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TWO NEW NEOTROPICAL TREEHOPPER GENERA AND INVESTIGATION OF
THE PHYLOGENY OF THE SUBFAMILY MEMBRACINAE
(HOMOPTERA: MEMBRACIDAE)

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Abstract.—Two new genera are described in the membracid tribe Membracini: *Havilandia*, new genus, including *H. pruinosa* (Haviland), new combination, and *H. hypso-proroides*, new species; and *Lewdeitzia*, new genus, including *L. lunata*, new species. *Havilandia* is morphologically and behaviorally similar to Talipedini and some *Leioscyta* Fowler (Membracini), but may be the sister-group of Hypso prorini. *Lewdeitzia* is apparently dimorphic for a feature of the forewing venation used to distinguish *Erechtia* Walker from *Leioscyta*. Preliminary cladistic analyses of 27 taxa in the subfamily Membracinae place the new genera among others in the tribe Membracini, but suggest that this tribe is paraphyletic, having given rise to other tribes in the subfamily. The analyses further suggest that the tribe Talipedini is paraphyletic and the genera *Leioscyta* and *Membracis* Fabricius are para- or polyphyletic. Reclassification of the Membracinae is needed, but should await elucidation of the limits of some genera of Membracini by more extensive cladistic analyses. A key to the tribes of Membracinae and the genera of Membracini is presented. Nomenclatural changes include restoration of the original spelling of *Paragara* Goding, 1926, and of the combination *P. tholoidea* (from *Paragargara*) and two new combinations, *Paragara nigra* (Funkhouser) (from *Paragargara*) and *Enchenopa beebei* (Haviland) (from *Leioscyta*). Two species most recently treated as *Membracis* are here considered Membracini *incertae sedis*.

Key Words: Cladistics, evolution, morphology, parsimony, paraphyly

The subfamily Membracinae constitutes a major component of treehopper diversity in the New World and is especially diverse in the tropics. The North American *Enchenopa binotata* species complex, whose females insert eggs into host plant tissue, has attracted attention as an example of host-mediated sympatric speciation (Wood 1993b). Polyphagy has been reported within

some tropical genera (Loye 1992, Wood 1993a) and may be explained partly by the habit in many species, but in Membracinae only, of depositing egg masses on the host plant surface, thereby obviating many of the plant's first-line structural and chemical defenses against herbivore colonization.

Cladistic analyses of the family-group taxa of Membracidae (Dietrich and Deitz 1993; Dietrich, Deitz, and McKamey, unpubl.) support the monophyly of Membracinae, but, until now, there has been no explicit cladistic analysis of relationships among its

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five tribes (Deitz and Dietrich 1993): Aconophorini, Hoplophorionini, Hypsoprporini, Talipedini, and Membracini. Nonetheless, three are supported by apparent synapomorphies. The Aconophorini and Hoplophorionini are well-supported monophyletic groups (Dietrich and Deitz 1991; McKamey and Deitz, unpubl.). The species of Hypsoprporini are also united by apparent synapomorphies that are unique among the Membracinae: pronotum with lateral margins of posterior process overlapping forewing at rest, and clavus of forewing acute and extensively associated with apical limbus. No synapomorphies have been found to support the monophyly of Talipedini or Membracini.

The tribe Talipedini was erected (Deitz 1975) to draw attention to the position of *Trinarea* (as *Talipes*) *appendiculata* (Fonseca) as morphologically intermediate between the tribes Membracini and Hoplophorionini. Talipedini and Hoplophorionini both have clavate hind tibiae and small hind tarsi, a unique synapomorphy, but features used by Deitz (1975) to distinguish Talipedini from Hoplophorionini are present in Membracini, suggesting that Talipedini may be paraphyletic. McKamey and Deitz (1991) transferred two more species into Talipedini, but did not list additional diagnostic features for the tribe.

The most diverse tribe in the subfamily is Membracini, which, now with 17 genera and nearly 200 described species, is twice as rich in genera and species as the next largest tribe, Hoplophorionini. Among the diagnostic features listed by Deitz (1975) for Membracini, none are unique to that tribe. Thus, Membracini (*sensu* Deitz 1975, expanded by McKamey 1992 and Sakakibara 1992), although defined by a unique combination of features, also may be paraphyletic.

Two new taxa were discovered that keyed to Membracini (Deitz 1975), but were not assignable to any known genus and have combinations of features traversing current

concepts of tribes and genera. Species of *Havilandia*, new genus, share morphological features with species of Hypsoprporini, Hoplophorionini, Talipedini, and Aconophorini. *Lewdeitzia lunata*, new genus, new species, may be sexually dimorphic for the forewing venation feature distinguishing *Leioscyta* Fowler from *Erechtia* Walker (tribe Membracini) and the female has a broad, obtusely rounded, marginally compressed, anterior pronotal horn similar to that of Aconophorini and some Hoplophorionini. The features of these new taxa accentuate problems with the generic and tribal classification of the Membracinae. To help place the new taxa, we analyzed the relationships among the genera of Membracini and representatives of other tribes of Membracinae.

Given the need of further taxonomic work revealed by the cladistic analysis, the numerous modifications to Membracini since the last key (Funkhouser 1951), and the discovery of some previously unknown or neglected intrageneric variation, we present a key to tribes of Membracinae and genera of Membracini to clarify current taxonomic concepts in the subfamily.

KEY TO THE MEMBRACINAE

1. Forewing vein R initially divided into R_{1+2+3} and R_{4+5} or venation reticulate, or with both conditions 2
- 1'. Forewing vein R initially divided into R_1 and $R_s (=R_{2+3+4+5})$ (Figs. 1, 2), venation not reticulate 4
2. Metathoracic legs with tibiae clavate and with tarsi distinctly shorter than anterior tarsi ... Hoplophorionini¹
- 2'. Metathoracic legs with tibiae not clavate and with tarsi as long as anterior tarsi (Fig. 2c) ... 3
3. Pronotum with lateral margins of posterior process overlapping portions of apical limbus and veins of forewing in repose; forewing clavus acuminate Hypsoprporini²

¹ Key to genera in prep. by McKamey and Deitz.

² See Funkhouser's (1951) key to genera of "Notoicerini," plus *Jibarita* Ramos and *Hypsoprporachis* Fonseca and Diringshofen.

- 3'. Pronotum evenly tapered posterolaterally, at most concealing part of apical limbus of forewing in repose; forewing clavus oblique apically Aconophorini³
- 4. Metathoracic legs with tibiae clavate and with tarsi distinctly shorter than anterior tarsi; abdomen with middorsal tuberosities Talipedini (monotypic: *Trinarea* Goding)
- 4'. Metathoracic legs with tibiae not clavate (Fig. 2c) or, if clavate, then abdomen without middorsal tuberosities; metathoracic tarsi at least as long as anterior tarsi (Membracini) 5
- 5. Metathoracic tibiae clavate, with dorsal edges flattened, and with cucullate setae numerous and small in row I, small or absent in row II (Fig. 1j) *Havilandia*, n. gen.
- 5'. Metathoracic tibiae with dorsal edges not flattened, with large cucullate setae in rows I and II (Fig. 2c) 6
- 6. Pronotal metopidium with 1 to several oblique carinae on each side and with pair of dorsolateral carinae or dorsum strongly bisinuate posteriorly, or with all three conditions 7
- 6'. Pronotal metopidium without oblique carinae, with or without dorsolateral carinae, dorsum sublinear or once-sinuate posteriorly 13
- 7. Pronotal lateral carinae extending to posterolateral margins or nearly so; pronotal integument coarsely punctate (pits distinct) and thick 8
- 7'. Pronotal lateral carinae terminating before or above humeral angles; pronotal integument sometimes smooth (pits indistinct), membrane-like 9
- 8. Pronotum bisinuate, declining stepwise from above humeral angle to posterior apex *Tylopetta* Fowler
- 8'. Pronotum declining evenly from above humeral angle to posterior apex *Campylenchia* Stål, *Enchenopa* Amy. & Serv.
- 9. Pronotum and its horn depressed, pronotal integument thick and coarsely punctate (pits large, deep, and distinct above humeri) *Kronides* Kirkaldy
- 9'. Pronotum and its horn, if present, foliaceous, thin, and smooth (pits small, shallow, and indistinct above humeri at least) 10
- 10. Pronotal horn present and distinct *Enchophyllum* Amy. & Serv.
- 10'. Pronotal horn absent or indistinct 11
- 11. Pronotal metopidium with a pair of dorso-lateral carinae and a ventral lobe produced in front of the vertex of the head *Phyllotropis* Stål
- 11'. Pronotal metopidium without dorsolateral carinae or without ventral lobe, or with neither feature 12
- 12. Pronotal dorsum strongly foliaceous, sides extensively compressed into a single plate-like median carina *Folicarina* Sakakibara⁴
- 12'. Pronotal dorsum not so strongly compressed, sides not extensively fused *Membracis* (in part; e.g. *M. carinulata* Richter)
- 13. Pronotum foliaceous and smooth (pits small, shallow, and indistinct above humeri at least); forewing surface coriaceous throughout (arcuate chaetoids conspicuous) *Membracis* (in part; e.g. *M. foliata* [L.]
- 13'. Pronotum depressed, at least posterolaterally, and more coarsely punctate (pits larger, deeper, and distinct above humeri); distal forewing surface more glossy (arcuate chaetoids absent or inconspicuous) 14
- 14. Anteromedial pronotal horn present (except in some ♂ *Tritropidia*, which are indistinguishable from *Leioscyta*) 15
- 14'. Anteromedial pronotal horn absent 16
- 15. Pronotal horn narrow in lateral aspect; clypeus distally narrowed (as in Fig. 1h) *Tritropidia* Stål
- 15'. Pronotal horn broad in lateral aspect; clypeus distally truncate (Fig. 2g) *Lewdeitzia*, n. gen.
- 16. Forewing with 2 or more r-m crossveins 17
- 16'. Forewing with only 1 r-m crossvein 18
- 17. Pronotum rugosely carinate, steeply declivous posteriorly, humeri without transverse carinae *Bolbonotodes* Fowler
- 17'. Pronotum evenly carinate, gradually declivous posteriorly, humeri often with transverse carinae *Erechtia*
- 18. Pronotal dorsum with irregular gibbositities throughout, transversely carinate or gibbous subapically, and without long straight lateral carinae; mesothoracic tibiae foliaceous *Bolbonota* Amy. & Serv.
- 18'. Pronotal dorsum without irregular gibbositities, usually with 1 pair sublinear lateral carinae extending posteriorly over dorsum; mesothoracic tibiae cylindrical to foliaceous 19
- 19. Pronotal contour in lateral aspect strongly sinuate *Paragara*⁵

³ See Dietrich and Deitz (1991) for keys to genera and species.

⁴ New distribution record for *Folicarina* nr. *bicolor*: Trinidad, Arima Valley, St. Andrew's Trace, 16-24 June 1981, leg. S.H. McKamey.

⁵ *Paragara* Goding, 1926a; original spelling here restored from *Paragargara*. Type species: *Paragara tho-*

- 19'. Pronotal contour in lateral aspect linear or nearly so 20
 20. Hind wing without r-m and m-cu crossveins, with vein M free *Eunusa* Fonseca
 20'. Hind wing with 1 r-m and 1 m-cu crossvein *Leioscyta*

DESCRIPTIONS OF NEW TAXA

Morphological terms, techniques, and the convention for quoting labels follow Deitz (1975), Dietrich (1989), and Dietrich and Deitz (1991), except forewing crossvein s (that connects veins R_{2+3} and R_{4+5}) equals "r" of Deitz (1975). Specimens for this study were provided by The Natural History Museum, London (BMNH); North Carolina State University, Raleigh (NCSU); the personal collection of S. H. McKamey (SHMC); and the United States National Museum of Natural History, Washington (USNM). Character states for taxa other than those described below are based on material identified and labeled in the NCSU and USNM collections.

Tribe Membracini Rafinesque

Havilandia, NEW GENUS

(Figs. 1a-k)

Type species: Tropidoscyta pruinosa Haviland.

Diagnosis.—Metathoracic tibia clavate and compressed along dorsal edge, with setal row I bearing numerous small cucullate setae and row II with few or none; forewing with cell membranes clothed by erect macrotrichia, without crossvein s.

Description.—*Head:* Vertex (Fig. 1h) impressed mesad of ocelli, ventrolateral margins weakly produced; ocelli approximately $2\times$ as far from each other as from mesal margins of eyes and approximately 1 ocellar diameter from dorsal margin of ver-

tex; frontoclypeus flat, diamond shaped, margins weakly produced, cibarial muscle scars parallel to ventrolateral margins; frontoclypeus, clypellus, and rostrum, in lateral view (Figs. 1a, i) forming continuous arc, rostrum extended to base of abdomen; in anterior view with distance between lateral margins of eyes slightly less than distance between pronotal humeri. *Thorax:* Pronotum (Figs. 1a, h-i) elongate and with midline strongly carinate and with 1 dorsolateral pair of strong carinae diverging from apex, extending to posterolateral margin of pronotum. Forewing (Figs. 1a, i) punctate in basal half between veins C and M and in anal area, vein R initially divided into R_1 and R_s , crossveins s and $r-m_1$ absent, 2 m-cu crossveins present, apical limb relatively narrow, contiguous with clavus for short distance only. Hind wing with crossveins r-m and m-cu present. *Legs:* Pro- and mesothoracic tibiae (Fig. 1i) compressed, translucent, margins of prothoracic tibia not expanded, mesothoracic tibia with posterior margin slightly expanded; mesothoracic coxa without acute process; metathoracic femur with pair of dorsoapical cucullate setae; metathoracic tibia (Figs. 1b, j) clavate, posterior margin compressed, row I with 15 or more small cucullate setae, row II with 5 or fewer, row III absent; all tarsi subequal in length; metathoracic tarsus relatively slender, tarsomere I with small apical cucullate seta. *Abdomen:* Sternum III without median tubercle, transverse carina indistinct or absent; terga without tuberosities or fenestrae. *Male:* Pygofer (Fig. 1d) with weak vertical lateral carina; lateral plate free, unarmed; aedeagus (Figs. 1f-g) with shaft slender, tapering apically, anterior face of apex evenly denticulate; gonopore membrane, in posterior view, occupying apical half of shaft; shank of style (Fig. 1e) slightly expanded preapically, shank sparsely setose, apex recurved, acute, in posterior view oriented dorsolaterally; subgenital plate with preapical dorsal lobe. *Female:* Posterior margin of sternum VII with arcuate emargination;

loidea Goding, 1926a, by original designation. Restored combination: *Paragara tholoidea* Goding. New combination: *Paragara nigra* (Funkhouser 1940). *Paragargara* (Goding 1926b) was an incorrect subsequent spelling and has no availability. *Paragargara* Goding, 1929, was an unjustified emendation and is an objective junior synonym of *Paragara*.

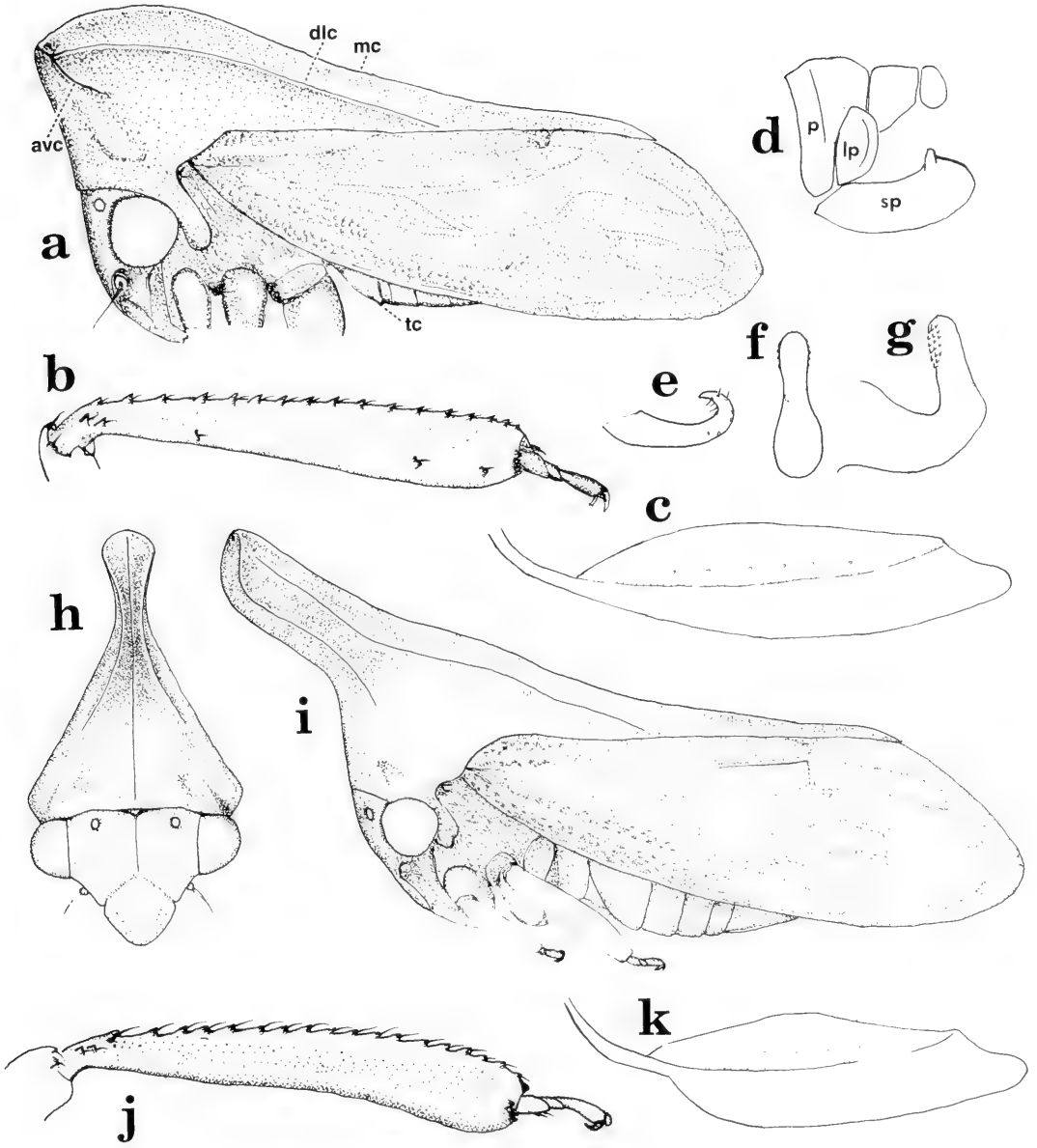


Fig. 1. *Haviglandia*, new genus. a-g, *H. pruinosa* (Haviland). a-c, holotype ♀: a, habitus, lateral view; b, left metathoracic tibia and tarsus, lateral view; c, second valvulae, lateral aspect; d-g, #7-90-337g ♂: d, terminalia, lateral view (genitalia removed); e, shank of left style, ventrolateral view; f-g, aedeagus, posterior and lateral views, respectively. h-k, *H. hypsoproroides*, new species, holotype ♀: h, head and pronotum, anterior view; i, habitus, lateral view; j, left metathoracic tibia and tarsus, lateral view; k, second valvulae, lateral view. avc, anteroventral carina; dlc, dorsolateral carina; dsc, dorsal submedial carina; p, pygofer; mc, median carina; lp, lateral plate; sp, subgenital plate; tc, transverse sternal carina.

2nd valvulae (Figs. 1c, k) in lateral view gradually expanded toward midlength, then tapering slightly toward apex, dorsal margin with arcuate emargination preapically, without distinct crenulae or teeth. *Integumental vestiture*: Vertex and pronotum evenly punctate; forewing membrane with semi-erect pale setae. Abdominal terga coarsely punctate, most pits associated with lateral seta; acanthae simple to dentate.

Notes and etymology.—Short-horned specimens of this genus resemble *Leioscyta* Fowler, but are distinguishable by the presence of a pair of anteroventral longitudinal carinae on the pronotum and the non-foliaceous front tibiae. Long-horned specimens resemble *Hypsoprora* Stål (Hypsoprorini), but lack apicolateral expansions on the posterior pronotal process. Although *Havilandia* best fits Deitz's (1975) concept of the tribe Membracini, certain features of the new genus resemble those of other tribes. Like species of Hoplophorionini and Talipedini, *Havilandia* has clavate hind tibiae with a reduced number of cuculate setae in row II. Like some species of Hypsoprorini, the new genus has a ventrolateral pair of carinae on the pronotal horn.

Generic recognition is based primarily on the tibial and abdominal features, but both species also have: vertex densely clothed with pale setae; thoracic pleuron pilose, setae clothed with white waxlike material; pronotum produced anterodorsally, with 1 ventrolateral pair of strong carinae diverging from the apex; and forewings densely clothed with arcuate chaetoids.

This genus is named in honor of Maud D. Haviland, a pioneer in the ecology and taxonomy of Neotropical Membracidae.

***Havilandia pruinosa* (Haviland),**

NEW COMBINATION

(Figs. 1a–g)

Synonymy: *Tropidoscyta pruinosa* Haviland, 1925:237.

Type locality: Kartabo, Cuyuni District, Guyana [BMNH].

Material examined.—Holotype ♀ [BMNH]. Other specimens: Nestor, Trinidad; San Martin and Shapajilla, Peru; and Culebra, Amazonas, Venezuela [all USNM]; road to Foco Mine, 33 km SE El Dorado, Bolivar, Venezuela [SHMC]. Dates of collection: February, April, May, August. A teneral ♂ specimen from Maroni, French Guiana [Figs. 1d–g; Dietrich Research #7-90-337g, NCSU] is probably conspecific with the holotype of *H. pruinosa* but lacks a pale macula on the forewing at the apex of vein Cu that is present in the holotype (Fig. 1a).

Notes.—Females of *H. pruinosa* guard their eggs and are not ant-attended (Haviland 1925), characteristics shared with Hoplophorionini and some Aconophorini and Membracini (Haviland 1925, Wood 1984, Dietrich and Deitz 1991). *H. pruinosa* females also deposit a pale waxlike material in spirals along the twig and leaf edges in the vicinity of their egg masses (Haviland 1925; McKamey, unpubl.). Similar deposits are produced by *Leioscyta spiralis* Haviland (Haviland 1925, Strümpel 1986) (tribe Membracini), an additional (unidentified) *Leioscyta* species (McKamey, unpubl.), *Ochropepla triangulum* (Germar) (tribe Hoplophorionini; Wood 1984 [as *O. pallens* Stål]), and *Aconophora mexicana* Stål (tribe Aconophorini; Wood 1984, Dietrich and Deitz 1991). Nymphs of *H. pruinosa*, *L. spiralis*, and *A. mexicana* are also clothed with irregular waxlike exudates that facilitate crypsis among the spiral deposits (as in Strümpel 1986: Fig. 2). Many other species of Membracinae have nymphs with white waxlike exudates but lack waxy deposits adjacent to their egg masses. Such features have not been reported for species of subfamilies other than Membracinae.

***Havilandia hypsoprroides*,**

NEW SPECIES

(Figs. 1h–k)

Type locality: Fonteboa, Amazonas, Brazil [BMNH].

Description.—Head, pronotum, and ab-

domen reddish brown, pronotal horn darker than rest of pronotum, legs yellow; head with vertex densely clothed with pale setae; thoracic pleuron pilose, setae clothed with white waxlike material; forewing membrane uniformly smoky hyaline. Pronotum (Fig. 1i) produced into an elongate, slender antero-medial horn, apex in lateral view expanded and obliquely rounded, with 1 ventrolateral pair of strong carinae diverging from apex; posterior process approximately even with crossvein r-m of forewing at rest, apex slightly elevated. Forewing densely clothed with arcuate chaetoids. Metathoracic tibia (Fig. 1j) with setal row I bearing 15–18 cucullate setae. *Dimensions* (mm): Body length (head to apex of forewing at rest) 5.1, width across humeri 1.7; vertex height 0.7, width 1.0; pronotum length 5.3; head to horn apex 2.1; forewing length 4.5; prothoracic tibia length 1.0; metathoracic tibia length 1.5; ovipositor length 1.0.

Material examined.—Holotype ♀ labeled: “Amazon./ Fonteboa; Riksmuseum/ Stockholm; Dietrich Res./ 7-90-33a♀; HOLOTYPE/ Havilandia/ hypsoprroides/ Dietrich and McKamey” [BMNH].

Etymology.—The trivial name was selected to indicate the similarity of this species to members of the genus *Hypsoprora* Stål.

KEY TO SPECIES OF *HAVILANDIA*

1. Anterior pronotal process, in lateral view, short, broad, and tapered, apex rounded (Fig. 1a) . . .
 *pruinosa* (Haviland)
- 1'. Anterior pronotal process, in lateral view, elongate and slender, apex obliquely truncate (Fig. 1i) *hypsoprroides*, n. sp.

Lewdeitzia, NEW GENUS

(Figs. 2a–m)

Type species: Lewdeitzia lunata, new species.

Diagnosis.—Anterior region of pronotum in lateral view elevated into broad, rounded process with 1 carina on each side, in female further developed into large, marginally

compressed horn; forewing with 1 or 2 r-m crossveins, with vein R initially divided into R₁ and R_s.

Description.—*Head:* Vertex (Fig. 2g) not impressed mesad of ocelli, ventrolateral margins foliaceous and strongly produced; ocelli approximately 2× as far from each other as from mesal margins of eyes and approximately 2 ocellar diameters from dorsal margin of vertex; frontoclypeus flat, lateral corners rounded and apex truncate, margins foliaceous; rostrum extended to base of abdomen; frontoclypeus, in lateral view, forming shelf above clypellus; in anterior view (Fig. 2g) with distance between lateral margins of eyes slightly less than distance between humeri. *Thorax:* Pronotum with broad, marginally compressed anterodorsal process, much larger in female (Fig. 2a) than in male (Fig. 2e), bearing pair of lateral carinae extending ventrolaterally from apex but not attaining posterolateral margins. Forewing (Figs. 2a, e) punctate in basal half between veins C and M and in base of anal area, vein R initially divided into R₁ and R_s, crossveins s and r-m₂ present, with crossvein r-m₁ present (Fig. 2a) or absent (Fig. 2e), 2 m-cu crossveins present, m-cu, perpendicular to veins M and Cu, 1st and 2nd M cells subequal in length, apical limb relatively wide, contiguous with clavus for short distance only. Hind wing crossveins r-m and m-cu present. *Legs:* Pro- and mesothoracic tibiae (Figs. 2h, i) compressed and foliaceous; mesothoracic femur with anteroapical cucullate seta; metathoracic tibia (Fig. 2c) straight, not compressed, row I with 7–8 enlarged cucullate setae, row II with 4–5 enlarged cucullate setae, row III without cucullate setae; metathoracic tarsus slightly longer than others, tarsomere I with 4 apical cucullate setae. *Abdomen:* Sternum III without median tubercle, sternum IV with distinct transverse carina; terga without tuberosities or fenestrae. *Male:* Pygofer with vertical lateral carinae; lateral plate free, with prominent rounded vertical ridge over entire height (Fig. 2j); aedeagus

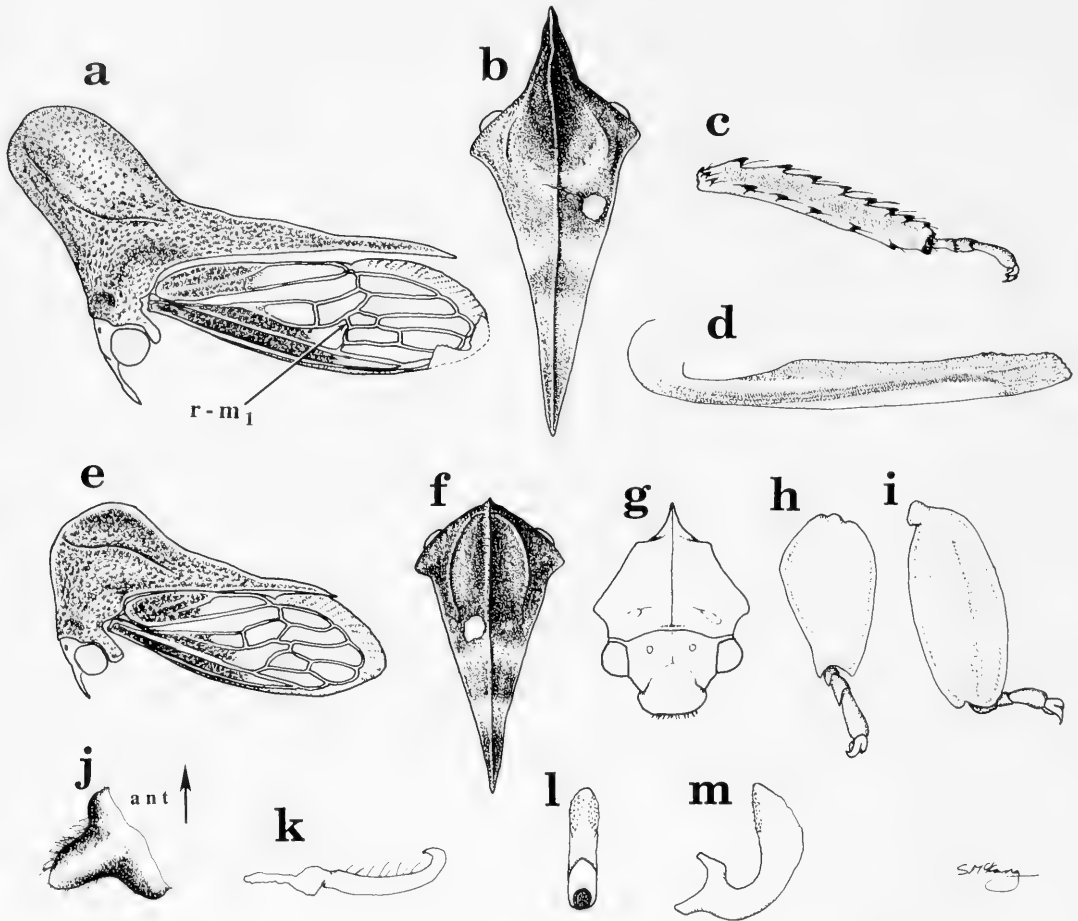


Fig. 2. *Lewdeitzia lunata*, new genus, new species. a-d, holotype ♀: a, head, pronotum, and forewing, lateral view (texture); b, head and pronotum, dorsal view (color); c, reversed right metathoracic tibia and tarsus, lateral view, same scale as 2h-i; d, second valvulae, lateral view; e-m, ♂: e, head, pronotum, and forewing, reversed lateral view (texture); f-g, head and pronotum, dorsal (color) and anterior views, respectively; h-i, left pro- and mesothoracic tibiae and tarsi, lateral views; j, left lateral plate, dorsal view (ant, anterior); k, left style, ventrolateral view; l-m, aedeagus, anterior and lateral views, respectively.

(Figs. 2l, m) with shaft slender, in anterior view subparallel, in lateral view tapering apically, anterior face of apex evenly denticulate laterally; gonopore membrane, in posterior view, occupying nearly entire width of shaft; shank of style (Fig. 2k) with numerous long setae, apex recurved and acute; subgenital plate evenly tapering apically, without lobes. *Female*: Posterior margin of sternum VII with arcuate emargination; 2nd valvulae, in lateral view (Fig. 2d), subparallel, apical $\frac{1}{3}$ irregularly cren-

ulate. *Integumental vestiture*: Vertex and pronotum coarsely punctate, sparsely clothed with pale recumbent setae; thoracic pleuron sparsely setose, setae not clothed with waxlike material; forewing membrane glabrous. Abdominal terga coarsely punctate, pits without lateral setae; acantheae dentate.

Notes and etymology.—The female of this genus resembles *Aconophora* Fairmaire (Aconophorini), while the male resembles *Leioscyta*. The genus is named to honor

Lewis L. Deitz, whose higher classification and bibliographies have greatly facilitated research on the Membracoidea.

Lewdeitzia lunata, NEW SPECIES
(Figs. 2a–m)

Type locality: São Paulo, São Paulo State, Brazil [NCSU].

Description.—Ground color brown; pronotal carinae, crescent-shaped band around posterior base of horn (female; Fig. 2b) or mottling between carinae and humeri (male; Fig. 2f), 2 transverse bands farther posterad on dorsum, transverse band on metopidium between humeri, and legs paler orange brown; forewing smoky hyaline with 2 pale transverse bands (1 near base, 1 aligned with end of clavus). Female pronotal horn with apically bifid lateral longitudinal gibbosity, apex obtusely rounded, lateral carinae weak, terminating slightly posterad of humeri; male horn short and rounded, carinae distinct, marginal compressed area narrower. Other morphology as described for genus.

Dimensions (mm).—Body length ♀ 6.3, ♂ 5.3; maximum width ♀ 2.8, ♂ 2.4; pronotal length ♀ 7.0, ♂ 4.5; head to horn apex ♀ 3.3; forewing length ♀ 5.5, ♂ 4.8; prothoracic tibia length ♀ 1.5, ♂ 1.2; metathoracic tibia length ♀ 2.2, ♂ 1.9; ovipositor length 1.9.

Material examined.—Holotype ♀ labeled: "Sao Paulo/ S. Paulo Brazil/ Nov. 1930; A.Maller,Coll./ FrankJohnson/ Donor; 1531 ♀/ S. Paulo/ S. Paulo/ 10.30; HOLOTYPE/ Lewdeitzia/ lunata/ Dietrich and McKamey" [NCSU]. Other material: ♂ from Corupá, Santa Catarina, Brazil, XI-1929, A. Maller, Coll. (Dietrich Research 15-91-40d ♂) [NCSU].

Notes and etymology.—The holotype lacks its left metathoracic leg. The male, which lacks its left hind tarsus and right hind tarsomeres II and III, was excluded from type status because it may not be conspecific, given the considerable differences compared to the female. Nonetheless, because extreme sexual dimorphism is com-

mon in other species of Membracinae (e.g. see Sakakibara 1976 and Strümpel and Strümpel 1978), we consider the nearly identical color pattern and similar size of both *Lewdeitzia* specimens sufficient to regard them as a single species. The species name is derived from Latin for the pale crescent-shaped band around the base of the female's horn.

CLADISTICS

Morphological characters

Head

1. Frontoclypeus: 0, apex in lateral view not forming a shelf over clypellus, margins not expanded laterally (Fig. 1h); 1, apex in lateral view not forming a shelf over clypellus, margins expanded laterally; 2, apex in lateral view forming a shelf over clypellus (Sakakibara 1992: Figs. 1, 2, 4).

Pronotum

2. Shape: 0, depressed or rounded (Figs. 1a, i); 1, compressed (Deitz 1975: Fig. 15S); 2, foliaceous (*op. cit.*: Fig. 15U).

3. Anteromedial horn: 0, absent or weak (Fig. 1a); 1, well developed (Fig. 1i). Although entirely enclosed by the foliaceous pronotal margins, the horns of *Phyllotropis* and *Folicarina* are nonetheless well indicated (Sakakibara 1992: Figs. 3, 4).

4. Transverse metopidial carinae: 0, absent; 1, restricted to humeri; 2, complete, two sides meeting medially.

5. Dorsolateral carinae: 0, absent; 1, one submedial pair (Figs. 1a, i); 2, two or more pairs (Deitz 1975: Fig. 15R). The pronotal carinae of Hoplophorionini converge at the base of the metopidium rather than at its apex, as in other Membracinae, and therefore may not be homologous.

6. Posterior extension of dorsolateral carinae: 0, absent; 1, terminated above humeri; 2, extended beyond humeri.

7. Dorsal submedial carinae: 0, absent; 1, meeting medial carina anteriorly (Fig. 1a); 2, not meeting medial carina anteriorly.

8. Anteroventral pair of carinae, which are contiguous with dorsolateral carinae: 0, absent; 1, present (Figs. 1a, h, i).

9. Irregular, oblique metopidial carinae: 0, absent; 1, present (Sakakibara 1992: Fig. 4).

10. Posterior transverse carina: 0, absent; 1, present (Haviland 1925: Pl. II, Fig. 6).

11. Posterior sublateral longitudinal carinae: 0, absent; 1, present (Fonseca and Diringshofen 1969: Fig. 3). Our treatment of this feature as a separate character from character 6 is supported by the presence of both dorsolateral and sublateral carinae in some taxa (e.g. *Erechtia*).

12. Punctuation: 0, coarse—distance between pits less than pit diameter, pits distinct above humeri; 1, fine—distance between pits greater than pit diameter, pits indistinct above humeri. Considerable variation exists among taxa coded as state 0, but state 1 (e.g. *Membracis*) is distinctive (compare Figs. 7 and 10 of Wood and Morris 1974).

Pleuron and legs

13. Pleural wax: 0, absent; 1, present. State 1 is considered to represent a homolog, although *Havilandia* has the pleuron densely pilose with waxy setae while *Hypsoprora* has the pleuron sparsely setose with waxlike deposits on the surface of the sclerite.

14. Pro- and mesothoracic tibiae: 0, narrow, semicylindrical; 1, subfoliaceous (Figs. 2h, i).

15. Mesothoracic acute coxal process: 0, absent; 1, present. State 1 is a synapomorphy of the tribe Hoplophorionini.

16. Metathoracic tibia: 0, not clavate, row II with numerous cucullate setae (Fig. 2a); 1, distinctly clavate, row II with few or no cucullate setae (Figs. 1b, j). Some *Erechtia* and *Leioscyta* species have the metathoracic tibia weakly clavate, but with numerous cucullate setae in row II, perhaps representing an intermediate state of this character.

