. sp. are included as well as North American distributional records and habitat preferences for all seven species based on the literature, the author's collection, and the Canadian National Collection (CNC), Biosystematics Research Centre, Ottawa.

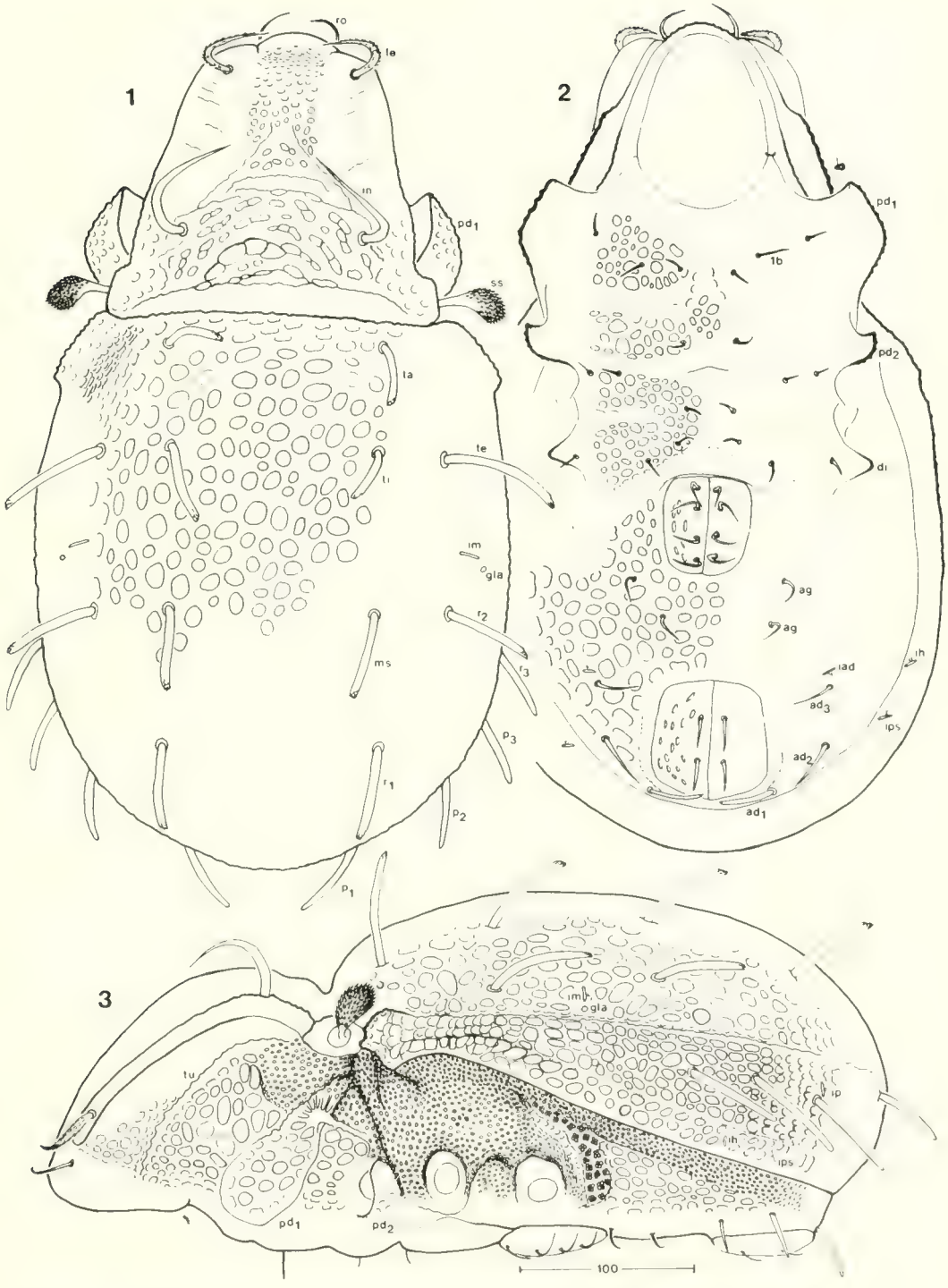
Terminology and abbreviations are those developed by F. Grandjean, as summarized by Balogh and Mahunka (1983). All measurements are in micromillimeters, and except for the holotype of *C. brevis*, are made from unmounted specimens. Specimen measurements are as follows: total length—tip of rostrum to posterior edge of notogaster, width—widest part of notogaster, height—from between genital and anal plates to highest point of notogaster, prodorsal length—tip of rostrum to posterior edge of dorsosejugal depression. Line drawings were made primarily from dissected specimens and may be a composite of more than one specimen. SEM's were made from mites stored in 70% ethyl alcohol, air dried, placed onto sticky tape on ½ inch aluminum stubs and coated with 200 Å AuPd in a Hummer IV Sputter Coater before observation in an AMR1000 Scanning Electron Microscope. Abbreviations of collectors names as follows: DSC—D. S. Chandler, RMR—R. M. Reeves.

Carabodes brevis Banks 1896

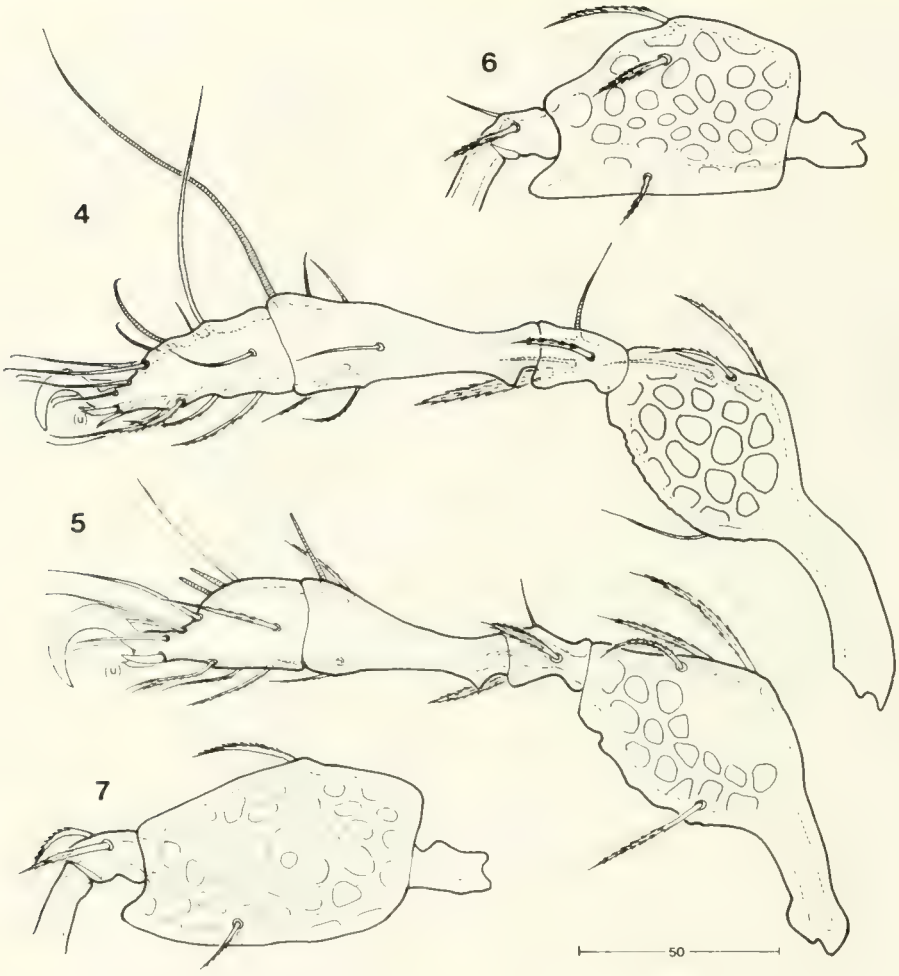
Figs. 1–17

Diagnostic characters: Notogastral setae long, nearly uniform in diameter with only a few distal barbs; dorsosejugal depression of nearly uniform width between bothridia; sensillus short, capitate; notogastral pits of moderate size (5–12 diameter) and usually separated by less than the diameter of largest pit; two pairs of aggenital setae present.

Adult.—*Measurements:* Total length: holotype ♂ 500; "cotypes" ♀ 520, ♂ 545; other material examined (mean (range), n = 13 unless otherwise noted) ♀ 524 (470–580), ♂ 481 (450–520). Notogastral width: holotype ♂ 270; "cotypes" ♀ 300, ♂ 305; other material examined ♀ 296 (270–330), ♂ 274 (250–300). Height: holotype (not measured); "cotypes" ♀ 240, ♂ 240; other material examined ♀ 238 (210–270) (n = 12), ♂ 209 (185–245). *Integument:* Yellow brown, distinctly lighter in color than *C. niger* Banks. *Prodorsum:* Prodorsal length: holotype ♂ 175; "cotypes" ♀ 180, ♂ 190; other material examined ♀ 170 (140–185), ♂ 158 (135–185). Prodorsal surface (Figs. 1, 10, 11) with generally smaller pits than on center of notogaster, most uniform in area between lamellae, becoming indistinct on lamellar surfaces, the lamellar surface with weakly developed anterolaterally directed striations. Base of prodorsum between interlamellar setae with transverse folds which terminate in an inverted V-shaped fold near middle of prodorsum. Dorsosejugal groove present on posterior edge of prodorsum, width uniform between bothridial bases. Rostral setae (*ro*) arched medially, minutely barbed, 32–37 long. Lamellar setae (*le*) inserted near tip of lamella, arched medially, more strongly barbed than *ro*, 45–48 long. Interlamellar setae (*in*) inserted close to where inverted V-shaped fold

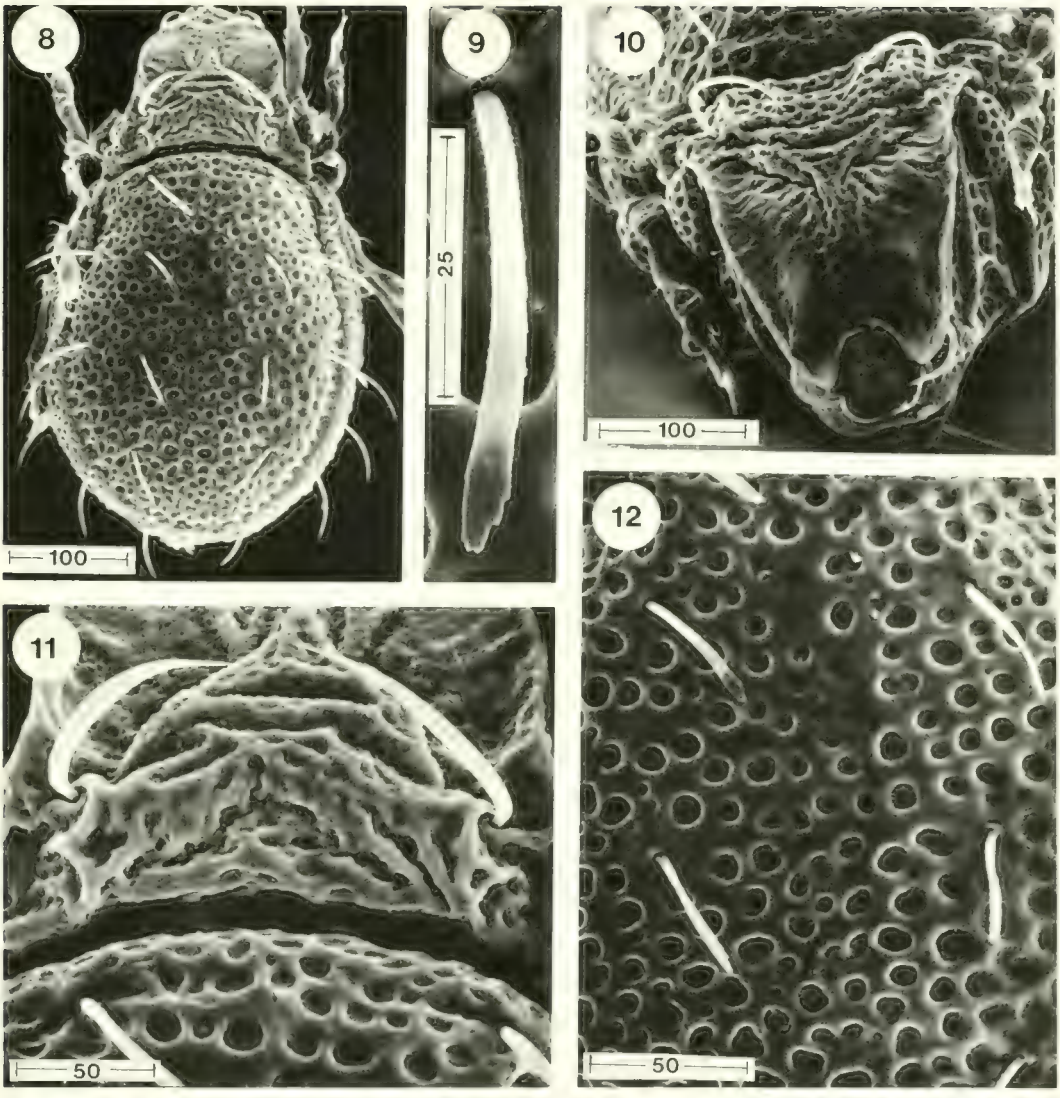


Figs. 1–3. *Carabodes brevis,* adult. 1, Dorsal view. 2, Ventral view. 3, Lateral view. Scale bar in μm.



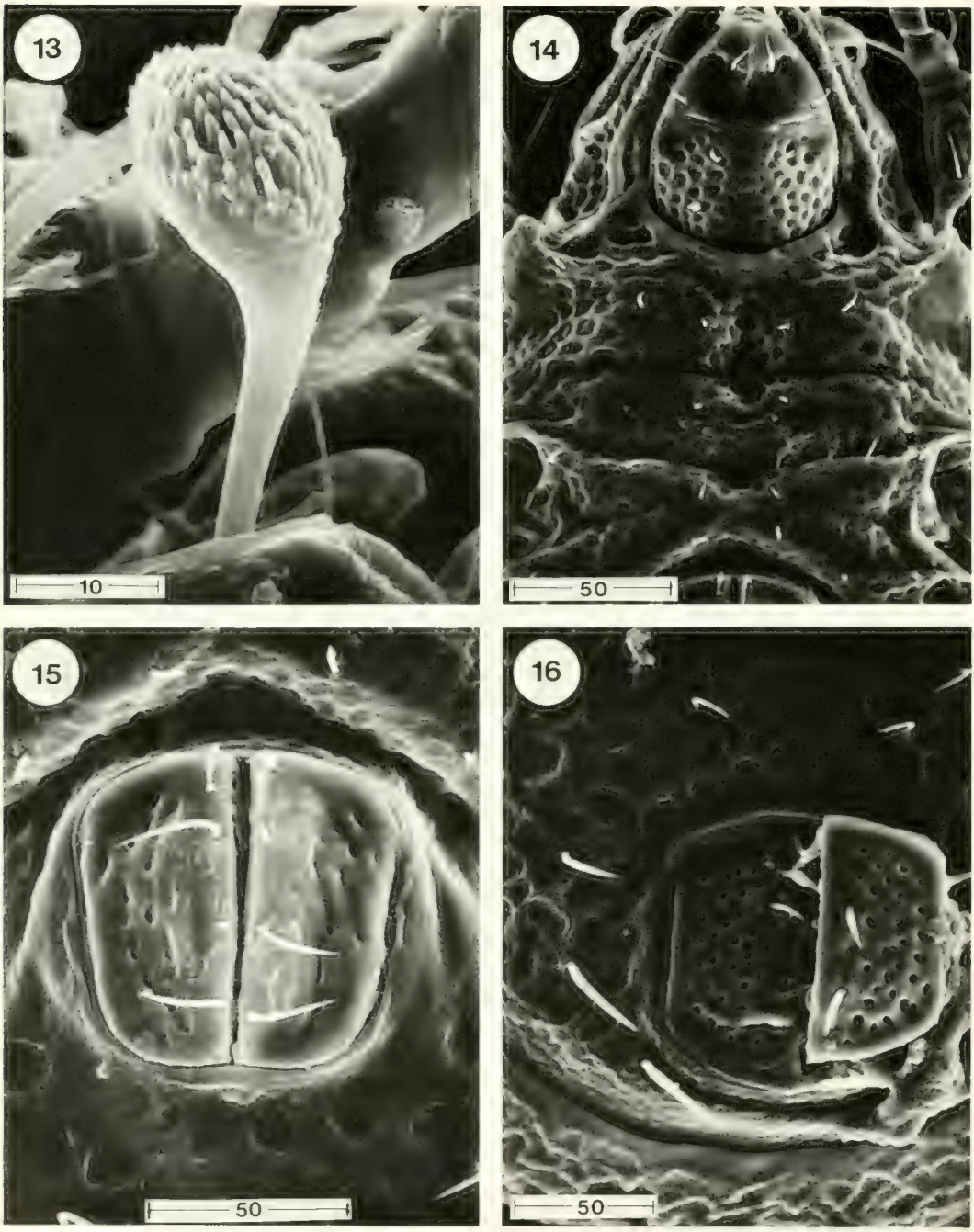
Figs. 4–7. *Carabodes brevis,* adult. 4, Leg I. 5, Leg II. Femur, genu, tibia and tarsus. 6, Leg III. 7, Leg IV. Femur and genu. Antiaxial views. Scale bar in μm.

begins, arched medially, acuminate distally, 82–88 long. Sensillus (*ss*) (Figs. 1, 13) short (length beyond bothridial opening 28–38), capitate, head spinose. Bothridial wall entire. Seta *ex* absent. *Notogaster:* Notogaster (Figs. 1, 8, 12) covered with round pits of variable size (5–12 diameter), inter-pit distance usually less than largest pit diameter. Pits less uniform in shape near edges of notogaster. Circumnotogastral depression (a depression parallel with lateral and posterior margins of notogaster) present (Fig. 8). Ten pairs of notogastral setae present (Banks (1896) erroneously notes that there are eleven pairs). All notogastral setae similar, long (*ta, ti* and *ms* extending at least half way to insertion of next posterior seta), nearly uniform in diameter, a few small barbs present at or near tip (minute bars on shaft seen only in SEM, Fig. 9), posteromarginal setae smoother at tip in dorsal view than central notogastral setae. Seta *ta* inserted anterior to *ti,* thus *ta, ti, ms* and r_1 form longitudinal row with *te* and r_2 forming a second parallel row laterally. (Banks' (1904, 1915) figures of *C. brevis* show only nine pairs of notogastral setae, one of the posteromarginal setae lacking, and the *te*-r_2 row is erroneously



Figs. 8–12. *Carabodes brevis*, adult. 8, Dorsal view (221×). 9, Seta *ti* (1910×). 10, Prodorsum, anterior view (394×). 11, Dorsosejugal groove detail (760×). 12, Pits on notogaster between *ti* and *ms* (580×). Scale bars in μm.

continued posteriorly in line with the posteromarginal setae.) Anterior notogastral setae slightly longer than posterior (50–55 vs. 40–45 respectively in "cotypes," 55–65 vs. 48–52 respectively in four specimens extracted from spruce branches). Position of *im* normal but gland *gla* sometimes ventrad of *im* (Fig. 3) or posterior to *im* (Fig. 1). *Gnathosoma:* Setal positions and pitting of ventral surface shown in Fig. 14. Palpal setal formula 0-2-1-3-9 (+1 solenidion). *Ventral surface:* Pits on epimera similar in size to those on prodorsum while pits on ventral plate similar in size to those on center of notogaster (Fig. 2). Pits on genital and anal plates much smaller than other ventral surface pits. Epimeral plates divided by furrows, enlarged depression in center of first



Figs. 13–16. *Carabodes brevis*, adult. 13, Sensillus (2530×). 14, Ventral view of gnathosoma and epimera (570×). 15, Genital plates (1114×). 16, Anal plates (760×). Scale bars in μm.

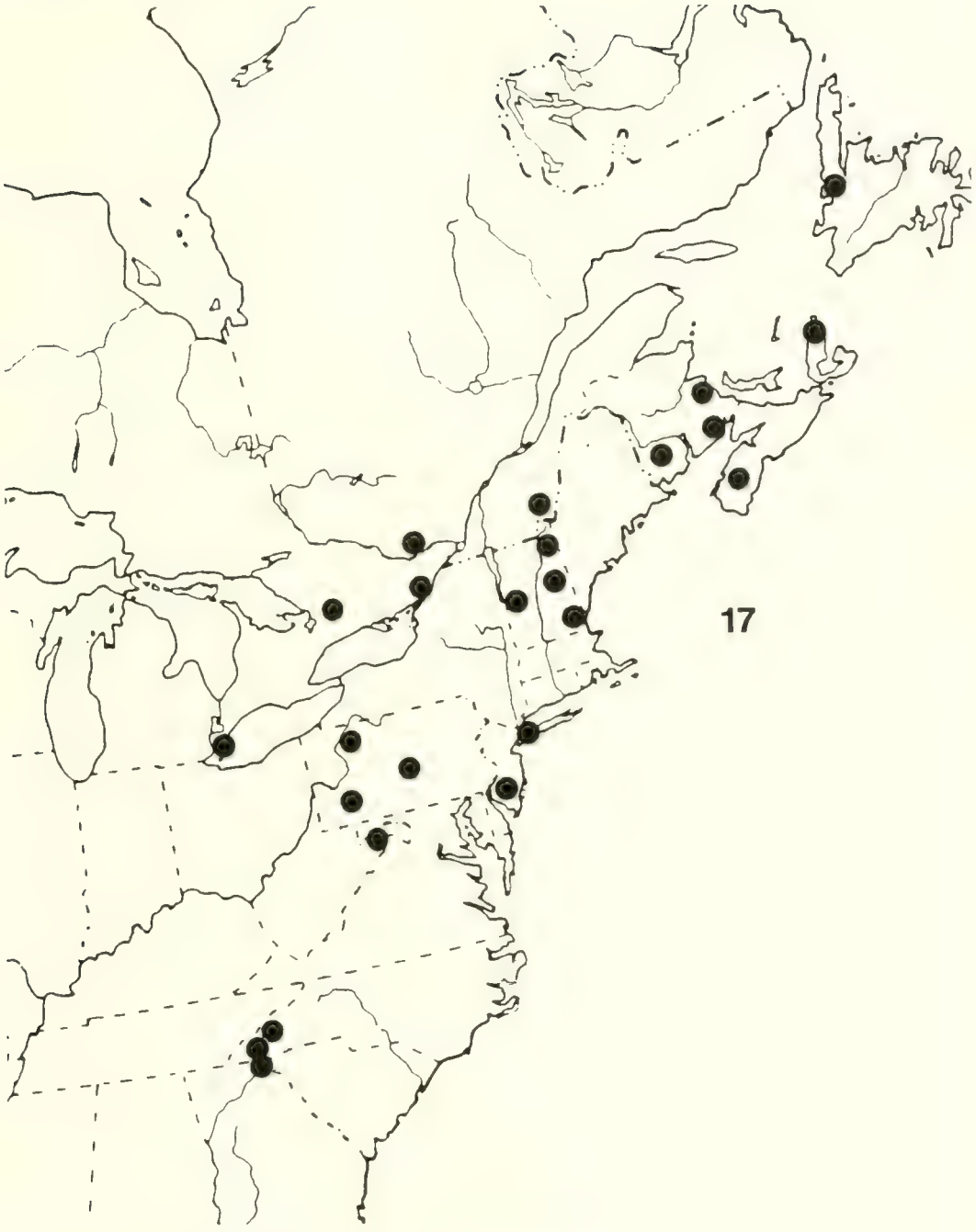


Fig. 17. Known North American distribution of *Carabodes brevis*.

two furrows (Figs. 2, 14). Epimeral setal formula 3-1-3-3, seta *1b* longest. Four pairs of genital setae, first pair directed posteriorly, others laterally, the latter extending ¾ distance to lateral edge of plate (Figs. 2, 15). Two pairs of aggenital setae (*ag*) on ventral plate (only one was found on one side of the male "cotype"). Two pairs of anal (*an*) and three pairs of adanal setae (*ad*) with ad_1 longest (length 35–40) and ad_3 shortest (length 20–25) (Fig. 16). Setal diameter increases from ad_3 to ad_1 with diameter of ad_1 similar to posteromarginal notogastral setae. Lyrifissure *iad* positioned anterior to ad_3. Pedotecta I and II (pd_1 and pd_2) and discidium (*di*) as shown in Fig. 2. *Lateral surface:* Generally surface below lamella, bothridium and edge of notogaster and above leg insertions with small tubercles; remainder with variously sized pits (Figs. 3). Area posterodorsad to insertion of leg IV with tubercles joined into groups of four or more. Pedotectum I covering base of acetabulum I, widest ventrally, tapering dorsally to near bothridial base. Ridge present above acetabulum II extends anteriorly onto pd_1 where it becomes palmate and demarcates tuberculate area dorsally and pitted area ventrally. Lyrifissures *ih* and *ips* on ventral edge of notogaster below r_3, p_3 and p_2 (Figs. 2, 3). Lyrifissure *ip* posterior and dorsal to insertion of p_2 (Fig. 3). Edge of ventral plate adjacent to notogastral plate with band of small tubercles. *Legs:* Pits present on antiaxial surfaces of trochanters III and IV, enlarged distal portion of femur I, lower half of enlarged distal portion of femur II, on all but the ventral flange of femur III, and all of femur IV (Figs. 4–7). Setation (I–IV, solenidia in brackets), trochanters (1-1-2-1), femora (4-4-3-2), genua (3(1)-3(1)-1(1)-2), tibiae (4(2)-3(1)-2(1)-2(1)), tarsi (15(2)-15(2)-15-12). Ventrodistal edge of femora III and IV with spur, that of femur III strengthened basally. Unguinal setae (*u*) of tarsi I–IV short, wide basally, abruptly tapered at tip. Tactile setae of all legs barbed except for those on the dorsal and lateral surfaces of tibiae and tarsi. Distal setae of tarsi, in particular *tc, it, a* and *p,* attenuate at tip.

Immatures.—Unknown.

Material examined.—*Holotype:* ♂, Sea Cliff, Long Island, New York, May, N. Banks, from dead fungus (*Polyporus*), mounted in balsam. "Cotypes": 1 ♀, 1 ♂, same collection data as holotype, in alcohol. The holotype slide has on the label "(3 left)" and probably refers to a third "cotype" mounted ventrally and mislabelled according to Norton (1978) as *Carabodes dorsalis.* This specimen was not seen. The holotype and "cotypes" are in the Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts. Additional specimens were examined from USA: Georgia, North Carolina, West Virginia, Pennsylvania, New Jersey, Vermont, New Hampshire; CANADA: Ontario, Québec, New Brunswick, Nova Scotia, Newfoundland. This species is thus widely distributed in eastern North America from the southern Appalachians to Newfoundland (Fig. 17).

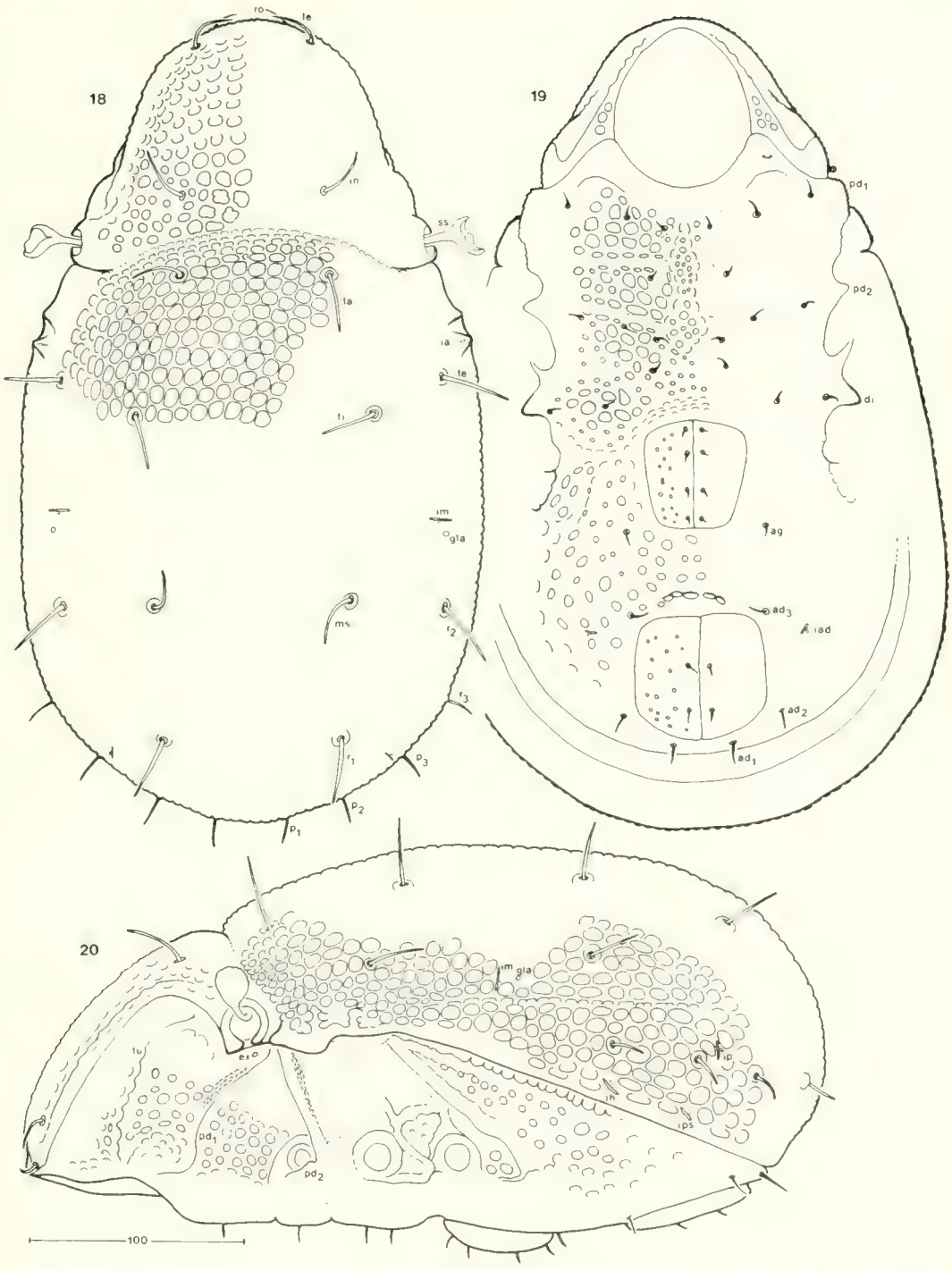
The collections examined which contain *C. brevis* are from a wide variety of forest habitats including leaf litter, rotten wood, moss, lichens, bark and fungi. Rarely has a sample of leaf litter or rotten wood contained more than three specimens while samples which include *Polyporus* fungi may contain as many as eight specimens and the largest collection examined (25 specimens) came from "loose bark with moss, lichens on birch trunk" from Newfoundland. *Carabodes niger* is present and usually in greater abundance in nearly all of my collections of *C. brevis.*

Carabodes higginsi Reeves

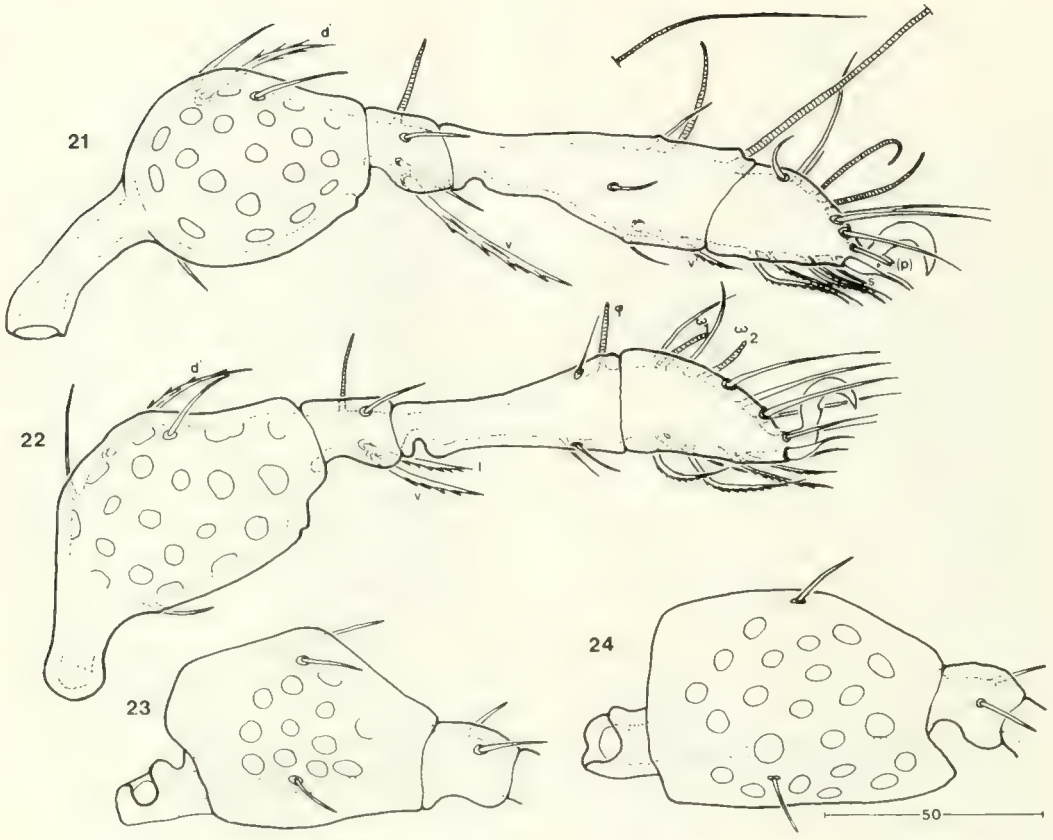
NEW SPECIES

Figs. 18–35

Diagnostic characters: Prodorsum with medium sized pits (5–7 diameter); dorsosejugal depression a narrow furrow; notogaster covered with tubercles (7–10 diam-



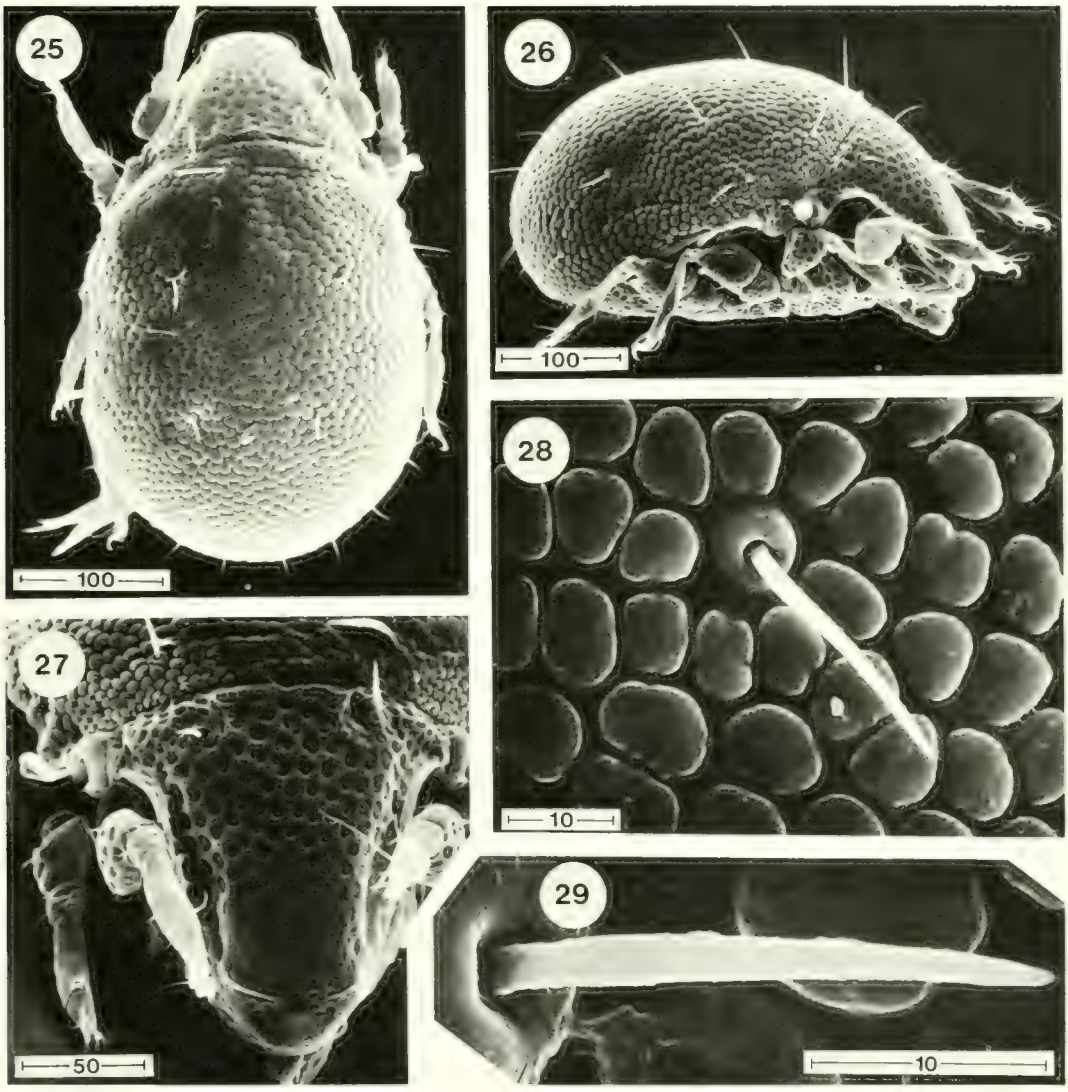
Figs. 18–20. *Carabodes higginsi*, adult. 18, Dorsal view. 19, Ventral view. 20, Lateral view. Scale bar in μm.



Figs. 21–24. *Carabodes higginsi,* adult. 21, Leg I. 22, Leg II. Femur, genu, tibia and tarsus. 23, Leg III. 24, Leg IV. Femur and genu. Antiaxial views. Scale bar in μm.

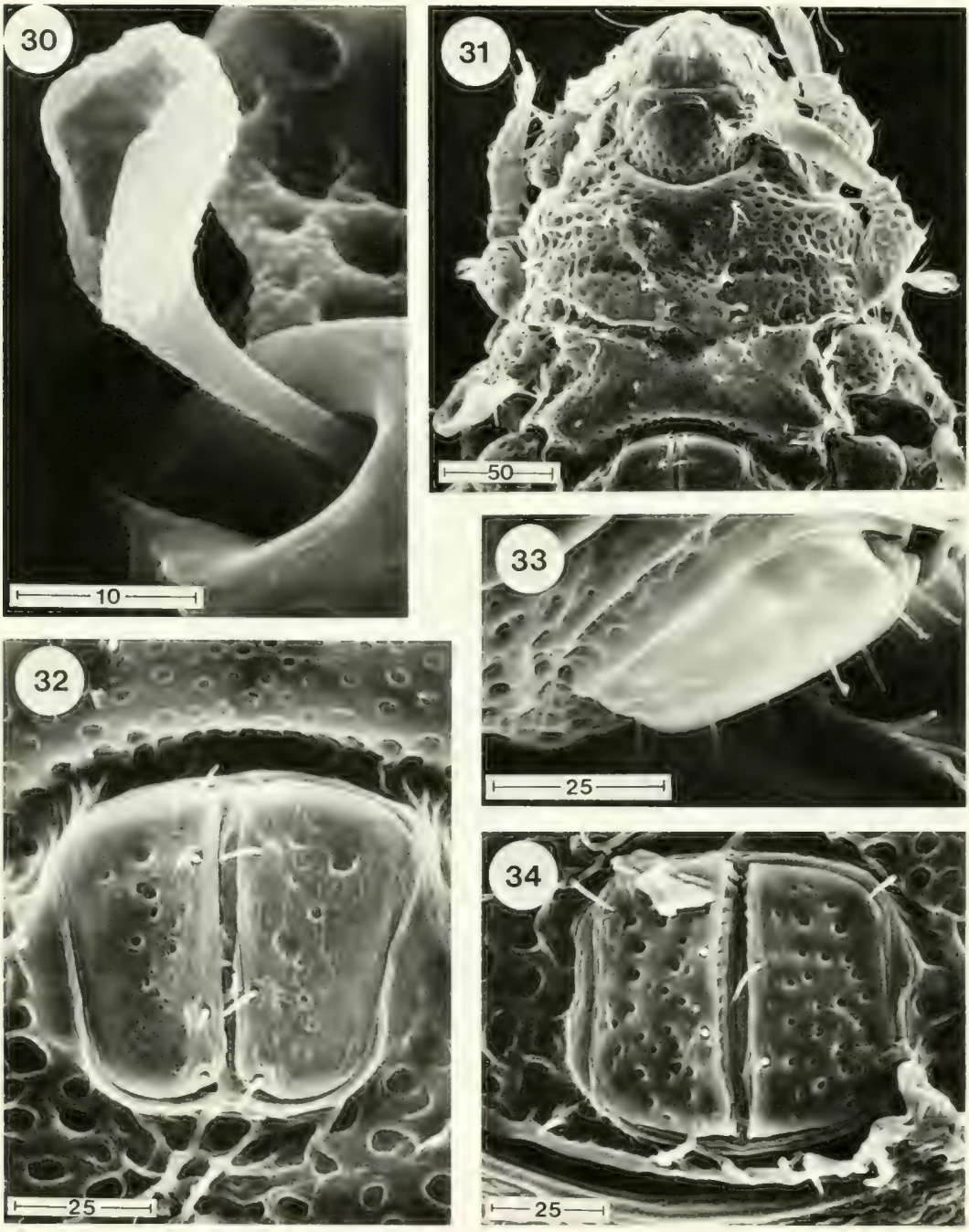
eter); all body setae setiform, notogastral setae arise from tubercles, *ta, ti* and *ms* ⅓ distance to next setal insertion; sensillus capitate, invaginated distally; 0–2 aggenital setae.

Adult.—*Measurements* (mean (range), n = 9 for ♀, n = 2 for ♂): Total length: ♀ 378 (355–390), ♂ 338 (315–360). Notogastral width: ♀ 221 (205–230), ♂ 192 (180–205). Height: ♀ 183 (170–195), ♂ 162 (145–180). *Integument:* Light brown. Thin cerotegument seen only on prodorsum. *Prodorsum:* Prodorsal length: ♀ 103 (95–110), ♂ 88 (85–90). Dorsosejugal depression a narrow furrow. Prodorsal surface (Figs. 18, 27) covered with pits (diameter 5–7), pits generally more circular in middle of prodorsum, extend to lateral edge of lamellae. Rostral (*ro*) and lamellar (*le*) setae setiform, bent medially, closely appressed to prodorsal surface, very minutely barbed at 1000×, *le* (length 27) longer than *ro* (length 17). Interlamellar setae (*in*) (length 32) longer than *le,* setiform, slightly arched. Sensillus (*ss*) (Figs. 18, 30) capitate with distal surface invaginated, forming an irregularly edged cup-like opening. Edge of bothridium with ventral notch (Figs. 20, 30). *Notogaster:* Notogaster (Figs. 18, 25) covered with tubercles (diameter 7–10), sometimes so closely appressed so as to partially flatten adjacent surfaces (Fig. 28). Circumnotogastral depression not apparent dorsally and only barely visible in lateral view (Fig. 20). Two short ridges present on lateral edge of notogaster just posteriad of humeral angle (Fig.



Figs. 25–29. *Carabodes higginsi*, adult. 25, Dorsal view (300×). 26, Lateral view (253×). 27, Prodorsum, anterior view (504×). 28, Notogastral tubercles around seta *ti* (2270×). 29, Seta *ms* (6400×). Scale bars in μm.

18). Lyrifissure *ia* present on posterior ridge. Notogastral setae (Figs. 18, 29) setiform, erect, seta *ta* longest (35–38), others decreasing in length posteriorly to posteromarginal setae (p_1–p_3, 15–20); each seta arising from middle of tubercle (Figs. 28, 29); *ta* and *ti* extending approximately ⅓ to ½ distance to insertion of *ti and ms*, respectively. Seta *ta* positioned anterior to *ti*, thus notogastral setae forming two rows: *ta*, *ti*, *ms* and r_1 medially and *te* and r_2 laterally. *Gnathosoma*: Pits and setae on mentum as shown in Fig. 31. Palpal formula: 0-2-1-3-9 (+ 1 solenidion). *Ventral surface:* Pits present on all ventral surfaces, pits variable in size and shape, generally smaller than those on center of prodorsum, smallest on genital and anal plates. Epimeral plates (ep_1–ep_4, Figs. 19, 31) divided by furrows, epimeral setal formula 3-1-3-3, setae setiform, short



Figs. 30–34. *Carabodes higginsi*, adult. 30, Sensillus (3670×). 31, Ventral view of gnathosoma and epimera (460×). 32, Genital plates (1100×). 33, Lateral view of genital plates (1390×). 34, Anal plates (890×). Scale bars in μm.

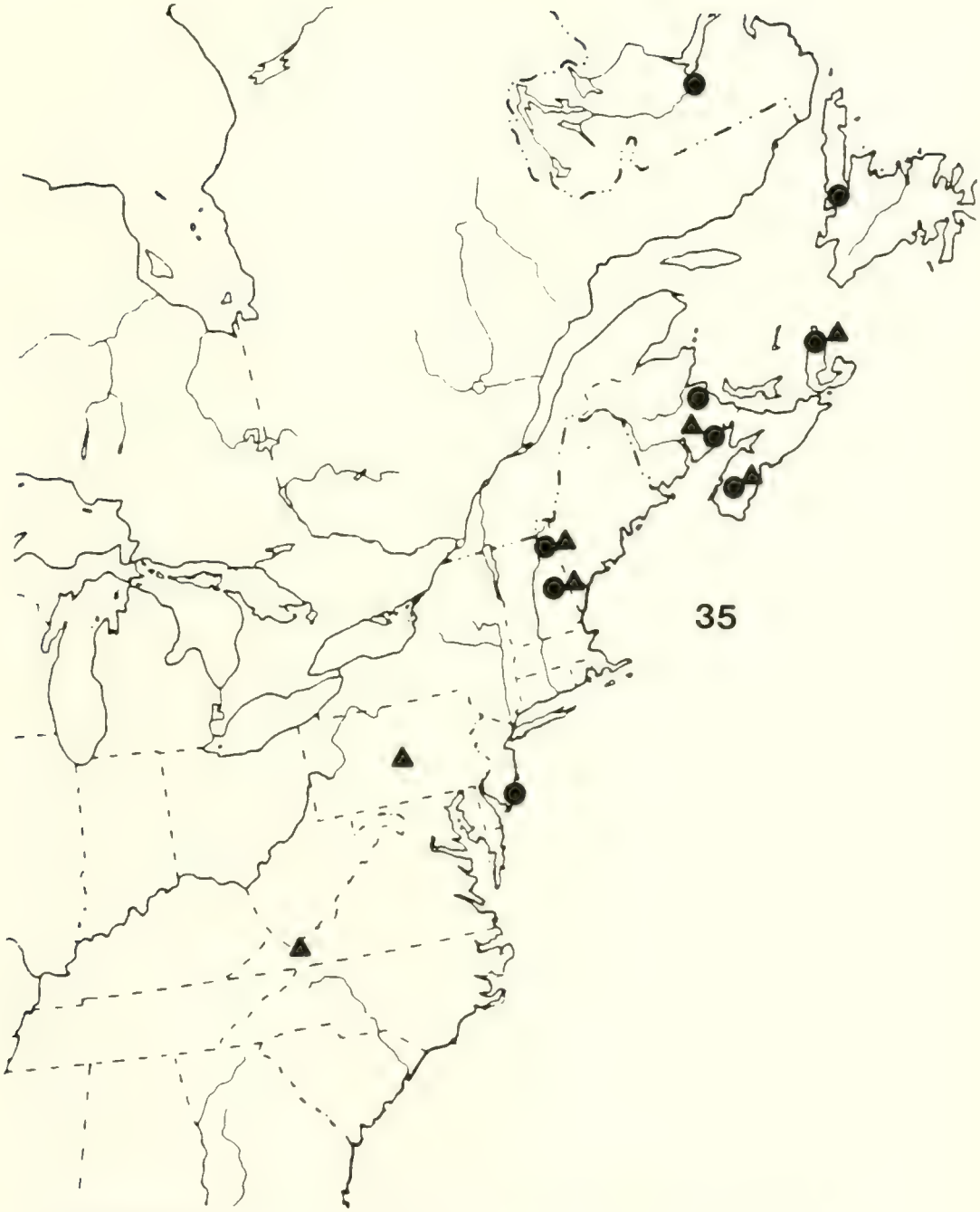


Fig. 35. Known North American distribution of *Carabodes higginsi* (▲) and *C. willmanni* (●).

(8–9). Genital, anal and aggenital setae setiform, short (8–9). One pair of aggenital setae (Figs. 19, 33) present in 8 of 9 females and 3 of 6 males, only one *ag* present on one female and one male and *ag* absent in two males. Adanal setae setiform, length of ad_3 similar to *ag*, ad_2 and ad_1 longer with ad_1 approximately twice length of ad_3. Lyrifissure *iad* lateral to ad_3. Pedotecta I and II and discidium present as shown in Figs. 19, 20. *Lateral surface:* Most of lateral surface below edges of lamellae, bothridium and notogaster but above leg insertions without pits (Fig. 20). Small tubercles present in area immediately above acetabulum I and partially hidden by pedotectum I and on posterior edge of integumental fold that extends from humeral angle ventrally to acetabulum II. Alveolar remnant of exobothridial setae (*ex*) present immediately below bothridium. Circumnotogastral depression faintly indicated below *im* and seta *ms*. *Legs:* Pits present on antiaxial surfaces of femora I and II and trochanters and femora III and IV (Figs. 21–24). Setation (I-IV, solenidia in brackets), trochanters 1-1-2-1, femora 4-4-3-2, genua 3(1)-3(1)-1(1)-2, tibiae 4(2)-3(1)-2(1)-2(1), tarsi 15(2)-15(2)-15-12. Ventral flange of femur III weakly developed. More leg setae are glabrous in *C. higginsi* than in *C. brevis* with the barbed condition retained on paraxial setae *d'* on femora I and II, *v'* on genu I, *v'* and *l'* on genu II, *v'* on tibia I and antiaxial setae *v''* on tibiae III and IV. Solenidion (φ) of tibia II shorter than in *C. brevis* and similar in size and shape to tarsal II solenidia ω_1 and ω_2, a condition also noted by Bernini (1976) for *C. minusculus*. Setae (*p*) of tarsus I short, blunt-tipped and only slightly longer than *s*. Distal setae of all tarsi, in particular *tc*, *it*, *a* and *p* (except leg I), attenuate at tip.

Immatures.—Unknown.

Material examined: Holotype: adult ♀, USA, NEW HAMPSHIRE, Carroll Co., 2.5 mi. NW Wonalancet, The Bowl, VIII-6-85, RMR, sifted spruce litter; deposited in Canadian National Collection. *Paratypes:* 1 ♀, same data except X-1-85, DSC, sifted conifer leaf litter; 1 ♀, same data except VII-30-85, DSC, sifted hemlock/fir leaf litter; 1 ♂, same data except VI-21-85, DSC; 1 ♂, same data except VIII-6-85, sifted litter by stream; 1 ♂, Strafford Co., College Woods, Durham, IV-8-65, RMR, moss on log; 1 ♀, same data except VIII-7-85, sifted leaf litter, rotten wood and stumps; 1 ♀, 1 ♂, 3 sex undetermined, Coos Co., 17 mi. N Crystal, IX-9/11-83, A. Godfrey, extracted from spruce branches; 2 ♀, same data except extracted from fir branches; 1 ♂, same data except 3 mi. NE Errol, IX-3/4-83, extracted from fir branches; 1 ♀, PENNSYLVANIA, Huntington Co., Alan Seeger Natural Area, V-30-85, DSC, sifted pine leaf litter; 1 ♀, VIRGINIA, Giles Co., White Pine Lodge nr. Mountain Lake, IX-12-67, J. M. Campbell, white pine duff; 1 ♀, CANADA, NOVA SCOTIA, Cape Breton Highlands Natl. Pk., Paquette Lake Trail, VIII-29-84, V. Behan, lichens on rocks on Glasgow Lake Trail; 1 ♂, Kejimkujik Natl. Pk., VIII-17-68, E. E. Lindquist, *Polyporus* on dead fir and spruce trunks; 1 ♂, 12 sex undetermined, same data except VIII-18-68, 1' white pine duff. Paratypes deposited in United States National Museum, Washington, D.C., Museum of Comparative Zoology, Cambridge, Massachusetts, Canadian National Collection, Biosystematics Research Centre, Ottawa and the personal collections of R. A. Norton and the author.

This species is distributed from the Canadian Maritime Provinces southwest to Virginia. It has been collected most often from conifer leaf litter, bark and branches and usually as single specimens. Fir and spruce branches and white pine duff have provided the largest number of specimens/sample.

Remarks.—*Carabodes higginsi* belongs to the *minusculus* group by having the notogaster covered with tubercles, a narrow dorsosejugal furrow and by the shape of the sensillus. It has longer and more tapered notogastral setae than *C. willmanni*, which

is the only other species of this group known from North America. The absence of aggenital setae in this group has been noted only in *C. pulcher* Bernini (Bernini 1976).

This species is named after an oribatologist and friend, the late Harold G. Higgins, of Salt Lake City, Utah.

Distribution and Habitat Comparisons

The distribution and habitat preferences for the remaining five species are based on literature, material in the CNC and my own personal collection.

Carabodes granulatus is known from Illinois, Kentucky, New York and North Carolina (Marshall et al. 1987). The additional specimens seen are from Newfoundland, Nova Scotia, New Brunswick and Ontario in Canada and New Hampshire, Vermont, Massachusetts, Pennsylvania, Virginia, South Carolina, Georgia, Florida, Mississippi, Missouri and Oklahoma in United States. It has possibly the widest distribution in eastern North America of any *Carabodes* species and is found from Newfoundland south to northern Florida and west to southern Ontario, Missouri and Oklahoma (Fig. 36). It is also one of the most abundant species in leaf litter and rotten wood samples from Pennsylvania and New Hampshire but may also be found in sphagnum and other mosses, lichens, bark, grass sod and fungi.

Carabodes labrynthicus is a commonly collected Holarctic species in Europe and North America. It has the most northerly distribution of any *Carabodes* in the Nearctic zone (Fig. 37). Marshall et al. (1987) lists this species from Québec, Northwest Territories, Yukon Territory, Alaska and Virginia. The CNC and my own collection have additional specimens from CANADA: Labrador, Newfoundland, Prince Edward Island, Nova Scotia, New Brunswick, Ontario and Manitoba and USA: Maine, New Hampshire, Vermont, New York, Pennsylvania and New Jersey. The CNC also has specimens from Magadan, Magadan Region, USSR. It is the only species of *Carabodes* I have collected above 1220 m elevation on Mt. Washington, New Hampshire with the highest collections at 1585 m elevation. The highest numbers I have seen in samples have come from leaf litter and rotten wood from New England, although specimens were also present in samples from moss, lichens, grass, fungi and wrack. Seyd and Seaward (1984), in their review of oribatid mite/lichen associations, consider that this species, while showing a preference for lichens, is also adapted for existence on other plants.

Carabodes niger has been recorded from New York, Ohio, Virginia and North Carolina (Marshall et al. 1987). Additional specimens in the CNC and my own collection extend this distribution to Newfoundland, Prince Edward Island, Nova Scotia, New Brunswick, Québec, Ontario and Manitoba in Canada and Maine, New Hampshire, Vermont, Massachusetts, Pennsylvania, New Jersey and Maryland in the United States (Fig. 38). It is difficult at this time to determine the southerly distribution of this species below Pennsylvania and Maryland because material I have seen from further south contain many as yet undescribed species closely related to *C. niger*.

Norton (1978) has pointed out that the length of the posteromarginal setae on specimens from Ohio are longer, nearly reaching the insertion of the next seta, while on type specimens from New York these setae are less than half this distance. I have also noted this and find the longer setal lengths predominate in samples from northern New England and Canada while shorter setal lengths predominate in samples from Massachusetts (Martha's Vineyard), New York (Long Island), New Jersey, Maryland and Pennsylvania. A detailed study of *C. niger* and closely related species will be necessary to resolve whether *C. niger* is a complex of species or simply showing clinal variation with latitude.

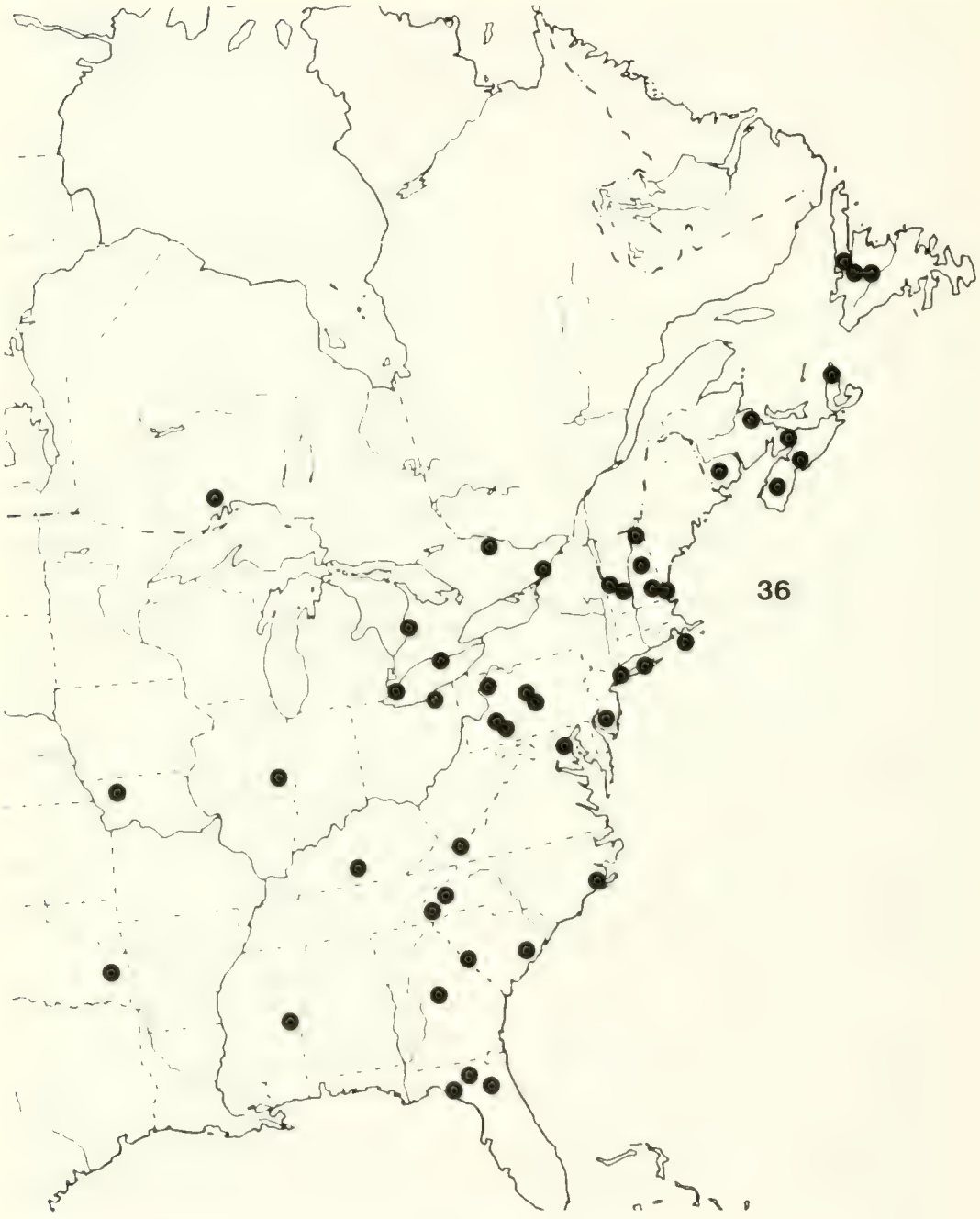


Fig. 36. Known North American distribution of *Carabodes granulatus*.