17. Length of metathoracic tarsi relative to pro- and mesothoracic tarsi: 0, longer; 1, subequal; 2, distinctly shorter (Deitz 1975: Fig. 14A).

Forewing

18. Vein R: 0, initially divided into R₁ and R_s (Fig. 1a); 1, initially divided into R₁₊₂₊₃ and R₄₊₅ (Deitz 1975: Fig. 11A).

19. Crossvein s: 0, absent; 1, present (Figs. 2a, e).

20. Crossvein(s) r-m: 0, one (Figs. 1a, i); 1, two or more (Fig. 2a).

21. Membrane, erect macrotrichia: 0, absent; 1, present.

22. Membrane, arcuate chaetoids: 0, absent, surface glabrous; 1, present, surface shagreen (Dietrich and Deitz 1993: Fig. 27).

Abdomen

23. Sternum III: 0, unarmed; 1, with medial tubercle; 2, with transverse carina (Fig. 1a).

24. Sternum IV: 0, unarmed; 1, with transverse carina (Deitz 1975: Fig. 3A).

25. Dorsal tuberosities or fenestrae, terga V–VIII: 0, absent; 1, paired (*op. cit.*: Fig. 3A); 2, unpaired medial (Dietrich 1989: Fig. 18). The presence, in *Trinarea* and some *Erechtia*, of paired tuberosities on the anterior terga and unpaired medial tuberosities on the posterior terga suggests that one feature was derived from fusion or separation of the other.

Second valvulae

26. Length: 0, elongate; 1, short and broad (Deitz 1975: Figs. 17H–J).

27. Dorsal teeth (*op. cit.*: Figs. 17C, M): 0, absent; 1, one; 2, two. The serrations found in many membracid groups (*op. cit.*: Fig. 8) were not considered homologous.

28. Dorsoapical emargination: 0, absent; 1, present (Figs. 1c, k).

Analysis

Our data matrix (Table 1) included at least one representative of each genus of Mem-

Table 1. Character state matrix for numerical cladistic analysis of the Membracinae. Missing values are represented by ?'s.

OTU	Character				
	1-5	6-10	11-15	16-20	21-28
Heteronotinae (outgroup)					
<i>Dysyncritus intectus</i> Fowler	20000	00000	00000	00010	00000000
Membracinae					
Aconophorini (<i>Guayaquila</i> Goding)	00100	00000	00010	01110	01011000
Hypsoprorini (<i>Hypsoprorora</i> Stål)	20101	11100	00110	00110	01010020
Hoplophorionini (<i>Potnia</i> Stål)	00102	22000	10001	12110	00012000
Membracina					
<i>Bolbonota</i> sp.	10002	22001	00010	01010	01010100
<i>Enchenopa binotata</i> (Say)	21101	21010	00010	00010	01011020
<i>Enchophyllum</i> sp. A	21101	11010	01010	00010	01011020
<i>Enchophyllum</i> sp. B	21101	11000	01010	00010	01011020
<i>Erechtia bicolor</i> Walker	20022	21000	10010	01011	01112000
<i>Erechtia</i> sp.	20022	21000	10010	01010	01112??0
<i>Eunusa concolor</i> Fonseca	00000	00000	00000	00010	00110000
<i>Havilandia pruinosa</i> (Haviland)	00001	21100	00110	11000	11100001
<i>H. hypsoproroides</i> gen. & sp. n.	00101	21100	00110	11000	11000001
<i>Kronides</i> sp.	00101	11010	00010	00010	01010020
<i>Enchenopa beebei</i> (Haviland)	21001	21010	00010	00010	01011020
<i>Leioscyta</i> sp. A	10001	21000	00010	00010	00010010
<i>Leioscyta</i> sp. B	20002	21000	10010	00010	01112000
<i>Lewdeitzia lunata</i> ♂ gen. & sp n.	20101	21000	00010	00010	01010000
<i>Lewdeitzia lunata</i> ♀	20101	21000	00010	00011	01010000
" <i>Membracis</i> " <i>ferruginea</i> (Funkh.)	21000	00000	00010	00010	11110000
<i>Membracis foliata</i> (L.)	22000	00000	01010	00010	01011020
<i>Membracis carinulata</i> Richter	21001	11010	01010	00010	01011000
<i>Phyllotropis cingulata</i> (Germar)	22101	11000	01010	00010	01011020
<i>Folicarina bicolor</i> Sakakibara	22101	11010	01010	00010	01010000
<i>Paragara nigra</i> (Funkhouser)	00001	?2000	00010	00010	00110100
<i>Tritropidia</i> sp.	11101	21001	00010	00010	00110100
<i>Tylopelta gibbera</i> (Stål)	20002	21011	00010	00010	01010000
Talipedini					
<i>Trinarea appendiculata</i> (Fonseca)	20112	21000	10010	12011	01112010
<i>Trinarea</i> sp. A	20022	21000	10010	12010	01112???

bracini except *Bolbonotodes*, which is known only from the ♀ holotype, and *Campylenchia*, which is identical to *Enchenopa binotata* for the included characters. Because *Lewdeitzia* is dimorphic for character 18, we included the male and female in the data as separate OTUs. The tribe Talipedini was represented by two species. The other membracine tribes, which are invariant for most of the characters, were each represented by one OTU.

A species belonging to the sister group of Membracinae (Dietrich and Deitz 1993), *Dysyncritus intectus* Fowler (type species of the genus; subfamily Heteronotinae) was chosen as the outgroup. Although clearly a member of Heteronotinae by virtue of the single r-m crossvein in its forewing, *D. intectus* shares certain features with Membracinae that are absent in other Heteronotinae. The metathoracic tibiae have cucullate setae enlarged in rows I and II but reduced

Table 2. List of apomorphies for the cladogram (Fig. 3) based on ACCTRAN character state optimization (Swofford 1990); other equally parsimonious optimizations are possible. Terminal taxa without apomorphies in the data are not listed. Nonhomoplasious changes are indicated by *.

Node	Apomorphies
52	14 (1), 22 (1)
51	5 (2), 6 (2), 7 (1)
50	11 (1)*, 25 (0 → 2)
49	4 (2), 17 (1)
47	16 (1), 17 (2)
46	3 (1), 4 (0)
45	23 (0)
44	10 (1)
43	5 (1)
42	1 (1), 22 (0)
41	23 (1), 26 (1)
40	3 (1)
39	6 (1), 27 (2)
38	9 (1)
37	2 (1), 25 (1)
36	12 (1)*
35	27 (0)
34	9 (0)
33	2 (2)
32	6 (2)
31	1 (0), 17 (1)
30	8 (1), 13 (1), 16 (1), 19 (0)*, 21 (1), 24 (0), 28 (1)*
Heteronotinae	23 (0), 24 (0)
Aconophorini	5 (0), 6 (0), 7 (0), 18 (1), 25 (1)
<i>Havilandia pruinosa</i>	3 (0), 23 (1)
Hypsoprorini	8 (1), 13 (1), 18 (1)
<i>Enchenopa beebei</i>	3 (0)
<i>Membracis foliata</i>	3 (0), 5 (0), 6 (0), 7 (0)
<i>Membracis carinulata</i>	3 (0)
<i>Folicarina</i>	2 (2), 25 (0)
<i>Kronides</i>	1 (0)
<i>Lewdeitzia</i> ♀	20 (1)
<i>Paragara</i>	1 (0), 7 (2)
<i>Tritropidia</i>	2 (1), 3 (1), 10 (1)
<i>Leioscyta</i> sp. A	27 (1)
<i>Bolbonota</i>	1 (1), 7 (2), 17 (1), 26 (1)
<i>Tylopetla</i>	9 (1)
Hoplophorionini	1 (0), 7 (2), 14 (0), 15 (1)*, 18 (1), 22 (0), 23 (0)
<i>Trinarea appendiculata</i>	4 (1), 20 (1), 27 (1)
<i>Erechtia bicolor</i>	20 (1)
<i>Membracis foliata</i>	2 (1), 21 (1)
<i>Eunusa</i>	1 (0)

in row III, a condition heretofore unknown outside of Membracinae, and forewing vein R is initially divided into R₁ and R_s.

We analyzed the data (Table 1) using Hennig86 version 1.5 (Farris 1988) and PAUP version 3.0s (Swofford 1990). Exact algorithms (guaranteed of finding minimal length trees) proved too time-consuming, so we used the command sequence "mh; bb*" of Hennig86 and the heuristic search with Tree-Bisection-Reconnection branch swapping (TBR) and MULPARS of PAUP. Among the 10 multistate characters, only characters 2 and 25 were arranged *a priori* in transformation series; thus only these 2 characters were treated as ordered (additive). Initially, we assigned all characters weight = 1. To find trees supported by the most consistent characters, we used the successive weighting facility of Hennig86 (command sequence "xs w; mh; bb*"). We compared the lengths of trees resulting from weighted and unweighted analyses by resetting the weight of each character to 1 (command sequence "ccode /1.; xsteps 1;").

RESULTS AND DISCUSSION

Hennig86 and PAUP yielded identical results for the unweighted analyses. Both found 4 equally most parsimonious trees of length = 88, consistency index (excluding autapomorphies) = 0.402, and retention index = 0.651. One of four most parsimonious trees is presented in Fig. 3. The others differ in whether the *Erechtia* species form a clade together or with *Trinarea* sp. A, and whether node 49 is supported. None of these 4 trees was preferred by successive weighting, which stabilized after 2 iterations at 71 trees of lengths 90–92, based on all character weights = 1.

Component 47 (Fig. 3) confirms Deitz's (1975) hypothesis that the closest relative of Hoplophorionini is Talipedini, which is a para- or polyphyletic group. Both tribes are apparently derived from Membracini, which is also apparently ancestral to Hypsoprorini and Aconophorini.

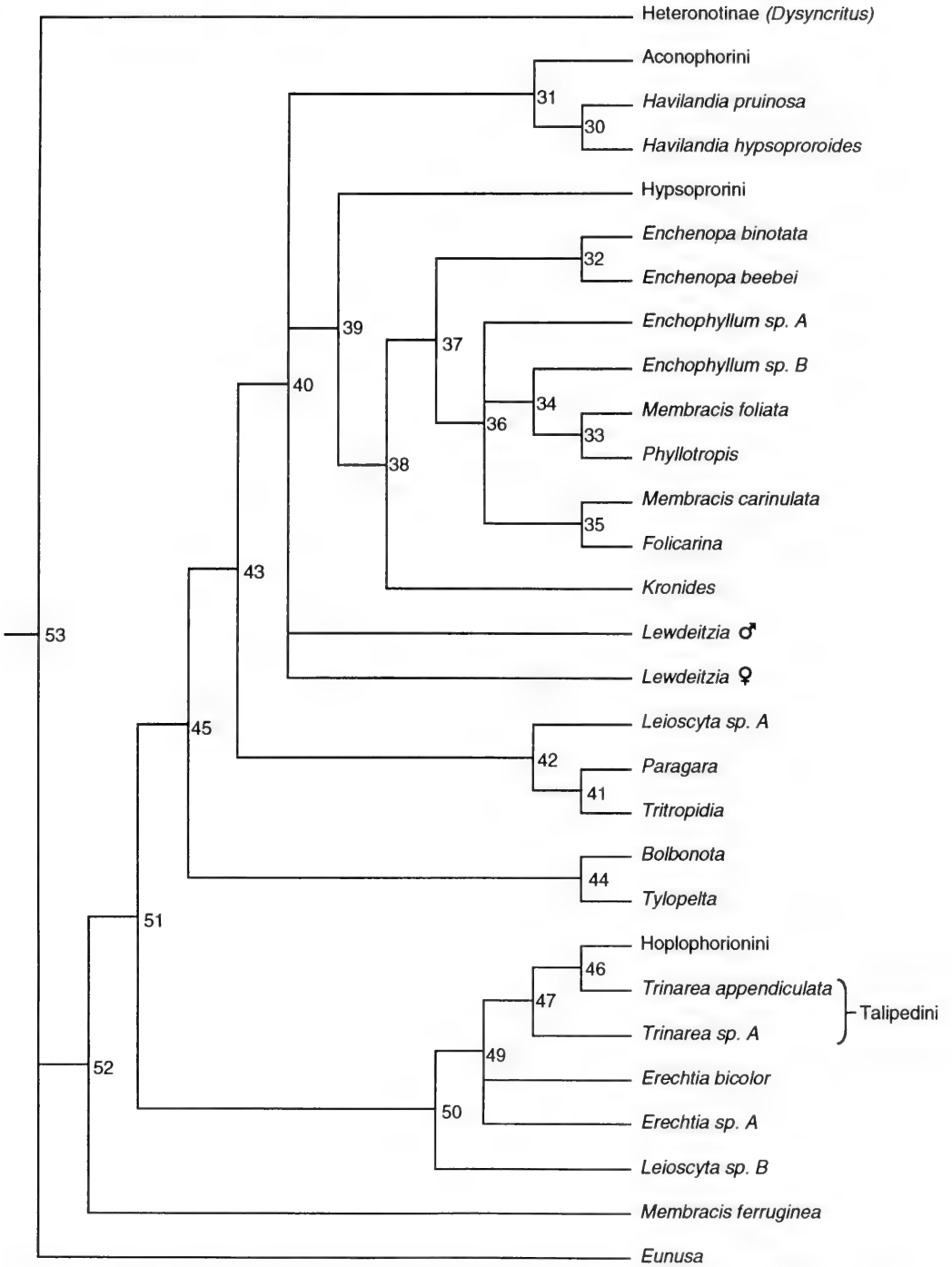


Fig. 3. Hypothesized cladistic relationships among Membracinae. Apomorphies are listed in Table 2.

Aconophorini, Hypsoprurini, and Hoplophorionini are diverse monophyletic groups with distinct morphologies and behaviors, so recognition of additional tribes for genera currently placed in Membracini seems preferable to treating all the tribes of Membracinae as synonyms. However, because some genera of Membracini (*Membracis* and *Leioscyta*) are polyphyletic and others are defined by individual features of the pronotum or forewing (Funkhouser 1951), the creation of new tribes should await species-level analyses that clarify the limits of genera within the two complexes.

One problematic complex of genera includes *Folicarina*, *Phyllotropis*, *Membracis*, and *Enchophyllum*, which, apart from the plesiomorphic horn in the latter genus, are distinguished from each other only by combinations of four pronotal features: (1) median carina extensively compressed into a plate-like carina or not; (2) metopidium with ventral lobe or not; (3) dorsolateral carinae present or not; and (4) oblique metopidial carinae present or not. *Membracis* exhibits the greatest variation, including among its species both states of all four characters (as examples of [1] and [2], *M. foliata* vs. *M. mexicana* Stål; of [3], *M. flava* Richter vs. *M. mexicana*; of [4], *M. carinulata* vs. *M. humilis* Fowler). The evolutionary polarities of these features need to be determined to establish better generic limits in this complex. The stability of the current genera is especially precarious because none is defined by a single feature—only by combinations.

The other problematic complex includes *Leioscyta* and its relatives (key couplets 14–20, and *Havilandia*). *Leioscyta* includes species with and without dorsolateral carinae and foliaceous mesothoracic tibia, and differs from the other genera only by the absence of their diagnostic (and seemingly apomorphic) traits, rather than by any synapomorphies of its own. Even the outgroup, *Dysyncritus intectus*, would fit the present concept of *Leioscyta* were it not for the fea-

tures distinguishing their respective subfamilies. Thus, *Leioscyta* probably comprises a diverse and polyphyletic set of species retaining different ancestral features, and is in great need of further work. Our preliminary estimate provides a framework for such studies.

Although some problems remain to be solved, other nomenclatural changes are already due. The *Leioscyta*-complex differs from the *Membracis*-complex in having coarser pronotal punctation. This feature was disregarded by Richter (1947) when he described the new species *Membracis micaniae* and by Fonseca and Diringshofen (1969) when they referred *L. ferruginea* Funkhouser to *Membracis*. Both species should be considered Membracini *incertae sedis* until generic limits in the *Leioscyta*-complex are better resolved. The *Leioscyta*-complex differs from *Enchenopa* in lacking oblique metopidial carinae, but not in lacking an anterior horn (e.g. males of *E. permutata* Van Duzee are hornless). We therefore refer *L. beebei*, whose holotype (BMNH) has oblique metopidial carinae but lacks a horn, to *Enchenopa*, creating the new combination *E. beebei* (Haviland).

Our analyses support recognition of the new genera *Havilandia* and *Lewdeitzia*. The most parsimonious trees indicate that *Havilandia* is the sister group of Aconophorini, but the genus shares at least one derived feature with some Hypsoprurini (character 8: pronotal horn with a pair of anteroventral carinae) and trees placing *Havilandia* as the sister group of Hypsoprurini required only one additional step. Although we included no characters in the analysis to unite the male and female of *Lewdeitzia*, the genus clearly represents a lineage distinct from other Membracini and therefore merits formal recognition. Our provisional placement of *Havilandia* and *Lewdeitzia* in Membracini reflects Deitz's (1975) concept of the tribe, which, for nomenclatural stability, is retained at present.

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**A NEW SPECIES OF *APHELINUS* (HYMENOPTERA: APHELINIDAE)
THAT PARASITIZES THE SPIREA APHID, *APHIS SPIRAECOLA*
PATCH (HOMOPTERA: APHIDIDAE)**

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Abstract. — A new species of an aphid parasitoid, *Aphelinus spiraecolae* Evans and Schauff (Hymenoptera: Aphelinidae) is described and figured. This species is parasitic on the spirea aphid, *Aphis spiraecola* Patch, and is being investigated for possible use in a biological control program against the spirea aphid and other citrus aphids including the brown citrus aphid, *Toxoptera citricida* (Kirkaldy). The new species is very similar to *Aphelinus gossypii* and characters to differentiate it from related species are given.

Key Words: Parasitoid, biological control, citrus, citrus tristeza virus

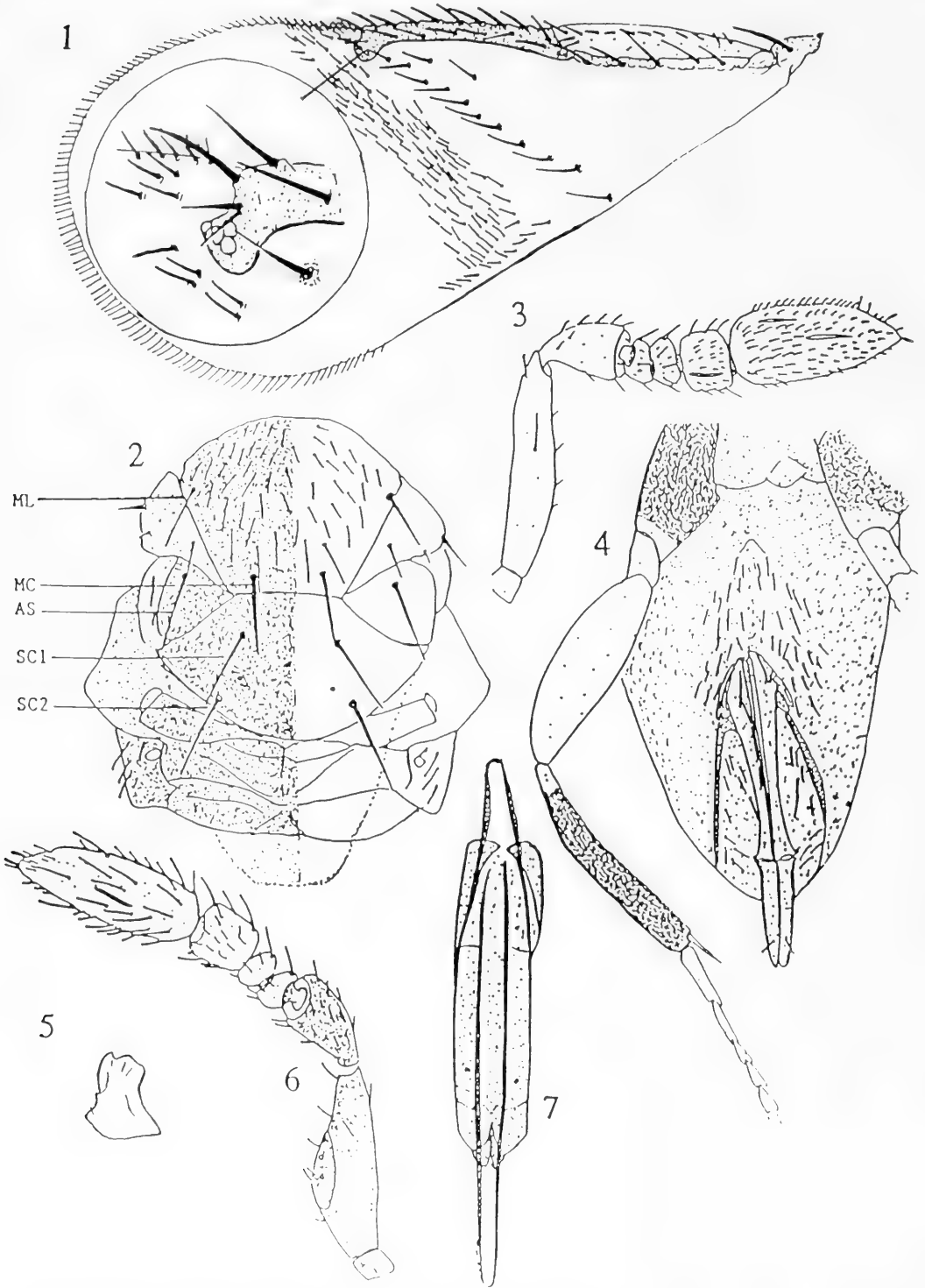
During 1992, collections of aphid parasitoids from citrus were made in four provinces of the People's Republic of China namely, Sichuan, Hunan, Fujian, and Guangdong. Some of the emerging parasitoids collected from the Guangzhou area (Guangdong Province) were brought to Florida for study as potential biological control agents of citrus aphids.

This research was undertaken because the brown citrus aphid, *Toxoptera citricida* (Kirkaldy), the most efficient vector of citrus tristeza virus has spread throughout the Caribbean Basin except the Bahamas (Yokomi et al. 1994) and is likely to be introduced into the continental U.S. in the foreseeable future. This aphid generally attacks only citrus and citrus relatives and is thought to be native to Asia where citrus originated. Because the aphid has potential to cause major damage to citrus, research is under way to

find control measures that would suppress the aphid population and mitigate the damage.

The species described in this paper was originally believed to be *Aphelinus gossypii* Timberlake, a common, widespread parasite of the melon or cotton aphid, *Aphis gossypii* Glover, and related aphids. However, investigation of the biology of the species from China revealed differences between it and that of *A. gossypii* including its ability to attack the spirea aphid, *Aphis spiraecola* Patch (Yokomi et al. 1993). Further examination revealed characters that were different from those of *A. gossypii* and we are, therefore, proposing a new species name for this taxon.

The importance of this new species is due to its potential as a biological control agent of the spirea aphid which has few effective parasitoids in the United States (Cole 1925,



Figs. 1-7. *Aphelinus spiraccolae*, female except Figs. 6, 7: 1, fore wing, disk setae excluded and stigmal vein magnified. 2, thorax. 3, antenna. 4, gaster (venter) and hind leg. 5, mandible. 6, antenna. 7, aedeagus.

Miller 1929, Tang et al. 1994). The spirea aphid is abundant on citrus worldwide and has a wide host range. It transmits citrus tristeza virus (Yokomi and Garnsey 1987), as well as some potyviruses (Adlerz 1987).

Aphelinus spiraecolae

Evans and Schauff, NEW SPECIES

Figs. 1–7

Diagnosis.—Head and thorax dark brown; legs yellow except dark brown coxae and hind tibiae; gaster dark brown with yellowish base; F1 and F2 broader than long, F3 quadrate; costal cell of fore wing with two lines of ventral setae, area proximal to lineal calva bordered by one complete row of 13–16 setae and one incomplete row of 2–5 setae.

Female: Length, 0.95–1.2 mm (Holotype, 0.98 mm). **Color:** Head and thorax dark brown, legs yellow except dark brown coxae and hind tibiae; gaster dark brown with base (terga I) yellowish; endophragma fuscous; third valvulae pale with dark brown lateral margins; antennae light brown; wings hyaline. **Structure:** Head dorsum about as broad as thorax; mandibles bidentate (Fig. 5) with an internal tooth, a blunt middle tooth and a truncation; lateral ocellus separated from eye margin by one ocellus diameter; occiput reticulate. Antenna (Fig. 3) with short radicle; scape about 4 to 5.5 times as long as broad; pedicel (ventral length) less than 2 times its width; F1 annuliform, with ventral margin longer than dorsal margin; F2 broader than long, as long as F1; F3 quadrate, about 2 times longer than F2 with one linear sensillum; club 2.4 times longer than broad, about 3 times longer than F3 with 6–7 linear sensillae and 7–8 papillae. Thorax (Fig. 2) with fine reticulations; mid-lobe of mesoscutum with two pairs of primary setae and approximately 40 setae, primary setae MC (posterior central) short, as long as ML (anterior lateral) setae, and axillar setae (AS), reaching base of SC1 setae; each side lobe with 2–3 setae; scutellum with

2 pairs of black setae, placoid sensillae small and widely separated, with pale, diamond-shape markings around each; endophragma short, about 0.7 times as long as the length of the thorax; tibial spur of middle leg slightly shorter than corresponding basitarsus; hind tibia with 7 conspicuous conical setae at apex, tibial spur of leg III about one-half as long as corresponding basitarsus. Fore wing (Fig. 1) broad, more than 2 times as long as wide (0.8:0.36 mm); costal cell 1.2 times longer than marginal vein and with 20–25 ventral setae in 2 rows and 11–13 dorsal setae; submarginal vein with 5–6 setae; marginal vein with 9 setae along the margin, all about 1.5 times longer than width of marginal vein; basal cell bare; stigmal vein short with stigma rounded; area proximal to lineal calva bordered by one complete row of 11–15 setae and one incomplete row of 1–5 setae; marginal fringe very short, less than 0.05 times as wide as fore wing disc; ciliation dense after the lineal calva. Gaster (Fig. 4) longer than thorax (0.56:0.35 mm); ovipositor (0.35 mm) inserted at middle of gaster, only slightly exerted distally, longer than hind tibia (0.29 mm) and mid tibia (0.21 mm); third valvulae (0.12 mm) one-third the length of entire ovipositor.

Male: Length (0.88–0.92 mm): Similar to female except central portion of femur II and tibia II slightly infuscate; radicle, scape and pedicel brown (Fig. 6); scape with 3 round sensoria and club with 2 linear sensillae; abdomen tapering distally; aedeagus as shown in Fig. 7.

Material examined.—Holotype female, Fushan City, Guangdong Province, P.R. China, VII 1992, ex *Aphis spiraecola*, R. Yokomi, deposited in the Institute of Zoology, Academy of Sinica, Beijing, P.R. China. Paratypes (19 ♀, 11 ♂) with same data as holotype. Paratypes deposited in: U.S. National Museum of Natural History, Washington, D.C.; Florida State Collection of Arthropods, Gainesville, Florida; The Natural History Museum, London, En-

gland; Canadian National Collection, Ottawa and the Collection of M. Hayat, Aligarh, India.

Known distribution.—Guangdong Province, P.R. China.

Comments.—*Aphelinus spiraeocolae* is placed in the *Aphelinus* subgenus of the genus *Aphelinus* as defined by Hayat (1990). This species is similar in body color and fore wing ciliation to species placed by Zehavi and Rosen (1988) in the *Aphelinus mali* group (*Aphelinus campestris* Jasnosh, *A. gossypii* Timberlake, *A. mali* (Haldeman), *A. paramali* Zehavi & Rosen, and *A. prociphili* Carver). However, it differs from the species in this group by the color of the legs. The femora of the middle legs of all of the *mali* group species are dark brown. The legs of the *A. spiraeocolae* female are entirely yellow except for its dark brown coxae and hind tibia. While differences in body color may be useful in discriminating different *Aphelinus* species, these differences alone may not always provide conclusive evidence to distinguish different species. Janssen (1961) and Michel (1969) reported considerable intraspecific variation in the color of the body (and legs) of *Aphelinus asychis* Walker (= *semiflavus* (Howard)) and *A. chaonia* Walker, respectively. Given this variation and the fact that species groups are not well justified nor widely used in this genus, we are not assigning *A. spiraeocolae* to a species group at this time.

Of the species mentioned above, *Aphelinus spiraeocolae* is most similar to *A. gossypii* (Timberlake) in coloration, shape and ciliation of the fore wing, and antennal structure. However, in *A. gossypii* the femora and tibiae of the fore and middle legs and basitarsi of the hind legs of females are dark brown. The MC setae are elongate, reaching the placoid sensillae (shorter and not reaching placoids in *spiraeocolae*); and the setae along the marginal vein are about 2 times as long as the width of the marginal vein (setae 1.5 times longer than width of marginal vein in *spiraeocolae*).

Aphelinus spiraeocolae is also similar to *Aphelinus chaonia* Walker. This species has a wide distribution and host range. It was introduced into California by Flanders and Fisher (1959) from South China for the control of the black citrus aphid, *Toxoptera aurantii*, and propagated in the laboratory on the spirea aphid. These two species can usually be easily distinguished from each other by the color of the legs. Normally, the femora of the fore and middle legs of *A. chaonia* are dark brown. However, the legs are yellowish in the light form of *A. chaonia*. Nevertheless, *A. chaonia* can be distinguished by the greater number of setae (more than 20) along the proximal border of the linea calva of the fore wing (less than 20 setae in *spiraeocolae*) and the dark base of the gaster (base of gaster yellow in *spiraeocolae*).

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A REVIEW OF THE MYDID GENUS *PSEUDONOMONEURA* BEQUAERT
(DIPTERA: MYDIDAE), WITH THE DESCRIPTION OF
TWO NEW SPECIES

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Abstract.—The mydid genus *Pseudonomoneura*, with six species is reviewed: *P. californica* (Hardy), *P. bajaensis*, n. sp., *P. hirta* (Coquillett), *P. micheneri* (James), *P. nelsoni*, n. sp. and *P. tinkhami* (Hardy). A lectotype is designated for *Leptomysdas concinnus* Coquillett, a previously recognized junior subjective synonym of *P. hirta*. The male and female genitalia of all species are illustrated and a key to the species is presented.

Key Words: Diptera, Mydidae, *Pseudonomoneura*, mydid flies, Nearctic

The genus *Pseudonomoneura* was proposed by Bequaert (1961) for a small group of Nearctic species of flies originally placed in the genus *Nomoneura* (Hardy 1950). In 1971 Wilcox and Papavero provided the first adequate generic description of *Pseudonomoneura* in their review of the American genera of Mydidae. The genus *Pseudonomoneura* is most similar and appears related to the Nearctic genus *Nemomydas*, and species of both genera are sympatric. Males of *Pseudonomoneura* are easily separated from males of *Nemomydas* by the ventral process of the gonocoxite either produced singly (*P. hirta* (Coquillett), *P. micheneri* (James)), reduced (*P. californica* (Hardy)), or absent (*P. bajaensis*, n. sp., *P. nelsoni*, n. sp.). In all species of *Nemomydas*, the gonocoxites have a dorsal and ventral digitate process (Kondratieff and Welch 1990). Additionally, the apex of the aedeagus is an erect slender tube or tongue in *Nemomydas*, and a thick ventral bulb in *Pseudonomoneura*. Females of *Pseudonomoneura* may be separated from *Nemomydas* by the antennal club being shorter than or subequal in length to the basal flagellomere (Wilcox 1981). In their key to the American genera

of Mydidae, Artigas and Papavero (1990) added that females of *Pseudonomoneura* have the "spermathecae with 3 capsules," and *Nemomydas* with "two capsules." The number of capsules actually range from two to three in *Pseudonomoneura*.

Hardy (1950) previously characterized *Pseudonomoneura* as having the proboscis "developed well beyond the oral margin." However, both *P. bajaensis*, n. sp. and *P. nelsoni*, n. sp. have vestigial mouthparts.

Wilcox and Papavero (1971) indicated that the geographic range of *Pseudonomoneura* included Utah and northern Mexico states of Sonora, Chihuahua and Coahuila. No specimens from these areas were available for examination.

Morphology and terminology follows Wilcox (1981). Abbreviations for depositories of specimens are: California Academy of Sciences (CAS); Arizona State University (ASU); C. P. Gillette Museum of Arthropod Diversity, Colorado State University (CSU); Florida State Collection of Arthropods (FSCA); Los Angeles County Museum of Natural History (LACMNH); University of Arizona (UA); University of California, Davis (UCD); National Museum of Natural

History, Smithsonian Institution (USNM); Utah State University (USU); Washington State University (WSU); W. F. Barr Entomological Collection, University of Idaho (WFBM).

KEY TO THE SPECIES OF
PSEUDONOMONEURA

(female unknown for *P. bajaensis*,
new species)

- 1. Mouthparts vestigial 2
- 1. Mouthparts well-developed 3
- 2. Male terminalia with upper forceps of epandrium simple (Figs. 20, 21). Female with abdomen globose, wider than thorax (Fig. 24); terminalia as Fig. 23 *P. nelsoni*, new species
- Male terminalia with upper forceps of epandrium bifurcate (Figs. 17 and 18)
..... *P. bajaensis*, new species
- 3. Proboscis long, extending to second flagellomere (club) 4
- Proboscis short, extending only to or middle of first flagellomere *P. tinkhami*
- 4. Male terminalia with upper forceps of epandrium with subapical digitiform inward projecting process (Figs. 1, 2). Male and female antennal flagellomeres black. Female terminalia as Fig. 4 *P. californica*
- Male terminalia with upper forceps of epandrium without a subapical digitiform process (Figs. 6, 10). Second antennal flagellomere tinged with red or yellow. Female terminalia as Figs. 8 and 16 5
- 5. Male with upper inner flange of upper forceps of epandrium weakly developed in lateral view, apex narrowly rounded (Fig. 5). Female terminalia as Fig. 8. Abdominal setae usually dense yellow, sometimes gray *P. hirta*
- Male with upper inner flange of upper forceps of epandrium strongly developed in lateral view, apex bluntly truncate (Fig. 9). Female terminalia as in Fig. 12. Abdominal setae usually white *P. micheneri*

Pseudonomoneura californica (Hardy)
Figs. 1–4

Nomoneura californica Hardy 1950: 11.
Holotype male (CAS), USA: California:
Riverside County, Blythe, 15 July 1947,
J. M. MacSwain, *Tamarix*; examined.

Diagnosis.—The red tergites will distinguish both sexes from all other species, except red variants of *P. micheneri* (James).

In the male of *P. californica*, the upper forceps of the epandrium have a subapical digitiform process which projects inward in dorsal view (Fig. 2), and posteriorly in lateral view (Fig. 1), whereas the upper forceps of *P. micheneri* lack this process (Figs. 9, 10). Females of *P. californica* can be separated from females of *P. micheneri* by the distinctive shape of the furca, and the more heavily sclerotized edge of tergite ten (Fig. 4). Additionally, the antennae of *P. californica* are entirely black, whereas the second flagellomere of *P. micheneri* are usually orange-yellow.

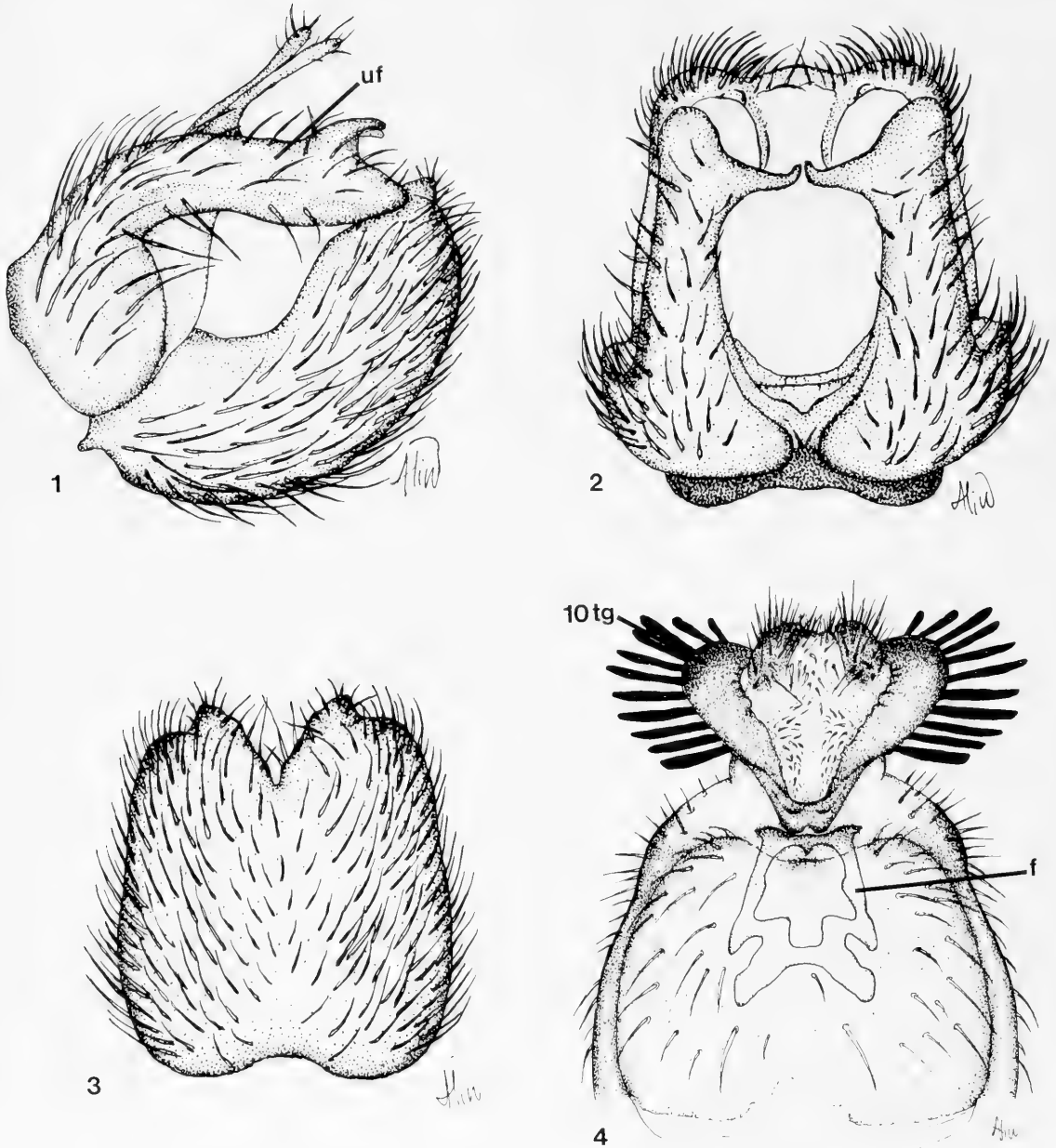
Discussion.—Hardy (1950) indicated that *P. californica* was related to *P. micheneri*. However, *P. californica* appears to be much more similar to *P. bajaensis*, n. sp. (Figs. 17–19), and *P. nelsoni*, n. sp. (Figs. 20–22). All three species lack the flanges of the upper forceps of the epandrium and the ventral processes of the gonocoxites are reduced or absent.