Banks (1895) collected the type specimens from *Polyporus* fungi, and Norton (1978) noted that most collections from New York and Ohio have been from fungi, especially *Polyporus*. There are many collections in the CNC labelled "bracket fungi" and "*Polyporus* fungi" in association with logs, stumps and tree trunks. The dominant

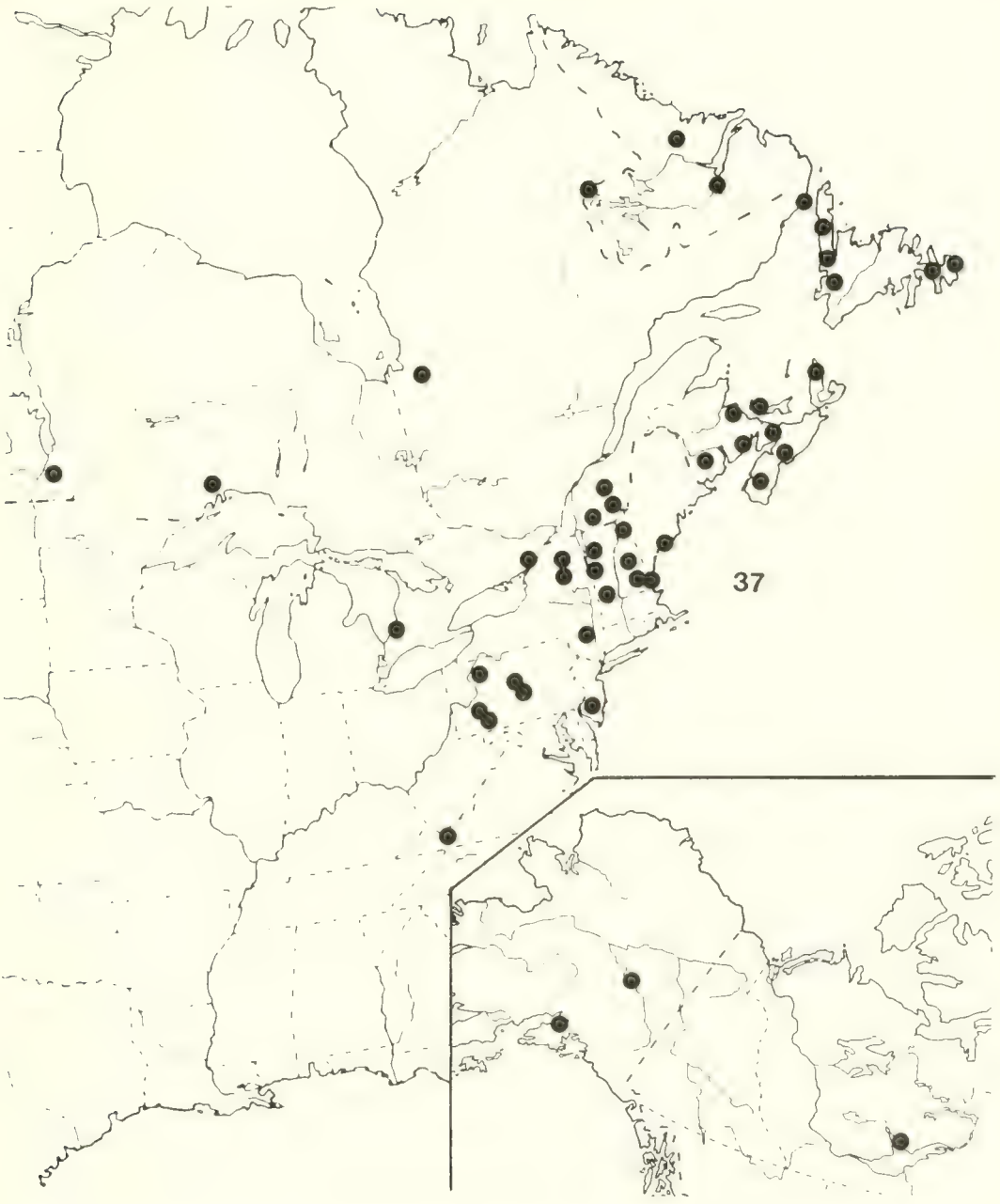


Fig. 37. Known North American distribution of *Carabodes labrynthicus*.

species in these samples is nearly always *C. niger* while the species most often found with *niger* is *C. brevis*. In my collection nearly all samples containing *C. brevis* also contain *C. niger* with the latter species dominant numerically. Thus, a close habitat association between these two species is evident. However, I have usually found *C. niger* is more abundant in forest leaf litter and the most commonly encountered *Carabodes*

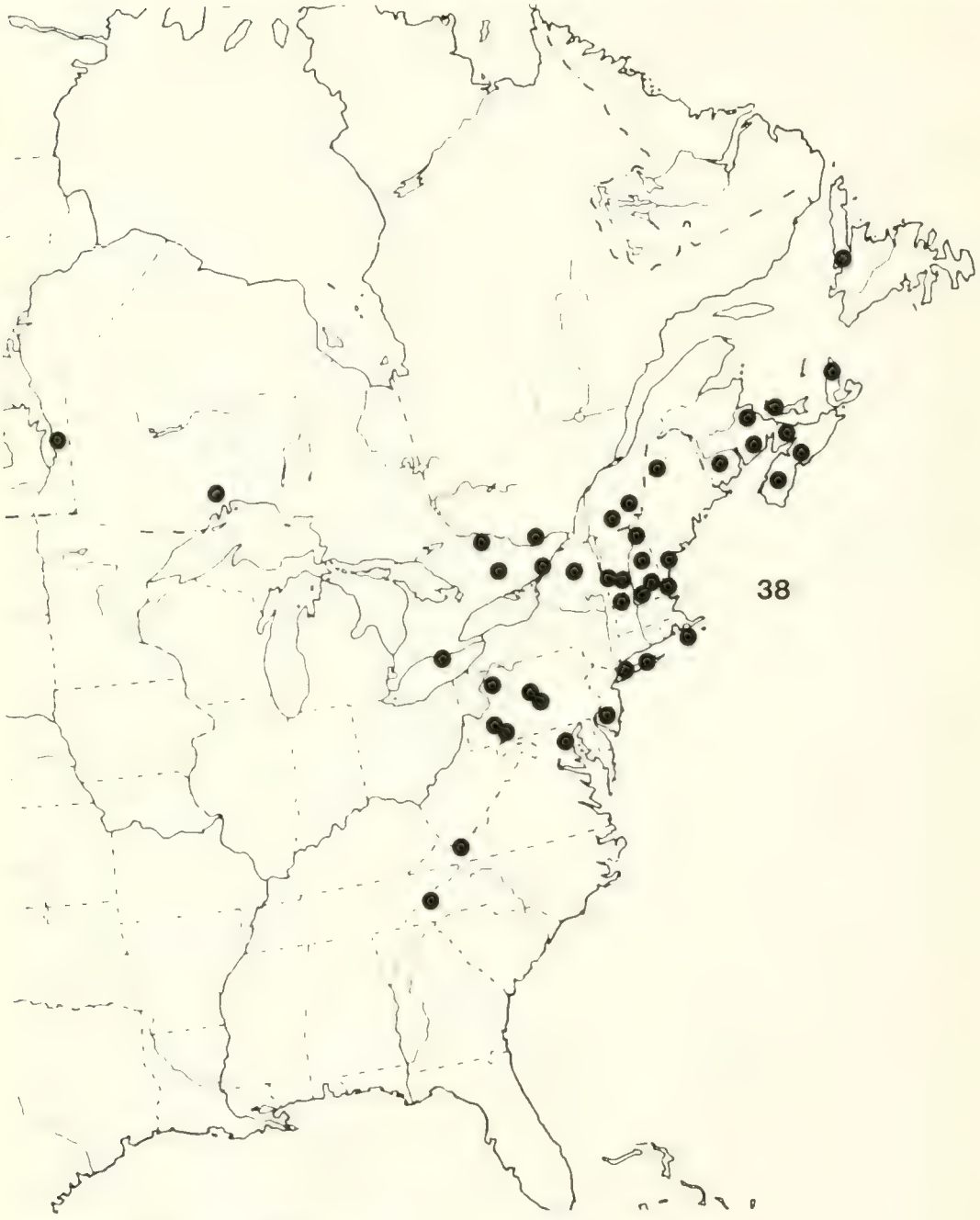


Fig. 38. Known North American distribution of *Carabodes niger*.

species from forest leaf litter, rotten wood, bark and fungi in Pennsylvania and northern New England. It has also been collected from moss, lichens and grass sod.

Carabodes willmanni is Holarctic and is distributed in Europe from Scandinavia south to Italy and Spain and known in North America only from central New Hampshire

Table 1. Percent representation of *Carabodes* species from branch extractions and from sifted leaf litter/rotten wood collections.

Species	Branch Extractions of Spruce-fir	Sifted Leaf Litter/Rotten Wood	
		Spruce-fir	Mixed forest
brevis	52	<1	<1
dendroetus	37	0	<1
higginsi	5	0	<1
willmanni	2	0	0
granulatus	2	<1	41
niger	<1	11	46
labrynthicus	<1	87	2
Other spp.	0	1	11
Total specimens	129	3546	1602

(Bernini 1975). I have seen additional material from Labrador, Newfoundland, Nova Scotia, New Brunswick, New Jersey and from spruce and fir branches in northern New Hampshire (Fig. 35). Samples with the largest number of specimens (43 maximum) are from lichens or lichens mixed with woody shrubs while samples from leaf litter, moss, bark or grass contain one to three specimens only. In Europe *C. willmanni* is a common inhabitant of lichens (Bellido 1979, Colloff 1983, Seyd and Seaward 1984) and Bellido (1979) has reported on the influence of temperature and moisture on the seasonal abundance of larvae, nymphs and adults of this species while feeding in lichens.

Table 1 gives the percentages of individuals recovered from branch samples processed with caustic soda and compares them with leaf litter/rotten wood samples from a virgin spruce-fir stand at Norton Pool, 3 mi. E of East Inlet Dam, Coos Co., NH, and a virgin mixed forest at "The Bowl," 2.5 mi. NW Wonalancet, Carroll Co., NH. A more complete description of these areas may be found in Lyon and Reiners (1971). The dominant *Carabodes* species on branches were *brevis* and *dendroetus* while leaf litter/rotten wood was preferred by *C. granulatus, niger* and *labrynthicus. Carabodes willmanni* and *higginsi* were absent or poorly represented in all these habitats suggesting that these are not favored habitats for these species. All seven species were collected from spruce branches while only four (*C. brevis, dendroetus, higginsi* and *granulatus*) were collected from fir branches. Also 85% (56 specimens) of *C. brevis* were collected from spruce branches. Thus spruce branches seem to be preferred to those of fir, possibly as a result of the rougher bark surface or the position of the needles around the twigs.

In summary the above evidence indicates considerable variation in habitat preferences for certain species. *Carabodes brevis* and *dendroetus* are primarily arboreal with *C. brevis* often associated with *C. niger* in fungal fruiting bodies. *Carabodes granulatus, labrynthicus* and *niger,* while more common in leaf litter/rotten wood, may be arboreal, with *granulatus* and *labrynthicus* usually associated with lichens and moss and *niger* with fungi. *Carabodes willmanni* is probably limited to bark and branches where lichens are present. The caustic soda wash technique did not indicate habitat preferences for *C. higginsi* but other collection information point toward a preference for coniferous litter or bark.

Acknowledgments

Scientific Contribution Number 1546 from the New Hampshire Agricultural Experiment Station.

The Central University Research Fund,

University of New Hampshire, provided financial support for scanning electron micrographs used in the descriptions. I thank Stanley S. Swier and April Godfrey for providing the extracted branch samples, Donald S. Chandler for collecting many of the leaf litter/rotten wood samples and Valerie Behan-Pelletier for providing access to the CNC material. I am grateful to Ardis Johnston, Museum of Comparative Zoology, Cambridge for the loan of the type specimens of *C. brevis*. I thank Valerie Behan-Pelletier, Biosystematics Research Centre, Ottawa, Canada and Donald S. Chandler and John S. Weaver III, University of New Hampshire, for review of the manuscript.

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PROC. ENTOMOL. SOC. WASH.
90(3), 1988, p. 393

NOTE

The Newly Discovered Spring Crown Gall of *Asphondylia rudbeckiaeconspicua* (Diptera: Cecidomyiidae) on *Rudbeckia laciniata* (Asteraceae) in Pennsylvania

Asphondylia rudbeckiaeconspicua Osten Sacken (Diptera: Cecidomyiidae) forms a conspicuous, apical summer gall on the meristems and flower discs of *Rudbeckia laciniata* L. (Asteraceae) (Felt, E. P. 1940. Plant Galls and Gall Makers. Comstock Publishing Co., Ithaca, N.Y. 364 pp.). The gall is large, globular, usually about 5 cm across, and always polythalamous. Until now, only the summer galls of *A. rudbeckiaeconspicua* were known.

Because all of the known *Asphondylia* spp. overwinter as larvae in living plant tissue (R. J. Gagné, personal communication) *A. rudbeckiaeconspicua* must either lay its eggs in the crown of *R. laciniata,* the only part of the plant that survives winter above ground, or use another host. Assuming the former to be the more likely case, I searched the crowns of *R. laciniata* in early June 1985 at Pittsburgh, Pennsylvania and there located six basal bud galls. They were approximately 4 cm high and 2.5 cm wide, and they originated at the base of the 1985 stems. This indicated that the eggs or young larvae overwintered in these buds. The galls were analogous to summer galls in that they were polythalamous, with one larva developing per cell.

Pupae taken from these spring galls, and adults reared on 10 June 1985 were identified as *A. rudbeckiaeconspicua* by Dr. R. J. Gagné of the Systematic Entomology Laboratory, USDA, Washington, D.C. This confirms that *A. rudbeckiaeconspicua* has two generations per year, one in spring crown galls, and the second in summer apical galls.

From this discovery it now seems likely that other *Asphondylia,* known only from apical summer galls on Asteraceae, also have another gall elsewhere on their host plant where they overwinter.

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PROC. ENTOMOL. SOC. WASH.
90(3), 1988, pp. 394–395

NOTE

A Polynomial Riley Name in Cecidomyiidae (Diptera) and Implications of Such Names for Cynipidae (Hymenoptera)

In an article on insects injurious to grape vines, Riley (1873, Fifth Ann. Rept. Noxious and Beneficial Insects of the State of Missouri, p. 117) coined the name *Vitis tomatos* for tomato-like galls on grape. This name has not to my knowledge been used in the scientific literature since then. Riley evidently intended to use the name to refer to the gall only, because he wrote that the gall was made by the gall midge *Lasioptera vitis* Osten Sacken 1862. A name proposed before 1931 for the work of an animal may be considered available in zoological nomenclature (Int. Code. Zool. Nomen. 1984, 3rd ed., Art. 1a), but Riley did not explain why he used separate names for the gall and gall maker. The question now is whether the generic or specific names of *Vitis tomatos* are available for taxonomic use. The answer is important because *L. vitis* is not the actual gall maker. Instead, that species appears to be only an occasional inquiline in galls caused by *Janetiella brevicauda* Felt 1908 (pers. observ.; R. B. Johnson unpub. thesis, Cornell University, 1952). If *Vitis* is an available generic name, it could be used for a group of grape-feeding species that includes *brevicauda* and that are now in the catch-all genus *Janetiella*; if *tomatos* is available, it would be a senior synonym of *brevicauda.*

Judged solely from the contents of Riley's paper (ibid.), *Vitis tomatos* would appear to be available for use. To find out what Riley might have intended, one needs to look elsewhere. Earlier in Riley's paper (p. 114), the name *Vitis pomum* Walsh and Riley is used for another gall on grape. That species had been described previously as [*Cecidomyia*] *Vitis pomum* (Walsh and Riley 1869, Am. Entomol. 1: 106). The name *Cecidomyia* was understood, being the heading (p. 105) of the section in which several gall midges and their galls were described. Walsh and Riley (ibid.) coined many other names in that formula: the generic name understood and not repeated for each species; another word capitalized and in the genitive form of the plant name; and the final word descriptive of the gall. For [*Cecidomyia*] *Vitis pomum* that meant, "apple [gall] of grape [formed by a *Cecidomyia*]."

Two separate reasons to invalidate *Vitis tomatos* appear to be present: that *Vitis tomatos* is in reality a polynomial and that *Vitis* is in the genitive case. Polynomials are not available according to binomial nomenclature and so are not considered by the International Code of Zoological Nomenclature (ICZN 3rd ed., 1985). There is a provision of the ICZN (Art. 11h(v)) to accept species-group names that were published as separate words referring to a single entity. For example, *Cecidomyia piniinopis* Osten Sacken was originally coined as *Cecidomyia pini inopis* but, because *pini inopis* is based on the host, then known as *Pinus inopis,* the separate words are closed up and the name considered available from its original description. But *Vitis pomum* is not available from 1869, when proposed by Walsh and Riley, but from 1878, when Osten Sacken (1878, Smithson. Misc. Colls. 270: 7) combined the two separate words as *Cecidomyia vitis-pomum,* thus satisfying the provisions of binominal nomenclature and making Osten Sacken the author as of 1878.

The second point one notices when leafing through the paper by Walsh and Riley is that the first word of any two-word name is in the genitive case, e.g. *Salicis brassicoides* Walsh (p. 105) and *Populi vagabunda* Walsh (p. 107). *Vitis,* too, if one assumes

the practice was continued, must be in the genitive case, although that name, being in the third Latin declension, takes the same form for the nominative and genitive cases. The International Code of Zoological Nomenclature (Art. 11g) requires that a generic name be in the nominative singular.

Indications are that Riley formed *Vitis tomatos* following the pattern used by Walsh and Riley of using polynomial names and using the penultimate word in the genitive case. *Vitis tomatos,* then, appears to be invalidly constructed and not available for taxonomic use.

While researching this problem, I noticed that the Catalog of Hymenoptera in America North of Mexico (Krombein, Hurd, Smith, and Burks 1979, Smithson. Inst. Press) improperly lists many cynipid names as available from the date their specific names were coined as two independent words that do not refer to a single unit, unlike *pini inopis* above. Consider *Atrusca quercuscentricola* (ibid., p. 1090), which was described as *Cynips quercus centricola* (Osten Sacken 1861, Proc. Entomol. Soc. Phila. 1: 58): the name should be *Atrusca centricola* and date from 1865 when Osten Sacken (1865, Proc. Entomol. Soc. Phila. 4: 345) first used a single word for the specific name of that species.

I am grateful to L. G. Clark for sending me a copy of the R. B. Johnson thesis and to W. N. Mathis, R. V. Peterson, C. W. Sabrosky, G. C. Steyskal, and F. C. Thompson for their comments on an early draft of this paper.

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PROC. ENTOMOL. SOC. WASH.
90(3), 1988, pp. 396–397

Book Review

The Behavioural Ecology of Ants. By John H. Sudd and Nigel R. Franks. Blackie, Chapman and Hall, New York. 1987, x + 206 pp. $55 cloth, $23 paperback.

The common perception of ants as busy automatons, harmoniously and altruistically functioning for the greater good of queen and colony, should be shaken by a reading of *The Behavioral Ecology of Ants,* by John H. Sudd and Nigel R. Franks. Instead of harmony and altruism, the authors describe oligogynous and polygynous colonies (those with few and many reproductive females), intracolonial struggles for reproductive dominance, workers killing their queens, workers producing all of a colonies' male off-spring, ritualized antagonistic interactions among workers, infiltration of colonies by murderous socially parasitic ants, and the use of propaganda pheromones; all to maximize each ant's reproductive success. The book deals with the eusociality of ants, wherein individual ants forgo reproducing to enhance the reproduction of a nestmate; how eusociality could evolve in ants, and why, except for termites, it is restricted to Hymenoptera. W. D. Hamilton's (1964) hypothesis of kin selection based on haplodiploid reproduction in Hymenoptera is used to explore and explain the social activities of ants, particularly social altruism to close kin.

Written for use by advanced undergraduates, graduate students, and researchers in entomology, ecology and behavior, the book may prove to be a bit too challenging for undergraduates. It is, however, admirably suited for a post baccalaureate audience familiar with the specialized terminology. While crucial terminology is defined, the inclusion of a glossary would have been useful.

In an undogmatic style, suited to a field in which today's truth can sometimes become tomorrow's fiction, Sudd and Franks steer the reader through the intricacies of ant communication, reproductive strategies, foraging behavior, caste systems, social parasitism and more. Not unexpectedly, some subjects receive a more thorough treatment than others, but for the most part they are adequately presented. A reader eager for more information on an interesting topic will notice how well, with few exceptions, the book is documented (over 300 references).

The illustrations are of generally high quality; however, the cover drawing both fascinates and irks me. It is a rather striking computer-generated 3D line image of an army ant worker. At first glance, something seemed amiss about the ant. A more focused inspection revealed that the antennae were thread-like; each drawn with a single line, egregiously and inexplicably out of proportion.

Some minor slip ups: grammatical (e.g. data was [sic]), factual (e.g. *Trachymyrmex septentrionalis* is primarily an ant of somewhat xeric woodlands from Texas eastward, rather than a desert ant, as stated), and in the adaptation of figures from other publications (e.g. Fig. 2.1), can be found. Some readers may disagree with some of the authors' statements, such as those about intra- and interspecific competition, which seem to ignore the phenomenon of invading species like the red imported fire ant, *Solenopsis invicta.* We are told about r and K strategists in Chapter 7, and referred to Section 1.4.1 for a prior explanation which is not to be found. Such slight defects are more than outweighed by the value of the book to myrmecologists and other interested parties, if only for the fact that it summarizes much of the information explosion on ant behavior and ecology, occurring over the past two decades.

Overall there is much which can be said

favorably about *The Behavioral Ecology of Ants*, and I especially recommend it for myrmecologists and those teaching courses in insect behavior and evolution. It is a relatively slender book (206 pages), but packed with facts and thought-provoking theories which fascinated me.

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PROC. ENTOMOL. SOC. WASH.
90(3), 1988, p. 397

Book Review

The Metallic Wood-boring Beetles of Canada and Alaska: Coleoptera: Buprestidae. By Donald E. Bright, Biosystematics Research Centre, Agriculture Canada, Ottawa, Ontario. Part 15. The Insects and Arachnids of Canada. (Publication 1810). 335 pp., 264 figures, 87 maps. 1987. Cost: $14.90 (Canada), $17.40 (Other Countries, Canadian funds).

This is another in the fine series of handbooks for the identification of Canadian arthropods written by systematists of the Biosystematics Research Centre and outside collaborators. Although this volume is primarily concerned with the Canadian fauna, it will be useful to workers in the United States since most of the species are found in both countries. The author included some of the species found in the northern states that should extend into Canada but that are not yet recorded north of the border.

The text is English but identification keys to all taxa are in both English and French. A generous diagnostic description for each genus and species is given along with an up-to-date nomenclature, the principal historical taxonomic combinations and references, lists of host plants, the general distribution, and identification notes. Habitus drawings are provided for at least one species in each genus, and male genitalia are illustrated for nearly all of the species. Distribution maps for the Canadian records of 119 of the 189 species or subspecies are included. A short glossary of morphological terms, a complete list of references, and an index complete the volume.

I can find little to criticize about this manual. One might wish for more habitus illustrations, but the keys and descriptions supported by line drawings of male genitalia appear to be adequate.

Taxonomists, museum workers, foresters, pest control operators, port identifiers, and students will find this a valuable reference for their libraries especially if they do not specialize in the family Buprestidae.

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PROC. ENTOMOL. SOC. WASH.
90(3), 1988, pp. 398–400

Book Review

The Ixodid Ticks of Uganda. By John G. Matthysse and Murray H. Colbo. Entomological Society of America, 4603 Calvert Road, College Park, MD 20740. xii + 426 pp., 166 plates. 1987. $35.00/paper. ISBN 0-938522-31-0 (500 copies printed).

In 1963, J. G. Matthysse was a member of a U.S. Department of Agriculture team sponsored by the U.S. Agency for International Development (USAID) concerned with livestock development in Uganda with special emphasis on improved cattle ranching in Ankole District. This was an area being successfully cleared of tsetse flies through USAID financial support. The final report submitted by that team recommended that a taxonomic, biological and economic survey of the ticks of Uganda be undertaken as a basis for tickborne disease control.

A joint research program between the Government of Uganda and USAID was initiated in July 1965 and later that same year Murray H. Colbo joined the team. From this work a book-length manuscript, including plates and maps, was completed in July 1969. As the Entomological Society of America flyer for this book announces, "it was twenty years in the making, but *Ixodid Ticks of Uganda* has finally arrived." I will discuss that delay a bit further in this review.

At the time this book was conceived, all East African countries and most countries in the rest of Africa carried out tick and tickborne disease control programs. However, in recent years, wars and other civil disturbances, as well as natural disasters, have combined to curtail control of ticks and tickborne diseases over much of the continent. Ticks and tickborne diseases are among the most important factors in preventing the improvement of livestock husbandry in Africa. In much of East Africa, breed improvement is prevented by the susceptibility of introduced cattle to tickborne diseases. Throughout Africa, ticks and the diseases they transmit cause great economic loss in livestock through death (especially in calves), stunting and poor growth, wound exposure to other infections and infestations, interference in trade, and great expense in application equipment, acaricides, immunizations and drug treatments.

The Ixodid Ticks of Uganda is the fifth book to be published dealing with the ticks of an East African country and, to my mind, it is the most useful. For those readers who are interested, the others are Harry Hoogstraal's *Ticks of the Sudan* (1956), a monumental piece of work but becoming outdated; Guy Yeoman and Jane Walker's *The Ixodid Ticks of Tanzania* (1967) and Walker's *The Ixodid Ticks of Kenya* (1974), both very useful references but without keys or figures; and Pierre Morel's *Étude sur les Tiques d'Éthiopie* (1976), again a useful work but with only a few figures of *Rhipicephalus* species and no keys.

The text of *The Ixodid Ticks of Uganda* is roughly divided into two parts (there are no chapters as such). The first part is introductory in nature, giving the reader a background of previous tick work conducted in Uganda, followed by a detailed description of the country, including physiography, climate, ecological zones, vegetation types, and livestock and wild host distributions. This is all important information and the authors subsequently discuss tick species in relation to these factors and show that tick distribution is regulated by rainfall, temperature, altitude and vegetation as well as by host availability. The only problem I have with this section is my inability to decipher some of the maps. For example, trying to read the

legend on the ecological zone map (p. 13) is impossible without the aid of a magnifying glass. There follows a methods section giving procedures for mapping tick collections and preparing transects, together with specific locality coordinates and a list of hosts by district from which ticks were collected. Again, the only difficulty I have with this section is the map on page 19 where Uganda collecting locations are marked with black circles, triangles, and squares. What do these three different symbols mean? There is no symbol legend with this map to guide us, and it is not until we reach the bottom of page 25 that the symbols are explained.

The remainder of the book is devoted to keys, descriptions, hosts, distributions, and figures of the genera and species of Ixodidae occurring or likely to be found in Uganda. Eleven genera are discussed, with the genera *Amblyomma, Haemaphysalis, Ixodes* and *Rhipicephalus* occupying the major portion of the book. The *Amblyomma* species are illustrated with light microscopy photographs, *Haemaphysalis* species by pen and ink drawings from Hoogstraal publications in the *Journal of Parasitology, Ixodes* species by both pen and ink illustrations and scanning electron photomicrographs, and *Rhipicephalus* species primarily by light microscopy photographs, but with a few SEM's and some pen and ink drawings of female genital apertures. For some strange reason, a few of the figures in the plates were printed upside down—see plate 68, fig. 3; plate 129, fig. 2; plate 155, fig. 5; and plate 164, fig. 4.

I have not tested all the keys, but for several years I have used the authors' *Rhipicephalus* key. Before running specimens through that key, any worker new to this genus should read the warning on page 273 on how difficult it can be to correctly identify African species of *Rhipicephalus.* As Harry Hoogstraal once said to me, "God created the genus *Rhipicephalus,* and even He can't identify them." I say that I have used the *Rhipicephalus* key for several years because a version of this book has been in the hands of a few tick taxonomists for a long time. Beyond the fact that this is a fine addition to the literature on African ticks, Matthysse and Colbo deserve medals for their patience and perseverence during the twenty years that preceded publication. A brief history of this long path to press may be of interest.

Originally, Matthysse planned to have this book published by the Commonwealth Institute of Entomology, and in August, 1969 delivered typescript to them in London. While still there, he received a cable from the State Department in Washington, D.C. instructing him to deliver it to the Uganda Government Printer in Entebbe, which he did. It should be noted that the Uganda Government Printer is part of the President's office and high level priorities rule the sequence of printing operations. It should also be noted that in 1966 Milton Obote led a revolution in Uganda and installed himself as President, so the government at that time was relatively unstable, and frequent border clashes were taking place with Tanzania. In 1971, Idi Amin Dada seized power, toppling the regime of Milton Obote, and in 1972 Amin ordered the expulsion of Uganda's 60,000 Asians, among whom were the skilled workers employed by the Uganda Government Printer. Between 1969 and 1973, despite repeated attempts, no news was received by Matthysse and Colbo on the fate of their book. In 1974, they were told that the book was scheduled to be out in June. In February 1975, they were told that a bound copy had appeared but without illustrations. In fact, a few copies of this book actually exist, though without figures, maps, publisher information, or even the authors' names! Torture of this kind continued until 1980 when Matthysse received a letter from Entebbe informing him that, "not a trace remains of the manuscript" and that the Uganda Government Printer had been hard hit by the war. So it was back to square one. The book was now out of date

and between 1980 and 1987 it was almost completely rewritten and updated. I want to emphasize that this is not the text of the 1969 manuscript; it is a true 1987 publication. Ultimately, the Entomological Society of America agreed to be the publisher. Congratulations to the authors for writing it and to the ESA for publishing it at a reasonable cost.

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PROC. ENTOMOL. SOC. WASH.
90(3), 1988, p. 400

Book Review

Revision of the Caddisfly Genus Psilotreta (Trichoptera: Odontoceridae). By C. R. Parker and G. B. Wiggins. Royal Ontario Museum, Life Sciences Contribution Number 144. 1987, v + 55 pp., 57 figs., 1 table. $12.00 (CDN), from Royal Ontario Museum, Publication Services, 100 Queen's Park, Toronto M5S 2C6, Canada.

The family Odontoceridae is a comparatively small family of caddisflies that contains representatives on all continents except the African. Their larvae, which live in lotic habitats, construct rigid cases made of small sand grains. In North America we recognize 6 genera of which only *Psilotreta* occurs in the east. In addition to the 6 species which the authors recognize in this genus from North America, another 14 are known from Asia.

In this revision the genus is characterized in its adult (including male and female genitalia), larval and pupal stages. Males, females and larvae of all North American species are separated by key, and they are grouped into 2 species groups: the *indecisa* group with *indecisa* (Walker), *frontalis* Banks and *labida* Ross, and the *rufa* group with *rufa* (Hagen), *rossi* Wallace and *amera* (Ross). The usual full synonymy, descriptions, distribution and complete illustrations are given for each species. The Asian species are less fully treated; males of only 10, females of 6 and larvae of 3 species being known. Two new species are described from Assam and Sikkim, India. The paper finishes with a cladistic and biogeographic analysis of the American species.

Considering the overall exhaustive coverage, I find it surprising that the authors did not illustrate more of the Asian species. The male genitalia are figured for only 5 of the 14 species, but illustrations exist for 7 more species and the types of many are readily available. Even if only the best available illustrations were copied photographically for these species, their identification would be made much easier than having to look them up in a number of journals, some rather obscure.

This consideration aside, their work is well done, with the printing and illustrations clear and crisp. Now for the first time, it is possible for workers to identify all the adults and larvae of this important component of the North American benthos. This study is a necessity for all Trichopterists and those that need to identify benthic collections from Eastern North America.

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VOL. 90 OCTOBER 1988 NO. 4
(ISSN 0013-8797)

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of

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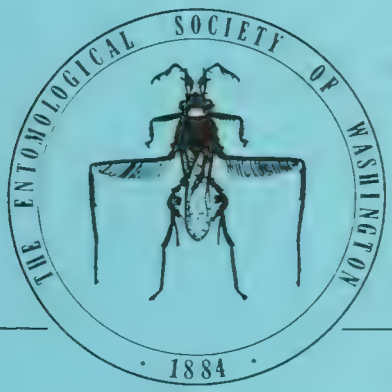

PUBLISHED
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THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

ORGANIZED MARCH 12, 1884

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PLEASE SEE P. 129 OF VOL. 90(1) FOR INFORMATION REGARDING PREPARATION OF MANUSCRIPTS.

STATEMENT OF OWNERSHIP

Title of Publication: Proceedings of the Entomological Society of Washington.

Frequency of Issue: Quarterly (January, April, July, October).

Location of Office of Publication, Business Office of Publisher and Owner: The Entomological Society of Washington, c/o Department of Entomology, Smithsonian Institution, 10th and Constitution NW, Washington, D.C. 20560.

Editor: Hiram G. Larew, B-470, ARS, USDA, Beltsville, MD 20705.

Managing Editor and Known Bondholders or other Security Holders: none.

This issue was mailed 12 October 1988

Second Class Postage Paid at Washington, D.C. and additional mailing office.

PRINTED BY ALLEN PRESS, INC., LAWRENCE, KANSAS 66044, USA

THIS PUBLICATION IS PRINTED ON ACID-FREE PAPER.

PROC. ENTOMOL. SOC. WASH.
90(4), 1988, pp. 401–406

THE PEST STATUS OF *PERIPLANETA FULIGINOSA* (SERVILLE) (DICTYOPTERA: BLATTIDAE) IN CHINA

WILLIAM H. ROBINSON AND NONGGANG BAO

Urban Pest Control Research Center, Department of Entomology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Abstract.—There are approximately 19 pest cockroach species in China. The most common household pests include the German cockroach, *Blattella germanica* (L.) and six *Periplaneta* species, including the smokybrown cockroach, *P. fuliginosa* (Serville). The pest status of *P. fuliginosa* in residences was determined by evaluating the attitudes and knowledge of apartment residents in Hangzhou, China that regularly experience this cockroach as a household pest. The questionnaire-survey indicated that a mean of 5 cockroaches was seen per day in the apartments. However, the residents considered the presence of 2 per day a problem. A majority of residents considered cockroaches more serious than a leaky faucet or a broken window, but considered having mice more serious than having cockroaches. Approximately 8% of the people questioned linked household cockroaches to the spread of disease. The apartment residents reported spending an average of 0.38Y ($0.11) (range 0–1.5Y) per month on cockroach control. Those interviewed in April were willing to spend an average of 2.65Y ($0.72) (range 0–5.5Y), and those interviewed in August were willing to spend 5.27Y ($1.44) (range 0–7.5Y) per month for elimination of their cockroach infestation. The attitudes and knowledge of cockroach pests by urban residents in China was similar to those in the U.S.

Key Words: cockroach pest status, China, survey

There are approximately 19 cockroach species that are pests in households in the People's Republic of China (Table 1). The major pest species are *Blattella germanica* (L.), and six *Periplaneta* species: *P. americana* (L.), *P. australasiae* (F.), *P. brunnea* (Burmeister), *P. fallax* (Bienko), *P. fuliginosa* (Serville), and *P. japonica* Karny. The German cockroach, *B. germanica,* occurs primarily in locations that are regularly heated in the winter, such as hotels, restaurants, and transportation vehicles (Woo and Guo 1984). *Periplaneta americana* and *P. fuliginosa* are more generally distributed, and occur in single- and multi-family dwellings, hotels, restaurants, stores, and food processing plants (Woo 1982). *Periplaneta japonica* is a serious household pest in northeastern China (Woo 1982). The oriental cockroach, *Blatta orientalis* L., has been recorded as a pest in Beijing, Xingjiang, and Yunnan provinces (Woo 1987). *Pycnoscelus surinamensis* (L.) has been reported from Yunan, Guangdong, and Fujian provinces (Woo 1987). *Eupolyphaga sinensis* Walker is a household pest in northern, central, and southeastern provinces (Woo 1987). *Eupolyphaga sinensis, Polyphaga plancyi* Bolivar, and *Opisthoplata orientalis* Burmeister are often used in traditional Chinese medicine (Woo 1987).

The urban population of the People's Republic of China is approximately 230 million. Although urban residents are only 22%

Table 1. The cockroaches species that are known to be household pests in China.

Species	Reference
Family Blattidae	
Periplaneta americana (L.)	Woo 1982
Periplaneta australasiae (F.)	Woo 1982
Periplaneta brunnea (Burmeister)	Woo 1982
Periplaneta fallax (Bienko)	Woo 1982
Periplaneta fuliginosa (Serv.)	Woo 1982
Periplaneta japonica Karny	Woo 1982
Blatta orientalis L.	Woo 1987
Hebardina concinna (Haan)	Chen et al. 1986
Neostylopyga rhombifolia (Stoll)	Woo 1987
Family Blaberidae	
Pycnoscelus surinamensis (L.)	Woo 1987
Family Blattellidae	
Blattella germanica (L.)	Woo and Guo 1984
Blattella latistriga (Walker)	Woo and Guo 1984
Blattella lituricollis (Walker)	Woo and Guo 1984
Parcoblatta kyotensis Asahina	Woo 1987
Family Corydiidae	
Eupolyphaga yunnanensis Kirby	Woo 1981
Eupolyphaga sinensis Walker	Woo 1987
Eupolyphaga thibetana Chopard	Woo 1981
Polyphaga plancyi Bolivar	Woo 1987
Family Epilampridae	
Opisthoplata orientalis Burmeister	Woo 1987

of the total population, this segment of society lives in more confined and crowded conditions than the rural population, and is often exposed to vertebrate and invertebrate pests. Information to homemakers on the biology and control of pests in urban areas is provided primarily by the Sanitation and Anti-epidemic Stations in each of the provinces and major cities.

Data on cockroach species biology and habits, distribution, aspects of chemical and non-chemical control, disease transmission, and insecticide resistance in China are available (Woo 1982, 1987, Woo and Guo 1984, Li and Nie 1984). However, there is little information on the attitudes and knowledge of urban residents toward cockroach pests. These data are important for the design and implementation of urban pest management programs (Zungoli and Robinson 1984).

The objective of the research presented here was to determine the pest status of the smokybrown cockroach, *P. fuliginosa,* by evaluating the attitudes and knowledge of residents that regularly experienced this cockroach as a household pest.

Materials and Methods

The study was conducted in April and August 1985, in the city of Hangzhou, Zhejiang Province, China. The survey (Table 2) consisted of 14 questions; of which nearly all were open ended, i.e. responses were not chosen from a list offered by the interviewer. The topics covered in the questions included, what causes cockroaches, what is the best method of control, the number of cockroaches seen daily, where in the apartment cockroaches are seen, the amount of money spent on cockroach control, and the amount the residents were willing to spend on control. The age of the person interviewed and the number of years living in the apartment were also recorded.

The survey method consisted of one interviewer questioning individual residents in their apartments. Five interviewers conducted the surveys. A total of 105 people were interviewed; 51 in April, when cockroaches were not active outside or inside the apartments; and 54 in August, when cockroaches were active inside and outside the apartments.

The survey sites were apartment buildings adjacent to Zhejiang Agricultural University. The apartment buildings were constructed within the last five years. The residents were primarily workers from nearby factories. The monthly earning per fam-

Table 2. The questions in the interviews conducted in Hangzhou, China to determine the pest status of *Periplaneta fuliginosa*.

General Opinion of the Cockroach Problem.

Q. Are roaches a serious problem?
A. Yes—67% (April), 94% (August); No—33% (April), 6% (August).

Q. How many roaches do you see per day (when you have them as a pest)?
A. $\bar{x}$ 4.5 (April), $\bar{x}$ 5 (August).

Q. Where do you see roaches in your apartment?
A. Bedroom—63%; Bathroom—54%; Kitchen—98%

Pest Status of *P. fuliginosa*.

Q. Which of these do you think is a worse problem?

A.	April	August
Roaches	65%	93%
Faucet leak	25%	6%
Equal	10%	2%
Roaches	63%	67%
Broken window	31%	30%
Equal	6%	4%
Roaches	43%	52%
Trash in hall	57%	44%
Equal	—	4%
Roaches	33%	4%
Mice	63%	87%
Equal	4%	9%

Q. What bothers you the most about having cockroaches?

A.	
Found around food—	53%
Found everywhere—	10%
Cockroach feces—	10%
Spread disease—	8%
Smell—	8%
Other—	12%

Q. If you are visiting someone's apartment and you see 20 (15, 10, 5, 2) roaches, would you think there was a problem with cockroaches?
A. 20 roaches considered a problem—97% yes
15 roaches considered a problem—97% yes
10 roaches considered a problem—97% yes
5 roaches considered a problem—88% yes
2 roaches considered a problem—59% yes

Knowledge of the Cause and Control of Cockroaches.

Q. What do you think causes roaches?

A.	
Food and filth—	43%
Don't know—	28%
Fly into apt.—	10%
Other—	19%

Table 2. Continued.

Q. What is the best way to control roaches?

A.	
Insecticides—	48%
Sanitation—	29%
Don't know—	14%
Other—	9%

Economic Impact of Cockroaches.

Q. Did you purchase insecticides to control roaches?
A. Yes—87%, No—13%

Q. How much did you spend on roach control last year (summer)?
A. $\bar{x}$ spent—0.38pY

Q. How much are you willing to spend for elimination?
A. $\bar{x}$ 2.65Y (April)
$\bar{x}$ 5.27Y (August)

ily (3–4 persons) was estimated to be between 150Y and 300Y.

All data were coded and analyses were performed using Statistical Analysis Systems programs (SAS Institute 1985). Statistical procedures included analysis of variance, linear regression, and Chi-square contingency analysis. For all analyses, an alpha level of significance was set at 0.05.

Results and Discussion

The survey questions are not presented in the sequence they occurred on the survey form, but are grouped to provide easier discussion of the results. Three questions were not evaluated; they pertained to the smell of insecticides, the rating of cockroach control, and the prospect of eliminating all cockroach pests.

Background information.—The mean number of years the residents lived in their apartment was 4.5 (median 3 yrs). The number of years of residence coincides with the age of the apartment buildings; most of the people surveyed were the first occupants of the apartments in the buildings.

General opinion of the cockroach problem.—The presence of *P. fuliginosa* in the apartments was considered a serious problem by the majority of the people ques-

tioned in either April ($\chi^2 = 5.78$; df = 1; $P < 0.025$) or August ($\chi^2 = 38.72$; df = 1; $P < 0.005$). In August, a larger percentage of residents (94%) considered cockroaches a serious problem than residents questioned in April (67%). Residents questioned in April reported they had a mean of 4.5 cockroaches per day in their apartment in the summer; and residents questioned in August reported a mean of 5.0 cockroaches per day in their apartment. Although residents were able to recall the approximate number of cockroaches in their apartments during the summer, their perception of the seriousness of the problem was influenced by whether cockroaches were present at the time or not. Residents questioned during the time cockroaches were actually present in their apartment (August) indicated they were a serious problem more often than when questioned during the time cockroaches were absent (April). Thoms and Robinson (1986) reported that observations by apartment residents on the distribution and seasonal abundance of domiciliary cockroaches can be accurate.

The reason residents consider the presence of approximately 5 cockroaches per day to be a serious problem may be due to the distribution of the cockroaches in the apartment. Cockroaches were reported throughout the apartments; 98% of the respondents reported cockroaches in the kitchen, and 63% reported cockroaches in the bedroom. Five cockroaches in an apartment may be considered few when compared to German cockroach infestations of similar structures (Akers and Robinson 1981). However, *P. fuliginosa* is the primary household cockroach pest in Hangzhou (Bao, unpublished data), and the residents have little or no experience with cockroach species that have a small body size or occur in large numbers.

Pest status of *P. fuliginosa*. Several situations, such as trash in the hall, or other pests, such as mice, were compared with a cockroach infestation. The "equal" responses were not more than 5% of the total responses, and these responses were excluded from the statistical analysis. A majority of residents considered cockroaches much more serious than a leaky faucet, or a broken window (April $\chi^2 = 3.38$; df = 1; $P < 0.025$; August $\chi^2 = 5.78$; df = 1; $P < 0.025$). Responses were nearly evenly divided on the comparison of cockroaches and the presence of trash in the hall. Sixty-three percent of the residents questioned in April considered mice more serious than cockroaches, and 87% of those questioned in August considered mice more serious.

Fifty-three percent of the people questioned reported being bothered by the presence of cockroaches around food, and some respondents (8%) linked cockroaches to the spread of disease. When responding to a question on distribution, 98% reported cockroaches in their kitchens. The response "they are everywhere" may indicate the difficulty people have in expressing what they disliked about cockroaches (Wood et al. 1981). The fecal pellets of *Periplaneta* species are large (2.5–4.5 mm), and can be scattered in cabinets and storage areas. Residents (10%) reported disliking the presence of *P. fuliginosa* fecal pellets in their apartments.

Fifty-nine percent of the people questioned considered the presence of just two cockroaches (in the hypothetical situation) to represent "a problem." The attitudes indicated in the questions regarding the number of cockroaches that constitute "a problem" indicate that pest control may not be considered successful unless the number of cockroaches seen per day is at least less than two. When there are severe infestations, maintaining low numbers of cockroaches may be difficult. Robinson and Zungoli (1985) suggested that the expectations of urban residents for cockroach elimination may need to be tempered by pest control personnel and education programs.

Knowledge of the cause and control of cockroaches.—When asked about the cause of cockroach infestations, a large majority

(43%) of the residents considered food scraps and filth to be the most important (χ^2 = 23.76; df = 3; $P < 0.005$). *Periplaneta fuliginosa* is capable of flying short distances, and 10% of the residents reported cockroaches flying into their apartments from the outside as the cause of their apartments being infested. Nearly one-third (28%) of the residents did not know the cause of cockroach infestations. When asked what was the best way to control cockroaches, only 29% of the residents mentioned sanitation, whereas 48% considered insecticides the best method of control.

Economic impact of cockroaches.—Evidence of the importance of the cockroach infestations was found in the amount of money the residents reported spending for control, and on the amount they were willing to spend for elimination. Residents reported spending 0.38¥ ($0.11) (range 0–1.5¥) per summer for cockroach control, but they were willing to spend considerably more, from 2.65¥ ($0.72) (range 0–5.5¥) for those questioned in April to 5.27¥ ($1.44) (range 0–7.5¥) for those questioned in August for elimination of the problem. The 0.38¥ per summer probably represents the purchase of several packets of cockroach control tablets (boric acid) for the four months that *P. fuliginosa* are present in apartments. The amount of money the residents reported they were willing to spend for cockroach elimination was considerable, and varied according to when they were questioned (April or August). At the time (August) cockroaches were most common in their apartments, the people questioned were willing to spend nearly twice the amount of money for control than what they stated they were willing to pay for control when cockroaches were not present. Sawyer and Casagrande (1983) stated that the severity of a pest problem can be determined by assessing the amount of money a person is willing to spend to alleviate the problem.

The results of the survey of the apartment residents in Hangzhou provide considerable information on the pest status of *P. fuliginosa*. Although the time this cockroach species is active inside apartments is limited to approximately one-third of the year, the residents considered it a serious household pest. The mean number of cockroaches the residents reported seeing was only five. The residents reported that the presence of just two cockroaches would be considered a problem. However, the apartments are small and there is considerable opportunity for interaction between cockroaches and people. Thoms and Robinson (1986) reported urban apartment residents intolerant of *B. orientalis* when found indoors. They reported that 82% of the apartment residents questioned in Roanoke, VA considered two oriental cockroaches indoors a problem, and 96% considered five a problem.

Thoms and Robinson (1986) reported that the low tolerance of oriental cockroaches reported by urban apartment residents may result from the size of the oriental as compared with the much smaller German cockroach, and the perception that the oriental cockroach is an invader from outdoor habitats. The residents in this study had little or no experience with infestations of small-sized cockroaches, such as the German cockroach, because this species is not a household cockroach pest in Hangzhou (Bao, unpublished data).

The response of the residents of Hangzhou to the questions comparing cockroaches to other household pests (mice), and to household problems (leaky faucet) was very similar to the responses by U.S. residents to similar questions. Wood et al. (1981) reported that urban apartment residents considered German cockroaches much more important than a broken window, leaky faucet, or trash in the yard, and they were nearly evenly divided in their opinions of cockroaches and mice. In the results reported here, the responses of the Hangzhou residents were nearly the same as those reported in the United States.

This information collected in this survey

can provide a basis for the education component of a cockroach pest control program (Robinson and Zungoli 1985). The responses to the questions concerning the causes and control of *P. fuliginosa* infestations indicate a need for some specific information. The dependence on chemical control for cockroaches is apparent by the large percentage (48%) of the residents that considered insecticides to be the best way to control these pests. Robinson and Zungoli (1985) reported a significant change in resident understanding of cause and control of household cockroaches as a result of an education program.

Acknowledgment

We appreciate the help of Wan Xingsheng, Zhu Kunyan, Chen Yi, and Zou Wanhe in conducting the interviews of the residents. Patricia A. Zungoli, Department of Entomology, Clemson University, reviewed and improved the manuscript.

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PROC. ENTOMOL. SOC. WASH.
90(4), 1988, pp. 407–410

FIRST RECORDS OF ERYTHRAEIDAE PARASITIC ON ORIBATID MITES (ACARI, PROSTIGMATA: ACARI, ORIBATIDA)

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Abstract.—Larvae of two undescribed species of the mite genus *Leptus* (Erythraeidae) were found attached to the heavily sclerotized cuticle of ten oribatid mites, representing four species and three families. Parasitized mites, each carrying a single *Leptus* larva, were collected from forest soils in Massachusetts, Mississippi, and Alabama. This is the first reported association between these taxa, but the specificity of the relationship is unknown.

Key Words: *Leptus*, ectoparasites, oribatid mites

Oribatid mites, most of which are saprophagous or fungivorous inhabitants of soil organic horizons, commonly serve as hosts for a variety of parasitic and commensal organisms. From the early work of Nicolet (1855) to the detailed studies of K. Purrini and colleagues (e.g. Purrini 1980), we have learned that these mites are parasitized by bacteria, fungi, virus-like organisms, various protozoans (amoebae, eugregarines, microsporidians, helicosporidians), and nematodes. Their servitude as intermediate hosts for anoplocephalid tapeworms is perhaps the most widely known parasitic relationship (see review by Sengbusch 1977). Records of commensal associations are fewer. Phoretic transport of nematodes (e.g. Travé 1956) or deutonymphs of the mite suborder Astigmata is not uncommon (unpublished obervations, R.A.N.), but is rarely reported. Ciliate protozoans, apparently related to Conidiophryidae and similar to those carried by soil-dwelling mesostigmatic mites (Dindal 1973), are also commonly attached to leg or body setae of oribatid mites (unpublished observations, R.A.N.); they are probably commensals.

To this list of relationships we can now add ectoparasitism by mites of the family Erythraeidae. These mites are protelean ectoparasites whose larvae utilize a wide variety of insect and arachnid hosts (Welbourn 1983 and included references), and whose deutonymphs and adults are free-living predators. Their red color and wide host range make them the most obvious of terrestrial protelean parasites.

METHODS AND RESULTS

From three different localities we observed multiple cases of parasitism by larvae of the erythraeid genus *Leptus* on adult oribatid mites which had been extracted by Berlese funnels from forest soil and litter. Each of four specimens of *Oribatella extensa* Jacot (Oribatellidae) from Mississippi (kudzu litter, Ecru, Pontotoc Co., 18-III-

1981, R. L. Brown, col.) carried a single *Leptus* larva attached dorsally on the posterior half of its notogaster (Figs. 1, 2). Four specimens of *Damaeus verticillipes* (Nicolet) (Damaeidae) from Massachusetts (white pine plantation litter, Babson College campus, Wellesley, Norfolk Co., 6-XI-1985, J. R. Philips, col.) also carried a single *Leptus* each. In three cases the larva was attached to the notogaster, behind the stacked exuvial scalps which this species usually carries (Figs. 3, 4); in one case attachment was on the ventral plate, immediately posteriad of the anus, but the general posture of the larva was as in Fig. 3. In the third collection, from Alabama (forest litter, Conecuh Co., 0.2 mi. W of junction of Sepulga River and Rt. I-65, 15-III-1986, R. D. Cave, col.), one specimen each of *Xenillus occultus* Banks (Xenillidae) and *Damaeus grossmani* Wilson (Damaeidae) carried a *Leptus* larva. In the former case, the parasite was positioned near the notogastral margin, midway along its left side; in the latter, attachment was similar to that of Fig. 1, but on the right side. None of the attached *Leptus* larvae were engorged when collected.

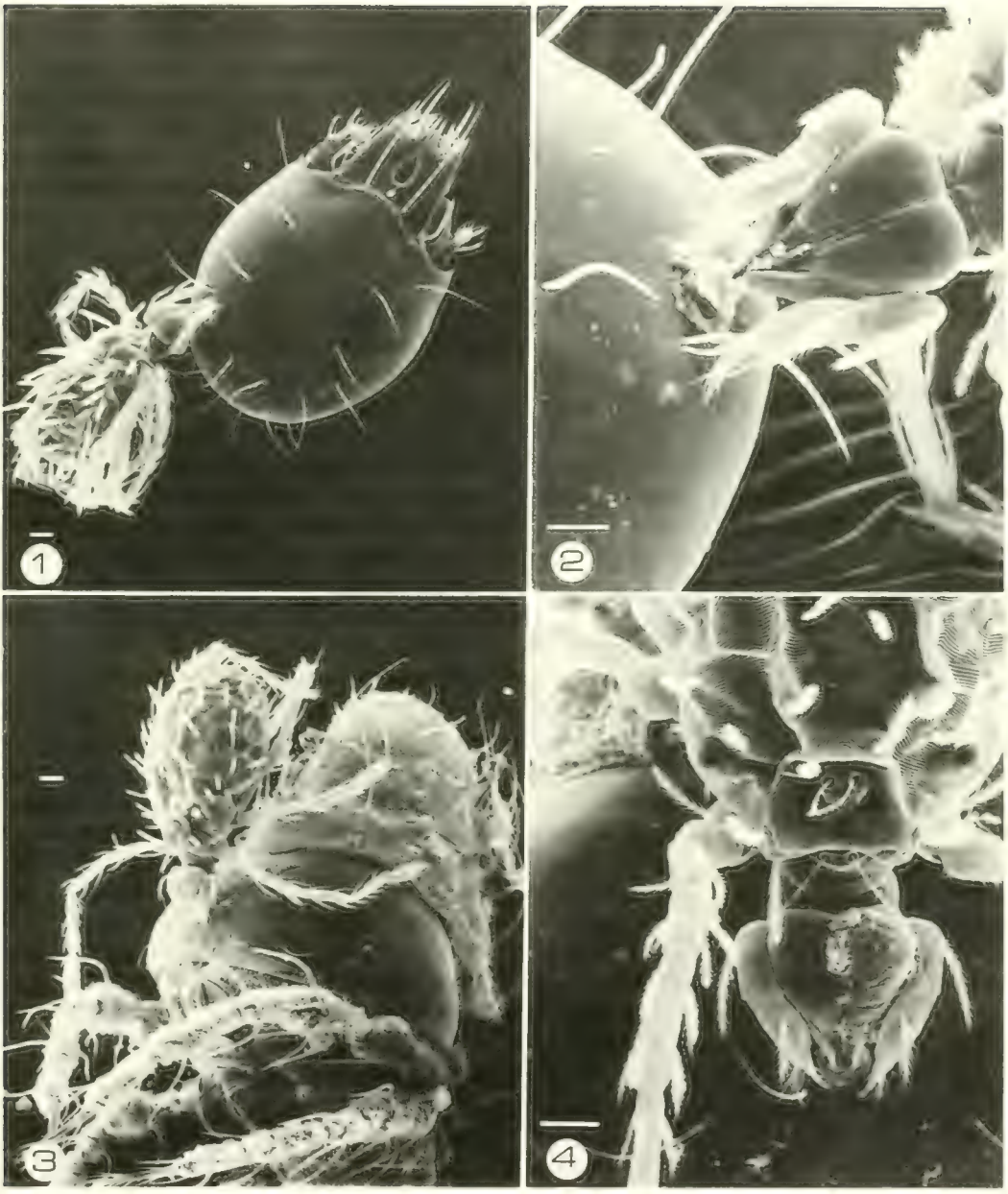
The host mites from Massachusetts were observed alive for one week to compare their behavior with that of non-parasitized individuals. Despite the relatively large size and sometimes non-axial positioning of the parasite (Fig. 1), the oribatid hosts were quite mobile, and showed no abnormal activity. Noticeable engorgement did not take place during this time. Although not observed alive, the oribatid mite hosts from the other two collections must have been active enough to respond to increasing desiccation and move through the litter column in the Berlese extractor.

Discussion

These examples illustrate the ability of *Leptus* larvae to attach almost anywhere on an arthropod integument. Whereas other erythraeid larvae, with short cheliceral bases, tend to attach along molting sutures (Young and Welbourn 1987), *Leptus* larvae have long, flask-shaped cheliceral bases (Baker 1982, Southcott 1961, Treat 1975) which facilitate the penetration of even well sclerotized cuticle, such as the notogaster of oribatid mites. Baker (1982) reported a "viscous substance" that was secreted just prior to attachment of *Leptus* larvae, and suggested that upon hardening it formed a cement which secured the mite to the host. It can be seen in Fig. 2, where the gnathosoma contacts the oribatid mite cuticle. Although the material seems to play a role in attachment (no stylostome is formed), it also forms a seal around the feeding lesion (Åbro 1988). In contrast to other erythraeid larvae, the gnathosoma of *Leptus* species lacks the buccal fringe or ring which usually performs the latter function (unpublished observations, W.C.W.).

Systematic studies of *Leptus,* which includes nearly 90 named species worldwide, have concentrated on the larval instar (e.g. Southcott 1961, Beron 1975, Fain and Elsen 1987, Fain et al. 1987). The American fauna is still poorly known, and all of the larvae from the oribatid mites represent undescribed species whose degree of host specificity is unknown. The *Leptus* larvae from Alabama and Mississippi are conspecific, and their occurrence on representatives of three oribatid genera, from three distinct families of Brachypylina, suggests little host specificity. Yet, no other parasitized arthropods were observed in the Mississippi sample, despite the presence of unattached *Leptus* larvae and numerous potential arthropod hosts (including other taxa of oribatid mites). Similarly, unattached larvae of the Massachusetts *Leptus* (representing a second undescribed species) were found in the original sample, but only individuals of *D. verticillipes* were parasitized.

Can a *Leptus* larva complete its development to a free-living deutonymph using a single oribatid mite host? We have no evidence at present, since no observed specimen had started to engorge. If we speculate



Figs. 1–4. *Leptus* larvae parasitizing adult oribatid mites. Fig. 1. *Oribatella extensa* Jacot, from Mississippi (dorsal aspect), with *Leptus* sp. larva attached to notogaster. Fig. 2. As in Fig. 1, except dorsolateral aspect. Note hardened "cementing" material at point of attachment. Fig. 3. *Damaeus verticillipes* (Nicolet), from Massachusetts (posterolateral aspect), with *Leptus* sp. larva attached to notogaster. Fig. 4. As in Fig. 3, except posterior aspect. All scanning electron micrographs; scale bars on Figs. 1 and 3 represent 45 μm, those on Figs. 2 and 4 represent 25 μm.

that it can, the parasitism would probably be lethal to the host, considering the relative size of the two mites. This would be consistent with the absence from the samples of hosts with engorged parasites, since decreased mobility in the Berlese funnels would be expected once engorgement begins; it would also be consistent with the absence of oribatid mites having noticeable lesions resulting from prior parasitism.

Acknowledgments

Facilities for scanning electron microscopy were provided by the N. C. Brown Center for Ultrastructure Studies, S.U.N.Y., C.E.S.F. We are grateful to V. M. Behan-Pelletier (Biosystematics Research Centre, Agriculture Canada, Ottawa), J. B. Kethley (Field Museum of Natural History, Chicago), and S. C. Palmer (S.U.N.Y.-C.E.S.F.), for providing constructive criticism of the manuscript, and to Dr. J. R. Philips for contributing specimens. Partial support for this work was provided by a National Science Foundation grant to R.A.N. (BSR 84 15747).