Distribution.—Arizona and California to Baja California, Mexico.

Specimens examined.—USA: Arizona: La Paz Co.: Ehrenberg, 16 June 1938, F. H. Parker, 1 female (USNM); Maricopa Co.: 1.6 mi. E. Barnes Butte nr. Papago Park, 1250', 26 May 1975, M. Kolner, 1 male, 2 females (1 male, 1 female in copula) (ASU); California: Imperial Co.: Walters Camp Road, 5–6 May 1985, R. Parks, 1 male (CSU); 15 mi. E. Calexico, UV light, 5 June 1961, G. H. Nelson, 1 male (FSCA); Riverside Co.: Blythe, 10 July 1947, J. M. MacSwain, 1 male (USNM); Whitewater, 3 July 1967, W. F. Barr, 1 male (WFBM); MEXICO: Baja California: 13 mi. N. San Felipe, 9 June 1968, low sandy hills, sand burrs, *Prosopis*, *Lophocerus*, and *Franseria*, N. Leppla, J. Bigelow, M. Cazier, J. Davidson, 1 male (ASU).

Pseudonomoneura hirta (Coquillett)
Figs. 5–8

Leptomydas hirta Coquillett 1905: 39. Holotype male (USNM), USA: California:



Figs. 1-4. *Pseudonomoneura californica*. 1, Male terminalia, lateral view. 2, dorsal view. 3, ventral view. 4, Female terminalia, ventral view. (Abbreviations: f, furca; tg, tergite; uf, upper forceps of the epandrium.)

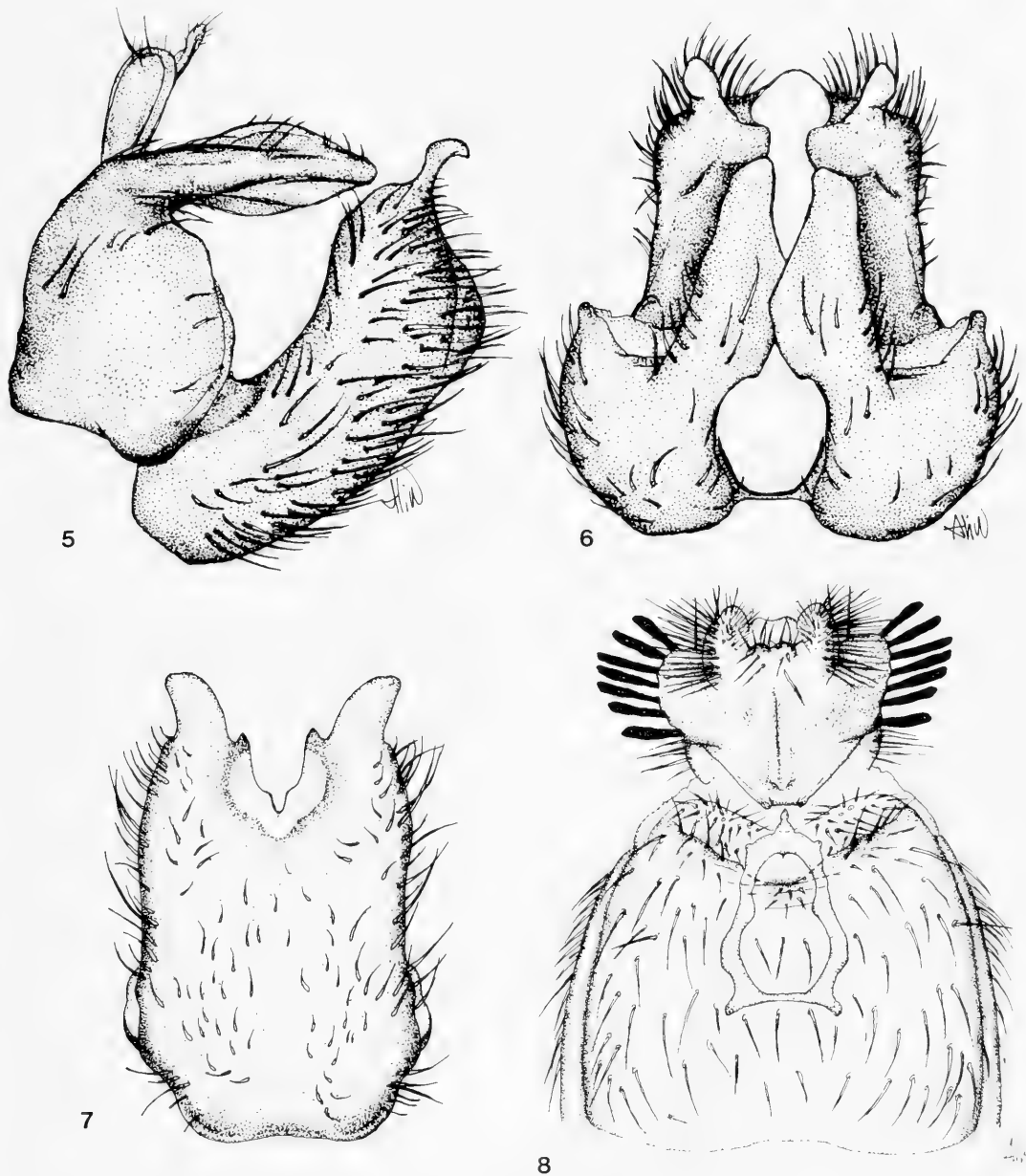
Los Angeles County, Claremont, Baker, Type No. 7731; examined.

Leptomydas concinnus Coquillett 1905: 39. (Synonymized by Hardy 1950: 15.) Lectotype (here designated) male (USNM), USA: California: Los Angeles County,

June, Coquillett collection. Washington, D.C.; examined.

Nomoneura hirta: Hardy 1950: 15.

Diagnosis.—*Pseudonomoneura hirta* is closely related to *P. micheneri* and *P. tink-*



Figs. 5-8. *Pseudonomoneura hirta*. 5, Male terminalia, lateral view. 6, dorsal view. 7, ventral view. 8, Female terminalia, ventral view.

hami based upon the similarity of male genitalia. In dorsal view the upper forceps of the epandrium of *P. hirta*, *P. micheneri* and *P. tinkhami* are very similar (Figs. 6, 10, 14). However, in lateral view the upper forceps of both *P. micheneri* and *P. tinkhami* have the upper inner flange strongly pro-

duced and the apex bluntly truncate (Figs. 9, 13), whereas the upper inner flange of *P. hirta* is weakly developed and the apex narrowly rounded (Fig. 5). In ventral view the gonocoxites of *P. hirta* are cleft about one-fifth their length with the ventral processes strongly produced into two outwardly and

ventrally projecting lobes (Fig. 7). Females of *P. hirta* are best separated by the presence of usually dense yellow pile on abdominal tergites, and the shape of the furca (Fig. 8).

Discussion.—Hardy (1950) provides an adequate description of both the male and female, including the occurrence of two morphs, a more common one with conspicuous yellow abdominal pile and populations with gray abdominal pile. Separation of unassociated females of *P. hirta* and *P. micheneri* can be difficult due to the similarity of terminalia and the variable coloration of these two species.

Through the kindness of Norman E. Woodley, Smithsonian Institution, syntypes of *Leptomysdas concinnus*, a previously recognized junior subjective synonym (Hardy 1950), were made available for study. These specimens are typical *P. hirta*. *Pseudonomoneura hirta* is apparently common in areas of southern California. This species is very similar in general habitus to the sympatric *Nemomydas pantherinus* (Gerstaecker) (Kondratieff and Welch 1990).

Distribution.—California to Baja California.

Material examined.—USA: California: Claremont Co.: "Topotype," 1 male, 1 female (USNM); 2 males, 3 females (USNM); Kern Co.: Short Cyn., 11 April 1976, J. B. Johnson, 1 male, 1 female (WFBM); Los Angeles Co.: Charlton Flat, San Gabriel Mts., 29 June 1975, Menke and Pulawski, 1 male (USNM); July, Coquillett coll., "Syntype," 2 females (USNM); Glendora Ridge 1 mi. above Mt. Baldy Village, 17 June 1987, 1 female (LACMNH); Pine Canyon, 6 July 1954, 2 males (LACMNH); Pearblossom, 2 mi. S., 3500', 1–2 May 1977, R. R. Snelling, 1 male (LACMNH); Crystal Lake, 9 July 1952, D. Shepherd, 2 males, 1 female (LACMNH); Tanbark Flat, 20 July 1952, D. Shepherd, 1 female (LACMNH); Tanbark Flat, 12 July 1952, D. Shepherd, 1 female (LACMNH); Tanbark Flat, 25 June 1952, D. Shepherd, 1 female (LACMNH); Tanbark Flat, 21 June 1950, J. K. Windsor,

1 female (LACMNH); Tanbark Flat, 27 June 1950, J. K. Windsor, 1 female (LACMNH); Tanbark Flat, 29 June 1952, B. Tinglof, 1 male, 1 female (LACMNH); San Gabriel Can., 3200', 28 June 1975, R. L. Westcott, 1 male (WFBM); Mono Co.: Sherwin Summit, Hwy. 395, 7000', 8 Sept. 1975, R. R. Snelling, on *Chrysothamnus*, 1 female (LACMNH); Orange Co.: Anaheim 7551 Vista Del Sol, 26 July 1977, ca. 180 m, P. H. Arnaud Jr., 1 male (CAS); Riverside Co.: Pinon Flat, San Jacinto Mts., 30 May 1939, P. D. Gerhardt, 1 male, 1 female (UA); San Bernardino Co.: Phelan, Sheep Crk. Can., 9 May 1949, A. L. Melander, 1 male (USNM); 1 female (USNM); vic. Cajon Summitt, 1250 m, 3 July 1980, R. L. Westcott, 1 male (CSU); Lytle Creek Road, 2700', 4 mi. NW Nealey's Corner, 5 June 1976, R. R. Snelling and C. D. George, 1 female (LACMNH); Camp Baldy, 8 July 1952, D. Shepherd, 1 female (LACMNH); same locality but, B. Tinglof, 2 males, 2 females (LACMNH); same locality but, 26 June 1950, J. K. Windsor, 1 male (LACMNH); Lonepine Can., 5 mi. SE Wrightwood, 1375 m, 2 July 1980, R. L. Westcott, 1 male (WFBM); San Gabriel Mts., 2 mi. E Wrightwood, 1 June 1986, G. H. Nelson, 1 male, 1 female (FSCA); San Diego Co.: Pala, 6 June 1945, A. L. Melander, 1 male (USNM); Rutherford Ranch, San Felipe Valley, 8 May 1993, R. Parks, 1 male (CSU); Point Loma, 28 May 1978, L. Guidry, 1 male (CSU); Point Loma, 28 June 1977, L. Guidry, 1 male (CSU); Co.?: Mt. Lowe, 3 July 1917, J. M. Aldrich, 6 males, 4 females (USNM); Forest Home, 2 June 1934, C. Dammers, 1 female (USNM); San Gabriel Mts., 4000 ft., Long canon, 3 July 1910, F. Grinnell Jr., 1 male, 1 female (USNM); San Gabriel Mts., 1–3 July 1914, F. Grinnell Jr., 1 female (USNM); MEXICO: Baja California: Norte Sierra Juarez, 6 mi. N. of Laguna Hanson, 3 June 1982, Faulkner and Brown, 1 male (CSU); same locality but, 22 June 1980, 1 male (CSU); Ensenada, 31 May 1954, 1 male (LACMNH).

Pseudonomoneura micheneri (James)

Figs. 9–12

Nomoneura micheneri James 1938: 63. Holotype male (WSU), California: Riverside County, 7 mi. S. White Water, 13 April 1935, C. D. Michener, in copulation; examined.

Nomoneura micheneri: Hardy 1950: 17.

Diagnosis.—The long proboscis, extending beyond the apex of the first flagellomere and the second flagellomere orange or tinged with red-orange will separate this species from the very closely related *P. tinkhami*. Additionally, males of *P. micheneri* can be distinguished by the more strongly produced upper inner flange of the forceps of the epandrium (Fig. 9).

The male genitalia of *P. micheneri* are also similar in structure to *P. hirta*, but in lateral view the upper inner flange of the upper forceps of *P. micheneri* is more strongly developed with the apex bluntly truncate (Fig. 9) in comparison to the weakly developed upper inner flange of *P. hirta*, with the apex narrowly rounded (Fig. 5). Additionally, in ventral view, the gonocoxites of *P. micheneri* have the ventral processes straight (Fig. 11) rather than divergent (Fig. 7), as in *P. hirta*.

Discussion.—*Pseudonomoneura micheneri* is very similar to *P. tinkhami*, and not closely related to *P. californica* as previously indicated by Hardy (1950). Apparently, Hardy based this relationship on the similarity of the red abdominal tergites of some *P. micheneri* populations. Records of this species include a good series from the Nevada Test Site. This unique area has been well described by Knight (1968).

Distribution.—Arizona, Nevada to California.

Material examined.—USA: Arizona: Mojave Co.: Chloride 4 mi. W., 28 April 1972, G. Bohart, P. Torchio and F. Parker, 1 male (USU); California: San Bernardino Co.: Morongo V., 16 April 1957, R. R. Snelling, 2 males, 1 female (LACMNH); 11

mi. N. Needles, 29 April 1982, *Eriogonum*, P. F. Torchio, 8 males, 1 female, 1? (missing tip of abdomen) (USU); 15 mi. N. Needles, 7 May 1982, P. F. Torchio, 1 male (USU); Cottonwood Wash, 2520', Sec. 3 T9N R12E, 10 May 1982, T. Griswold, 1 male (USU); Winston Wash, 2500', Sec. 19 T109 R13E, 10 May 1982, T. Griswold, 1 male (USU); Kelso Dunes, 2600', Sec. 30 T10N R13E, 10 May 1982, T. Griswold, 1 female (USU); Lake Havasu, 15 April 1966, D. L. Coates, 2 males, 1 female (WFBM); San Diego Co.: 1 mi. S. Ocotillo Wells, 26 March 1977, R. W. Brooks, 1 male (UCD); Nevada: Clark Co.: Mercury, 28 April 1962, [BYU AEC NTS], 8 males, 11 females (USNM); same locality but 6 May 1961, 1 male, 1 female (USNM); same locality but 7 May 1961, 1 female (USNM); same locality but 12 May 1962, 1 female (USNM); Juanita Spr. Ranch S. of Riverside, 11–21 May 1983, F. D. and J. H. Parker, 3 males (USU); Riverside, 11–21 May 1983, F. D. and J. H. Parker, 1 female (USU); Lincoln Co.: Alamo, 28 April 1973, F. Parker and P. Torchio, 1 female (USU).

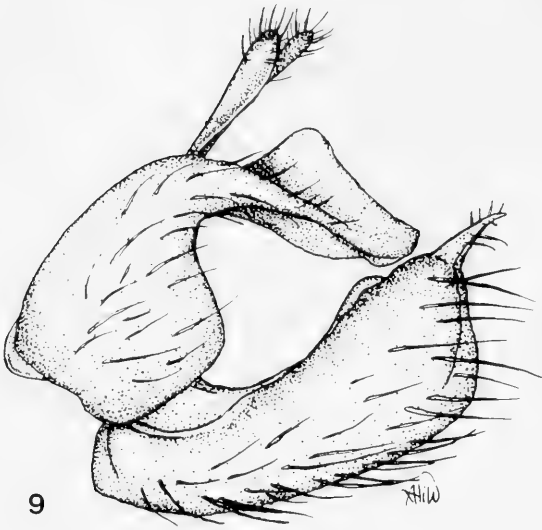
Pseudonomoneura tinkhami (Hardy)

Figs. 13–16

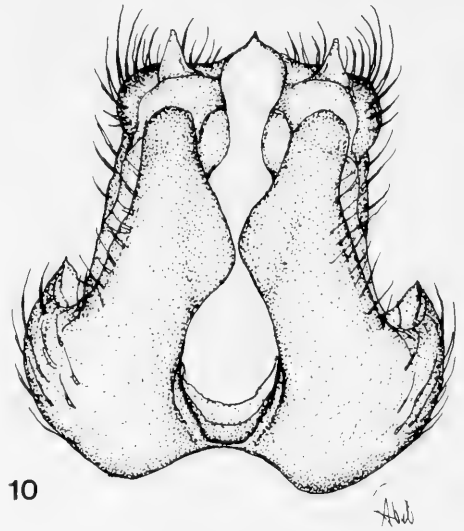
Nomoneura tinkhami Hardy 1950: 18. Holotype male (CAS) (lost), USA: California: Inyo County, above Glacier Lodge, 21 August 1938, E. R. Tinkham.

Diagnosis.—This species is very similar to *P. micheneri* but can be separated by the shorter proboscis, with the apex not extending beyond middle of the first flagellomere, black antennae and shape of the upper forceps of the epandrium (Fig. 13).

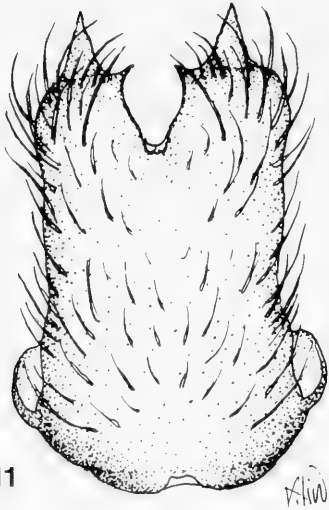
The male genitalia of *P. tinkhami* are also similar in structure to *P. hirta*, but in lateral view the upper inner flange of the upper forceps of *P. tinkhami* is more strongly developed with the apex bluntly truncate (Fig. 13) in comparison to the weakly developed upper inner flange of *P. hirta*, with the apex narrowly rounded (Fig. 5). Additionally, in



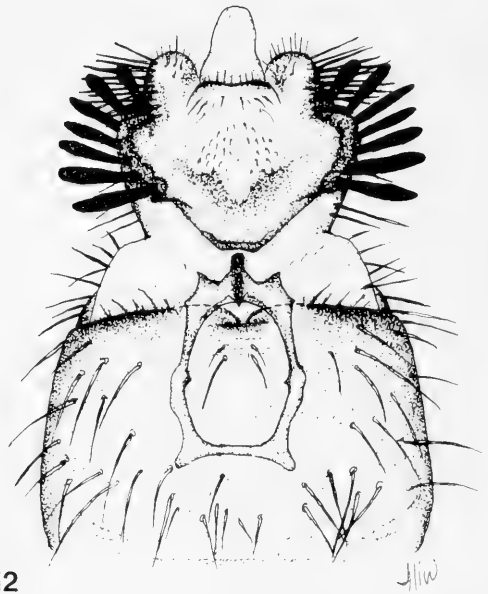
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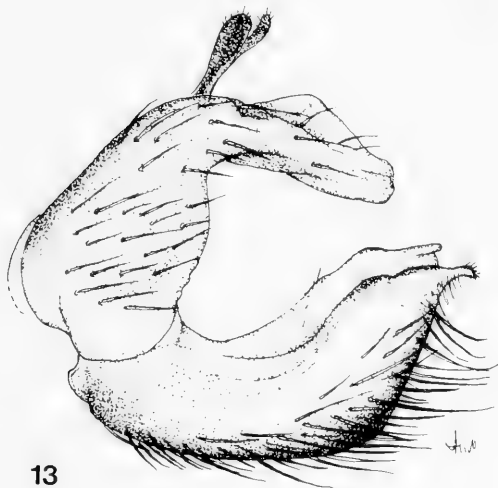
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Figs. 9–12. *Pseudonomoneura micheneri*. 9, Male terminalia, lateral view. 10, dorsal view. 11, ventral view. 12, Female terminalia, ventral view.

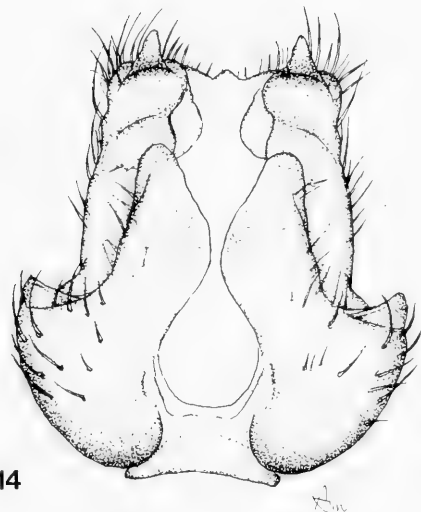
ventral view, the gonocoxite of *P. hirta* has the ventral process strongly developed into divergent lobes (Fig. 7). Females of *P. tinkhami* can distinguished most reliably from *P. hirta* by the shape of the furca (Fig. 16).

Discussion.—The original description of

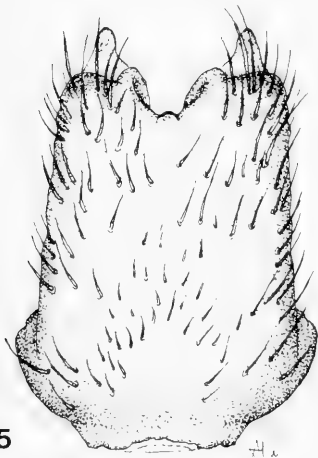
P. tinkhami was based on a single male from “above Glacier Lodge, California.” The holotype was returned to the E. R. Tinkham Collection (Hardy 1950), which was later donated to the CAS. Unfortunately, this specimen is apparently lost (Dr. Paul H. Ar-



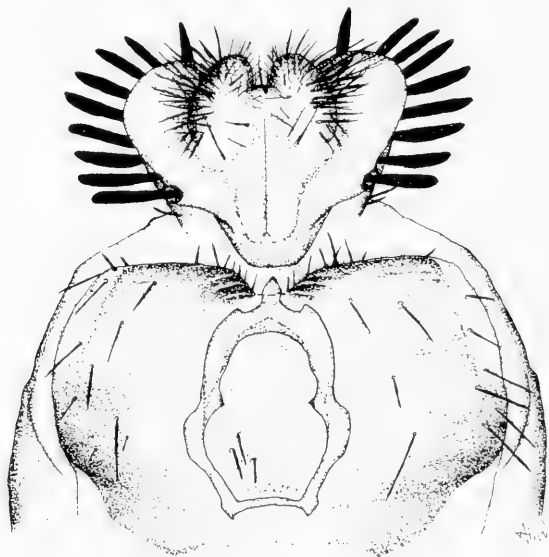
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Figs. 13–16. *Pseudonomoneura tinkhami*. 13, Male terminalia, lateral view. 14, dorsal view. 15, ventral view. 16, Female terminalia, ventral view.

naud, Jr., personal communication). Additional inquiries were made to Mark O'Brien, Museum of Zoology, University of Michigan, where some of Tinkham's material is deposited. However, no *Pseudonomoneura* specimens were located. A male specimen in the CAS, labeled as a "topotype" [of *P. tinkhami*] by the late Joseph Wilcox, is identical to Hardy's (1950) orig-

inal description and has the distinctive short proboscis as figured for *P. tinkhami* (Hardy 1950; Fig. 4a), and we base our concept of the species on this specimen. This late season species is apparently rare and has a limited distribution in California.

Distribution.—California.

Material examined.—California: Inyo Co.: Sherwin Summit, 14 Sept. 1963, J. Wil-

cox, 1 female (CAS); Big Pine, Glacier Lodge, 8–9000', 9 Aug. 1957, Dorothy Martin, 1 male (labeled as Topotype of *P. tinkhami*, Det. J. Wilcox) (CAS); Big Pine, 12 Aug. 1957, J. Wilcox, 1 male (CAS); Big Pine, 6500', 7 Aug. 1966, J. Wilcox, 2 males, 1 female (CAS); Toms Place, 8 Aug. 1962, L. A. Stange, 1 male (CAS); Symmes Creek, 6900', 18 Aug. 1982, A. S. Menke, 1 female (USNM); Mono Co.: 6.5 mi. NW Benton Hot Springs, 2000 m, 3 Aug. 1980, R. L. Westcott, 2 males, 2 females (WFBM).

***Pseudonomoneura bajaensis*
Fitzgerald and Kondratieff,**

NEW SPECIES

Figs. 17–19

Holotype: Male (CAS), MEXICO: Baja California Sur, 10 June 1975, Pto. Chale, 60 km S. San Carlos, Howard E. Evans, Biological Note No. 2443.

Paratypes: Male, MEXICO: Baja California Sur.: 7–9 June 1975, San Carlos, Howard E. Evans, W. Rubink, and D. Gwyne (CSU). There was no biological note attached to this specimen.

Description.—*Male*: Frons densely silver-white tomentose with dense white pile. Occiput, middle of face, and vertex black; vertex with white-yellow pile on either side of occiput. Antenna short, stout, black, with long black setae on pedicel and scape. Mouthparts vestigial. Thorax: Mesonotum opaque black in ground color with four broad densely tomentose, silver-white vittae, which are narrowly joined on the hind part of the thorax just before the scutellum. Pleura shining dark brown. Halter yellow. Scutellum dark brown with thin white pile medially. Legs: Entirely brown. Hind leg with brown hair, femur swollen, and black flexor spines moderately developed. Pro- and mesothoracic legs clothed with longer white setae. Wings: Hyaline 6.5–7 mm. Venation as in other *Pseudonomoneura*. Abdomen: Tergite 1 brown-black, tergites 2–6 dark brown-black with yellow-white posterior margins. Tergites 1–3 with long white pile, tergite 1

tomentose throughout, tergite 2 laterally and sparsely medially, and tergite 3 only anteromedially. Remaining tergites with short black setae and some short yellow setae posterolaterally. Sternites brown. Bullae larger and black. Genitalia: Upper forceps of the epandrium bifurcate, in dorsal view inner lobe longer and square tipped, outer lobe shorter and acute (Fig. 18). In lateral view both lobes appear acute, the lower outer lobe shorter (Fig. 17). Gonocoxites with U-shaped cleft extending about one-fourth their length, ventral processes of the gonocoxites absent (Fig. 19).

Female: Unknown.

Etymology.—The epithet is derived from the Baja Peninsula.

Diagnosis.—The male of *P. bajaensis* is easily distinguished from other *Pseudonomoneura* by the vestigial mouthparts and from *P. nelsoni*, n. sp. by the bifurcate upper forceps of the epandrium (Figs. 17, 18). The female is unknown.

Discussion.—The holotype male was excavated by H. E. Evans from cells of a ground nest of *Bembix rugosa* Parker (Hymenoptera: Sphecidae). This specimen was still fresh when collected and along with two specimens of *Ablautus flavipes* Coquillett (Asilidae), were provisions for a nearly full grown wasp larva (Evans 1976). The terminalia of the paratype are missing.

***Pseudonomoneura nelsoni*
Fitzgerald and Kondratieff,**

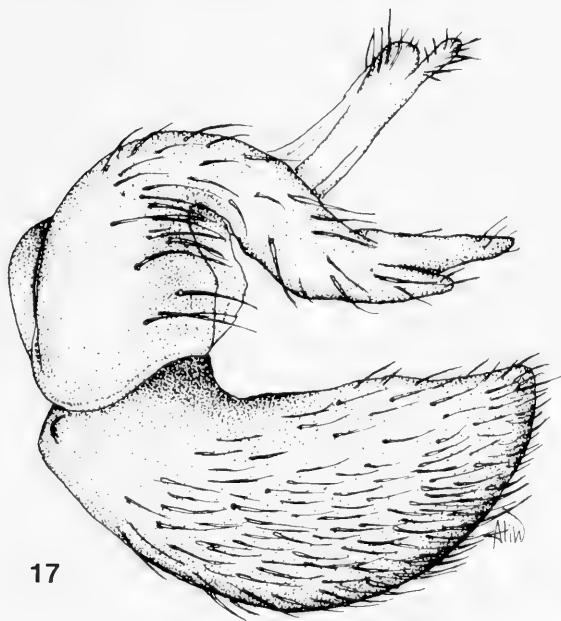
NEW SPECIES

Figs. 20–24

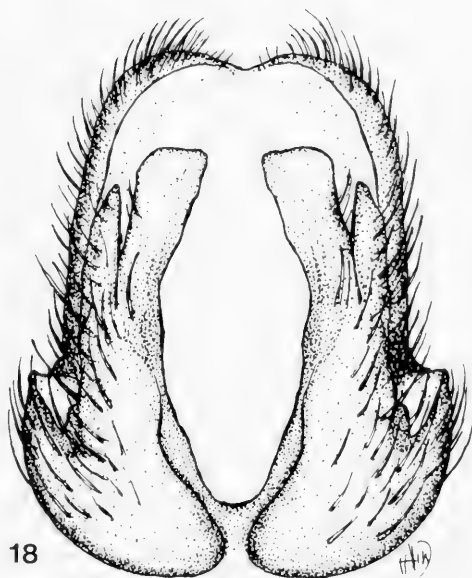
Holotype: Male (CAS), USA: California: Riverside Co., 7 mi. S. W. Palm Springs, 7 September 1971, N. Papavero.

Paratypes: USA: California, San Bernardino Co., Cottonwood Wash, S3T9NR-12E, 2520', 23 August 1981, T. Griswold, 1 male (USU); same data as holotype, 1 male, 19 females (CAS); Coachella Dunes (near Washington Street), 9 April 1988, R. Rogers, 3 males (LACMNH).

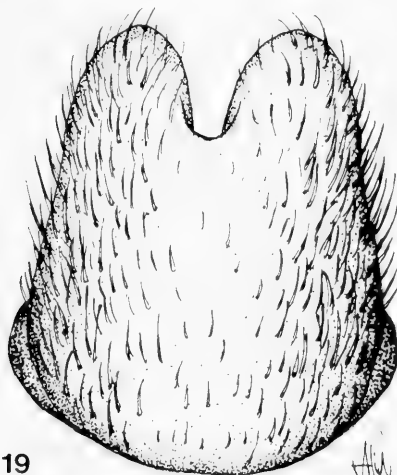
Description.—*Male*: Frons densely sil-



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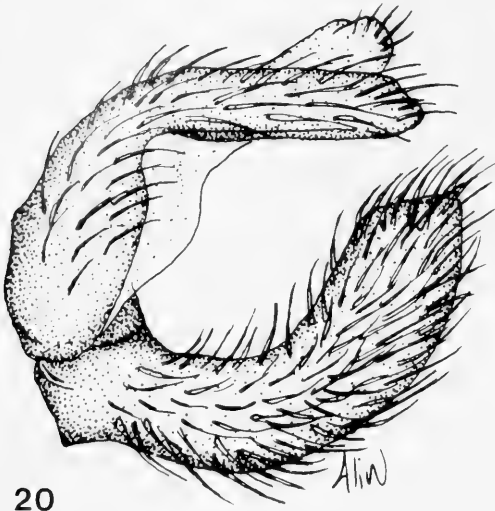


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Figs. 17–19. *Pseudonomoneura bajaensis*. 17, Male terminalia, lateral view. 18, dorsal view. 19, ventral view.

ver-white tomentose. Occiput black, middle of face black-brown. Antenna short, stout, light brown with short white setae on pedicel and scape. Mouthparts vestigial. Thorax: Mesonotum densely tomentose opaque gray in ground color with four broad densely tomentose silver-white vittae, which are narrowly joined on the hind part of the thorax just before the scutellum. Pleura shining

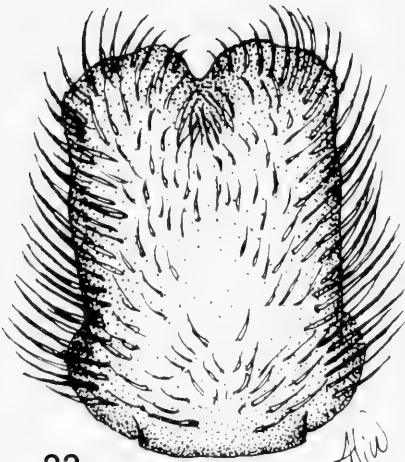
brown with some areas of thin silver-white tomentum. Halter yellow. Scutellum silver-white tomentose. Legs: Entirely light brown-yellow. Hind leg with brown-yellow hair, femur not swollen, and brown flexor spines weakly developed. Pro- and mesothoracic legs clothed with longer white setae. Wings: Hyaline, 5–7 mm. Venation as in other *Pseudonomoneura*. Abdomen: Tergites gray-



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Figs. 20-23. *Pseudonomoneura nelsoni*. 20, Male terminalia, lateral view. 21, dorsal view. 22, ventral view. 23, Female terminalia, ventral view.

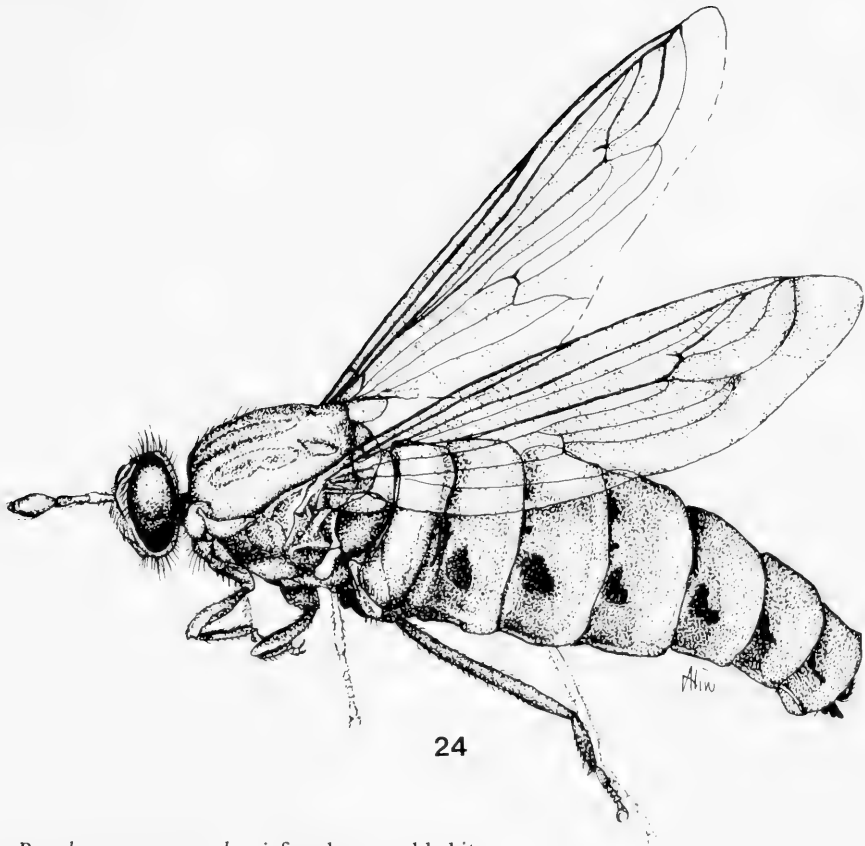


Fig. 24. *Pseudonomoneura nelsoni*, female general habitus.

brown with yellow-white posterior margins sometimes as wide as the posterior half of the tergite. All tergites with thin silver-white tomentum and long white decumbent pile. Sternites entirely yellow-brown with short yellow-white pile. Bullae dark brown. Genitalia: In dorsal view the upper forceps of the epandrium slender and bent outward apically (Fig. 21), in lateral view, slightly square tipped, lacking upper and lower flanges (Fig. 20). Gonocoxites cleft only about one-eleventh of their length, with the ventral processes absent (Fig. 22).

Female: Head: Yellow-brown with some light brown tomentum. Occiput dark brown shining. Antenna short, stout, yellow, about twice as long as head. Mouthparts vestigial. Thorax: Yellow-brown in ground color with three brown vittae on mesonotum. Mesonotal pattern densely tomentose. Halter yellow.

low. Pleura mostly shining with some tomentose areas. Legs: Yellow, hind femur with strong flexor spines. Wings: Hyaline, 9–12 mm. Venation as in other *Pseudonomoneura*. Abdomen: Yellow-brown with dark brown markings anteromedially and anterolaterally on tergites (Fig. 24). Bullae small and inconspicuous. Abdomen globose, wider than thorax (Fig. 24). Terminalia as Fig. 23.

Etymology.—The patronym honors Dr. C. Riley Nelson, University of Texas. He has provided much kind assistance with the junior author's studies of Diptera.