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PROC. ENTOMOL. SOC. WASH.
90(4), 1988, pp. 411–421

NOTES AND REDESCRIPTIONS OF SOME *ANOPHELES* SERIES ARRIBALZAGIA HOLOTYPES (DIPTERA: CULICIDAE) IN THE BRITISH MUSEUM (NATURAL HISTORY)

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Abstract.—Notes and redescriptions are given for four holotypes of *Anopheles* (*Anopheles*) Series Arribalzagia in the British Museum (Natural History). *Anopheles mediopunctatus*, *An. maculipes* and *An. venezuelae* (=*punctimacula*) are described and illustrated and notes given for *An. amazonicus* (=*mattogrossensis*). Dissection of male genitalia of *An. mediopunctatus* shows that this species is probably commonly misidentified throughout South America.

Key Words: *Anopheles*, Arribalzagia, *mediopunctatus*, *maculipes*, *venezuelae*, *punctimacula*, *amazonicus*, *mattogrossensis*, taxonomy

Series Arribalzagia (Theobald 1903, as genus) is a neotropical group of *Anopheles* (*Anopheles*) mosquitoes containing 33 nominal species, among which are known or suspected vectors of malaria parasites. In the only objective attempt to define this group Reid and Knight (1961) listed 19 valid names. Two additional species, *An. veruslanei* Vargas and *An. anchietai* Correa and Ramalho, have been added since by their respective authors. Reid and Knight considered all New World *Anopheles* (*Anopheles*) with laticorn pupal trumpets to belong in the Arribalzagia Series.

The following is part of a review of Series Arribalzagia. This review demands revalidation of present species concepts. Below are redescriptions and/or comments on the four nominal species present in the British Museum (Natural History). Two of these, *An. maculipes* (Theobald) and *An. mediopunctatus* (Theobald) are valid species and are described and illustrated in full. The other two, *An. venezuelae* Evans and *An. amazonicus* Christophers are junior synonyms of *An. punctimacula* Dyar and Knab and *An. mattogrossensis* Lutz and Neiva respectively. Since both are adequately described in the literature, there is no need for detailed redescriptions, though *venezuelae* is illustrated. *Anopheles maculipes* and *An. mediopunctatus* have clear priority and there is no doubt as to their status. I have seen the types of *An. punctimacula* and *An. mattogrossensis* and agree that *An. venezuelae* and *An. amazonicus* are indeed junior synonyms.

Anopheles mediopunctatus (Theobald)
(Figs. 1A–E, 2A–D)

Theobald 1903, 3: 60–62 (as *Cycloleppteron*).

Diagnosis.—A yellow and brown to dark brown species with predominantly yellow palpi and 3 small dark spots on the scutum. Wings with broad brown and pale yellowish scales and 3 primary costal dark spots. Legs

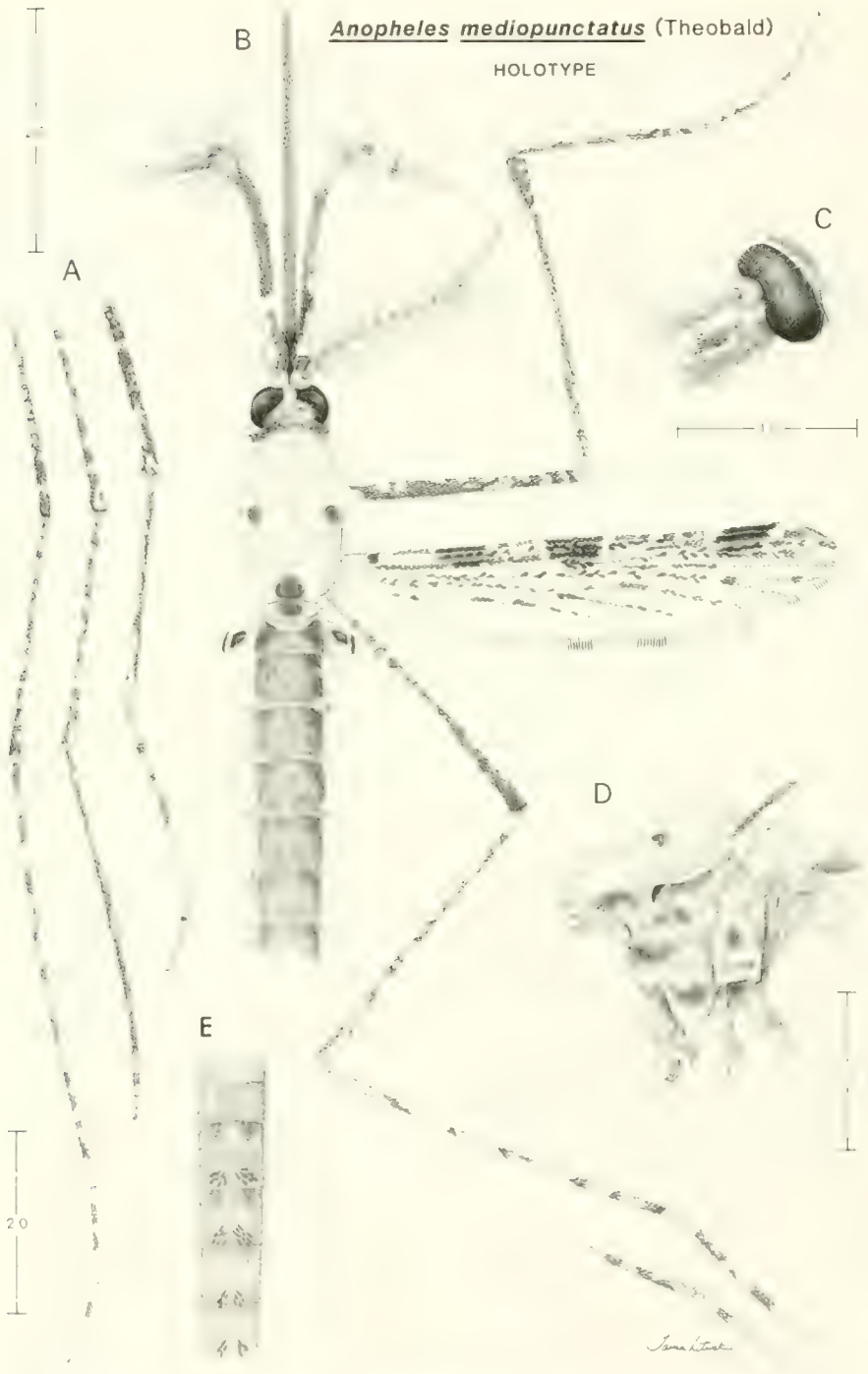

Fig. 1. A–D, holotype *Anopheles mediopunctatus* (Theobald). A, legs, posterior view. B, habitus. C, head lateral view. D, thorax, lateral view. E, venter of abdomen. All scale lines in mm.

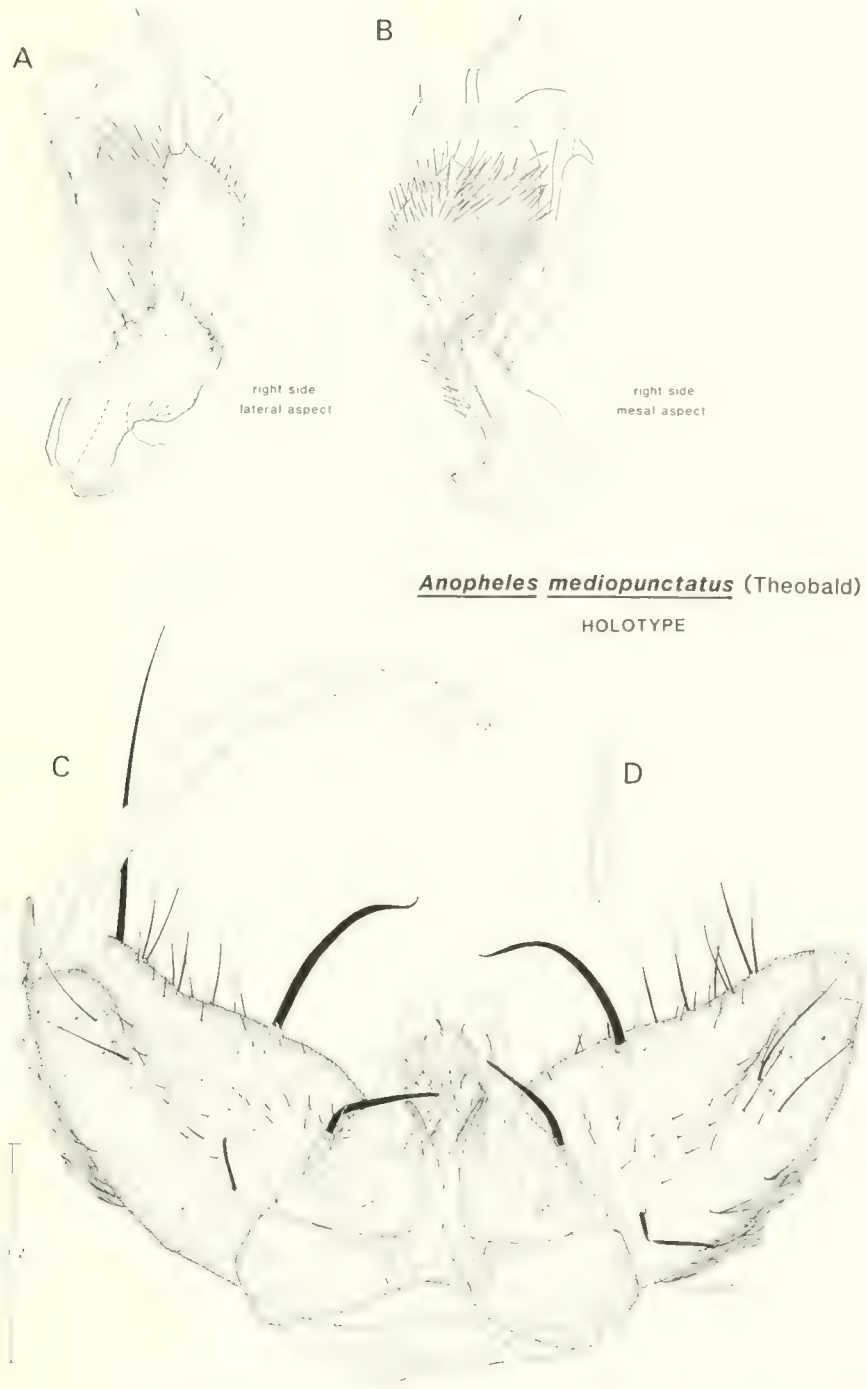

Fig. 2. A–D, holotype *Anopheles mediopunctatus* (Theobald) male genitalia. A, claspette, lateral view. B, claspette, mesal view. C, genitalia before dissection. D, aedeagal leaflet. Scale line in mm.

speckled pale yellowish on brown, tarsomere 5 of all legs pale. Pleuron with a patch of scales on the middle of the mesokatepisternum and several scales on the upper mesanepimeron. Abdomen with posterolateral brown and pale yellow scale patches on terga II–VI.

Label data.—Red circle "Holotype"; handwritten "Cycloleppteron mediopunctatus (Type male) (F.V.T.)"; handwritten "Sao Paulo Dr. Lutz"; cardboard circle to which specimen is attached by a small pin has on its underside some nearly illegible writing "Santos S---ya 14 VI 02 E--- Carva?"

Also affixed to the pin with the specimen is a piece of thin glass attached to a piece of cardboard. Originally this held the male genitalia which is now mounted on a slide with the following labels: Left label, handwritten "male genitalia Cycloleppteron mediopunctatus Theobald," printed "Holotype." Right label, handwritten "Brazil: Sao Paulo Dr. Lutz Santos ?Suanija 14.VI.02 ?ex carva see pinned collection." Also a red circle holotype label. This preparation was remounted for study.

Also received from the British Museum was a slide mount of a wing presumably in Canada balsam. It also has a red circle holotype label but cannot be part of the adult holotype since both wings are present even though part of one is glued to the cardboard to which the specimen is pinned. This one is probably the mount sent by Lutz to Theobald as mentioned in the original description.

Condition of specimen.—Male. Overall in very good condition, not rubbed or faded. Left foretarsomere 5 missing. Left wing broken off at the presector dark spot, the broken portion glued to the cardboard base. Genitalia dissected, slide mounted; abdominal segments I–VI present. A small pin is inserted through sternum I, the tip emerging posteriorly on the scutum. The genitalia were mounted in a water soluble medium of unknown composition. When the media was dissolved the genitalia proved to be very brittle and the weight of the small coverslip caused much damage to the gonocoxites. Further manipulation in order to see the claspettes also resulted in some damage. Published here are drawings before remounting and interpretation of the structures revealed by remounting (Fig. 2A–D).

Description.—Wing length 4.2 mm; width 0.8 mm; proboscis 3.9 mm; Forefemur 2.0 mm.

Head: Integument of postgena, occiput, vertex, interocular space, pedicels and clypeus dark brown, with a light covering of silvery pollinosity, more dense and apparent at the vertex. Frontal tuft of long pale yellowish white setae; tuft continuous onto the vertex. Five or 6 slender pale yellowish white appressed, ocular scales present. Vertex and occiput with numerous erect pale brown spatulate, truncate scales; 8 to 10 long, pale brown ocular setae present on each side; about 8 long pale brown postgenal setae and a few long pale brown labial basal setae present. Antennal pedicel with 6 to 7 scattered slender pale yellowish scales on its outer surface; 14 antennal flagellomeres present; flagellomere 1 with 6 or 7 slender pale yellowish white scales on its mesal and dorsal surfaces and a few dark brown scales and setae on its lateral surface; flagellomeres 2–12 quite plumose, the setae pale yellowish brown; flagellomeres 13 and 14 elongated, 13 about twice length of 14, with sparser much shorter setae than remainder of antenna. Palpi dark brown in ground color; dark scales dark brown, pale scales pale yellow but darkening to nearly golden yellow on palpomere 5; basal scales broad and erect, the scales of palpomere 5 long slender and appressed; setae at tip of palpomeres 4 and 5 mostly pale yellow but with some brown setae mostly at the tip of palpomere 4. Proboscis dark brown, covered with slender mostly appressed dark brown scales and short dark setae; scattered pale yellowish brown scales intermixed on basal half; the scales at the base broader, more numerous and erect.

Thorax: Scutal integument with 3 prom-

inent dark brown spots, 2 on either side just posterior to the ends of the prescutal sutures and one at the posterior margin of the scutum which continues onto the scutellum. Scutum otherwise pale brown to brown in ground color covered with silvery blue pollinosity and scattered slender pale yellowish to pale brown setae; a few slender scales present between the scutal angle and the wing base; denser pale narrow scale-like setae present anteriorly; small darker spots which lack pollinosity are scattered over the surface of the scutum corresponding to setal insertions. Ground color of pleuron brown to dark brown, the pale areas made so by a covering of silvery pollinosity, the dark areas by dark brown pollinosity; antepronotum with a dense patch of dark brown spatulate scales anteriorly and a few pale scales posteriorly; antepronotal setae numerous, pale yellowish brown; upper proepisternum with 3–4 pale setae, below and anterior to these 1–2 small pale scales present; pleural setae and scales pale yellow and pale yellowish white, respectively; mesokatepisternum with upper intermixed scales and setae, a small median dense patch of scales, and a few setae below; upper mesanepimeron with a patch of long setae and just below these 2 broad scales. Forecoxa with an upper anterior patch of small yellow scales, intermixed with and continuing below these scales are about 12 long dark setae; laterally a small dense patch of white scales below and a few scattered pale yellow scales above; posteriorly is a dense patch of long dark brown scales with a few dark setae intermixed. Foretrochanter mostly with small appressed yellow scales and a few short pale setae, the posterior scales dark brown. Mid- and hindcoxae and trochanters with white scale patches except for a small patch of pale yellow scales and pale yellow setae mesally on the trochanters. Other leg segments as figured, the dark areas dark brown, the light areas pale yellow. Tarsomere 5 pale on all legs. Wing scales mostly broad, the dark scales mostly dark brown; with 3 main dark costal spots underlain by dark integument; white scales present on either side of the 3 main dark spots, remainder of wing a mixture of white and pale yellowish scales; pale yellowish scales predominate on veins R_{4+5}, M_{1+2}, M_1, M_2 and much of CuA. A slight notch present where costa and subcosta intersect. Humeral crossvein with dark scales above and below. Halteres dark brown with white scales on the dorsal aspect of the pedicel and around the dorsal margins of the scooped out capitellum.

Abdomen: Mottled dark brown to pale brown, with long and abundant, pale yellowish brown setae. Posterolateral margins of terga II–VI with small patches of broad dark brown and pale yellowish scales; the pale scales mostly dorsal to the dark scales; ventrally with a scattering of quite broad pale yellowish scales and paired patches of dark brown scales apically on either side of the midline of sterna III–V. Segments VII+ not present and the apical portion of sternum VI has been disturbed.

Male genitalia (Fig. 2A–D).—Fig. 2C is the genitalia as observed before dissection. The dorsal and ventral lobes of the claspettes were obscured and are illustrated separately (Fig. 2A, B). Dorsal lobe with 3 modified setae corresponding to the clubbed setae of other anophelines; 2 of these are shorter and rounded at the apex, the third is modified into a hook-like structure. Apex of ventral lobes with strong sinuous setae which appear to be in a symmetrical conformation; just below the apex are 2 smaller but prominent setae on the mesoventral aspect; numerous long strong spicules along the dorsomesal aspect for most of the length of the lobe. Lobes of tergum IX prominent, slightly arched outward from each other. With one pair of aedeagal leaflets, leaflets with small aciculae on their inner margins at the base. Gonocoxite with 2 primary setae which may correspond to the parabasals of other *Anopheles* (*Anopheles*), or one parabasal and one internal seta; the most basal seta originates on a prominently raised base; a primary long seta apparently present subapically on the dorsal aspect.

Discussion.—*Anopheles mediopunctatus* is the oldest name in a group of what may prove to be several closely related species. The names presently considered as junior synonyms of *An. mediopunctatus* are *Cyclolepidopteron rockefelleri* Peryassu, *An. costai* Da Fonseca and Da Silva Ramos and *An. costalimai* Coutinho. *Anopheles bonnei* Da Fonseca and Da Silva Ramos is considered valid. I cannot speculate on the identities of the above nominal species without further study and material. *Anopheles mediopunctatus* and the other or others in this group all share complex male genitalic structures which feature very long 9th tergal lobes, highly modified dorsal and ventral lobes and unusual placement of the parabasal and internal spines.

One of the characters commonly used to distinguish *mediopunctatus* is the presence of white scales on the first sternum. This character cannot be seen in the holotype since the first sternum was destroyed by a mounting pin.

Examination of approximately 40 male terminalia from specimens which key to *An. mediopunctatus* from many localities in South America yielded none that are true *mediopunctatus*. It now seems likely that there are many misidentifications of this species in the literature and in museums.

Anopheles maculipes (Theobald)
(Fig. 3A–E)

Theobald 1903, 3: 81–83 (as *Arribalzagia*).

Diagnosis.—A brown to dark brown species with 3 faint dark spots on the scutum, speckled legs and posterolateral abdominal scale tufts. Wing with 3 distinct costal dark spots and slender dark brown and pale yellow scales.

Label data.—Red circle "Holotype"; handwritten "Anopheles maculipes (Type) Theobald" and "Sao Paulo Brazil Dr. Lutz."

Condition of specimen.—Female. In fair condition, both front legs missing, midtarsomere 5 missing on left, hindtarsomere 5 missing on both sides, right hindtarsomere 4 missing. Abdomen flattened out and twisted around but intact. Last 4 flagellomeres of left antenna missing. Specimen is mounted on a small pin through prosternal area, emerging in the middle of the scutum; pin is affixed to a cardboard circle.

Description.—Wing length 4.5 mm; width 1.5 mm; proboscis 2.3 mm; palp 2.19 mm (1, 0.13; 2, 0.53; 3, 0.78; 4, 0.45; 5, 0.3); abdomen approximately 3.35 mm.

Head: Occiput and clypeus with dark brown integument covered with concolorous pollinosity. Posterior and lateral vertex with erect slender spatulate and mostly truncate brown scales; frontal tuft with elongate and some spatulate whitish-yellow scales and setae; inner margin of eye at the vertex with small recumbent white scales; several pale scales on gena below where eyes meet; postgenal setae brown; 5 to 6 brown ocular setae per side. Clypeus as figured, original description says of "peculiar form" but what Theobald meant is not clear. Antennal pedicel dark brown with slender white scales on dorsolateral third; flagellomere 1 with slender white scales, most on inner surface. Palp clothed with numerous slender brown erect and semierect spatulate scales with basal rings of white scales at juncture of palpomeres 2,3: 3,4 and 4,5; tip of 5 with a few white scales; 3 with a few white scales which suggest a pair of ill-defined median patches. Proboscis with erect brown scales at its base and recumbent brown scales and short semierect setae along its length, evidence of a few small pale scales just before labellum.

Thorax: Thorax somewhat rubbed, integument yellowish brown to reddish brown, covered with silvery pollinosity and sparsely clothed with pale yellowish setae. Scutum with 2 small dark spots just posterior to the ends of the prescutal sutures and one dark spot at the posterior margin of the scutum which continues onto the scutellum; scutum with scattered, mostly small spots which lack pollinosity and correspond to the insertion

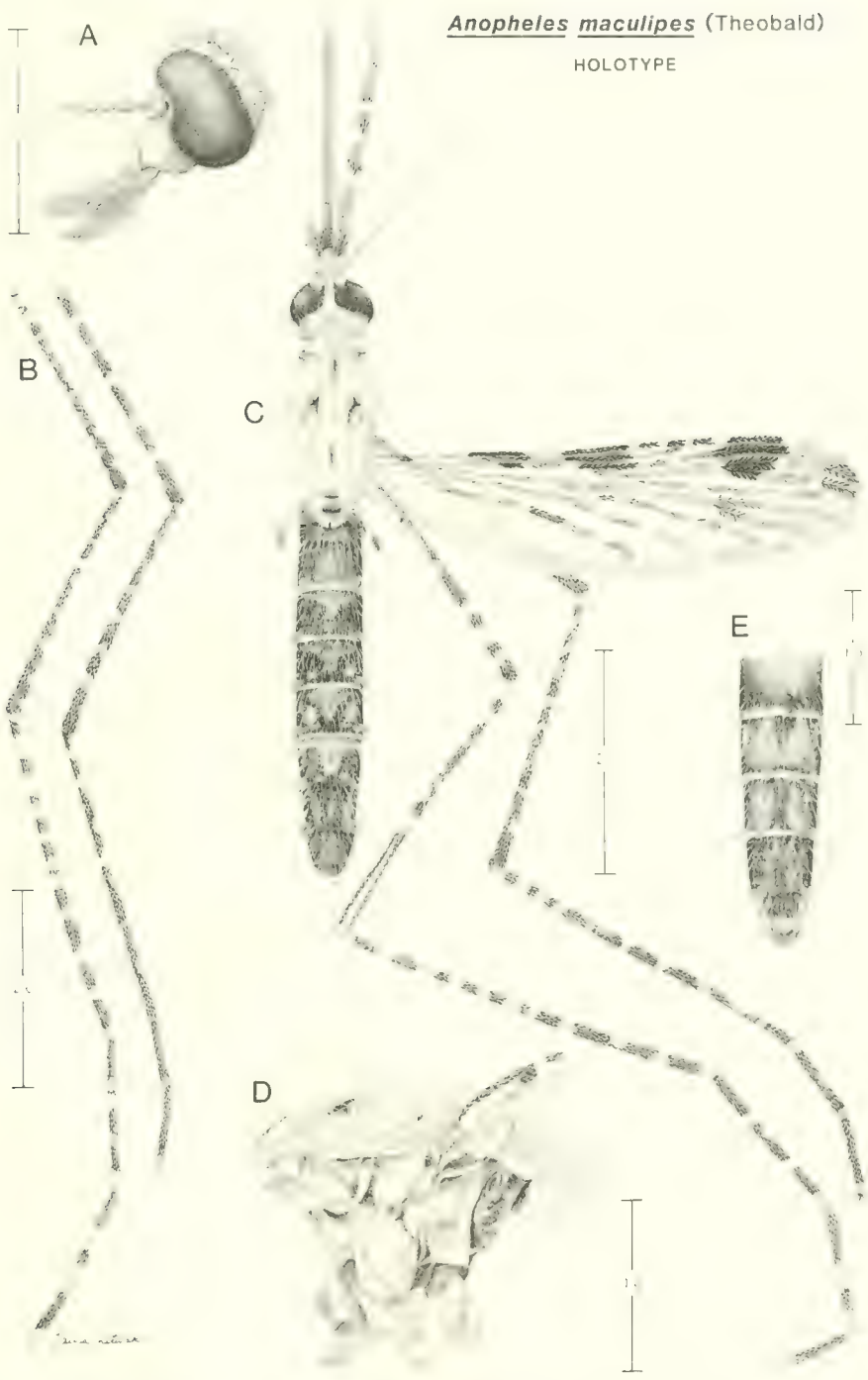

Fig. 3. A–E, holotype *Anopheles maculipes* (Theobald). A, head, lateral view. B, legs, posterior view. C, habitus. D, thorax, lateral view. E, venter of abdomen. All scale lines in mm.

of scattered setae. Antepronotum with a dense tuft of brown scales anteriorly, the remainder with approximately 25 long yellowish to brown setae. Mesopostnotum with a small median posterior dark streak. Pleuron. Proepisternum with 3 long upper setae and a slender white scale; 4 pale spiracular setae present; mesokatepisternum with 6 long upper setae and 3 lower setae and 6 lower white scales; prealar knob with 10 long setae; upper mesanepimeron with 4 long setae. Legs. Forecoxa with an anterior dense patch of small brown scales and long brown setae and an apical patch of white and brown scales. Midcoxa with 2 outer and one inner white scale patches. Hindcoxa with a single white scale patch. Mid- and hindfemora and tibiae brown scaled with speckling of yellowish scale patches. Midtarsomere 1 speckled, midtarsomere 2 with a single yellowish spot, the remaining tarsomeres brown except tip of midtarsomere 5 which is yellowish; tips of hindtarsomeres 1–4 pale scaled; hindtarsomere 1 with about 6–9 yellowish white spots some of which form rings; hindtarsomere 2 with 2–3 spots, one forming a median ring on left side; hindtarsomeres 3 and 4 brown except for broad white apices as noted above. Wing scales brown, dark brown on the presector, middle and preapical dark marks of costa, the remainder yellowish except for some white patches interspersed. No notch where costa and subcosta intersect. Humeral crossvein with scales above and below. Halteres with a yellowish stem, capitellum dark brown ventrally but mostly white-scaled dorsally except for the dark bare center of the depressed area.

Abdomen: Integument of abdomen dark brown with paler dorsolateral areas; with covering of yellowish-brown pollinosity. Dorsum with numerous, sometimes long, pale yellowish setae, without scales except for a few pale brown scales posterolaterally on terga II–VIII, most numerous on terga VIII where they are narrower and not concentrated in patches as the other terga. Ventrally only sterna IV–VIII plainly visible, with sparse yellowish-brown setae and scattered scales in an irregular pattern as follows: irregular lines of white scales midventrally and small lateral clumps on V–VII; small patches of brown scales posterolaterally on IV–VI; a large tuft of brown scales midapically on VII; sternum I bare.

Discussion.—This species was the first member of the nominal taxa Arribalzagia to be described, *Anopheles mediopunctatus,* also an Arribalzagia, was described in the same publication in a different genus. In his description of the genus, Theobald (1903: 81) says it is closely related to old world *Myzorhynchus.* Subsequent speculation (Reid and Knight 1961) has also suggested this. Comment on this relationship is beyond the scope of the present paper. Theobald in characterizing Arribalzagia says "No scaly ventral apical tuft can be detected," but this apical tuft can easily be seen on the type of *An. maculipes* described here.

Anopheles amazonicus Christophers

Christophers 1923: 71–78, Plate IV.

Anopheles amazonicus is a junior synonym of *An. mattogrossensis.* The original description is quite adequate, therefore only notes and further comments will be presented here.

Label data.—Pink circle "Type female"; red circle "Holotype"; "Holotype of Anopheles amazonicus Christophers"; "Anopheles (Myzorhynchella) nigra(?) Theob."; "A.A. Clark R. Amazon June 1915"; School of Trop. Med. Liverpool University label "Anopheles amazonicus Christophers Amazon."

Condition of specimen.—Female. In fairly good condition except slightly rubbed. Small pin through mesanepimeron. Right antenna present only to 4th flagellomere. About half the fringe scales of the right wing are missing. Left midleg missing. Tarsomeres 3–5 on right midleg missing. Right hindleg missing. Left hindleg with all tarsomeres missing.

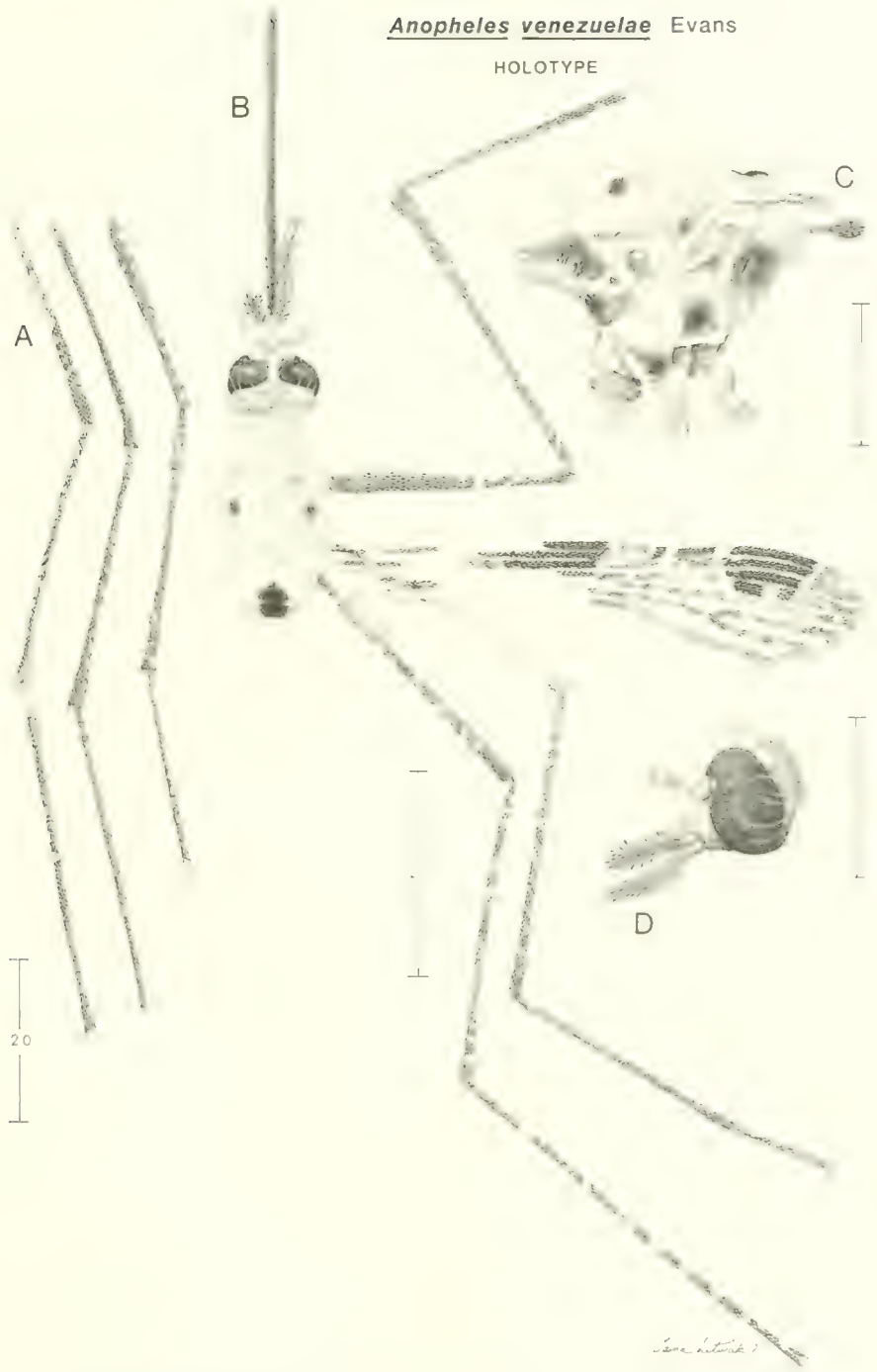

Fig. 4. A–D, holotype *Anopheles venezuelae*. A, legs, posterior view. B, habitus. C, thorax, lateral view. D, head, lateral view. All scale lines in mm.

Discussion.—The original description agrees well with the holotype specimen with a few small differences or additions as follow. Palpi have a few white scales at junctures of palpomeres 2,3; 3,4 and 4,5. Antennal flagellomere 1 with narrow pale scales mostly on the inner aspect but some outer scales also present, no dark scales as stated in the original description. Upper middle of mesanepimeron with 3 setae, the upper mesanepimeron with a patch of long setae. Abdominal sternum 1 with a few small pale setae. The white scales mentioned in the original description on the venter of the abdomen are actually yellowish. The median tuft of scales on sternum VII has yellow scales anteriorly and dark brown scales posteriorly.

Anopheles amazonicus was synonymized with *An. mattogrossensis* by Shannon (1933: 135) after comparison by Evans of several specimens of presumed *An. mattogrossensis* with the type of *An. amazonicus*. I have also seen the holotype of *An. mattogrossensis* and fully agree. *Anopheles mattogrossensis* has several characters unique among the Arribalzagia: Upper middle of mesanepimeron with setae; midventral pale scale patches on the abdomen and small setae on sternum 1. In addition *mattogrossensis* lacks leg speckling, no dark spots on the notum, and posterolateral scale tufts, all typical of most other Arribalzagia.

Anopheles venezuelae **Evans**
(Fig. 4A–D)

Evans 1922: 213–222, Plate XI, in subgenus *Arribalzagia*.

Anopheles venezuelae is a junior synonym of *An. punctimacula*.

Label data.—School of Trop. Med., Liverpool University label "A. venezuelae Evans La Cabrero Estado Carabobo 1921 Dr. M Nunez Tovar"; "Holotype of Anopheles venezuelae Evans det. J. Chainey 1975."

Condition of specimen.—Female. The specimen is incomplete but the remaining portions are in good condition. Missing: Abdomen; right wing and part of left wing, most of left wing is affixed to plastic base into which is pinned the specimen; flagellomeres 3–5 missing on both sides; palpomeres 2–5 missing on both sides though half of 2 on left is present; left and right foretarsomeres 2–5, left midtarsomeres 2–5, right midtarsomeres 3–5, left and right hindtarsomeres 2–5.

Discussion.—*Anopheles venezuelae* was described from a single specimen in 1922. When Evans received more material it became apparent that the characters that she used to distinguish it from *An. punctimacula* were no more than normal variation. In 1923 Evans sunk *An. venezuelae* under *An. punctimacula*. I have seen the type of *An. punctimacula* and studied in great detail material of all stages from throughout its range and agree with her assessment.

Acknowledgments

Special thanks to Taina Litwak for her excellent illustrations and interpretation of slide mounted structures, and to E. L. Peyton for his valuable advice and for the difficult dissection of the *An. mediopunctatus* genitalia. I also thank Bruce Townsend for the loan of the material reviewed here and Ronald Ward for critical review of the manuscript and generous assistance in publication of the manuscript.

The views of the author do not purport to reflect the position of the Department of the Army or the Department of Defense.

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GENETIC VARIATION AND SYSTEMATICS OF FOUR TAXA OF NEOTROPICAL WALKING STICKS (PHASMATODEA: PHASMATIDAE)

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Abstract.—Electrophoretically detectable genetic variation for six isozymes encoded by seven loci was analyzed in four taxa of walking sticks (Phasmatidae) that occur in a neotropical rainforest in eastern Puerto Rico. No phylogenetic analysis previously has been conducted on any phasmatid. All seven loci exhibited variation among *Diapherodes achalus*, *Lamponius portoricensis*, *Pseudobacteria yersiniana*, and an unnamed taxon (species X). Coefficients of genetic distance between these four taxa ranged from 0.349 to 0.571. The UPGMA of Rogers' genetic distance indicated considerable genic dissimilarity among taxa (the two taxa which were least dissimilar connected at a value of 0.350). The four taxa represent a holophyletic group for which an outgroup was not analyzed, this situation, in conjunction with the short internode distance in the Fitch-Margoliash analysis, provides only limited resolution of the phylogenetic associations among the four taxa.

Key Words: electrophoresis, isozymes, Puerto Rico, *Diapherodes*, *Lamponius*, *Pseudobacteria*.

The Phasmatidae, or walking sticks, are primarily a tropical group of folivores that occasionally have an economic impact on human-manipulated systems (Campbell 1960, 1961, 1966, 1974, Campbell and Hadlington 1967, Mananec 1966, 1967, 1968, Paine 1968). Most phasmatids are active nocturnally, and remain inactive on the surface of leaves and stems, or in leaf litter, during the day. Even at night, walking sticks are usually immobile and cryptic (Cott 1940, Moxey 1972). Besides these few cursory observations, the natural history of the Phasmatidae is poorly known. The best contemporary review of their biology was presented by Bedford (1978); however, his review primarily focused on Old World taxa. Although many studies have been conducted on the taxonomy of the Phasmatidae (see Bedford 1978), a dearth of information is available concerning their phylogenetic relationships. Detailed studies in the New World have lagged far behind those in the Old World.

Moxey (1972), in a detailed but yet unpublished study concerning systematics of walking sticks from the West Indies, recognized 54 Antillean species, distributed into 16 genera. Many of these species are restricted to one or only a few islands. Other than the work by Moxey (1971, 1972), the most recent research on phasmatids of the West Indies focused on population dynamics and natural history of *Lamponius por-*

toricensis from the Tabonuco rainforest of Puerto Rico (Willig et al. 1986). We presently are conducting studies aimed at examining the genetic bases of food preference and spatial distribution in *L. portoricensis*. The only other published study on Puerto Rican walking sticks examined the karyotypes in a selected few species and evaluated their response to low-level gamma irradiation (Virkki 1970). No phylogenetic analysis has been attempted on the Phasmatidae.

Puerto Rico and nearby Mona Island are inhabited by 11 species of walking sticks representing six genera (Moxey 1972). Of these 11 species, eight are endemic to Puerto Rico, two are found only on Puerto Rico and St. Thomas, and one is restricted to Mona Island. Of the taxa that we examined from eastern Puerto Rico, *D. achalus, L. portoricensis,* and *P. yersiniana* have widespread distributions throughout the mountainous regions of Puerto Rico. The fourth taxon is unnamed, and taxonomic work is being pursued by Garrison and Willig (pers. comm.). Although this unnamed taxon shares some morphological characteristics with the genus *Lamponius,* Moxey's (1972) morphological treatment of the West Indian taxa was not based upon features of the male genitalia (the primary characteristics used in systematic studies of the Orthoptera) and may represent spurious results. We do not formally classify this taxon and refer to it hereafter as species X. Species X occurs primarily in the mossy dwarf-forests (above 1000 m) of the Caribbean National Forest, located in the Luquillo Mountains on the eastern part of the island. The purpose of this project was to examine, using protein electrophoresis, the phylogenetic and phenetic relationships of phasmatids that occur in eastern Puerto Rico.

Materials and Methods

Walking sticks were collected in the Caribbean National Forest (18°10′N, 65° 30′W), Puerto Rico, between 12 June and 2 August 1985. Specific localities of collection and sample sizes (N) for the four taxa examined were: *Diapherodes achalus,* (a.) km 10.6 on route 186 (N = 1), El Yunque Quadrangle, Municipality of Naguabo; (b.) km 13.5 on route 191 (N = 4), El Yunque Quadrangle, Municipality of Naguabo; species X, km 13.5 on route 191 (N = 13), El Yunque Quadrangle, Municipality of Naguabo; *Lamponius portoricensis,* near route 180 (N = 66), El Verde Field Station, Municipality of Rio Grande; *Psuedobacteria yersiniana,* (a.) km 10.6 on route 186 (N = 13), El Yunque Quadrangle, Municipality of Naguabo; (b.) km 13.5 on route 191 (N = 5), El Yunque Quadrangle, Municipality of Naguabo. After collection, all individuals were transported to El Verde Field Station and were identified to specific level. Each specimen (minus abdomen) was placed in a 1.5 ml Eppendorf tube and immediately frozen; upon arrival at the Department of Biological Sciences, Texas Tech University, specimens were stored at −70°C.

Prior to allozymic analysis, each individual was homogenized in a buffered solution (pH = 6.8). The tissue homogenate was analyzed using standard horizontal starch-gel electrophoretic techniques (Selander et al. 1971, Harris and Hopkinson 1977). The following loci were examined: acid phosphatase (Ap); aldehyde oxidase (Ao); esterase-1, -2, and -3 (Es-1, -2, -3); glucose dehydrogenase (Gdh); glucose phosphate isomerase (Gpi); glutamate oxaloacetate transaminase-1 and -2 (Got-1, -2); leucine amino peptidase-1 and -2 (Lap-1, -2); malate dehydrogenase-1, -2, and -3 (Mdh-1, -2, -3); nucleoside phosphorylase (Np); peptidase-1 and -2 (Pep-B-1, -2); and phosphoglucomutase-1, -2, and -3 (Pgm-1, -2, -3). Only loci with consistent banding patterns (Ap, Es-1, Gdh, Lap-1, Mdh-1, -2, Pgm-1) were used in the subsequent analyses.

When multiple isozymes of a protein were present, the locus that migrated the farthest anodally was designated as "1," and loci

that migrated progressively in the direction of the cathode were given higher numerical designations. For each locus, the most common allele was designated as "100" and other alleles were assigned numeric values according to their mobility relative to the most common allele.

Genetic distances between each pair of taxa were calculated from allelic frequency data (Nei 1972, Rogers 1972). Nei's (1972) and Rogers' (1972) genetic distance values were similar, therefore, only Rogers' (1972) genetic distance values were used in subsequent analyses. Relationships among species X, *D. achalus, L. portoricensis,* and *P. yersiniana* were analyzed by genetic distances (Rogers 1972) and summarized in the form of a distance dendrogram that was obtained from a UPGMA (unweighted pair-group method using arithmetic averages; Sneath and Sokal 1973) clustering method. Phyletic relationships also were summarized in the form of an unrooted tree, produced by the Wagner parsimony analysis (Farris 1970) using the WAGNER78 package and the Fitch-Margoliash analysis of the distance matrix (Fitch and Margoliash 1967).

Results

Allele frequencies of the seven polymorphic loci and their distribution within taxa appear in Table 1. For the Ap locus, in which a total of seven alleles were detected, *D. achalus* was polymorphic for the two slowest alleles ("85" and "90"), species X was fixed for the "95" allele, and *L. portoricensis* was fixed for the "100" allele. *Pseudobacteria yersiniana* was extremely polymorphic in possessing the five fastest alleles ("95" through "110") at the Ap locus, thereby sharing the "95" allele with species X and the "100" allele with *L. portoricensis.* Only three alleles were detected at the Es-1 locus. *Diapherodes achalus,* species X, and *P. yersiniana* were each fixed for the "100" allele, whereas *L. portoricensis* was polymorphic and possessed all three alleles. No fixed differences or unique distribution of alleles was detected for either Gdh or Lap-1, with the exception that *P. yersiniana* possessed a greater number of alleles than any other taxon examined for these loci. For Mdh-1, *D. achalus* and species X shared two of the six alleles ("95" and "100" alleles) and each had approximately the same frequency in each taxon. *Lamponius portoricensis* was fixed at this locus for the "100" allele, which also was detected in *D. achalus* and species X. Again, *P. yersiniana* exhibited a high degree of polymorphism by possessing all six of the alleles for Mdh-1. For Mdh-2, only *D. achalus* was fixed for an allele ("100" allele), whereas the other three taxa were each characterized by the presence of all three alleles. Finally, for Pgm-1, only *L. portoricensis* was fixed for an allele ("100" allele), whereas the other three taxa each exhibited much polymorphism. Rogers' (1972) genetic distance values between *D. achalus* and species X, *D. achalus* and *L. portoricensis,* and *D. achalus* and *P. yersiniana* were 0.349, 0.524, and 0.475, respectively. Distance values between species X and *L. portoricensis,* species X and *P. yersiniana,* and *L. portoricensis* and *P. yersiniana* were 0.455, 0.426, and 0.571, respectively. Genetic distance relationships among the four taxa of walking sticks are summarized in the form of a distance dendrogram (Fig. 1).

Based on a phenetic analysis of allozymic data, species X is more similar to *D. achalus* than to *L. portoricensis* or *P. yersiniana.* Both the Wagner and Fitch-Margoliash analyses for phyletic relationships gave identical tree topologies; therefore, only the result of the Fitch-Margoliash analysis is presented. Phyletic relationships, summarized by the Fitch-Margoliash analysis were generated from an unrooted tree that reflects the actual observed genetic distance in the length of the branches (Fig. 2). The average value of heterozygosity (H) for these four taxa is 0.060. Heterozygosity estimates for each taxon are: $H = 0.051$ (species X), $H =$

Table 1. Allele frequencies of seven variable loci for four taxa of walking sticks collected from the Caribbean National Forest (18°10′N, 65°30′W), Puerto Rico. See text for locus abbreviations. The common allele is designated as the "100" allele and additional alleles are numbered according to the mobility of their products relative to that of the common allele. Alleles not listed in the table are: Ap-110, Es-1-95, Gdh-95, Mdh-1-115, Mdh-2-115, and Pgm-1-120 (their frequencies can be obtained by subtraction).

Locus	Allele	*D. achalus*	Species X	*L. portoricensis*	*P. yersiniana*
Ap	105	0.000	0.000	0.000	0.267
	100	0.000	0.000	1.000	0.233
	98	0.000	0.000	0.000	0.367
	95	0.000	1.000	0.000	0.100
	90	0.400	0.000	0.000	0.000
	85	0.600	0.000	0.000	0.000
Es-1	105	0.000	0.000	0.562	0.000
	100	1.000	1.000	0.308	1.000
Gdh	115	0.400	0.143	0.000	0.067
	112	0.000	0.000	0.000	0.133
	110	0.000	0.000	0.000	0.667
	105	0.200	0.214	0.175	0.067
	100	0.400	0.643	0.635	0.067
Lap-1	110	0.400	0.000	0.000	0.056
	105	0.600	0.286	0.063	0.000
	100	0.000	0.500	0.813	0.167
	95	0.000	0.215	0.125	0.778
Mdh-1	110	0.000	0.077	0.000	0.177
	100	0.500	0.462	1.000	0.118
	95	0.500	0.462	0.000	0.177
	90	0.000	0.000	0.000	0.441
	80	0.000	0.000	0.000	0.059
Mdh-2	110	0.000	0.357	0.273	0.177
	100	1.000	0.571	0.561	0.235
	95	0.000	0.071	0.167	0.529
Pgm	110	0.100	0.214	0.000	0.250
	105	0.100	0.286	0.000	0.056
	100	0.800	0.393	1.000	0.583
	98	0.000	0.036	0.000	0.000
	95	0.000	0.000	0.000	0.028
	85	0.000	0.000	0.000	0.056
	75	0.000	0.071	0.000	0.000

0.057 (*D. achalus*), $H = 0.044$ (*L. portoricensis*), and $H = 0.087$ (*P. yersiniana*).

Discussion

Rogers' genetic distance values indicate that considerable genetic divergence has occurred among the four taxa examined. Values range from 0.349 for the pairwise comparison of species X and *D. achalus* to 0.571 for the pairwise comparison of *L. portoricensis* and *P. yersiniana*. Nevo (1978) reported levels of heterozygosity for a variety of invertebrates; however he did not report data for the Phasmatidae. The heterozygosity values in this study occur within the range of those reported for closely related Orthoptera and other insects.

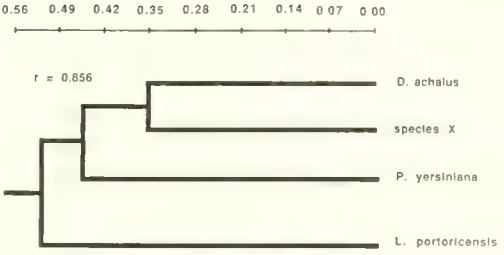

Fig. 1. Dendrogram that depicts the relationship of *Diapherodes achalus, Lamponius portoricensis, Pseudobacteria yersiniana,* and an unnamed taxon (species X) derived from a UPGMA of Rogers' genetic distance coefficients.

The limited research that has been reported on stick-insects from Puerto Rico has focused on taxonomy (Gray 1835, Burmeister 1838, Saussure 1868, Brunner and Redtenbacher 1892, Rehn 1903, Rehn and Hebard 1938, Wolcott 1923, 1936, 1941, 1948, Moxey 1971, 1972), systematics (Moxey 1972), population dynamics and natural history (Wolcott 1951, Willig et al. 1986), or effects of radiation (Virkki 1970). Based upon distributional data, Moxey (1972), suggested that the Antillean genera considered herein (*Diapherodes, Lamponius,* and *Pseudobacteria*) probably each evolved from Central American stocks, which subsequently invaded the West Indies from west to east. Moreover, he noted that *Lamponius* and *Diapherodes* probably evolved from a common stock. Our allozymic data provide limited support to the hypothesis that *L. portoricensis* and *P. yersiniana* may have evolved from different ancestral stocks in that they are separated by a genetic distance much greater than are the other taxa in the UPGMA (Fig. 1).

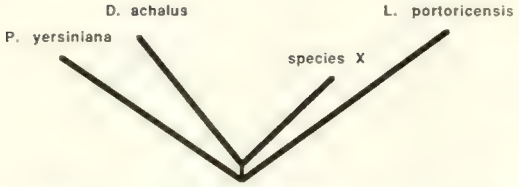

Fig. 2. Unrooted tree generated by a Fitch-Margoliash analysis based on Rogers' genetic distances for *Diapherodes achalus, Lamponius portoricensis, Pseudobacteria yersiniana* and an unnamed taxon (species X).

Nonetheless, the large genetic distance between all taxa in the UPGMA (Fig. 1) and the short internode distance in the Fitch-Margoliash tree (Fig. 2) fail to provide conclusive information about the systematic relationships of these taxa or the proper affiliation of species X. Clearly, the phylogenetic tree should be viewed with caution because it does not involve a monophyletic group and no out group was used to root the tree. Five possible phylogenies (we exclude those with unresolved trichotomies if rooting occurs at vertices) are congruent with the Fitch-Margoliash topology (Fig. 2). In three of them, species X is more closely related to *D. achalus* than to any of the other taxa. Alternatively, species X may be less related to any of the other taxa than those taxa are to each other, or *L. portoricensis* and *P. yersiniana,* as a group, may be more closely related to species X than any of those three taxa are to *D. achalus.*

Future studies addressing phasmatid systematics in the West Indies should obtain adequate samples of all taxa occurring throughout the West Indies, and include an outgroup by which one could root a phylogenetic tree. Thereafter, it would be possible to test a variety of hypotheses concerning phasmatid systematics and thereby facilitate the classification of species X as well.

Acknowledgments

We thank J. K. Jones, Jr., R. W. Garrison, G. S. Spicer, J. C. Cokendolpher, R. D. Bradley, G. R. Camilo, M. J. Hamilton, and especially R. D. Owen for providing critical reviews of an earlier draft of this manuscript. This study was funded by the Office of Health and Environment Research, Department of Energy, and Oak Ridge Associated Universities via a Faculty Participation grant to MRW. We also acknowledge the Graduate School of Texas Tech University for support of MRW and RAVDB, and State of Texas Organized Research Fund for support to MRW.

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ANTENNAL SENSILLA AND SETAE OF *EVAGETES PARVUS* (HYMENOPTERA: POMPILIDAE)

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Abstract.—The antennae of cleptoparasitic female *Evagetes parvus* were investigated using scanning electron microscopy. Setae and sensilla placodea, corrugated conical sensilla, pit organs, sensilla campaniformia, sensilla trichodea A, B, C, D, sensilla basiconica and sensilla spatulata were located, described and illustrated. The sensilla of *E. parvus* most clearly resemble those of two other pompilids, *Anoplius tenebrosus* and *A. viaticus*; however, spatulate sensilla were not found in either of these species. Two large zones on the flagellum of *E. parvus* are dominated by corrugated conical sensilla and placoid sensilla, respectively. The former are found only on the flattened ventral surfaces of flagellomeres 2–10, whereas the latter surround these sensilla and occur also on flagellomere 1. The corrugated conical sensilla in conjunction with the sensilla basiconica and sensilla spatulata are probably used in locating the host (buried spider) because of their ventral position on the antennal surface and their morphology.

Key Words: cleptoparasite, chemoreception, mechanoreception, proprioception

Members of the genus *Evagetes* are cleptoparasitic, ovipositing on spiders which have been captured by other genera of Pompilidae. The most distinguishing characteristic of the genus is the short antennae which are thickened and somewhat flattened ventrally in the female (Evans 1950). Females are usually observed walking on sandy surfaces while tapping the soil with their antennae, or stalking nesting pompilid wasps. Female *Evagetes* frequently enter nests being provisioned by other pompilids either before or after closure. Such a wasp is able to detect a buried spider by some clue, most likely olfactory and/or tactile, whereupon she unearths the paralyzed prey, destroys the pompilid's egg, and lays her own egg on the prey (Evans and West Eberhard 1970). The subsequent closure by a female *Evagetes* may be thorough or loose. Such cleptoparasitic behavior has been noted in *E. parvus* (Cresson) by Evans (1950) and Evans and Yoshimoto (1962). Similar activities of other species of *Evagetes* have been reported by Richards and Hamm (1939) and Evans et al. (1953) and summarized by Krombein (1979).

While searching for the buried paralyzed spider, *Evagetes* females extend their antennae outward in a stiff "V" and rapidly tap the ground with the ventrally flattened surfaces. The particular sensory sensilla used in detecting the spider are probably located on the ventral surfaces of the antennae. The intent of this paper was to examine and identify the antennal sensilla and setae of

female *Evagetes parvus*, using SEM, and to attempt to determine which sensilla are used to locate the buried prey.

Methods and Materials

Female *E. parvus* were collected from a sand pit near Auburn, Cayuga County, New York, during the summers of 1981 and 1982. They were kept refrigerated in ventilated glass vials until used. Preparation consisted of excising either the antennae or heads, and immersing these in methylene chloride for two days to dissolve the waxy layer. Two pairs of antennae were then mounted with silver paint, and sputter-coated in a Technics sputter-coater with ionized gold-palladium alloy. Another specimen, kept in methylene chloride, was mounted on a stud with silver paint and coated with gold in a Kinney SC2 high vacuum metal evaporator.

One specimen was air-dried in an attempt to see if there were any differences in the final appearances of the sensilla. This specimen was then mounted on double sticky tape, grounded with silver paint, and sputter-coated with gold-palladium alloy. Specimens were then viewed on an ETEC Autoscan scanning electron micropscope, at accelerating voltages of 10 and 20 KV. There were no differences found in antennal features between this method and the first one used.

The nomenclature used to describe the various sensilla has been modified from Ågren (1977) and Alm and Kurczewski (1982).

Results

Female *Evagetes parvus* have filiform antennae, ca. 2.6 mm long, which are composed of scape, pedicel, and flagellum with flagellomeres designated 1–10 proximally to distally. The ventral surface is in contact with the substrate during host-searching, is flattened from flagellomere 2–10, and is highly sensory. The scape, pedicel, and flagellomere 1 are mainly setaceous. In describing the sensilla we refer to the antennae being held horizontally in front of the wasp as during host-searching. When the antennae are curled back in the resting position (Fig. 1), the medial and ventral surfaces are actually facing outward away from the insect. The sensilla found are described below in order of their prominence and complexity except for s. spatulata which are described near the end because they resemble s. basiconica.

Fig. 1. Antenna of female *Evagetes parvus*, as viewed dorsally, showing the curled, resting position typical of many female Pompilidae.

Sensilla

Sensilla placodea: A placoid sensillum is elongate, convex and has a membranous fold encircling its base (Figs. 2A, B). It is oriented parallel to the long axis of the antenna, and its dimensions are 5 × 15 µm. Placoid sensilla are abundant, extending from a small area on flagellomere 1 along the sides and over most of the dorsum of the remaining flagellum. They are spaced evenly and num-

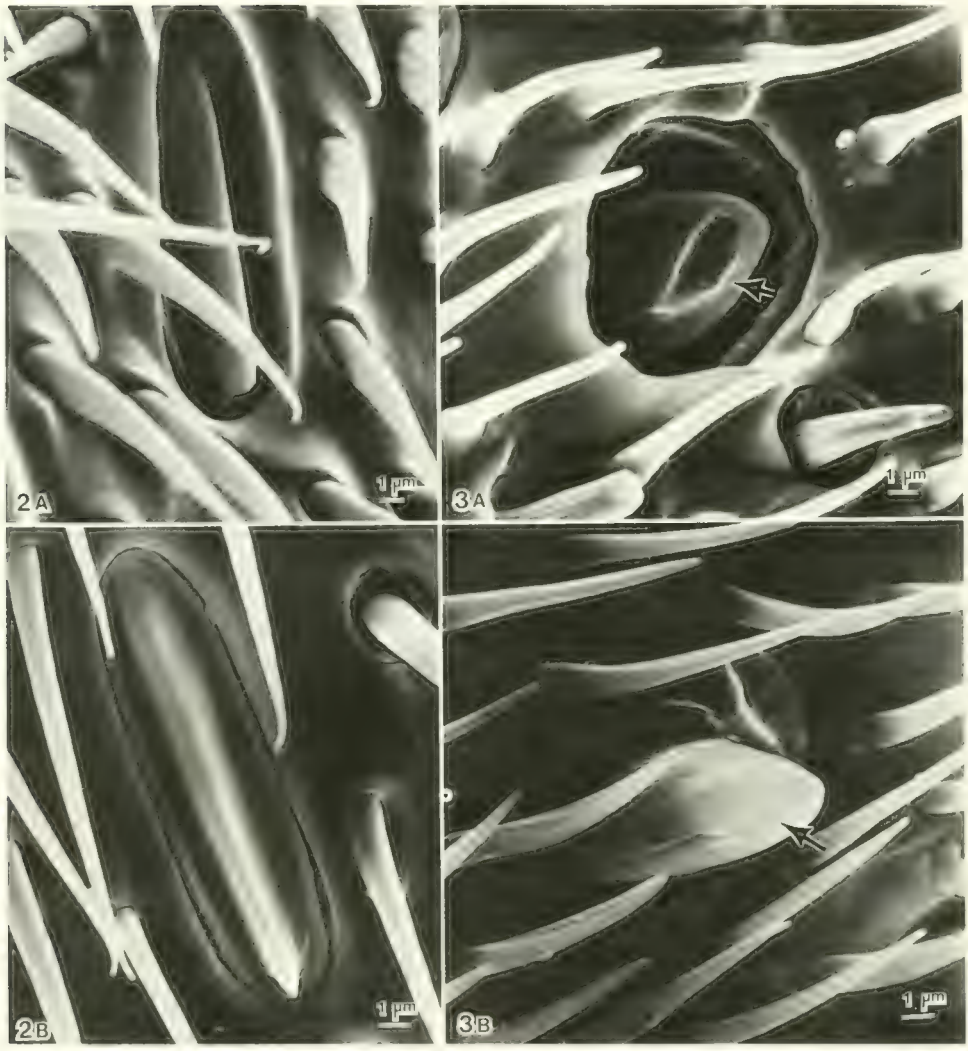

Fig. 2. A, Sensillum placodeum, flagellomere 8, sunken into cavity, with distal end projecting above antennal surface. B, Sensillum placodeum, dorsal view, showing membranous fold around base, flagellomere 4.

Fig. 3. A, Corrugated conical sensillum with subterminal furrow (arrow), flagellomere 3. B, Corrugated conical sensillum showing exudate covering furrow (arrow), flagellomere 6.

ber ca. 17 in a column down the length of a typical flagellomere.

Corrugated conical sensilla: Corrugated conical sensilla are stout, truncate receptors (Figs. 3A, B) which lean distally and are cushioned against the cuticle by a thick membrane. Numerous grooves extend from base to apex. The tip may be indented (Fig. 3A) or covered with an exudate (Fig. 3B). The sensillum is ca. 10 µm long and 5 µm wide at the base. It is found abundantly only on the flattened ventral surface of the flagellum. These sensilla form a small triangle on the underside of flagellomere 2, continue along the entire ventral surface of the flagellum, and end in a triangular area on the underside of flagellomere 10.