Diagnosis.—Males of *P. nelsoni* can be separated from all other species of *Pseudonomoneura* with the exception of *P. bajaensis* by the vestigial mouthparts. Additionally, this species can be easily distinguished from *P. bajaensis* by the sim-

ple rather than bifurcate structure of the upper forceps of the epandrium. The combination of a globose abdomen (Fig. 24) and vestigial mouthparts will separate *P. nelsoni* from all other known females of *Pseudonomoneura*.

Discussion.—The form of the upper forceps of the epandrium of the male are unique within this genus, lacking the digitate structure of *P. californica*, the bifurcate structure of *P. bajaensis*, or the upper and lower flanges of *P. hirta*, *P. micheneri* and *P. tinkhami*.

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**HERMESIA LEFÈVRE, A RESURRECTED GENUS OF NEOTROPICAL
EUMOLPINAE (COLEOPTERA: CHRYSOMELIDAE)**

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Abstract.—*Hermesia* Lefèvre is reinstated as a valid genus name in the Neotropical Eumolpinae. The genus is redefined to include the species *H. aurata* (Olivier), *H. cyanea* Bowditch, and *H. inermis* Bowditch. Characters for separation of *Hermesia* and *Hylax* Lefèvre, and the disposition of other species formerly placed in *Hermesia* are given. Taxonomic characters found in the male endophallus are discussed and illustrated.

Key Words: Chrysomelidae, Eumolpinae, *Hermesia*, *Hylax*, ovipositor, endophallus

In the course of making an inventory of the Eumolpinae of Costa Rica and developing a key to Central American genera of this taxonomically confusing subfamily, I repeatedly encounter instances where incorrect application of genus names causes confusion and needlessly complicates recognizing phylogenetically meaningful groups of species. In the present paper I discuss the correct placement of a small but showy group of eumolpines that are widespread in Neotropical forests and are frequently found in general collections of Chrysomelidae.

Lefèvre (1877) established the genus *Hermesia* to include *Colaspis aurata* Olivier and two new species, *H. purpurea* and *H. fulgidicollis*, later adding *H. janthina* Lefèvre (1885). By the time of Blackwelder's checklist (1946), 12 additional species had been described by Bowditch (1921), Jacoby (1882, 1900a, b, 1904), and Weise (1921). In his catalogue of the Neotropical Eumolpinae, Bechyné (1953) synonymized *Hermesia* with *Hylax* Lefèvre (1884) and transferred *Hermesia aurata* (Ol.) and *Hermesia cyanea* Bowditch to this genus. The remaining species of Lefèvre's *Hermesia* were transferred to other genera (see second list below). Later, Bechyné (1954) stated that although the

modified hind tibiae of the male *H. auratus* (Fig. 1) were not spinose as in most *Hylax* (Fig. 2), *H. auratus* was not otherwise separable from the rest of *Hylax*. Still later, Bechyné (1955) reiterated his transfer of *H. auratus*, placed *Rhabdopterus violaceus* Jacoby as a subspecies of *Hylax auratus*, and renamed *Hylax violaceus* (Jacoby) as *Hylax pseudoviolaes*.

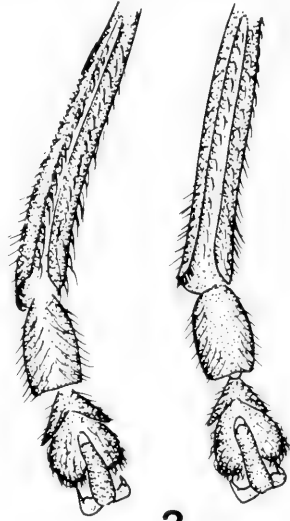
While working with Costa Rican Eumolpinae I found many specimens of a species lacking any modification of the hind tibiae of the male but agreeing closely with *Hylax auratus* in all other respects. This form proved to be *Hermesia inermis* Bowditch listed under *Parachalcoplacis* by Bechyné (1953) in his catalog. On further study, it became clear that *H. auratus* and *P. inermis* are congeneric, that both show substantial differences in structure of the pronotum from all *Hylax* that I have been able to examine, and that neither species is congeneric with *Chalcoplacis* (= *Parachalcoplacis* as synonymized by Monrós and Bechyné 1956). I have examined a long series of *P. inermis* in the collections of the National Biodiversity Institute of Costa Rica, identified specimens of *Hermesia* and *Hylax* in the Bowditch Collection of the Museum of



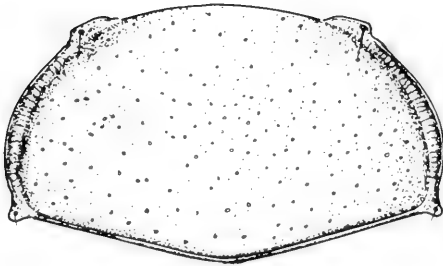
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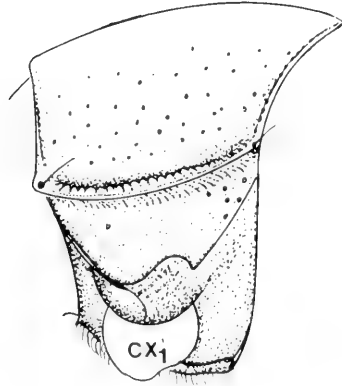
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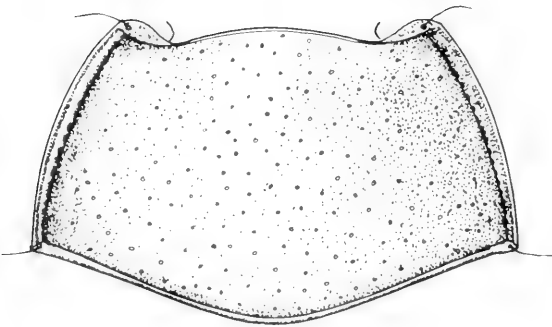
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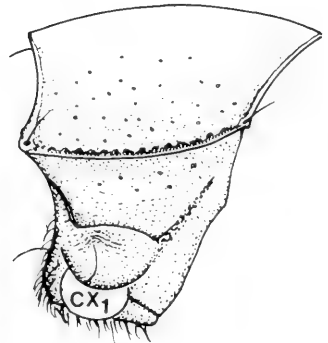
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Comparative Zoology, Harvard University, and general collections of Eumolpinae at Cornell University and the California Department of Food and Agriculture. As a result of these studies, I regard *Hermesia* as a valid genus, based on external characters and supported by internal characters of the male endophallus and the female ovipositor.

Endophallic structures used in this study

Terminology used for structures of internal female genitalia follow Askevold and Flowers (1994). There is no accepted terminology for the structures of the male endophallus of Eumolpinae. Askevold (1988, 1990, 1991) has studied the Donaciinae and identified a system of sclerites of the male endophallus. Of these, the endophallic lateral digits (ELD), the basal supporting block (BSB), the median ejaculatory guide (MEG), and the basal setal brush (bb) appear to be analogous to structures visible in the endophalli of a number of Eumolpinae I have studied. I am provisionally adopting Askevold's terminology in this paper to refer to these structures, which are analogous in position and appearance to those illustrated for the Donaciinae. The most important difference between the Donaciinae and the Eumolpinae is that in the Donaciinae the endophallus is relatively short with the ELD's in the apical position. In most Neotropical genera of Eumolpinae so far examined, the endophallus is a very long tube that, when retracted, is doubled back upon itself and lies within the basal hood. There appear to be two groups of sclerites that deploy as the endophallus is everted. The apical lateral digits (ELD in Figs. 8–17), analogous to the

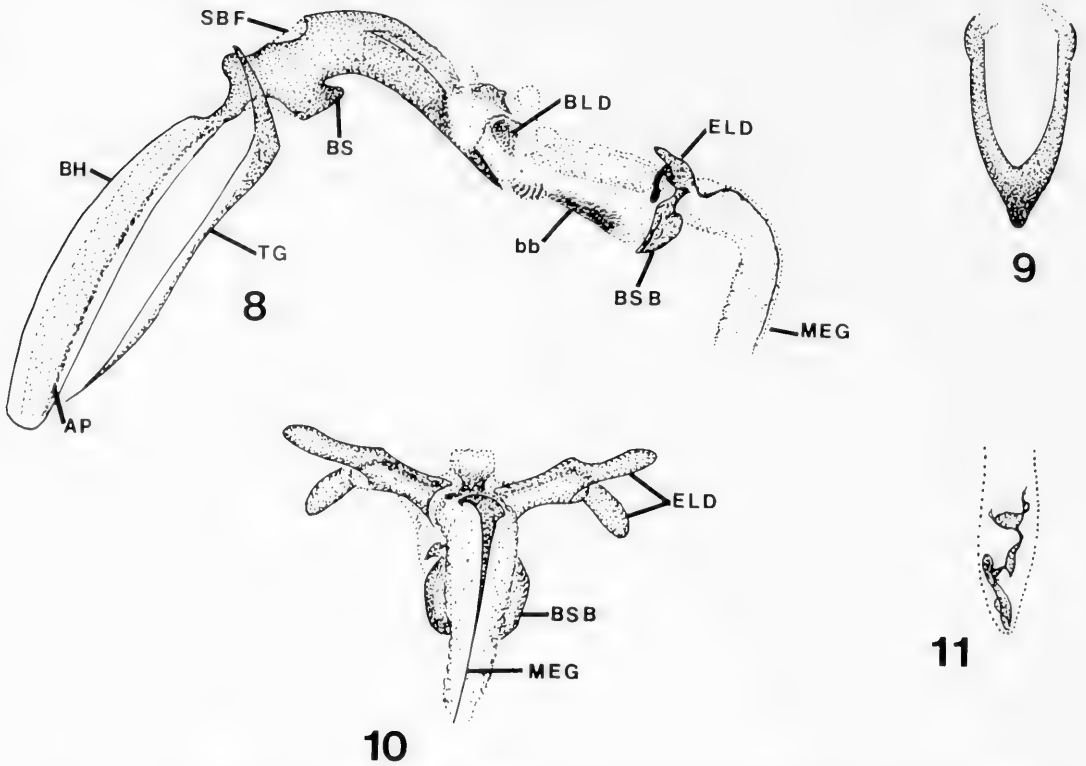
endophallic lateral digits of Askevold, are associated with complex basal supporting block (BSB) from which a long flexible sclerite (MEG) protrudes forward; the ELD's are thus subapical and the endophallus continues distally beyond them, sometimes for a considerable distance. At the base of the endophallus there are additional sclerites, presumably derived from the dorsal and basolateral sac supporting sclerites of Askevold. Among these is another pair of less sclerotized but movable basal lateral digits (BLD) which apparently have no homolog in Donaciinae (Askevold, pers. com.). Below the two sets of digits, there is often a field of fine setae on the underside of the endophallus (bb).

The main difficulty in everting eumolpine endophalli is trying to pull this compact mass of sclerites, which is under tension when retracted, out through the delicate membranous tube, and work it free without tearing the membrane. Failures are frequent. Fig. 8 shows the endophallus of *H. aurata* after an unusually successful preparation in which both sets of lateral digits and the MEG are everted. However, even here over half the endophallus is still retracted. The ELD's are shown in apical view in Figs. 10 and 14. Basal digits (BLD) are blunt membranous lobes with sclerotized distal surfaces (Fig. 13). Distad of the basal block, the endophallus is a simple membranous tube with a small internal apical sclerite (Figs. 11, 16) that may be a guide for the flagellum (not illustrated).

Hermesia Lefèvre 1877: clxxviii
resurrected name

Type species: Colaspis aurata Olivier
1808, designated by Bechyné (1950a).

←
Figs. 1–7. External characters of *Hermesia* and *Hylax*. 1, 2, posterior tibia of male (redrawn from Bechyné 1949). 1, *Hermesia aurata*. 2, *Hylax viani*. 3, fore (left) and middle (right) tibiae and tarsi of *Hermesia aurata*. 4, 5, prothorax of *Hermesia aurata*. 4, pronotum. 5, lateral view of prothorax. 6, 7, prothorax of *Hylax* sp. 6, pronotum. 7, lateral view of prothorax. CX1 = insertion of forecoxa.



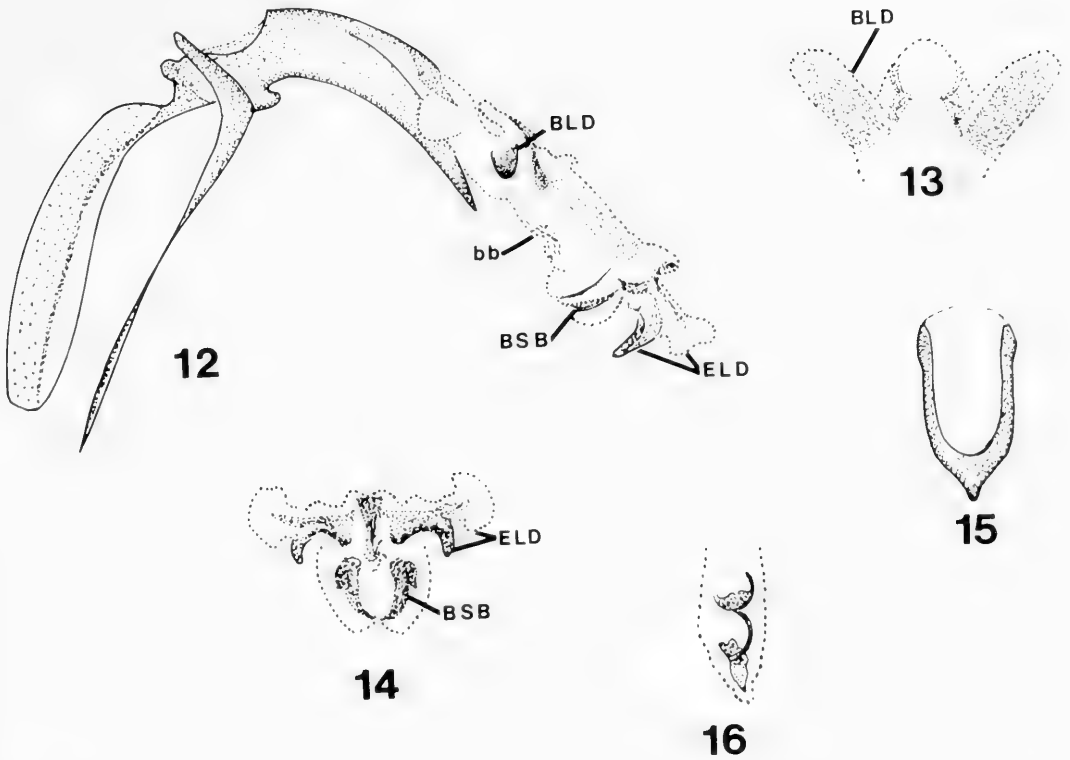
Figs. 8–11. *Hermesia aurata*, male genitalia. 8, lateral view of median lobe with partially everted endophallus. 9, apex of median lobe. 10, apical view of ELD's. 11, apical sclerites of endophallus. Abbreviations: AP = apodeme, bb = basal setal field, BH = basal hood, BLD = basal lateral digit, BS = basal spur, BSB = basal supporting block, ELD = endophallic lateral digit, MEG = median ejaculatory guide, SBF = subbasal fenestra.

Body oblong; length 4.8–6.2 mm; head, pronotum, elytra, underside, and legs bright metallic green, gold-green, or cobalt blue.

Head with labrum apically emarginate, with 2 submedian setae and short row of lateral setae along outer apical angle. Frons and clypeus coarsely, sparsely punctate; punctures on clypeus separated by distance equal to the diameter of a puncture, and on frons by distance greater than the diameter of a puncture; surface between punctures smooth or with widely scattered punctulae; antennal calli impunctate; genae with microreticulate area anteriorly between eye and base of mandible; frons with longitudinal impressed median line, deep between antennal calli, becoming obsolete toward vertex. Eyes oval, weakly emarginate at antennal insertion.

Antennae with scape oval, pedicel subglobose, shorter than scape, distinctly shorter than segment 3; scape and pedicel yellowish to reddish brown ventrally, metallic green or cobalt blue dorsally; segments 3–6 reddish brown to piceous, usually paler at extreme apex, remaining segments piceous; all segments filiform, each slightly wider at apex, elongate (L/W seg. 7 = 3.5–4); segments 3–6 with scattered adpressed setae, segments 7–11 densely pubescent, with whorl of long erect setae at apex of each segment from 3–10; segment 11 short, conical.

Mouthparts reddish brown to piceous; maxillary palp with apical segment spindle-shaped. Mandibles short, broad, strongly angulately curved, with outer surface smooth and shiny; apical teeth broad, acute.



Figs. 12–16. *Hermesia inermis*, male genitalia. 12, lateral view of median lobe with partially everted endophallus. 13, frontal view of BLD's. 14, apical view of ELD's. 15, apex of median lobe. 16, apical sclerites of endophallus. Abbreviations as in Figs. 8–11.

Prothorax distinctly wider than long, $L/W = 0.48-0.61$; disc of pronotum evenly, finely punctate, punctures separated by 1–2 times the diameter of a puncture, surface between punctures smooth, shining, with scattered punctulae. Apical and basal marginal bead narrow; lateral margin evenly rounded, with broad distinct flange, broadest at middle, and with fine transverse striae on dorsal surface of flange (Fig. 4). Anterior and posterior angles distinct, outwardly directed, formed from projections of lateral flange, each angle with single long erect seta in large puncture. Proepisternum with anterior margin straight, surface alutaceous to wrinkled. Proepimeron coarsely punctate, punctures separated by distance greater than the diameter of a puncture, surface smooth, shiny. Prosternum weakly declivous anterior to procoxae (Fig. 5), surface with long

erect yellow setae, intercoxal process broad, $1.1-1.6 \times$ diameter of procoxa, widened behind procoxae, longer than mesosternum, subequal to metasternum.

Mesosternum broad, subequal in width to prosternum, strongly convex between coxae, width $1.4 \times$ width of mesocoxa, surface smooth, slightly wrinkled with sparse short yellow setae.

Metasternum smooth, slightly swollen anterior to metacoxae, with sparse short yellow setae; metepisternum gradually narrowed posteriorly, surface alutaceous.

Legs sparsely covered with short prostrate setae, all surfaces alutaceous. Femora strongly swollen in middle; tibiae gradually widening toward apex, multicarinate, slightly to moderately sulcate between carinae, with setae linearly arranged in sulci and increasing in length toward apex of tib-

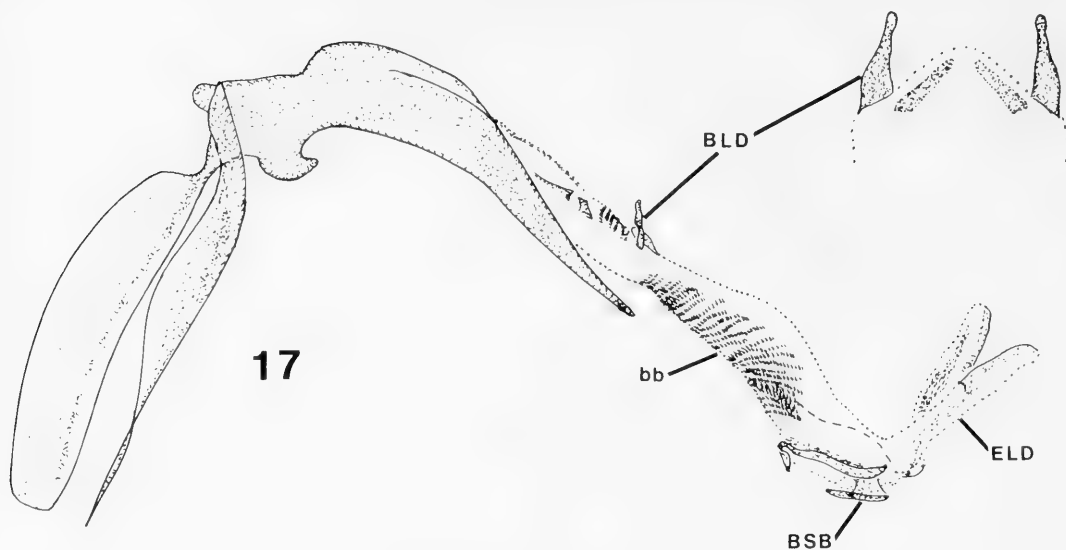


Fig. 17. *Hylax* sp., median lobe with partially everted endophallus (left), frontal view of BLD's (right). Abbreviations as in Figs. 8–11.

iae. Hind tibiae of male with broad low internal carina at middle (Fig. 1), or at apical fourth, or tibiae unmodified. Tarsi densely and uniformly pilose beneath, basal tarsomere of fore- and middle legs expanded (Fig. 3), distinctly longer than wide; second tarsomere broadly triangular, with acute apicolateral angles; third tarsomere longer than second, deeply bilobed; terminal tarsomere distinctly surpassing apex of 3rd tarsomere; claws divergent, appendiculate.

Elytra moderately punctate, punctures arranged in 13–14 irregular rows separated by two or more times the diameter of a puncture; apical third of elytra with punctures in four regular rows which follow sutural and lateral margins; surface between punctures smooth, shining, with sparse punctulae; humeri prominent, rounded; basal calli moderately developed; postbasal depression present, deeper laterally. Sides subparallel, convergent; apices conjointly broadly rounded. Basal margin moderately costate, costa obliterated toward scutellum. Epipleuron narrow, acutely raised, slanted, tapering evenly from base to apex.

Scutellum triangular, base subequal to length; surface smooth, with few punctulae.

Abdomen with all segments subequal in length, with sparse short yellow setae; with long yellow setae in central transverse row on four basal segments; surface between punctures finely alutaceous. Male sternum VI with shallow lateral depressions, sternum VII with flattened smooth median area, coarsely punctate laterally, apical emargination broad and shallow. Female sternum VI weakly crenulate on apical half, sternum VII flat, alutaceous, with strongly crenulate lateral margins, apical emargination narrower than in male, with median denticle (Fig. 24).

Pygidium with longitudinal median groove broad, shallow, extending to apical margin (Fig. 23); lateral margin of groove slightly acutely projecting inward, demarcated by subbasal bisinuate and apical arcuate carinae; surface alutaceous, with scattered coarse setiferous punctures; apical and lateral margins crenulate.

Male genitalia.—Median lobe strongly curved (in lateral view) to sharply bent (Figs.

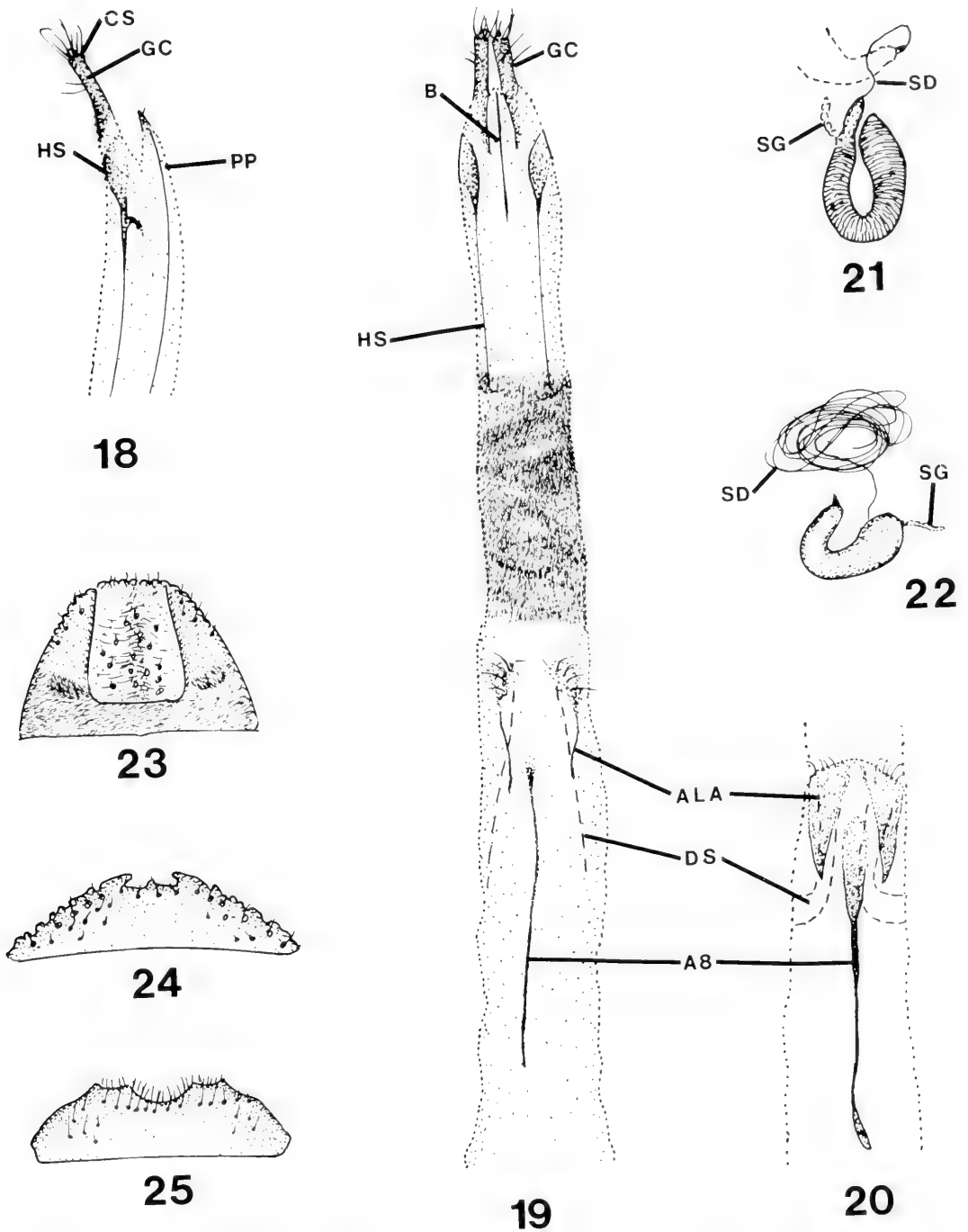


Fig. 18–25. Female characters of *Hermesia aurata* and *Hylax* sp. 18–19, ovipositor of *Hermesia aurata*: 18, apex, lateral view; 19, ventral view. 20, *Hylax* sp., base of ovipositor tube (sternum VIII), ventral view. 21, 22, spermatheca: 21, *Hermesia aurata*; 22, *Hylax* sp. 23, pygidium of *Hermesia aurata*. 24, 25, female sternum VII: 24, *Hermesia aurata*; 25, *Hylax* sp. Abbreviations: ALA = apicolateral arms of sternum VIII, A8 = apodeme of sternum VIII, B = baculum, CS = coxostyli, DS = dorsal sclerites of segment VIII, GC = gonocoxae, HS = hemisternites of segment XI, PP = paraprocts, SD = spermathecal duct, SG = spermathecal gland.

8, 12), apex pointed (Figs. 9, 15); basal hood (BH) long, lightly sclerotized, apodemes (AP) distinct at lateral margins of hood; subbasal fenestra (SBF) present; basal spurs (BS) prominent; tegmen slender. Endophallus elongate, with two pairs of lateral digits, the basal pair (BLD) simple, lobe shaped (Figs. 12, 13), the apical pair (ELD's) bifurcate, articulating with a basal supporting block (BSB); a ventral basal brush (bb) between the two pairs of lateral digits; with thin median ejaculatory guide (MEG) projecting forward when endophallus is everted (Figs. 8, 10); with small, internal, complex scerite at tip of endophallus (Figs. 11, 16); flagellum extremely long.

Female genitalia.—Segments VIII–XI forming elongate ovipositor (Fig. 19). Sternum VIII with long rod-like basal apodeme (A8) and weakly sclerotized apicolateral arms (ALA) with several setae; dorsal sclerites (DS) weak, rod-like. Segment IX covered with minute setae in basal half; hemisternites (HS) with long basal rods, poorly sclerotized apically; paraprocts (PP) separated into pair of slender dorsal rods, apically forming hood-like projection above genital orifice (Fig. 18); baculum (B) distinct, apical, subequal in length to gonocoxae (GC). Gonocoxae narrow, elongate, with long setae in apical half; coxostyli (CS) distinct, with several long apical setae. Spermatheca (Fig. 21) with fine annuli, narrowed at ramus; duct short, straight, transparent, with sclerotized outlet into bursa.

Species included

- Hermesia aurata* (Olivier)
Colaspis aurata Olivier 1808: 882
 (original description)
Chalcophana nitidissimus Erichson
 1847: 162 (original description);
 Bechyné 1953: 165 (catalogue)
Hylax auratus; Bechyné 1953: 165
 (catalogue)
Hermesia cyanea Bowditch 1921: 193
 (original description)

Hermesia inermis Bowditch 1921: 194
 (original description)

Parachalcolpacis inermis; Bechyné
 1953: 170 (catalogue)

Rhabdopterus violaceus Jacoby 1882:
 151 (original description), **new
 synonymy**

Hylax auratus violaceus; Bechyné 1953:
 165 (catalogue)

The remaining species listed as *Hermesia* in Blackwelder (1946) were placed by Bechyné (1953) and Bechyné and Bechyné (1961) in the following genera. I can make no judgements at this time as to the correctness of these generic placements; I can only confirm that they do not belong in *Hermesia* as defined herein.

Corysthea Baly: 1865: 336

gregalis (Weise) 1921: 49

rufa (Weise) 1921: 49

Hermesilla Bechyné: 1954: 216

fulgidicollis (Lefèvre) 1877: clxxix

f. lampros (Jacoby) 1900a: 352

janthina (Lefèvre) 1885: 39

similis (Bowditch) 1921: 193

Allocolaspis Bechyné: 1950b: 81

brunnea (Jacoby) 1900b: 489

confusa (Bowditch) 1921: 194

jacobyi (Bowditch) 1921: 193

Lyraletes Bechyné: 1952: 15

purpurea (Lefèvre) 1877: clxxix

varicolor (Jacoby) 1904: 514

Ledesmodina Bechyné: 1951: 263

erosula aenea (Jacoby) 1900a: 351

KEY TO MALE HERMESIA

(Female *Hermesia* cannot be distinguished at present except by association with males.)

1. Inner margin of hind tibia straight, lacking apical emarginate area *H. inermis*
 Inner margin of hind tibia expanded, with apical emarginate area lined with long setae (Fig. 1) 2
2. Hind tibia expanded at middle, apical emarginate area almost one-half the length of tibia *H. aurata*

Hind tibia expanded in apical third, emarginate area no more than one-fourth the length of tibia *H. cyanea*

DISCUSSION

The single male of *Rhabdopterus violaceus* mentioned by Jacoby and deposited in the Bowditch Collection is a *Hermesia* lacking tibial modifications, hence this form belongs under *H. inermis*. Both *H. aurata* and *H. inermis* are found in bright metallic green and cobalt blue color forms (all specimens of *H. cyanea* I have seen are metallic green). Males of *Hermesia* I have seen from Central America have all been *H. inermis*; this species also extends into Colombia (Bowditch Collection); *H. aurata* and *H. cyanea* are apparently limited to South America.

In the field, the brightly colored *Hermesia* species are likely to be confused only with members of a group of *Colaspis* that also are bright metallic green or cobalt blue (the "bridarollei" group of Bechyné). These *Colaspis*, however, have clear yellow to rufotestaceous legs (in *Hermesia* the legs are metallic, always the same color as the elytra) and much more densely and/or coarsely punctate elytra and pronotum. Host plant data for these species are (as usual for the Eumolpinae) scarce but I have collected *H. aurata* from leaves of *Psychotria* (Rubiaceae) in Rondonia, Brazil.

Hermesia, as here delineated, is most similar to *Lyraletes* Bechyné but can be distinguished by the following combination of characters (based on specimens referable to *Lyraletes* in the Bowditch Collection): the lateral flange of the pronotum is distinctly sinuate in *Lyraletes*, evenly rounded in *Hermesia*; and the elytra of *Lyraletes* are widest in their apical third (in *Hermesia* the sides are subparallel).

Aside from differences in the hind tibiae of the males (discussed above), *Hermesia* can be clearly differentiated from *Hylax* on the following characters. In *Hermesia* the prosternum (Fig. 5) is gradually declivous

anteriorly and its anterior margin meets the gula well behind the mouthparts. This condition is widespread in the Eumolpinae and can be seen in the familiar North American *Colaspis* and *Brachypnoea* (= *Nodonota*, see Flowers et al. 1994) species. In *Hylax*, on the other hand, the anterior margin of the prosternum is somewhat to distinctly concave for reception of the postgenal area of the head. Viewed in profile (Fig. 7) the prosternum appears to meet the gula almost perpendicularly. When the head is in the resting position, the prosternum rests against the gula close to the base of the mouthparts. This condition is less common in the Eumolpinae but is found in other Neotropical genera such as *Eumolpus* Weber and *Lepronota* Chapuis.

The pronotal lateral marginal bead of *Hylax* is narrow, evenly rounded, lacks striations and is slightly thickened as it passes around the apex of the apical angles (Fig. 6). The anterior apical angles are very large, directed forward and formed from the pronotum itself. This is quite different from the wide striate bead of *Hermesia* (Fig. 4) which ends in a small beveled angle at the anterior apical angle.

The apical abdominal sternite of the female is quite different between the two genera for all specimens examined. In *Hermesia*, the lateral margins are strongly crenulate and the apical notch is narrow, with a median tooth (Fig. 24). In *Hylax*, this sternite is smooth on the margins and the apex has a broad bisinuate emargination (Fig. 25).

There are some differences between the genitalia of *Hermesia* and *Hylax* (based on dissection of a series of *H. aurata* from Peru, *H. inermis* from Panamá and Costa Rica, and specimens of *Hylax* nr. *chalybaeus* Lef. from Costa Rica). In females, segment VIII is more extensively sclerotized in *Hylax*, the basal apodeme has a more marked apical expansion (Fig. 20); the spermatheca has a different shape (Fig. 22), and the sperma-

thecal duct is very long and convoluted. In males, the general morphology of the *Hylax* endophallus is like that of *Hermesia* but shape of both pairs of lateral digits (ELD and BLD) is different in the two genera. In *Hylax* the basal setal brush is much more extensive than in *Hermesia*, the setae are arranged in definite rows and there are rows of setae on the dorsal surface behind the basal digits (Fig. 17). The median lobe apex also differs slightly but this character varies within genera and is not of generic value. It is difficult to say if differences in these structures identified here are phylogenetically useful at the genus level. They do, however, weigh in favor of restoring *Hermesia*.

ACKNOWLEDGMENTS

This research was begun during a six-month sabbatical with the National Biodiversity Institute of Costa Rica (INBio) in 1991. I thank Dr. Rodrigo Gámez, MSc. Angel Solís and the INBio staff for their many kindnesses during that time. I also thank Dr. David G. Furth, Museum of Comparative Zoology (MCZ), Harvard University, for his invaluable assistance in providing specimens from the Bowditch Collection for this project. I also thank Dr. Michael C. Thomas, Florida State Collection of Arthropods (FSCA), Gainesville, Florida, and Dr. Fredrick G. Andrews, California Department of Food and Agriculture, for the loan of additional specimens; and Dr. Ingolf S. Askevold for useful comments on the manuscript. This research was funded in part by a grant (FLAX 91005) and in part by a National Science Foundation Mid-Career Fellowship (BSR-9003898).

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THE LARVA AND PUPA OF THE CADDISFLY SPECIES,
HELICOPSYCHE PARALIMNELLA HAMILTON
(TRICHOPTERA: HELICOPSYCHIDAE)

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Abstract.—Descriptions and illustrations of the larva and pupa of the caddisfly species, *Helicopsyche paralimnella*, are presented. Although the larva of this species most closely resembles that of *H. borealis*, diagnostic characteristics are noted. This species possesses a case typical of all other North American species. The known distribution of this species is limited to three localities in southwestern North Carolina and northwestern South Carolina.

Key Words: Caddisfly, *Helicopsyche*, Helicopsychidae, North Carolina, South Carolina, Trichoptera

The caddisfly genus *Helicopsyche* is represented by six species in America north of Mexico. These include *Helicopsyche borealis* (Hagen) (widespread and common throughout much of North America), *H. limnella* Ross (Arkansas and Oklahoma), *H. mexicana* Banks (Arizona, California, Texas, and Utah), *H. paralimnella* Hamilton (North and South Carolina), *H. piroa* Ross (Kansas, Louisiana, and Texas), and *H. sinuata* Denning and Blickle (California) (Hamilton and Holzenthal 1984). Although only the immature stages of *H. borealis* have been described and illustrated (Vorhies 1909, Elkins 1936, Ross 1944, and Wiggins 1977), larval characters (i.e. color patterns of the head capsules) have been found that will readily separate three additional species: *H. limnella*, *H. mexicana*, and *H. piroa* (Hamilton and Holzenthal 1984, S. W. Hamilton, pers. comm.).