Pit organs: These hollowed pits resemble domes with holes in the centers (Figs. 4A, B). A smooth peg may be visible in the bot-

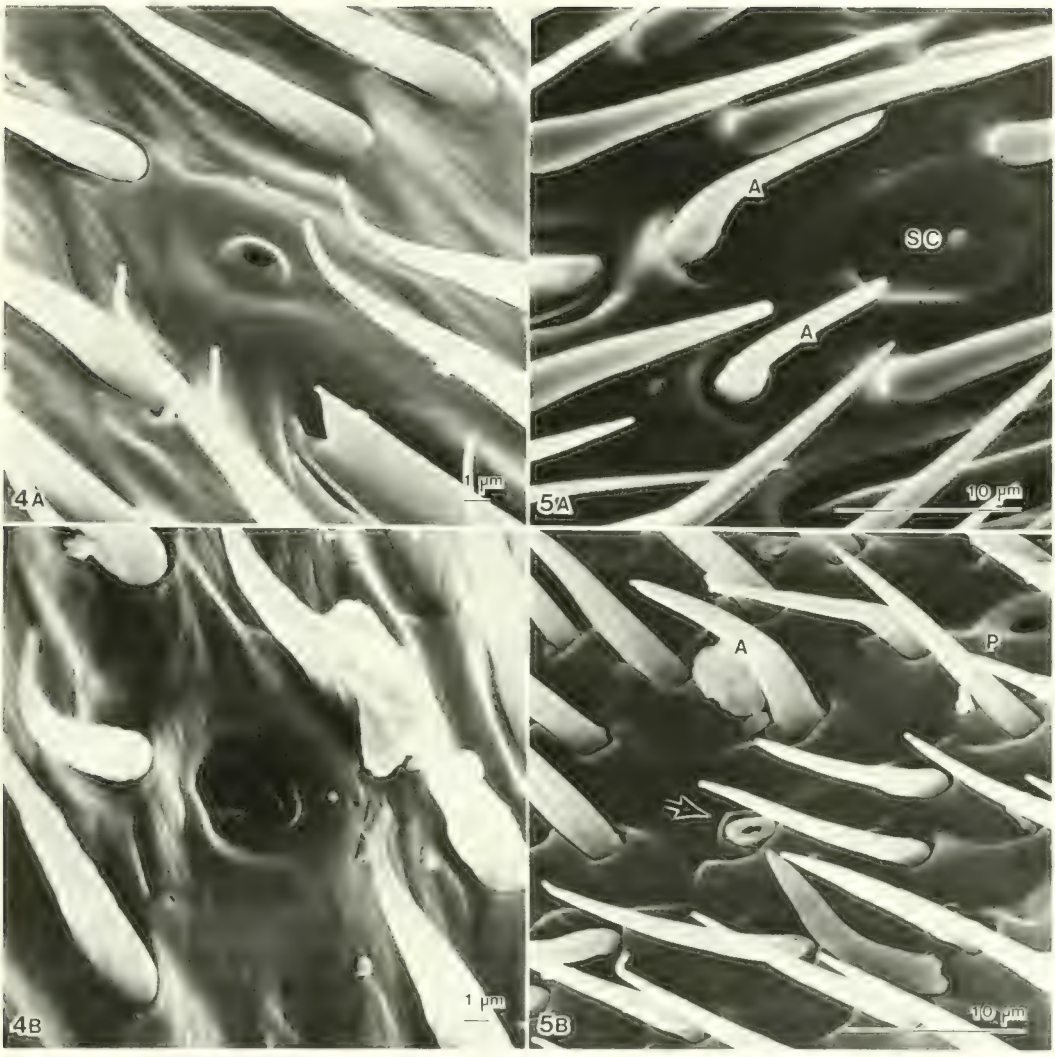

Fig. 4. A, Small pit organ, distal end, flagellomere 7. B, Large pit organ, revealing peg within pit, dorsal surface, flagellomere 10. Irregular surface may be due to fixation.

Fig. 5. A, Sensilla campaniformia (SC) and s. trichodea A (A) in asymmetrical sockets, flagellomere 1. B, Broken sensillum trichodeum A, showing hollow center (arrow), flagellomere 5. p = pit organ.

tom of the pit (Fig. 4B). Two types of pit organs are distinguished by the size of the central aperture, one being ca. 1 μm and the other, 3 μm in diameter (Figs. 4A, B). Pit organs are relatively few in number, varying from 2 to 9 per flagellomere. They are found in clusters on the medial and lateral surfaces on the proximal half of the flagellum. Toward the distal end of the flagellum the clusters are placed dorsally.

Sensilla campaniformia: This receptor has a shallow circular depression with a central papilla (Fig. 5A), is oval in shape, and has a diameter of ca. 6 × 10 μm. Campaniform sensilla occur only on the flagellum, their greatest concentration being a group of 5–8 on the ventrolateral surface of flagellomere 1. They occur in small clusters at the middle and distal ends of the remaining flagellomeres.

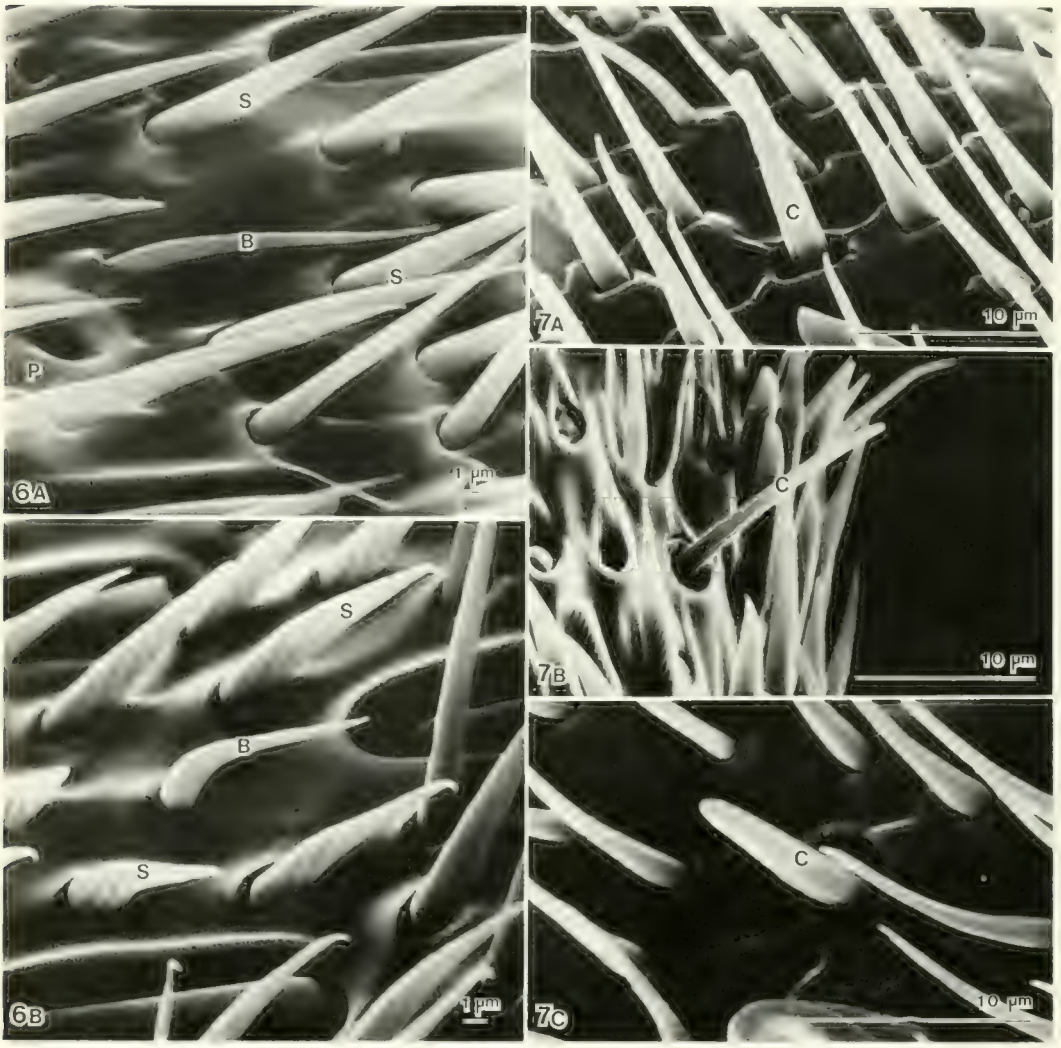

Fig. 6. A, Sensillum trichodeum B (B), flagellomere 8. p = pit organ S = setae. B, Sensillum trichodeum B (B) with heavy sculpturing, flagellomere 8. S = setae.

Fig. 7. A, Medium-length sensillum trichodeum C (C), typical form, with sunken socket, flagellomere 3. B, Long sensillum trichodeum C (C) with raised socket, ventral surface, flagellomere 1. C, Short sensillum trichodeum C (C) among corrugated conical sensilla, flagellomere 3.

Sensilla trichodea A: These hairs have abrupt tips, are ca. 12 μm long (Fig. 5A), and sit in asymmetrical sockets. The base is large and bulbous and the thick shaft bends acutely at about a 70° angle toward the distal end of the antenna. The broken sensillum in Fig. 5B shows that s. trichodea A are hollow. Trichodea A occur in patches down the center of the lateral surfaces of flagellomeres 2–9 and are scattered on the medial surfaces of flagellomeres 3–10.

Sensilla trichodea B: These slender hairs, ca. 13 μm long, taper gradually to a point, and have no visible socket at the base (Fig. 6A). Trichodea B lie parallel to the antenna and point distally. This sensillum is thinner than surrounding setae, but is similar in shape and sculpture to them. The sensillum in Fig. 6B is only 9 μm long and is scarce on the dorsum of the antenna. The sensillum shown in Fig. 6A is most dense in occurrence laterally on the flagellum and is

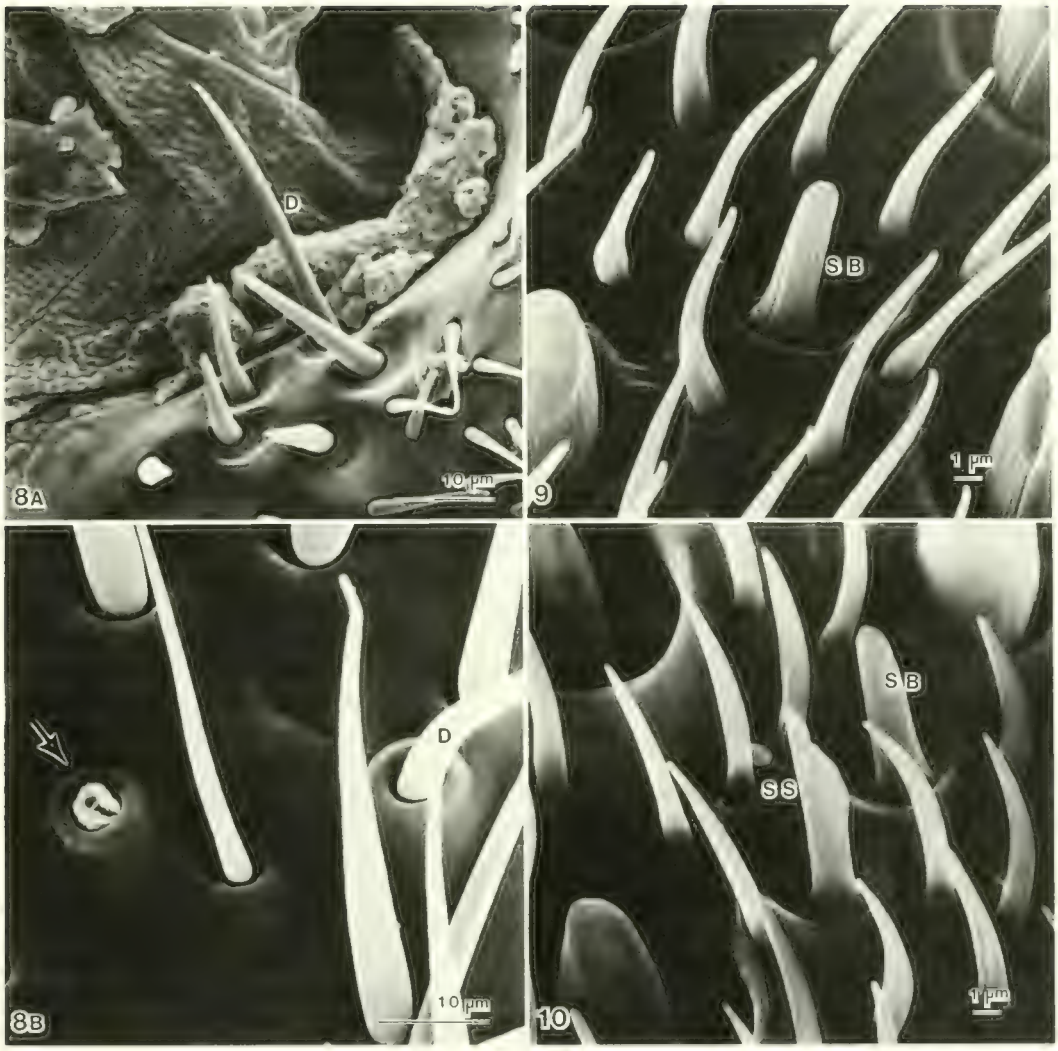

Fig. 8. A, Group of sensilla trichodea D (D), proximal end of scape. B, Broken sensillum trichodeum D, with hollow double chamber (arrow), pedicel.

Fig. 9. Sensillum basiconicum (SB), proximally set in socket, flagellomere 3.

Fig. 10. Sensillum spatulatum (SS) next to s. basiconicum (SB), flagellomere 6.

spaced evenly. Only one or two trichodea B are seen on the dorsum of the scape and pedicel.

Sensilla trichodea C: This slender, hair-like sensillum (Figs. 7A, B, C) has a blunt tip and 4–5 faint vertical furrows running from base to tip. The flexible socket has a circular, membranous collar which may be depressed or elevated. This sensillum is straight or curved slightly, 5–25 µm long, and stands nearly perpendicular to the antennal surface. Sensilla trichodea C are located on all of the flagellomeres: the longest at the distal ends, the shortest on the ventral surfaces, and medium-length ones in indistinct, widely-spaced rings.

Sensilla trichodea D: Sensilla trichodea D are similar to trichodea C, the difference being a ring around the base of the hair in trichodea D (Figs. 8A, B). The longest sensilla, 50 µm long, are located near the distal ends of the scape and pedicel. The broken

trichodeum D in Fig. 8B shows a distinct double chamber internally.

Sensilla basiconica: These pegs are ca. 6 μm high, straight and stout, with a blunt, almost flat, apex (Figs. 9, 10). There are 11–12 vertical grooves on each sensillum. The socket is large, round, and rarely depressed, with the sensillum placed in the proximal side of the socket. Sensilla basiconica are distributed on the flattened ventral surface of the flagellum.

Sensilla spatulata: This unusual fan-shaped sensillum (Fig. 10) is oriented with the concave face of the fan directed away from the antennal surface. It has a large round socket and is ca. 8 μm long. It is found scattered widely on the ventral surface among the corrugated conical sensilla.

Setae.—The setae are highly variable in size and shape, commonly long and straight, smooth or fluted, and not innervated (Fig. 11A). On the extreme dorsal surface of the antenna they are short, thick, and deeply grooved (Fig. 11B). On the distal half of the flagellum the setae occur among the corrugated conical sensilla and are broadly saber-shaped with deep grooves (Fig. 11C). The setae at the antennal tip are relatively long, broad apically, and longitudinally grooved (Fig. 11D).

Sensillar zones and interrelationships.—Two large zones on the flagellum are dominated by corrugated conical sensilla and placoid sensilla, respectively (Fig. 12). The corrugated conical sensilla are found only on the flattened ventral surfaces of flagellomeres 2–10. The placoid sensilla surround the corrugated conical sensilla, extending from flagellomeres 1–10. Each zone has a characteristic sensillar composition. Sensilla basiconica and s. spatulata are distributed among the corrugated conical sensilla (Fig. 13). Pit organs, s. campaniformia, and s. trichodea A are found among the placoid sensilla (Fig. 14). The pit organs and s. campaniformia are coincidentally dispersed in two longitudinal bands which border the sides of the corrugated conical sensillar zone. There are 2–4 of each type per band per segment. On the distal half of the flagellum the two bands gradually merge dorsally into one broad band. In addition there are two specialized sensory spots. There is a concentration of 5–8 campaniform sensilla on the ventrolateral surface of flagellomere 1 within the triangular patch of placoid sensilla. There is a group of 7–9 pit organs on the medial surface of flagellomere 2.

The majority of s. trichodea A is concentrated along the border of the corrugated conical sensillar zone with the remainder widely dispersed on the dorsum of the flagellum. Sensilla trichodea D are found in small groups on the scape and pedicel, whereas s. trichodea C are evenly distributed over the entire flagellum. The last third of the terminal flagellomere is devoid of s. placodea and corrugated conical sensilla, but has an abundance of s. trichodea B and C.

Discussion

In Hymenoptera, placoid sensilla are abundant (Slifer 1970) and are thought generally to be olfactory organs (Schneider 1964). In female *Evagetes parvus* they are distributed evenly and densely in a zone directed dorsad and along both sides of most of the flagellum. The sensilla placodea of female *E. parvus* are nearly identical to those of females of the pompilids *Anoplius viaticus* (L.) and *A. tenebrosus* (Cresson) (Walther 1979, Alm and Kurczewski 1982), are smooth-walled, project from a sunken pit above the antennal surface, and are moderately elongate. In addition, s. placodea of *A. viaticus* end in a point (Walther 1979). Shapes of placoid sensilla vary within Hymenoptera. Compared to those of *E. parvus*, placoid sensilla of Braconidae and Ichneumonidae are more elongate and often extend above the antennal surface at their distal ends. In Vespidae, placoid sensilla are shorter, flatter on the surface (Callahan 1970), and similar to those of Pompilidae in size and arrangement. Higher Apoidea

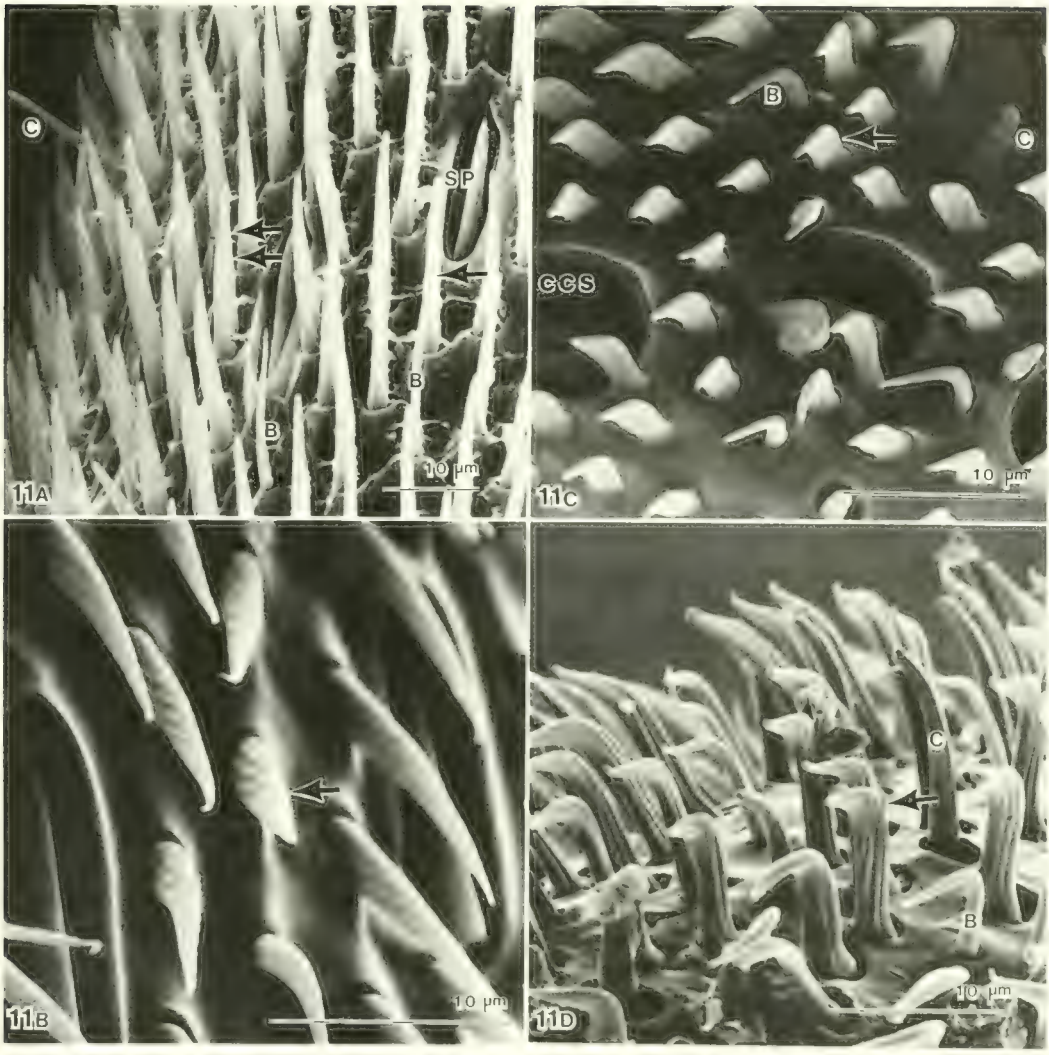

Fig. 11. A, Long and straight setae, both smooth (single arrow) and fluted (double arrow) types, flagellomere 10. B = s. trichodeum B; C = s. trichodeum C; SP = s. placodeum. B, Short, thick, spiralled seta (arrow), dorsum, flagellomere 8. C, Grooved, saber-shaped seta (arrow), ventral surface, flagellomere 10. B = s. trichodeum B; C = s. trichodeum C; CCS = corrugated conical sensillum. D, Thick, curved seta (arrow), tip of antenna. B = s. trichodeum B; C = s. trichodeum C.

have numerous circular and flat placoid sensilla (Slifer and Sekhon 1960, Dietz and Humphreys 1971, Ågren 1977, 1978). Based upon the presence of numerous small pores, Norton and Vinson (1974) suggested that elongate s. placodea of Ichneumonidae and Braconidae are chemoreceptors. Kaissling and Renner (1968) showed electrophysiologically that, in both sexes of *Apis mellifera* L., this sensillum was stimulated by the queen substance and the scent of Nasanov's gland.

The corrugated conical sensilla of *E. parvus* closely resemble those of *Anoplius viaticus* (described as s. basiconica P1) (Walther 1979) and *A. tenebrosus* (Alm and Kurczewski 1982). Callahan (1970) coined the term "conical" for this type of sensillum in the vespids *Polistes metricus* Say and *P. annularis* (L.). Those of *Polistes* species have

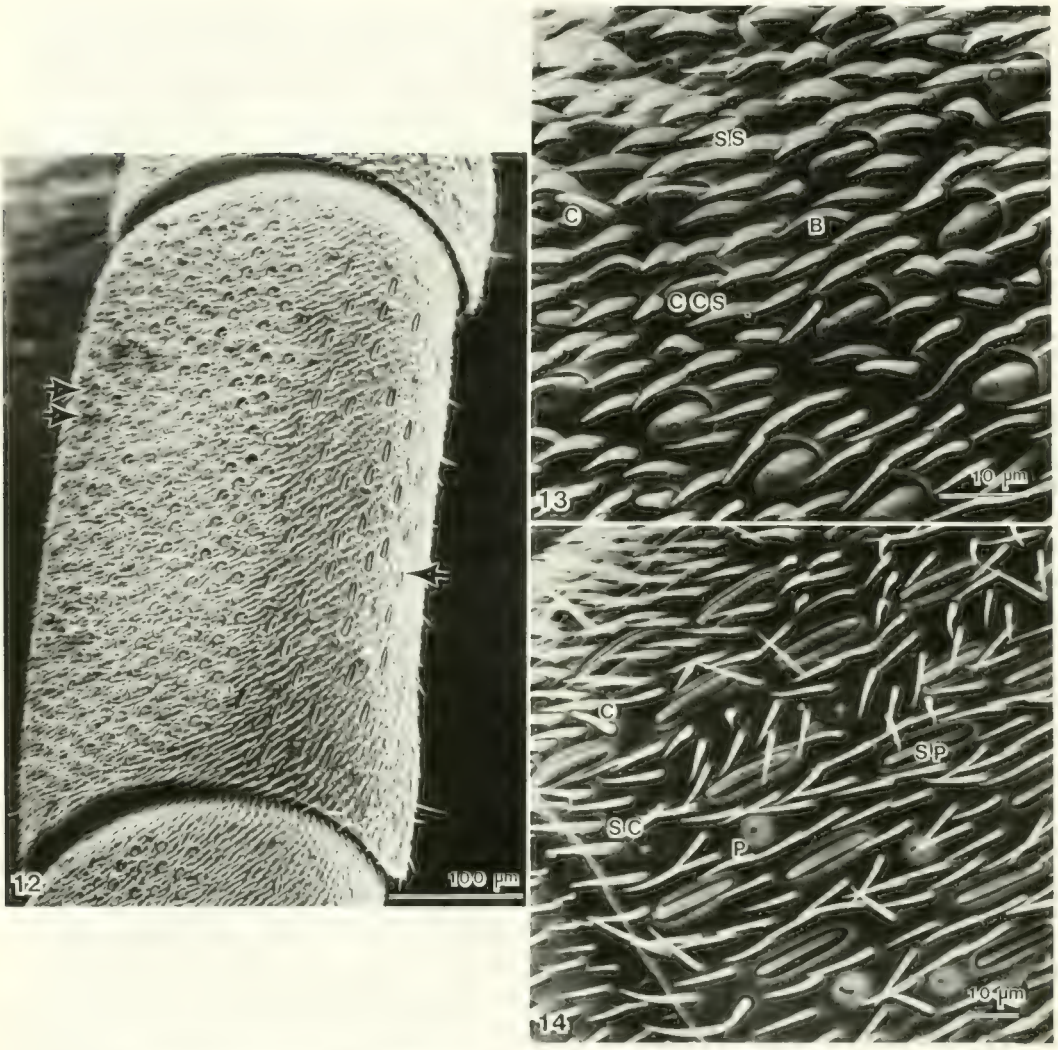

Fig. 12. Medioventral surface of flagellomere 7, showing areas containing sensilla placodea (single arrow) and corrugated conical sensilla (double arrow).

Fig. 13. Zone dominated by corrugated conical sensilla (ccs), containing s. basiconica, s. spatulata (ss), and s. trichodea C (C). B = s. trichodea B.

Fig. 14. Zone dominated by sensilla placodea (sp), containing s. campaniformia (sc), pit organs (p), and s. trichodeum C (C).

a distinct terminal pore, while those of *Anoplius viaticus* and *A. tenebrosus* (Walther 1979, Alm and Kurczewski 1982) and *E. parvus* have a deep furrow which probably indicates a terminal pore. Alm and Kurczewski (1982) reported that Kaissling and Klein (personal communication) found these sensilla to be reminiscent of gustatory bristles.

Alm and Kurczewski (1982) noted that these sensilla were found only on the antennae of female *Anoplius tenebrosus,* and Walther (1979) found the same for females of *A. viaticus.* In *E. parvus* females the corrugated conical sensilla may be used to detect buried, paralyzed spiders. These sensilla are abundant on the ventral antennal surface and their morphology suggests that

they are gustatory. The corrugated conical sensilla may receive a chemical residue or heavy odor molecule from buried prey or from pompilid-manipulated sand particles, and this provides the impetus for the wasp to unearth the spider. The broad, flattened apex provides a large surface area for chemoreception. There are no long sensilla or setae on the flattened ventral surface of the antenna of *E. parvus*, thus allowing the corrugated conical sensilla to contact the ground surface without interference.

The pit organs of *Evagetes parvus* resemble those of *Anoplius viaticus* and *A. tenebrosus* (Walther 1979, Alm and Kurczewski 1982), Colletidae (Ågren 1977), and Andrenidae (Ågren 1978). They appear as different-sized apertures through which the largest reveals an internal peg. They are similar to the s. ampullaceae and s. coeloconica of *Apis mellifera* which Dietz and Humphreys (1971) differentiated as "smaller" and "larger" pores, respectively. Altner and Prillinger (1980) reported that s. coeloconica are associated with chemo-, thermo-, or hygroreception. In both *E. parvus* and *A. mellifera* (Esslen and Kaissling 1976) the pit organs lie in a zone along the lateral and medial surfaces of the antenna. In *E. parvus* there are two different-sized and shaped apertures, indicating perhaps two functions.

Campaniform sensilla have a flexible socket which, when distorted, exerts pressure on an internal mechanoreceptor. They therefore act as proprioceptors responding to exocuticular stresses. These sensilla are frequently concentrated near joints or on structures subject to cuticular distortion (McIver 1975). In *E. parvus* they are found typically in groups of 1–4 at the middle and distal parts of the flagellomeres in close association with the pit organs located on the medial and lateral surfaces of the flagellum, at which points they would be effective as proprioceptors. The antennal musculature extends only to the first segment of the flagellum, and this might explain the rather high number located on flagellomere 1. Sensilla campaniformia on the antennae of Colletidae (Ågren 1977) and *Apis mellifera* (Dietz and Humphreys 1971, Esslen and Kaissling 1976) have patterns of distribution similar to those of *E. parvus*, but structurally have a more pronounced central node. The campaniform sensilla of *Anoplius tenebrosus* (Alm and Kurczewski 1982) are similar in structure and distribution to those of *E. parvus* but Walther (1979) described s. campaniformia of *A. viaticus* to be distributed singly, not in groups.

The s. trichodeum A of *Evagetes parvus* looks similar to the s. trichodeum A 1 of *Anoplius tenebrosus* (Alm and Kurczewski 1982), trichodeum A of *Prosopis communis* (Nylander) (Colletidae) (Ågren 1977), and the sicula-type sensilla of *Odontomachus ruginodis* (Wheeler) (Formicidae) (Callahan 1975). They bend sharply over the antennal surface, and are broadest along the axis perpendicular to the surface. Sensilla trichodea A are distributed mainly on the lateral surface of the flagellum in *E. parvus* and *A. tenebrosus* (Alm and Kurczewski 1982). The trichodeum A sensillum of *E. parvus* has an asymmetrical socket which appears to be flexible in only one plane or direction. The hole in the center of the broken sensillum (Fig. 5b) indicates a chemoreceptor with a sensory dendrite extending the length of the hair-like sensillum. Although pores were not seen on the s. trichodea A of *E. parvus* the sensillum, because of its location, comes into contact with many different substances and substrates and may function as a chemoreceptor.

The thin, curved s. trichodea B are evenly distributed around the flagellum of *E. parvus*. They are usually faintly grooved but become thickened and deeply grooved on the dorsum and among the thick and spiralled setae. The s. trichodea B of *E. parvus* have no visible articulating membrane and, therefore, are probably not mechanoreceptors.

The s. trichodea C of *E. parvus* appear identical to the s. basiconica of *Anoplius*

tenebrosus (Alm and Kurczewski 1982) and the s. chaetica of *Apis mellifera* (Whitehead and Larson 1976). Because they extend above the other sensilla, the long trichodea C at the distal end of each flagellomere may tactilely sense the adjacent segment.

There are few s. trichodea D in *E. parvus* and these are found on the scape and pedicel. They resemble the s. trichodea C, except that they have a ring of cuticle surrounding the base, rather than a broad open socket. The collar forms a narrow socket which may or may not be flexible. The double chamber observed in the broken sensillum (Fig. 8b) indicates the presence of a mechanoreceptor and a chemoreceptor, although it would be difficult to explain why a sensillum located only on the segments closest to the head would be chemosensory.

The sensillum basiconicum of *E. parvus* is stout, blunt, grooved longitudinally, and set into a broad and flattened socket. The basiconic pegs are interspersed among the corrugated conical sensilla on the ventral surface of the flagellum. Here they come into contact with, or close to, surfaces or objects and therefore may be mechano- and/or chemoreceptive.

The sensillum spatulatum has not been described in Hymenoptera. The term "spatulata" was derived from its peculiar shape and a similar sensillum described by Callahan (1975). This sensillum has a cylindrical base and the distal half fans out into a lightly grooved, concave shell. The socket is broad and flattened and nearly indistinguishable from the socket of a sensillum basiconicum. The s. spatulata occur infrequently within the corrugated conical zone. Based on the broad surface area, it is likely that this sensillum is a chemoreceptor.

Acknowledgments

We thank R. A. Norton, D. L. Dindal, and W. A. Coté, Jr., all of SUNY-CESF, for their constructive criticism of the manuscript. We also thank A. C. Day and J. J. McKeon, N. C. Brown Center for Ultrastructure Studies, SUNY-CESF, for their assistance with SEM. K. V. Krombein, Smithsonian Institution, introduced us to Walther's (1979) study of the antennal sensilla of aculeate Hymenoptera.

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REVISION OF THE GENUS *LORITA* BUSCK (LEPIDOPTERA: TORTRICIDAE: COCHYLINI), WITH A DESCRIPTION OF A NEW SPECIES

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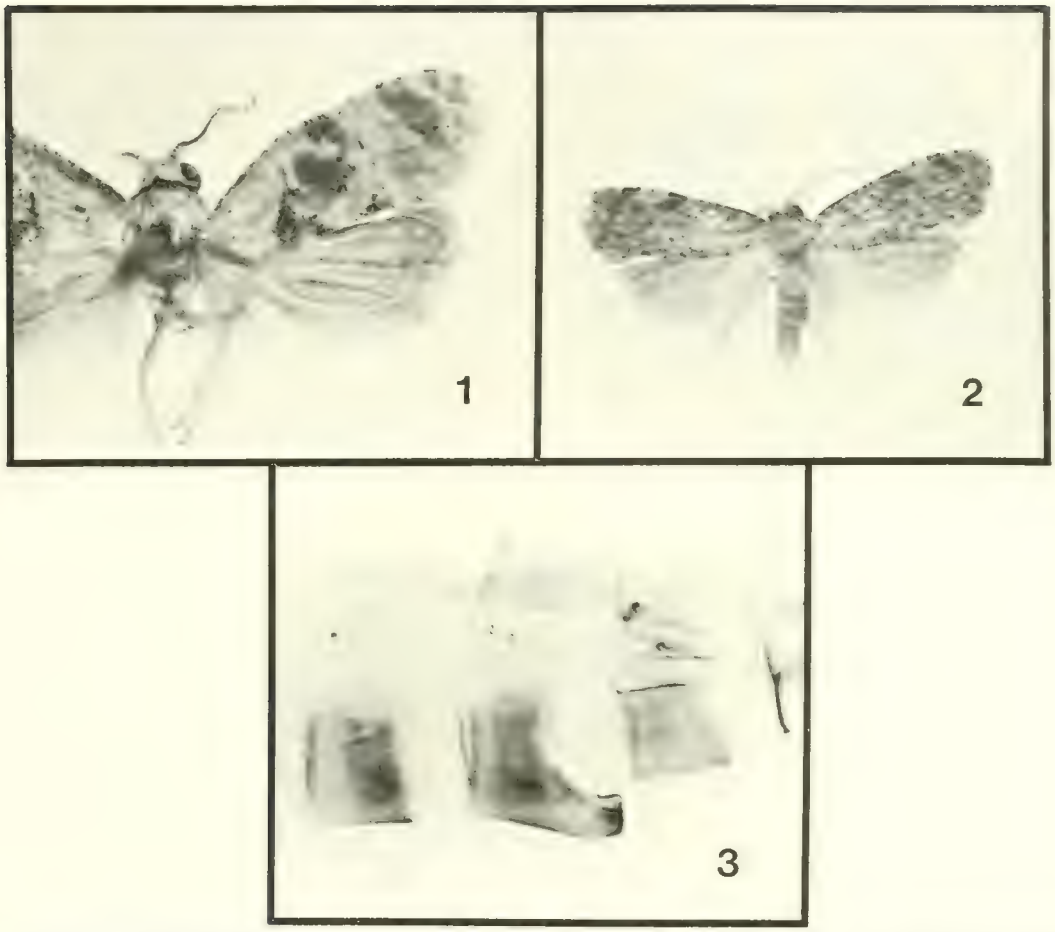
Abstract.—The genus *Lorita* Busck contains two species at present. The type species, *L. abornana* Busck, is now considered a subjective junior synonym of *Phalonia scarificata* Meyrick. A new species, ***L. baccharivora*** Pogue, is described. For this revision 154 adults, 3 larvae, and 4 pupae were studied. They are described and illustrated for both species, and the egg is described and illustrated for ***L. baccharivora***. *Lorita scarificata* occurs in northeastern Brazil northward to French Guiana, northeastern Venezuela, Antigua, Puerto Rico, Costa Rica, Mexico, southern California, Florida, and has been introduced to Hawaii. ***Lorita baccharivora*** occurs in the Florida peninsula, northeast coast of Texas, and has been released in southeastern Queensland, Australia, for the biological control of sea myrtle, *Baccharis halimifolia* L.

Key Words: biological control of weeds, *Lorita baccharivora*, *L. scarificata*, *Baccharis*

A revision of *Lorita* Busck was necessary to correct nomenclature of the type species, and to describe a new species being released in Australia for biological control of the weedy shrub, *Baccharis halimifolia* L. *Lorita* was proposed by Busck (1939) to accommodate a new species feeding on dodder, *Cuscuta californica* Choisy, and injurious to bell peppers, *Capsicum annuum* L., being imported from Sinaloa and Sonora, Mexico. Larvae bore into the stalks and capsules of the latter, thus reducing their commercial value (Busck 1939).

Saphenista, *Thyraylia*, and some *Cochylis* are very similar in coloration and maculation, making it difficult to identify them correctly without genital dissections. During the present study *Phalonia scarificata* Meyrick was discovered to be a senior synonym of *Lorita abornana* and the valid type species of *Lorita*. Clarke (1963) illustrated the lectotypes of *galbanea* Meyrick and *scarificata* and placed them in *Lorita*. Based on these illustrations and examinations of paratypes of both species, I concluded that *scarificata* is a senior synonym of *abornana* and *galbanea* belongs to the genus *Saphenista*. Forbes (1931) described *Saphenista semistrigata* from El Yunque, Puerto Rico, but illustrated the male genitalia (pl. XLV, fig. 26) of *Lorita scarificata*. The type of *S. semistrigata* is a female and is not conspecific or congeneric with *L. scarificata*. Therefore, *Saphenista semistrigata* is a valid species, and the illustration by Forbes is a misidentification.

For this revision 153 adults, 3 larvae, and 4 pupae were studied. Means and standard deviations are given for some measurements. The letter "n" denotes number of specimens examined. The supraocular index equals height of head capsule above compound eye divided by total height of head capsule (from top of epicranium to tip of subgenal process) (Kristensen and Nielsen 1979). Valval length was measured from



Figs. 1–3. Adult moths: 1, *Lorita scarificata* (Meyrick), ♂, forewing length 4.3 mm; 2, *L. baccharivora*, new species, ♂, holotype, forewing length 4.0 mm; 3, *L. scarificata*, ♂, ventral projection of 6th abdominal sternite.

proximal tip of sacculus to apex of valva, and maximum width was measured in a vertical line from valval costa to ventral edge of sacculus. Color names are followed by a parenthetical number indicating colors under the system of Smithe (1975, 1981). Larval chaetotaxy follows Hinton (1946).

Lorita Busck

Figs. 1–47

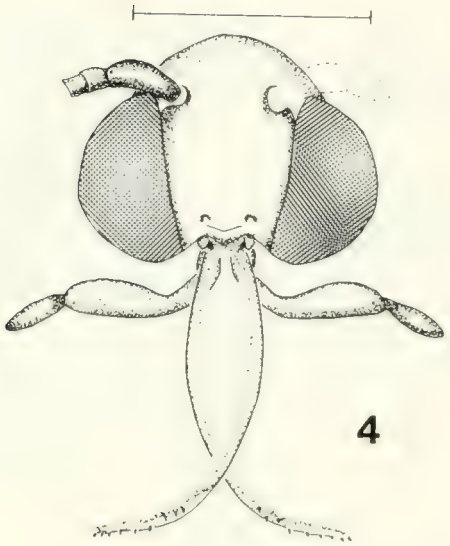
Lorita Busck, 1939: 100.—Clarke, 1963: 20.—Razowski, 1977: 256.—Powell, 1983: 42.

Type-Species.—*Phalonia scarificata* Meyrick 1917 (Fig. 1), senior synonym of *Lorita abornana* Busck.

Adult (Figs. 1–2).—Forewing length 3.4–5.4 mm.

Head (Fig. 4): Vestiture rough. Eye well developed. Supraocular index 0.26–0.28. Ocellus absent. Antenna filiform, scaled dorsad, setose ventrad, 33–38 segments. Labial palpus porrect, scales of second segment with dorsal expansion greater than ventral; third segment exposed, not covered by second segment scaling, sensory setae distributed along entire length of third segment; third segment 1.3× first segment; second segment 3.3× first segment, equal to vertical eye diameter, length 5.2× width. Maxillary palpus 1-segmented.

Thorax: Posterior crest present, but often



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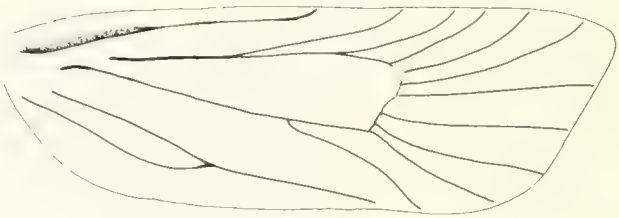

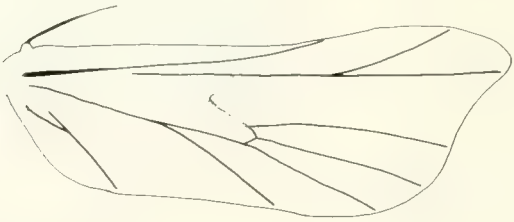

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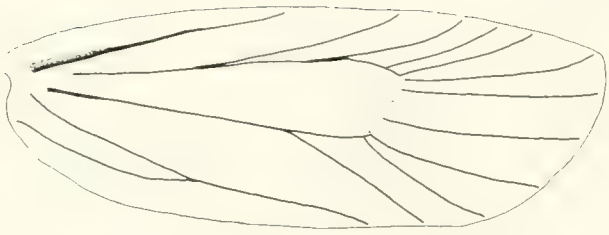

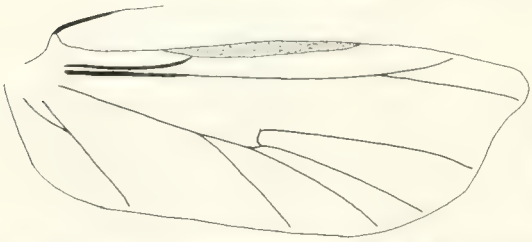

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Figs. 4–6. Head structure and wing venation: 4, *L. scarificata* (Meyrick), anterior view (scale = 0.5 mm); 5, *L. scarificata*; 6, *L. baccharivora*, new species.

inconspicuous. Lateral scale tufts of metanotum hairlike. Prothoracic leg with epiphysis 0.4–0.5 length of tibia. Mesothoracic tibia with a single pair of unequal sized apical spurs, longest 0.5–0.6 length of tibia. Metathoracic tibia with 2 pairs of unequal sized spurs; basal pair originating at 0.6 from tibial base, with longest spur 0.4 length of tibia; apical pair at subapex with longest spur 0.4 length of tibia. Leg indices [femur : tibia : (basitarsus)tarsus] for prothoracic leg 1:0.7:(0.5)1.6; mesothoracic leg 1:0.9:(0.5)1.1; metathoracic leg 1:1.6:(0.8)1.4.

Forewing (Figs. 5–6): Male length 3.4–4.6 mm; length 2.5–3.1× maximum width. Female length 3.8–5.4 mm; length 2.4–3.2× maximum width. Costa straight; apex rounded; termen straight, oblique. Sc less than 0.5 wing length. R1 originating beyond middle of discal cell; R2 originating nearer R3 than R1; R5 ending at termen. M3 and CuA1 separate. CuA2 originating at 0.67 length of discal cell. CuP absent. A1+2 stalked at 0.4 total length.

Hindwing (Figs. 5–6): Male length 2.9–4.0 mm; length 2.6–3.3× maximum width. Female length 2.1–4.4 mm; length 2.6–3.4× maximum width. Costa straight; apex produced; termen concave below apex. Sc+R1 less than 0.5 wing length. Rs and M1 stalked at 0.67 length of M1. M3 and CuA1 connate. CuA2 originating at 0.67 length of discal cell. Female with 3 frenular bristles.

Abdomen: Male with prominent ventral projection of 6th sternite (Fig. 3); female normal.

Male genitalia (Figs. 7–10): Uncus present, thin, elongate, or divided. Gnathos absent. Socii attached to posterior margin of tegumen. Tegumen well developed, trapezoidal. Transtilla a broad, well-developed band with an elongate, stout, apically rounded median projection. Valva length 1.7–2.0× maximum width; costa a thin sclerotized band; sacculus a well defined band appressed to ventral edge of valva. Vinculum arms free. Aedoeagus large and robust, 1.4–1.7× length of valva, bent at apical 0.2 with a sharp ventrally produced spine, cornuti numerous minute spinules on vesica.

Female genitalia (Figs. 11–12): Papillae anales setaceous, thin, apices broadly rounded, joined by narrow connection. Length of apophysis anterior 1.0–1.7× apophysis posterior. Sterigma well developed, rectangular, joined to ventral branch of apophysis anterior. Ductus bursae short, encircled by a series of elongate, narrow sclerotizations. Corpus bursae covered with numerous minute convolutions, signa consisting of many spinules. Accessory bursa present.

Discussion.—*Lorita* has a Nearctic distribution from Florida to California and northern Mexico. Neotropical distribution includes Mexico (Razowski 1986, Razowski and Becker 1986), Costa Rica (Razowski 1986, Razowski and Becker 1986), Puerto Rico (Forbes 1931), Antigua, British Guiana, Venezuela, and Brazil (Razowski 1967, Razowski and Becker 1986). This is the only cochyline genus known from the Pacific Ocean islands; *L. scarificata* has been introduced to Hawaii on the islands of Oahu (Beardsley 1977) and Kauai (Mau 1979).

Males of *Lorita* can be distinguished from those of other cochyline genera by the elongate ventral process of the 6th sternum (Fig. 3). I have found *Lorita* mixed with specimens of *Spinipogon* (Cochylini) in collections.

***Lorita scarificata* (Meyrick)**

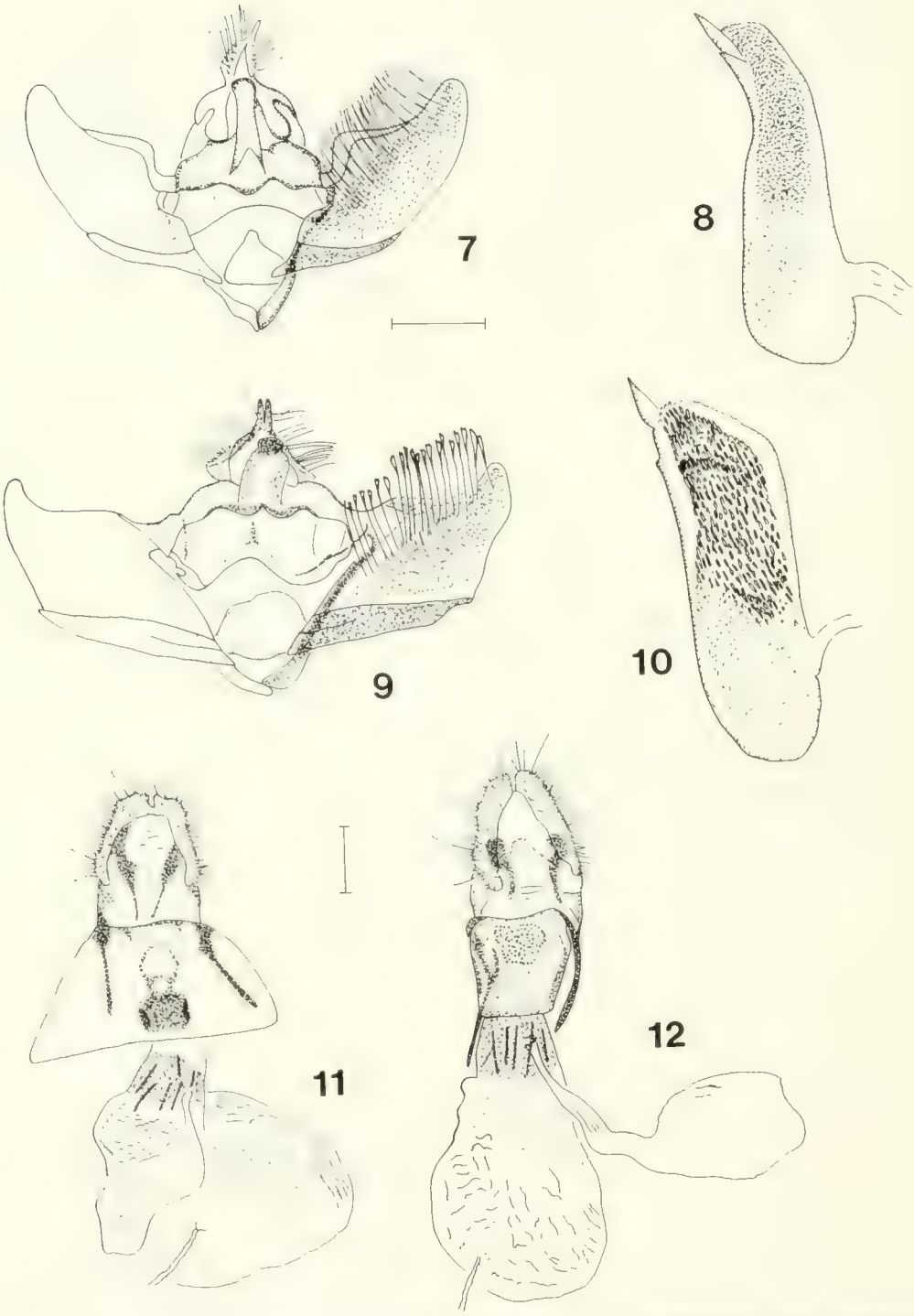
Figs. 1, 3–5, 7–8, 11, 13–25

Phalonia scarificata Meyrick, 1917: 3.

Saphenista semistrigata; Forbes, 1931: 355 [misidentification, pl. XLV, fig. 26, male only].

Lorita abornana Busck, 1939: 101.—Comstock, 1939: 119.—Razowski, 1967: 202.—Beardsley, 1977: 391.—Mau, 1979: 4. NEW SYNONYM.

Lorita abornana chatka Busck, 1939: 101. NEW SYNONYM.



Figs. 7–12. Male and female genitalia: 7, *L. scarificata* (Meyrick), ventral view; 8, lateral view of aedoeagus; 9, *L. baccharivora*, new species, ventral view; 10, lateral view of aedoeagus; 11, *L. scarificata*, ventral view; 12, *L. baccharivora*, ventral view (scale = 0.2 mm).

Lorita scarificata (Meyrick), Clarke 1963: 20.

Adult (Fig. 1).—A small moth with pale horn (92) (color slightly less yellow than cream (54)) ground color that reflects light, giving a shiny appearance in fresh specimens. An indistinct submedian band, a smaller postmedian spot, and darker terminal band mark the forewing. Coloration and markings are variable throughout its range.

Male: Forewing length 3.5–4.5 mm ($\bar{x}$ = 4.2 ± 0.4 mm, n = 8).

Head (Fig. 4): Labial palpus pale horn color; scales of middle segment expanded dorsad, extending to middle of apical segment. Antennal scape pale horn, with a few dusky brown scales around base, rest of antenna pale horn with a few dusky brown scales at base. Front and vertex pale horn.

Thorax: Mesonotum and tegula pale horn with scattered darker scales along anterior edge. Underside shining white; pro- and mesothoracic legs with femur pale horn having scattered dusky brown (19) scales along posterior edge, tibia with 4 bands: starting at apical end, bands 1 and 3 speckled pale horn and dusky brown, 2 and 4 pale horn color, tarsi speckled pale horn and dusky brown with pale horn apical rings; metathoracic leg pale horn lightly scattered with drab (27) scales.

Forewing (Figs. 1, 5): Length 2.6–3.0× maximum width. Ground color pale horn with iridescence in fresh specimens; indistinct submedian band clay (123B), indistinctly bordered along proximal and distal margins with a few dusky brown scales, dusky brown scales more concentrated at proxmial margin; a small indistinct clay-colored postmedian spot just above tornus; indistinct terminal band extending from costa to termen clay-colored; small dusky-brown scale patches evenly spaced along costa from base to apex. Fringe yellow ocher (123C) above and below. Underside dark drab (119B) with distinct pale horn scale patches evenly spaced along costa from base to apex.

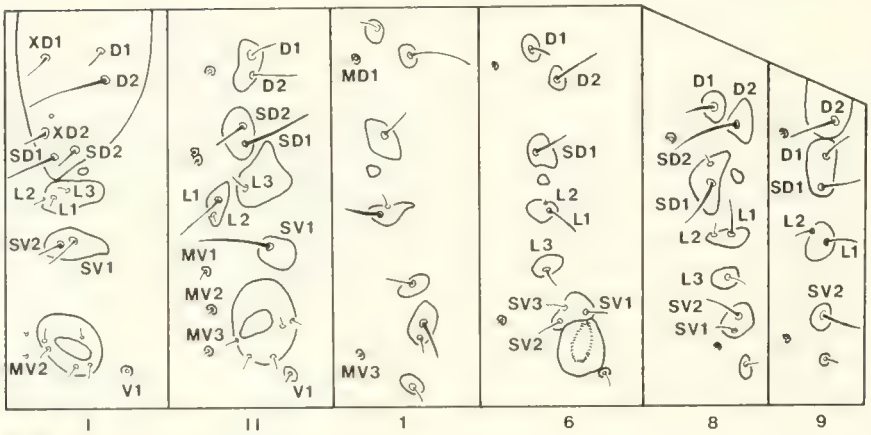
Hindwing (Figs. 1, 5): Length 2.9–3.9 mm ($\bar{x}$ = 3.6 ± 0.4 mm, n = 8); length 2.9–3.3× maximum width. Costal fold atrophied; light drab (119C). Underside white with light drab scaling along costa, termen, and vein M2. Fringe light drab with slightly darker basal band above and below.

Abdomen: Pale horn above and below.

Male genitalia (Figs. 7–8): Uncus present, thin, apex truncate. Socii attached apically to tegumen, bases fused dorsally, basal 0.5 forming thumblike lobes that lack setae, apical 0.5 bulbous and setose. Transtilla a broad, well-developed band with an elongate, stout, apically rounded median projection; median projection flanked by 2 broad, apically concave projections; these lateral projections are 0.5 length of median projection and extend to just below base of socii. Valva length 1.8–2.0× maximum width; costa forming a right angle at valval base, continuing in a concave arc to round apex; sacculus a thin well-defined band appressed to ventral edge of valva. Vinculum arms free as denoted by median suture. Aedoeagus large, base round, apex truncate, with ventrally produced spine, 1.4–1.6× length of valva, length 3.1–3.6× maximum width; cornuti consisting of numerous minute spinules on vesica.

Female: Coloration and markings as in male. Length of forewing 3.9–5.2 mm ($\bar{x}$ = 4.5 ± 0.5 mm, n = 8); length 2.7–2.9× maximum width. Length of hindwing 3.2–4.4 mm ($\bar{x}$ = 3.8 ± 0.5 mm, n = 8); length 2.9–3.2× maximum width.

Female genitalia (Fig. 11): Papillae anales setaceous, thin, slightly curved, apices broadly rounded, joined by narrow connection. Length of apophysis anterior 1.0–1.7× apophysis posterior. Sterigma rectangular, poorly developed, a median lightly sclerotized oval plate surrounding ostium. Colliculum well sclerotized, quadrate. Ductus bursae distinct, basal 0.67 sclerotized. Corpus bursae with fine convolutions, many



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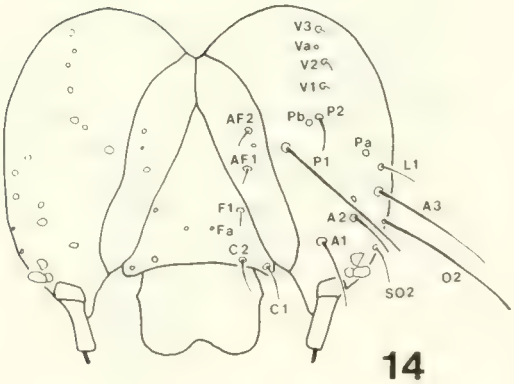

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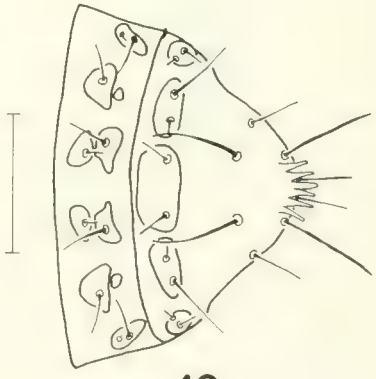

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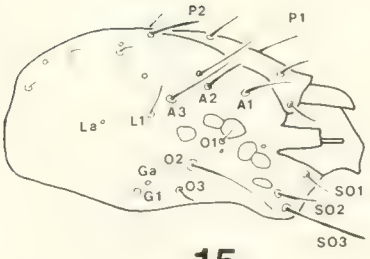

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Figs. 13–19. *L. scarificata* (Meyrick), larval chaetotaxy: 13, lateral view of prothorax, mesothorax, and abdominal segments 1, 6, 8, and 9; 14, dorsal view of head; 15, lateral view of head (scale = 0.2 mm); 16, right mandible (scale = 0.1 mm); 17, labrum, dorsal view; 18, labrum, ventral view (scale = 0.1 mm); 19, dorsal view of abdominal segments 8–10 (scale = 0.5 mm).

minute spinules. Accessory bursa originating ventrally, just below middle of ductus bursae. Ductus seminalis from proximal half of corpus bursae.

Larva (Figs. 13–19).—Length of last instar 4.8–6.4 mm ($\bar{x}$ = 5.6 ± 1.1 mm, n = 2).

Head: Hypognathous, maximum width 0.6 mm. Color burnt sienna (132) to clay (123B) in alcohol. Puncture Pb closer to P2 than P1. Puncture Pa equidistant between P2 and L1. Puncture Ga dorsal and anterior to G1. Six stemmata present with 2,3 and 4,5 contiguous. Mandible with 5 cusps, first truncate. Labrum with 6 pairs of dorsal setae, 3 pairs of ventral epipharyngeal setae.

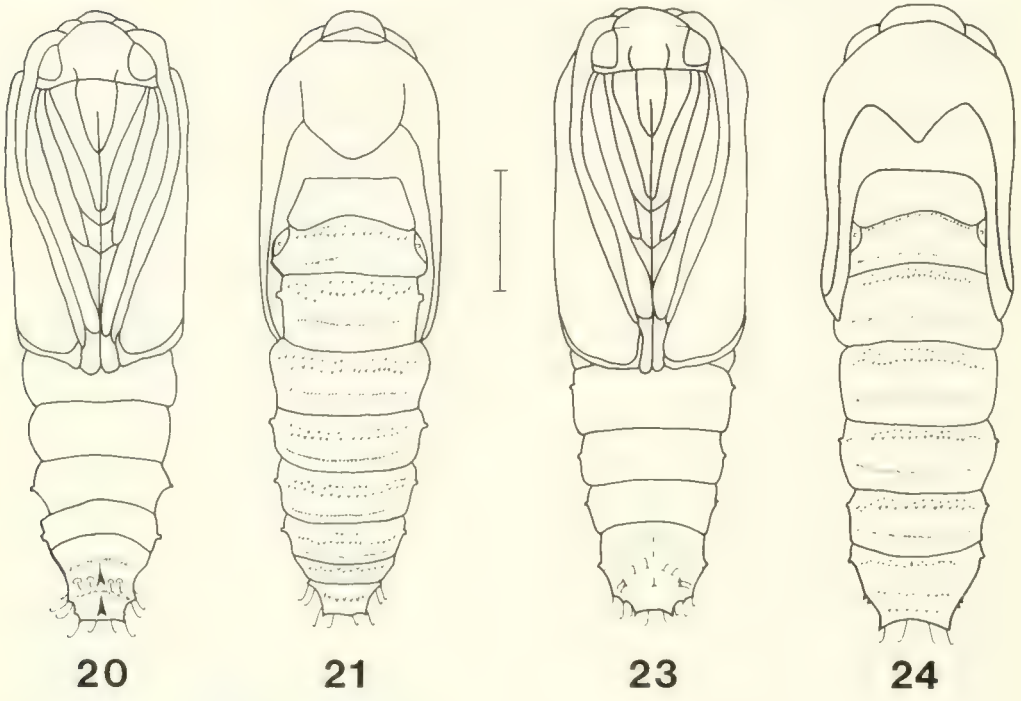
Thorax: Prothoracic shield concolorous with head. Prothorax with L group on same pinaculum; mesothorax with L3 on separate, large pinaculum. Prothorax with SV1 and SV2 on same pinaculum; mesothorax with SV2 absent. Legs 3-segmented, single tarsal claw.

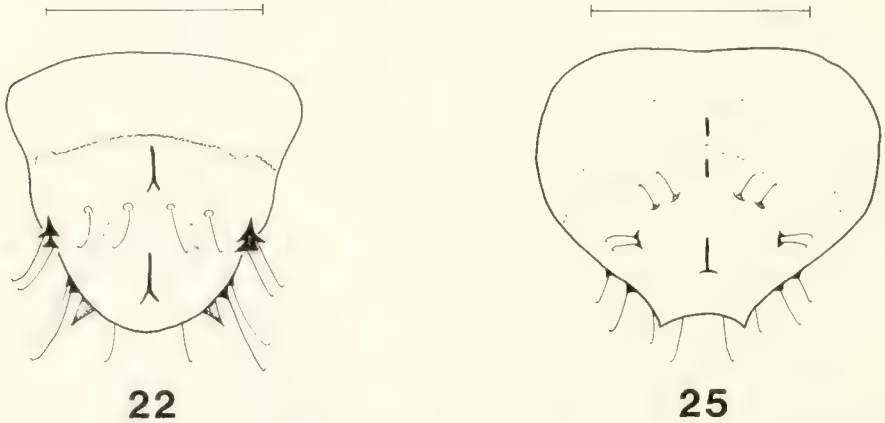
Abdomen: SD2 minute, and present only on segment 8. Ninth segment with D1 and SD1 on same pinaculum; L group consists of 2 setae, L1 and L2. SV3 present only on segment 6; SV1 and SV3 absent on segment 9. Prolegs on segments 3–6 and 10; crochets on abdominal segments 3–6 uniordinal and arranged in a complete circle; anal prolegs with crochets uniordinal and arranged in a semiellipse.

Pupa (Figs. 20–25).—Male length 5.6 mm (n = 1); female length 5.7 mm (n = 1) (in alcohol). Eyes clearly visible. Anterior group of spines on abdominal segments 2–8 in male and 2–6 in female consisting of 2 rows, the anterior row having fewer and smaller spines than second row. Segment 9 in male and segments 8–9 in female consisting of a single row of slightly larger spines. Posterior row of spines minute and on segments 2–8 in male and 2–7 in female. Spiracles peg-shaped. A single saggitate genital slit on anterior edge of segment 9, another similarly shaped slit in middle of segment 10. Female with 3 genital slits, one on anterior edge of segment 8, a second on anterior edge of segment 9, and a third on a pad in middle of segment 10. Cremaster with 4 hooks on anterior edge and a pair of lateral hooks from spines on ventral side of segment 10; 3 pairs of lateral hooks and one pair of caudal hooks on edge of segment 10.

Types.—Lectotype (*Phalonia scarificata* Meyrick), designated by Clarke (1963), ♂, "Bartica, British Guiana, Parish, .12.12.," genitalia slide No. 6284, in British Museum (Natural History). Holotype (*Lorita abornana*), ♀, U.S.A., California, Los Angeles Co., El Segundo, emerged 11 July 1938, W. D. Pierce, larva on *Cuscuta californica*, U.S. National Museum type no. 53250, genitalia slide USNM 23826, in U.S. National Museum, Smithsonian Institution, Washington, D.C.

Material examined.—BRITISH GUIANA: Bartica, Parish .1.13, 1 ♀ genitalia slide USNM 23726. "Mallali, Parish .3.13," 1 ♂, genitalia slide USNM 23725. BRITISH WEST INDIES: ANTIGUA: Flat Top Point, 13 Apr. 1958, J. F. G. Clarke (Smithsonian-Bredin Exped.), 2 ♂; English Harbor, 20 Apr. 1958, J. F. G. Clarke (Smithsonian-Bredin Exped.), 2 ♂; St. Anns Hill, 21 Apr. 1958, J. F. G. Clarke (Smithsonian-Bredin Exped.), 1 ♂. MEXICO: 30 Jan. 1942, in bell peper fruit, Nogales No. 51068, Lot No. 42-1560, 1 ♀. SINALOA: 12 Jan. 1939, in bell pepper, Nogales No. 28970, Lot No. 39-1430, 1 ♂; 20 Jan. 1939, in bell pepper, Nogales No. 28978, Lot No. 39-1464, 1 ♂; 19 Jan. 1939, in bell pepper, Nogales No. 28990, Lot No. 39-1807, 1 ♂; 24 Jan. 1939, in bell pepper, Nogales No. 28994, Lot No. 39-1873, 1 ♂; March 1939, from bell pepper, 1 ♂; San Blas, iss[ued] (=emerged) 3 March 1939, Nogales No. 29358, on bell pepper, 1 ♂. SONORA: 21 Jan. 1939, in bell pepper, Nogales No. 28971, Lot No. 39-1463, 1 ♀; 21 Jan. 1939, in bell pepper, Nogales No. 29098, Lot No. 39-2240, 1 ♂. PUERTO RICO: Coamo Springs, 4 Apr. 1930, Cornell Univ., Lot No. 795, Sub 15, 1 ♂, genitalia slide USNM 23785. UNITED





Figs. 20–25. *L. scariticata* (Meyrick), pupal structure: 20, ♂ ventral view; 21, ♂ dorsal view (scale = 1.0 mm); 22, ♂ ventral view of terminal segments (scale = 0.5 mm); 23, ♀ ventral view; 24, ♀ dorsal view (scale = 1.0 mm); 25, ♀ ventral view of terminal segments (scale = 0.5 mm).

STATES: CALIFORNIA: Los Angeles Co.: El Segundo, emdg. 11 July 1938, larva on *Cuscuta californica*, W. D. Pierce, 1 ♀, genitalia slide USNM 23826 [holotype of *Lorita abornana* Busck]; emdg. (=emerged) 13 July 1938, 1 ♂, genitalia slide USNM 23856;

emdg. 14 July 1938, 1 ♀, genitalia slide USNM 23856; emdg. 15 July 1938, 1 ♂, wing slide USNM 23856, genitalia slide USNM 23856. San Diego Co.: Del Mar, 12 Aug. 1959, R. A. Mackie Coll., 1 ♂; 19 Aug. 1959, 1 ♀; 26 Aug. 1959, 1 ♀, genitalia slide MGP 637; 2 Sep. 1959, 1 ♀; Mission Bay, 10 June 1959, 1 ♂. FLORIDA: Collier Co.: Chokoloskee, 19 ♂, genitalia slides USNM 23126, USNM 23163, 12 ♀, genitalia slide USNM 23125. Dade Co.: Homestead, 22 Oct. 1959, D. O. Wolfenbarger, 1 ♀; 29 Oct. 1959, 1 ♂, SEM slide USNM 23465; 2 Nov. 1959, 3 ♀, genitalia slide USNM 23219; 4 Nov. 1959, 1 ♀. Escambia Co.: Pensacola, 23 Sep. 1961, Shirley Hills, 1 ♀. Highlands Co.: Archbold Biol. Sta., S. W. Frost, 1 ♂. Manatee Co.: Bradenton, Gulf Coast Exp. Sta., 24 March 1955, E. G. Kelsheimer, 1 ♂. Monroe Co.: Key Largo Key, 1 Nov. 1964, Mrs. Spencer Kemp, 1 ♀, wing slide USNM 23130; 3 Jan. 1967, 1 ♀; 3 Jan. 1968, 2 ♀; 7 Jan. 1968, 2 ♂, genitalia slides USNM 23164, USNM 23850; 22 Jan. 1968, 2 ♀; 3 Nov. 1967, 1 ♀; 24 Nov. 1967, 1 ♂; 19 Dec. 1967, 1 ♀; Key Largo, 19 Oct. 1964, Mrs. Spencer Kemp, 1 ♂, 2 ♀. Sarasota Co.: Siesta Key, 3 Jan. 1960, C. P. Kimball, 1 ♂; 11 Jan. 1960, 1 ♂; 14 Jan. 1960, 1 ♂; 13 March 1953, 1 ♂; 27 March 1960, 1 ♀; 2 April 1964, 1 ♂; genitalia slide USNM 23131; 3 April 1960, 2 ♂; 13 April 1960, 1 ♂; 29 April 1960, 1 ♀; 3 May 1960, 1 ♂, 1 ♀; 4 May 1960, 2 ♂; 13 May 1960, 1 ♂, wing slide USNM 23846; 21 Nov. 1953, 1 ♀; 10 Dec. 1953, 1 ♂; 19 Dec. 1959, 1 ♀, genitalia slide USNM 23218; 24 Dec. 1953, 1 ♂, genitalia slide USNM 23162. HAWAII: Oahu: Waianae, Dec. 1974, J. W. Beardsley collector, reared on *Chrysanthemum* blossom, 2 ♂, genitalia slide USNM 24208; Ewa, Oct. 1974, J. W. Beardsley collector, light trap, 1 ♂; Honolulu, Mar. 1974, J. W. Beardsley collector, light trap, 1 ♂, genitalia slide USNM 23751. VENEZUELA: BOLIVAR: 5 km E. Tumeremo, 12 Feb. 1976, C. M. & O. S. Flint, Jr., 1 ♀, genitalia slide USNM 25452; Cd. Guayana, Rio Caroni, Parque Llovizna, 13 Feb. 1976, C. M. & O. S. Flint, Jr., 1 ♀.

Host.—Several hosts have been recorded for *L. scarificata*. This species is a pest on bell peppers with larvae boring into the stalks and capsules, which may reduce their commercial value (Busck 1939). *Capsicum* is also native to the Neotropics and West Indies and has been cultivated since pre-Inca times (Hill 1952). Comstock (1939) and Busck (1939) also report dodder as a food plant of *L. scarificata* in the sand dune area of El Segundo, Los Angeles Co., California. This species has also been reared from *Chrysanthemum* (Compositae) blossoms in Waianae, Oahu, Hawaii.

Distribution (Maps 1–2).—*Lorita scarificata* is widely distributed in the southern Nearctic and Neotropical Regions and has been introduced into Hawaii. It has been collected in California, Texas, Florida, Mexico, Puerto Rico, Antigua, Venezuela; Razowski (1967) reported it from Brazil.

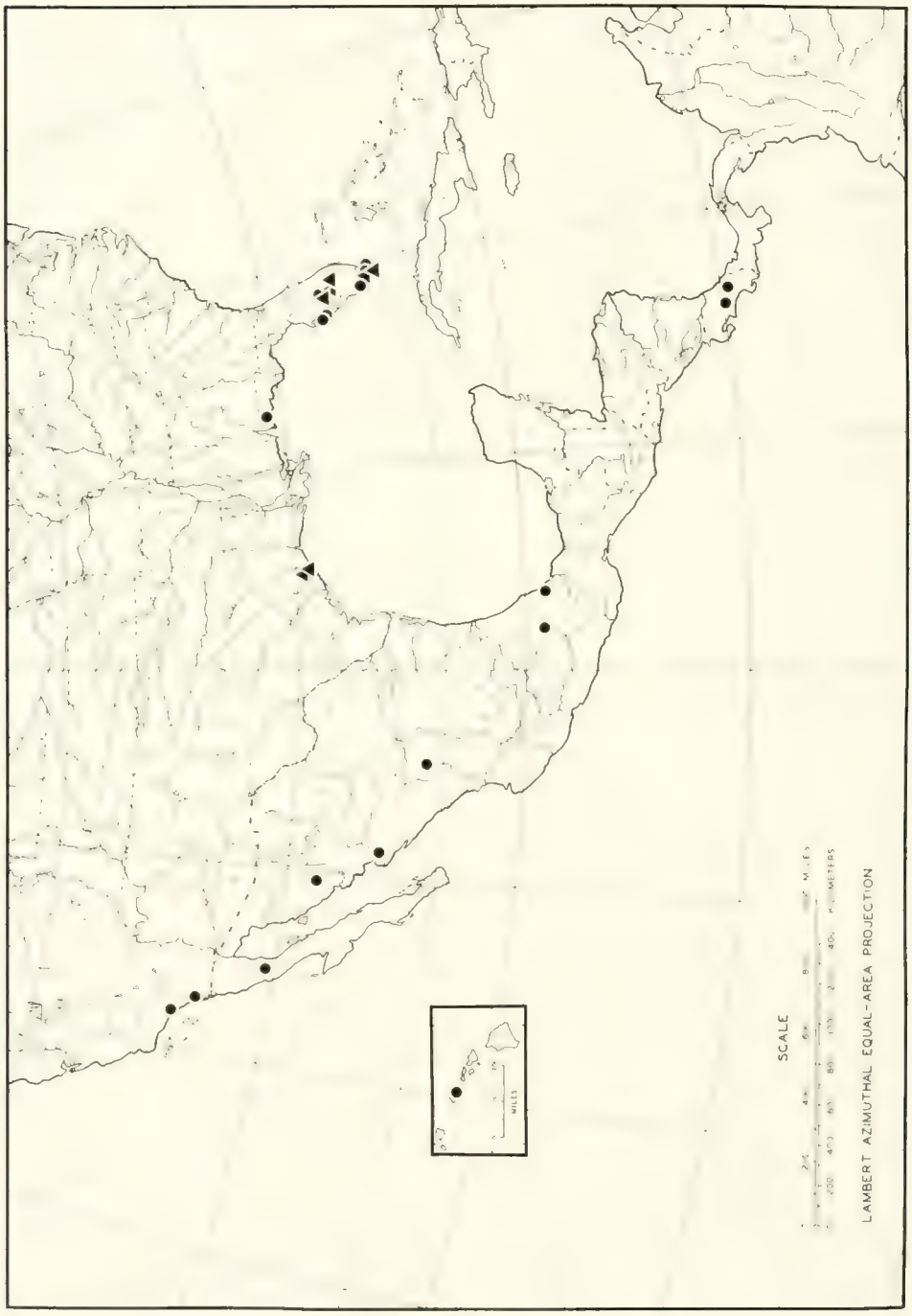
Discussion.—This species is variable in coloration. Darker forms have the forewing markings dark drab (119B) with more dusky drab scales along their margins, or the forewings are covered with dusky brown scales with barely any evidence of banding. These darker forms are found within the same series as the lighter form described above. Genitalia do not vary within the sexes.

Males of *L. scarificata* can be separated from those of *L. baccharivora* by: 1) lack of a hindwing costal fold, 2) hindwing vein Sc longer, 3) uncus thin, elongate, 4) socius fused to base of uncus, and 5) thumblike lobes lack setae and are attached laterally to tegumen. Female genitalia are differentiated by: 1) sterigma less heavily sclerotized, with a median oval plate surrounding ostium basally, 2) presence of a well-developed colliculum, and 3) ductus bursae more slender and distinct from corpus bursae.

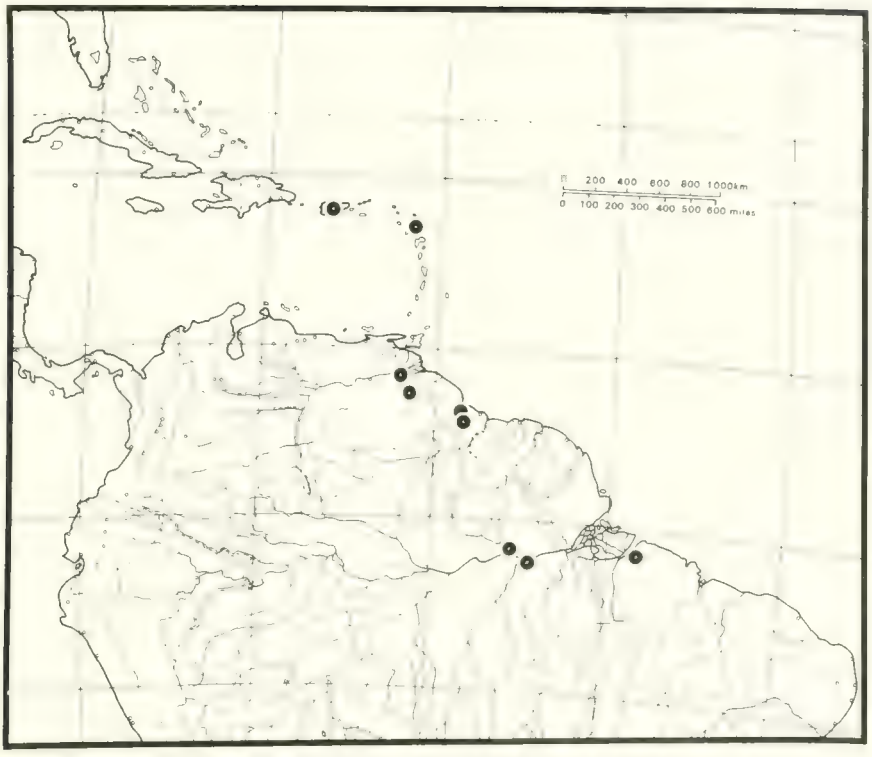
Lorita baccharivora, new species

Figs. 2, 6, 9–10, 12, 26–47

A small moth with forewing ground color pale horn (92) having a darker median costal spot and terminal band (Fig. 2).



Map 1. Distribution of *Lorita* in North and Central America (circle = *L. scarificata* (Meyrick); triangle = *L. baccharivora*, new species).



Map 2. Distribution of *L. scarificata* (Meyrick) in South America.

Male: Forewing length 3.7–4.5 mm ($\bar{x}$ = 4.0 ± 0.3 mm, n = 8).

Head: Labial palpus pale horn, speckled with dusky brown (19); scales of middle segment expanded dorsad, extending to middle of apical segment. Antennal scape pale horn, with a few dusky brown scales around base, rest of antenna pale horn with a few dusky brown scales at base. Front and vertex pale horn scattered with dusky brown scales.

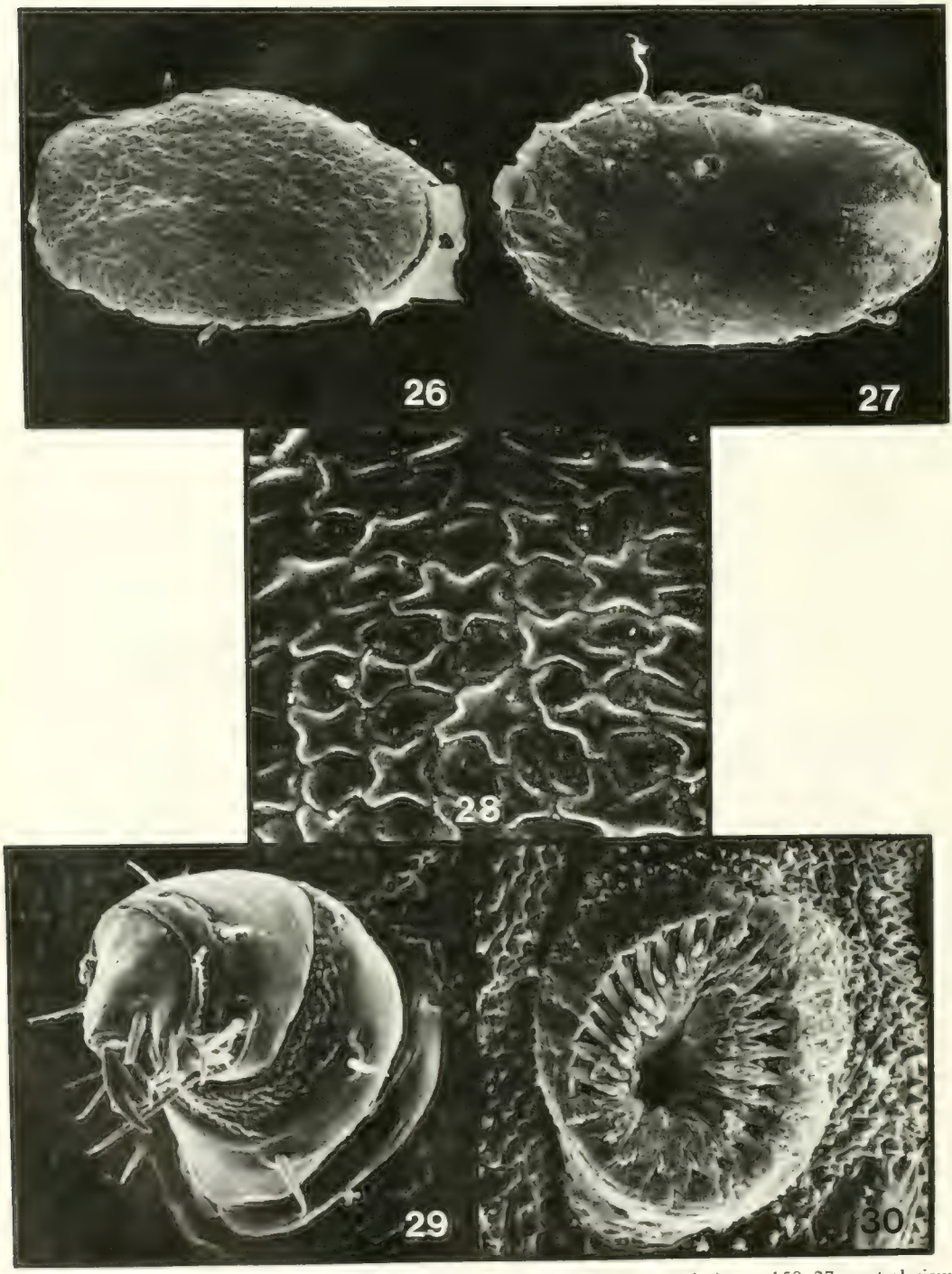
Thorax: Mesonotum and tegula varying from pale horn with indistinct anterior, median, and posterior bands of dusky brown to drab (27). Underside shining white; prothoracic coxa and femur dusky brown with scattered pale horn scales, tibia dusky brown with a median band of pale horn, tarsi dusky brown with apical ring of pale horn; mesothoracic femur pale horn with scattered dusky brown scales, tibia and tarsi as in prothoracic leg; metathoracic leg pale horn with scattered dusky brown scales, tarsal color lighter than in other legs.

Forewing (Figs. 2, 6): Length 2.5–2.9× maximum width. Ground color pale horn with median costal spot extending to anterior margin of discal cell, and dusky brown terminal band extending from costa to termen; remainder of wing heavily suffused with dusky brown scales. Fringe drab. Underside and fringe grayish horn (91).

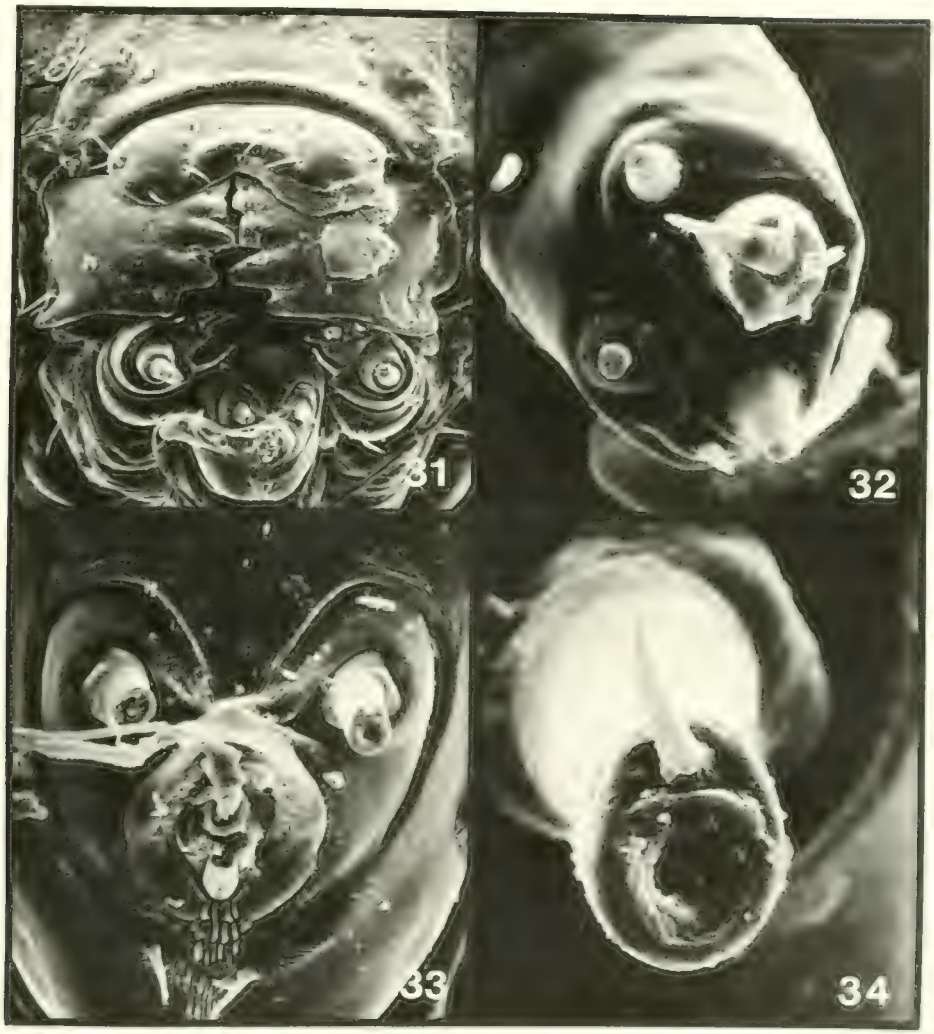
Hindwing (Figs. 2, 6): Length 3.1–4.0 mm ($\bar{x}$ = 3.1–4.0 ± 0.3 mm, n = 8); length 2.8–3.2× maximum width. Costal fold present, enclosing hair pencils; dirty white becoming smoke gray (45) toward apex. Underside dirty white with dusky brown striations in costal half. Fringe dirty white with smoke gray basal band above and below.

Abdomen: Dirty white above and below.

Male genitalia (Figs. 9–10): Uncus bifid. Socius fused from basal 0.5 of uncus to middle of tegumen. Transtilla a well developed band with a broad median projection extending to base of uncus. Valval length 1.7–2.0× maximum width; costa sinuate; elon-



Figs. 26–30. *L. baccharivora*, new species, egg and larval structure: 26, dorsal view, ×150; 27, ventral view, ×150; 28, dorsal surface detail, ×700; 29, foreleg, ×600; 30, crochets of abdominal segment 6, ×600.

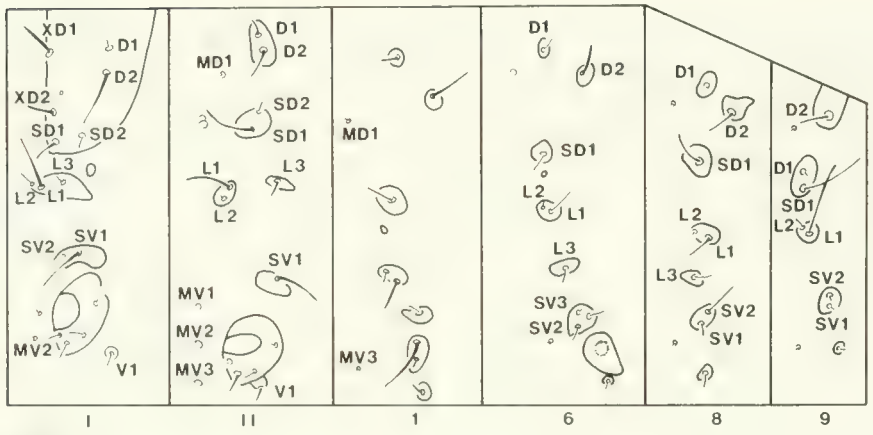


Figs. 31–34. *L. baccharivora*, new species, larval mouthpart structure: 31, ventral view, ×300; 32, tip of maxilla, ×2200; 33, labium, ventral view, ×1200; 34, tip of labial palp, ×6000.

gate spatulate scales arising from costal half of valva and extending from base to apex; apex sharply rounded; sacculus well developed, extending along entire ventral edge of valva. Vinculum arms free. Aedoeagus 1.5–1.7× length of valva, length 2.7–3.3× maximum width; cornuti numerous minute spinules on vesica.

Female: Markings of forewings similar, but cinnamon (123A) in color. Hindwing coloration as in male. Length of forewing 4.0–4.5 mm ($\bar{x}$ = 4.3 ± 0.2 mm, n = 8); length 2.6–2.9× maximum width. Length of hindwing 3.4–3.9 mm ($\bar{x}$ = 3.7 ± 0.2 mm, n = 8); length 2.7–3.2× maximum width.

Female genitalia (Fig. 12): Papillae anales setaceous, elongate. Length of apophysis anterior 1.0–1.1× apophysis posterior. Sterigma well sclerotized, quadrate, minute spinules medially, just posterior to ostium. Colliculum absent. Ductus bursae short, broad, gradually merging with corpus bursae. Corpus bursae convoluted, covered with many minute spinules at juncture of ductus bursae. Accessory bursa present, from mid-



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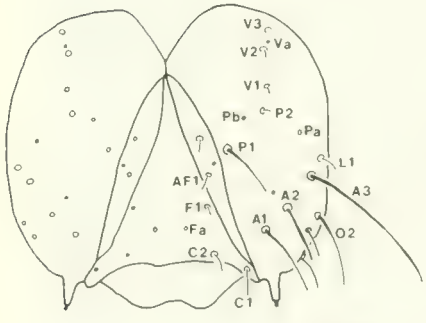

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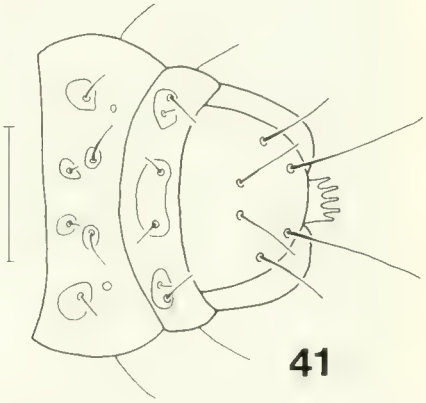

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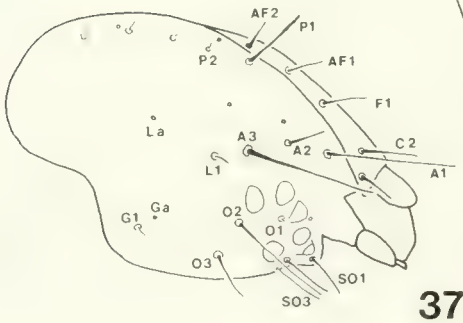

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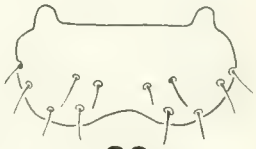

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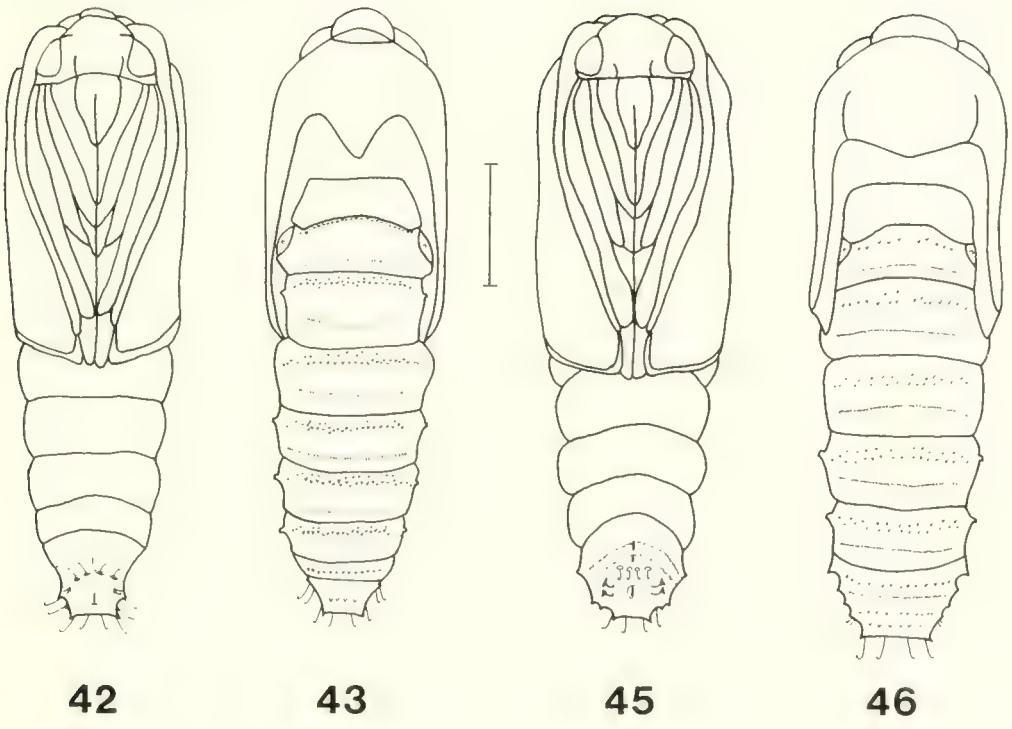
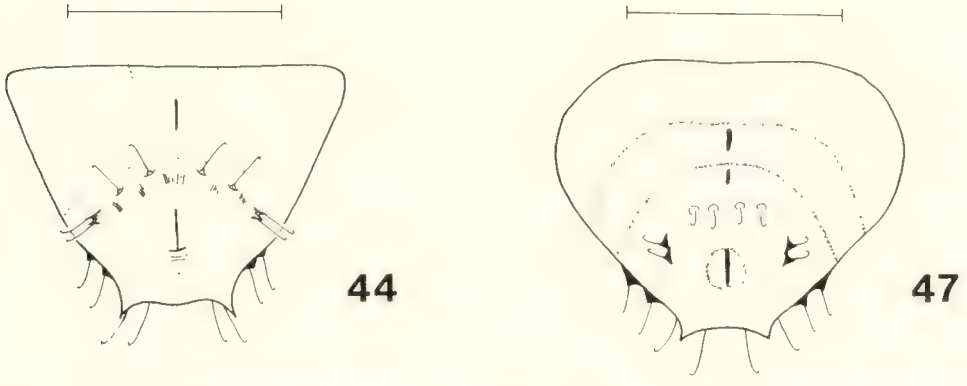
Figs. 35–41. *L. bacchartvora*, new species, larval chaetotaxy: 35, lateral view of prothorax, mesothorax, and abdominal segments 1, 6, 8, and 9; 36, dorsal view of head; 37, lateral view of head (scale = 0.1 mm); 38, right mandible (scale = 0.1 mm); 39, labrum, dorsal view; 40, labrum, ventral view (scale = 0.1 mm); 41, dorsal view of abdominal segments 8–10 (scale = 0.5 mm).





Figs. 42–47. *L. baccharivora*, new species, pupal structure: 42, ♂ ventral view; 43, ♂ dorsal view (scale = 1.0 mm); 44, ♂ ventral view of terminal segments (scale = 0.5 mm); 45, ♀ ventral view; 46, ♀ dorsal view (scale = 1.0 mm); 47, ♀ ventral view of terminal segments (scale = 0.5 mm).

dle of ductus bursae. Ductus seminalis from proximal end of corpus bursae.

Egg (Figs. 26–28).—Length 0.6 mm. Dorsal side sculptured with 4- and 5-point star shapes; ventral side smooth. Laid singly on leaves of host.

Larva (Figs. 29–41).—Maximum length of last instar 7.3 mm, n = 1.

Head: As in *L. scarificata*, except color raw umber (223); puncture Pb closer to P2 than P1, but less so than in former species; first cusp of mandible pointed.

Thorax: As in *L. scarificata*, except mesothorax with L3 on smaller pinaculum.

Abdomen: As in *L. scarificata*, except SD2 absent from segment 8; SV1 present on segment 9.

Pupa (Figs. 42–47).—As in *L. scarificata*, except anterior group of spines minute and in a single row on abdominal segment 2; anterior group of spines on abdominal segments 3–8 in male and 3–7 in females consisting of 2 rows, the anterior row having fewer and smaller spines than second row; segment 10 in male and segments 9–10 in female consisting of a single row of spines; posterior row of spines minute and on segments 2–7 in both sexes. Male with a single genital slit on a pad in middle of segment 9, another slit in middle of segment 10. Female with 3 genital slits, in middle of segment 9, a second on anterior edge of segment 10, and a third longer slit just posterior to middle of segment 10. Cremaster with 4 hooks on anterior edge and a pair of lateral hooks from spines on ventral side of segment 10; 3 pairs of lateral hooks and one pair of caudal hooks on edge of segment 10.

Holotype.—♂, genitalia slide USNM 23928, Lake Okeechobee, Okeechobee Co., Florida, 27°N, 81°W, September, 1984, leg. D. Green, laboratory reared, Brisbane, Australia, leg. W. A. Palmer. Type in the U.S. National Museum of Natural History, Smithsonian Institution, Washington, D.C.

Paratypes.—UNITED STATES: FLORIDA: 1967, W. Haseler, 1 ♂, genitalia slide MGP 923. Dade Co: Homestead, 1 April 1958, 1 ♂, 22 April 1959, 1 ♂, 8 February 1959, 1 ♀, 10 April 1959, 1 ♀, D. O. Wolfenbarger. Glades Co.: Lakeport, 26°59′N, 81°06′W, 5 October 1984, leg. D. Green, ex larva, *Baccharis halimifolia* L., 1 ♂, genitalia slide USNM 23755, 1 ♀. Highlands Co.: Lake Placid, Archb. Biol. St., 10-11-67, W. H. Haseler, ex foliage *Baccharis halimifolia*, 1 ♂, genitalia slide MGP 924, Parker Is., 26–29 May 1964, R. W. Hodges, 2 ♂. Monroe Co.: Tavernier, 25°00′N, 80°28′W, 9 May 1985, leg. W. A. Palmer, 85129-2-1, ex larva, *Baccharis halimifolia* L., 2 ♂, 2 ♀, genitalia slide USNM 23862. Okeechobee Co.: Lake Okeechobee, 27°N, 81′W, Sep. 1984, D. Green leg., laboratory reared Brisbane, Australia, W. A. Palmer leg., 9 ♂, genitalia slides USNM 23860, 23861, 23863, 4 ♀, genitalia slide USNM 23859. TEXAS: Harris Co.: Houston, 15 May 1979, 1 ♂, USNM 23930; 19 August 1966, A. & M. E. Blanchard, 2 ♂, genitalia slide USNM 23931. Clear Lake City, Armand Bayou, 20 May 1986, Coll. P. E. Boldt, reared from leaves of *Baccharis halimifolia*, 1 ♂. Deposited in USNM.

Host.—*Baccharis halimifolia* L., Compositae, sea myrtle.

Distribution (Map 1).—Known from south central to southern Florida, and eastern Texas.

Discussion.—This species is smaller and the males are darker than in *L. scarificata*. Males are easily recognized by the prominent costal fold on the hindwing, which is atrophied in *L. scarificata*. Male genitalia of *L. baccharivora* can be separated from those of *L. scarificata* by: 1) uncus bifid, 2) valva with sinuate costa, apex pointed, and elongate spatulate scales arising from costal half, 3) a more developed sacculus, and 4) a wider aedoeagus. Female genitalia can be differentiated by: 1) papillae anales more elongate, 2) sterigma more heavily sclerotized and quadrate with a median patch of minute spicules above ostium, and 3) colliculum absent.

Acknowledgments

I thank W. A. Palmer of the North American Field Station, Queensland Department of Lands, Temple, Texas for the specimens of *Lorita baccharivora* and J. K. Liebherr of Cornell University for the loan of the holotype of *Saphenista semistrigata*. For reviewing the manuscript, I thank J. F. G. Clarke and D. R. Davis, of the National Museum, Smithsonian Institution, Washington, D. C., R. W. Hodges, Systematic Entomology Laboratory, BBII, % National Museum of Natural History, Smithsonian Institution, Washington, D. C., and W. E.

Miller, Department of Entomology, University of Minnesota, St. Paul, Minnesota.

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PROC. ENTOMOL. SOC. WASH.
90(4), 1988, pp. 458–461

THE HOST SPECIFICITY AND BIOLOGY OF *ARISTOTELIA IVAE* BUSCK (GELECHIIDAE) AND *LORITA BACCHARIVORA* POGUE (TORTRICIDAE), TWO MICROLEPIDOPTERA SELECTED AS BIOLOGICAL CONTROL AGENTS FOR *BACCHARIS HALIMIFOLIA* (ASTERACEAE) IN AUSTRALIA

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Abstract.—The host specificities and biologies of two microlepidoptera, *Aristotelia ivae* Busck (Gelechiidae) and *Lorita baccharivora* Pogue (Tortricidae) were determined prior to their utilization for the biological control of the noxious weed *Baccharis halimifolia*. Both species were multivoltine foliage feeders with generation times of approximately 6 weeks. Host specificity was assessed by the ovipositional preference and ability of larvae to feed on 65 plant species. *Aristotelia ivae* oviposited all but 2 eggs on *B. halimifolia* and larvae developed only on this plant. *Lorita baccharivora* oviposited all but two eggs on *B. halimifolia* and larvae also only developed on this plant. It was concluded that both species were host specific to *Baccharis*. Permission for their introduction into Australia was obtained. Both species were released in Australia and establishment of *A. ivae* has been confirmed.

Key Words: *Aristotelia, Lorita, Baccharis*, biological control, host specificity

Following its introduction into Queensland, Australia, before 1900, the North American shrub *Baccharis halimifolia* L. (Asteraceae: Astereae: Baccharineae) became a serious weed in SE Queensland and NE New South Wales by invading pastures and land cleared for reforestation. The plant was declared noxious in 1951 and subsequently a biological control program to find and introduce suitable host specific insects from the New World was implemented. This program consisted, in essence, of intensively surveying appropriate areas, selecting stenophagous species from available knowledge, testing the host range of these species experimentally and, if their host range were limited to *Baccharis*, mass rearing and releasing the insects in Australia.

Two foliage feeding microlepidoptera *Aristotelia ivae* Busck (Gelechiidae) and *Lorita baccharivora* Pogue (Tortricidae) were found infesting *B. halimifolia* along the eastern seaboard of the United States (Palmer and Bennett 1988). Literature reviews and consultations with relevant experts indicated that they might be host specific to *Baccharis*. Furthermore their occurrence in Florida was thought advantageous as this state has a climatic similarity to Queensland.

The genus *Aristotelia* Huebner contains 39 species none of which is considered an agricultural pest (Arnett 1985). Busck (1904) described both the moth and larva of *A. ivae* from material collected at Palm Beach, Florida and reared by H. Dyar in 1900. Two

other species have been recorded from *Baccharis*. Tilden (1951) described the life history of *A. argentifera* Busck which has *B. pilularis* DC. and the closely related *Ericameria ericoides* (Lessing) as hosts. Recently we found a very similar undescribed species (R. Hodges pers. com.) on *B. pilularis* that might also be host specific to *Baccharis*.

The genus *Lorita* Busck, recently revised by Pogue (1988), contains two species, *L. baccharivora* and *L. scarificata* (Meyrick). *L. scarificata* is a widely distributed, polyphagous species that is a pest of bell peppers, *Capsicum annuum* L. (Solanaceae) (Pogue 1988).

This paper describes the host specificity studies undertaken to ascertain the host range of these insects. Before permission could be sought to introduce them into Australia, it was necessary to demonstrate that they were specific to *Baccharis* and that no native or commercial plant species in Australia would be endangered. In the course of these studies the biologies of the insects were observed and these are also reported.

Biology

The following descriptions are based on our laboratory and field observations of the various life stages.

Aristotelia ivae.—Eggs which are 25 mm in length, oval in shape and greenish-white with characteristic orange markings in color, were oviposited in leaf axils, furrows of young stems or the midribs of leaves. Eclosion occurred in 5 to 10 days and larvae moved to young growing tips to feed beneath a loose silken webbing. Five larval stadia were observed by the finding of cast head capsules. The first four stadia were of about 4 days duration. The final stadium was 9 days including a prepupal period of 3 days. Pupation occurred in leaf litter surrounding the plant and adult eclosion occurred after 10 to 14 days. The life cycle was completed in about 6 weeks.

Lorita baccharivora.—Eggs are round and slightly flattened, whitish in color and translucent. They were oviposited along the midrib on the upper surface of fully expanded leaves where they were relatively easily discernible. Eclosion occurred in 10 to 20 days. Neonate larvae were active and fed on nearby leaves. After 2 to 3 days larvae moved to growing tips where they fused young leaves together with silk to form a tube. The larva lived within this tube but left it to feed on adjacent leaves. The leaves and the growing point in the tube usually died so that further growth of the stem was arrested. Pupation occurred within the tube and the life cycle was completed in 4 to 6 weeks.

Hosts, Distribution and Phenology

Aristotelia ivae is found throughout much of the range of *B. halimifolia* and has been collected from Maryland (Kraft and Denno 1982) to Texas where it has also been found on *B. neglecta* Britton (Palmer 1987). Except for one series, all specimens have been collected from *Baccharis* sp. Busck (1904) gave *Iva frutescens* L. as the host for the type series he described but we believe that the host was misidentified (cf. Palmer and Diatloff 1987).

A. ivae is a multivoltine species. Although more abundant in spring and early summer, it was found throughout most of the year in Florida. Occasionally damage to the plant was extensive with the leaves of the plant having a characteristic skeletonised appearance. Defoliation usually proved to be only a temporary setback for the plant which invariably recovered. High rates (>50%) of parasitism were observed and a species of *Apanteles* sp. (Braconidae) was collected from larvae.

Lorita baccharivora has been collected in Florida and Texas (Pogue 1988). In Florida we collected it from Gainesville to the Florida Keys and found it almost throughout the year. While it is an abundant, widespread species in Florida it is only rarely encountered in Texas. Damage to the plant

Table 1. Plant species against which *A. ivae* and *L. baccharivora* were tested to obtain permission for their introduction into Australia.

Apiaceae: *Daucus carota* L.; *Pastinaca sativa* L.
Anacardiaceae: *Mangifera indica* L.
Asteraceae: *Baccharis halimifolia* L.; *Carthamus tinctorius* L.; *Chrysanthemum* sp.; *Dahlia* sp.; *Helianthus annuus* L.; *Lactuca sativa* L.
Brassicaceae: *Brassica oleraceae* (L.) Alef.; *Brassica rapa* L.
Bromeliaceae: *Ananas comosus* (L.) Merr.
Caricaceae: *Carica papaya* L.
Chenopodiaceae: *Beta vulgaris* L.
Convolvulaceae: *Ipomoea batatas* (L.) Lam.
Cucurbitaceae: *Cucumis melo* L.; *Cucumis sativus* L.; *Curcubita maxima* Duch.
Fabaceae: *Arachis hypogaea* L.; *Centrosema pubescens* Benth.; *Desmodium canum* (Gmel.); *Glycine wightii* (R. Grah. ex Wight & Arn.) Verdc.; *Glycine max* L. Merr.; *Medicago sativa* L.; *Phaseolus atropurpureus* DC.; *Phaseolus vulgaris* L.; *Pisum sativum* L.; *Stizolobium* sp.; *Stylosanthes gracilis*; *Trifolium repens* L.; *Vigna catjang* V.
Linaceae: *Linum usitatissimum* L.
Malvaceae: *Gossypium hirsutum* L.
Mimosaceae: *Leucaena leucocephala* (Lam.) de Wit.
Musaceae: *Musa sapientum* M.
Passifloraceae: *Passiflora edulis* Sims
Pinaceae: *Pinus radiata* D. Don.; *Pinus taeda* L.
Poaceae: *Avena sativa* L.; *Digitaria decumbens* Stent.; *Panicum maximum* Jacq.; *Paspalum dilatatum* Poir.; *Pennisetum clandestinum* Chiov.; *Saccharum officinarum* L.; *Sorghum vulgare* L.; *Triticum aestivum* L.; *Zea mays* L.
Proteaceae: *Macadamia integrifolia* Maid & Betche
Rosaceae: *Fragaria vesca* L.; *Malus sylvestris* Mill.; *Prunus domestica* L.; *Prunus persica* (L.) Batch.; *Pyrus communis* L.; *Rosa* sp.
Rutaceae: *Citrus limon* (L.) Burm. F.; *Citrus paradisi* Macfady.; *Citrus reticulata* Blanco; *Citrus sinsensis* (L.)
Sapindaceae: *Litchi chinensis* Sonn.
Solanaceae: *Capsicum annuum* L.; *Lycopersicum esculentum* Miller; *Nicotiana tabacum* L.; *Solanum tuberosum* L.
Vitaceae: *Vitis vinifera* L.
Zingiberaceae: *Zingiber officinale* Roscoe.

was significant when populations were high, especially on plants under 2 m high. High rates (>50%) of parasitism were observed and *Apanteles* sp. (Braconidae) and *Macrocentrus* sp. (Braconidae) emerged from larvae. The only known host plant for this species is *B. halimifolia*.

Host Specificity

The host specificity testing was conducted at the Archbold Experimental Station at Lake Placid, Florida in 1968. The same experimental design was used for both species although testing was not done concurrently. The ovipositional preference of the moths and the food preference of larvae were tested against a list of plants suggested by the Commonwealth Department of Health (Table 1).

Ovipositional preference was determined by placing cuttings of young actively growing foliage from all of the test plants (Table 1) in a 40 × 36 × 30 cm glass-sided cage. The cuttings were held in glass vials with water. Twenty unsexed moths were placed in the cage with a honey-water mixture. When the *B. halimifolia* was obviously infested, all the cuttings were carefully observed and all eggs counted. Any infested cuttings were kept for further observations on the hatching and survival of larvae. The experiments were replicated twice.

Food preference was determined by placing five field collected, partly grown larvae on each of the 65 test plants, held in plastic pots. The plants were carefully observed daily for 10 days and any larvae noted. These experiments were also replicated twice.

Aristotelia ivae.—Heavy oviposition occurred on *B. halimifolia* within 3–5 days and the resulting larvae developed rapidly. Two eggs were found on one cutting of *Leucaena leucocephala* (Lam.) de Wit. but eggs were not found on any other plant. These two eggs hatched but the neonate larvae did not feed and had disappeared by the next day. When the field collected larvae were placed on test plants they left all but the *B. halimifolia* plants within 2 days. Some wandered away and died while others moved to the *B. halimifolia* plants and commenced feeding. No feeding was attempted on any plant other than *B. halimifolia*.

Lorita baccharivora.—Heavy oviposition occurred on *B. halimifolia* cuttings within 3 to 7 days. Resulting larvae fed on the expanded leaves for 2–3 days before moving to the growing tips to form silken tubes.

Two eggs were also found on one cutting of *Prunus persica* (L.) Batch but eggs were not found on any other plant. These two eggs hatched but the resulting larvae did not attempt to feed. When field collected larvae were placed on test plants they left all plants other than *B. halimifolia* within 3 days. Some wandered away and were lost but most moved onto the *B. halimifolia* plants where they occupied almost every available terminal. Neither feeding nor fusing of leaves to form a tube was attempted on any plant other than *B. halimifolia*.

In both cases, the tests indicated that the insects were sufficiently specific to release in Australia. Both insects exhibited a strong host finding mechanism in that virtually all their eggs were laid on the *Baccharis* cuttings. This evidence is particularly significant as, under cage conditions, many species of moths oviposit on plants and objects that would not be utilised under natural conditions. The subsequent feeding tests confirmed the narrow host range indicated by the oviposition tests. Larvae could survive on only *B. halimifolia* of the 65 plant species tested.

Release in Australia

Permission was obtained to import the insects into Australia. On arrival, both species were required to be bred through one generation in quarantine facilities to ensure that all parasites were eliminated. They were then mass reared in non-quarantine facilities to produce sufficient numbers for field release.

Aristotelia ivae was introduced in southeastern Queensland in 1969 when approximately 25,000 moths were released at five locations. It readily established in this area; at one site it spread out over 40 sq. k within 2 years of release. By 1974 it was found throughout the range of *B. halimifolia* in Australia. Although there have been localized areas where high populations have caused significant damage on smaller plants, generally it has not occurred in sufficient densities to control the weed.

Lorita baccharivora was imported into Australia in 1969 but was not then successfully reared. Following further importations in 1984, it was successfully mass reared at the Alan Fletcher Research Station and released at various locations in southeastern Queensland in 1986. Moths have not yet been recovered from the field so establishment has not been confirmed. Further releases were made until the end of 1987.

Acknowledgments

We thank R. W. Hodges of the Systematic Entomology Laboratory, Agricultural Research Service, USDA who identified *A. ivae* and M. G. Pogue of the Department of Entomology, National Museum of Natural Histoyr, Smithsonian Institution who reviewed the genus *Lorita* and described *L. baccharivora*.

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PROC. ENTOMOL. SOC. WASH.
90(4), 1988, pp. 462–470

NESTING, MATING AND FORAGING HABITS OF *MELISSODES* (*MELISSODES*) *TEPIDA TEPIDA* CRESSON IN IDAHO (HYMENOPTERA: ANTHOPHORIDAE)

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Abstract.—Field studies are reported on nest construction, mating, and female foraging behavior of *Melissodes tepida tepida* Cresson, at two nesting sites in southwestern Idaho. Females form loose nesting aggregations but construct and provision individual burrows in the ground. Adult males exhibit protandry and their flight activity approaches territorial behavior patterns. *Melissodes tepida tepida* is a polylectic subspecies visiting a number of different host plants for pollen as well as nectar.

Key Words: flower bee, native bee biology, protandry, groundnesting.

Studies of wild bee species, especially those which evidence potential for population enhancement and management, form an integral part of a continuing research program for pollination of seed crops in Idaho. *Melissodes tepida tepida* Cresson, an aggregate nester, frequently found in seed growing areas of southwestern Idaho, exhibits characteristics which initially suggest potential for management as a pollinator in forage and hybrid vegetable seed production. This paper records the first portion of our detailed studies on the biology of this subspecies.

The species is found nesting gregariously in well-defined "bee beds." Like most others of more than 90 species of *Melissodes, M. t. tepida* biology has been unknown. LaBerge (1956a, b) reclassified the *M. tepida* complex into three subspecies, *M. t. tepida* Cresson, *M. t. timberlakei* (Cockerell) and *M. t. yumensis* LaBerge, and mapped the geographic ranges of each. Recent papers recording details on nesting habits of other *Melissodes* species, and serving as background information for our studies, include Hurd and Linsley (1959), Evans and Linsley (1960), LaBerge (1961,1963), Butler et al. (1962), Thorp and Chemsak (1964), Clement (1973), Batra and Schuster (1977), Buchmann and Jones (1980), Parker et al. (1981), Tepedino and Parker (1982), and Bouseman (1987). Refer to Thorp and Chemsak (1964), Clement (1973), and Buchmann and Jones (1980) for list of earlier recorded publications on *Melissodes* spp. biology.

Linsley (1946) has presented the only previously recorded information on the biology of the species.

Ours and other collecting records indicate *M. t. tepida* is a polylectic group with preference for visiting flowers of the families Euphorbiaceae, Lamiaceae, Fabaceae, and the composite genus *Gutierrezia*.

Nesting Sites

Two nesting sites near Parma, Canyon County, Idaho, were selected for field studies and as a source of laboratory material. Site 1 was a 2 m × 30 m strip along the southern edge of a farm road. *Distichilis stricta* (Torr.) Rydg., a salt grass, provided

the only vegetative cover overlaying the entire site in varying density. The soil is a Moulton sandy loam saline with the top 5–6 cm a mixture of litter and sandy loam, and with moist sandy loam densely packed beneath. *D. stricta* roots and rhizomes are found matted to a depth of over 20 cm throughout the site. Site 2, nearly 4 km from site 1, was approximately 90 m square with an evenly, densely distributed cover of *D. stricta*. The site was otherwise markedly similar to site 1 in soil characteristics.

Methods and Materials

Twelve equal-sized plots delimited by plastic stakes were established at each site. Wind velocity was recorded continuously during field observation periods using anemometers set at elevations of 30 cm, 1 m and 2 m. Humidity and temperature data were also recorded. At site 1, soil temperatures were monitored at depths of 5, 10, 15, 20, 25 and 30 cm beneath the surface using copper-constant thermocouples recording directly through a Leeds and Northrup potentiometer.

Early field observations centered upon determining emergence periods of *M. t. tepida* and associated insects. Metal screen mesh emergence cages (1.5 × 2 × 1 m) distributed randomly on the sites were used to trap the emerging insects. Daily checks were made, data recorded, and trapped specimens were then released.

To facilitate tracking individual bee activity, specimens were captured with nets, dusted with a powdered, daylight, fluorescent dust (trade name Day-Glo) and released. Three distinctive colors were used: neon-red, fire-orange, and arc-yellow. After release, individual bees were easily observed and the color identified at distances up to 10 m. This pigmented powder was also used to follow construction of burrows. Selected burrows were tagged by placing numbered plastic stakes near each entrance. Each numbered burrow was then dusted with Day-Glo. The burrows were marked from three to six times at intervals during the day using an aspirator bulb and directing the powder into the burrow through a tapered glass nozzle. Movements of earth in the burrow and accompanying brushing action by females distributed the powder throughout the burrow. Their excavating and burrow sealing activities incorporated the dust into the plugging material of the laterals and the cells walls. In addition, females returning from foraging were dusted before entering a marked burrow. Using this burrow-marking technique, 51 nests were dusted and studied over the two-year study period.

Each fall all marked burrows were excavated using a standarized technique which exposed the details of burrow construction. The technique consisted of digging a trench, with a 45 cm deep vertical face 30 cm from the burrow entrance. Using a small knife, brush, and air tubing, each burrow was exposed step-by-step from the entrance to the distal cells. A model of each burrow was then constructed. Exposure of the burrow construction was always complicated by the maze of *D. stricta* roots.

All cells removed from excavated burrows were placed in plastic cups, numbered, stored in a styrofoam cooler, and taken to the laboratory for detailed examination. Over two hundred cells were removed and used in the laboratory studies to supplement observations and experiments conducted at the nesting sites. These studies concentrated primarily upon anatomical evaluations of the life stages, determination of developmental stadia reared under controlled temperatures, and observations on larval feeding. Results of the laboratory studies are being presented in a subsequent paper.

Female activity at the nesting site was charted continuously, including timing the periods of foraging and nest construction. Cylindrical screen cages (30 cm diameter) were placed over individual burrows. As a marked female emerged from the burrow or approached the burrow subsequent to foraging, the cage was removed, allowing ac-

tivity of that individual to continue. Each phase of insect activity was recorded. Stop watches were used to time the activity intervals.

Pollen was removed from a sample of cells and from pollen loads on females at irregular intervals as the bees returned from foraging. Pollen slides were prepared for microscopic examination to determine the pollen sources employing the MacCallum-Goodpasture method which uses a gentian dye for staining and consequently highlighting individual pollen grains.

Biology

Adult emergence.—Following ecdysis from the pupal case, teneral adults commonly remained in the cells for several days before burrowing to the surface. During emergence the bees chewed through the cocoon and fecal cap, and burrowed vertically through the soil leaving the old cell filled with the shredded cocoon, fecal material, and soil. Emerging bees remained in the mouth of the exit burrow approximately 24 hours before beginning flight activity. *M. t. tepida* exhibited protandry with males emerging and establishing territorial flight patterns over the nesting site approximately seven days prior to emergence of the first female bees. However, some overlap in the range of emergence times for male and female bees did occur.

At the first nesting site, emergence began at the west end of the site and extended to the east end over approximately a two-week period. Increase in plant cover on the site west to east influenced soil temperature and undoubtedly accounted for differences in emergence times. Soil temperature records taken at varying soil depths in the site supported this conclusion.

Male bees began actively establishing flight patterns over the nesting sites in early July. Excavation of nest samples at the time of first male emergence exposed both developing pupae and female adults ready to emerge.

The normal life span of adult male bees generally varied from 12 to 15 days (average 14 days). Two weeks after initial emergence, a decline could be noted in the number of male bees present at the sites, and by the end of July few males were observed. The normal life span of the female ranged from 18 to 23 days with an average of 20 days. With the range in the emergence times, nesting activity continued through early August.