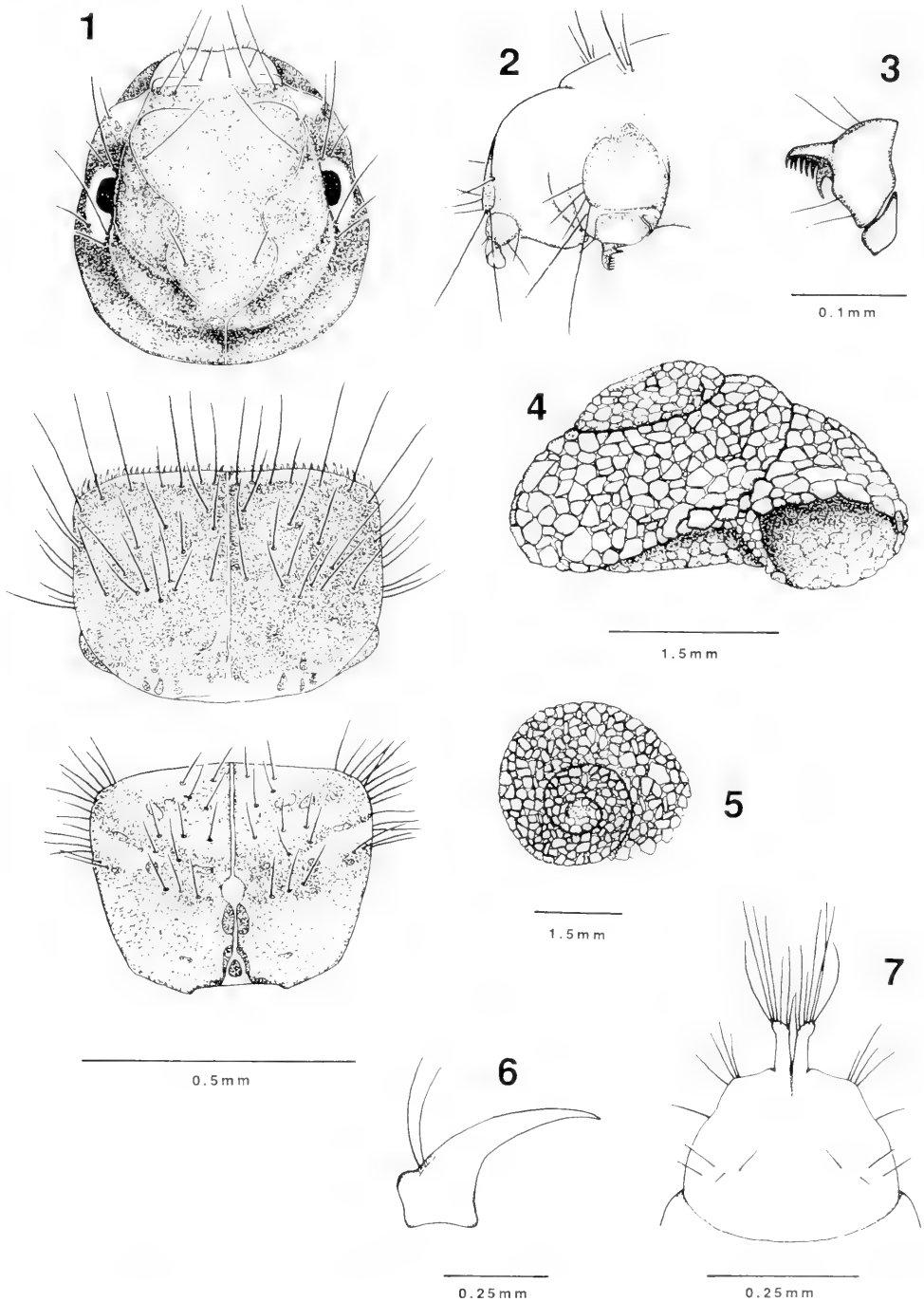
Collections that I made in the Blue Ridge Mountains of North and South Carolina, as well as examination of additional material (Morse et al. 1989) housed in the Clemson University Arthropod Collection (CUAC), have resulted in discovery of the previously unknown larva and pupa of *H. paralimnella*. Association of immatures and adults was made by using metamorphotypes (Milne 1934, Wiggins 1977). Morphological terminology follows that of Wiggins (1977). Representative specimens have been deposited in the Entomology Collection of the Royal Ontario Museum (ROM), the Illinois Natural History Survey (INHS), the U.S. National Museum of Natural History (USNM), and the CUAC.

Helicopsyche paralimnella
Hamilton 1989
(Figs. 1-7)

Helicopsyche paralimnella Hamilton, in
Morse et al. 1989: 30.

Material examined.—NORTH CAROLINA: Jackson/Transylvania County,

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Figs. 1-7. *Helicopsyche paralimnella* larva, larval case, and pupa. 1-3, larva: 1, head, pronotum, and mesonotum, dorsal view; 2, abdominal segment IX, right posterolateral view. 3, anal claw, lateral view. 4, 5, larval case: 4, lateral view; 5, dorsal view. 6, 7, pupa: 6, right mandible, ventral view; 7, abdominal segments VIII and IX with anal rods, dorsal view.

Whitewater River at Route 281, 27 June 1991, M. Floyd, 3 larvae, 2 pupae (ROM); 3 larvae, 2 pupae (INHS); 3 larvae, 2 pupae (USNM); 4 larvae, 1 pupa (CUAC); same locality, 25 Oct. 1989, E. Chen, 1 larva (CUAC); same locality, 7 May 1991, K. Hoffman, 5 larvae (ROM), same locality, 16 March 1989, E. Chen, 3 larvae (INHS), same locality, 7 May 1991, J. Morse, 15 larvae (USNM); M. Floyd, 59 larvae (CUAC); SOUTH CAROLINA: Oconee County, Thompson River at North Carolina border, 18 May 1987, S. Hamilton and K. Hoffman, 2 larvae (CUAC); Pickens County, Wildcat Creek, Clemson University Experimental Forest, 28 August 1986, J. Wilson, 2 larvae (CUAC).

Mature larva.—Figs. 1–3. Length 4–5 mm. Head dark brown except for lightly pigmented labrum, periocular areas, and portion of genae anterior to antennae (Fig. 1). Pronounced carinae running posteriad from anterolateral corners of frontoclypeal apotome near antennae, mesad to eyes, then forking to posterolateral corners of frontoclypeal apotome and to coronal suture. Anterior half of frontoclypeal apotome twice as wide as posterior half, the apotome lyre-shaped, with sinuous lateral margins. Pronotum dark brown, heavily setose; anterior margin with regular row of about 40 to 50 short, stout spines; few dark muscle scars present on posterior half. Foretrochantin long, with apical seta. Mesonotum brown, with contrasting darker muscle scars and dark, irregular bands running from meson to mesolateral and anterolateral areas; pale, circular area present at midlength of mid-dorsal ecdysial line, just anterior to pair of dark muscle scars. Lateral sclerite of abdominal segment I roughly triangular, with many small spines and one seta along posterior border (similar to Fig. 5.1A, Wiggins 1977). Abdominal segment VIII with row of lateral tubercles (similar to Fig. 5.1E, Wiggins 1977). Abdominal segment IX with pair of dorsomesal tufts, each with five setae (Fig. 2). Lateral sclerite of anal proleg heavi-

ly sclerotized and dark brown, with five to six long, posterior setae. Anal claw comb-like (Fig. 3).

Pupa.—Figs. 6, 7. Length 5 mm. Mandibles long, blade-like, without teeth or serrations (Fig. 6). Anal rods of abdomen narrow, finger-like, with posterior setae nearly twice as long as rods (Fig. 7).

Case.—Figs. 4, 5. Length 5 mm. Snail-shaped, composed of fine sand grains. Dorsal lip of anterior opening extending hood-like over ventral lip.

Discussion: The larva of *H. paralimnella* most closely resembles *H. borealis*. It can be differentiated from *H. borealis* by the lack of muscle scars on the head, the presence of darkly pigmented lateral sclerites on the anal proleg, and its small size (mature larva ≤ 5 mm). These two species have not been found to occur in the same streams. The Ozarkian species, *H. limnella*, the probable sister species of *H. paralimnella* (Morse et al. 1989), is much less darkly pigmented and has large, pale muscle scars on the head. Except for its small size, the pupa of *H. paralimnella* does not seem to differ from those of other North American *Helicopsyche* species. In addition, no distinguishing characters have been found for pupae of *H. borealis*, *H. limnella*, *H. mexicana*, or *H. piroa* (Hamilton and Holzenthal 1984).

At present, *H. paralimnella* is known from only three streams in North and South Carolina. Thompson River (Oconee County, South Carolina) and Whitewater River (Jackson/Transylvania County, North Carolina) are clear, fourth order, mountain streams (439 m altitude), which have moderate to fast current and substrates composed of bedrock, cobble, and smooth boulders. Riparian vegetation is composed primarily of rhododendron and mixed hardwoods. Wildcat Creek is a clear, third order, upper Piedmont stream (240 m altitude) with a sand and cobble substrate. Riparian vegetation consists of mixed hardwoods. Larvae and pupae were found either in bedrock areas among patches of river

weed, *Podostemum* sp., or the underside of cobble and boulders. Morse et al. (1989) reported adult collection dates of 15 June to 21 July.

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FOUR NEW SAWFLIES FROM EASTERN NORTH AMERICA, THREE
SPECIES OF *TENTHREDO* AND ONE OF *DOLERUS*
(HYMENOPTERA: TENTHREDINIDAE)

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Abstract.—Three new species of *Tenthredo* and one new *Dolerus* from eastern North America are described and illustrated. *Tenthredo appalachia* and *T. masneri* occur from southern Canada to Great Smoky Mountains National Park in North Carolina and Tennessee. *Tenthredo fernowi* is more restricted and is known only from northern Virginia and West Virginia to Great Smoky Mountains National Park. Though rarely previously collected, adults of these three species are common in collections from a broadleaf forest in West Virginia. *Dolerus klokeorum* was discovered in collections from three localities in the Virginia Piedmont. Flight records and habitat data are given for each species.

Key Words: *Dolerus*, North America, sawflies, Tenthredinidae, *Tenthredo*

Four sawflies are described here so that names will be available for future papers on sawfly studies in the mid-Atlantic states. The three species of *Tenthredo* are relatively common in collections from within a broadleaf forest of the central Appalachians of West Virginia. The *Dolerus* is from Virginia, and it is an addition to the revision of nearctic *Dolerus* (Goulet 1986).

Most specimens of the three *Tenthredo* species were collected during a study of non-target insects and diflubenzuron (E. M. Barrows, Georgetown University) in a broadleaf forest in the central Appalachians, the Fernow Experimental Forest, Monongahela National Forest, about three miles south of Parsons, Tucker Co., West Virginia (39°3'N, 79°40'W; map in Griffith and Perry 1992). The forest is dominated by oaks, intermixed primarily with beech, sweet birch, maple, yellow poplar (tulip tree), black cherry, pin cherry, white ash, basswood, rhododen-

dron, and black locust (Anonymous 1987). Elevations of the collection sites vary between 2300 to 2600 feet. Twenty Townes-style Malaise traps were utilized, five in each of four watersheds, for the non-target study, and all were in operation from mid-April to the end of September each year. In each watershed, one trap was adjacent to a stream, two traps were about 20 m up each slope, and another 2 traps were about 40 m up each slope. All were within dense forest. The Malaise trap numbers in the specimen data sections indicate the watershed-trap number, e.g. 4-1 is watershed 4, trap 1, etc. Trap 1 was the top trap on the northerly-facing slope, trap 2 the middle trap on this slope, trap 3 near a stream, trap 4 the middle trap on the southerly-facing slope, and trap 5 the top trap on this slope. Trap numbers of 6 or higher are Cornell-style Malaise traps set up at forest edges.

Much of the terminology, especially for

sculpturation, is based on Goulet (1986). Format and terminology are consistent with that being used for ongoing revisionary studies of Nearctic *Tenthredo* by the senior author. The character choice in descriptions is a function of species closely related to the one being described. *Tenthredo appalachia*, n. sp., and *T. masneri*, n. sp., are closely related, and their descriptions are similar. *Tenthredo fernowi*, n. sp., is related to *T. rufopecta* (Norton), *T. nimbipennis* Cresson, and *T. mellicoxa* Provancher, and its description stresses characters significant among these species.

Tenthredo appalachia
Goulet and Smith, NEW SPECIES
 (Figs. 1, 4, 9)

Diagnosis.—Adults are distinguished from those of other Nearctic species of *Tenthredo* with minute pulvilli (length of pulvillus of first metatarsomere 0.15–0.20 × length of second metatarsomere) and with microsculpture on the mesonotal median lobe by the following character combination: ventral portion of metasternum completely orange, clypeus white (except on basal one-fourth to one-third), and tergites 2–8 not appreciably paler along posterolateral margin.

Female.—Length, 10.5–12.0 mm. Antenna and head black, with apical $\frac{2}{3}$ clypeus, mandible, labium, and maxillary and labial palpi white; minute white spot present on lower outer orbit (may be lacking) and one on upper inner orbit. Thorax black with tegula, spot on lower posterior margin of mesepisternum near mesocoxa, and metepisternum white; posteromedial portion of pectus orange. Abdomen black with lateral margin of tergite 1 white and basal sternite and sometimes part of sternite 2 orange. Legs orange with apical $\frac{2}{3}$ of metatibia and metatarsus black. Wings hyaline; veins and stigma black.

Head in dorsal view slightly narrower behind eyes (maximal distance between outer

margins of eyes $1.05 \times$ maximal distance between outer margins of gena). Antennal flagellum long: sixth flagellomere $4 \times$ longer than wide and first flagellomere $1.10\text{--}1.20 \times$ as long as second flagellomere. Head and body mostly shining and impunctate, with thorax more dulled by surface sculpture than head. Malar area near mandible with convex sculpticells and fine punctures (10–15 μm in diameter); central portion of gena with lightly imprinted meshes of microsculpture; remainder of head smooth. Mesepisternal spine obtusely angular (about 130° , Fig. 9). Most of thorax with fine surface microsculpture, with rugose microsculpture on posterior half of mesepisternum, and without microsculpture on medial portion of posttergite, on lateral lobe of mesoscutum, and anterior half of mesoscutellum. Punctures on pectus and on mesoscutum fine (10–15 μm in diameter), 20–30 μm apart on median lobe and pectus, and 10–40 μm apart on lateral lobe; punctures of mesoscutellum larger (30 μm in diameter) and 30–60 μm apart. Abdomen shining but with fine surface microsculpture, meshes of microsculpture about 10 μm in length by 15–60 μm in width, posterior margin of sculpticells clearly elevated and scale-like. Setae lacking at base of tergite 1. Pubescence developed over half of tergite 7, and dense on tergites 8–9, 40–50 μm apart. Tarsal pulvilli minute (length of pulvillus of first metatarsomere 0.15–0.18 × length of second metatarsomere) and narrow (width of pulvillus of first metatarsomere about $\frac{1}{3}$ apical width of second metatarsomere) (Fig. 4). Serrulae of lancet as in Fig. 1.

Male.—Length, 10.0 mm. Similar in coloration to female except for the following: gena with large white spot on lower third; pronotum in lateral view with white spot on ventral surface; mesepisternum black with white spot extended from mesocoxa forward beyond middle, ventral portion of pectus black anteriorly but gradually becoming orange in posterior half; tergites 1–8 dark brown but white at side of tergite 1

and whitish on medial half of tergites 2–5; sternites 2–5 whitish orange.

Head in dorsal view clearly narrower behind eyes (maximal distance between outer margins of eyes $1.14\times$ maximal distance between outer margins of gena). Setae at base of tergite 1 present only at side and medially. Metatarsus in dorsal view narrow as in female; metatarsomere 2 about $6\times$ longer than wide. Genitalia as in Fig. 6; penis valve with apical spine.

Holotype.—Female, labeled “West Virginia: Tucker Co., Fernow Expt. Forest, 31-V-9-VI-91, E.M. Barrows,” “Malaise trap 7-2.” Deposited in the National Museum of Natural History, Washington, D.C.

Paratypes (14 F, 1 M).—CANADA: QUEBEC: Knowlton, 1-VII-36 (1M). U.S.A.: NEW HAMPSHIRE: Lancaster, Mount Prospect, 19-VI-82 (1F). NORTH CAROLINA/TENNESSEE: Great Smoky Mts. Natl. Park, 8-VII-57 (2F). WEST VIRGINIA: Same data as holotype except for dates and trap numbers, 10-19-VI-91, trap 1-2 (1F); 20-29-VI-91, trap 1-3 (1F); 21-30-V-91, trap 4-1 (1F); 10-19-VI-91, trap 4-2 (1F), trap 4-6 (1F), trap 7-6 (1F); 10-19-VII-91, trap 13-3 (1F); 20-29-V-92, trap 1-2 (1F), trap 7-6 (1F), trap 13-6 (1F); 19-V-28-VI-92, trap 7-6 (1F). Deposited with the holotype and in the Canadian National Collection, Ottawa.

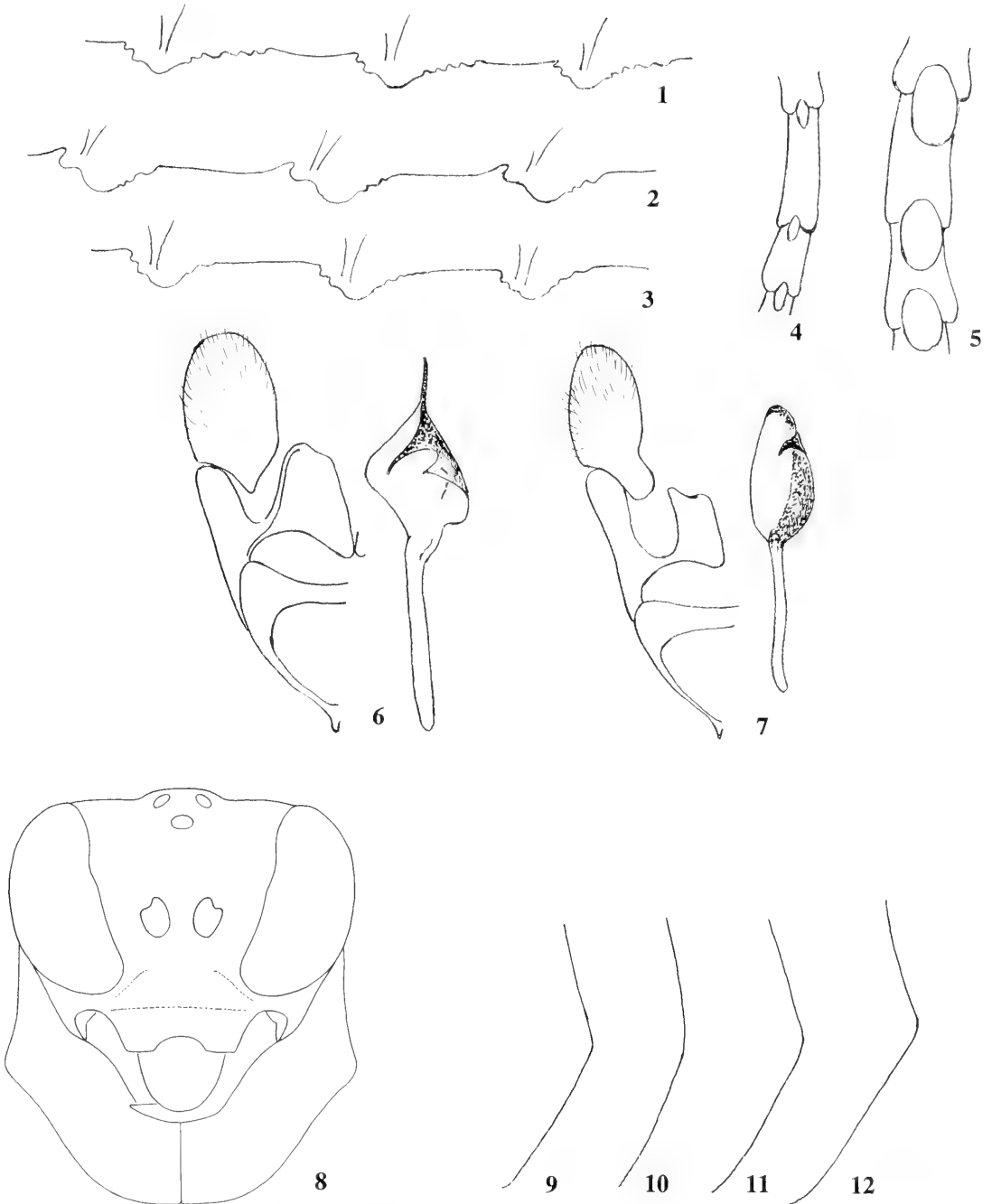
Distribution.—This species occurs in the Appalachian Mountains from Great Smoky Mountains National Park northwards to southernmost Quebec.

Etymology.—The specific epithet is a noun in apposition and refers to the Appalachian Mountain range distribution of this species.

Discussion.—Females of *T. appalachia* have a mostly black body with orange legs except for the black apical one- to two-thirds of the metatibia and the metatarsus. This color pattern is very similar to those of *T. leucostoma* Kirby and other similarly colored species with an angular mesepisternal spine. The male is rather different in color

pattern from those of *T. leucostoma* and similarly colored species. Females of *T. leucostoma* and similarly colored species are differentiated from *T. appalachia* as follows: pulvilli very long and wide (length of pulvillus of first metatarsomere $0.40-0.70\times$ length of second metatarsomere; width of pulvillus of first metatarsomere about two-thirds that of second metatarsomere) (Fig. 5); ventral portion of metepisternum black or black with white on posterior half; posterior margin of pronotum white or black, apical one- to two-thirds of metatibia black; and head slightly duller because of surface sculpture, especially on hindorbits. The male of *T. leucostoma* and of species alluded to above have black stripes or spots on the coxae, trochanters, and femora. From *T. masneri*, its closest species, *T. appalachia* is distinguished by the black posterior margin of the pronotum in dorsal view, black posterolateral margin of tergites 2–8, black posterior margin of tergite 1, wider black base of clypeus, longer antennal flagellum (sixth flagellomere $4\times$ longer than wide), smaller pulvilli, and lack of setae over at least portion of base of tergite 1.

This species is part of the lineage to which most North American *Tenthredo* species belong. The following species groups proposed by Ross (1951) and followed by Smith (1979) belong in this lineage: *basilaris*, *pectoralis*, *rufopecta* (only *T. rurigena* MacGillivray), *angulifera*, *leucostoma* (excluding *nimbipennis*), *occidentalis*, *verticalis*, *semirufa*, *secunda*, *xantha*, and *begimina*. This lineage is characterized as follows: metatibial spurs less sharp than those of mesotibiae; penis valve with short, straight, ventroapical spur; and tergites 7–10 or 8–10 of female completely or almost completely pubescent (except *T. fernaldii* MacGillivray, fully pubescent from tergite 2). Except for species of the *pectoralis* group, species in other groups are often difficult to associate together in groups because character states (other than color pattern) have not been discovered. However, adults of *T.*



Figs. 1-12. Central serrulae of lancet of 1, *Tenthredo appalachia*; 2, *T. masneri*; 3, *T. fernowi*. Metatarsal pulvilli of 4, *T. appalachia*; 5, *T. leucostoma*. Male genitalia of 6, *T. masneri*; 7, *T. fernowi* (ventral view of half of genital capsule on right, lateral view of penis valve on left). Mesepisternal angle (posterior view) of 8, *T. masneri* (showing head and thorax in anterior view); 9, *T. appalachia*; 10, *T. fernowi*; 11, *T. mellicoxa*; 12, *T. rufopecta*.

appalachia and *T. masneri* are the only ones with an orange metepisternum on the ventral surface and with minute pulvilli. The color pattern of the legs and body of the male (coxae, trochanters, basal two-thirds of femora orange or whitish orange, tergites brown except medially on tergites 3–5) supports this proposed relationship. Large pulvilli are seen in the earliest lineages of *Tenthredo* as well as in other genera of the Tenthredinini; therefore, small pulvilli are a departure from the ground plan, which probably evolved several times in *Tenthredo*, especially in species of most Eurasian groups. Elongation of the flagellum is usually associated with reduction in size of the pulvilli. The lineage to which *T. appalachia* belongs seems to be very rare in Eurasia. Only *T. procera* Klug with a short spur on the penis valve seems to be related. Otherwise, the putative sister group is the *atra* group (*piceocincta* group in Ross 1951) in which the spur on the penis valve is long and curved up (similar to Fig. 6).

Ecology.—The host is unknown. Adults have been recorded from about 500' (Knowlton, Quebec) to 5200' (Great Smoky Mts. Natl. Park, N.C./Tenn.) in deciduous forests. Flight dates are from May 21 to July 19. Twelve specimens were collected in the Fernow Experimental Forest in West Virginia from May 21 to July 19 with most collected in May and June. Specimens were rather uniformly distributed throughout the four study watersheds, with 3 specimens from watershed 1, 3 from watershed 4, 4 from watershed 7, and 2 from watershed 13. Five were from forest-edge traps. The seven specimens from within the forest were all from traps in valleys and northerly-facing slopes: traps 1, 1 specimen; traps 2, 4 specimens, and traps 3, 2 specimens.

***Tenthredo masneri* Goulet and Smith,**

NEW SPECIES
(Figs. 2, 6, 8)

Diagnosis.—Adults are distinguished from those of other Nearctic species of *Ten-*

thredo with minute pulvilli (length of pulvillus on first metatarsomere, 0.20–0.30 × length of second metatarsomere) and with microsculpture on the mesonotal median lobe by the following character combination: ventral portion of metasternum completely orange, clypeus white, and tergites 2–8 white along posterolateral margin.

Female.—Length, 11.5–12.5 mm. Antenna and head black; clypeus, labrum, basal $\frac{2}{3}$ mandible, labium, and maxillary and labial palpi white; apical $\frac{1}{3}$ mandible reddish; usually minute but occasionally large white spot on lower outer orbit and with minute white to brown spot on upper inner orbit. Thorax black with posterior corners and (in most specimens) ventral margin of pronotum, tegula, spot (may be as large as pale portion of mesepisternum above mesepisternal spine) on lower posterior corner of mesepisternum, and metepisternum white; mesosternum and most of mesepisternum orange (white or whitish orange in some specimens) except for broad black stripe on upper $\frac{1}{3}$ or less of posterior margin of mesepisternum. Abdomen black; small white spot on lateral margin of tergite 1 extended along posterior margin, and tergites 2–8 each with narrow white band visible at least posterolaterally. Legs orange with extreme tip of meso- and metafemora, apical $\frac{1}{3}$ – $\frac{1}{2}$ metatibia, and metatarsus, black. Wings hyaline; veins and stigma black.

Head in dorsal view narrower behind eyes (maximal distance between outer margins of eyes 1.10 × maximal distance between outer margins of gena). Antennal crest moderately elevated with weakly developed angular projection behind it. Antennal flagellum moderately long; sixth flagellomere about 3 × longer than wide and first flagellomere 1.15–1.25 × as long as second flagellomere. Malar area near mandible with convex sculpticells and fine punctures (10–15 μ m in diameter); central portion of gena without microsculpture; remainder of head smooth. Mesepisternal spine obtusely angular (about 115°, Fig. 8). Most of thorax

with meshes of microsculpture and sculpticells flat, but central area in upper half of mesepisternum, mesoscutellum anteromedially, medial region of posttergite and mesonotal lateral lobe without microsculpture. Punctures on pectus and on mesoscutum fine (10–15 μm in diameter), 25–30 μm apart on median lobe and pectus, and 20–40 μm apart on lateral lobe; punctures of mesoscutellum larger (25–30 μm in diameter) and 25–50 μm apart. Abdomen shining but with fine surface sculpture: sculpticells about 15 μm in length by 15–60 μm in width, posterior margin of sculpticells clearly elevated and scale-like. Setae visible over most of tergite 1. Pubescence developed over all of tergite 7 and dense on tergites 8–9, 40–50 μm apart. Tarsal pulvilli minute (length of pulvillus of first metatarsomere 0.20–0.28 \times length of second metatarsomere) and narrow (width of pulvillus of first metatarsomere about $\frac{1}{3}$ apical width of second metatarsomere) (as in Fig. 4). Serulae of lancet as in Fig. 2.

Male.—Length, 9.0 mm. Antenna and head black; clypeus and mouthparts white with apex of mandible reddish; lower $\frac{1}{3}$ of outer orbit from mandible and minute spot on upper inner orbit whitish. Thorax mostly black dorsally, with large spot on lower pronotum, posterior corner of pronotum, tegula, cervical sclerite, prosternum, central stripe on mesepisternum dorsal to angle, and metepisternum white; mesosternum to angle of mesepisternum pale orange. Abdomen mostly black above with tergites 2–5 to 2–7 yellowish orange at side gradually becoming darker toward dorsal surface; lateral margin of tergite 1 narrowly white; posterior margin of each segment narrowly whitish; mostly orange ventrally with apical 2–3 sternites black. Legs pale orange to yellow, fore- and midlegs more yellowish and hindleg more orange; upper surface of tip of each femur with black spot (may be lacking on profemur); metatibia brownish to dark orange; metatarsus black; outer surface of mesotibia and mesotarsus darker orange

than inner surface. Wings hyaline; veins and stigma black with vein R apical to stigma, amber.

Head in dorsal view clearly narrower behind eyes (maximal distance between outer margins of eyes 1.20 \times maximal distance between outer margins of gena). Setae visible over most of tergite 1. Metatarsus in dorsal view wider than in female: metatarsomere 2 about 4 \times longer than wide. Genitalia as in Fig. 6; penis valve with long apical spine.

Holotype.—Female, labeled “QUE. Gatineau Pk, Luskville Falls, 5–22-VII-1988, J. Denis 300 m.” Deposited in the Canadian National Collection, Ottawa, Ontario, Canada.

Paratypes (63 F, 5 M).—CANADA: NOVA SCOTIA: Cape Breton Highlands Natl. Park, 60°41'W–46°48'N (1F); Cape Breton Highlands Natl. Park, 60°44'W–46°48'N (1F). ONTARIO: 7 mi. E Griffith (1F); Finland (1F). QUEBEC: Mont Albert (1F); Park Reserve (1F); Portneuf Co., St.-Augustin (1F); Berthierville (1M); St. Hilaire (1F); Knowlton (1F); Ste. Agathe des Monts (1F); Mont Pinnacle (1F); Montford (1F); Ste. Anne de Bellevue (1M, 3F); Rigaud (4F); King Mountain (summit) near Old Chelsea (2F); Gatineau Prov. Park, Luskville Falls (1F); Lac Roddick (1F). U.S.A.: MICHIGAN: Cheboygan Co. (1M). NEW HAMPSHIRE: Coos Co., First Connecticut Lake (1F). NEW YORK: Ithaca (1F); Ludlowville (1M). NORTH CAROLINA/TENNESSEE: Great Smoky Mts. Natl. Park, Indian Gap (1F). WEST VIRGINIA: Tucker Co., Fernow Expt. Forest, E. M. Barrows, 11–20-V-91, trap 7-3 (1F); 21-30-V-91, trap 4-3 (1F), trap 7-3 (2F), trap 13-2 (1F); 31-V-9-VI-91, trap 4-5 (1F), trap 13-4 (1F); 10–19-VI-91, trap 4-2 (1F), trap 4-6 (1M), trap 7-4 (1F), trap 13-1 (1F), trap 13-3 (2F); 20–29-VI-91, trap 1-1 (1F), trap 1-3 (1F), trap 4-1 (1F), trap 4-2 (1F), trap 7-3 (1F), trap 13-1 (1F), trap 13-3 (1F); 30-VI-9-VII-91, trap 1-1 (1F), trap 1-5 (3F), trap 13-4 (1F); 10–19-VII-91, trap 1-5 (1F),

trap 7-1 (1F); 30-VII-8-VIII-91, trap 7-1 (1F); 30-V-8-VI-92, trap 13-3 (1F); 9-18-VI-92, trap 4-5 (1F); 19-28-VI-92, trap 13-5 (1F); 8-VII-92, on leaf of maple near trap 7-4 (1F); 9-18-VII-91, trap 4-5 (1F); 19-28-VII-92, trap 4-3 (1F), trap 13-2 (1F); 29-VII-7-VIII-91, trap 13-2 (1F); 8-17-VIII-92, trap 1-5 (1F); 18-27-VIII-92, trap 13-5 (1F); 24 km E Richwood, (1F). Deposited with the holotype; National Museum of Natural History, Washington, D.C.; University of Montreal; Lyman Entomological Museum; and Carnegie Museum.

Distribution.—This species is recorded from northwestern Ontario near the Manitoba border to the Atlantic coast in Nova Scotia, and south along the Appalachian Mountains to Great Smoky Mountains National Park on the Tennessee-North Carolina border.

Etymology.—We name this elegant species in honor of Dr. Lubomir Masner, a dear colleague, who, through his unabated enthusiasm for field work, has provided us with numerous specimens and unusual species of sawflies. Dr. Masner also collected the northernmost record at the fringe of the boreal forest (Roddick Lake, Quebec).

Discussion.—Adults of *T. masneri* appear to resemble those of *T. rufopecta* and *T. mellicoxa* in the *rufopecta* group. However, *T. masneri* does not belong to this group, but is part of a very large lineage to which most North American species belong (see discussion under *T. appalachia*). Females of *T. masneri* are near perfect color matches of *T. rufopecta*. However, both sexes of *T. rufopecta* are differentiated from those of *T. masneri* by the following features: antennae partly brownish (usually the undersurface); clypeus entirely or partly black (at least with some black and not entirely white); approximately upper half of mesepisternum black; minute white spots on lower outer eye orbit and upper inner orbit lacking; pro- and mesotarsal segments ringed with black at their apices; and mesepisternal spine more obtuse (angle about

135°, Fig. 12). Both sexes of *T. mellicoxa* are differentiated from *T. masneri* by: a sharply defined white lateral stripe on the abdomen; posterior margins of abdominal segments narrowly but distinctly white; minute white spots on the upper inner orbit lacking; and the mesepisternal spine hardly suggested (rather flatly rounded without trace of an angle, Fig. 11). From *T. appalachia*, probably its nearest species, *T. masneri* is differentiated by the white posterior margin of the pronotum in dorsal view; white posterolateral margin of tergites 2–8; white posterior margin of tergite 1; lack of black at base of clypeus (except at side in some specimens); shorter flagellum (sixth flagellomere about 3× longer than wide); and presence of setae over at least base of tergite 1.

Ecology.—The host is unknown. Adults of the species have been recorded from sea level (Montreal, Quebec, region) to 5200' (Great Smoky Mts. Natl. Park, N.C./Tenn.) mainly in deciduous forest habitats. Flight is recorded from May 11 to September 10. In the North (Ontario, Quebec, Nova Scotia and New England) most specimens were collected from mid-July to early August, but in the South (West Virginia) the peak flight is from mid-June to mid-July. Thirty-eight specimens were collected in the Fernow Experimental Forest in West Virginia. They appeared to be rather uniformly distributed throughout the study watersheds. Traps in watershed 1 yielded 8 specimens; watershed 4, 8 specimens; watershed 7, 7 specimens; and watershed 13, 13 specimens. Most specimens were collected from traps near streams and on the southerly-facing slopes. Traps 1 yielded 7 specimens; traps 2, 5 specimens; traps 3, 11 specimens; traps 4, 3 specimens; and traps 5, 10 specimens. In the two years of the study, the flight period was rather long, beginning May 11 and ending August 27. Most specimens were collected June 10–29, with numbers gradually decreasing to August.

***Tenthredo fernowi* Goulet and Smith,**
NEW SPECIES
 (Figs. 3, 7, 10)

Diagnosis.—Adults are distinguished from those of other Nearctic species of *Tenthredo* with very small metatarsal pulvilli (length of pulvillus on first metatarsomere $0.15\text{--}0.20\times$ length of second metatarsomere), and without meshes of microsculpture on dorsal surface of head, mesonotal median lobe, and mesepisternum (including pectus) by the following character combination: clypeus black with sublateral white spots in female; tergites 2 and 3 orange and remaining tergites black; and mesepisternum (including pectus) black with white spot near mesocoxa or with stripe from mesocoxa to about middle of mesepisternum anteriorly.

Female.—Length, 10.5–12.0 mm. Antenna and head black; clypeus mostly white laterally, black centrally; labrum, basal $\frac{2}{3}$ of mandible, labium, and maxillary and labial palpi white; apical $\frac{1}{3}$ of mandible reddish. Thorax black with posterior corner of pronotum, tegula, short stripe or spot on lower posterior corner of mesepisternum, and metepisternum white. Abdomen black with small white spot on lateral margin of tergite 1 and 2nd and 3rd segments and anterior $\frac{1}{3}\text{--}\frac{1}{2}$ of 4th sternite orange. Legs orange with extreme tip of meso- and metafemora, extreme apex of mesotibia, apical $\frac{1}{4}$ of metatibia, and metatarsus black; apical $\frac{1}{3}$ of mesotarsal segments usually blackish; basal $\frac{1}{4}\text{--}\frac{1}{3}$ of first metatarsomere orange. Wings hyaline; veins and stigma black with costa and vein R apical to stigma, amber.

Head except near mandible, mesoscutum, mesoscutellum (except at side), mesepisternum, pectus (except on outer half in some specimens), mesoscutellar appendage (except at side) and metascutellum without meshes of microsculpture, thus surface of these structures very bright. Gena near mandible with deeply impressed meshes of microsculpture and convex sculpticells, and

with some very fine punctures (about $15\ \mu\text{m}$ in diameter). Punctures on mesoscutum $10\text{--}15\ \mu\text{m}$ in diameter; slightly denser on median lobe ($50\text{--}75\ \mu\text{m}$ apart) than on lateral lobe ($40\text{--}100\ \mu\text{m}$ apart); on mesoscutellum coarse ($20\text{--}25\ \mu\text{m}$ in diameter) and $50\text{--}100\ \mu\text{m}$ apart. Mesoscutellar appendage with fewer than 8 punctures. Mesepisternum slightly extended outward and rounded without distinct medial angle (Fig. 10). Metascutellum with fewer than 10 setae. Tergites 2–8 with meshes of microsculpture variably transverse (length about $10\ \mu\text{m}$ and width $15\text{--}60\ \mu\text{m}$); sculpticells flat and very slightly raised along posterior margin and scale like. Tarsal pulvilli minute, short (length of pulvillus of first metatarsomere $0.18\text{--}0.20\times$ length of second metatarsomere) and narrow (width of pulvillus of first metatarsomere about $\frac{1}{3}$ apical width of second metatarsomere) (as in Fig. 4). Serrulae of lancet as in Fig. 3.

Male.—Length, 9.0–9.5 mm. Similar in coloration to female except clypeus white or with slight indication of black medially, no white spot laterally on tergite 1, 2nd and 3rd abdominal segments sometimes blackish laterally, and apical $\frac{1}{3}$ or more of metatibia black. Second metatarsomere in dorsal view not widened, similar to female, about $5\text{--}6\times$ longer than wide. Genitalia as in Fig. 7; penis valve without apical spine.

Holotype.—Female, labeled “WEST VIRGINIA: Tucker Co., Fernow Expt. Forest, 31-V-9-VI-1991, E.M. Barrows” “Malaise trap 4-2.” Deposited in the National Museum of Natural History, Washington, D.C.

Paratypes (97 F, 5 M).—U.S.A.: MARYLAND: Prince Georges Co., Patuxent Wildlife Center, 6-10-VII-90 (1F); Montgomery Co., Plummers Island, 24-V-75 (1F). NORTH CAROLINA: Great Smoky Mts. Natl. Park, 4-VII-62 (1F). VIRGINIA: Fairfax Co., near Annandale, Malaise trap, 27-V-3-VI-84 (1F); Falls Church, 24-VI-16 (1F), 1-VI (1M); Giles Co., Cold Spring, Va. Hwy 700 14-VI-75 (1F); Loudoun Co.,

Bluemont, 6-V-13 (1F); Clarke Co., Univ. Va. Blandy Exp. Farm, 2 mi S Boyce, 19-30-IV-90, trap 8 (2F), 1-13-V-90, traps 8, 9 (3F), 14-24-V-90, trap 8 (2F); Shenandoah Co., Mount Jackson, 25-V-62 (1F); Shenandoah Co., Shenandoah Natl. Park, Compton Gap, 22-V-2-VI, 87 (1F); Shenandoah Co., Shenandoah Natl. Park, Big Meadows, 14-VI-82 (1F). WEST VIRGINIA: Same data as holotype, except for dates and trap numbers: 21-30-V-91, trap 1-4 (1F), trap 4-1 (1F), trap 4-4 (1F), trap 7-1 (3F), trap 7-2 (1F), trap 7-3 (1F), trap 7-4 (2F), trap 13-3 (2F), trap 13-4 (1F); 31-V-9-VI-91, trap 1-4 (1F), trap 1-5 (1F), trap 4-3 (1F), trap 4-4 (1F), trap 4-6 (1F), trap 7-2 (1F), trap 7-3 (2F), trap 7-6 (1F), trap 13-3 (1F), trap 13-4 (2F); 10-19-VI-91, trap 1-2 (2F), trap 4-1 (1F), trap 4-3 (1F), trap 4-6 (1F), trap 7-3 (1F), trap 7-6 (1F); 20-29-VI-91, trap 1-1 (1F), trap 4-2 (1F), trap 4-3 (1F), trap 7-3 (1F), trap 13-4 (1F); 30-VI-9-VII-91, trap 1-1 (1F), trap 4-3 (1F); 10-19-V-92, trap 1-1 (1F); 20-29-V-92, trap 1-2 (1F), trap 4-1 (1F), trap 4-2 (1F, 1M), trap 4-3 (2F), trap 7-3 (1F, 2M), trap 13-2 (1F), trap 13-4 (1M), trap 13-6 (1F); 30-V-8-VI-92, trap 4-3 (2F), trap 7-2 (1F); 9-18-VI-92, trap 1-1 (1F), trap 1-2 (1F), trap 4-3 (1F), trap 4-4 (1F), trap 7-3 (1F), trap 7-5 (1F), trap 13-3 (1F); 19-28-VI-92, trap 1-3 (1F), trap 4-2 (2F), trap 4-3 (2F), trap 13-4 (1F); 29-VI-8-VII-92, trap 4-1 (3F), trap 4-3 (1F), trap 7-1 (1F), trap 13-4 (1F); 9-18-VII-92, trap 1-1 (1F), trap 4-1 (2F), trap 4-2 (1F), trap 7-1 (1F), trap 7-4 (1F), trap 13-3 (1F), trap 13-4 (1F); Cranberry Glades, 3-4-VI-55 (2F). Deposited with the holotype; Museum of Comparative Zoology; Florida State Collection of Arthropods; Snow Entomological Museum; and the Canadian National Collection, Ottawa.

Distribution.—This species is recorded from Maryland, Virginia, West Virginia, and North Carolina.

Etymology.—This species is named for Bernhard E. Fernow, a German-born forester who pioneered scientific forestry in the

United States (Anonymous 1987). The Fernow Experimental Forest, the type locality and area from which most of the type material was collected, was named in his honor.

Discussion.—*Tenthredo fernowi* is a slender species with very small pulvilli (similar to Fig. 4). The orange color of the second and third abdominal segments, white spot laterally on the clypeus of the female, and mostly orange legs is a color combination not known in other North American *Tenthredo*. The clypeus of the male may be mostly white, but lack of meshes of microsculpture on the head, mesepisternum, pectus, and mesonotal median lobe will aid in its separation.

Coloration is rather stable, but a few minor variations occur. The white area at the lower posterior portion of the mesepisternum may vary from a small spot to a stripe extending anteriorly for about half the length of the mesepisternum; the third abdominal segment may be all orange or slightly blackish posteriorly; the fourth sternite may be all black to mostly orange; and the lateral white spots on the clypeus may be large or small in the female and the clypeus mostly or all white sometimes with a medial blackish area in the male.

Based on Ross' (1951) classification, *T. fernowi* would belong in the *rufopecta* group. Ross created groups for the Nearctic species of the genus in the 1951 Hymenoptera Catalog, but, to our knowledge, did not characterize them elsewhere. A study in progress by the senior author based on numerous structures in both sexes does not support some of the species associated with the *rufopecta* group. *Tenthredo repleta* MacGillivray (type not studied yet) is, if correctly interpreted, a member of the *grandis* group (median lobe of mesoscutum clearly with microsculpture, mesepisternum densely punctate, antennal flagellum flattened and apical joints white), and *T. rurigena* is more closely allied to Ross' *secunda* or *semirufa* groups (metatibial spurs less sharp than me-

sotibial ones, male penis valve with ventro-apical short and straight spine). This leaves *T. rufopecta* and *T. mellicoxa* in the *rufopecta* group. In North America, the *rufopecta* group is nearest to species related to *T. grandis* (Norton) (not Ross' *grandis* group, excluding *T. colon* Klug) and *T. ruma* MacGillivray. However, the *rufopecta* group appears nearest to Euroasiatic lineages. The *rufopecta* group is characterized as follows: microsculpture lacking (no traces of meshes) on dorsal surface of head and mesonotal median lobe; pulvilli very small (length of pulvillus of first metatarsomere 0.15–0.20 length of second metatarsomere) and narrow (width of pulvillus on first metatarsomere about one-third that of second metatarsomere); at least tergites 6–10 completely or almost completely pubescent in female; penis valve without ventro-apical spine; metatibial spurs as sharp as those of mesotibia; antennal crest developed but low, hardly or not angularly produced between level of median ocellus and antennal socket; and at least mesotarsomeres 1–4 darkened on apical 0.20–0.40 (thus ringed with brown or black at apex).

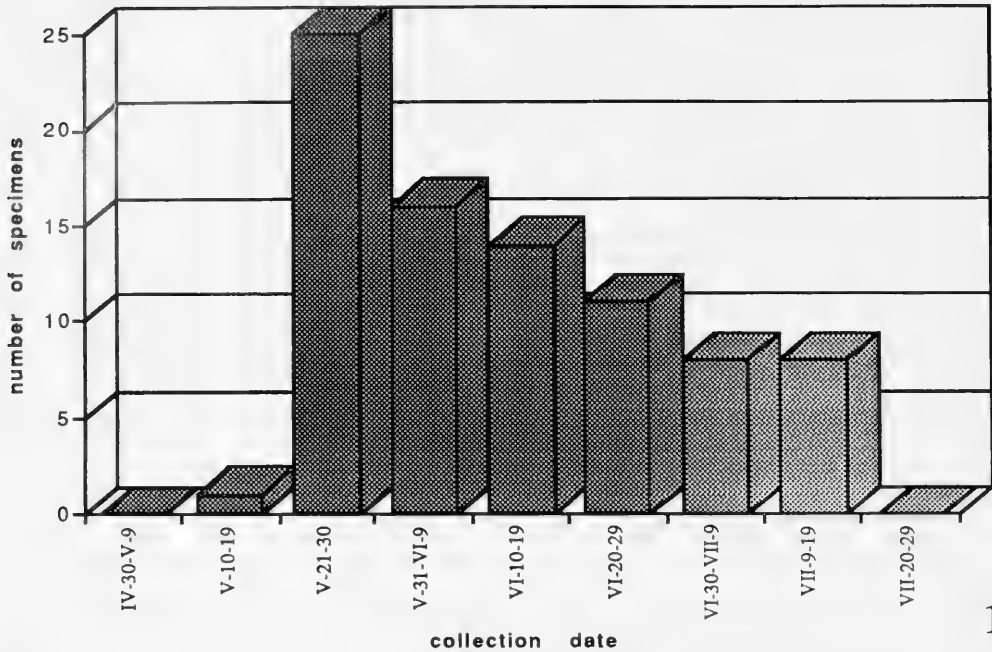
Except for color characters the above definition applies closely to some species in Eurasia such as *T. hilalis* Smith. In North America, the group as here defined consists of above three species and *T. nimbipennis*. Within this group, *T. fernowi* is nearest to *T. rufopecta*. Adults of *T. fernowi* share the following derived character states with *T. rufopecta*: first flagellomere barely longer than second; mesepisternum and pectus smooth (shared also with *T. nimbipennis*); clypeus with white spots sublaterally (shared also with *T. nimbipennis*); and complete lack of angular projection between antennal crest and level of median ocellus. Adults of *T. fernowi* are unusual in that the mesepisternal spine is hardly suggested and that the first metatarsomere of the male is not widened. In these two features, adults of *T. fernowi* match those of the Eurasian species, *T. hilalis*.

Ecology.—The host is unknown. Adults of this species have been recorded from sea level (Patuxent, Maryland) to 4200' (Great Smokies Mts. Natl. Park, N.C./Tenn.) in broadleaf forests. Flight is recorded from April 19 to July 18. Most specimens were collected from mid-May to mid-June and were still common until mid-July. Eighty-three specimens were taken in traps in the Fernow Experimental Forest in West Virginia in 1991 and 1992. This was the most commonly collected species of *Tenthredo* in the forest. The species appeared to be uniformly distributed throughout the study watersheds. Five of the specimens were taken from forest-edge traps. Traps in watershed 1 yielded 13 specimens; watershed 4, 30 specimens; watershed 7, 21 specimens; and watershed 13, 14 specimens. Among the traps within the watersheds, traps 1 yielded 18 specimens; traps 2, 15 specimens; traps 3, 27 specimens; traps 4, 16 specimens; and traps 5, 2 specimens. Adults appeared to be most common in the valleys and on the northerly-facing or shaded slopes. They were least common in the high traps on the south-facing slopes. Flight period for the two years combined was from May 10 to July 19 (Fig. 13). Most specimens were collected May 21–30 with numbers steadily decreasing to July.

Specimens collected at the University of Virginia Blandy Experimental Farm, Clarke Co., Va., were all from one trap which was within a dense 85-year-old, oak-elm-hickory woodlot. After three years of collecting in the same general area in other habitats, no additional specimens were obtained. Thus, this species appears to be associated with the dense broadleaf forests.

Dolerus (Achaetoprion) klokeorum
Goulet and Smith, NEW SPECIES
 (Fig. 14)

Diagnosis.—Females are distinguished from other Nearctic species of *Dolerus* by the following combination of character states: punctures of mesepisternum large (100–150 μm in diameter); mesonotum



13

Fig. 13. Flight period for *Tenthredo fernowi*, Fernow Experimental Forest, West Virginia, 1991–1992. Number of specimens captured per collection date.

black only on lateral lobes; abdomen and base of sheath (valvifer 1 and 2) completely orange; and wings uniformly lightly infuscated.

Female.—Length, 7.5–8.5 mm. Antenna, head, and mouthparts black. Thorax orange with mesosternum, lower $\frac{1}{4}$ – $\frac{1}{3}$ of mesepisternum, and most of mesonotal lateral lobes except posterior corners black. Abdomen orange with cercus black and apical segment (valvula 3) of sheath black laterally. Legs black. Wings moderately, uniformly infuscated; veins and stigma black.

Surface microsculpture generally lacking except on outer half of pectus, head (between punctures dorsally), side of tergites 7–9, last segment of sheath (valvula 3), coxae, and femora where flat sculpticells are outlined. Clypeal emargination deep, subequal to medial length of clypeus. Punctures on postocellar area on both sides of postocellar region as far as upper $\frac{1}{3}$ of gena densely punctate (a little less so near postocellar region) and about 80 μ m in diameter.

Punctures on mesepisternum large (100–150 μ m in diameter) and on pectus very small (20 μ m in diameter) and 30–80 μ m apart except on oblique furrow (about 50 μ m in diameter). Mesonotal lateral lobe without large punctures laterally. Mesoscutellar appendage about 175 μ m in length medially. Distance between cenchri about 1.3 \times width of a cenchrus. Setae of mesepisternum about 100 μ m in length. Cercus about 3 \times wider than long. Sheath in posterior view widely concave, in dorsal view with longest setae regularly curved, forming an angle of about 10°; ventral margin of last segment of sheath (valvula 3) regularly curved and forming an angle of about 45° with dorsal margin. Lanacet as in Fig. 14; annuli each with one small spine and without seta-like sculpticells; serrulae except basal two, each with 4 or 5 coarse posterior subbasal teeth.

Male.—Unknown.

Holotype.—Female, labeled “VIRGINIA: Louisa Co., 4 mi. S. Cuckoo, 12–25-IV-88, J. Kloke & D.R. Smith, Malaise trap.”

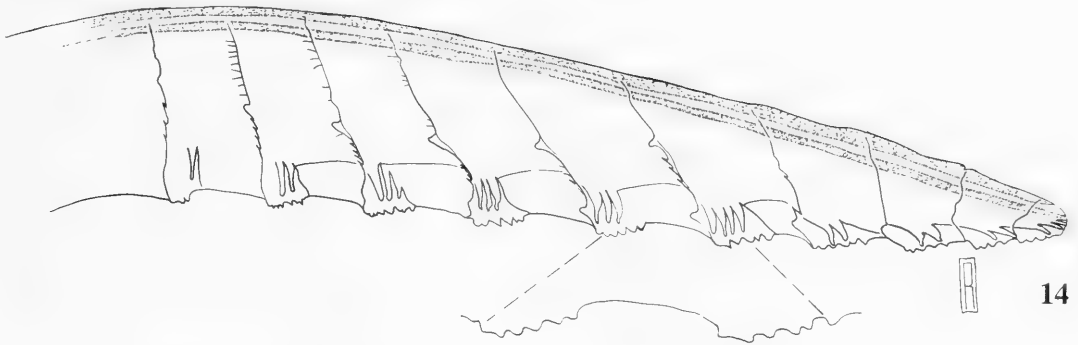


Fig. 14. Female lancet of *Dolerus klokeorum*.

Deposited in the National Museum of Natural History, Washington, D.C.

Paratypes (4 F).—U.S.A.: VIRGINIA: Same locality as holotype, 29-III-11-IV-88 (1F), 5-25-IV-89 (1F); Essex Co., 1 mi SE Dunnsville, 12-29-IV-91, David R. Smith, Malaise trap 10 (1F); Fairfax Co., Springfield, 29-IV-1973 (1F). Deposited with the holotype and in the Canadian National Collection, Ottawa.

Distribution.—Known only from Virginia.

Etymology.—This species is named for Jack and Beth Kloke, who have kindly allowed the junior author access to their properties in Virginia for field work.

Discussion.—Females of this species resemble those species of *Achaetoprion* with large punctures on mesepisternum (couplets 1-4 of Goulet's 1986 key), especially those of the *Dolerus abdominalis* (Norton) and *D. eurybis* Ross lineage defined by the following shared derived character states: clypeus deeply emarginate (shallowly emarginate in other *Achaetoprion* and most Dolerini) and punctures large on mesepisternum (small in other *Achaetoprion* except *D. versus* Norton). Females of *D. eurybis* are especially similar to *D. klokeorum* in color, but *D. eurybis* has the basal half of the wings deeply infuscated and the apical half hyaline; the longest setae of the sheath in dorsal view regularly curved and directed posteriorly (at about 10°); and broad, laterally projecting

winglike processes on the annuli of the apical half of the lancet. *Dolerus abdominalis* has the thorax entirely black, except sometimes the metapleuron, the sheath entirely black with apex convex, and broad, laterally projecting winglike processes on the annuli of the apical half of the lancet. Despite similarities of the above external character states with other species, there is a major difference in the ovipositor structure. In *D. klokeorum* each annulus of the lancet has a spurlike process, while in *D. eurybis* and *D. abdominalis* it consists of a winglike process on the apical annuli. If this very unusual winglike process on the apical annuli of the lancet is derived (see Goulet 1986, figures 47 and 321, notes on affinities, p. 88), then *D. abdominalis* and *D. eurybis* would not be closely related to *D. klokeorum* which has only a spurlike process on the annuli as in *D. nortoni* Ross, *D. mimus* Goulet, *D. tacoma* Goulet, and *D. neoagcistus* MacGillivray (see Goulet 1986, figures 310, 312, 314 and 317). The spurlike process represents an earlier stage leading to the evolution of the winglike process. The relationship of species with a spurlike process on the annuli is unresolved. It is unlikely that winglike processes of the type described in Goulet (1986) would evolve independently. Thus, the similarities in external characters noted above between *D. klokeorum* and *D. eurybis* and *D. abdominalis* may be convergent.

Ecology.—Specimens were from traps in lowlands next to streams or drainages, areas frequently flooded during heavy rainfall. Trap 10 in Essex Co. traversed a small intermittent stream in a woodlot; the stream bed was moist in early spring but dry most of the summer. This species may feed on grasses or sedges in such stream beds or other similar seepage areas. *Equisetum*, a common host for other groups of *Dolerus*, was not present in these habitats. The five females were collected from March 29 to April 29.

ACKNOWLEDGMENTS

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versity, Cambridge, Massachusetts; Florida State Collection of Arthropods, Gainesville, Florida; and the Snow Entomological Museum, University of Kansas, Lawrence. We thank the following for review of the manuscript: Edward M. Barrows, Georgetown University, Washington, D.C.; Gary A. P. Gibson, Biological Resources Division, Agriculture Canada, Ottawa; and Raymond J. Gagné and David A. Nickle, Systematic Entomology Laboratory, U.S.D.A., Washington, D.C.

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**MIRABILIS-FEEDING HELIODINES
(LEPIDOPTERA: HELIODINIDAE) IN CENTRAL ILLINOIS, WITH
DESCRIPTION OF A NEW SPECIES**

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Abstract.—We report finding in central Illinois an example of simultaneous, sympatric use of *Mirabilis nyctaginea* (Michx.) Sweet (Nyctaginaceae) by larvae of four species of Heliodinidae. The insects involved are *Heliodines tripunctella* Wlsm., *H. nyctaginella* Gibson, *H. ionis* Clarke, and an undescribed *Heliodines* species. We provide a description of the new moth and keys to adults of the four Illinois species.

Key Words: Heliodinidae, *Heliodines*, new species, Nyctaginaceae, *Mirabilis*

Members of the genus *Heliodines* are very small, primarily diurnal moths; most have golden-orange forewings adorned with raised patches of metallic lead-gray scales. The 22 described species are predominantly Nearctic or Neotropical, the exceptions being single European and Australian representatives. Larval host plants have been published for five species: *Heliodines roesella* (L.) on Chenopodiaceae (e.g. Stainton 1854, Emmet 1985); *Heliodines quinqueguttata* Walsingham (1897) on Portulacaceae; *Heliodines extraneella* Walsingham (1881) on Onagraceae (Braun 1925); and two species, *Heliodines nyctaginella* Gibson (1914) and *Heliodines ionis* Clarke (1952), on Nyctaginaceae.

Heppner and Duckworth (1983) listed 11 North American species of *Heliodines* north of Mexico, and Hodges (1983) noted that the moths are seldom collected, probably because they are diurnal. A documented characteristic of heliodinid larval biology is the occurrence of more than one species in close proximity to each other (Wester 1956), sometimes with larvae feeding simultaneously on the same individual plant. We

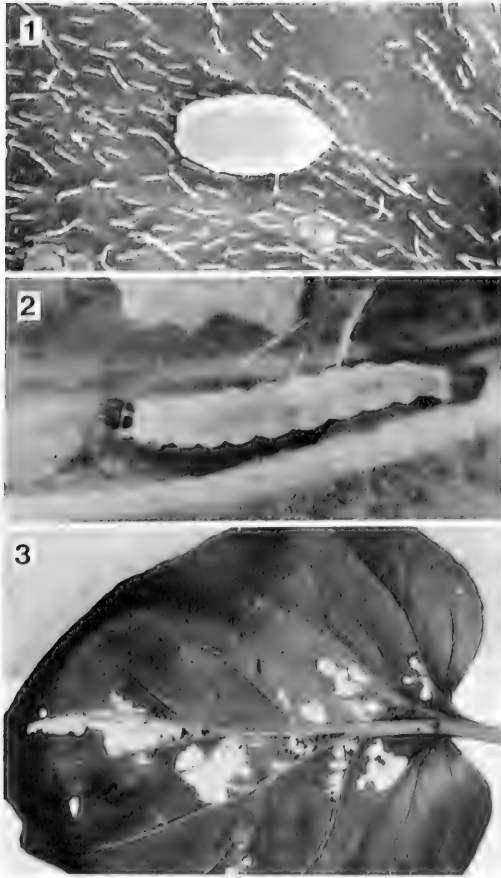
report finding in central Illinois a striking example of sympatric, simultaneous use of *Mirabilis nyctaginea* (Michx.) Sweet (Nyctaginaceae) by four heliodinid species: *Heliodines tripunctella* Walsingham (1892), a leaf miner; *H. nyctaginella*, a flower feeder and upperside leaf skeletonizer; *H. ionis*, a stem borer; and an undescribed *Heliodines* species (underside leaf skeletonizer). As a preliminary step in our study of this insect-plant interaction, we provide a description of the new moth and keys for identifying adults of the four Illinois species.

Heliodines cliffordi

Harrison & Passoa, NEW SPECIES

(Figs. 1–3, 6–8, 12–13, 16)

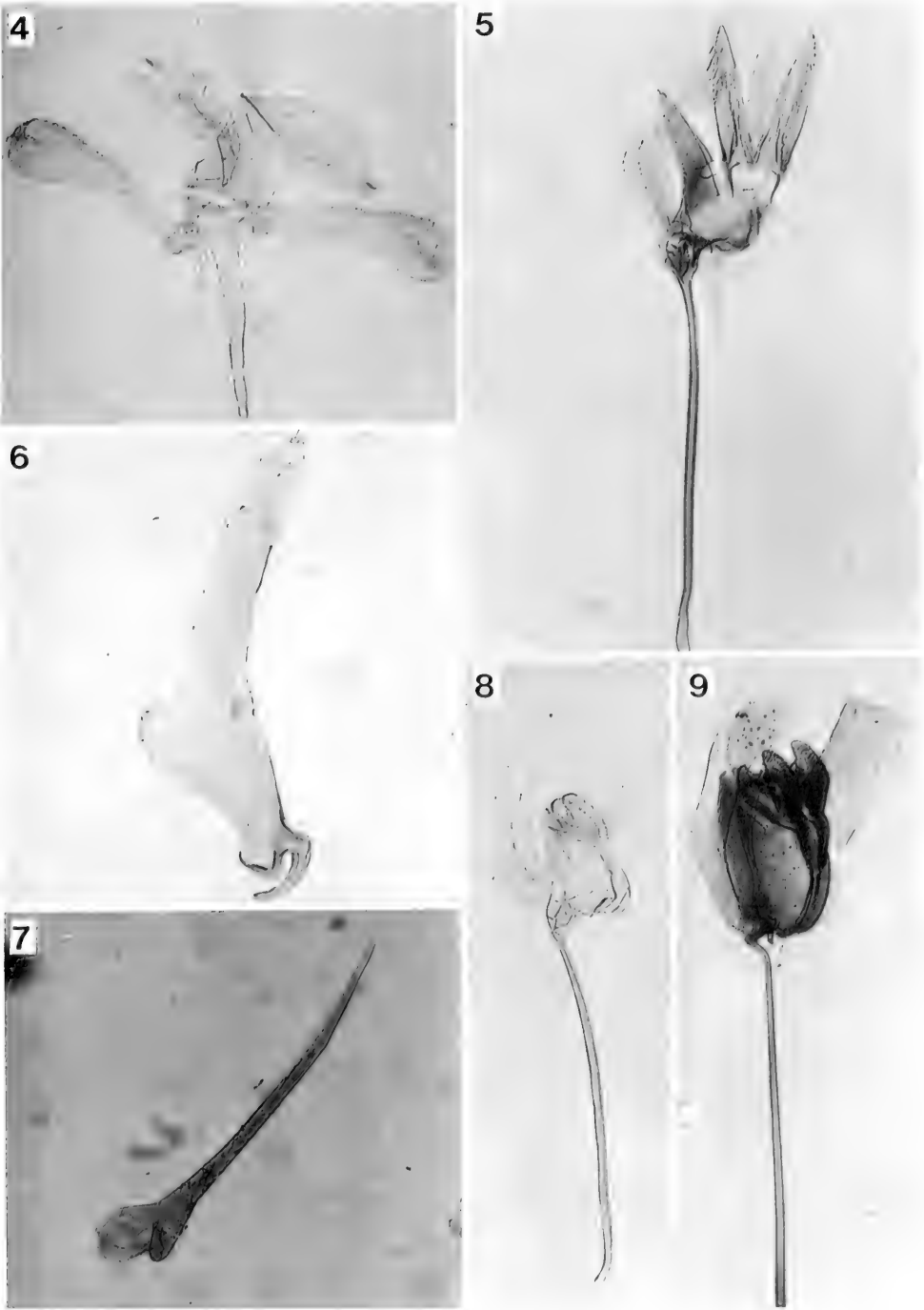
Ovum (Fig. 1): Whitish, somewhat flattened. Laid on the underside of a leaf. After hatching, the larva does not eat the remains of the egg. *Larva* (Fig. 2): On *Mirabilis nyctaginea* in Illinois; also known from *Mirabilis longiflora* L. in Arizona (our comments refer to Illinois specimens). One to several larvae on a single leaf, usually on the lower leaves of the plant. There are four larval instars. Upon hatching, the larva moves a



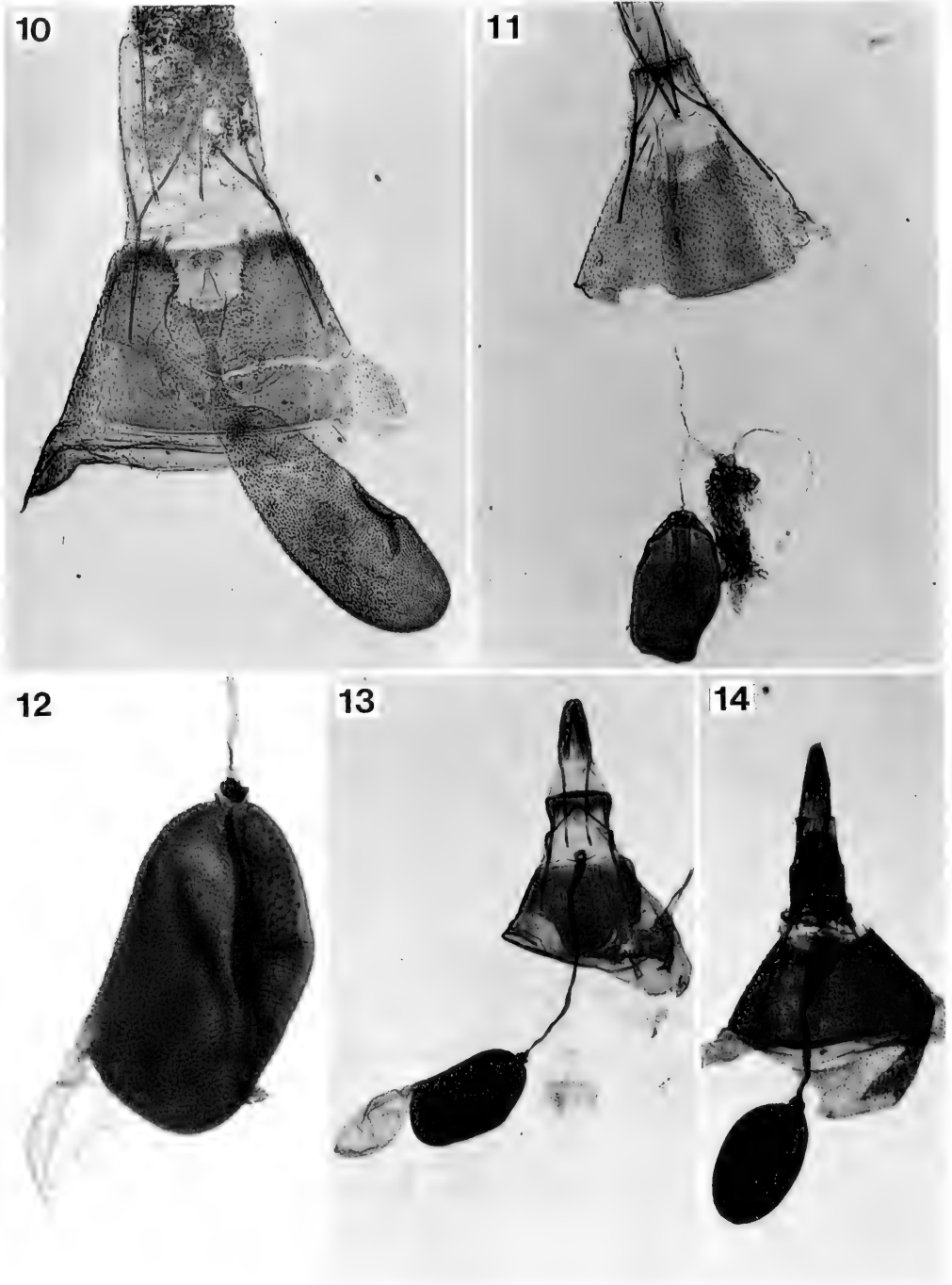
Figs. 1–3. *Heliodines cliffordi*. 1, Ovum. 2, Mature larva. 3, Larval damage to *Mirabilis nyctaginea*, with several larvae on underside of leaf.

small distance from the remains of its egg and burrows into the leaf. First two instars spent as a leaf miner, third and fourth instars as a leaf skeletonizer, feeding beneath a flat sheet of fine white silk on the underside of the leaf, eating all but the upper epidermis in an irregular blotch pattern (rarely, feeding on upperside of leaf). The “window” of damage (Fig. 3) is conspicuously visible on the upper surface of the leaf. Frass is deposited outside the feeding area and persistently adheres to the external surface of the silken sheet. General color of mature larva pale green, with no contrasting pinacula or other external markings; cuticle translucent, the aorta faintly visible as a dark dorsal

midline; head blackish brown throughout larval life; prothoracic shield concolorous with body during first three instars, blackish brown and divided longitudinally at the midline during fourth instar. A single SV seta on segment A9 in all instars. *Pupa*: Object; flattened dorsally, keeled laterally. No dorsal transverse rows of spines. No cocoon, pupation occurring among a slight, loose mass of silk from which the pupa is not protruded at eclosion. *Adult* (male and female): *Head*: Labial palpus: First and second segments dull yellow, the second slightly darker dorsally toward apex; third segment dull yellow suffused with light brownish gray. Antenna: Shining dark gray with violet reflections; apical five segments white. Face and head capsule: Smoothly scaled, shining gray; reflections brassy, greenish, or violet with differing angles of incident light; ocellus large and prominent; occipital scale band contrastingly dull yellow. *Thorax*: Shining gray as for head. Forewing: Length 4.5–5.0 mm. Ground color bright golden orange. Five costal, raised, metallic lead-gray spots, designated C1 (basal) to C5 (apical), at approximately 0.07, 0.19, 0.35, 0.50, and 0.67 (numbers represent respective average distances from wing base to centers of spots, expressed as percentages of total wing length, $n = 5$); spots C2 and C3 extend farther toward posterior margin of wing than do the other costal spots; C5 appearing triangular due to a shining-gray patch that narrows as it extends along costa from apical edge of the spot. Three dorsal, raised, metallic lead-gray spots, designated D1 (basal) to D3 (apical), at approximately 0.27, 0.44, and 0.60; D1 and D3 extend farther toward costal margin of wing than does D2. Anterior margin from wing base to spot C2, and posterior margin from wing base to D1, broadly margined with black; between these anterior and posterior areas, a discal, longitudinally oriented, yellowish-orange patch extends from near wing base to a point between C2 and D1, where it blends into the golden-orange



Figs. 4-9. Male genitalia. 4, *Heliodines tripunctella* (ventral aspect, spread and flattened, aedeagus removed). 5, *H. nyctaginella* (lateral aspect, aedeagus removed). 6, *H. cliffordi*, valve (lateral aspect). 7, *H. cliffordi*, aedeagus (lateral aspect). 8, *H. cliffordi* (lateral aspect, aedeagus removed). 9, *H. ionis* (lateral aspect, aedeagus removed).



Figs. 10-14. Female genitalia. 10, *Helioidines tripunctella* (ventral aspect). 11, *H. ionis* (ventral aspect). 12, *H. cliffordi*, detail of signum. 13, *H. cliffordi* (ventral aspect). 14, *H. nyctaginella* (ventral aspect).

ground; amount of black between spots C2 and C3 variable, always with at least a wide black anterior margin but in some specimens filled with black to the height of the two spots. Other spots margined with black to a varying degree, in most specimens at least finely so. Orange area extending farther apically on anterior margin than on posterior; costoapical extremity of orange area often with a small yellowish-orange patch. Wing distad of orange area very dark shining gray, with one small black patch in basal region of this area near costa and one from apical margin of spot D3. A discal, metallic lead-gray spot, rather small and only slightly raised, at approximately 0.77; the apical half of this spot lies in the outer gray area of the wing, the basal half interrupts the distal edge of the orange area. Fringe dark gray. All veins separate, including R_4 and R_5 . Hindwing: Length 4.0–4.5 mm. Lanceolate, very dark gray; fringe dark gray. R_s and M_1 separate, CuA_1 and CuA_2 present; remnants of two anal veins persistent. Legs: Foreleg with coxa shining gray, cream colored at apex; femur shining gray on outer surface from body, cream colored on inner; tibia shining gray laterally, cream colored medially; tarsus shining gray. Midleg colored as foreleg but tibia ringed with cream color at apex. Hindleg colored as midleg but apex of femur cream colored, and tibia with two dark-gray bands, one from tibial base to first pair of spurs, the other from two-thirds tibial length to edge of apical cream-colored band; spurs shining gray on outer surfaces from tibia, cream colored on inner; tibia smooth, not spined or otherwise modified. *Abdomen*: Shining gray, somewhat darker than thorax. *Genitalia*: As illustrated and described below in the key.

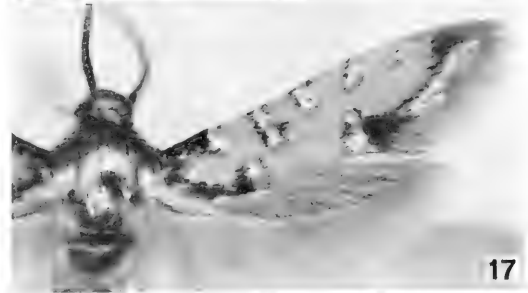
Volitinism: Probably four complete generations per year; mature larvae appear in central Illinois from late May to mid-June, again from mid- to late July, and at all times from early August through mid-September. Generations become asynchronous so that by August and afterward larvae of all instars



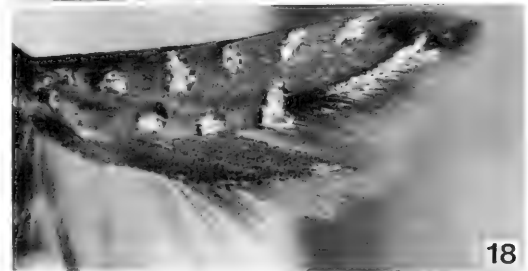
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17



18

Figs. 15–18. Wings of adult moths. 15, *Helioidines tripunctella*. 16, *H. cliffordi*. 17, *H. nyctaginella*. 18, *H. ionis*.

can be found at once. Viable pupae from mature larvae collected 17 September 1993 had not produced adults by mid-November 1993; this suggests that the insect overwinters as a pupa.

Distribution: In addition to the type lo-

cality, Charleston, Coles County, Illinois, this species is represented by specimens from Putnam, Mason, and Champaign counties in Illinois [in the collection of the Illinois Natural History Survey, Champaign (INHS)]; and from the states of New Mexico (INHS), Iowa, Kansas [in the collection of the United States National Museum of Natural History, Washington, D.C. (USNM)], and Arizona (reared from *Mirabilis longiflora* by R. Wielgus; in the collection of D. Wagner, Storrs, Connecticut). Data for all Illinois specimens are entered into the Illinois State Lepidoptera Data Base, Springfield.