Male flight activity.—The flight activity of male *M. t. tepida* following emergence exhibited a basic territorial behavior pattern. The individual bee defended an area 14 cm to 30 cm in diameter from intrusion by other male bees. A male would chase an intruding bee for a distance of up to 3 m from the defended area, and then return.

Male bees, captured and removed from their territory and released elsewhere on the site, would return to their original area of activity usually within 30 minutes.

Mating.—Male aggressiveness was displayed in its mating behavior. As virgin females emerged from their burrows, they were literally pounced upon by the males either before they took flight or as they began to fly. Virgin females which attained flight were knocked back down to the ground. In many cases a newly emerged female accepted the male's attempt to copulate without rejection. All mating took place on the ground. The male mounted the female dorsally with his prothoracic legs grasping the female around the mesothorax and his mesothoracic and metathoracic legs hooked around the female's abdomen. During copulation the male displayed two different pulsating actions of his abdomen. Commonly, first pulsations were very rapid and short, lasting from five to ten seconds in duration. Following this, pulsations became slower and stronger, lasting approximately ten seconds. During these copulatory activities the antennae of the male came in contact with the female's antennae, but no definite stroking patterns were noted. The total period in copula ranged from 40 to 65

seconds with an average of 45 seconds. Following copulation the female departed and began nesting activity.

Mated females remained attractive to all males for a few days following copulation. This suggests a probable sex attractant secreted by the female. During this period of continued attraction, as females approached their burrows carrying pollen, males would dart from an established flight pattern, knock females to the ground and attempt copulation. These copulatory attempts were repulsed by the females who freed themselves within seconds and resumed nesting activity. Mated females became less attractive to males with time and, after approximately one week following copulation, they were ignored by male bees as they flew about the nesting site.

On two occasions during our extensive nesting site observations, males were seen attempting copulation with other males. In each case contact between the two males was terminated within a few seconds.

Sleeping behavior.—Males slept at the nesting site, finding shelter under debris or at the entrance of a female nesting burrow. In a burrow, males slept with their heads positioned outward. Females always slept in the burrow. Excavation of burrows after 10:30 pm exposed inactive females in the lower distal portion of the burrow.

Daily activity.—Although both soil temperatures and air temperatures were recorded at nesting site 1, it was difficult to determine specific temperature thresholds for *M. t. tepida* activity. Generally, air temperatures reached 21°C before full bee flight activity was observed. At air temperatures above 36°C activity was greatly reduced, although a few individuals remained active at temperatures of 38°C. Bee flight activity was much reduced when wind velocities exceeded 24 km per hour. Normally male bee activity began between 9:00 am and 9:30 am and continued throughout most of the day. It gradually decreased following 1:00 pm and ceased by 5:30 pm. Female bee foraging activity began between 10:00 am and 10:30 am. Generally, foraging activity reached a maximum by 11:00 am, decreased sharply between 1:00 pm and 2:00 pm, and continued to decline during the afternoon as females spent more time in the burrows. Foraging activity virtually ceased by 6:30 pm. During the course of these studies two non-foraging females were observed returning to the nesting site after 6:30 pm.

Nest construction.—Female *M. t. tepida* constructed and provisioned individual burrows. Generally, a female constructed only one burrow during the season, but some females were observed excavating a second or even a third burrow in the event of destruction or obstruction of the burrow entrance.

This subspecies showed a tendency to construct entrances at the edge of rocks or other ground debris, although some bees burrowed in open areas covered only by the salt grass vegetation. In areas supporting large numbers of females, entrances were frequently 2.5 cm to 12 cm apart, while in less active areas distances between holes frequently varied from 0.3 m to 2 m. When numerous rocks were placed on the ground in a central area of bee activity, small aggregations of female bees, sometimes as many as seven, began constructing burrows at the edge of the rocks.

While initiation of nest construction at the sites was noted at many differing hours throughout the day, the majority of females began nest construction during the morning hours subsequent to 10:30 am.

Once a female had chosen an area for nest construction, she landed and began scratching vigorously with the prothoracic legs, kicking the soil behind the abdomen with these and the mesothoracic legs. She quickly penetrated the soil surface and removed the dirt from the main shaft as she backed out of the burrow. Tumulus formed by the removal of the soil from the main shaft was dissipated in a few days with weathering and bee activity about the entrance. Below the

Fig. 1. Section of a soil profile from site 1 exposing the main shaft and lateral of a *M. t. tepida* nest. Note cell beneath lateral and partial outline of a second lateral and cell extending from first lateral.

first 5 cm of soil the ground became increasingly more compacted. Here the female was seen to use a twisting action of the head, loosening the soil particles with her mandibles. Following completion of the first cell, the female began excavation of a second lateral, at an angle out from the main shaft. Dirt excavated from this lateral was repacked into the first lateral completely plugging it to the main shaft.

Nest description (Fig. 1; Fig. 2A, B; Fig. 3A–C).—The open circular entrance (diameter 7 mm) had no turret. The burrow was formed at angles approaching 90° to soil surface with the main shaft (diameter 6 mm) extending to a depth of 7 to 13 cm. Laterals branched out from the main shaft at different levels at angles of 15° to 90° from the main burrow. The distal end of each lateral was curved and widened to 7 mm and ended in a single, vertical cell. Depths of cells ranged between 10 and 20 cm beneath the soil surface at both nesting sites. The main shaft and the laterals were smooth-walled but lacked a lining as found in the cell. In constructing a cell, the female first "roughed out" the cell to a diameter of 1.4 cm, then repacked the soil leaving a hard, smooth crust lining the cell wall. The finished cylindrical cell (diameter 7 mm, length 15 mm) had a rounded base and tapered near the top to about 6 mm in diameter. The specially constructed cell was found to be highly resistant to water penetration.

Provisioning.—The female transported unmoistened pollen on the scopal hairs of the metathoracic legs. She approached her nest, landed near the opening, and entered the burrow immediately. In the burrow a female must reverse position either at the widened distal end of the lateral or within the nest cell in order to deposit the pollen load at the base of the cell. The female removed the pollen load by rubbing the meta-

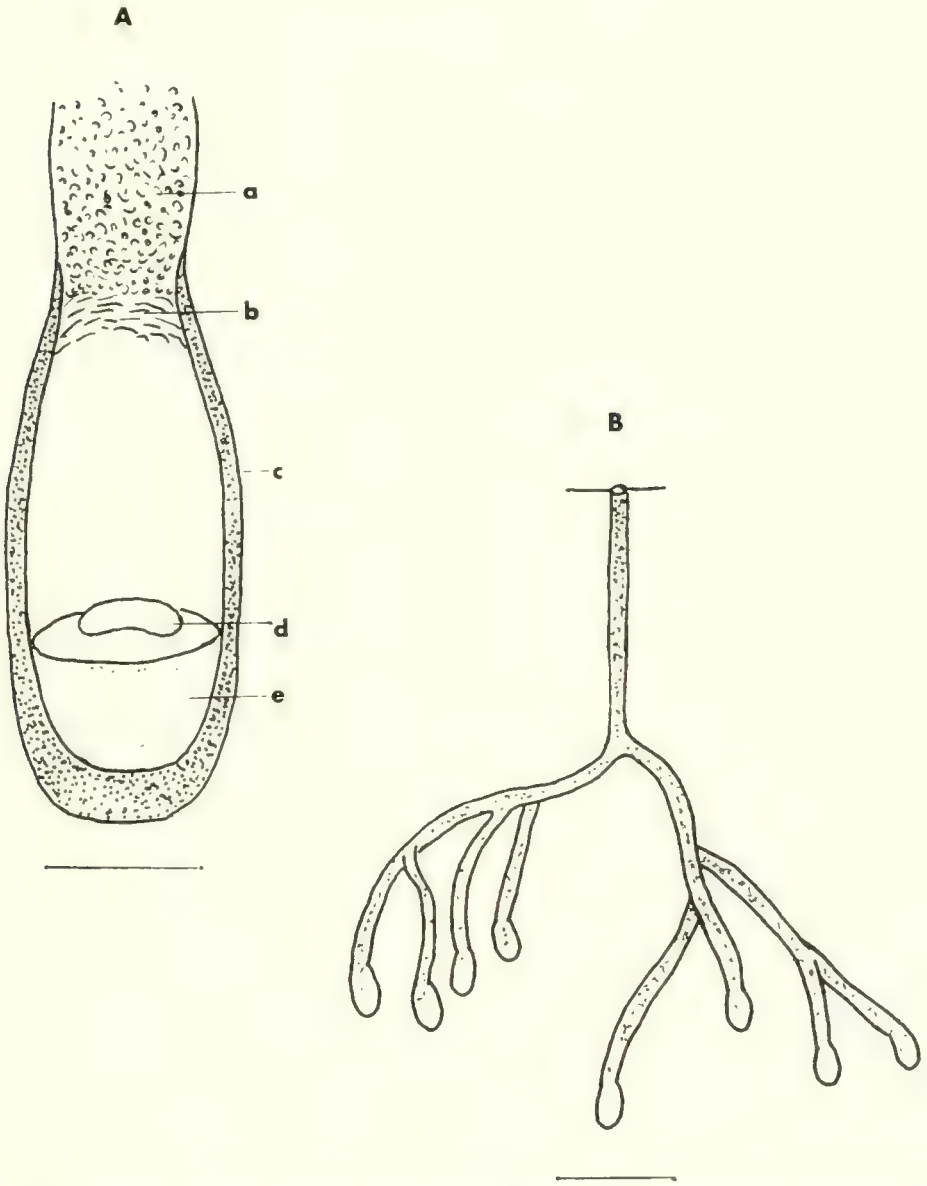

Fig. 2. A. Drawing of enlarged nest cell of *M. t. tepida* to illustrate (a) plugged lateral, (b) spiraled cell cap, (c) repacked and mixed cell wall, (d) egg, (e) pollen mass. Bar equals 0.5 cm. B. Illustration of generalized nest of *M. t. tepida*. Bar equals 4 cm.

thoracic legs against the abdomen and utilizing the lever action of the tibial spurs of the opposing leg. Later, after the female had completed stocking that cell, she mixed the pollen mass with nectar and packed this larval food into a semi-solid mixture, leaving the upper surface slightly concave. These pollen masses occupied about 30% of cell volume in the lower portions of cells examined and averaged 4.5 grams in weight. During embryogenesis the pollen-nectar mixture fermented, forming a semi-liquid mass which increased in volume.

Pollen samples extracted from cells or re-

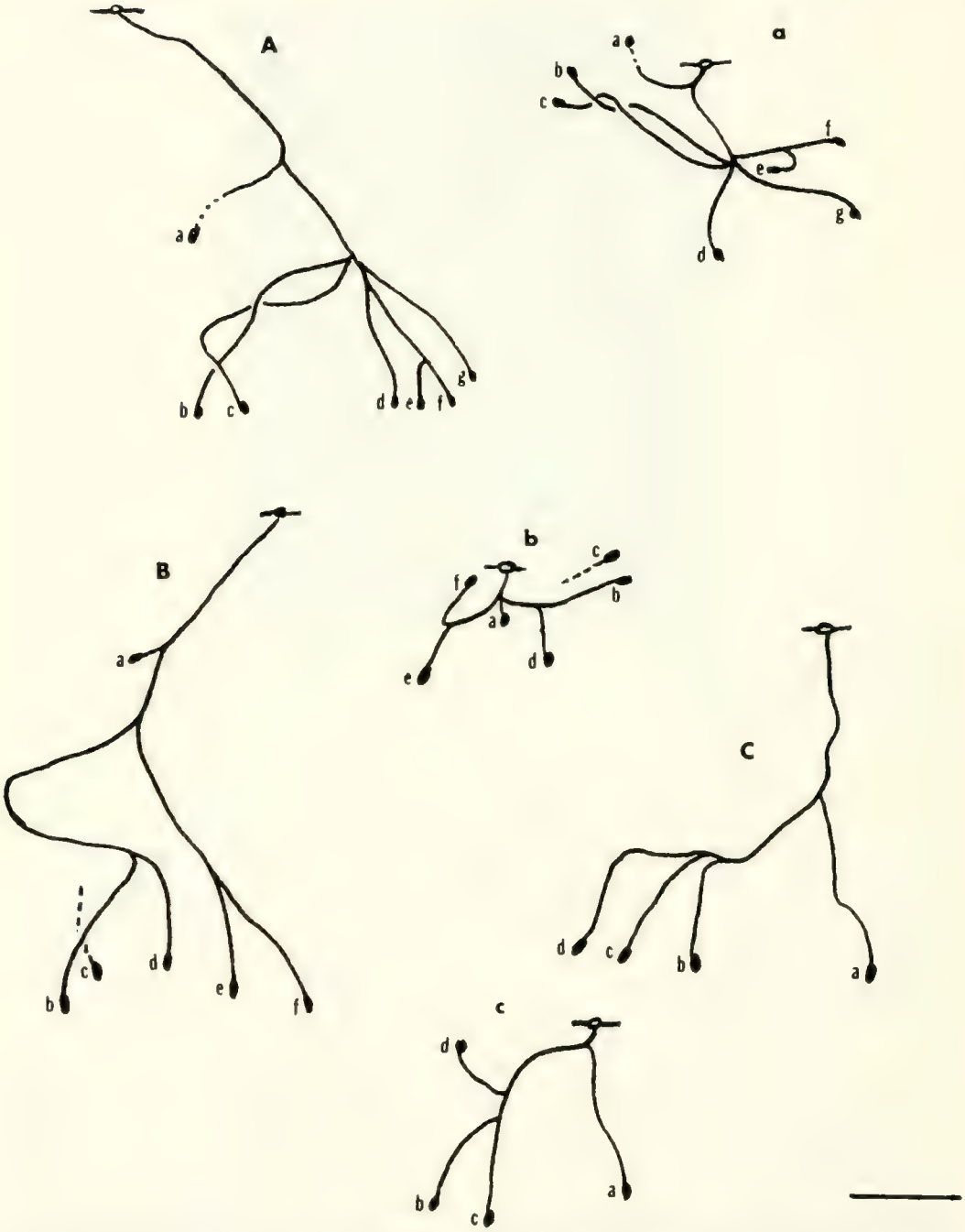

Fig. 3. Schematic sketches of three nests of *M. t. tepida* reconstructed after excavations during this study. A.B.C. Lateral aspects of three nests. a.b.c. Dorsal aspects of same nests. Bar equals 4 cm; —o— represents burrow entrances.

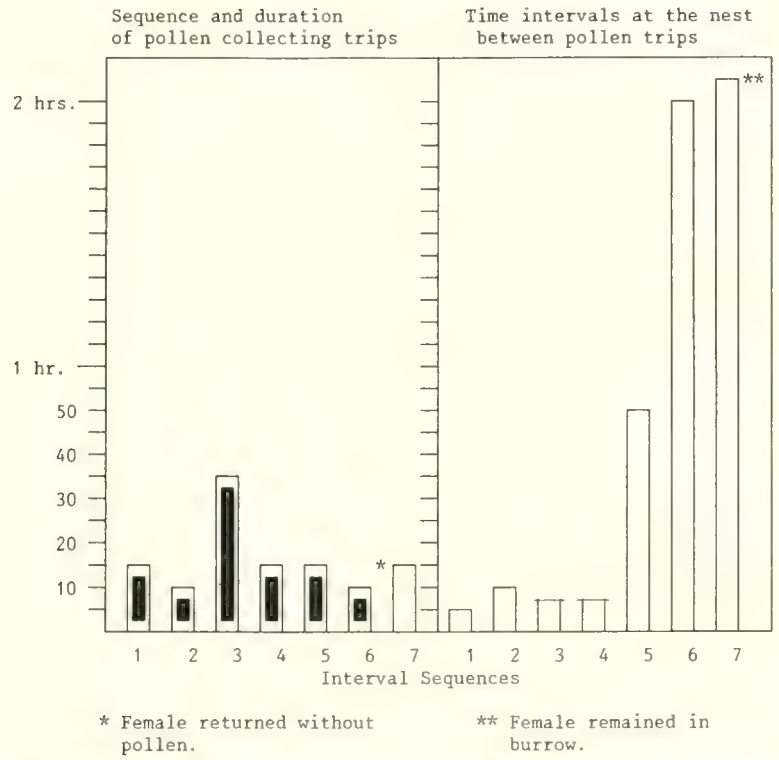

Fig. 4. Histogram illustrating a typical time sequence of foraging and at nest activities by an individual female *M. t. tepida* in stocking a single cell.

moved from foraging females were collected from several species of Fabaceae (*Medicago sativa* L., *Melilotus officinalis* (L.) Pall., *Trifolium* sp.), an Asteraceae species *Gutierrezia sarothrea* (Pursh) Britt. & Rusby., and a Chenopodiaceae *Atriplex* sp., verifying that female *M. t. tepida* are indeed polylectic.

Our records established that 5–6 foraging trips by a female were required to provision a nest cell. The time spent collecting pollen in the field varied from 13 minutes to 35 minutes per trip with an average time of 15 minutes. The average period of time required for depositing a pollen load was approximately six minutes. As the female neared completion of cell provisioning, she often remained in the burrow for longer periods of time, mixing and packing the pollen-nectar mass or resting. A graphical presentation typical of the time sequence of foraging and pollen deposition for a single cell by an individual female bee is illustrated in Fig. 4. The authors did not observe any variation in female foraging times as correlated to plant species visited.

Summary and Discussion

The extent of variability in the behavior patterns among *Melissodes* species is noteworthy. Nesting of *M. t. tepida* appears restricted to alkali soils. This differs from reports for other species in the genus, but agrees with other species in that all nest in soils with a sandy surface and moist compacted soil below. Others have found species generally nesting in bare soil areas while *M. t. tepida* was found on sites reasonably well-covered by *Distichilis stricta*, an alkaline soil indicator plant. Nesting is aggregated displaying a tendency for concentration of burrows under ground debris or along edges of rocks or soil clods. Females were not seen

to share burrows or burrow entrances and did not plug those entrances until the completion of the foraging period. Unlike some species reported to construct single cell burrows, *M. t. tepida* develops multicelled nests and coats each cell with a waterproof lining which, we suspect, from Batra and Hefetz studies (1979), is of acetate material from Dufour's gland. They stock these cells about one-third full with pollen mixed with some nectar and compacted into a cylinder with a concave surface.

Males begin to emerge from southwestern Idaho nesting sites in early July and establish flight patterns of a territorial-like nature a week prior to female emergence. Females begin emerging in mid-July and nesting activity extends to about mid-August.

Our studies of the pollen sources showed *M. t. tepida* to be polylectic, visiting a variety of host plants for pollen including *Atriplex* sp., *Gutierrezia sarothrea, Medicago sativa, Melilotus officinalis*, and *Trifolium* spp. Studies of pollen samples revealed a preference for *Atriplex* sp. Because of the relatively small populations in this area and the fact that the legumes comprise only 5% to 10% of the pollen collected for cell provisioning, the economic value of *M. t. tepida* as an important pollinator remains questionable. Nevertheless the fact these insects form nesting aggregations in a specific nesting medium and are relatively polylectic offers potential for manipulation in hybrid seed production, especially under large cage management conditions. Further study and experimentation with this potential is desirable.

Acknowledgments

The authors express their appreciation to G. E. Bohart, Logan, Utah for his species determinations, and to him, M. A. Brusven and G. W. Bishop, University of Idaho, for their advice on the study. We are also indebted to A. L. Steinhauer and F. G. Wood, University of Maryland, and to J. B. Johnson and M. Rice, University of Idaho, for their valuable assistance with this manuscript. Contribution No. 88721 from the University of Idaho, Agricultural Experiment Station.

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PROC. ENTOMOL. SOC. WASH.
90(4), 1988, pp. 471–473

TAXONOMIC NOTES ON RHYSSALINI AND RHYSIPOLINI (HYMENOPTERA: BRACONIDAE) WITH FIRST NEARCTIC RECORDS OF THREE GENERA

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Abstract.—The braconid genera *Dolopsidea* Hincks, *Neurocrassus* Šnoflák and *Rhyssalus* Haliday are reported from the New World Nearctic Region for the first time. Notes are provided to facilitate identification of these genera with reference to the key to Nearctic braconid genera of Marsh et al. (1987), and with respect to other genera in their respective tribes. Figures are provided but formal species descriptions await revisions of the respective genera.

Key Words: distribution, *Dolopsidea, Neurocrassus, Rhyssalus*

In recent sorting of undetermined rogadine and hormiine Braconidae from my own collection, I have come across several closely related genera that have not previously been reported from North America, and were not included in the recent manual of Nearctic braconid genera (Marsh et al. 1987). A reclassification of the subfamilies containing these genera is now in preparation by the author; the discovery of these genera in the North American fauna is being published now to facilitate the discovery of additional material of these groups, and to update the generic keys.

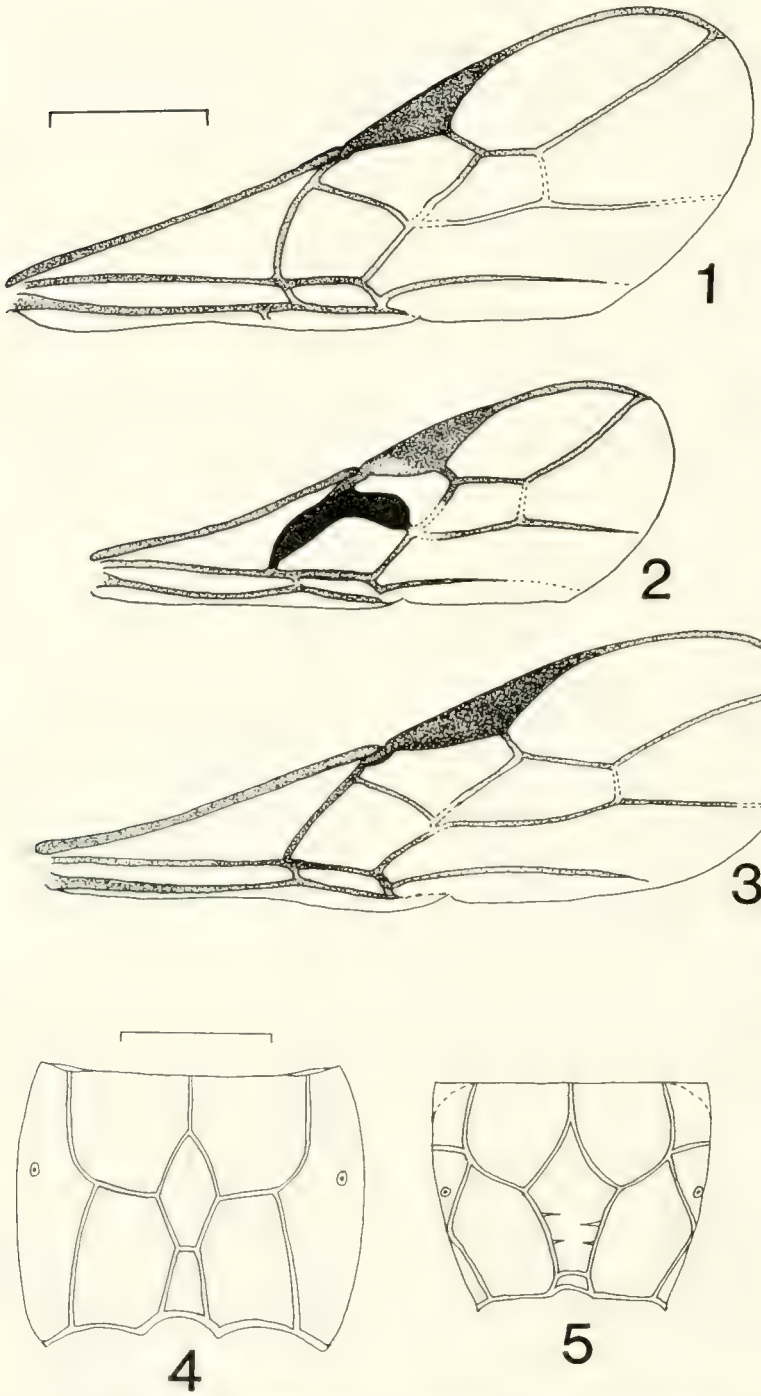
Dolopsidea Hincks, 1944

One female specimen of this genus, very similar to the Palearctic *D. indagator* (Haliday), was collected by malaise trap in the Hocking Hills, Hocking Co., Ohio, by the author, 3–9 June 1987.

The genus has often been confused, even in Britain and Europe, with *Rhyssalus* Haliday (see, e.g. Stelfox 1951) and *Oncophanes* Foerster. It will run in the key of Marsh et al. (1987) to *Oncophanes* (couplet 181) with some difficulty but differs from *Oncophanes* in having the medial lobe of the mesoscutum sharply and strongly raised above the lateral lobes, and in the metasomal tergites 2 and 3 being enlarged and highly polished, and not sharply delineated from the epipleura by creases. In addition, the ovipositor and sheaths are usually at least as long as the metasoma. In the mesoscutal structure and metasomal sculpturing *Dolopsidea* also differs from *Rhyssalus* Haliday (see below), which, in addition to being much smaller, has a relatively unraised medial mesoscutal lobe and normal-sized and weakly sclerotized second and third metasomal tergites. All three genera have a distinctive propodeal carination pattern (Fig. 4), and have the spiracles of metasomal terga 2 and 3 positioned lateroventrally, below the lateral edges of the dorsal faces of the terga. The fore wing venation of the Ohio specimen is shown in Fig. 1.

Neurocrassus Šnoflák, 1945

A single male specimen was recovered from the same malaise trap as the above genus, 5 September 1987, at the same site. It appears to be a rare genus even in Europe.



Figs. 1–5. 1–3: Fore wings of 1, *Dolopsidea* sp., ♀, Hocking Co., Ohio; 2, *Neurocrassus* sp., ♂, same locality; 3, *Rhyssalus* sp., ♀, Old Chelsea, Quebec. 4–5: Propodea of 4, *Dolopsidea* sp. (same specimen as above); 5, *Neurocrassus* sp. (also same as above). Scale line = 0.5 mm (1–3); 0.2 mm (4–5).

The obvious distinguishing feature of the genus is its peculiar, partially swollen wing venation (Fig. 2 and see also Šnoflák 1945 and Tobias 1986). Otherwise the genus fits within the Rhysipolini *sensu* Belokobyl'skii (1984), near *Cantharoctonus* Viereck, *Noserus* Foerster and *Pseudavga* Tobias, although it possesses a mosaic of characters from these genera (c.f. Whitfield & van Achterberg 1987). It will run in the key of Marsh et al. (1987) with some difficulty, due to equivocal hind wing characters, to couplet 180, containing *Cantharoctonus* and *Rhysipolis* Foerster. It agrees best with *Cantharoctonus* but has a less broad transverse groove at the base of the propodeum, as well as the conspicuous wing features. The propodeal carination is shown in Fig. 5.

Rhyssalus Haliday, 1833

From earlier collections I discovered a female from Old Chelsea, Quebec, collected on 18 July 1987. I have seen several other specimens in the Canadian National Collection, all from eastern Canada (Ontario and Quebec), and probably conspecific.

This genus will run to the same point in the key of Marsh et al. (1987) as *Dolopsidea* (see above). I have given characters that will separate these two genera from each other and the other genera in the key. The fore wing venation is shown in Fig. 3. *Rhyssalus* also shares many characters with *Pseudobathystomus* Belokobyl'skii (1987), which so far has not been discovered in the Nearctic fauna. *Rhyssalus* is distinctive in having metasomal terga 2 and 3 mostly weakly sclerotized and not enlarged relative to the succeeding terga; some species also possess clavate hind tibiae. This group of genera, the Rhyssalini *s.s.*, is much in need of revision at the generic and specific levels.

Acknowledgments

I appreciate the funding of the CanaColl Foundation in supporting my studies of these genera and related groups at the Canadian National Collection of Insects, Ottawa. A fellowship awarded by the North Atlantic Treaty Organization supported earlier studies at the British Museum (Natural History) and the Rijksmuseum van Natuurlijke Historie, Leiden, that clarified the identities of these genera. I would also like to thank Paul M. Marsh (U.S. National Museum, Washington) for loaning the Stelfox collection of exothecine Braconidae to me, which proved critical in interpreting some earlier papers on these wasps. Norman F. Johnson and Sydney A. Cameron provided useful comments on a draft of this manuscript.

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PROC. ENTOMOL. SOC. WASH.
90(4), 1988, pp. 474–479

NOTES ON THE BIOLOGY AND IMMATURE STAGES OF *POECILOGRAPHA DECORA* (LOEW) (DIPTERA: SCIOMYZIDAE)

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Abstract.—The puparium and third-instar cephalopharyngeal skeleton of the enigmatic sciomyzid fly, *Poecilographa decora* (Loew), are described, and the distribution is mapped. Notes on life history are presented, as well as ecological and taxonomic predictions based upon morphology of the immature stages.

Key Words: Diptera, Sciomyzidae, *Poecilographa,* immature stages

While working as a consultant entomologist with the Arctic Health Research Center of the U.S. Public Health Service at Anchorage, Alaska, during the summers of 1950–1952, the late Professor Clifford O. Berg discovered that larvae of Sciomyzidae prey upon mollusks. Following that discovery, his own research and that of many students and associates turned mainly to the careful elucidation of life histories of the sciomyzids of the world. About one third of the approximately 600 described species in this cosmopolitan family have been reared, and the larvae of all are obligate predators or parasitoids of various mollusks. Most species feed on freshwater or terrestrial, nonoperculate snails, but some attack snail eggs, operculate snails, salt marsh snails, slugs, or sphaeriid clams. Berg and Knutson (1978) reviewed the biology and systematics of the Sciomyzidae.

Nearly all students of Nearctic Sciomyzidae have attempted to rear the striking and distinctive species, *Poecilographa decora* (Loew), the sole member of its genus. However, no researcher has ever reared it through the entire life cycle, and the literature on this species is largely restricted to basic taxonomy and Johannsen's (1935) brief description of a puparium. My recent discovery of three puparia in the field has prompted the writing of this paper, which I hope will stimulate renewed interest in elucidating the life history of this mysterious species.

BIOLOGY

Puparia were collected at Black Creek Swamp, on Koontz Rd., Voorheesville, New York (42°39′57″N, 73°58′05″W). They were found among moist litter under a thin canopy of *Ulmus rubra* Muhlenberg and *Fraxinus pennsylvanica* Marshall in an unflooded area where adults had been collected previously. The dominant low vegetation is *Aster simplex* Willdenow and *Onoclea sensibilis* Linnaeus. The locality is frequently flooded during the spring and after heavy rains, and it is surrounded by a creek and a *Typha* and *Sparganium* marsh.

A puparium collected June 2, 1983, yielded an adult female on June 15, and one collected on June 16, 1983, yielded a female on June 27. The third puparium, collected June 30, 1983, yielded no adult and upon close inspection was found to have a 0.7

mm diameter circular hole in the integument, probably an emergence hole of a parasitoid. The single puparium that Johannsen (1935) reported upon ". . . was found in a bog in woods near Ithaca, New York, on June 2" (p. 48), and it yielded an adult on June 17. Johannsen's puparium is not in the Cornell University Insect Collection with the adult it yielded, and it probably has been lost. The others are deposited in the New York State Museum.

On July 6, 1981, one male and three female *P. decora* adults were collected at Black Creek Swamp and placed in a 5.0 × 8.5 cm clear plastic vial fitted with a screen cap and containing a layer of moist cotton, forest litter, a resting stick, and an artificial diet for the adults consisting of honey, brewer's yeast, and dehydrated milk. They were held in an incubator at 20°C under a LD 16:8 lighting schedule. They mated and laid eggs readily and frequently. The eggs, which are creamy white, 0.83–0.91 mm long, and striate, were placed in scattered, unorganized groups, usually along the edge of a piece of drying litter in the bottom of the vial. On July 15, the eggs laid over the previous nine days were harvested from the breeding vial, and it was found that none had hatched. The eggs were placed on moist cotton, and four of them hatched on July 29. These four had been kept especially moist—so that the chorion actually appeared wet; others had dried somewhat from evaporation. The larvae were placed in a dish of water, but no matter how carefully they were manipulated, it was impossible to make them float, even though microscopic examination reveals that they possess short, interspiracular, hairlike processes or "float hairs." Other researchers have found that first-instar larvae of *P. decora* float readily, with the posterior end at the surface film (B. A. Foote, pers. comm.).

The eggs laid July 15–31 were submerged in water for about 2 hours on July 31. None had hatched up to that date, but by August 3, 15 had hatched; by August 6, 10 more; by August 10, 36 more; and by August 19, the remaining 16 had hatched. Very few more eggs were laid, and all adults soon died.

Attempts were made to rear first-instar larvae on various gastropods, including *Gyraulus* sp. (Planorbidae), *Lymnaea* sp. (Lymnaeidae), *Oxyloma* sp. (Succineidae), and an unidentified land snail (Discidae: *Discus* sp.?), collected at Black Creek Swamp. No feeding was observed, and all larvae perished. Failure also resulted from attempts to rear first-instar larvae on living *Biomphalaria glabrata* (Say) and *Helisoma trivolvis* (Say) (Planorbidae); living and freshly killed *Deroceras laeve* (Müller) (Limacidae); living *Haplotrema concavum* (Say) (Haplotrematidae); living *Lymnaea palustris* (Müller) [= *Stagnicola elodes* (Say)]; living *Oxyloma decampi* (Tryson) [= *O. retusa* (I. Lea)] and eggs of *Oxyloma* sp.; living *Physella gyrina* (Say) (Physidae); juveniles and eggs of *Stenotrema hirsutum* (Say) (Polygyridae); and living and dead *Ventridens demissus* (Binney), and living *Zonitoides arboreus* (Say) and *Z. nitidus* (Müller) (Zonitidae) (B. A. Foote, pers. comm.).

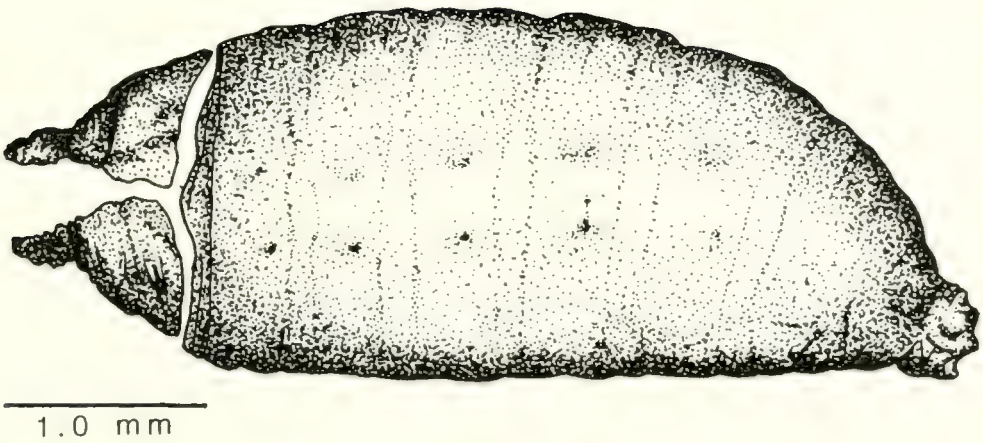
Records of 210 adult male and 254 adult female museum specimens reveal that *P. decora* has a distribution typical of many nearctic sciomyzids. Specimens have been collected from central Saskatchewan east to New Brunswick, south to Virginia, and west to Colorado (Fig. 1). Adults are first seen in late May, they peak in numbers in July, and specimens are rarely taken after mid August, although one male from Dickinson County, Michigan, was collected on September 22, 1982. Therefore, it seems likely the species is univoltine.

Description

Puparium (Fig. 2): Length, 4.8–5.4 mm; greatest width, 1.7–2.0 mm; greatest height, 1.7–1.9 mm. Unicolorous reddish brown, but segments 2–4 and 12 somewhat darker than remainder. Integument opaque, with finely pebbled sculpturing, especially dor-

Fig. 1. Collecting sites for *Poecilographa decora*.

sally and laterally; densely wrinkled on segments 2–4 and 12. Puparium elongate, subcylindrical, dorsally convex and ventrally nearly straight in profile. Primary and secondary integumentary folds faint; 2 secondary folds dorsally, 3 ventrally. Segment 1 invaginated. Segments 2–4 strongly tapered anteriorly. First 2 apparent segments (segments 2 and 3) dorsoventrally flattened, not upturned, distinctly narrower than succeeding segments. Anterior spiracles projecting from anterolateral angles of segment 2, dark brown, subcircular, bearing about 8 distinct, marginal papillae. Distinct tubercles



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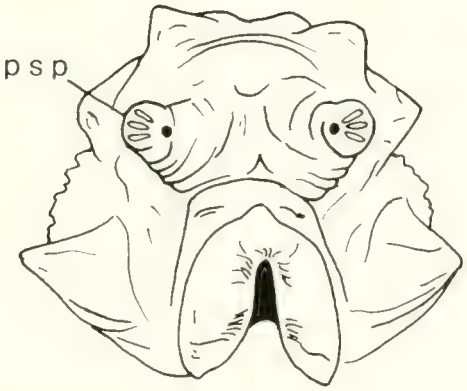

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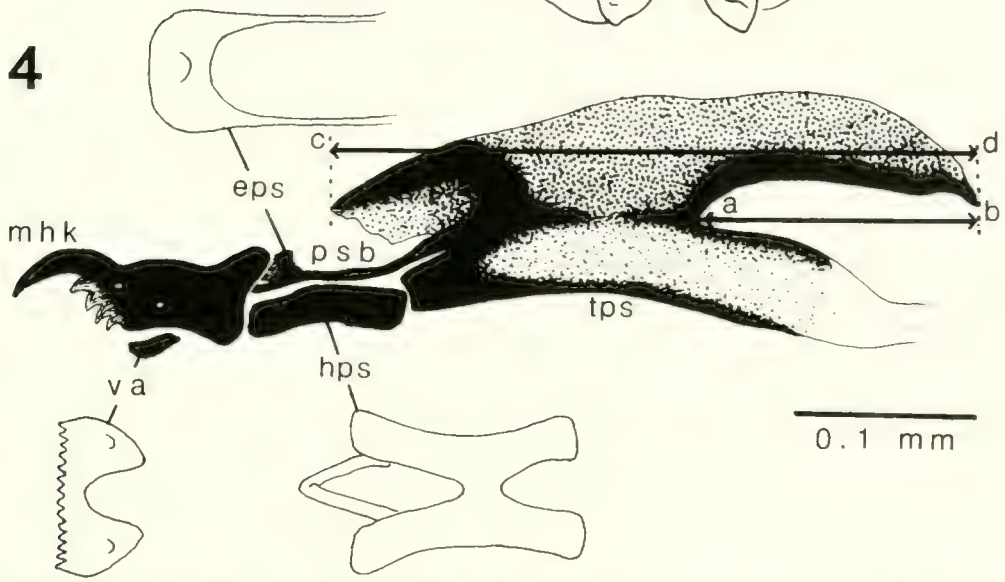

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Figs. 2–4. *Poeciloptera decora*. 2, Puparium, cephalic caps separated. 3, Posterior spiracular disc; psp = posterior spiracle. 4, Cephalopharyngeal skeleton; eps = epipharyngeal sclerite; hps = hypopharyngeal sclerite; mhk = mouthhook; psb = parastomal bar; tps = tentoropharyngeal sclerite; va = ventral arch; ab/cd = indentation index.

and creeping welts absent from segments 2–11. Segments 11 and 12 tapered posteriorly. Segment 12 distinctly ventral in position, not upturned, truncate, with mid-dorsal indentation. Anus invaginated.

Posterior spiracular disc (Fig. 3) strongly indented posteroventrally, bearing 4 pairs of short, wrinkled lobes (indistinguishable in 1 specimen) and 2 dorsomedial spiracular plates. Dorsolateral and lateral lobes shortest, about as long as diameter of spiracular plates; ventrolateral and ventral lobes longer, 0.35–0.40 mm. Spiracular plates subcircular, at apices of 2 dark brown to black spiracular tubes; tubes shorter than diameter of plates, longer on lateral surface than on mesial; each spiracular plate with 3 elongate-oval, diverging, yellow spiracular slits and a mesial, subcircular, black spiracular scar; plates lacking well-developed, interspiracular, hairlike processes (float hairs).

Cephalopharyngeal skeleton (Fig. 4) brown, 0.53 mm long; indentation index (ab/cd) 44. Paired mandibles not fused, with decurved mouthhooks; 4–5 decurved, lightly pigmented accessory teeth anteroventrally; and 2 small windows posterior to accessory teeth. Ventral arch convex below, with 14 small teeth on anterior margin, deeply emarginate posteromesially. Epipharyngeal sclerite fused to anterior ends of parastomal bars. Posterior ends of parastomal bars fused to tentoropharyngeal sclerites. Hypopharyngeal sclerite H-shaped, not fused to mandibles or tentoropharyngeal sclerites; anterior emargination about 1.5× length of posterior emargination. Ligulate sclerite anterior to hypopharyngeal sclerite, small, V-shaped. Paired tentoropharyngeal sclerites not fused, lacking dorsal bridge and fenestrations; ventral cornua distinctly shorter than dorsal cornua.

Discussion

Data from this preliminary study indicate that *Poecilographa decora* is a typical member of the subfamily Sciomyzinae, tribe Tetanocerini, and that the third-instar larva and puparium are terrestrial. Morphological characteristics that support placement of this species in the Tetanocerini include the striate egg chorion, lack of well-developed ventral spinule patches on the larval integument, presence of accessory teeth on the mandibles, lack of a dorsal bridge between the tentoropharyngeal sclerites, lack of a window in the dorsal cornu, lack of tentoropharyngeal-hypopharyngeal fusion, and a third-instar indentation index of less than 50. The facts that this species can pupate and oviposit in the absence of a host also support placement in the Tetanocerini. Knutson (1966), Knutson et al. (1970), and Boyes et al. (1969, 1972) provide good summaries of morphological and behavioral differences between the Tetanocerini and Sciomyzini.

The lack of well-developed interspiracular float hairs on the puparium, the fact that the posterior end is not upturned (thus not allowing the spiracles to contact atmospheric air if the puparium were floating), and the microhabitat of the puparia discussed here indicate that the immature stages of *P. decora* are terrestrial. However, most reared species of Tetanocerini are aquatic predators; their larvae live in water, floating just beneath the surface film, and they attack snails effectively there as well as on moist shores or floating vegetation. All reared species of Sciomyzini are parasitoids in terrestrial or semi-aquatic situations, but this type of feeding behavior is also seen in a few species of Tetanocerini and the only reared species of Salticellinae. The tetanocerine terrestrial parasitoids are usually host specific at the species, genus or family level. As they mature, the larvae become quick-killing predators and eventually leave the shell of their last victim to pupate in soil or litter. A few Tetanocerini feed on decaying snails as well as fresh prey (Berg and Knutson, 1978). These observations suggest handling methods and potential hosts to be used in future attempts to rear *Poecilographa decora*.

Acknowledgments

Distributional data or pinned adults for examination were provided by: D. Azuma, The Academy of Natural Sciences, Philadelphia; H. J. Teskey, Agriculture Canada; D. Grimaldi, American Museum of Natural History; P. H. Arnaud, California Academy of Sciences; B. C. Kondratieff, Colorado State University; K. R. Valley, Commonwealth of Pennsylvania, Department of Agriculture; J. K. Liebherr, Cornell University; C. Salvino, Field Museum of Natural History; S. L. Heydon, Illinois Natural History Survey; R. E. Lewis, Iowa State University; B. A. Foote, Kent State University; C.-c. Hsuing, Macdonald College, McGill University; R. L. Fischer, Michigan State University; C. Vogt, Museum of Comparative Zoology, Harvard University; E. W. Balsbaugh, North Dakota State University; C. A. Triplehorn, Ohio State University; G. B. Wiggins, Royal Ontario Museum; L. Knutson, United States National Museum; R. E. Orth, University of California, Riverside; S. Marshall, University of Guelph; F. Merickel, University of Idaho; J. K. Gelhaus, University of Kansas; M. F. O'Brien, University of Michigan; P. J. Clausen, University of Minnesota; M. Coulloudon, University of Montreal; D. S. Chandler, University of New Hampshire; S. Krauth, University of Wisconsin; and M. Kosztarab, Virginia Polytechnic Institute and State University. B. A. Foote, L. Knutson, and K. R. Valley reviewed the manuscript and provided helpful comments. B. A. Foote kindly granted permission to incorporate material from his notes on rearing efforts.

Contribution number 560 of the New York State Science Service.

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PROC. ENTOMOL. SOC. WASH.
90(4), 1988, pp. 480–483

GENERIC REASSIGNMENTS OF NORTH AMERICAN SPECIES CURRENTLY ASSIGNED TO THE GENUS *SERICOTHRIPS* HALIDAY (THYSANOPTERA: THRIPIDAE)

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Abstract.—Although the concepts of *Sericothrips* and related genera were revised in 1973, only 14 of the 51 *Sericothrips* species heretofore reported from North America (i.e. Panama northward and the Caribbean Islands) have been reviewed and reassigned to the proper genera thus far. In order to conform to current concepts, the North American species were reviewed and assigned to *Hydatothrips*, *Neohydatothrips* or retained in *Sericothrips*, and 1 species was treated as a nomen dubium. The current scientific names, distributions, and literature citations for 2 *Hydatothrips* spp., 47 *Neohydatothrips* spp. (including 3 spp. recently described from Mexico) and 3 *Sericothrips* spp. known to occur in North America are presented here.

Key Words: Thysanoptera, Thripidae, *Sericothrips*, *Hydatothrips*, *Neohydatothrips*, North America, new combinations

In a preliminary revision of the genus *Sericothrips* Haliday and related genera, Bhatti (1973: 403) revalidated *Hydatothrips* Karny and transferred most of the *Sericothrips* species he examined to *Hydatothrips* and *Neohydatothrips* John. Although 51 species of *Sericothrips* were reported by Jacot-Guillarmod (1971: 359), Johansen (1979: 169) and Sakimura (1986: 356) from North America (i.e. from Panama northward and the Caribbean Islands), only 14 species have been reevaluated thus far for their proper generic assignments. Bhatti (1973: 405) transferred 1 species to *Hydatothrips*, 7 species to *Neohydatothrips* and retained 2 species in *Sericothrips;* Johansen (1983: 107) transferred 2 species to *Neohydatothrips;* and Sakimura *in* Cho et al. (1987: 507) transferred 1 species to *Neohydatothrips*. O'Neill (1972: 276) treated *S. campestris* Hood (1939: 556) as a junior synonym of *N. floridanus* (Watson). The remaining species are brought into conformity with current concepts here by reassigning 1 species to *Hydatothrips*, 34 species to *Neohydatothrips*, retaining 1 species in *Sericothrips*, and treating 1 species as a nomen dubium. The generic assignments are based on the types except for *N. desmodianus* (Stannard), which is based on identified type material, and *N. mirandai* (Johansen), which is based on Johansen's opinion (pers. comm., 1987). The examined specimens are deposited in the Thysanoptera collection of the U.S. National Museum of Natural History (USNM) located at Beltsville, Maryland.

According to Jacot-Guillarmod (1971: 395), the type depository of *Sericothrips trifasciatus* (Ashmead) is the USNM, but I have not been able to find the types. This species, originally described as *Thrips trifasciatus* (Ashmead 1894: 27), was assigned to *Sericothrips* by Hood (1957: 53) in a footnote. He also stated: "Watson suggested

(Bull. 168, Fla. Agr. Exp. Sta., p. 44, 1923) that this might be *Franklinothrips vespiformis*, but scarcely a word or phrase of Ashmead's description could be applied to that species." Hood did not give his reason for this assignment. Ashmead's brief description is inadequate for distinguishing the species. Because the types of *trifasciatus* cannot be found, this species is here considered a nomen dubium.

The following list treats 2 *Hydatothrips* spp., 47 *Neohydatothrips* spp. (including 3 spp. described by Johansen (1983: 107)) and 3 *Sericothrips* spp. for North America. The literature citation for the original description is given for each species. References for species assigned by Bhatti (1973), Johansen (1983) and Sakimura (1987) are also cited. The distribution records are based on the work of Bailey (1957: 195), Beshear (1973: 11; 1979:211), Chiasson (1986: 45), Huntsinger et al. (1982: 48), Jacot-Guillarmod (1971: 359), Johansen (1979: 169; 1983: 107), Sakimura (1985: 30; 1986: 356), Stannard (1968: 345) and material in the USNM collection. For the United States (US), the states in postal abbreviations are given.

Hydatothrips Karny

sternalis (Hood) 1935: 148; Bhatti 1973: 405. Dist. Panama.

tricinctus (Hood) 1928: 231. New Combination. Dist. Brazil, Dominica, Guadeloupe, Jamaica, Martinique, Trinidad.

Neohydatothrips John

albus (Jones) 1912: 6. New Combination. Dist. US (CA).

andrei (J. C. Crawford) 1943: 39. New Combination. Dist. US (VA).

annulipes (Hood) 1927a: 211; Bhatti 1973: 405. Dist. US (GA, IA, IL, NJ, NY, VA).

apicalis (Hood) 1927b: 137. New Combination. Dist. Canada (Alberta), US (IA, IN, ND).

aztecus Johansen 1983: 113. Dist. Mexico.

baileyi (Hood) 1957: 53. New Combination. Dist. US (CA).

baptisiae (Hood) 1916: 113; Bhatti 1973: 405. Dist. US (GA, IL, MD, NJ, NY, VA).

basilaris (Hood) 1941: 139. New Combination. Dist. Cuba.

beachae (Hood) 1927b: 133. New Combination. Dist. Canada (Alberta), US (IA, IL, ND).

burungae (Hood) 1935: 150; Johansen 1983: 113. Dist. Jamaica, Mexico, Panama.

catenatus (Hood) 1957: 51. New Combination. Dist. US (AZ).

chrysothamni (Hood) 1936: 85. New Combination. Dist. US (CA, NV, OR).

collaris (Hood) 1936: 91. New Combination. Dist. US (AZ, NM).

ctenogastris (Hood) 1936: 93. New Combination. Dist. US (AZ, TX).

desertorum (Hood) 1957: 52. New Combination. Dist. US (NM).

desmodianus (Stannard) 1968: 351. New Combination. Dist. US (GA, IL, NJ).

ephedrae (Hood) 1957: 51. New Combination. Dist. US (AZ, NM).

flavicollis (Hood) 1954: 204. New Combination. Dist. Brazil, Jamaica.

floridanus (Watson) 1918: 53; Bhatti 1973: 405. Dist. US (FL, GA, IL, MD, MO, TN, TX, VA).

fraxinicola (Hood) 1940: 545. New Combination. Dist. US (NY).

geminus (Hood) 1935: 146. New Combination. Dist. Jamaica, Mexico, Panama, Puerto Rico.

gracilipes (Hood) 1924a: 149; Sakimura *in* Cho et al. 1987: 507. Dist. Jamaica, Mexico, US (HI, TX).

interruptus (Hood) 1927b: 136. New Combination. Dist. US (GA, IA, IL, MD, NJ).

inversus (Hood) 1928: 232. New Combination. Dist. Dominica, Jamaica, Panama, Trinidad.

langei (Moulton) 1929: 230. New Combination. Dist. US (IL, WI).

mimosae (Hood) 1955: 134. New Combination. Dist. Costa Rica.

mirandai (Johansen) 1979: 169. New Combination. Dist. Mexico.

moultoni (Jones) 1912: 7; Bhatti 1973: 405. Dist. US (CA, UT).
nubilipennis (Hood) 1924b: 312. New Combination. Dist. US (IA, IL, ND, MD, NY, PA, VA).
opuntiae (Hood) 1936: 88. New Combination. Dist. US (AZ, CA, NM).
pedicellatus (Hood) 1927b: 131. New Combination. Dist. US (IL, NJ, TX).
portoricensis (Morgan) 1925: 3; Bhatti 1973: 405. Dist. Brazil, Cuba, Guadeloupe, Jamaica, Panama, Puerto Rico, St. Lucia, Trinidad.
pseudoannulipes Johansen 1983: 109. Dist. Mexico.
pulchellus (Hood) 1908: 363. New Combination. Dist. US (IL, MD).
rapoporti Johansen 1983: 110. Dist. Mexico.
sambuci (Hood) 1924b: 313. New Combination. Dist. Canada (Ontario), US (DC, IA, IL, MD, NJ, NY).
sensillis (Hood) 1936: 95. New Combination. Dist. US (AZ).
setosus (Hood) 1927b: 135. New Combination. Dist. US (AZ, TX).
signifer (Priesner) 1932: 172; Johansen 1983: 115. Dist. Mexico.
spiritus (Hood) 1927b: 138. New Combination. Dist. US (AZ).
tibialis (Priesner) 1924: 528; Bhatti 1973: 405. Dist. Mexico.
tiliae (Hood) 1931: 151. New Combination. Dist. US (IA, IL, IN, ND, NY).
tissoti (Watson) 1937: 4. New Combination. Dist. US (FL).
variabilis (Beach) 1896: 220; Bhatti 1973: 405. Dist. Canada (British Columbia), Mexico, US (AL, AR, AZ, CA, DE, GA, IA, KS, LA, IL, IN, MA, MD, MO, NC, NJ, OK, SC, TN, TX, UT, VA).
vicenarius (Hood) 1955: 133. New Combination. Dist. US (TX).
williamsi (Hood) 1928: 230. New Combination. Dist. Mexico, St. Croix.
zebra (Hood) 1940: 543. New Combination. Dist. US (NY).

Sericothrips Haliday

cingulatus Hinds 1902: 141; Bhatti 1973: 405. Dist. Canada (Alberta, Manitoba), US (AR, GA, IA, IL, LA, MA, MD, MS, NE, NY, TN, TX, VA).
pubescens Hood 1957: 50. New Combination. Dist. US (NY).
smithi Stannard 1951: 129; Bhatti 1973: 405. Dist. US (GA, IL, NC, SC).

Acknowledgments

I thank R. M. Johansen, Universidad Nacional, Autonoma de Mexico for lending material for this study and providing information on Mexican species, and the following colleagues for their reviews of the manuscript and useful suggestions: L. A. Mound, British Museum (Nat. Hist.), London; R. J. Beshear, University of Georgia, Experiment; H. A. Denmark, Florida Dept. of Agriculture and Consumer Services, Gainesville; and R. D. Gordon and A. L. Norrbom, Systematic Entomology Laboratory, Washington, D.C.

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PROC. ENTOMOL. SOC. WASH.
90(4), 1988, pp. 484–494

REDESCRIPTION OF THE HOLOTYPE OF *CULEX* (*CULEX*) *PEUS* SPEISER AND TAXONOMY OF *CULEX* (*CULEX*) *STIGMATOSOMA* DYAR AND *THRIAMBUS* DYAR (DIPTERA: CULICIDAE)

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Abstract.—Examination and redescription of the holotype *Culex* (*Culex*) *peus* Speiser 1904 (substitute name for *affinis* Adams 1903) established that it is conspecific with *Cx. thriambus* Dyar 1921. Therefore, *Cx. thriambus* is synonymized under *peus; Culex stigmatosoma* Dyar 1907 is resurrected from synonymy; and *Cx. eumimetes* Dyar and Knab 1908 is transferred to synonymy under *stigmatosoma.* This paper also clarifies identification of these species in the literature.

Key Words: *Culex, affinis, eumimetes, peus, stigmatosoma, thriambus,* taxonomy, redescription

While studying the *Culex* (*Culex*) of Central America, I noticed several differences between descriptions (Adams 1903, Stone 1958) of the holotype of *Culex peus* Speiser 1904 (= *affinis* Adams 1903) and other specimens and descriptions of the species. As a result, I undertook a study with the purpose of identifying the holotype. Since the holotype is a damaged female adult from Arizona, I examined female adult specimens of *Cx.* (standard abbreviation for *Culex,* Reinert 1975) *peus* and the similar species, *Cx. thriambus* Dyar 1921, with the objective of finding diagnostic characters still present on the holotype of *Cx. peus.* Examination of specimens was limited to the United States in order to assure that the specimens belonged to one of the two species involved and not to a possibly undescribed form from Mexico or Central America.

The study established that the holotype of *Cx. peus* is conspecific with *Cx. thriambus.* As a result, *Cx. thriambus* is made a synonym of *Cx. peus.* Furthermore, *Cx. stigmatosoma* Dyar 1907 is resurrected from synonymy with *Cx. peus. Culex eumimetes* Dyar and Knab 1908 is transferred from synonymy under *Cx. peus* to synonymy under *Cx. stigmatosoma.* Specimens identified as *Cx. peus* since Stone (1958) are actually *Cx. stigmatosoma,* and specimens identified as *Cx. thriambus* are *Cx. peus.*

The holotype of *Cx. peus* is redescribed in this paper in much greater detail than by Adams (1903) or Stone (1958). This detailed description was considered necessary because of the central role of the holotype in the nomenclature of the species involved. The redescription documents characters that are not currently known to be significant, but which could conceivably influence future taxonomic decisions. Since the holotype is already damaged, redescription helps assure that any future deterioration will not result in permanent loss of characters.

Methods

Evaluation of color on the holotype of *Cx. affinis* was based on comparison of the specimen to color samples of the four-color

printing process. The color samples (Kueppers 1982) present mixtures of black (B), cyan (C), magenta (M), and yellow (Y) in all combinations of three of the colors against a white page at 10% intervals (i.e. percentage coverage of the page with minute dots used in color printing). A particular color is designated as a combination of the percentage of each of the color inks (e.g. $B_{10}M_{20}C_{99}$ is a sky blue color). Each color sample was viewed surrounded by a gray mat under unfiltered tungsten light. For color evaluation, the specimen was also viewed under unfiltered tungsten light set at 5 volts. Unfortunately, the same color may appear as more than one combination of inks and, the human eye is much more sensitive to certain color ranges, such as light yellow, than the 10% intervals can identify. Therefore, light yellow scales have been called "yellowish" in the description. Nevertheless, the system is useful because it provides an objective reference to color and a measurement of color that is reproducible on a printed page.

Abbreviations and notations require some explanation. The symbols "♂" and "♀" represent adults of the respective sex. The symbol "♂G" is male genitalia. Fourth instar larva is represented by "L" and pupa is represented by "P." An asterisk indicates that the stage was illustrated in the cited paper. Where possible, collection or specimen numbers were reported to allow location of the exact specimen examined. All specimens are in the U.S. National Museum (USNM) unless otherwise noted (UAz = University of Arizona, SEM = Snow Entomological Museum, University of Kansas). Morphological nomenclature and abbreviations were taken from Harbach and Knight (1980).

Taxonomy

Culex peus Speiser

Culex peus Speiser, 1904: 148, replacement name for *affinis* Adams.

Culex affinis Adams, 1903: 25, Oak Creek Canyon, Arizona, USA, ♀, SEM; Coquillett 1904: 261, synonymized under *Cx. tarsalis*; Theobald 1907: 394, synonymy questioned.

Culex thriambus Dyar, 1921: 33, Kerrville, Texas, USA, ♂, USNM. **New Synonymy**; Dyar 1928: 368, synonymized under *stigmatosoma*; Edwards 1932: 206, listed as var. of *stigmatosoma*; Galindo and Kelley 1943: 87, resurrected.

Additional descriptions.—*Cited as* Cx. peus: Stone 1958 (♀). *Cited as* Cx. thriambus: Dyar 1921 (♂, ♀, ♂G, L). Dyar 1922 (♀, ♂, L); Galindo and Kelley 1943 (♀, ♂G, L); Freeborn and Brookman 1943 (♀, L); Freeborn and Bohart 1951 (♀, ♂G, L); Breland 1957 (L); Martinez Palacios 1952 (♂, ♀, ♂G*, L); Usinger et al. 1952 (♀, L); Bohart and Washino 1957 (2nd and 3rd instar L); Carpenter and LaCasse 1955 (♀*, ♂, ♂G*, L*); Dodge 1963 (L); Nielsen and Linam 1963 (♀, L); Myers 1964 (L); Forattini 1965 (♀, ♂G, L); Chapman 1966 (♀, ♂G, L); Cova Garcia et al. 1966a (♀, ♂G*); Cova Garcia et al. 1966b (L*); Dodge 1966 (1st instar L); Mukherjee et al. 1966 (chromosomes* of L); Bram 1967 (♀, ♂G*, L); Nielsen 1968 (♀, ♂G, L); McDonald et al. 1973 (♀); Bohart and Washino 1978 (♀*, L*); Darsie and Ward 1981 (♀*, L*); Clark-Gil and Darsie 1983 (♀, L).