Holotype male: Collected as larva on *Mirabilis nyctaginea*, USA: Illinois, Coles County, Charleston, T12N, R9E, NW ¼ Sec. 11, 14-VI-1992, T. Harrison. Iss. 30-VI-1992 (USNM). *Allotype female*: Same data as for holotype except collected 8-VI-1990, iss. 22-VI-1990 (USNM). *Paratypes*: Deposited in the following collections: USNM; INHS; Illinois State Museum, Springfield; collection of S. Passoa, Reynoldsburg, Ohio; University of California, Berkeley; Cornell University, Ithaca, New York; American Museum of Natural History, New York, New York; Florida State Collection of Arthropods, Gainesville; Academy of Natural Sciences, Philadelphia, Pennsylvania; Canadian National Collection, Ottawa; The Natural History Museum, London, England.

Etymology: This species is named for the senior author's son, Clifford R. Harrison.

Discussion: *Heliodines cliffordi* is similar to *H. nyctaginea* and *H. ionis* but displays darker and more extensive gray and black scaling than do those two species. The wing venation is the same among the three. Genitalia differ as specified below in the key. In all three species, there is one SV seta on larval segment A9. There are four larval instars in *H. cliffordi*, in contrast to five instars in *H. nyctaginea* and non-overwintering *H. ionis*, and six instars in overwintering *H. ionis* (Wester 1956). *Heliodines*

tripunctella differs from *H. nyctaginea*, *H. ionis*, and *H. cliffordi* in that veins R₄ and R₅ in the forewing and Rs and M₁ in the hindwing are stalked; CuA₂ is absent in the hindwing; and there are two SV setae on larval segment A9. Other characters that distinguish *H. tripunctella* from the other three Illinois species are mentioned in the keys.

For field identification of mature larvae of the two leaf-skeletonizing species, *H. cliffordi* is pale green with a blackish-brown head and is found on the underside of the leaf, while *H. nyctaginea* is deep reddish brown with a tan head, and it skeletonizes the upper surface of the leaf. As for mature larvae of the other two Illinois species, *H. ionis* is yellowish white and is a stem borer; *H. tripunctella* is dull green with dark thoracic markings and is a leaf miner throughout larval life.

KEY TO ADULTS OF ILLINOIS
MIRABILIS-FEEDING *HELIODINES*,
BASED ON GENITALIA

- | | |
|---|---------------------|
| 1. Males | 2 |
| 1'. Females | 5 |
| 2. Each lobe of socius bifid; saccus and aedeagus relatively short, saccus less than three times as long as tegumen (Fig. 4) | <i>tripunctella</i> |
| 2'. Each lobe of socius single, not bifid; saccus and aedeagus relatively elongate, saccus greater than three times as long as tegumen | 3 |
| 3. Each lobe of socius at least five times as long as its maximum width, acuminate apically; tegumen small (Fig. 5) | <i>nyctaginea</i> |
| 3'. Each lobe of socius much less than five times as long as wide, bluntly rounded apically; tegumen large | 4 |
| 4. Valve composed of broad, triangular basal region and narrow, slightly curved apical region (Figs. 6, 8) | <i>cliffordi</i> |
| 4'. Valve rather uniformly narrow along entire length, expanding slightly in width from base to apex (Fig. 9) | <i>ionis</i> |
| 5. Ductus bursae much less than 20 times as long as wide, its junction with corpus bursae occurring posteriorly of anterior margin of segment A7; signum a uniformly sclerotized patch with one inwardly protruding spinelike process (Fig. 10) | <i>tripunctella</i> |
| 5'. Ductus bursae at least 20 times as long as its | |

- width at narrowest point, its junction with corpus bursae occurring well anterior of anterior margin of segment A7; signum not as above . . . 6
- 6. Signum divided into two sclerotized plates that lie on opposite surfaces of corpus bursae; ductus seminalis arising from ductus bursae, at a point posterior of corpus bursae (Fig. 11) . . . *ionis*
- 6'. Signum a single elongate-rhomboid plate lying lengthwise along side of corpus bursae (Fig. 12); ductus seminalis and ductus bursae originating very near each other, both from posterior end of corpus bursae 7
- 7. Ductus bursae uniformly narrow from ostium to corpus bursae; a prominent accessory corpus bursae arising from near anterior end of corpus bursae (Fig. 13) *cliffordi*
- 7'. Ductus bursae widened near ostium (Fig. 14); no accessory corpus bursae *nyctaginella*

- (Fig. 17); occipital scale band shining gray, concolorous with head and thorax; antennae white tipped *nyctaginella*
- 3'. Posterior margin of forewing not lined with black at base (Fig. 18); occipital scale band black, contrasting with head and thorax; antennae entirely dark *ionis*

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KEY TO ADULTS OF ILLINOIS
MIRABILIS-FEEDING *HELIODINES*,
 BASED ON EXTERNAL CHARACTERS

- 1. Dorsum of abdomen predominantly orange; at rest, living moth with metathoracic legs held elevated above body; forewing with a nearly uniformly wide, shining-gray border extending unbroken around wing margin from distal edge of spot C2 to a point slightly distad of spot D1; each forewing with three costal and one dorsal raised, lead-gray spots (Fig. 15) *tripunctella*
- 1'. Dorsum of abdomen dark gray or black, not orange; metathoracic legs not held elevated; no continuous shining-gray border around margin of forewing; forewing always with more than four lead-gray spots 2
- 2. Occipital scale band dull yellow, contrasting with shining-gray head and thorax; forewing with five costal, raised, lead-gray spots; distal margin of orange area of forewing interrupted by discal lead-gray spot; anterior margin of forewing from base to spot C2 and posterior margin from base to spot D1 broadly margined with black, the discal longitudinal patch between these black areas yellowish orange (Fig. 16) *cliffordi*
- 2'. Occipital scale band concolorous with thorax or contrastingly black; six costal, lead-gray spots on forewing; no discal lead-gray spot, distal margin of orange area on forewing an unbroken curve; basal area of forewing narrowly or not at all margined with black; orange ground unicolorous, no contrastingly yellowish areas
- 3. Posterior margin of forewing distinctly lined with black from base to basal edge of spot D1

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**ATACTOCORIS PERNERI, N. SP., A NEW APTEROUS CARVENTINAE
FROM JAMAICA (HETEROPTERA: ARADIDAE)**

ERNST HEISS

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Abstract.—The first record of the monobasic genus *Atactocoris* since its description 30 years ago is reported and the new species *A. perneri*, is described. A habitus of both sexes and the male genital structures of *A. perneri* are figured. Additional data are given for the female holotype and only known specimen of the type species, *A. farri* Kormilev, 1964.

Key Words: Heteroptera, Aradidae, Carventinae, *Atactocoris*, new species, Jamaica

The genus *Atactocoris* was created by Kormilev (1964) to contain the species, *A. farri* Kormilev from Jamaica. The description was based on a single female and no further specimens have been reported since. I have recently had the opportunity to collect additional material that proved to belong to a new species which is described and figured below.

The holotype of *A. farri*, preserved in the collection of the Institute of Jamaica in Kingston is redescribed.

Measurements are given in millimeters.

***Atactocoris perneri* Heiss**

NEW SPECIES

Figs. 1-5, 7-12

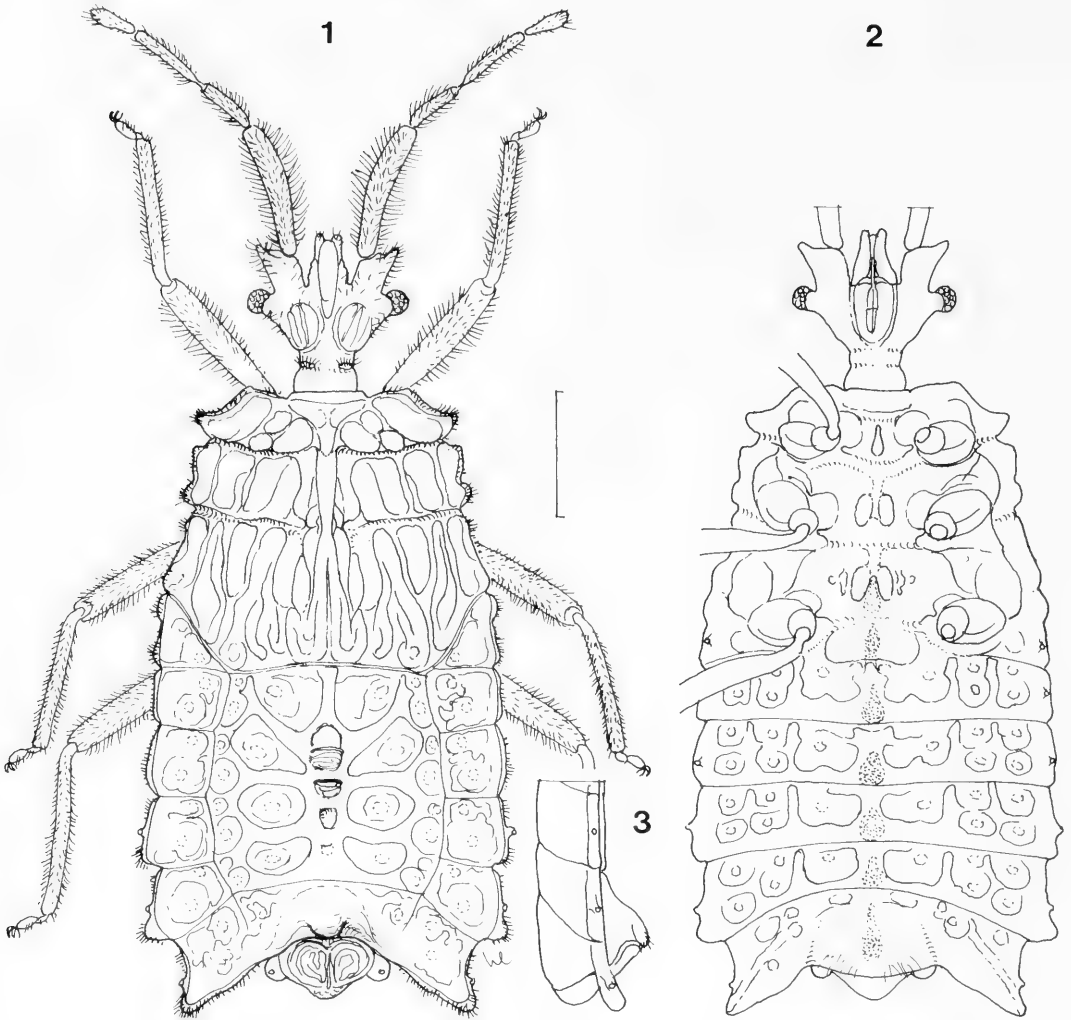
Diagnosis: Distinguished from the only known species of this genus, *A. farri*, by smaller size, shorter antennae and antennal segment I distinctly shorter than width of head across eyes (longer in *A. farri*). In the female it is further separated by shorter posterolateral projections of tergite VII (Figs. 4, 6).

Description: Male. Apterous; body elongate, smooth and shiny beneath incrustation that usually conceals the taxonomically

important cuticular structures. Head, antennal segments I to III, and legs with long erect bristles, lateral borders of body beset with shorter ones which are partly present also on dorsal and ventral surface.

Head.—Wider than long (1.31:1.15) (length measured from apex of genae to transverse furrow delimiting the vertex posteriorly); anterior process of genae slightly produced over clypeus, its apex rounded. Antenniferous tubercles cylindrical with pointed anterolateral process. Eyes small, stalked. Postocular portion of head strongly converging; neck with 2 (1 + 1) transverse bladelike elevations that bear a tuft of long bristles. Vertex with a median elevation that is separated by deep curved sulci from rugose lateral portions. Antennae about twice as long as width of head across eyes (2.70:1.39), relative length of antennal segments I:II:III:IV = 1.15:0.45:0.72:0.37. Antennal segment I distinctly shorter than width of head (1.15:1.31 = 0.88). Rostrum short, not reaching closed elevated border of wide rostral groove, rostral atrium slitlike.

Thorax.—Pronotum about 4.5 × as wide as long with an ill defined collar. Lateral margins sinuate, thickened, elevated and



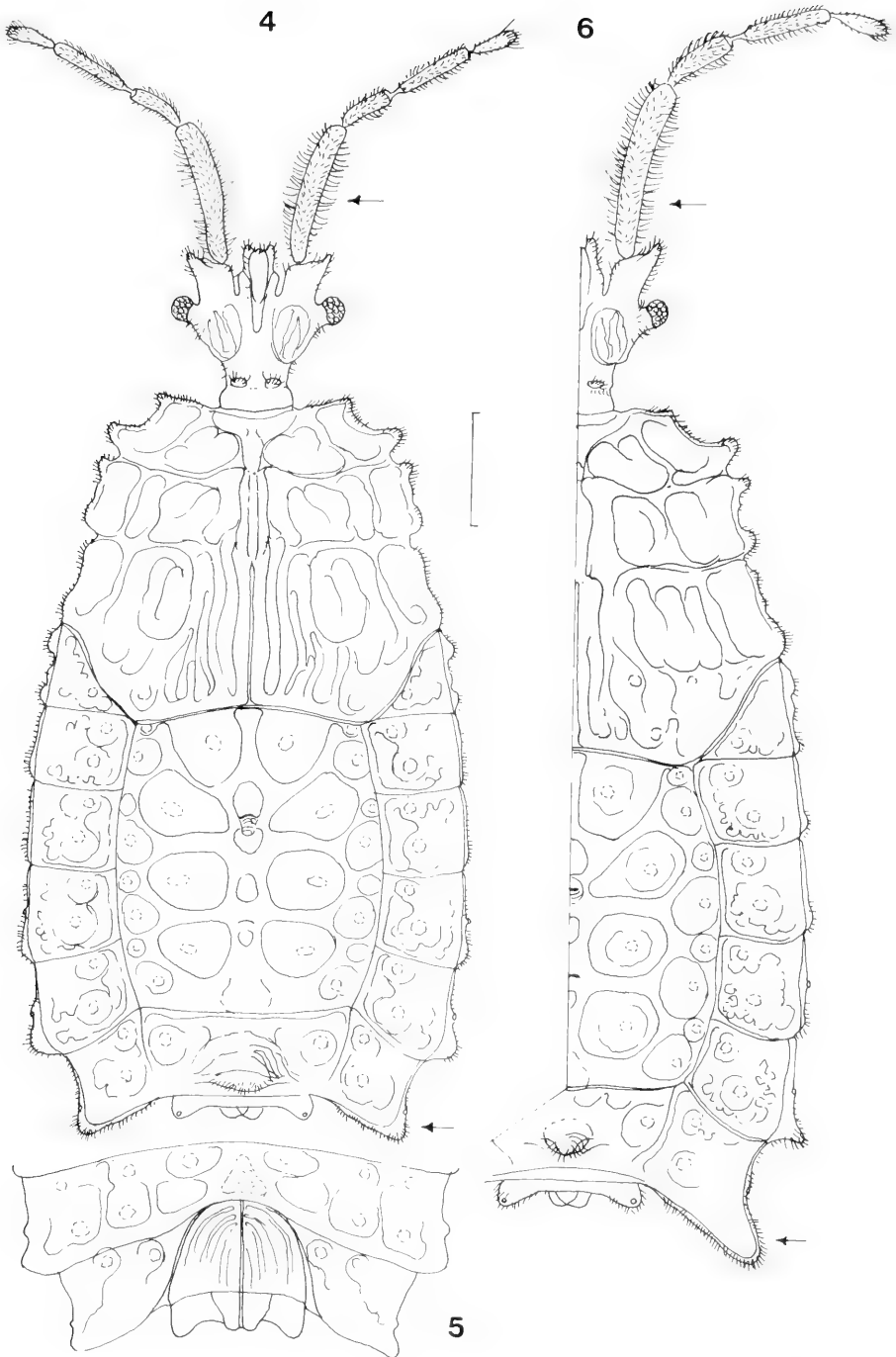
Figs. 1-3. *Atactocoris perneri*, n. sp., holotype male. 1, dorsal view; 2, ventral view, pilosity omitted; 3, lateral view of terminal segments. Scale 1 mm.

granular, posterolaterally produced and converging to angular anterolateral corners. Disc with smooth oblique elevations separated by deep furrows, medially with a small longitudinal ridge that is narrowed anteriorly and transversely depressed marking the posterior limit of pronotum.

Metanotum wider than pronotum with sinuate lateral margins that are also projecting, thickened and elevated. Separated from pronotum and metanotum by deep transverse furrows laterad of median ridge

that extends posteriorly over fused metanotum and tergites I + II. Disc with smooth longitudinal elevations, deeply excavated laterad of the median ridge.

Metanotum wider than mesonotum, completely fused with tergites I + II, its lateral margins similar to those of mesonotum, converging anteriorly. Fused median ridge enlarging posteriorly where it is incised. Disc with irregular smooth longitudinal ridges that show a certain variability within the examined type series as well as



Figs. 4-6. 4, 5. *Atactocoris perneri*, n. sp., female; 4, dorsal view; 5, ventral view of terminal segments. 6. *Atactocoris farri*, holotype female dorsal view. Arrows indicate distinguishing characters. Scale 1 mm.

the position and extension of the sulcus of the median ridge that may reach the line of the anterior border of metanotum.

Abdomen.—Tergal plate formed by fused mediotergites III to VI with deep depressed glabrous areas and a flat median ridge bearing the dorsal abdominal scent gland openings and smaller depressions of different size. Mediotergites and dorsal laterotergites (Dltg) separated from each other and from thorax by a suture. Surface of Dltg II to VII rugose with deep apodemal impressions, their lateral margin is formed by the reflexed ventral laterotergites which are partly projecting. Dltg I + II separated by a suture. Dltg VII raised medially for the reception of the pygophore, paratergites VIII small, rounded.

Ventral side.—Pro-, meso-, and metasternum and sternites I + II fused but marked by deep transverse furrows. Prosternum with a deep median impression; mesosternum medially with paired deep impressions, the ridge between is partly lowered; metasternum shows similar pits as mesosternum with additional rugosities laterad of them. Sternite III only medially fused to I + II, IV to VII completely separated. Surface of sternites III to VII shiny, deeply excavated around apodemal impressions with a mat median subtriangular area that is also present on fused medioternites (Mst) I + II, Mst VII (in male) and metasternum. Spiracles II to IV ventral, close to margin, V to VII lateral and visible from above, VIII terminal.

Male genitalic structures (Figs. 7–12).—Pygophore with a median dorsal sulcus flanked by irregular curved ridges covering the exposed part. Upper margin formed by an elevated curved ridge that bears long setae. Parameres long and slender, bladefike, projecting from dorsal opening at rest.

Legs long and slender, trochanters fused with femora, claws with thin curved pulvilli.

Female.—Similar to male but larger and abdomen more rounded laterally. Dltg VII medially with an elevated transverse ridge bearing dense pilosity. Paratergites VIII

short and rounded, reaching apex of tergite IX.

Coloration.—Uniformly dark brown, appendages yellowish brown.

Holotype.—Male, Jamaica, Portland, Fern Hill near Frenchman Cove, in rain forest under bark of rotten log 1.3.1993 leg. F. Perner and E. Heiss. The holotype is presented to the Tiroler Landesmuseum Innsbruck and deposited as permanent loan in the collection of the author.

Paratypes.—24 males and 6 females collected with holotype. 2 males and 2 females are from Jamaica, Portland, Sherwood forest near Dragon Bay on dead log of Akee tree (*Blighia sapida* König, Sapindaceae) 24.2.1993 leg. E. Heiss. Paratypes also will be deposited at National Museum of Natural History, Washington, D.C., and Institute of Jamaica, Kingston, and the collection of E. Heiss.

Measurements.—Holotype male: Length 6.3 mm; thorax length 2.2 mm; max. width of pronotum 2.1 mm, mesonotum 2.3 mm, metanotum 2.65 mm. Width of abdomen across tergite V 3.0 mm, VI 2.9 mm, VII 2.35 mm. Ratio length of antennae/width of head across eyes 2.05, ratio antennal segment I/width of head 0.88. Male paratypes range in size from 6.2–6.6 mm, females from 7.6–8.2 mm.

Etymology.—Named in honour of my friend F. Perner on the occasion of his 60th birthday and in recognition of his efforts and enthusiasm when searching for apterous Aradidae.

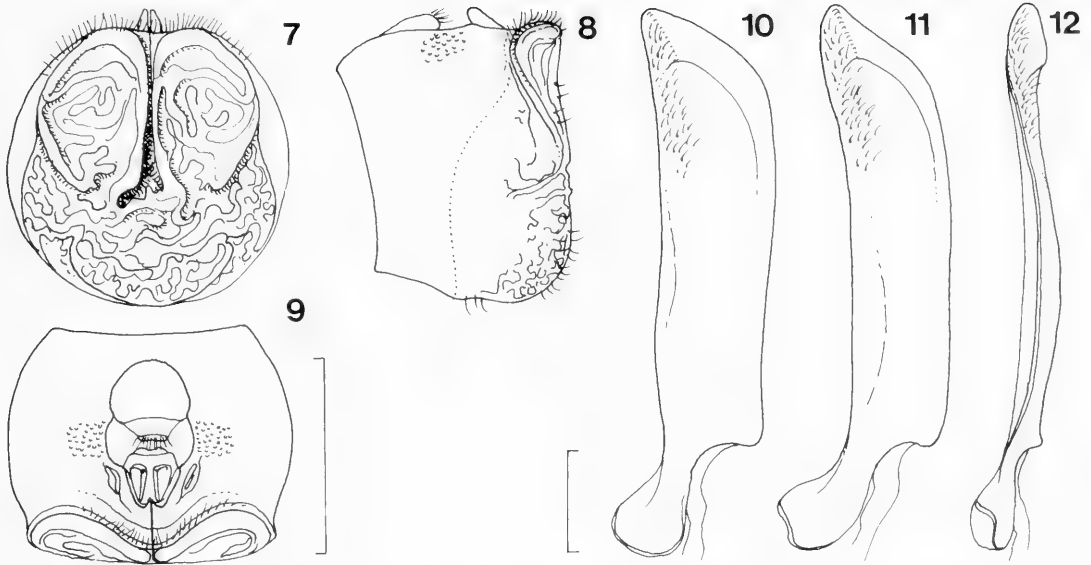
Atactocoris farri Kormilev

Fig. 6

Atactocoris farri Kormilev 1964:115.

The female holotype has been cleaned from incrustation for comparison of cuticular structures with those found in *A. perneri*, n. sp. As the description given by Kormilev is sufficient, only some additional information is given.

The characteristic depressions on pro-, meso- and metasternum are also present and



Figs. 7–12. *Atactocoris perneri*, n. sp., male genital structures; 7, pygophore caudal view; 8, lateral view; 9, dorsal view. 10–12, left paramere in different positions. Scale Figs. 7–9, 0.5 mm, 10–12, 0.1 mm.

might be of generic importance, as a different extension and position of such pits were observed in other apterous Carventinae genera. Contrary to the description and figure 4 given by Kormilev (1964) there are no postocular tubercles present.

Measurements of the cleaned specimen.—Length 9.1 mm; thorax length 2.95 mm, width of pronotum 2.92 mm, mesonotum 3.3 mm, metanotum 3.85 mm; width of abdomen across tergite V 4.2 mm, VI 4.05 mm, VII 3.45 mm. Head width/length 63/56, antennal segments I:II:III:IV = 67:28:39:19. Ratio length of antennae/width of head 2.43, antennal segment I/width of head 1.06.

Discussion: From the Neotropical Region 27 genera of Carventinae are known, of which 24 are apterous. Kormilev and Van Doesburg (1977) provided a key for the then known 11 apterous genera (12 catalogued by Kormilev and Froeschner 1987), which was also the basis for a new key given by Grillo Ravelo (1988) where he included his 12 new genera from Cuba.

The genus *Apterocoris* belongs to a group of three genera characterized by closed labial atrium, tergites I + II fused with metanotum and Dltg II + III separated by a suture, including also *Peggicoris* Drake (1956) and *Rhysocoris* Usinger and Matsuda (1959).

Peggicoris is distinguished by its uninterrupted median longitudinal ridge, which extends from pronotum to anterior margin of abdominal disk; *Rhysocoris* by narrow and long head without stalked eyes and the position of spiracles which are all lateral and visible from above. The 12 genera described from Cuba by Grillo Ravelo are difficult to recognize without respective illustrations and belong to another group of genera with fused Dltg II + III.

ACKNOWLEDGMENTS

Special thanks are due to Mr. T. Farr, Kingston, Jamaica, for the loan of Aradidae under his care and Mr. Fred Perner, Innsbruck, for his able assistance during our collecting trip to Jamaica.

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SYSTEMATIC NOTES ON SOME SRI LANKAN SCOLIIDAE
(HYMENOPTERA: ACULEATA)

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Abstract.—*Campsomeriella litoralis* Krombein, new species, is described from both sexes, *Scolia (Discolia) lankensis* Krombein, new species, is described from a male, and the previously unknown female of *Scolia (Discolia) gunawardaneae* Krombein is also described. Distributional and systematic notes are added for 20 other species obtained since the family was revised in 1978.

Key Words: Wasps, Scoliidae, Sri Lanka, systematics, distribution

A revision of 25 taxa of Ceylonese Scoliidæ (Krombein 1978) was based on specimens collected during the Smithsonian's "Ceylon Insect Project," 1969-1976, augmented by material borrowed from other collections. Additional specimens were collected from 1977 to 1981 by teams that included a specialist from the United States and two or more Sri Lankan technicians. Personnel who participated during this last 5-year period of the Smithsonian's "Ceylon Insect Project" were as follows in alphabetical order: D. W. Balasooriya, P. Fernando, T. Gunawardane, V. Gunawardane, M. D. Hubbard, M. Jayaweera, L. Jayawickrama, P. B. Karunaratne, S. Karunaratne, M. Kosztarab, K. V. Krombein, P. A. Panawatta, P. Leonage, S. Siriwardane, L. Weeratunge, N. V. T. A. Weragoda, and T. Wijesinhe. Two specimens are also included from my recent field work in Sri Lanka during 1993.

Two new species and the previously unknown female of another species were collected. Descriptions of these are followed by new distributional data and a few systematic notes on other species arranged in the systematic sequence used in my revision.

The abbreviations T 1-7 and S 1-7 are used in the descriptions to denote abdominal terga and sterna 1-7.

***Campsomeriella litoralis* Krombein,**

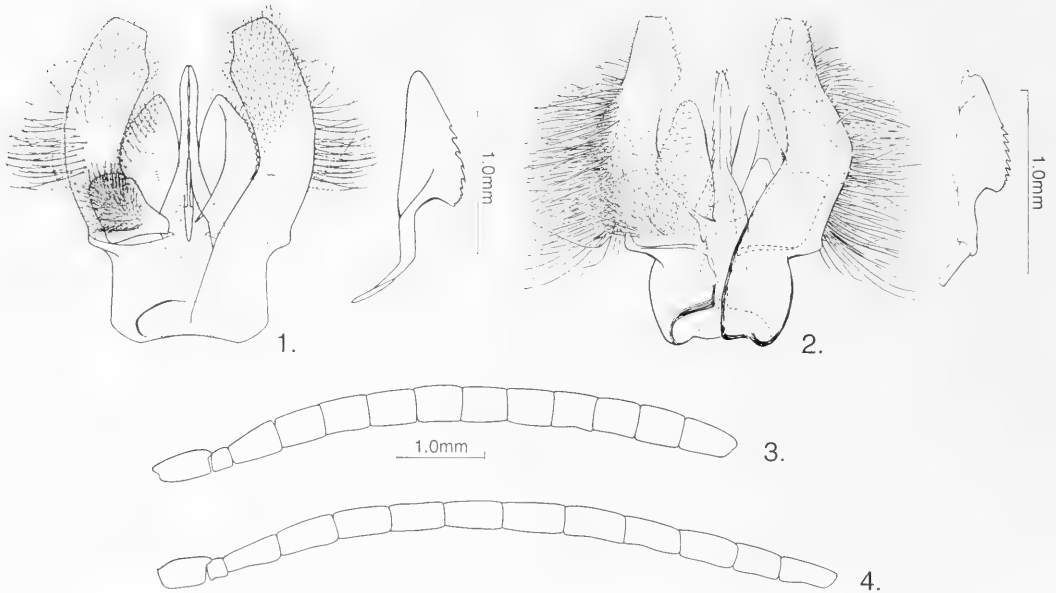
NEW SPECIES

Figs. 1, 3, 5

Campsomeriella collaris collaris Betrem. Krombein, 1978, in part: 18-19 (Ja-Ela specimens only).

Etymology.—From the Latin *litoralis*, of the seashore.

Male.—Length 14.0 mm, forewing 11.5 mm. Black, the following pale yellow: narrow streak on basal two-thirds of outer mandibular surface, clypeus except narrowly at apex and a spot on basal two-thirds, narrow at upper end and expanding into a quadrate spot in middle, small narrow streak along lower inner eye orbit, pronotum with a narrow apical streak interrupted for a short distance toward scapula and a narrow streak adjacent to propleuron, small anterior spot on tegula, tiny anterolateral spot on scutellum, streak posteriorly on apical half of fore- and midfemora and on most of hindfemur, outer surface of tibiae except apices, outer surface of forebasitarsus, broad band cov-



Figs. 1-4. 1-3, *Campsomeriella* species. 1, *C. litoralis*, n. sp., genitalia, ventral aspect at left, dorsal aspect in middle, aedeagus, lateral aspect at right; 2, *C. c. collaris* (Fabricius), genitalia, oriented as in 1 (Krombein 1978: fig. 15, by M. C. Druckenbrod); 3, *C. litoralis*, n. sp., antenna, lateral aspect. 4, *Micromeriella m. marginella* (Klug), antenna, lateral aspect.

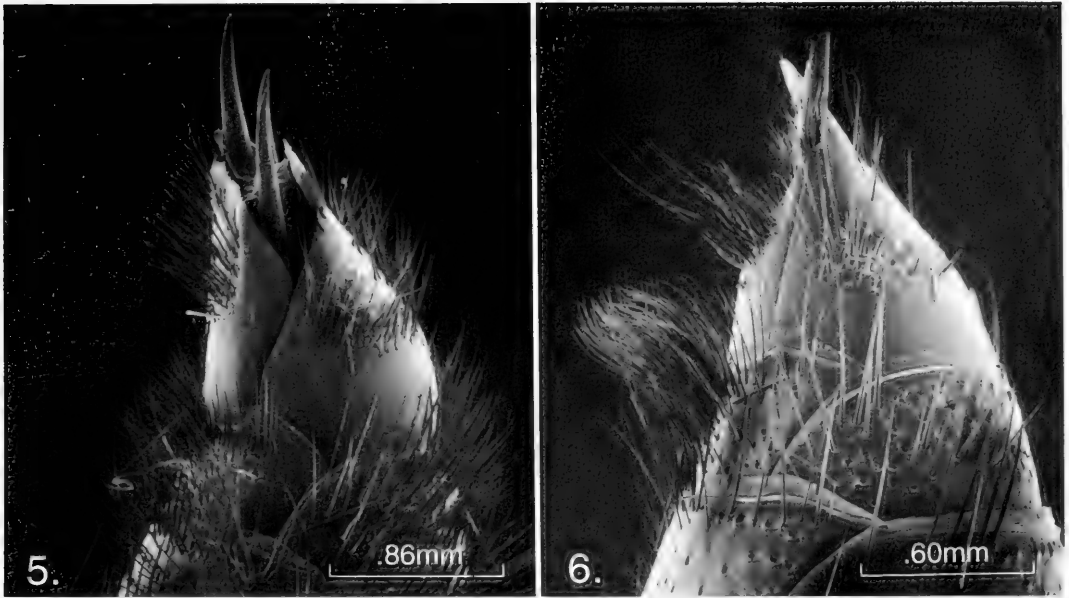
ering most of dorsum of T 1 shallowly emarginate anteriorly in middle and narrowing laterally, broad bands on apical three-fourths of T 2-3 emarginate anteriorly in middle and narrowing laterally, band on apical half of T 4, a pair of transverse spots on apical half of T 5 narrowly separated at midline, and a pair of small posterolateral spots on S 2. Erect vestiture abundant, glittering white except black on seventh abdominal segment, S 6 without a median tuft of longer, dense, black setae as in *C. c. collaris* (Fabricius) (cf. Figs. 5, 6); head and thorax with silvery tomentum, especially dense on thorax as in *C. c. collaris*. Wings slightly infumated with weak yellowish reflections. Genitalia as figured, paramere broader and volsella not so setose as in *C. c. collaris* (cf. Figs. 1, 2).

Female.—Length 15.3-18.2 mm, forewing 11.3-13.4 mm. Integument black. Vestiture white except becoming infuscated on apical abdominal segments, erect on occiput and dorsum of thorax anteriorly form-

ing a distinct dense ruff, sparse and recumbent on abdomen; temple, vertex posteriorly, pronotal dorsum and anterior third of scutum with dense, short, appressed setae as in *C. c. collaris*. Wings brown, not so dark as in *C. c. collaris*, basal two-thirds lighter than apex, with weak bluish reflections. Punctuation much as in *C. c. collaris*, differing as follows: vertex with a few more scattered punctures, although still mostly smooth; and lower metapleural plate with fewer punctures.

Holotype.—♂, Sri Lanka, Col[ombo] Dist[rict], Pamunugama, seashore, 16 March 1981, K. V. Krombein, T. Wijesinhe, L. Weeratunge (USNM).

Paratypes (all USNM).—2 ♂, ♀, same label data as holotype; 4 ♂, 2 ♀, same locality, but 16 January 1977, K. V. Krombein, P. Fernando, D. W. Balasooriya, V. Gunawardane. 2 ♂, same locality, but 26 July 1993, K. V. Krombein, A. W. Norden, P. B. Karunaratne. ♂, Col[ombo] Dist[rict], Usweetakeiyawa, seashore, same date and collec-



Figs. 5, 6. *Campsomeriella* species, apex of abdomen, lateral aspect. 5, *C. litoralis*, n. sp.; 6, *C. c. collaris* (Fabricius).

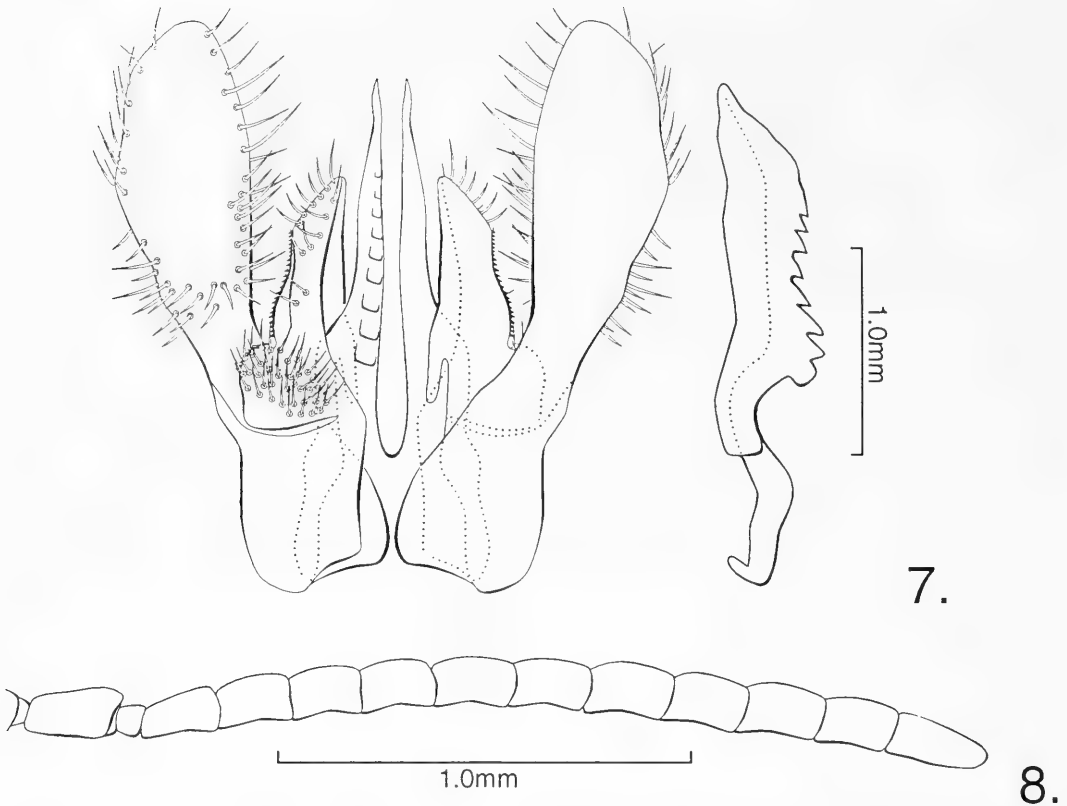
tors as holotype. ♂, same locality as preceding specimen, but 0–50 ft, 8 May 1976, K. V. Krombein, P. B. Karunaratne, S. Karunaratne, D. W. Balasooriya. 25 ♂, Col[ombo] Dis[trict], Ja-Ela, Old Dutch Canal, sea level, 8 May 1976, K. V. Krombein, P. B. Karunaratne, S. Karunaratne, D. W. Balasooriya. 2 ♂, Sri Lanka, Ham[bantota] Dist[ri]ct, Palatupana, W[ild] L[ife and] N[ature] P[rotection] S[ociety] Bungalow, 0–50 ft, 18–21 January 1979, K. V. Krombein, P. B. Karunaratne, T. Wijesinhe, S. Sirawardane, T. Gunawardane. A pair of paratypes have been deposited in the National Museum, Colombo, and a male paratype in the Natural History Museum (BMNH), London, and in the Staatliches Museum für Naturkunde, Stuttgart.