Material examined (all adult females).—Arizona: Coconino Co.: Oak Creek Canyon, holotype, F. H. Snow. Cochise Co.: St. David, 24 Sep 1953, C. S. Richards, 2 ♀. Maricopa Co.: Wickenburg, 29 Jun 1953, W. W. Wirth. Pima Co.: Lake Sabino Canyon, 20 Oct 1962, J. Burger coll. no. 349, 5 ♀; 17 Nov 1962, coll. no. 353; 17 Nov 1962, coll. no. 357, 2 ♀; 10 Mar 1963, coll. no. 373, 3 ♀; 20 Apr 1963, coll. no. 378; 26 May 1963, coll. no. 383, 2 ♀; 28 Jun 1963, coll. no. 388; 17 Oct 1963, coll. no. 410, 3 ♀. Pinal Co.: Boyce-Thompson Arboretum, 3 mi. S. of Superior, 7 Jul 1963, J. Burger coll. no. 390, 9 ♀. Santa Cruz Co.: Madera Canyon, 21–26 Aug 1954, W. A. McDonald coll. no.

Table 1. Characters of various populations of *Culex stigmatosoma* and *Culex peus*, including the type specimens, specimens from the states of type localities, and all specimens examined from the United States. Percentages are followed by 95% confidence limits (CL) (Rohlf and Sokal 1969) and means are followed by standard deviations (SD).

Population	Proboscis Band Complete % (CL) (n)	Palpi with White Scales % (CL) (n)	HT-5 with Dark Band % (CL) (n)	Ratio of Basal Band to Length of HT-2 Mean ± SD (n)
affinis type	yes[a]	no	no[a]	0.06
Arizona *peus*	24 (10–41) (38)	3 (0–16) (37)	30 (17–52) (33)	0.09 ± .02 (38)
Texas *peus*	10 (0–44) (10)	0 (0–29) (11)	22 (3–62) (9)	0.08 ± .02 (10)
California *peus*	15 (6–34) (34)	0 (0–11) (34)	42 (25–62) (33)	0.08 ± .02 (33)
All *peus*	18 (10–29) (82)	1 (0–8) (82)	35 (24–47) (75)	0.08[b] ± .02 (81)
stigmatosoma type	yes	yes	yes	0.15
Arizona *stigmatosoma*	100 (71–100) (11)	100 (71–100) (11)	100 (65–100) (9)	0.15 ± .02 (11)
California *stigmatosoma*	98 (93–100) (127)	100 (97–100) (126)	100 (97–100) (127)	0.13 ± .02 (128)
All *stigmatosoma*	98 (93–100) (139)	100 (97–100) (138)	100 (97–100) (137)	0.13[b] ± .02 (140)

[a] Destroyed on type specimen, extracted from original description (Adams 1903).
[b] Significantly different at the 95% level in a t-test of group means.

133, 8 ♀. California: Inyo Co.: China Ranch, 29–30 Oct 1955, Blodget and McDonald coll. no. 177, 10 ♀. Riverside Co.: 1 mi. S. Hurkey Creek Campground, San Jacinto Mts., 9 Apr 1962, C. L. Hogue coll. no. 233, 5 ♀. San Bernardino Co.: Saratoga Springs, Death Valley, 29 Oct 1955, Blodget and McDonald coll. no. 176, 8 ♀. San Diego Co.: Jamacha Junction, 11 Jul 1954, Belkin and McDonald coll. no. 124, 10 ♀. San Luis Obispo Co.: San Luis Obispo, 22 Aug 1948, W. W. Wirth. Shasta Co.: US 299 and Trinity Center Rd., 8 Sep 1950, J. N. Belkin coll. no. 68. Texas: Bexar Co.: San Antonio, 14 Jul 1942, E. S. Ross, 2 ♀. Kerr Co.: Kerrville, 20 Aug 1920, H. G. Dyar coll. no. Y2, coll. no. Y4, coll. no. Y7 (type no. 23926), coll. no. Yπ 5 ♀. Travis Co.: Austin, 24 Oct, A. L. Melander.

Diagnosis.—The adult female of *Cx. peus* may be distinguished from *Cx. stigmatosoma* on the basis of characters presented in Table 1. In contrast to *Cx. stigmatosoma*, the proboscis band of *Cx. peus* is usually incomplete; the palpi lack broad, opaque white scales; the dark band in the middle of hindtarsomere 5 is usually absent making this tarsomere completely white; and the width of the basal light band on hindtarsomere 2 is usually less than 0.10 of length of hindtarsomere 2.

Culex peus sometimes has a complete proboscis band and hindtarsomere 5 with a dark band, character states usually associated with *stigmatosoma*. Only three examples out of 81 specimens displayed both these characters. Of these, two (Inyo Co., San Diego Co., CA) were associated with exuviae definitely identified as *Cx. peus*. The third (Riverside Co., CA) was from a collection of more typical adult females of *Cx. peus*. Conversely, three female adults of *Cx. stigmatosoma* displayed an incomplete proboscis band, a character typical of *Cx. peus*. Two of these specimens were from collections of *stigmatosoma*. The third was the sole individual in a collection (Huntington Beach, Orange Co., CA).

Although the proboscis band does not provide complete separation of the species, it is an important character (Table 1). As in other members of the subgenus, light scales on the middle of the proboscis form a band that is either complete or incomplete dorsally. Bands with a narrow dark dorsal line less than one scale wide were considered complete. The bands seem to be the result of a separation of the two sides of the labial sheath, exposing the dark, unscaled stylets within. The majority (82%) of *Cx. peus* had an incomplete proboscis band restricted to the ventral and lateral portions of the la-

bium. Although the proportion of specimens with a complete proboscis band varied from 10% in Texas to 24% in Arizona, the differences between regions were not significant at the 95% level, as judged by confidence limits. Almost all *Cx. stigmatosoma* specimens had complete proboscis bands with a greater density of whiter scales than in *Cx. peus*. There was no consistent difference between the two species in the length of the band.

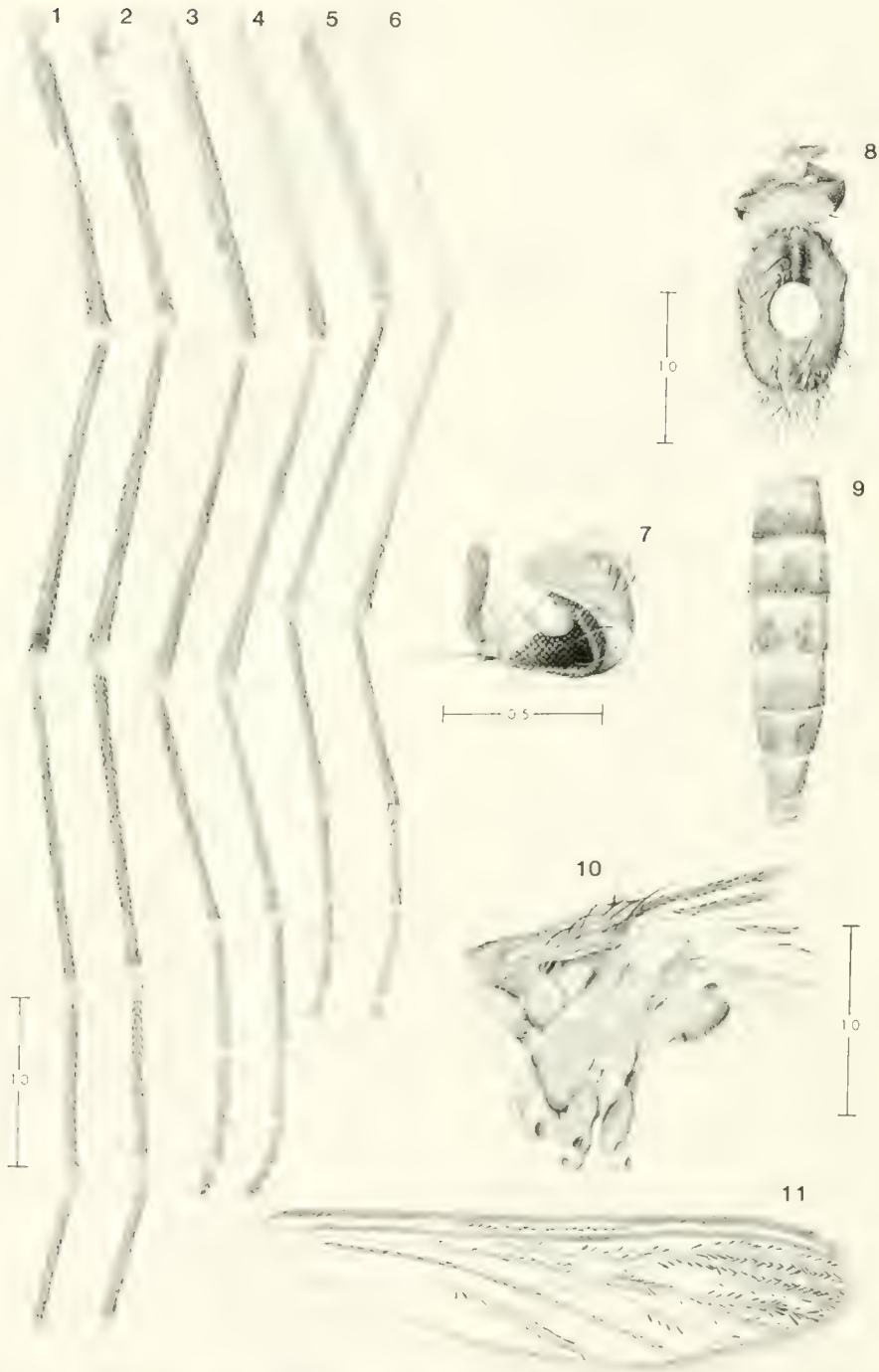
The presence or absence of white scales on the palpi is a consistent difference between the species (Table 1). Every specimen of *Cx. stigmatosoma* examined had at least several large, opaque, white scales on the dorsal and mesal sides of the apex of the palpi. Often, the scales formed large, distinctive patches. Most *Cx. peus* lacked large, opaque white scales on the palpi. The palpi were either entirely dark scaled, or had small, light, pearly scales on some of the surfaces. Only one specimen had opaque white scales; five scales were on one palpus.

Hindtarsomeres 1–4 of both species were ornamented with white basal and apical bands. Hindtarsomere 5 (HT-5) always followed this same pattern in *Cx. stigmatosoma*, displaying a distinct dark band in the middle of the tarsomere. *Culex peus* varied in this character, with 35% of those examined having HT-5 with a dark band and the remaining specimens with HT-5 all white (Table 1). As in the case of the proboscis band, the proportion of *peus* with the dark HT-5 band varied among populations, but not significantly so. Generally, the dark-scaled portion of HT-5 was not as distinct in *peus* as in *Cx. stigmatosoma*.

Another character useful for separating the two species was the ratio of the width of the basal band to tarsomere length on HT-2 (Table 1). The mean ratio was 0.13 for *Cx. stigmatosoma* and 0.08 for *peus*. There were no significant differences between populations within each species. Figure 12 presents the data as frequency distributions, showing that the central value of the ratio is different for the two species, though the distributions overlap.

Remarks.—The lectotype of *Cx. thriambus* and associated specimens conform to the description of *Cx. peus* given above. The lectotype was selected by Stone and Knight (1957) from three syntypes designated by Dyar. One female has the same accession number (USNM Type No. 23926) and label information as the type, including Dyar's code "Y7." Seven other females were collected on the same date by Dyar in Kerrville, but have different code numbers. Since it is not clear what Dyar intended by his code numbers (A. Stone, personal communication; search of Smithsonian Archives failed to find relevant notes or letters), the eight females may have come from the same collection despite the application of four different code numbers, lending confidence to the assumption that the females are the same species as the lectotype male. One of the specimens has a dark band on HT-5, six have HT-5 all white, and one lacks HT-5 on both hindlegs (code number Y7, USNM Type No. 23926). All of the females lack white scales on the palpi and have incomplete proboscis bands (one has no proboscis). The mean value for the ratio of the length of the light basal band to the length of HT-2 for seven of the specimens is 0.075 with a range of 0.065 to 0.087.

Redescription of holotype (Figs. 1–11).—*Condition of specimen:* Specimen damaged. On head, proboscis missing up to clypeus except for short segment of single internal stylet. Front of head collapsed horizontally so that vertex overlies pedicels. Scales obviously missing from parts of vertex, though pattern and color of scales still discernible. Antennae broken, all flagellomeres beyond pedicels missing. Damage to thorax caused by original pinning. No. 1 insect pin pierces thorax, obscuring center of scutum and lower right pleuron. Area posterior to pin generally less rubbed of scales and setae than area anterior to pin. Missing portions of legs: left foretrochanter, forefemur, foretibia, and



Figs. 1–11. *Culex peus* Speiser, holotype. All scale bars are in millimeters. 1. Anterior side of hindleg (HT-4, 5 missing). 2. Posterior side of hindleg (HT-4, 5 missing). 3. Anterior side of midleg. 4. Posterior side of midleg. 5. Anterior side of foreleg. 6. Posterior side of foreleg. 7. Lateral view of head. 8. Dorsal view of head and thorax. 9. Dorsal view of abdomen. 10. Lateral view of thorax with small piece of abdominal tergite I. 11. Dorsal view of wing.

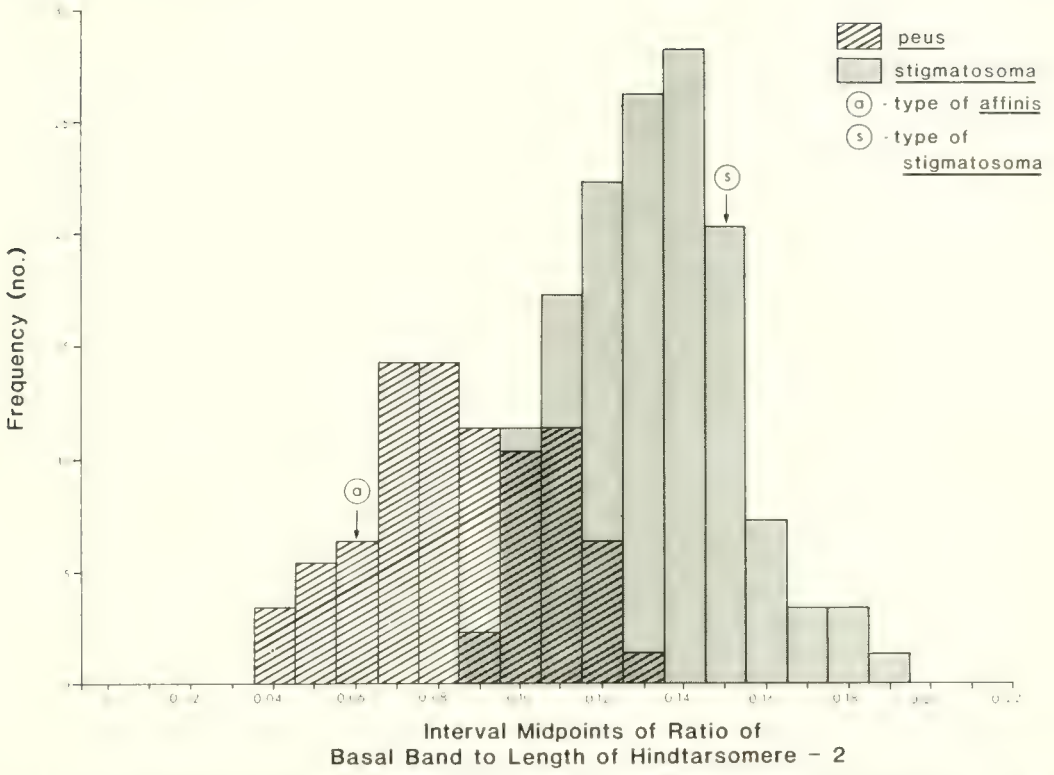


Fig. 12. Frequency distribution of the ratio of the width of the white basal band on hindtarsomere 2 to the length of hindtarsomere 2 on female *Culex peus* (n = 81) and *stigmatosoma* (n = 140) from the United States.

foretarsus; left midfemur, midtibia, and midtarsus; and left and right hindtarsomeres 4 and 5. Portions of abdomen rubbed, but scale patterns visible on all segments. Gravid condition of abdomen has stretched it in such a way that sternites hidden by paper of label, to which abdomen is glued.

Head: Palpomere 3 clothed in dark brown ($B_{99}Y_{70}M_{90}$) scales, broader on dorsal side than on ventral. Integument of each pedicel dark mesally. Scape about same color as lighter parts of pedicel. White decumbent scales of vertex and occiput narrow, flat, curved, and end in fine point. Broad scales on ocular suture and on postgena either truncate or rounded at tip. Erect, furcate scales on occiput and lateral potions of vertex. Integument of vertex medium brown ($B_{70}Y_{80}M_{80}$). Postocciput darkly pigmented on lateral edge and coronal suture.

Dorsum of thorax: Anterior promontory with 16 narrow, curved, flat, pointed white scales. Lateral scutal fossal scales white, similar to scales on anterior promontory but broader. Median scutal fossal scales yellowish, slightly curved, and uniformly wide along length. Supraalar scales and lateral prescutellar scales white, narrow, flat, curved, and pointed. All undamaged setae alike. Integument dark brown ($B_{90}Y_{70}M_{80}$) with darker brown ($B_{99}M_{30}C_{60}$) acrostichal area. Scutellar scales narrow, curved, white, and pointed; lateral scutellar scale groups (7 scales on left, 5 scales on right) smaller than median scutellar scale group (greater than 30 scales). Each lateral scutellar lobe with sockets for 5 large setae arranged in row of 4 ventrally and one dorsally. Insertions of 6 median scutellar setae in same plane. Integument of scutellum lighter than that of prescutellum.

Pleuron: Integument of pleural sclerites

light brown ($B_{00}Y_{70}M_{40}$) or dark brown ($B_{90}Y_{70}M_{80}$). Positions and shapes of setae as illustrated (Fig. 10). Antepronotum uniformly light brown; 11 broad, truncate, white scales on ventral portion. Postpronotum with narrow, curved, flat, pointed scales grouped on dorsal half of sclerite; most scales yellowish, dorsal few white; integument other than ventroposterior portion dark brown. Proepisternum light brown with white area just ventrad of setae. On mesanepisternum, postspiracular area with 8 broad, rounded, white scales; integument dark on post- and subspiracular areas, light on hypostigmal area. Mesokatepisternum with 21 broad, rounded, white scales; integument dark on most of ventral half and central portion of prealar knob; edges of prealar knob and of ventral half of mesokatepisternum light. Paratergite apparently lacks scales and setae (surface partially obscured by shrinkage of pleuron). Basalare, pleural wing process, and subalare with pale integuments. Two groups of broad, rounded, white scales on mesanepimeron; 12 scales in upper group, 11 scales in lower group. Integument dark in center, light on edges. Integument of mesokatepimeron, metepisternum, and metameron pale; mesomeron and mesotrochantin dark.

Wings: Scales of costa, subcosta, radius, and radius-one broad and either rounded or truncate; some broad scales paler than other scales. Clear membrane between veins minutely stippled. Knob of haltere clothed in minute pale scales; integument darker on knob than on stem.

Legs: Pale scales probably discolored with age (white on recently collected specimens of *Cx. peus*); others dark brown ($B_{90}M_{90}C_{90}$). Femora, tibiae, and tarsi illustrated (Figs. 1–6). Forecoxa with 14 small, round, white scales dorsally and inconspicuous scales ventrally colored like integument; on left side, ventral scales arranged in row below white scales, followed ventrally by loosely scattered scales; on right side, ventral group of scales more densely arranged than on left side. Foretrochanter with a few scattered small, light-colored scales on ectal surface; integument light except for darkening at apical margin. Midcoxa with 5 broad, white scales on middle of anterior surface. Trochanter with six light, broad scales on mesal surface; integument of posterior apical margin darkly pigmented. Hindcoxa has scattered broad white scales on ectal surface. Hindtrochanter with scattered light scales on mesal and ventral sides; integument darkened apically on mesal and ventral sides.

Abdomen: Pattern of white and dark scales as illustrated (Fig. 9). Integument appears to darken posteriorly on each segment.

Culex stigmatosoma Dyar

Culex stigmatosoma Dyar, 1907: 123, Pasadena, California, USA, ♀, USNM; Stone 1958: 236, synonymized under *peus*.

Culex eumimetes Dyar and Knab, 1908: 61, Orizaba, Mexico, ♂, USNM. **New Synonymy.**

Additional descriptions.—*Cited as* Cx. stigmatosoma: Dyar 1907 (♀, L). Howard et al. 1912, 1915 (♀, ♂G*, L*); Dyar and Knab 1917 (♂G, L); Dyar 1922 (♀); Freeborn 1926 (♀, ♂, ♂G*, L); Dyar 1928 (in part *peus*: ♀, ♂, ♂G*, L*); Aguilar 1931 (♂G, L); Martini 1935 (♀); Ripstein 1935 (♀*, ♂, ♂G*, L*); Aitken 1942 (Aitken's identification tentative: ♀, L); Galindo and Kelley 1943 (♀, ♂G, L); Rees 1943 (♀, ♂G, L); Freeborn and Brookman 1943 (♀, L); Matheson 1944 (♀, ♂G, L); Pierce et al. 1945 (♀); Martinez Palacios 1950 (in part *peus*: ♂G*); Freeborn and Bohart 1951 (♀, ♂G, L*); Usinger et al. 1952 (♀, L); Martinez Palacios 1952 (♂G*); Stage et al. 1952 (♀, ♂G*, L); Lane 1953 (in part *peus*: ♀, ♂G*, L*); Carpenter and LaCasse 1955 (♀*, ♂, ♂G*, L*); Breland 1957 (L*); Bohart and Washino 1957 (2nd and 3rd instars L*). *Cited as* Cx. eumimetes: Howard et al. 1912, 1915 (♀, ♂, ♂G*, L*); Dyar 1918 (♂, ♂G, L). *Cited as* Cx. peus: Dodge 1963 (L); Myers 1964 (L*); Forattini 1965 (♀, ♂G*, L*); Cova Gar-

cia et al. 1966a (♀, ♂G*); Cova Garcia et al. 1966b (L*); Chapman 1966 (♀, ♂G, L); Bram 1967 (♀, ♂G*, L); Gjullin and Eddy 1972 (♀, ♂G*, L*); McDonald et al. 1973 (F); Bohart and Washino 1978 (♀, L*); Darsie and Ward 1981 (♀*, L*).

Material examined (all adult females).—California: Los Angeles Co.: Pasadena, holotype, 21 May 1906, Dyar and Caudell coll. no. C78. Arizona: Cochise Co.: Douglas, 23 Aug 1939, T. K. Ryan, 2 ♀; Lowell, 2 Aug 1939, T. K. Ryan, 3 ♀; Tombstone, 1 Sep 1939, T. K. Ryan. Pima Co.: Lake Sabino Canyon, 17 Aug 1963, J. Burger coll. no. 399, 2 ♀; Tucson, Jul 1920 (UAz); Tucson, 9 Feb 1941, R. A. Flock (UAz). Santa Cruz Co.: 2 mi. W. of Patagonia, 24 Aug 1954, W. A. McDonald. California: Alameda Co.: Oakland, I. McCracken: 24 Jul 1903, 6 ♀; 26 Aug 1903, 4 ♀. Clear Lake Co.: Rocky Point, 9 Nov 1947, H. P. Chandler. Contra Costa Co.: Richmond, 3 Oct 1947, W. W. Wirth. Humboldt Co.: Fortuna, 13 Aug 1948, W. W. Wirth. Kings Co.: Hanford, 8 Jul 1947, W. W. Wirth. Los Angeles Co.: Bixby, 25 Jul 1949; Chilao Flat, San Gabriel Mts., 18 Aug 1955, C. L. Hogue, 5 ♀; Malibu, 17 Sep 1952; Malibu Beach, 30 Nov 1963, T. J. Zavortink coll. no. 487, 9 ♀; Malibu Beach, 17 Dec 1963, T. J. Zavortink coll. no. 488; Pasadena, 21 May 1906, Dyar and Caudell coll. no. C78, 11 ♀; Reseda, 25 May 1955. Marin Co.: Ft. Barry, 20 Sep 1957, Carpenter et al., 8 ♀; Lucas Valley, 10 Sep 1957, Carpenter et al., 9 ♀. Mariposa Co.: Mariposa Co., 20 May 1960, A. R. Barr, 5 ♀. Merced Co.: Snelling, R. M. Bohart. Monterey Co.: Monterey, 10 Aug 1945. Orange Co.: Alyso Canyon, 10 Oct 1952, J. N. Belkin coll. no. 91, 16 ♀; Buelia Park, 22 Jul 1949, 6 ♀; Buena Park, 6 Jun 1949, 3 ♀; Buena Park, 22 Jul 1949, 2 ♀; Huntington Beach, 17 Jul 1949; Irvine Park, 24 Jun 1949; Laguna Beach, 4 Jun 1949; Orange Co., 23 Jul 1950; San Juan Capistrano, 29 Jul 1949; Santa Ana, 2 Jun 1949; Santa Ana, 22 Jul 1949, 2 ♀. San Diego Co.: San Diego, H. G. Dyar: 10–18 Apr 1916, coll. no. C, 4 ♀; 17 Apr 1916, coll. no. C7, 2 ♀; 17 Apr 1916, coll. no. ABC, 2 ♀; 5 May 1916. Santa Clara Co.: Mt. View, 15 Jul 1903, I. McCracken; Stanford, I. McCracken: 26 May 1903, 5 ♀; 27 May 1903, 3 ♀; 8 Jul 1903; 10 Jul 1903; Stanford, 15 Jul 1961, A. L. Melander. Solano Co.: Vacaville, 4 Jul 1949, R. M. Bohart. Tulare Co.: Coffee Canyon, Tulare River, 29 Jul 1947, W. W. Wirth. Ventura Co.: Lake Sherman, 17 Sep 1952, J. N. Belkin. Oregon: Curry Co.: Harbor, 8 Oct 1944, W. W. Yates.

Diagnosis.—See diagnosis for *Cx. peus.*

Remarks.—The holotype (Stone and Knight 1957) of *Cx. stigmatosoma* is a female adult from Pasadena, California, collected by H. G. Dyar in 1906 and part of a long series of reared specimens. The type is in excellent condition and conforms completely to the diagnosis of *Cx. stigmatosoma.* Larvae and male genitalia from the same collection fit descriptions of these stages in recent literature.

The lectotype of *Cx. eumimetes* is a male selected by Stone and Knight (1957) from a series of 10 originally collected by Knab in 1908 in Orizaba, Mexico. The genitalia of the lectotype are not mounted, but the appearance of the specimen is consistent with other male *Cx. stigmatosoma.* The mounted genitalia from one of the other 10 specimens in the original series (no. 437.2) is definitely that of *Cx. stigmatosoma* based on the presence of seta d on the subapical lobe of the gonocoxite (Bram 1967).

Discussion

Examination of specimens from the United States showed that adult females of *Cx. peus* and *Cx. stigmatosoma* are usually distinguishable by the proboscis band (usually incomplete in *Cx. peus,* complete in *Cx. stigmatosoma*), white scales on the palpi (absent in *Cx. peus,* present in *Cx. stigmatosoma*), a dark band in the middle of hindtarsomere 5 (usually absent in *Cx. peus,* present in *Cx. stigmatosoma*), and the width of the basal band on hindtarsomere 2 (nar-

rower in *Cx. peus,* wider in *Cx. stigmatosoma*). The only constant character for separating the female adults of the species was presence or absence of white scales on the palpi. The other three characters were useful, however, because very few individuals had more than one of the other 3 character states from the opposite species.

The holotype of *Cx. peus* (= *affinis*) was more similar to material formerly designated *Cx. thriambus* and dissimilar to the holotype of *Cx. stigmatosoma.* Adams (1903) described hindtarsomere 5 on *Cx. affinis* as all white, a character state present in the majority of *Cx. peus* (formerly *thriambus*) specimens and never present in *Cx. stigmatosoma.* Also, the holotype of *Cx. peus* lacks the white scales on the palpus always associated with *Cx. stigmatosoma* and never associated with *Cx. peus.* Finally, the width of the basal band on hindtarsomere 2 is within the range of *Cx. peus* and outside the range of *Cx. stigmatosoma* (Fig. 12). Adams (1903) implied that the proboscis band of the holotype of *Cx. peus* was complete, a condition more typical of *Cx. stigmatosoma,* but commonly present in individuals of *Cx. peus.*

Previous descriptions mentioned some of the characters used to identify the holotype of *Cx. peus.* The descriptions attributed a complete proboscis band to *Cx. stigmatosoma* and, with only two exceptions (Dyar 1921, Martinez Palacios 1950), an incomplete proboscis band to *Cx. peus.* Since *Cx. peus* often has a complete proboscis band (Table 1), the use of this character to separate *Cx. stigmatosoma* and *Cx. peus* has probably led to misidentifications. The presence of light and dark bands on the hindtarsus has also been treated in past descriptions and these descriptions agreed with the findings presented here, though none quantified either the proportion of *Cx. peus* with HT-5 all white or the width of the light hindtarsal bands. Some (Freeborn 1926, Ripstein 1935, Carpenter and LaCasse 1955, Bram 1967, and McDonald et al. 1973) described the white scales on the palpi of female adult *Cx. stigmatosoma,* contrasting them with the lack of white scales on the palpi of *Cx. peus.* Significantly, McDonald et al. (1973) made this distinction between the species in the state where the holotype of *Cx. peus* was collected, lending support to the importance of this character in the type locality.

Geographic distribution of the species in Arizona and Utah supports the nomenclatorial changes made in this paper. *Culex stigmatosoma* is restricted to the southern part of Arizona in Yuma, Pima, Pinal, Santa Cruz, and Cochise counties (McDonald et al. 1973), well south of the type locality of *Cx. peus* in Oak Creek Canyon, Coconino County. Records of *Cx. stigmatosoma* in Utah (Dyar 1928) were apparently false, as the species has never been collected in the state despite extensive collecting (L. T. Nielsen, personal communication) and Dyar's original specimens are lost. *Culex peus,* on the other hand, occurs throughout much of Arizona, extending north through Coconino County (McDonald et al. 1973) all the way to Washington County in southern Utah (Nielsen and Linam 1963).

Acknowledgments

The University of Arizona and the University of Kansas for lending specimens; Smithsonian Archives for searching for H. G. Dyar's notes and letters; M. Sanderson for visiting the type locality of *Cx. peus;* E. L. Peyton, B. A. Harrison, and L. T. Nielsen for helpful comments on taxonomy; R. A. Ward and R. C. Wilkerson for helpful comments on the manuscript; and Taina Litwak for preparing the figures. Opinions and assertions contained herein are the private views of the author and are not to be construed as official, nor as reflecting the views of the supporting agencies.

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PROC. ENTOMOL. SOC. WASH.
90(4), 1988, pp. 495–500

WORKER SIZE AND PIRACY IN FORAGING ANTS

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Abstract.—Foraging ants (1.8 to 12 mm long) vied for small (≤3.2 mg, ≤1.5 mm) cheese baits of two sizes. Small ants succeeded in gathering only the smaller baits. Although small ants found the larger baits first ca. 50% of the time, they always lost the large baits to solitary foragers of larger species. Small baits were generally gathered by the first species to find them with the smallest (≤2 mm long) ants successful in ca. 80% of the cases. Recruitment was of no consequence in the success of these encounters. Control of baits was exchanged only to species of ants of equal, or, more often, larger size. The largest species, *Camponotus pennsylvanicus*, never foraged the small baits.

The niche of the small (<2 mm long) species of ants appeared to be defined in part by consistently unsuccessful confrontations with individual foragers of larger species for discrete food particles of a certain size range (i.e. too large or cumbersome for a solitary forager of a small species to carry easily, but easily carried by individuals of a larger species). The pirating of food items by solitary foragers may be an important part of the foraging repertoire of many medium-sized and large ants.

Key Words: baits, *Camponotus, Aphaenogaster, Myrmica, Leptothorax, Tapinoma, Paratrechina*

Ants exploit a variety of food resources (e.g. honeydew, seeds, and living and dead invertebrates) and, according to Carroll and Janzen (1973), forage primarily for particulate and widely scattered food items. If small enough, items are garnered by solitary foragers, while recruitment is important in foraging for items too large or cumbersome for an individual ant to carry by itself. The size of food items taken by various insect species has been found to be related to the overall size of the insect or the dimensions of its food gathering organs (Hespenheide 1973, Wilson 1975). Such size-match relationships are known among the Formicidae (Davidson 1977a, b, Bernstein 1979, Wilson 1978), but may not be universal in the family (Rissing and Pollock 1984).

Larger ants can take food particles of a greater size range than small species, resulting in overlap of dietary resources (Chew and DeVita 1980). Direct interspecific competition by foragers for large baits has been well documented (e.g. Levins et al. 1973). Field observations of single foragers of large ant species wresting food items (primarily dead arthropods) from groups of several workers of small species prompted this investigation of the frequency of this sort of competition.

MATERIALS AND METHODS

Observations were made at two sets of bait stations at Beltsville, Maryland. One set of 10 bait observation sites was on an infrequently used sandy road through an

upland Virginia pine, *Pinus virginiana*, and mixed xerophilous oak woods, while the second set of 10 stations was along a path through a more mesic woods of mixed hardwoods (mostly oaks). Mosses, grasses, herbs and sapling trees and shrubs grew between the wheel ruts, but there was little litter on the sandy road. The path was more shaded and leaf litter plentiful. Bait stations were a minimum of 10 m apart. Studies were conducted May–September, 1200 to 1800 h EDT.

Cheese cubes of two sizes ($\bar{x} = 3.2 \pm 0.21$ mg [n = 10] ca. 1 × 1 × 1 mm and $\bar{x} = 0.52 \pm 0.20$ mg [n = 10], ca. 0.5 × 0.5 × .50 mm) served as baits. At each station a large cube was dropped without respect to locations of foraging ants, but so that I could observe it. I observed the ensuing bait-related ant activity until the bait was carried into an ant nest. This procedure was repeated, using the smaller baits. Entrances of some ant nests were hidden beneath leaf litter. In such cases, I waited ca. 3 min after an ant with a bait disappeared in the litter, and then I brushed away the litter to find the nest entrance. The distances ants carried baits were measured. I recorded the species of ants involved in the fates of the cubes and the type and sequence of the activities. These bait drops were made in June and July between 1215 EDT and 1715 EDT with temperatures of 24 to 33°C.

Additional random drops, elsewhere along the road and in the woods brought the total number of bait stations to 31 for small baits and 29 for large baits on the road and 20 for small baits and 32 for large baits in the woods. To further verify the patterns of foraging success observed with the bait drops, additional baits were placed in the paths of foragers of species more commonly involved in the random drops. All the additional drops were between 1215 and 1800 EDT at 24–33°C, but over a longer period, May–September. While ants may exhibit species-specific patterns in their daily foraging periods, the cast of characters, observed during the daily and late May–early September time frames of this study, nevertheless remained remarkably constant. *Prenolepis imparis* (Say), a dominant species in cooler seasons was commonly seen at the sites during those times, but was never involved in the observations reported here.

The ant species were classified according to size as Class I (≤4 mm long), II (>4 and ≤8 mm), III (>8 mm). The ants were measured in an extended position from the frons to the tip of the gaster. Samples of each species were collected for identification. The species composition of the ant fauna of the wooded and road sites was similar with the pertinent exceptions that *Aphaenogaster treatae* (Forel) was strictly limited to the road, and the *A. rudis* (Emery) to a lesser degree to the woods, and that the Class III *Camponotus pennsylvanicus* (DeGeer) was also more prevalent in the woods.

The frequencies with which ant species were first to find baits and frequencies of successfully removing baits were analyzed by Chi square contingency tables. Ant specimens were identified by D. R. Smith, the U.S. Department of Agriculture Systematic Entomology Laboratory, U.S. National Museum of Natural History, Washington, D.C.

Results

Small baits both on the road and the path were never found first by the largest ants (Class III), whereas, the smallest species (Class I) were first to find both large and small baits significantly more often than the other size classes ($P < 0.05$) (Table 1). There was no significant difference ($P > 0.05$) in the frequency with which Classes II–III found large or small baits (Table 2). On only 2 of 20 occasions Class III species were the first to find the large baits.

Although Class I species were first at baits for >50% of random drops, they never succeeded in gathering a larger bait, nor did they remove fragments visible to the naked eye from the larger baits. In every instance

Table 1. The size classes of ant species which were first to find cheese baits randomly dropped with respect to foraging ants.

Subfamily	Species	Size Class	First to Find					
			Small Bait			Large Bait		
			Road	Woods	Total	Road	Woods	Total
Myrmicinae								
	Myrmica pinetorum (Wheeler)	II	2	1	3	2	1	3
	M. emeryana (Forel)	II	6	5	11	7	8	15
	Aphaenogaster rudis (Emery)	II	2	0	2	1	1	2
	A. treatae (Forel)	II	0	0	0	4	0	4
	A. sp. A	II	0	1	1	1	2	3
	Pheidole bicarinata vinelandica (Forel)	I	1	0	1	0	0	0
	P. pilifera (Roger)	I	1	0	1	0	0	0
	Leptothorax curvispinosus Mayr	I	3	2	5	2	3	5
Dolichoderinae								
	Tapinoma sessile (Say)	I	3	1	4	1	1	2
Formicinae								
	Paratrechina parvula (Mayr)	I	12	9	21	10	11	21
	Lasius alienus (Foerster)	I	1	1	2	1	0	1
	Camponotus pennsylvanicus (DeGeer)	III	0	0	0	0	2	2
	Formica pallidefulva nitidiventris Emery	II	0	0	0	0	1	1
	F. subsericea Say	III	0	0	0	0	2	2
			31	20	51	29	32	61

[a] Small bait ca. 0.5 mg, ca. 0.5 mm^3; large bait ca. 3.2 mg, ca. 1.5 mm^3.
[b] Class I ≤4 mm long, Class II >4 and ≤8 mm long, Class III >8 mm long.

solitary foragers of larger species pirated the baits from Class I ants, even when as many as 5 of the smaller ants were present. Recruitment of co-workers was of no consequence in the final outcomes of these trials. Occasionally a Class II forager relinquished a large bait to a solitary large forager of another species.

On the other hand, the ant to initially discover a small bait, usually successfully carried the bait to its nest. Class I species *Paratrechina parvula* (Mayr) successfully foraged all nine small baits it was first to find on the road and 7 of 8 of the small baits in the woods, while *Lepotothorax curvispinosus* Mayr garnered 1 of 2 small baits on the road and 2 of 3 in the woods. *Tapinoma sessile* (Say) relinquished the only small bait it found to *P. parvula*. Class II species were always successful in garnering the smaller baits when they were first to find them. For baits on the sandy road or on leaf litter along the path, the foraging success results were similar. *Myrmica emeryana* (Forel) (Class II) foragers were first to the large baits in just 3 of 20 random drops, but garnered them 10 times.

Class I species *P. parvula, L. curvispinosus,* and *T. sessile* relinquished large baits when they were first to find them in all of 20, 5 and 2 instances respectively. Whereas Class II species *M. emeryana, Aphaenogaster treatae* and *A. rudis* successfully foraged large baits on 7, 4 and 4 instances respectively. In about half the observations, three or four species of ants were involved in the fate of large baits (Table 3). Typically, when a forager of a small species (e.g. *P. melanderi*) was the first ant to find a large bait, it palpated and tugged at the bait. Unable to move the bait, the ant would repeatedly move 1 to 3 cm from the bait, only to return in a few seconds and repeat the palpating and tugging. In a few instances, the ant would

Table 2. Fates of two sizes of cheese baits foraged by three size-defined class worker ants of various species.

Bait Size[a]	Stations[b]	Size Class of Ants	No. Times First to Find Bait	No. Times Successfully Foraged Bait
Small	Road	I	7A	7A
		II	3A	3A
		III	0B	0B
	Woods	I	6A	6A
		II	4A	4A
		III	0B	0B
	Road and Woods	I	3A	13A
		II	7A	7A
		III	0B	0B
Large	Road	I	6A	0A
		II	4A	9B
		III	0B	1A
	Woods	I	4A	0A
		II	5A	8B
		III	1B	2A
	Road and Woods	I	0A	0A
		II	9A	17B
		III	1B	3A

[a] Small bait ca. 0.5 mg, ca. 0.5 mm^3, large bait ca. 3.2 mg, ca. 1.5 mm^3.

[b] Ten bait drops each on road and in woods.

[c] Class I ≤4 mm long, Class II >4 mm and ≤8 mm long, Class III >8 mm long.

[d] Numbers in the same column, pertaining to the source bait size and station, and followed by the same letter are not significantly different (Chi square contingency tables, $P < 0.05$).

leave and not return and fewer still were instances of recruitment of nestmates. However, a forager of one of the larger species generally arrived while the small forager was alone at the bait. The larger ant wandered to within about 1 cm of the bait before it turned abruptly toward the bait. The interloper often seized the bait, or when necessary, tore it from the grip of the smaller ant, and carried it directly nestward. Other times the larger ant nipped the smaller one, particularly if the latter accidentally or aggressively interfered with the larger ant seizing the bait. Such brief attacks drove away the smaller species even when two or three of them were at the bait; nor did the smaller ants pursue the interloper as it carried the cube nestward.

Table 3. Sequence of control of large baits by ant species and speed and distance baits were carried to ants' nests.[a]

Station	Sequence of Species Controlling Bait[b]	Distance Bait Carried (cm)[c]	Time Bait Carried (min)[c]	Speed Bait Carried (cm/min)[c]
Road	PP, MP, PP, AT	91	8.0	11.4
Road	PP, TS, PP, TS, PP, TS, ME	127	5.0	25.4
Road	AT	36	1.0	35.6
Road	ME	122	4.0	30.5
Road	TS, MP, TS, LC, TS, MP, MP, AT	61	1.5	40.7
Road	AT	229	2.0	114.3
Road	ME	168	8.0	21.0
Road	LC, MP, ME	86	3.0	28.8
Road	PP, ME	122	7.0	17.4
Road	PP, AT	130	0.8	155.4
Woods	CP,[d] PP, ME	196	4.5	43.3
Woods	FP,[d] LC, CP	1128	6.5	173.5
Woods	LC, ME	97	1.5	64.4
Woods	LC, PP,[e] ME	71	2.5	28.5
Woods	PP, ME	48	3.0	16.1
Woods	PP, AR	46	1.0	45.7
Woods	AS	30	5.75	5.3
Woods	FS, ME, CP	549	1.25	438.9
Woods	AR, CP,[e] AR	104	1.5	69.4
Woods	ME	117	2.5	46.7

[a] Baits ca. 3.2 mg, ca. 1.5 mm^3.

[b] Abbreviations for ant species: AR = *Aphaenogaster rudis*, AS = *A.* sp., AT = *A. treatae*, CC = *Camponotus castaneus*, CP = *C. pennsylvanicus*, FP = *Formica p. nitidiventris*, FS = *F. subsericea*, LC = *Leptothorax curvispinosus*, ME = *Myrmica emeryana*, MP = *M. pinetorum*, TS = *Tapinoma sessile*, PP = *Paratrechina parvula*.

[c] By the last ant that took control of the bait and brought the bait to its nest.

[d] Abandoned bait.

[e] Attacked ant at bait, but did not gain control.

Discussion

The 0.5–3.2 mg, 0.5–1.0 mm range appeared to be the lower limit of food particle size at which relative forager size/strength operated as a significant factor in the outcome of competitive foraging for this assemblage of ant species and type of food. Success in foraging for items smaller than this threshold size appeared to be more dependent on a forager's ability to find a food item before competitors. Unwieldiness of food items (arthropods with appendages in-

tact) probably effectively creates the same sort of strength related barrier to foraging ants. Studies with larger baits (e.g. Levins et al. 1973, Lynch et al. 1980) suggest that there is a food item size threshold above which the largest species must resort to recruitment to efficiently exploit the item (Oster and Wilson 1978). Such large food items are therefore subject to multi-species use before one colony can dominate or later through pilfering by small species.

For large food items multi-species use is likely and small items are more apt to be gathered by individual small ants rather than very large foragers. However, there may not be a smooth ant size/bait size usage gradient between the extremes, because small ants may derive little or no food material from particles that are too large for their individual foragers to carry easily, yet which are readily pirated by solitary foragers of common large species.

In terms of energetics, it seems inefficient for a small ant to consistently compete unsuccessfully for a resource (i.e. food items like the large cheese baits). One explanation may be that the minimal quantity a worker manages to remove in her infrabuccal pocket before the food item is lost is a worthwhile payload. Also, food items of the dimensions of the large cheese baits may be scarce in natural conditions and thereby represent an abnormal situation. However, baits of both sizes did approximate the sizes of many small invertebrates, which might die of a variety of causes (e.g. drowned by a down pour). Certainly the relative size distribution of available foods is of utmost importance in the natural environment (Wilson 1975).

The pirating of food items from rather ubiquitous smaller ants by solitary foragers may be an important behavior in some larger species (e.g. *Aphaenogaster* spp., *Myrmica emeryana*). In this study, *A. treatae* successfully foraged more large baits (6) by seizing them from smaller ants, than by being the first to find them (4), while *M. emeryana* pirated 8 large baits and garnered 12 which they found first. Foragers of regularly interloping species may have been aided in detecting baits by the activity of the smaller ants already at the baits.

According to Oster and Wilson (1978), the main disadvantage to reliance on recruitment is the time it consumes. In this study recruitment occurred infrequently, and with no more than 3 to 5 workers of *P. parvula* at a bait at one time. Recruitment rates have been related to food patch size and sucrose content (Taylor 1977). Perhaps the size or content of the cheese baits used in this study were not attractive enough to elicit strong recruitment, although the small baits were gathered by the first species to find them. Lynch et al. (1980) reported that *P. melanderi* (Wheeler) showed greater recruitment to sugar baits. In the case of food items similar in size and attractiveness to large baits, it might be inefficient for small ant species to recruit and mobilize several workers only to lose virtually the entire food items to unrelated ants.

Based on their bait studies, Lynch et al. (1980) considered *P. melanderi* and *L. curvispinosus* as timid ants and *Prenolepis imparis*, an aggressive dominant speices. *P. imparis* was common at the site of this study, but since most of the trials were conducted in mid-summer, this species, which is more active in cooler weather, was not actively involved. According to Lynch et al. (1980), a single *P. imparis* worker can hold its own at a bait against the large *A. rudis*. No smallish ant seemed to fit this role in this study. A detailed investigation of paired interspecific interactions for control of small baits might explain competitive relationships in assemblages of ant species.

Acknowledgment

I thank Dr. R. Smith of the Systematic Entomology Laboratory, Biosystematics and Beneficial Insects Institute, U.S. Dept. of Agriculture, U.S. National Museum of Nat-

ural History, Washington, D.C. for identifying some of the ants involved in this study.

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PROC. ENTOMOL. SOC. WASH.
90(4), 1988, pp. 501–507

HOST SPECIFICITY OF ADULT *EUSTENOPUS HIRTUS* (WALTL) (COLEOPTERA: CURCULIONIDAE), A POTENTIAL BIOLOGICAL CONTROL AGENT OF YELLOW STARTHISTLE, *CENTAUREA SOLSTITIALIS* L. (ASTERACEAE, CARDUEAE)

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Abstract.—Host specificity of the flower head weevil *Eustenopus hirtus* (Waltl) was investigated in Italy and supported its potential and safety as a biological control agent for yellow starthistle, *Centaurea solstitialis* L., in the United States. Adults damaged yellow starthistle by feeding on young buds and larvae consumed developing seeds. In the laboratory, adults fed and damaged capitula of several test plants but females oviposited only on *C. solstitialis* and two congeneric species. Females experienced little or no oocyte development when confined to plants other than *Centaurea*.

Key Words: weevil, bud-feeding, seed-feeding

Yellow starthistle, *Centaurea solstitialis* L. (Asteraceae, Cardueae), is a winter annual or biennial plant of Eurasian origin that has become a major threat to rangelands in the western United States (Callihan et al. 1982, Maddox et al. 1985, Maddox and Mayfield 1985, Roché et al. 1986). In the late 1950's, weed biocontrol workers began surveying southern Europe to find potential biological control agents for yellow starthistle and other weedy *Centaurea* (Zwölfer 1965, Zwölfer et al. 1971, Sobhian and Zwölfer 1985, Clement and Mimmocchi 1988). To date, two natural enemies of *C. solstitialis* in Europe have been found safe for introduction into the U.S. but only one of these, the flower head weevil *Bangasternus orientalis* (Capiomont) (Coleoptera: Curculionidae), has become established on the plant in the U.S. (Maddox et al. 1986).

One of the first insects we considered as a new biocontrol agent to supplement the action of *B. orientalis* was *Eustenopus hirtus* (Waltl) (Coleoptera: Curculionidae), a capitulum-infesting weevil that Sobhian and Zwölfer (1985) indicated (cited as *E. abbreviatus* Faust) was probably restricted to *C. solstitialis* in Greece. These workers also reported that hibernating adults of this univoltine weevil become active in late May or June in northern Greece and lay eggs in well-developed buds of *C. solstitialis*. Moreover, they reported that a single larva destroys almost all of the achenes in a small head. Near Thermi, Greece, we have observed beetles feed on small, young buds (Bu stages 1–2), copulate on mid-size, older buds (Bu 3–4), and lay eggs in the largest and most mature closed buds (Bu 4) of *C. solstitialis* (see Maddox 1981 for description of floral bud [Bu] stages).

Csiki (1934) recognized a number of subgenera in the weevil genus *Larinus* of the subfamily Cleoninae, tribe Lixini, including

Fig. 1. Adult *Eustenopus hirtus* and the yellow starthistle bud (Bu 2) it fed upon. Arrow indicates the damaged and withered bud.

the subgenus *Eustenopus*. However, Ter-Minasyan (1978) and other workers (M. L. Cox, pers. comm.) recognized *Eustenopus* as a valid genus. In addition to *E. villosus* (Boheman) (= *E. hirtus*), Ter-Minasyan (1978) listed two other species, *E. lanuginosus* Faust and *E. abbreviatus*.

Eustenopus hirtus is about 4–7 mm long with white longitudinal stripes on its elytra and is covered with long, erect hair-like setae (Fig. 1). It is recorded from Greece, Turkey, the Caucasus, Syria, and Iran (Ter-Minasyan 1978, Sobhian and Zwölfer 1985). In the literature, only *C. solstitialis* is recorded as a host plant of *E. hirtus* (Sobhian and Zwölfer 1985). The insect is not recorded from any crop plant in Europe, the Middle East, or western Asia (Review of Applied Entomology [Series A, 1913–1986], Zoological Record [1950–1971], Grandi 1951, Hoffman 1954, Bonnemaison 1962, Balachowsky 1963, Scherf 1964, Avidov and Kotter 1966, Ter-Minasyan 1978, Fremuth 1982, Petney and Zwölfer 1985). Ter-Minasyan (1978) reported that *E. lanuginosus* was "found on" *Cousinia* (Compositae) in Kazakhstan, USSR.

After we found *E. hirtus* on *C. solstitialis* in areas of Greece and Turkey with climates similar to North American sites infested with the weed, we initiated laboratory studies at the USDA-ARS Biological Control of Weeds Laboratory-Europe (BCWLE) in Rome, Italy, to learn more about the adult reproductive behavior and host range of this species. The results of these investigations are presented in this paper.

Materials and Methods

Test plants and insects.—Plants taxonomically related to *Centaurea solstitialis* (family Asteraceae; tribes Heliantheae, Cardueae [Cynareae], and Cichorieae) were used in host-specificity tests, and were chosen with 4 features in mind: (1) related weedy species—*Onopordum acanthium* L.; *Carthamus lanatus* L.; *Carthamus dendatus* (Forskal) Vahl; *Cirsium arvense* (L.) Scop.; *Centaurea nicaeensis* All; *Centaurea diffusa* Lam.; *Centaurea cineraria* L.; *Cnicus benedictus* L.; *Galactites tomentosa* Moench; *Cichorium intybus* L.; *Scolymus hispanicus* L.; (2) related crop plants—*Carthamus tinctorius* L., 'Hartman' safflower; *Cynara scoly-*

mus L., 'Green Globe' artichoke; *Helianthus annuus* L., 'Parendovik' common sunflower; *Lactuca sativa* L., 'Bibb' lettuce; (3) U.S. native plants in the Cardueae—*Cirsium undulatum* (Nutt.) Spreng.; *Cirsium douglasii* DC.; *Centaurea americana* Nutt.; and (4) Palaearctic and Nearctic populations of the target weed—*Centaurea solstitialis* L. grown from seed collected in Thermi, Greece, Rome, Italy (control plants), and Walla Walla and Yakima, Washington (U.S.). Since breeding hosts of species closely related to *E. hirtus* are unknown, we did not consider this factor in the selection of test plant species.

Entomologists (USDA, ARS) in Albany, California provided seed of U.S. *Cirsium* spp., *Centaurea americana, Carthamus tinctorius,* the Washington forms of *Centaurea solstitialis,* and rootstock of *Cynara scolymus.* Other test plant species were grown from young plants field collected in Italy and Greece and from seed obtained in the wild or from European botanical gardens. Whenever possible, test plants were allowed to flower and herbarium specimens were deposited in the collection of the BCWLE.

Reproductively active beetles were hand-collected from *C. solstitialis* in northern Greece, near the village of Doirani and on the southern outskirts of Thessaloniki, in June 1985 and 1986. In 1985 and 1986, 275 and 407 beetles respectively survived the air shipments to Rome and were allowed to feed on closed *C. solstitialis* buds (Bu 1–4) for at least 48 hours before they were selected for host-specificity tests. Groups of teneral beetles, reared from *C. solstitialis* capitula collected in central Greece (Xiniada) in August 1984 and northern Greece (Thermi) in July and August 1985, were allowed to overwinter in cages at the BCWLE so pre-reproductive beetles would be available for feeding, mating, and oviposition behavior studies in spring 1985 and adult feeding and specificity studies in May 1986. No external morphological differences were found between the sexes, so males and females were selected from mating pairs in holding containers.

Feeding and reproductive behavior.—Adult feeding and reproductive behavior were investigated by offering beetles a progression of *C. solstitialis* growth stages as they would normally appear in the field in northern Greece. Eight unsexed beetles (4 beetles and one plant per covered 500 cm^3 cardboard carton) were first exposed to rosettes from March 5–April 28, then to bolting plants from April 29–May 7. Twice a week, these plants (roots held in water-filled vials plugged with cotton) were replaced with fresh ones from a garden at the BCWLE. On May 8, the eight beetles were placed in a cage (clear plastic cylinder [diameter 20 cm; length 70 cm] with nylon organdy cover) which enclosed a potted plant with Bu 1 buds, and on May 22 these heavily feeding beetles were transferred to another plant with Bu 1 buds. By June 4, this plant supported all closed bud stages (Bu 1–4) and flowering buds. Cartons and cages were observed at least once but usually several times a day to record beetle feeding, mating, and oviposition.

The reproductive rate (number of eggs laid over time) of females was measured by placing a mating pair of beetles in each of five cages (500 cm^3 carton) for 18 days and counting the number of eggs laid per female every three days when the *C. solstitialis* buds were replaced with fresh ones. The oviposition substrates were two Bu 2, two Bu 3, and two Bu 4 buds, with their stems held in a water-filled vial. If a male died during this study, it was replaced.

Host specificity tests.—Adult feeding and ovipositional specificity, and mortality, were measured under "no-choice" (tests 1–4; one plant species per cage) and two choice (test 5; two plant species per cage) test conditions. In tests 1 and 2, each nylon organdy sleeve cage (diameter 14–20 cm; length 30–42 cm) contained 2–9 beetles (1–4 females) and branches of mature buds of one test

plant species. Each plant species was represented by 1–15 potted plants. Data were recorded for each plant as soon as it started to flower (after 3–11 days). Plants tested are listed in Table 1. In test 3, each cardboard cage (covered 500 cm^3 cartons) contained a mating pair of beetles and *Centaurea solstitialis* (Rome population) buds (one each Bu 2, 3, and 4) or one closed bud (diameter 10–15 mm) of *Carthamus tinctorius*. There were 20 cartons per plant species. Every three days during this 15 day test, buds (stems held in water-filled vials) were replaced with fresh ones from potted, greenhouse-grown plants. If a male died during this test, it was replaced with a new one. In contrast to tests 1–3, pre-reproductive beetles were used in test 4. For this test, two unsexed beetles were confined to each nylon sleeve cage for 15 days. Each cage enclosed branches of closed buds of one test plant species (*Centaurea solstitialis* [Rome population], *Centaurea nicaeensis, Centaurea cineraria, Galactites tomentosa,* or *Onopordum acanthium*). There were five potted plants of *Centaurea solstitialis* and three of each of the other plant species. In test 5, beetles (two males and two females per sleeve cage) were allowed to choose between buds of *Centaurea solstitialis* (Thermi, Greece population) and buds of another plant species for nine days. Branches from each potted plant supported all degrees of bud development. There were five replications of each of the four *Centaurea solstitialis*-test plant combinations listed in Table 2.

At the end of the tests, or every three days in test 3, beetle mortality was recorded, and buds were examined for feeding damage and eggs. Feeding damage was classified in four ways: (−), no feeding or very slight nibbling on buds; (+), light to moderate feeding, some buds with two or more feeding punctures; (++), moderate to heavy feeding, less than ⅓ of buds riddled with feeding punctures; and (+++), heavy feeding, more than ⅓ of buds riddled with punctures. All dissected females in tests 2 (n = 50) and 3 (n = 20) were examined to determine egg maturation associated with each test plant.

All studies were conducted in the BCWLE quarantine greenhouse under temperatures of 16–33°C, 35–85% RH, and natural daylight. Twist-ems® were used to close the ends of nylon sleeve cages in tests 1, 2, 4, and 5, and to bundle branches from separate potted plants in test 5.

Results

Feeding and reproductive behavior.—When beetles were offered a progression of *C. solstitialis* growth stages between March 5 and June 10, no feeding of any consequence took place until beetles were exposed to Bu 1 buds on May 8. The beetles continued their heavy feeding on all closed bud stages (Bu 1–4) until the end of the study on June 10. From June 4–10, mating occurred only on Bu 3 and 4 buds, and oviposition occurred only on Bu 4 buds. Beetles did not feed on or oviposit in flowering buds.

The mean (±SE) number of eggs laid by five females during six consecutive three-day periods was 2.83 ± 0.52, 3.67 ± 0.61, 3.67 ± 0.67, 3.17 ± 0.52, and 3.67 ± 0.37 ($F = 0.59$; df = 4, 25; means are not significantly different, $P > 0.05$). The five females died on July 20 (n = 2) and 26 and August 3 and 13 after laying 18, 23, 28, 34, and 60 eggs, respectively.

Host specificity tests.—Although adult feeding was moderate to heavy on most plants in tests 1 and 2, beetles oviposited only in Bu 4 buds of *Centaurea solstitialis,* and mature closed buds of *Centaurea nicaeensis* and *Centaurea diffusa* (Table 1). Only two larvae were found in *Centaurea diffusa* buds and these died before molting to second instar. Beetle mortality was significant (60–100%) on all plant species except *Centaurea solstitialis, Centaurea nicaeensis, Centaurea americana,* and *Cirsium douglasii* (Table 1). In test 2, dissections of 50 females revealed oocyte development, albeit rudimentary, in only two females, one

Table 1. Synopsis of host specificity screening of *Eustenopus hirtus* adults allowed contact with only one plant species (tests 1 & 2), June–July, 1985–1986, Rome, Italy.

Plant Species	Test No.	Total No. of Plants	Total No. of Closed and Flowering Buds	Total No. of Beetles[1]	Amount of Bud Feeding[2]	No. Found in Buds: Eggs	No. Found in Buds: Larvae	No. Days Beetles Confined to Plants	Beetle Mortality (%) During Test
Centaurea solstitialis Greece	1 & 2	12	105	36 (18)	+++	54	14	6–10	16.67
Centaurea solstitialis Washington State, US	1	3	18	6 (3)	+++	3	4	10–11	33.3
Centaurea nicaeensis	1 & 2	8	73	26 (13)	++	12	12	4–10	11.54
Centaurea diffusa	1	5	203	10 (5)	+++	0	2 (dead)	7–8	60.0
Centaurea americana	2	5	23	20 (10)	+++	0	0	9–10	0.0
Carthamus tinctorius	1 & 2	15	72	56 (28)	++	0	0	3–10	76.79
Carthamus lanatus	1	5	57	19 (8)	+	0	0	4–7	100.0
Carthamus dentatus	1	5	43	22 (12)	−	0	0	4–6	100.0
Cynara scolymus	1	1	1	9 (4)	+	0	0	5	100.0
Helianthus annuus	1	3	10	6 (3)	−	0	0	4–7	100.0
Lactuca sativa	1	3	141	6 (3)	+	0	0	5	100.0
Cnicus benedictus	1	5	21	10 (5)	+++	0	0	8	80.0
Scolymus hispanicus	2	5	56	20 (10)	+	0	0	5–6	100.0
Cirsium arvense	1	5	77	10 (5)	++	0	0	4–8	60.0
Cirsium undulatum	1	2	15	12 (6)	++	0	0	4	100.0
Cirsium douglasii	1	1	7	6 (3)	+++	0	0	5	16.7

[1] Numbers of females in parentheses.
[2] (−), no feeding or very slight nibbling; (+), light to moderate feeding; (++), moderate to heavy feeding; (+++), heavy feeding (see text for more details).

each from a *Carthamus tinctorius* and a *Scolymus hispanicus* plant.

In test 3, none of the closed buds of *Carthamus tinctorius* were accepted for oviposition, but they did suffer light to moderate feeding damage. However, feeding was insufficient for normal oogenesis because no eggs were found in the ovarioles of the 20 females examined. Moderate to heavy feeding occurred on *Centaurea solstitialis*, and the 18 females that lived to the end of the 15 day test laid an average of 12.83 (±0.74 SE) eggs. The 20 females confined to *Centaurea solstitialis* had an average of 0.90

Table 2. Feeding and oviposition of *Eustenopus hirtus* adults under two choice test conditions, June 29–July 7, 1986, Rome, Italy.

Plant combinations	Degree of Bud Feeding on[1]: *C. solstitialis*	Degree of Bud Feeding on[1]: Other Plant	Number of Eggs and Larvae Found in Buds of: *C. solstitialis*	Number of Eggs and Larvae Found in Buds of: Other Plant
Centaurea solstitialis, Greece vs. *Carthamus tinctorius*	+++	+	35 eggs; 5 larvae	0
Centaurea solstitialis, Greece vs. *Cirsium arvense*	+++	−	31 eggs; 4 larvae	0
Centaurea solstitialis, Greece vs. *Cichorium intybus*	+++	−	21 eggs; 3 larvae	0
Centaurea solstitialis, Greece vs. *Centaurea nicaeensis*	+++	+	29 eggs; 5 larvae	10 eggs

[1] (−), no feeding or very slight nibbling; (+), light to moderate feeding; (++), moderate to heavy feeding; (+++), heavy feeding (see text for more details).

(±0.14 SE; range 0–2) mature eggs in their ovarioles. Beetle mortality during the test was 42.5% in the *Carthamus tinctorius* cartons and 17.5% in the *Centaurea solstitialis* cartons.

In test 4, feeding was heavy on *Centaurea solstitialis*, moderate on *C. nicaeensis* and negligible on *Centaurea cineraria* and *Galactites tomentosa*. Beetles did not feed on closed buds of *Onopordum acanthium* and 83.3% died on this plant. Mortality was 16.6% or less on other plants. Eggs were not found in the closed buds of any plant.

In test 5, when the beetles were given a choice between *Centaurea solstitialis* and either *Centaurea nicaeensis*, *Cichorium intybus*, *Carthamus tinctorius*, or *Cirsium arvense*, eggs were laid only in the mature closed buds of the two *Centaurea* species (Table 2). There was no evidence of feeding on *Cirsium arvense* and *Cichorium intybus*, but a few feeding punctures were observed on closed buds of *Carthamus tinctorius* and *Centaurea nicaeensis*. Feeding was heavy on *Centaurea solstitialis* (Table 2).

Discussion

Host specificity tests and field observations indicated that a strong relationship exists between *E. hirtus* and *C. solstitialis*. First, *C. solstitialis* is the only known breeding host of *E. hirtus* in nature. In the laboratory, mating and oviposition only occurred on Bu 3–4 buds of *C. solstitialis*. Second, females experienced little or no oocyte development when confined to nonhost plants. Third, the failure of females to oviposit on plants other than *C. solstitialis* and two other *Centaurea* species suggests that the egg-laying response may be triggered by specific stimuli of mature closed buds of *C. solstitialis* and other *Centaurea*. Fourth, although adult bud feeding was moderate to heavy on several nonhost plants in the absence of *C. solstitialis*, it was absent or negligible when adults were offered a choice between *C. solstitialis* and a nonhost plant. Last, beetle longevity was generally reduced when they were forced to feed exclusively on nonhost plants.

Although we found that adults were able to feed on some nonhost plants, and other researchers found that a few larvae could complete their development when placed as neonates in safflower buds (Sobhian and Zwölfer, 1985; Mimmocchi and Clement, unpublished data), we still considered *E. hirtus* a potential biocontrol agent. The adult is the only mobile stage and our tests demonstrated the specificity of oviposition by females. Moreover, when beetles were exposed equally to four plant species, including safflower and artichoke, under field experimental conditions in Thermi, Greece, the beetles fed and oviposited only on mature closed buds of *C. solstitialis* (Clement and Sobhian, unpublished data). Like many monophagous and oligophagous insects (Force 1966), *E. hirtus* may have a broader host-feeding range in artificial environments than in the field. The collective evidence suggests that there is little or no danger of a crop like safflower being attacked by *E. hirtus* as long as *C. solstitialis* is present.

Eustenopus hirtus scored 40 by Goeden's system (1983) for rating the potential effectiveness of biocontrol agents, indicating that it could be a partially effective agent. This monophagous beetle has been cleared for introduction into the USDA quarantine facility in Albany, California, for additional study.

Acknowledgments

We thank L. Andres, G. Piper, C. Turner, D. Whitehead and two anonymous reviewers for helpful comments on the manuscript, and M. Cristofaro and A. Laregina (BCWLE) for technical assistance. We also thank E. Colonnelli of the Dipartimento di Biologia Animale e dell Uomo, Vaile dell Universita, Rome, Italy, and M. Cox of the C.A.B. International Institute of Entomology, London, England, for determination of the beetle. Mention of a proprietary product does not constitute an endorsement or a recommendation for its use by the USDA.

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NOTE

A New Synonym and Revised Status in *Apterothrips* (Thysanoptera: Thripidae)

Sericothrips apteris Daniel (1904, Entomol. News 15: 295), synonymized under *Anaphothrips secticornis* (Trybom) by Hood (1927, Pan-Pac. Entomol. 3: 173), is a valid species (REVISED STATUS) based on my study of three paratypes of *apteris*, one paratype of *Apterothrips subreticulatus* Bagnall (1908, Trans. Nat. Hist. Soc. North. Newcastle-on-Tyne (N.S.) 3: 185) (= *secticornis*), and an identified specimen of *secticornis* from a type locality, Albany, Oregon. I also conclude that *apteris* belongs in *Apterothrips*. The type depository of *secticornis* is unknown. According to Mound and Walker (1982, Fauna of New Zealand No. 1: 55), one of the localities mentioned in the original description of *secticornis* by Trybom was Albany, Oregon. *Sericothrips stanfordii* Moulton (1911, U.S.D.A. Bur. Entomol. Tech. Ser. No. 12, part III, p. 52) was assigned to *Anaphothrips* by Moulton (1926, Pan-Pac. Entomol. 3: 23) and later to *Apterothrips* by zur Strassen (1973, Senckenbergiana Biol. 54: 142). A syntype of this species examined in this study is identical to *apteris* (NEW SYNONYMY). The types of *apteris* and *stanfordii* were collected in the same geographic area of California; *apteris* at San Francisco in 1902? and *stanfordii* at Stanford University, Palo Alto, in 1904. Only two species, *apteris* and *secticornis*, are currently assigned to *Apterothrips*.

Apterothrips apteris and *secticornis* are apterous; their antennae are 8 or 9-segmented with segment VI occasionally partially divided; and abdominal tergites and sternites have extensions of the posterior margin (posteromarginal flange). The body coloration of females varies from completely dark brown to the pterothorax or thorax and first abdominal segment yellow with the rest of the body brown. Antennae are completely brown or the bases of segment III are yellowish brown or segment III and distal part of segment II are yellowish brown; tarsi are yellow or occasionally brown, and remainder of the legs varies from mostly yellow to mostly brown. Body coloration of the males is similar to those of the females; however, *secticornis* males may also have bodies that are mostly yellow with brown head. The two species are readily differentiated by the six major setae on the posterior margin of abdominal sternites IV–VI: *apteris* has the laterad-most setae (B3) at the extreme side of the sternite, thus the insertions of the six setae divide the posteromarginal flange into five sections; conversely, the B3 setae of *secticornis* are located submarginally, thus the insertions of the six setae divide the posteromarginal flange into seven sections. Also, *apteris* usually has the fifth dorsal seta from the middle on abdominal tergites III–VII anterior to the posterior margin and the setal insertion does not divide the posteromarginal flange (occasionally 6 dorsal setae may be present); whereas, the fifth dorsal seta of *secticornis* is on the posterior margin and the posteromarginal flange is divided at the setal insertion.

Jacot-Guillarmod (1974, Ann. Cape Prov. Mus. (Nat. Hist.) 7(3): 589) lists *secticornis* from Russia, Europe, Canada, United States (California, Oregon, Hawaii), Argentina, Chile, South Georgia I., Juan Fernandez Is., Easter I., and New Zealand. Mound and Houston (1987, Occ. Pap. Syst. Entomol. 4: 5) report it from Australia, Crozet I., Falkland Is. and Peru. Some of these records are based apparently on misidentifications of *apteris*. I have examined, in the collection

of Thysanoptera in the United States National Museum of Natural History, *secticornis* specimens from Europe, Canada (Alberta, British Columbia, Labrador) and United States (Alaska, Colorado, Idaho, Nevada, Oregon, Washington). The following *apteris* records from Argentina, Chile, Ecuador, Guadelupe I., Mexico, Panama, Peru, Australia and New Zealand are based on reexaminations of previously identified *secticornis* material.

I thank W. H. Ewart, University of California, Riverside for reviewing the manuscript and for additional distribution records, and to the following reviewers for their comments and suggestions: T. Kono, California Dept. of Food and Agriculture, Sacramento; R. J. Gagne and F. C. Thompson, Systematic Entomology Laboratory, ARS, USDA, Washington D. C. and M. B. Stoetzel, same laboratory, Beltsville, Maryland.

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PROC. ENTOMOL. SOC. WASH.
90(4), 1988, pp. 510–512

NOTE

Feeding by *Medetera* Species (Diptera: Dolichopodidae) on Aphids and Eriophyid Mites on Apple, *Malus domestica* (Rosaceae)

Adults and most known larvae of dolichopodids are predaceous on soft-bodied arthropods (Robinson, H. and J. R. Vockeroth. 1981. *In* J. F. McAlpine et al., eds., Manual of Nearctic Diptera, Vol. 1. Agric. Canada Monogr. No. 27. Biosystematics Research Institute, Ottawa. 674 pp.). Several *Medetera* larvae are subcortical predators living under the bark of dead and dying trees. Immatures of *Medetera aldrichii* Wheeler are major predators of scolytid larvae (Schmid, J. M. 1971. Can. Entomol. 103: 848–853.), (Hopping, G. R. 1947. Can. Entomol. 79: 150–153), (Nagel, W. P. and T. D. Fitzgerald. 1975. Entomophaga 20: 121–127). The feeding habits of adult *Medetera* remain obscure. Bickel (1985. U.S.D.A. Tech. Bull. 1692. 109 pp.) reported *Medetera petulca* Wheeler (Fig. 1) preying on arthropods such as spiders, mites, small centipedes, Collembola, Diptera (Sciaridae, Psychodidae, and Cecidomyiidae), Homoptera (including Aphididae) and small lepidopterous larvae. Here we describe feeding behavior of 3 species of *Medetera* from central Washington: *Medetera petulca* Wheeler, *M.* n. sp. nr. *alpina* and *M.* n. sp. nr. *xerophila* or *utahensis*. *Medetera petulca* was the most common species encountered on apple and has previously been collected on *Salix* and cultivated apple trees (Bickel 1985). Present observations cannot be linked to any one of the 3 species. *Medetera* n. sp. nr. *alpina* and *Medetera* n. sp. nr. *xerophila* or *utahensis* will be described in a later publication.

During our study adult *Medetera* spp. were observed on unsprayed 3-year-old apple trees, *Malus domestica* (Borkhausen) var. "Red Delicious." The trees (ca. 1–1.2 m high) were in 2 experimental "mini-orchards" planted within a deciduous riparian habitat near the Wenatchee River (Washington: Chelan Co., elev. 220 m). The 2 "mini-orchards," Sunnyslope (SS) and River County Park (RCP), were being studied by the senior author (RJR) to determine the contribution of colonists from native habitat to young apple trees. Vegetation surrounding the 2 "mini-orchards" was an important source pool for *Medetera* adults colonizing apple and included: *Rosa woodsii* Lindley (Rosaceae), *Populus trichocarpa* Torrey & Grey (Salicaceae), *Cornus stolonifera* Michaux (Cornaceae), *Salix exigua* Nutall (Salicaceae), *Crataegus douglasii* Lindley (Rosaceae), and *Amelanchier alnifolia* Nutall (Rosaceae). *Medetera* adults were collected in sweep samples of plants surrounding the apple trees at both the RCP and SS sites. The SS orchard, 10 km northwest of Wenatchee, was partially shaded and the RCP orchard, 12 km northwest of Wenatchee, was in direct sunlight. At 2-week intervals from late May until late July, 1987, visual observations were made on the trees at each site. The behavior of adult *Medetera* on the main stem, lateral branches, and foliage of the apple trees was recorded by ground level observations. Approximately 10 hours were spent recording *Medetera* feeding behavior. All observations were made between 8 a.m. and noon.

Flies remained in a stationary position for ca. 90% of the total observation time with prothoracic legs fully extended and meso- and metathoracic legs pressed against the body. Individual flies oriented themselves at 30–40° angles to the branch or leaf upon which they rested. During feeding the pro-

thoracic legs were retracted and the meso- and metathoracic legs were extended, forcing the head downward. Striking at leaf and bark surfaces was repeated as a "pecking" motion until either the prey had been secured between the labellae or had escaped.

Medetera spp. adults were first noted feeding on apple rust mites, *Aculus schlechtendali* (Nalepa) (Acari: Eriophyidae) on 2 June 1987 at the SS site. Flies were observed making a "pecking" motion on bark and leaf surfaces. *Medetera* spp. could have been feeding on any micro-arthropods present (scales, whiteflies, other mite species). However, examination of leaf and bark samples in the laboratory with a binocular microscope revealed eriophyids were the only arthropods present in high numbers. Other mite species, including *Tetranychus* spp. and *Panonychus ulmi* (Koch) (Tetranychidae), were absent from the trees at RCP and SS in 1987. From May through August, 1987, counts of eriophyids were made at 2-week intervals. On 4 June at SS the rust mite population peaked at $\bar{x} = 232.0 \pm 80.39$ mites/leaf [Mean $\pm$ SE (n = 75)]. Feeding by *Medetera* on rust mites at SS was also observed on 16 and 20 June. Twenty-eight "pecking actions" were recorded during an 8-minute observation period of one fly on 20 June. The observed fly concentrated "pecking" at the veins on the upper leaf surface. Examination of the leaf with a hand lens (16×) showed the highest density of *A. schlechtendali* near the veins on the upper surface of the leaf. One fly feeding on the upper surface of a leaf was collected with an aspirator and immediately transferred to alcohol. In the laboratory the mouth parts of this fly were examined, and a rust mite was found between its labellae.

On 27 June, *Medetera* spp. were again observed feeding on eriophyid mites at SS. They were also seen consuming apple aphids, *Aphis pomi* De Geer. Within a 15 minute period, 9 *Medetera* adults were observed attacking apterous aphids which were moving up and down a single apple tree.

Fig. 1. Line drawing of male *Medetera petulca* (Magnification ×30).

After capture, duration of feeding was ca. 60 seconds/aphid. *Medetera* were observed preying on aphids on 3 additional dates: 11, 13, and 15 July at both the RCP and SS sites. Estimates of mean aphid abundances for 20 trees were 103.55 $\pm$ 31.64 aphids/tree and 1384 $\pm$ 679.4 aphids/tree, at SS on 1 and 15 July, respectively, and 332.5 $\pm$ 120.10 aphids/tree on 13 July at RCP.

The importance of predation by adult dolichopodids on 2 apple pests, rust mites and aphids, remains to be determined. Based on these preliminary observations, we conclude that *Medetera* probably does not have a significant impact as a biological control agent on apple. To our knowledge this is the first record of feeding by dolochopodid adults on *A. schlechtendali* and *A. pomi*. We also observed *Medetera* feeding on immature thrips at both RCP and SS. Further studies are planned to tie feeding observations with the different *Medetera* species.

We thank W. J. Turner, C. H. Shanks, S. C. Hoyt, and W. W. Cone for critical review of the manuscript. W. J. Turner is also acknowledged for taxonomic determination of *Medetera* species, and J. C. Rodriguez is acknowledged for the line drawing. We thank T. Kono for identification of the eriophyid mites. This research was supported by the

Washington State Tree Fruit Research Commission and conducted under project 1090.

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PROC. ENTOMOL. SOC. WASH.
90(4), 1988, pp. 513–523

OBITUARY

Carl Muesebeck in the 1920s

Carl Muesebeck in 1976

Carl Frederick William Muesebeck
1894–1987
Honorary President, Entomological Society of Washington,
1971–1987

The long career of Carl Muesebeck, one of the 20th century's most noted and productive entomologists, came to an end at age 93 on 13 November 1987. He was born 24 September 1894 in Medina, New York, to William and Marie Koch Muesebeck. Both parents emigrated to America in the 1880s. William (christened Carl Friedrich Wilhelm Müsebeck[1]), came from Stettin, Pomerania, in eastern Germany (now part of Poland), and Marie from Angermunde, northeast of Berlin. They met and were married in America. The father served an apprenticeship as a tailor in Stettin, and worked as a tailor in Medina, later moving to Brockport to establish his own tailoring business. The parents were Lutheran and Carl was brought up in that faith. He left the church after college, not caring for formal ritual, but had a deep and abiding belief in God throughout his life.

Carl attended elementary school in Medina and then Brockport High School. He also helped in his father's tailoring business, and greatly enjoyed working on a farm for six months after high school graduation.

He entered Cornell University in 1912,

[1] Carl's first cousin, Carl W. Muesebeck, traces the Muesebeck ancestry as far back as the 10th century, the family name being variously spelled Musbach, also Muespach, and later Meusebach. A patent (or charter) of nobility was conferred in 1690 on Johann Gregor von Meusebach, Imperial Aulic Counselor, and Lord Lieutenant and Treasurer of Upper and Lower Saxony.

and was impressed at once by the Victorian inscription on the gates of what was at that time the principal entrance to the university: "So enter that daily thou mayest become more learned and more thoughtful; so depart that daily thou mayest become more useful to thy country and to mankind." This admonition guided Carl's subsequent life, and he quoted it admiringly to friends. He thought that he might prepare himself to become a professor of English, and he was also keenly interested in mathematics. During his later undergraduate years he excelled in tutoring foreign born students at Cornell in English.

He had no particular interest in natural history when he began his studies at Cornell, but several courses under the inspired teaching of John Henry Comstock and his wife, Anna Botsford Comstock, were a revelation to young Carl. Comstock was the founder of the first department of entomology in an American university, and his wife was a gifted teacher also, but of general natural history. Carl once told a reporter that Comstock "made the study of insects sound so fascinating that I switched to entomology."

Carl received a Bachelor of Science degree in 1916. Inspired by his love of entomology, he applied for and received his first professional appointment in December, 1916, from the U.S. Department of Agriculture (USDA) in the laboratory of the Bureau of Entomology at Melrose Highlands, Massachusetts. He served there for nearly two years in the grade of Scientific Assistant, working on a biological study of the parasites of the introduced gypsy and brown-tail moths.

He resigned from USDA in August, 1918, to return to Cornell where he registered for a doctorate. His graduate committee consisted of Professors R. Matheson (insect parasitology), J. C. Bradley (systematics), and Moore (middle initials unknown, in bacteriology). Moore was later replaced by O. A. Johannsen (morphology) when Carl changed his minor in bacteriology to parthenogenesis in insects. He also served as an instructor in entomology at Cornell with the responsibility for conducting courses in biological control of insects and in taxonomy of parasitic Hymenoptera. The need to provide more adequate support for his family led him to terminate his graduate studies, just a semester short of completing the mandatory residency requirements for the doctorate. His doctoral thesis, the large revision of North American *Apanteles* (#3)[2], carried the byline, "C. F. W. Muesebeck, Instructor in Entomology, Cornell University." He mentioned in the introductory paragraph that the contribution was the result of studies made during a temporary USDA appointment in the summer of 1919 to work on the great mass of valuable material in the collection at the U.S. National Museum, and that contributory data had been obtained earlier during his work at the Melrose laboratory and during the winter and spring of 1918–1919 at Cornell.

He returned to the USDA laboratory at Melrose Highlands in April, 1921. For the next decade he conducted research on biosystematics of parasitic Hymenoptera and directed the work of other employees in this field. His taxonomic studies during this period resulted in the completion and publication of additional large revisionary studies on the Braconidae (#4, 6, 7, and 10). Early in 1926 he was assigned temporarily for 2½ years to Budapest, Hungary, where he had the responsibility for directing USDA studies in Europe on the biology of European parasites of the gypsy and brown-tail moths. He accepted this assignment with the provision that he would be able to spend periods during the winter months traveling to various museums to study type specimens of earlier workers in parasitic Hymenoptera. These visits included the collections in Kiel, Dublin, London, Berlin and

[2] Numbers in parentheses refer to articles listed in the appended bibliography.

others. He travelled extensively in central Europe searching for effective parasites of these two forest pests, and was responsible for collecting, rearing and shipping the biologically effective species to America.

During the stay in Europe he received the first of a number of honors to be conferred during his lifetime, that of honorary membership in the Hungarian Entomological Society. His entomological career was memorialized at the 583rd meeting of that society on 19 February 1988.

In the fall of 1931 he was reassigned to Washington to serve as Assistant Leader of the Division of Insect Identification, USDA, with additional responsibilities of carrying on taxonomic research on several groups of parasitic Hymenoptera, primarily the Braconidae, Bethyloidea and Proctotrupoidea, and providing identification service in these groups. He also supervised the updating and development of the insect host-parasite card catalog that had been initiated by L. O. Howard. Most of the national collection of insects on which Carl worked was in the U.S. National Museum, now known as the National Museum of Natural History of the Smithsonian Institution (SI). In 1935 he became Leader of the Division of Insect Identification with his administrative office in the South Building, USDA, 5 minutes across the Mall from the Museum. He continued his research and identification work on parasitic Hymenoptera, and, as older staff members retired or died, he added identification and curatorial responsibility for lice, fleas and ticks to an already superhuman load. In connection with his work on these latter three groups of ectoparasites, he continued to add data to the card files of host-parasite lists, and made these files available to other investigators.

Carl was always a prodigious, dedicated and conscientious professional, working 12 to 14 hours or more on weekdays, and frequently additional hours on the weekend. The normal working period for USDA employees early in 1941 was 8:45 a.m. to 5:15 p.m. By the time all of us had arrived at the Museum, he would already have been working there from 6 a.m., and would have left for his administrative office by 8:30 a.m. Usually he returned at noon to have lunch with us in the cafeteria of the Internal Revenue Service Building across the street from the Museum, bringing with him specimens that required urgent identification or letters that had been typed for us in the South Building. He then went back to administrative work for the afternoon, returning to the Museum at 5 p.m. to spend another 3–4 hours over the microscope.

World War II imposed additional burdens on him, for some of the younger specialists in the Division, J. F. Gates Clarke, A. B. Gurney, D. G. Hall, K. V. Krombein, P. W. Oman and B. E. Rees, entered military service, most of them to serve as Army entomologists. A caring, warmhearted person, Carl wrote occasional lengthy personal letters to each of us to send news of what was happening at the Museum and what our colleagues in military service were doing. He looked forward with keen anticipation to receiving letters with news of our entomological activities in distant parts of the world. He even found time to write several times to the wife of one of our group to inquire about her wellbeing and that of a prematurely born child, and to ask for any recent news from her husband.

During the war he was able to bring to the Museum for shorter or longer periods such specialists as M. T. James, V. S. L. Pate and H. K. Townes, to curate parts of the collection and to provide identification service. Wartime transportation difficulties meant that he was one of the few people to continue working at the Museum on Sundays, usually between 8 a.m. and 3 p.m. Earlier on Sunday and again late in the afternoon, he visited the USDA research facility at Beltsville to care for the silkworms being reared there because no one else was available on that day to care for them.

He retired from Federal service in 1954,

having suffered a serious heart attack two years earlier. Upon his retirement he was appointed a Collaborator in the Insect Identification and Parasite Introduction Section, USDA, and a Research Associate in the Smithsonian Institution, the latter appointment enabling him to have an office and a parking space at the Museum. Relieved of the burden of administrative responsibilities, he continued industriously working over his microscope and cataloguing at the Museum seven days a week from early in the morning until noontime. After returning home, he continued work on other entomological projects such as editorial work and additional cataloguing. From 1962 until he left the Washington area in 1980 he was editor for *Entomological Review,* the translation of the important Russian periodical, *Entomologicheskoye Obozreniye.* With his usual meticulous attention, he mastered the difficult Russian language, thus ensuring that translations by the language experts made good entomological sense.

Carl's marriage in 1917, to Ida C. Praedel of Brockport, New York, ended with her death in 1975. An only son, Carl, Jr., died suddenly from a brain tumor at age 16 in 1935. The loss of their gifted son was a grievous blow to Carl and Ida. For many years he took fresh flowers weekly from his garden to the boy's grave. Carl moved to the state of Washington in 1980, and married Luella M. Walkley, a former cataloguer and specialist on Ichneumonidae in the Division of Insect Identification (USDA). She died a year later, and he returned to New York state in 1982 to live in Schenectady with a cousin, Elfrieda Geissler. He was physically active through 1986. Although handicapped by occasional cardiac or respiratory problems, he enjoyed daily walks along the Mohawk River and regularly drove his car nearly 250 miles on the New York Thruway several times a year between Schenectady and a vacation home in western New York. He remained in full mental vigor until his death, enjoying occasional long distance conversations about Bethylidae, friends in Washington, and the Washington Redskins football team.

Carl was keenly interested in sports throughout his life. During his high school years he was a catcher on the baseball team. At Cornell he participated annually in the 5-mile cross-country run in Ivy League competition, never finishing less than 5th in the race, and once coming in 2nd. He was an active bowler during the late 1920s and early 1930s, a sport in which he was joined by several entomological colleagues. He became particularly proficient at duckpins and maintained a high average. He was so enthusiastic about this sport, that sometimes, playing by himself, he used two adjacent alleys, bowling a frame on one while the pins were being set up in the other alley. An injury to his foot while on the bowling alley necessitated his withdrawal from active sports. After the advent of television he watched various sporting events, particularly football, with great enthusiasm.

Another avocational interest was gardening to which he was very dedicated. He maintained a large garden at his home in suburban Maryland, containing about 100 varieties of hybrid tearoses and other flowers.

Carl was active in a number of professional societies including the Entomological Society of America (Fellow in 1934, Second Vice President in 1938, President in 1946, Honorary Member in 1959), Entomological Society of Washington (President in 1940, Honorary Member in 1957, Honorary President from 1971 until his death), Biological Society of Washington, Society of Systematic Zoologists, Washington Academy of Sciences, and Sigma Xi. He was also a member of the Cosmos Club (1936–1954). The Department of Agriculture recognized his exceptional service by awarding him its Distinguished Service Award in 1951. The eloquent citation for this award paid tribute to him, "For his contributions to science and public welfare as an internationally rec-

ognized insect taxonomist; for his ability to inspire and guide his associates in entomology throughout the world in the acquisition and dissemination of information on destructive and beneficial insects; and for his devotion to duty." The Eastern Branch of the Entomological Society of America honored his professional and societal accomplishments in 1978 by presenting him its L. O. Howard Distinguished Achievement Award.

He was the author of more than a hundred scientific contributions, many of them longer revisionary studies of the highest quality such as his contributions on the genera *Apanteles* (#3), *Meteorus* (#6), *Macrocentrus* (#21), *Orgilus* (#123), *Macroteleia* (#135), *Psilus* and *Coptera* (#137), and his revisions of higher categories such as Microgasterinae (#4), Braconinae (#10), and Euphorinae (#32). His papers in systematics were models of clarity and precision, reflecting his early love of the English language.

His single most important contribution to hymenopterology was the leadership that resulted in the monumental synoptic catalog (#60), "Hymenoptera of America North of Mexico." This catalog, published by USDA as Agriculture Monograph No. 2 in 1951, was the first on the North American fauna since 1887. It was a collaborative effort by a couple of dozen American and Canadian specialists in various groups of Hymenoptera. Carl served as one of three co-editors and prepared in co-authorship the sections on Braconidae and parts of Proctotrupoidea. His stature in the profession ensured the reasonably prompt completion of manuscripts by the 20 collaborators, and his influence within the Department of Agriculture facilitated the allotment of funds from that agency for publication of this indispensable tool of 1400+ pages. Twenty years later, when the volume of publications on North American Hymenoptera necessitated preparation of an updated, computerized edition by the Smithsonian and Agriculture hymenopterists at the Museum, he participated by preparing the sections on Pelecinoidea, Proctotrupoidea and Ceraphronoidea (#116–118).

The impact and stimulation generated by the 1951 catalog were assessed astutely by E. O. Wilson in a review of the revised 1979 edition (*Science*, 208: 721–722, 1980). He stated in part: "In 1951 C. F. W. Muesebeck and a group of associates provided a complete taxonomic record of the species of North America north of Mexico, with summaries of natural history data. Important syntheses always work toward their own obsolescence, and so it was that the Muesebeck catalog stimulated a rush of new systematic and biological studies."

The Entomological Society of Washington dedicated the September 1969 issue of its *Proceedings* to Carl in recognition of his 75th birthday. Dedicatory remarks by three contributors are included here to give an appreciation of the impact of his work in three diverse groups of arthropods.

The late, eminent tick expert, Harry Hoogstraal, honored his work on ticks by describing a new argasid tick, *Ornithodoros* (*Alectorobius*) *muesebecki*, from a remote island off the coast of Saudi Arabia. In a deft allusion to Carl's great work on the common names of insects, he christened this bird tick, Muesebeck's Arabian Booby Argasid. Carl, possessed of a wonderful sense of humor, must have given a hearty guffaw when he first read this name. Hoogstraal's dedicatory remarks were: "This new species is dedicated to Mr. C. F. W. Muesebeck on his 75th birthday in token recognition of the selfless and devoted service that he has provided to several generations of entomologists throughout the world. The Jubilee for the ever helpful Curator Muesebeck thus extends to one of the most remote spots of arthropod-inhabited land on the globe."

The renowned flea specialist, Robert Traub, prefaced his description of the new flea genus, *Muesebeckella*, with the following perceptive dedication: "Scientists fa-

miliar with the multitude of significant contributions made by C. F. W. Muesebeck to the study of Hymenoptera may be surprised to see an article on Siphonaptera in a Jubilee Volume dedicated in his honor. It would seem that an entomologist who had accomplished so much in such a difficult field and who also nevertheless somehow managed to serve as an authority on the principles of taxonomy and on the standardization of common names of insects, could surely not find the time to master the systematics of fleas and lice. The fact is, however, that Mr. Muesebeck is expert enough on both of these groups of ectoparasites to have repeatedly provided definitive identifications of obscure species, despite the dearth of taxonomic keys, proper descriptions and illustrations for which at least the Siphonapteran literature is notorious. Even if this were not the case, it would be fitting to include a paper on fleas in this volume because of all that Mr. Muesebeck has done to stimulate students of ectoparasites and to ensure that the U.S. Department of Agriculture and the Smithsonian Institution would always be able to identify specimens and answer queries submitted from all parts of the world. When one considers the serious problems posed over the years by the shortage of funds to support such activities, the true value of Mr. Muesebeck's 'extracurricular' activities becomes apparent."

A fellow hymenopterist, Karl Krombein, dedicated to him the new cuckoo wasp genus, *Muesebeckidium*, and offered these thoughts: "During his many years at the U.S. National Museum, formerly as the head of systematic entomology investigations for the U.S. Department of Agriculture, and presently as an honored Research Associate of the Smithsonian Institution, I have come to know and cherish Carl Muesebeck very highly. His quietly skillful and dynamic leadership of the Insect Identification Division, USDA, brought it to a peak in professional and support strength not equaled before or since. Had it not been for his effective and tactful direction, an epochal contribution such as the catalog of North American Hymenoptera might not be a reality today. Finally, his warm personal interest in the professional development and well-being of his staff endeared him to all of those privileged to work under his leadership."

In another article in the issue of the *Proceedings* celebrating Carl's 75th birthday, R. H. Nelson, Executive Director Emeritus, Entomological Society of America (ESA), wrote at length of Carl's numerous services to that society. Among other activities in ESA Carl was a member of the small, joint committee that proposed the merger of the original ESA with the American Association of Economic Entomologists to form the present, larger national society representing all of entomology.

All of his professional life Carl had a kindly concern for his associates, and for the friends and neighbors outside of his profession. Always generous in his praise of scientific contributions by others, as late as 1986 he expressed his great delight in receiving the monumental study of the Russian Braconidae by Tobias and his esteem for the quality of the work.

One reviewer of the revised Hymenoptera catalog commented felicitously (*Quart. Rev. Biol.*, 55: 444–445, 1980) that ". . . all among its users will appreciate and find most fitting its dedication, with admiration and affection, to Mr. C. F. W. Muesebeck, himself a paragon among entomologists." Carl was a gentleman and a gentle man, loved by his friends and close colleagues, and held in affectionate regard and respect by his associates all over the world.

Acknowledgments.—We are grateful to Carl's cousin, Miss Elfrieda Geissler, Schenectady, for sharing with us her recollections of things he had told her about his family and early years. We also thank Victor E. Krantz, Chief of the Natural History Branch of the Photographic Division, SI, for his skillful copying of the photographs from

Miss Geissler that are used in our sketch. Several colleagues, J. F. Gates Clarke, Kenneth W. Cooper, John G. Franclemont, Beth and Arnold Norden, Paul W. Oman, Louise M. Russell, Curtis W. Sabrosky, and Robert Traub were kind enough to comment on a preliminary draft and/or to provide helpful information. Mrs. Isabel T. S. Gardner, Office of the Dean, The Graduate School, provided the available information from Cornell archives on Carl's registration for graduate work.

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PROC. ENTOMOL. SOC. WASH.
90(4), 1988, pp. 524–528

Book Review

Acarology. Mites and Human Welfare. Tyler A. Woolley. Wiley-Interscience (John Wiley & Sons), New York. 1988, 484 pp. $57.75.

The mites, more than any other group, have successfully explored the advantages of combining the arthropod body plan with small size. Evidence lies in their tremendous diversity, whether the latter term is used in the context of taxonomy or of adaptations affecting morphology, nutrition, or life-cycle. This book is intended as a general textbook of acarology, and thus an introduction to this diversity.

The book contains 23 chapters, arranged in four parts, plus a brief Appendix containing references relating to study techniques and control. The first part presents glimpses of biological diversity (Chapter 1), offers some generalizations on morphology (Chapter 2), and attempts a general discussion of the Arachnida and the relationships of mites within the class. The second part, comprising more than 60% of the book, deals with external morphology (Chapters 4–6), internal anatomy (Chapters 7–12), and pheromones (Chapter 13). Coverage of other aspects of biology is interspersed in ways which are not immediately obvious from chapter headings. As examples, feeding biology is discussed in Chapter 7 (Digestive System), behavior is treated in Chapter 11 (Nervous System), and embryology and life cycles are covered in Chapter 12 (Reproductive System). The third part (about 20% of the book) deals with classification. As an introduction, Chapter 14 contains a brief historical review and an ineffectually illustrated key to orders; following this is one chapter on each of the seven recognized orders in the subclass Acari (Chapters 15–21). Very brief, superficial chapters on the history of acarology (Chapter 22) and ecology (Chapter 23) compose the fourth part of the book. There is no glossary. References are listed at the end of each chapter, which facilitates access with only a minor cost in redundancy for those which are repeated throughout the book. Including such repetition, there are slightly more than 2000 citations; about 17% are of non-English language sources, but often these are indirect ("fide") references.

At first opening, the book seems to be an attractive, polished, informative product, the kind we would expect from a major publisher of scientific texts. Yet, after even a quick perusal of chapter headings, one starts to question its subtitle, "Mites and Human Welfare." Most readers will expect to find substantive discussions of mites important to medical and veterinary science, mites as agricultural pests, mites as biocontrol agents acting on arthropod pests of crops and forests, and mites of interest in stored product protection. They will be disappointed; there is no significant treatment of these topics. Reading lists provided at the end of the three-page chapter on ecology (Chapter 23) and after an Appendix section entitled "Control," will lead the ambitious reader to a small portion of the important literature, but the subtitle is nonetheless greatly misleading. Indeed it is mysterious that it could even be considered. As examples: there is only cursory mention of the important honeybee parasites *Acarapis woodi* and *Varroa jacobsoni*, which are causing widespread concern in North America; there is no mention of the much-publicized Lyme disease or its tick vector; and the human parasite *Sarcoptes scabei* is briefly mentioned in several places, but the important disease it engenders (scabies) is ignored.

The book is illustrated with 220 text figures, many of which are compound plates. They include both line drawings and scanning electron micrographs (SEMs). Most of the figures are redrawn from original sources,

but a few are clearly copies of originals; no distinction is made in the captions, and at least one (Figs. 6–10A) is wrongly attributed. A frequent problem with SEMs (and some line drawings) is the absence of labeling, such that the caption describes only a small part of the figure, which the reader may not be able to locate (e.g. Figs. 2–3, 4–5, 11–11E). Occasionally, figure labels do not match caption descriptions, or are not explained at all, and sometimes the absence of notes on orientation will cause confusion. Text references to figures are sometimes incorrect; for example, in a discussion of musculature in gamasid mites (p. 103) the cited figure is of *Listrophorus,* one of the Astigmata.

Like any text of wide scope, a book attempting to cover the field of acarology is difficult to write, and one cannot hope to include all relevant data and literature. But success is governed by more than the number of facts or citations one can squeeze into the text. Just as important are effectiveness of synthesis and various mechanical concerns, such as organization, clarity of writing, and the ease with which the book can be used for reference. In these areas, which are within the purview of the editors as well as the author, the book is deficient. Much of it seems to have been written as a mosaic, with sections simply juxtaposed after being written at different times, using different sources. The result is often a conspicuous lack of synthesis and an unusually large number of mechanical problems. The quality of organization within major sections of text is inconsistent, and at times the flow of ideas is nearly impossible to discern. Frequently a subject is introduced, dropped for another, then returned to just as abruptly. Ideas or summaries may be repeated several times within a chapter, with the same or different wording; reinforcement is often a valid writing technique, but clearly that is not the intent in most cases. The discussion in Chapter 3, regarding phylogenetic relationships with other arachnid groups and the question of monophyly of the Acari, is especially disjointed and difficult to follow, as are many parts of Chapter 12, on reproduction. Statements out of context also may be misleading. For example, the discussion of the chemical "gyplure" (p. 328) implies that it is a mite pheromone; no statement, reference, or even implication informs the reader that it is a gypsy moth sex pheromone. The quality of sentence structure is inconsistent, with one or more examples of poor syntax found on most pages. The result may be simply awkward, or make no grammatical sense, but sometimes poor structure makes sentences factually misleading.

Inconsistency in usage of names and specialized terminology is especially damaging in an introductory text, and it is common in this book. In Part 3 (Classification), the cohort names Parasitiformes and Acariformes are used for the two principal lineages, but the respective synonyms Anactinotrichida and Actinotrichida are used in most of the preceding text. The ordinal name Actinedida is used in preference to its synonyms, but the latter are commonly seen in adjectival form (i.e. trombidiform mites, prostigmatic mites). Examples of other names and terms used interchangeably include: Acaridae/Tyroglyphidae, Histiostomatidae/Anoetidae, *Dermatophagoides farinae/Tyroglyphus farinae, Sancassania/Caloglyphus,* Eriophyoidea/Tetrapodili, Bimichaeloidea/Pachygnathoidea, Claparède's organ/urstigma, segment/joint/article, eupathidion/acanthion, areae porosae/porose areas, and subcapitulum/infracapitulum. Sometimes terms are used as synonyms when they clearly are not (e.g. hysterosoma/notogaster, ovoviviparity/viviparity, integument/cuticle, trichobothria/pseudostigmata). The author is also inconsistent in giving the taxonomic affiliations of species used as examples; commonly these names are not mentioned in sections on classification, or even in the index, so a reader must turn to other references. Sometimes terms are criticized, then incon-

gruously used with regularity. For example, a paragraph (p. 132) is devoted to explaining the inappropriateness of the term "podocephalic canal", then the term is used consistently in subsequent chapters. Similarly, the term "opisthosoma" is said to be not applicable to mites (p. 17), but it is used without comment in later sections.

An abundance of contradictory statements will frustrate the reader. For example, on p. 18 the author implies an absence of trichobothria from the legs of mites, then discusses their presence on several later pages. On p. 84 we learn that members of the Astigmata do not possess a rutellum; on p. 411 we learn that they do. The esophagous is said to be of midgut origin, with no cuticular lining (p. 136), then a cuticular lining (implying ectodermal origin) is discussed (p. 141). On p. 199 the excretory product guanine is said to be nontoxic, followed by a discussion of how some mites prevent it from reaching toxic level in the hemolymph. Sometimes there are multiple contradictions. The normal palp of members of the Astigmata is variously described or implied to be four-segmented (p. 84), two-segmented (p. 96), or one-segmented (p. 411). On p. 391 we learn that actinedid mites have no sejugal body division, on p. 393 we learn that they do, and later (p. 394 and Fig. 19-2) we learn the truth by implication and illustration; it may be present or absent. Contradictions also occur with regard to classification. On p. 230 *Heterochthonius* is considered a member of the Cosmochthonoidea (sic); in the classification (p. 432) it is in its own superfamily, the Heterochthonoidea (sic). On p. 367 Uropodellidae and Ichthyostomatogasteridae are listed separately; on p. 368 they are considered synonyms. On p. 430 the Parhypochthonoidea is included in the suborder Enarthronota; on p. 433 of the same classification it comprises a separate suborder, the Parhypochthonata.

There are relatively few typographical errors, but they are concentrated in the sections on classification, where mispelled names will not be obvious to many readers. In some cases the errors introduce "new" names or terminology, for example "digophagous" for oligophagous (p. 145) or "*Bujobia*" for *Bryobia* (p. 231).

An important part of a general text dealing with an unfamiliar subject is a glossary—or in its absence, a good index. The author addresses the lack of a glossary, deferring to the two volumes of a glossary of mite terminology prepared by van der Hammen (mentioned on p. viii, but without specific citation until p. 320). But the latter publications are expensive, and have a much more restricted distribution than will this book. Many specialized terms are not even indexed, and some of them are first introduced well before their definition, or else lack definitions altogether. The index is also difficult to use in places; as many as four levels of indentation subdivide a main entry. In some cases, cited terms have absolutely no relevance to the main entry; for example, under the entry "rutellum" incongruously are listed pages for "lyrifissure," "palpal-apoteles," and "picket-fence-setae." Instances of incorrect page references were also noted. As a test of the index, page references to the mammalian follicle mites were examined. Under the family name "Demodicidae" two pages were listed, yet the name is used in discussions of family-level information on at least 12 pages, from a cursory examination of the text. Similarly, under the species name "*folliculorum*" (one of the two human follicle mites) three pages are listed. In fact, there is no actual reference to the species on one of these, and at least five pages with such information are not indexed, one of which (p. 303) contains most of the biological information regarding this species. Five other species of *Demodex* are discussed at various places in the text, some on multiple pages, but are not listed in the index under the generic or specific names. Curiously, the second species parasitizing humans, *D. brevis*, is never mentioned.

There are no index entries under such logical words as "follicle mite" or "human follicle mite"; in fact, the relationship of *D. folliculorum* with humans is never mentioned in the text.

The book contains numerous factual errors, of which only a small sample can be mentioned here. Usually errors seem to be introduced by the author, such as the association of Tsutsugamushi disease with ticks instead of chiggers (p. 386), or the parasitism of locusts by the honeybee mite (p. 41). Sometimes obviously incorrect statements are taken intact from literature sources—for example, the greatly inflated numbers of solenidia on the legs of oribatid mites (p. 430, taken from Johnston, 1982). Misinterpretations of literature sources were also noted. For example, a misreading of the French apparently caused the author to attribute to F. Grandjean (uncited, but certainly his 1964 paper; Acarologia 6: 170–198) the erroneous idea that some oribatid mites use their pteromorphs as gliding airfoils. This was actually introduced as an unsupported speculation by A. P. Jacot (an uncited 1930 paper; Amer. Naturalist 64: 285–288) but is treated by the author as observed fact (pp. 107, 238). Witalinski's cited (1979) paper was apparently the source for a suggestion (p. 364) that peritremes of gamasid mites function in hygroreception, despite his clear statement that they lack any association with sensory cells.

Errors also commonly appear in the form of incorrect generalizations. Page 107 alone has three such instances. The author generalizes that "Phoretic mites use the legs to clasp hairs or to hold to their transport hosts"; in fact, chelicerae, sucker plates, anal stalks, or other structures are more commonly used than legs, and some of these mechanisms are discussed elsewhere in the book. He states that "The first legs of Oribatids (sic) are tactile and carried above the substrate"; in fact, this obtains for a small minority of species. He also claims that "among mites leaping is limited to a single family of Oribatida" (the Zetorchestidae); in fact, jumping is encountered in several well-known families of Actinedida, as discussed in several papers which are cited elsewhere in the text, as well as one or two other families of oribatid mites. Some incorrect generalizations are clearly more important, such as the statement that ". . . relatively few mites consume particulate food" (p. 146); in fact, particulate feeding is the rule for two of the three major groups of Acariformes (Oribatida, Astigmata) and for early derivative members of the third (Actinedida), and is found as well in the Opilioacarida.

Errors of omission can be expected in a work of this magnitude, but some are surprising. In a discussion of gamasid morphology (p. 365), the author claims that no "function is ascribed to the tritosternum . . .", but the excellent study of Wernz and Krantz (Can. J. Zool. 54: 202–213; 1976), clearly demonstrated its role in fluid distribution during feeding.

Perhaps the most unfortunate shortcoming of the book is its failure to invoke any sense of wonder or challenge. Other than suggesting how many undescribed species there are, the author rarely makes a statement which resembles an unanswered question, a testable hypothesis, or even original speculation. We know so little about the most basic aspects of the biology of even the most common species that questions should flow freely in the text. Indeed, the function of such a book should be as much stimulation as elucidation. As one of earth's dominant arthropod groups, mites offer unlimited opportunities for experimental study in ecology, physiology, genetics, evolution, and nearly every other subdiscipline of biology, opportunities which are nearly untapped. A seminal, comprehensive synthesis of our current knowledge of this group, which could attract the attention of nonspecialists and influence the direction of students, has been conspicuously overdue, and remains so.

In summary, the book is not recommended as a textbook of acarology, nor as a source for comparative information on mites, although the reference lists may be useful. It seems carelessly written and edited, and generally fails to synthesize the diversity of cited information in a meaningful way. Factual errors are common, so original sources should always be consulted.

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PROC. ENTOMOL. SOC. WASH.
90(4), 1988, pp. 529–532

Society Meetings

937th Regular Meeting—January 7, 1988

The 937th Regular Meeting of the Entomological Society of Washington was called to order by President Gene Wood in the Naturalist Center, National Museum of Natural History, at 8 p.m. on 7 January 1988. Because of a severe snowstorm, only 16 members and one guest were present. Minutes of the previous meeting were read and approved. No old business was transacted, nor were there any applicants for membership.

Mignon Davis noted that the staff of the Naturalist Center would very much appreciate donations of local natural history specimens—including insects. She then displayed various insects that had been embedded in plastic blocks; these are especially suitable for the sort of "hands on" instruction offered at the Center.

President Wood announced that there would be a meeting of the Executive Committee in the Museum of Natural History at 10 a.m. on Monday, 8 February.

F. C. Thompson exhibited the Diptera volume of the 1986 *Zoological Record* and observed that this invaluable taxonomic reference is once again being printed within a year of the date that is indexed. Moreover, the publishers have agreed to resume offering the *Zoological Record* on file cards, only now the cards will be laser-printed.

The speaker for the evening was the Recording Secretary, R. G. Robbins, whose talk was entitled "Ticks: An Introduction to the Ixodoidea and to the National Tick Collection." At the conclusion of his presentation, copies of the text *Bloodsucking Ticks (Ixodoidea)—Vectors of Diseases of Man and Animals,* by Yu. S. Balashov, were distributed to the membership.

The sole guest was introduced and the meeting was adjourned at 9:30 p.m., after which refreshments were served.

Richard G. Robbins, *Recording Secretary*

938th Regular Meeting—February 4, 1988

The 938th Regular Meeting of the Entomological Society of Washington was called to order by President Gene Wood in the Naturalist Center, National Museum of Natural History, at 8 p.m. on 4 February 1988. Thirty members and 10 guests were present. Minutes of the January meeting were read and approved.

Membership Chairman G. B. White read the names of the following applicants for membership: Alfred P. Arthur, Agriculture Canada, Saskatoon, Saskatchewan; Art Borkent, Biosystematics Research Centre, Ottawa, Ontario, Canada; Hans K. Loechelt, Tieton, Washington; Stephen R. Moulton II, Lusby, Maryland; and Robin J. Rathman, Tree Fruit Research Center, Wenatchee, Washington.

R. G. Robbins exhibited a picture of an amblyommine tick crafted from peacock feathers for the late Harry Hoogstraal. This and other acarological objets d'art were Christmas gifts from Dr. Hoogstraal's Egyptian colleague Sherif Tewfik.

W. E. Bickley announced the death on 26 February of George S. Langford, former Maryland State Entomologist. Dr. Langford was the oldest active member of this Society, having paid dues since 1924. He is widely remembered for his leadership in a program aimed at controlling the Japanese beetle (*Popillia japonica*) through dissemination of milky white disease.

J. M. Kingsolver announced the recent death of Lewis J. Stannard, an active ESW member since 1948. Dr. Stannard worked

for the Illinois Natural History Survey where he specialized in thrips and mites.

The speaker for the evening was Thomas E. Wallenmaier, Program Planning Staff, U.S. Department of Agriculture, APHIS-PPQ. His much anticipated talk, "A New Theoretical Foundation for Systematics," advocated the primacy of genetic characters in evolutionary analysis.

President Wood reminded Society officers that the meeting of the Executive Committee previously scheduled for 8 February had been postponed to the 11th at 2 p.m.

Guests were introduced and the meeting was adjourned at 9:30 p.m. Refreshments followed.

Richard G. Robbins, *Recording Secretary*

939th Regular Meeting—March 3, 1988

The 939th Regular Meeting of the Entomological Society of Washington was called to order by President Gene Wood in the Naturalist Center, National Museum of Natural History, at 8 p.m. on 3 March 1988. Twenty-five members and six guests were present. Minutes of the February meeting were read and approved.

Membership Chairman G. B. White read the names of the following applicants for membership: Robert M. Eisenberg and Lawrence E. Hurd, both at the School of Life Sciences, University of Delaware, Newark; Edward A. Lisowski, Illinois Natural History Survey, Champaign; Terry D. Miller, Moscow, Idaho; Roy A. Norton, SUNY College of Environmental Science and Forestry, Syracuse; John D. Sedlacek, Department of Entomology, University of Kentucky, Lexington; and Gary J. Steck, Laurel, Maryland.

R. G. Robbins read the minutes of the Executive Committee meeting held at the National Museum of Natural History on 8 February between 2 and 3:45 p.m. Among the items discussed were obituaries for C.F.W. Muesebeck and Frederick W. Poos; possible increases in membership dues and subscription rates for 1989; future reductions in the net press run of the *Proceedings*; committee review of manuscripts submitted for publication as *Memoirs*; procedures to be followed when members request Emeritus status; and the location of this year's banquet.

President Wood explained that during the Executive Committee's meeting a motion had been submitted by M. B. Stoetzel recommending that Honorary Member Curtis W. Sabrosky be nominated Honorary President. Also during this meeting, T. E. Wallenmaier had moved that Louise M. Russell be nominated to fill the position of Honorary Member that would be vacated if Dr. Sabrosky were elected Honorary President. Both motions were unanimously passed by the Executive Committee. President Wood now placed these nominations before the membership, which approved them by acclamation.

E. S. Saugstad displayed photoenlargements of the epaulets worn by officers in the army of the Ivory Coast. These insignia are entomologically remarkable in that they are ornamented with the likenesses of several kinds of African insects.

J. H. Fales reported that his paper, "The Butterflies of Rock Creek Park, Washington, D.C.," has appeared in the revived *Maryland Naturalist* (31: 5–24), published by the Natural History Society of Maryland. Fales' 45 years of collecting in Rock Creek Park have yielded 58 of the 97 species of butterflies and skippers known from the District of Columbia. Photocopies of this valuable reference were distributed to the membership.

W. E. Bickley announced that Alan Stone, a Life Member of this Society, has been honored with the John N. Belkin Award of the American Mosquito Control Association in recognition of Dr. Stone's many outstanding contributions to mosquito systematics.

R. G. Robbins exhibited some of the

hundreds of metal plates used to illustrate the acarological papers of the late Harry Hoogstraal. Noteworthy examples include a zinc plate depicting the distribution of *Haemaphysalis longicornis* in the western Pacific and a copper halftone plate showing St. Mary's Church in Kraków, Poland, the type locality of *Argas polonicus*.

The speaker for the evening was Christopher K. Starr, Postdoctoral Fellow, Smithsonian Institution, whose talk was entitled "Getting Around the Archipelago: The Distribution of Bugs and a Bug-Watcher in Southeast Asia." During his presentation, Dr. Starr distributed handouts showing the zoogeographic tracks of various genera of pachyrrhynchine weevils and stenogastrine wasps in the Malay Archipelago and adjacent areas. He also exhibited several insect specimens that he had collected in Southeast Asia and provided the membership with a list of references to the natural history of this region.

Visitors were introduced and the meeting was adjourned at 9:30 p.m. Refreshments followed.

Richard G. Robbins, *Recording Secretary*

940th Regular Meeting—April 7, 1988

The 940th Regular Meeting of the Entomological Society of Washington was called to order by President Gene Wood in the Naturalist Center, National Museum of Natural History, at 8:08 p.m. on 7 April 1988. Twenty-eight members and six guests were present. Minutes of the March meeting were read and approved.

Membership Chairman G. B. White read the names of the following applicants for membership: Christopher H. Dietrich, Department of Entomology, North Carolina State University, Raleigh; and John D. Glaser, Baltimore, Maryland.

President-Elect F. C. Thompson announced that the Society's annual banquet will be held on Monday, 6 June, at the University of Maryland's Center of Adult Education. The guest speaker will be James M. Carpenter, Department of Entomology, Museum of Comparative Zoology, Harvard University. The title of his presentation will be "Testing Scenarios: Wasp Social Behavior."

President Wood called for a round of applause for new Honorary Member Louise M. Russell and new Honorary President Curtis W. Sabrosky. Dr. Sabrosky was present and warmly thanked the membership.

C. K. Starr reported on three species of Philippine jumping spiders (Salticidae), each of which apparently is a species-specific mimic of a different otiorrhynchine weevil. Dr. Starr illustrated this relationship with slides that he had taken of one of the spiders and its model.

R. G. Robbins exhibited a set of three Malaysian stamps commemorating the Institute for Medical Research, Kuala Lumpur. One of these stamps features a well-executed drawing of a chigger belonging to the subgenus *Leptotrombidium*, which includes all known vectors of scrub typhus (*Rickettsia tsutsugamushi*).

T. J. Spilman observed that a recent U.S. commemorative stamp honoring the State of Massachusetts includes the minute figure of a grasshopper atop the weather vane on Boston's Faneuil Hall. He also distributed an assortment of surplus entomological publications.

Mignon Davis again asked that members and their friends contribute local natural history specimens to the Naturalist Center. Insects are an especially important component of several courses offered at the Center.

The speaker for the evening was Gary F. Hevel, Collections Manager, Department of Entomology, Smithsonian Institution. His talk, entitled "Durians and Trilobite Beetles: Collecting Experiences in Sabah," recounted his entomological, botanical and cultural adventures with teammate Warren

E. Steiner, Jr., during their ascent of Kinabalu, the highest mountain on the island of Borneo (indeed, in all Southeast Asia). Mr. Hevel's presentation was accompanied by some unusual sound effects provided by the President-Elect.

Visitors were introduced and the meeting was adjourned at 9:45 p.m. Refreshments followed.

Richard G. Robbins, *Recording Secretary*

PUBLICATIONS FOR SALE BY THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

Miscellaneous Publications

Cynipid Galls of the Eastern United States, by Lewis H. Weld	$ 5.00
Cynipid Galls of the Southwest, by Lewis H. Weld	3.00
Both papers on cynipid galls	6.00
Identification of Alaskan Black Fly Larvae, by Kathryn M. Sommerman	1.00
Unusual Scalp Dermatitis in Humans Caused by the Mite *Dermatophagoides*, by Jay R. Traver	1.00
A Short History of the Entomological Society of Washington, by Ashley B. Gurney	1.00
Pictorial Key to Species of the Genus *Anastrepha* (Diptera: Tephritidae), by George C. Steyskal	1.50
Taxonomic Studies on Fruit Flies of the Genus *Urophora* (Diptera: Tephritidae), by George C. Steyskal	2.00

Memoirs of the Entomological Society of Washington

No. 1.	The North American Bees of the Genus *Osmia*, by Grace Sandhouse. 167 pp. 1939	$15.00
No. 2.	A Classification of Larvae and Adults of the Genus *Phyllophaga*, by Adam G. Boving. 95 pp. 1942	(out of print)
No. 3.	The Nearctic Leafhoppers, a Generic Classification and Check List, by Paul Wilson Oman. 253 pp. 1949	15.00
No. 4.	A Manual of the Chiggers, by G. W. Wharton and H. S. Fuller. 185 pp. 1952	15.00
No. 5.	A Classification of the Siphonaptera of South America, by Phyllis T. Johnson. 298 pp. 1957	15.00
No. 6.	The Female Tabanidae of Japan, Korea and Manchuria, by Wallace P. Murdoch and Hirosi Takahasi. 230 pp. 1969	15.00
No. 7.	Ant Larvae: Review and Synthesis, by George C. Wheeler and Jeanette Wheeler. 108 pp. 1976	11.00
No. 8.	The North American Predaceous Midges of the Genus *Palpomyia* Meigen (Diptera: Ceratopogonidae), by W. L. Grogan, Jr. and W. W. Wirth. 125 pp. 1979	12.00
No. 9.	The Flower Flies of the West Indies (Diptera: Syrphidae), by F. Christian Thompson. 200 pp. 1981	10.00
No. 10.	Recent Advances in Dipteran Systematics: Commemorative Volume in Honor of Curtis W. Sabrosky. Edited by Wayne N. Mathis and F. Christian Thompson. 227 pp. 1982	11.00
No. 11.	A Systematic Study of the Japanese Chloropidae (Diptera), by Kenkichi Kanmiya. 370 pp. 1983	18.00
No. 12.	The Holarctic Genera of Mymaridae (Hymenoptera: Chalcidoidae), by Michael E. Schauff. 67 pp. 1984	5.00
No. 13.	An Identification Manual for the North American Genera of the Family Braconidae (Hymenoptera), by Paul M. Marsh, Scott R. Shaw, and Robert A. Wharton. 98 pp. 1987	18.00

Back issues of the Proceedings of the Entomological Society of Washington are available at $25.00 per volume to non-members and $13.00 per volume to members of the Society.

Prices quoted are U.S. currency. Postage extra except on prepaid orders. Dealers are allowed a discount of 10 per cent on all items, including annual subscriptions, that are paid in advance. All orders should be placed with the Custodian, Entomological Society of Washington, c/o Department of Entomology, NHB 168, Smithsonian Institution, Washington, D.C. 20560.

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