Variation.—Male paratypes are 10.1–13.9 mm long. Coloration is variable: the least maculated specimen from Pamunugama has reduced pronotal markings, lacks the lateral spots on scutellum, and the bands on T 2–3 are about half the width of tergum, and spots are lacking on T 5; on other specimens from Pamunugama, the spots on T 5 range

from tiny dots to narrowly separated transverse bars; a male from Uswetakeiyawa has a complete band on T 5; and the two specimens from Palatupana have the clypeus yellow except extreme apex and small median and basal spots, scutellar spots are larger, almost meeting on midline in one specimen which also has a median spot on metanotum, T 5 has an apical band narrowly emarginate anteriorly on midline, spots on S 2 are larger, and S 3 has a pair of small posterolateral spots.

Discussion.—*Campsomeriella litoralis* is known from only four localities in Sri Lanka, all on the seashore, one in the extreme southeastern part of the country, the other three about a third of the distance northward on the west coast. I expect that *C. litoralis* is more widely distributed in sandy parts of the litoral area in Sri Lanka, and that it may also occur in similar habitats in southern India. It should be noted that *C. c. collaris* (Fabricius) has not been collected in the litoral area, although it is otherwise widely distributed in Sri Lanka.

The female runs to *C. c. collaris* in my



Figs. 7, 8. *Scolia (Diliacos) lankensis*, n. sp. 7, genitalia, ventral aspect at left, dorsal aspect in middle, aedeagus, lateral aspect at right; 8, antenna, lateral aspect.

key (1978), and is distinguished by having the basal two-thirds of the forewing lighter and with weak bluish reflections, the mostly pale, sparse vestiture of the abdomen, and the smaller average size (14–27 mm in *C. c. collaris*).

The male also runs to *C. c. collaris*, but with some difficulty because of the frequent maculations on T 5. It is separated from *C. c. collaris* by the absence of a relatively long tuft of dense, erect, long, black setae (“copulation brush” of Betrem 1967) on S 6 (cf. Figs. 5, 6), and markedly by the conformation and vestiture of the male genitalia (cf. Figs. 1, 2). The more abundantly maculated specimens will run to *Micromeriella m. marginella* (Fabricius). The antennae are shorter in both *C. c. collaris* and *C. litoralis* than in *M. m. marginella* (cf. Figs. 3, 4), and

the apical flagellar segments are two-thirds as wide as long rather than half as long. The genitalia of *M. m. marginella* are also markedly different (Krombein 1978: fig. 12)

***Scolia (Discolia) lankensis* Krombein,
NEW SPECIES
Figs. 7, 8**

Etymology.—From Lanka, the ancient Sinhalese name for Sri Lanka.

Male.—Length 22.4 mm, forewing 19.3 mm. Black, the following orange: upper half of clypeus, lower half of area frontalis; large area on face including narrow line along lower inner eye orbits, ocular sinus, and front to posterior edge of fore ocellus, small mark behind and between posterior ocellus and upper eye margin narrowing to a streak along

upper two-thirds of outer eye orbit; oblique rectangular mark on scapula extending from anterolateral margin to tegula; a pair of large, transverse, anterolateral marks on T 3; wide bands on T 4–6; a pair of small, anterolateral spots and a narrow median band on T 6; and a narrow, median band on T 7. Vestiture black, reddish on orange areas except scapula, apical fringes of T 2–6 and S 2–6 and base of S 7. Wings dark brown with golden reflections, anterior third of forewing more strongly infuscated, microtrichiae present on wing membrane beyond marginal and submarginal cells.

Antenna long, tapering gradually at apex (Fig. 8); spatium frontale with small, contiguous punctures; front with somewhat larger punctures except for a small, smooth area between median patch and punctate ocular sinus, well developed fissura frontalis extending to anterior ocellus; vertex with more scattered, small punctures.

Scapula except narrow, micropunctate posterior margin with small, mostly subcontiguous punctures; scutum with somewhat larger, mostly subcontiguous punctures except a small, median, posterior area with slightly more separated punctures; scutellum similarly punctate but more sparsely along midline and a small, wider posterior area; metanotum similarly punctate except a narrow, median strip; upper metapleural plate with punctures as on scutum except lower anterior area smooth and micropunctate; punctation of dorsal propodeal surface similar to that on scutum; lateral propodeal surface contiguously punctate on upper third, elsewhere with most punctures separated by about a puncture width.

Apical fringes of T 1–6 and S 2–6 with a single row of tiny, contiguous punctures; T 1–2 with small punctures mostly separated by half a puncture width; T 3–6 with small, more dispersed punctures; genitalia (Fig. 7).

Female.—Unknown.

Holotype.—Sri Lanka, Kan[dy] Dist[riect], Udawattakele Sanct[uary], 510–580 meters, 2-5-XI-1977, K. V. Krombein, P. B. Ka-

runaratne, T. Wijesinhe, M. Jayaweera. Deposited in National Museum of Natural History (USNM).

Remarks.—This species runs to couplet 21 in my key (1978), but is distinguished from *S. picteti* Saussure and *S. ceylonicola* Betrem, both members of the *S. erythrocephala* group, by the dark brown rather than yellowish or slightly infumated wings, lack of pale thoracic markings except on scapula, and the orange rather than yellow maculations of the abdomen. The genitalia differ from those of other Scoliinae in lacking setae on the dorsal surface of the paramere.

In Betrem's key (1928: Tabelle III, pp. 256–263) *S. lankensis* runs to *S. pseudosinensis* Betrem from Sidapur, Coorg, India, a member of the *S. pekingensis* group. The unique male allotype of *S. pseudosinensis* in the Agricultural Station, Pusa, India, is not available for study, and I am not certain that *S. lankensis* belongs to this group of species. Betrem did not figure the genitalia, and his description indicates the following differences in coloration and punctation between *S. pseudosinensis* and *S. lankensis*: area frontalis all black in the former species, orange on the lower half in the latter; spatium frontale and tegula posteriorly orange in former, black in latter; thorax beneath and legs with reddish brown setae in former, black in latter; pronotum not thickly, finely punctate in former, scapula mostly contiguously punctate in latter; and metanotum not thickly punctate in former, most of punctures on latter separated by half the diameter of a puncture.

Betrem characterized females of the *S. pekingensis* group as follows: front and vertex mostly yellow or red, and mostly or entirely smooth with very few punctures; laminae frontales short, broader below than above; thorax entirely black; propodeum densely and deeply punctate; abdominal terga often finely punctate posteriorly; and at least T 3 with pale markings. The unknown female of *S. lankensis* should agree

in most of these details if the taxon is, indeed, a member of the *S. pekingensis* group.

Scolia (Discolia) gunawardaneae
Krombein

Scolia (Discolia) gunawardaneae Krombein, 1978: 23, fig. 30.

I described this rare species of the Dry Zone from a single male from Tennamaravadi, Trincomalee District, on the northeast coast. We collected a second male and three females on the southeast coast. The specimens are unworn and appear to have eclosed recently. They were visiting a flowering plant for nectar, and all specimens bear a few to many pollen grains especially beneath the head.

Female.—Length 14.7–19.0 mm, forewing 12.8–16.2 mm. Black, the following light red: largest female with a narrow stripe behind eye on vertex, and a diffuse, narrow spot anteriorly on scapula; broad bands on T 3–5, largest female also with a pair of small, rounded, sublateral spots on middle of 2; sterna black in smallest female, S 2 of intermediate female with a diffuse, narrow reddening anteriorly and a pair of small, elliptical spots laterally at midline, S 3 of largest female with broad anterior band and a pair of transverse spots posterolaterally, and S 4 and 5 with successively smaller, paired posterolateral spots. Wings dark brown, forewing with blue reflections, anterior third darker than rest of membrane, microtrichiae confined to cells except a small patch adjacent to marginal cell. Erect vestiture black except white on occiput, narrowly on anterolateral margin of pronotum and more widely anterodorsally.

Anterior margin of clypeus rounded, flat anterior rim with dense, small punctures, raised upper area glossy, with scattered micropunctures and a few larger ones laterally; area frontalis with a few, large punctures laterally; spatium frontale with large, mostly subcontiguous punctures; front with large punctures separated by less than the width

of a puncture narrowly along midline and along upper eye margin, scattered elsewhere; fissura frontalis lacking; vertex with scattered medium punctures, narrow patch of close punctures behind ocelli extending toward upper inner eye margin; occiput with close, subcontiguous punctures.

Scapula mostly subcontiguously punctate; scutum with a smooth, more or less U-shaped area on posterior half, anterior third with small, subcontiguous punctures, narrow area inside parapsidal furrows with larger subcontiguous punctures, area laterad of parapsidal furrows with larger scattered punctures, posterior margin with 2–3 rows of close, smaller punctures; scutellum mostly with larger, subcontiguous punctures, and a few small, scattered, impunctate areas; median area of metanotum similarly punctate, lateral areas with smaller, contiguous punctures; mesopleuron with moderate, subcontiguous punctures except anterior half of anterior slope below tubercle smooth with numerous micropunctures, and posterior half of posterior slope and tubercle similarly micropunctate; upper plate of metapleuron smooth with numerous micropunctures except for a few larger punctures dorsally, lower plate with larger punctures separated by about half the diameter of a puncture except a narrow, subtriangular posterior area densely micropunctate; median horizontal area of propodeum punctate as on scutellum except a narrow median strip impunctate; lateral horizontal area of propodeum smooth on inner anterior fourth, with somewhat smaller, subcontiguous punctures elsewhere; lateral surface of propodeum with mostly medium size punctures separated by no more than half a diameter and with scattered small impunctate areas; median area of posterior propodeum with medium size, frequently subcontiguous punctures on upper half, more scattered punctures on lower half; lateral area of posterior propodeum with mostly subcontiguous punctures except a small, smooth, micropunctate area at upper inner angle.

Dorsal surface of T 1 with a small tubercle, small area immediately posterad with scattered punctures of medium size, punctures elsewhere subcontiguous to contiguous especially laterally.

Discussion.—The female of *S. gunawardaneae* runs to couplet 28 in my key (1978), sharing the distinction with *S. keiseri* Krombein and *S. karunaratnei* Krombein of having the occiput partly or entirely clothed with white setae. It differs from both in having broad, light red bands on T 3–5; neither of the other species has red on T 5, and T 3 has a pair of spots rather than a band. The female of *S. keiseri* also differs in having abundant white setae on the entire body rather than just on the occiput and neck, the fissura frontalis is present on lower half of front, and the scutellum has most of the surface devoid of large punctures. The female of *S. karunaratnei* also differs in having a fissura frontalis on the lower part of the front, the upper front virtually devoid of large punctures, the scutum with a large, quadrate, impunctate area posteriorly, and the scutellum also is less punctate posteriorly.

The male agrees well with the holotype in coloration and punctation, and in the characteristic genitalia.

Additional locality data.—3 ♀, ♂; Hambantota District, Palatupana, 29 Mar–2 Apr 1981, K. V. Krombein, T. Wijesinhe, L. Weeratunge. One female has been placed in the National Museum, Colombo, Sri Lanka. The unique male holotype which was on loan to USNM has now been returned to the National Museum in Colombo.

Phalerimeris phalerata turneri
(Betrem)

Additional localities.—Trincomalee District: Tennamaravadi, 3 ♂, 20 Mar. Anuradhapura District: Amarivayal, 12 ♂, 21 Mar; Padaviya, 6 ♂, 12–22 Mar; and Gal-kadawala, ♂, 13 Mar. Kurunegala District: Kurunegala, Badegamuwa Jungle, 3 ♂, 14–15 Mar, and ♀, 2 ♂, 20 Sep. Kandy District:

Ulhitiya Oya, 15 mi NNE of Mahiyangana, ♂, 5–6 Sep; and Thawalamtenne, ♂, 16–18 Sep. Ratnapura District: Sinharaja Jungle, 2–3 mi S of Weddagala, ♂, 8–12 Feb, and 4 ♂, 22–23 Sep; Belihul Oya, Rest House, ♂, 23 Mar, and 24 ♂, 9–11 Apr; and Ambame Hena, 8 mi N of Kalawana, ♂, 4 Apr. Monaragala District: Angunakolapelessa, ♂, 17–19 June.

Colpacampsomeris indica eliformis
(Saussure)

Additional localities.—Ratnapura District: Gilimale, Induruwa Jungle, ♂, 12–15 Mar; and 2 mi S of Weddagala, Sinharaja Jungle, ♂, 8–12 Feb.

Sericocampsomeris pseudindica
(Betrem)

Additional localities.—Kegalla District: Kitulgala, Bandarakele Jungle, ♂, 17–18 Mar. Ratnapura District: 2 mi S of Weddagala, Sinharaja Jungle, 3 ♂, 8–12 Feb.

Campsomeriella collaris collaris
(Fabricius)

The paired lateral spots on T 5 of the male may occasionally coalesce medially to form a narrow strip.

Additional localities.—Mannar District: Kondachchi, Ma Villu, ♀, 6 ♂, 11–12 Apr, and ♂, 19 Sep. Trincomalee District: Tennamaravadi, 9 ♂, 20 Mar. Colombo District: Katunayaka, ♂, 16 June. Kegalla District: Kitulgala, Bandarakele Jungle, ♂, 15 Apr, and ♂, 25–26 Oct. Ratnapura District: Belihul Oya, Rest House, ♂, 10–11 Apr. Galle District: Kanneliya section, Sinharaja Jungle, ♂, 2–5 Oct. Monaragala District: Angunakolapelessa, 3 ♂, 17–19 June.

Micromeriella marginella marginella
(Klug)

A large male from Colombo, 12 mm long, has abnormally broad bands on T 1–3, similar in extent to those of *Campsomeriella collaris collaris* (Fabricius). Unlike *C. c. collaris*, it has the usual apical band on T 5,

and the genitalia are normal for *M. m. marginella*.

Additional localities.—Mannar District: Kondachchi, Ma Villu, ♂, 22–28 Jan, ♀, 17–21 Feb, ♀, 13 ♂, 11–12 Apr, and ♀, 16–19 Sep. Colombo District: Pamunugama, sea shore, ♂, 16 Jan, and ♀, 16 Mar; and Gampaha Botanical Garden, ♂, 27 Sep. Hambantota District: Bundala Sanctuary, Circuit Bungalow, 5–50 ft, 8 ♀, 17 ♂, 22–24 Aug.

Megacampsomeris ceylonica ceylonica
(Kirby)

The male from Thawalammenne is very small (10.5 mm) and has reduced yellow markings: head with only clypeus mostly yellow, elsewhere black; thorax entirely black; apical bands of T 1–3 narrower, those of 2 and 3 separated in middle; and legs with normally red areas brownish.

Additional localities.—Kandy District: Thawalammenne, ♀, ♂, 12–13 Mar; and Adams Peak Trail, 4.5 mi W of Maskeliya, 1610–1690 m, 14 ♂, 20–21 Oct. Kegalla District: Kitulgala, Makande Mukalana, ♂, 3–4 Feb, and ♂, 25–26 Oct.

Liacos erythrosoma cruszi Krombein

Additional locality.—Trincomalee District, Thiriyaya, ♂, 14 Mar.

Megascolia (Regiscolia) azurea michaae (Betrem)

Additional localities.—Anuradhapura District: Galapitawewa, 2 ♂, 19 Mar; and Amarivayal, 3 ♂, 21 Mar. Trincomalee District: Thiriyaya, 7 ♂, 14 Mar. Kandy District: Thawalammenne, ♂, 7–8 Sep. Colombo District: Handapangoda Timber Reserve, ♀, 18 Jan.

Microscolia hydrocephala (Micha)

Additional localities.—Kandy District: Thawalammenne, ♂, 21 Mar, and 11 ♂, 7–8 Oct. Monaragala District: Angunakolapelessa, ♀, 17–19 June.

Austroscolia ignota (Betrem)

Additional localities.—Mannar District: Cashew Corporation, Ma Villu, 2 ♂, 17–21 Feb. Trincomalee District: Tampalakaman Naval Head Works, ♂, 29 Jan; and Ten-namaravadi, ♂, 20 Mar. Amparai District: Ekgal Aru Sanctuary Jungle, ♀, 9–11 Mar. Galle District: Kanneliya, Sinharaja Jungle, 2 ♂, 24–26 Jan.

Austroscolia ruficeps henryi
Krombein

This is the second known male of this rare taxon. It agrees very well with the description of the allotype, but it is smaller, only 14.5 mm long rather than 20 mm.

Additional locality.—Trincomalee District: Tampalakaman Naval Head Works, ♂, 29 Jan.

Scolia (Discolia) cyanipennis
Fabricius

Additional localities.—Matale District: Sigiriya, ♀, Aug. Hambantota District: Palatupana, 3 ♀, ♂, 29 Mar–2 Apr.

Scolia (Discolia) affinis
Guérin-Ménéville

Additional localities.—Anuradhapura District: Padaviya Archeological Site, ♂, 11–14 Oct. Colombo District: Labugama Reservoir, ♀, ♂, 11 Jul. Ratnapura District: Gilimale, Induruwa Jungle, ♂, 7–8 Mar, and ♂, 16–19 Apr. Galle District: Kanneliya section, Sinharaja Jungle, ♂, 2–5 Oct.

Scolia (Discolia) trivandrumensis
Betrem

Additional localities.—Mannar District: Kondachchi, Ma Villu, 3 ♂, 11–12 Apr; and 0.5 mi NE Kokmotte Bungalow, Wilpattu Natl. Park, 2 ♂, 22–23 Jan. Trincomalee District: China Bay, Ridge Bungalow, 2 ♂, 8–11 Oct. Galle District: Kanneliya section, Sinharaja Jungle, ♂, 2–5 Oct. Hambantota District: Palatupana, ♀, 29 Mar–2 Apr.

Scolia (Discolia) aureipenniformis
Betrem

Additional localities.—Trincomalee District: Trincomalee, China Bay, 2 ♂, 8–11 Oct. Colombo District: Labugama Reservoir, 10 ♂, 11 Jul. Galle District: Kanneliya section, Sinharaja Jungle, 2 ♂, 2–5 Oct.

Scolia (Discolia) fasciatopunctata
Guérin-Ménéville

Additional localities.—Mannar District: Kondachchi, Ma Villu, ♂, 11–12 Apr. Anuradhapura District: Galkadawala, ♂, 13 Mar. Amparai District: Ekgal Aru Sanctuary Jungle, ♂, 9–11 Mar. Kegalla District: Kitulgala, ♂, 3–5 Feb. Ratnapura District: Gilimale, Induruwa Jungle, ♂, 13–15 Mar. Galle District: Hiniduma, ♀, 15 Jul.

Scolia (Discolia) bipunctata
bipunctata Fabricius

Additional localities.—Trincomalee District: Nilaweli, 9 ♂, 19–20 Nov; and Ten-namaravadi, 5 ♂, 20 Mar.

Scolia (Discolia) karunaratnei
Krombein

Additional localities.—Mannar District: Ma Villu, Cashew Corporation, ♀, ♂, 17–21 Feb. Puttalam District: Pannika Wila, Wilpattu Natl. Park, ♂, 1 Nov. Colombo District: Colombo, ♂, 27 June. Hambantota District: Palatupana, WLNPS Bungalow, 3 ♂, 18–21 Jan.

Scolia (Discolia) keiseri Krombein

Additional locality.—Mannar District: Kondachchi, Ma Villu, ♂, 11–12 Apr.

Scolia (Discolia) picteti Saussure

Additional locality.—Mannar District: 0.5 mi NE of Kokmotte, Wilpattu Natl. Park, ♂, 15–16 Feb.

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NOTES ON THE BEHAVIOR AND TAXONOMY OF
MEGACHILE (XEROMEGACHILE) BRIMLEYI MITCHELL
AND ITS PROBABLE CLEPTOPARASITE,
COELIOXYS (XEROCOELIOXYS) GALACTIAE MITCHELL
(HYMENOPTERA: MEGACHILIDAE)

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Abstract.—*Megachile brimleyi* Mitchell and its probable cleptoparasite, *Coelioxys galactiae* Mitchell, were studied in south central Florida during August, 1992. Foraging adults were collected along with other bees and wasps attracted to the flowers of *Galactia regularis* and *Tephrosia chrysophila*. Excavation of two active *M. brimleyi* nests provided details of nest structure and cell construction. Difficulties in keying both female and male *C. galactiae* are discussed, and revised couplets are provided for females.

Key Words: *Megachile*, nest, *Coelioxys*, cleptoparasite

A brief visit to the Archbold Biological Station (ABS), Highlands County, Florida, provided an opportunity to observe and collect *Megachile brimleyi* Mitchell and its probable cleptoparasite, *Coelioxys galactiae* Mitchell. Bees were collected 14–16 August 1992, and two active nests were dug up on the 15th. Plants visited by the bees were collected and pressed. Voucher insect and plant specimens are deposited in the National Museum of Natural History, Smithsonian Institution (USNM) and the Archbold Biological Station (ABS).

STUDY SITE

Bees were studied along a firebreak cutting through sand pine scrub near the southern end of the Lake Wales Ridge. This narrow, north-south ridge of sandy uplands is part of the ancient line of dunes that remained above water during Pleistocene inundations. The substrate is composed of loose, small grained, white quartz sand and particles of charred organic material, the residue from repeated scrub fires. The ster-

ile, sandy soil is well drained but moist below the surface.

MATERIALS AND METHODS

Adult bees were collected on plants, and observed as they excavated nests. Plant specimens were put in plastic bags and transferred later to a plant press. The two bee nests were examined after blowing plaster-of-Paris into the nest openings to trace their paths, and then carefully removing sand grains from around the tunnels with a tablespoon, penknife, and small paint brush. Nest contents were preserved in Kahle's solution, then examined and measured in the laboratory. The bees were identified using Mitchell (1962, 1973) and by comparison with specimens identified by him in USNM.

RESULTS AND DISCUSSION

Nest architecture.—Nesting data have been reported for only one other species of the subgenus *Xeromegachile*, *M. rubi* Mitchell in North Carolina (Sivik 1954) and Georgia (Eickwort et al. 1981). We found

Table 1. Wasp and bee visitors to flowers of *Galactia regularis*.

Tiphidae

Tiphia intermedia Malloch: ♂.

Larridae

Trypoxylon johannis Richards: ♂.

Philanthidae

Cerceris toteca Saussure: ♂.

Halictidae

Nomia maneei Cockerell: ♀ without pollen.

Augochloropsis sumptuosa (Smith): ♀ without pollen.

Megachilidae

Anthidium maculifrons Smith: ♀ without pollen.

Anthidiellum notatum rufimaculatum Schwarz: ♂.

Megachile (*Litomegachile*) *brevis pseudobrevis* Mitchell: ♂, ♀ with abundant *G. regularis* pollen on scopa.

Megachile (*Litomegachile*) *mendica mendica* Cresson: 3 ♀, two with abundant *G. regularis* pollen on scopa, one with no pollen.

Megachile (*Xeromegachile*) *brimleyi* Mitchell: ♂, 2 ♀ without pollen.

Megachile (*Xeromegachile*) *integra* Cresson: 5 ♂, 2 ♀, one female with *G. regularis* pollen on the scopa, one without.

Coelioxys (*Xerocoelioxys*) *galactiae* Mitchell: ♀.

M. brimleyi females digging their own nests in sandy soil exposed to full sunlight, similarly to *M. rubi*. *M. brimleyi* tunnels were in level ground, and penetrated the substrate at an angle of 45°. The entrances of the two *M. brimleyi* nests were 8.5 and 10.0 mm in diameter. The females used their hindlegs to kick the sand grains 3–6 cm from the nest entrances, thus forming a semicircular spoil heap. Both tunnels were 10 cm long, and ended in an enlarged chamber, a single cell. It was our impression that these nests, the only two found in the area, were newly initiated, and eventually might have contained more cells. Sivik reported that nests of *M. rubi* had 1–3 cells in a linear series, while 1–4 cells were reported by Eickwort et al.

The cell of one *M. brimleyi* nest was lined with 11 leaf pieces cut from *Galactia regularis*. Eight of the pieces were ca 9 mm wide and 15.5 mm long with rounded edges. Three subcircular pieces, used to form the cell base, were ca 7 mm wide and 8 mm long. The leaf cuttings were weakly cemented together. The cell was ca 17 mm

long, and it had not been provisioned or capped. Sivik found that *M. rubi* formed cells of similar size from leaves of *Betula lenta*, and capped the cells with 4–5 leaf pieces. Eickwort et al. reported ca 14 leaf pieces used to form a cell, and ca 3 to cap it.

Plant and insect associations.—Two leguminous plants, the pink-flowered *Galactia regularis*, and the white-flowered, prostrate *Tephrosia chrysophylla*, attracted a variety of wasps and bees (Tables 1, 2). Both sexes of *Megachile brimleyi* visited flowers of both plants, and one nesting female carried *G. regularis* pollen on the scopa. Interestingly, females of *Coelioxys galactiae* also visited both plants. Behavioral data strongly suggest that *C. galactiae* is a cleptoparasite of *M. brimleyi*. We watched two females of *C. galactiae* each following a *M. brimleyi* female, and then entering her nest after her. We also observed other *Coelioxys* females, presumably *galactiae*, following *M. brimleyi* females as they flew over the sand and among the plants.

Megachile integra Cresson is the only oth-

Table 2. Bee visitors to flowers of *Tephrosia chrysophylla*. (No wasps were noted on this plant.)

Halictidae	
<i>Nomia maneei</i> Cockerell:	3 ♀, one with abundant <i>T. chrysophylla</i> pollen on the scopa, others with lesser amounts.
Megachilidae	
<i>Megachile (Xeromegachile) brimleyi</i> Mitchell:	♂, ♀ without pollen.
<i>Coelioxys (Xerocoelioxys) galactiae</i> Mitchell:	2 ♀.

er *Xeromegachile* that we collected at the study site. Both sexes were collected on *Galactia* flowers, but only one female had numerous pollen grains of *Galactia* on the scopa. Nothing is known of the nesting habits of *M. integra*.

Coelioxys galactiae Mitchell
Fig. 2

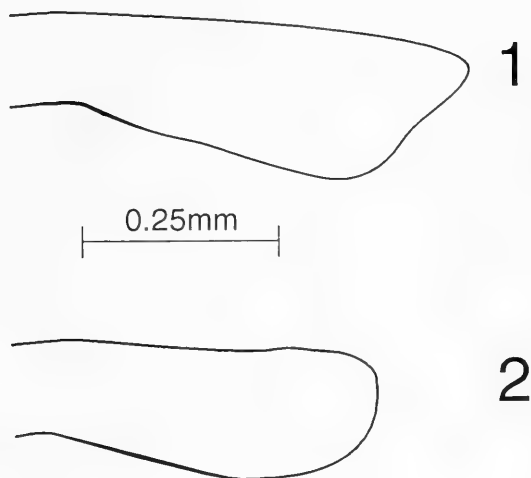
The syntype series of *C. galactiae* is from North Carolina, Illinois, and northern Florida (Clay and Levy counties). Both sexes have light red legs except for the coxae. However, nine females and four males from ABS in south central Florida have the legs predominantly black or dark brown except for two females which have reddish brown tibiae and tarsi. This is a striking reversal of the normal coloration of aculeate Hymenoptera in which there is an increasing amount of red in more southern populations.

Mitchell (1962) separated females of three species of *Coelioxys*, *galactiae* Mitchell, *sodalis* Cresson and *immaculata* Cockerell, from the other eastern species of the genus by the similarly shaped sixth sternum. It is not notched laterally but is incurved apically to form a short, acute, subtriangular projection. Females of *C. galactiae* from ABS do not key out properly in Mitchell (1962, couplets 13–14). In a series of nine females from ABS the tibiae and tarsi are predominantly black or dark brown in seven, reddish brown in two.

We examined the series of these three species in the National Museum of Natural History (USNM), and the syntypes of *C. galactiae* in the collection at North Carolina State University. We believe that the following key will distinguish the three taxa with greater certainty. It should replace couplets 13 and 14 in Mitchell (1962).

- 13. Carina on pronotal lobe strongly raised, lamellate; vestiture of head short, appressed, dense on clypeus and lower front; thorax with areas of short, dense, appressed white setae—narrow bands anteriorly and posteriorly on scutum, narrow anterior band on scutellum sometimes interrupted medially and the posterior declivous surface, small median patch on metanotum, narrow anterior and posterior bands on mesopleuron; clypeus slightly convex, not elevated above level of face *C. galactiae* Mitchell
- Carina on pronotal lobe not raised, obscured by vestiture in *C. sodalis*; vestiture of head appressed and not so dense on clypeus and supraclypeal area only; thorax either without appressed setae, or with such areas greatly reduced in extent; clypeus slightly convex or elevated 14
- 14. Clypeus slightly convex, not elevated above level of face; vestiture of head, except clypeus and supraclypeal area, and thorax long, erect and silvery *C. sodalis* Cresson
- Clypeus more strongly convex, elevated above level of face as viewed in profile; vestiture appressed on clypeus and supraclypeal area, suberect laterally along orbit and erect on upper front, shorter than in *C. sodalis*; bands of appressed, decumbent hair on scutum absent anteriorly, evanescent laterally and posteriorly; appressed setae on scutellum forming a narrower anterior band than in *C. galactiae*, sparser on posterior declivous surface; metanotum with longer, suberect, evenly distributed setae; mesopleuron with narrower anterior and posterior bands of longer, suberect setae *C. immaculata* Cockerell

Floridian males of *C. galactiae* key to *C. boharti* Mitchell (Mitchell 1962) because of their dark legs. We examined the unique holotype of *C. boharti* (USNM), and find that it is readily distinguished by the abundant, broad, short setae on the mesopleural disk, 2–3 times as long as wide, the more



Figs. 1, 2. *Coelioxys* species, apical half of paramere, lateral aspect, ventral margin at bottom. 1, *C. boharti* Mitchell; 2, *C. galactiae* Mitchell.

infuscated wings, and the paramere (Fig. 1) which in lateral view widens gradually for most of the apical half, and then tapers obliquely to the narrowly rounded apex. In *C. galactiae* the discal setae of the mesopleuron are narrower, mostly more than four times as long as wide, and the apical half of the paramere (Fig. 2), in lateral view, widens gradually over most of its length with the apex broadly rounded. The discal vestiture of the mesopleuron is variable in width in specimens from ABS, but it is never as broad and short as in *C. boharti*.

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**NATIVE BLACK GRASS BUGS (*IRBISIA-LABOPS*) ON INTRODUCED
WHEATGRASSES: COMMENTARY AND ANNOTATED BIBLIOGRAPHY
(HEMIPTERA: HETEROPTERA: MIRIDAE)**

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Abstract.—The introduction of crested wheatgrasses (*Agropyron* spp.) into North America to improve the carrying capacity of western rangelands resulted in unanticipated increases in the population levels of native black grass bugs (*Irbisia* spp. and *Labops* spp.). The more than two hundred publications, reports, and theses listed in this annotated bibliography contain information on the systematics, biology, and ecology of the bugs and management techniques for controlling and minimizing bug damage to these non-indigenous species of wheatgrasses.

Key Words: Black grass bugs, *Irbisia*, *Labops*, Hemiptera: Heteroptera, Miridae, plant bugs, bibliography, rangeland, non-indigenous species, wheatgrasses, *Agropyron*

INTRODUCTION

Grasslands play an important environmental role worldwide. Over 7 billion hectares occur, including rangeland and pasture, exceeding forests and woodlands by over one-half billion hectares (Lauenroth 1979, Turner and Meyer 1992). Grasslands of all types have always received extraordinary use as a resource for grazing by both wild and domestic animals (Crawley 1983).

The area occupied by grasslands globally declined from 1700 to 1980, chiefly because the land was being converted to other agricultural uses, largely croplands. Grassland areas have increased since 1950, primarily at the expense of forests and woodlands (Turner and Meyer 1992). Such shifts in global carbon storage patterns are becoming more apparent and the consequences of these

conversions are attracting worldwide concern.

This paper addresses the interaction between several groups of native grass insects—the black grass bugs (Hemiptera: Heteroptera: Miridae) and range grasses, chiefly non-indigenous species that have been planted widely throughout western North America for range improvement. Most of the annotated references deal with some aspect of the habits and characteristics of plant bugs of the genera *Irbisia* Reuter and *Labops* Burmeister.

While no simple solution to the problems caused by these insects emerged from this review, we have documented the diverse interactions between introduced organisms (here, several grass species from Central Asia) and elements of the native insect fauna, some with close relatives in the original

home of the grasses. While it is more common for crop pests to be non-indigenous themselves, host plant shifts of native insects onto introduced plant species do occur (Kogan and Lattin 1993). The basic problem of damage to the planted wheatgrass species results from these host shifts. The bugs continue to feed on their native hosts, of course, but the coevolution of these insects with their native hosts generally results in resistance to extensive damage by the bugs. This resistance normally is not present in the introduced grass species. Breeding programs for rangeland grasses have tended to emphasize agronomic improvements rather than resistance to insects (Watts et al. 1982).

If, at the time of original introduction of the wheatgrasses, a thorough review of potential pests had been made, it would have disclosed that at least one native species of *Labops* found in Central Asia feeds upon species of *Agropyron* Gaertn. (Kerzhner 1973). This example illustrates the desirability of careful screening of plant materials (and, of course, animals) *before* their introduction to new regions.

HISTORICAL BACKGROUND

The grasses

Dillman (1946) provided a detailed account of the introduction of the crested wheatgrasses into North America. N. E. Hansen of the U.S. Department of Agriculture first encountered crested wheatgrasses in Asia when he visited the Valuiki Experiment Station about 150 miles north of St. Petersburg in 1897–1898. These grasses (*Agropyron* spp.) were already being raised and tested for cultivation by Vasili S. Bogdan. Hansen obtained seed samples to be tested upon his return to the United States. Samples were sent to five different states but information about the results of these early plantings is scarce.

A second shipment provided by Bogdan arrived in late 1906. This was the one that

led to the successful planting and distribution of crested wheatgrass in North America. One lot was labeled *Agropyron cristatum* (L.) Gaertn. and five lots were labeled *A. desertorum* (Fisch.) Schult. The second shipment was divided and sent to 15 experiment stations from 1907 to 1913. According to Dillman (1946) “All evidence thus far collected points to the conclusion that the successful plantings made at the Belle Fourche Station, Newell, S. Dak., from 1908 to 1915, and the experiments begun in 1915 at the Northern Great Plains Field Station, Mandan, N. Dak., were responsible for the early distribution and establishment of crested wheatgrass in the northern Great Plains.” Love and Hanson (1932) provided an early treatment on the life history of crested wheatgrass and included a key to identify the species then involved. Dewey (1983) reviewed the taxonomy of wheatgrass and related grasses. Barkworth and Dewey (1985) provided an overview of the perennial Triticeae of North America, including the crested wheatgrasses.

Although Rogler and Lorenz (1983) extolled the virtues of crested wheatgrass as being just about the perfect range grass, they did suggest that some improvements were possible and needed—including insect resistance. Most of the references included below are related to insect problems of only one type—black grass bugs, mainly as pests of crested wheatgrasses. One wonders how intensive breeding programs using native grasses might have resulted in breeding lines of similar forage desirability.

The bugs

The insects belong to the family Miridae (Hemiptera: Heteroptera), the largest family of the true bugs, about 2000 species are known from Canada and the United States (Henry and Wheeler 1988). While most of the species are herbivorous, some are predaceous and some feed on both plants, insects and other arthropods. Several genera have species that feed on grasses. Most of

these genera are found in the tribe Stenodemini, subfamily Mirinae. Some of these genera are mentioned in the papers below, including *Leptopterna* Fieber, *Litomiris* Slater, *Stenodema* Laporte, and *Trigonotylus* Fieber. Also mentioned in several papers is *Conostethus* Fieber, a genus that is placed in the tribe Phylini, subfamily Phylinae.

The two genera discussed here as black grass bugs are *Irbisia* (Mirinae: Mirini) and *Labops* (Orthotylinae: Halticini). Some of the earlier literature referred to species of the genus *Thyrillus* Uhler, but this genus was synonymized with *Irbisia* many years ago.

The species of *Irbisia* and *Labops* that feed on crested wheatgrasses are all native species. The only non-indigenous species of bug mentioned in the literature reviewed here is *Leptopterna dolabrata* (Fallén), the meadow plant bug, a species introduced into North America many years ago from Europe. There are other non-indigenous species of mirids that are known to feed upon grasses in North America (Wheeler and Henry 1992); they were not included in this annotated bibliography.

Irbisia Reuter, 1879, contains 23 species (Schwartz 1984); all of the species are found in North America, mainly in the western provinces and states. The currently accepted species are *I. bliveni* Schwartz, 1984, *I. brachycera* (Uhler), 1872, *I. californica* Van Duzee, 1921, *I. cascadia* Schwartz, 1984, *I. castanipes* Van Duzee, 1921, *I. cuneomaculata* Van Duzee, 1934, *I. elongata* Knight, 1941, *I. fuscipubescens* Knight, 1941, *I. incomperta* Bliven, 1963, *I. knighti* Schwartz and Lattin, 1984, *I. limata* Bliven, 1963, *I. mollipes* Van Duzee, 1917, *I. nigripes* Knight, 1925, *I. oreas* Bliven, 1963, *I. pacifica* (Uhler), 1872, *I. panda* Bliven, 1963, *I. sericans* (Stål), 1858, *I. serrata* Bliven, 1963, *I. setosa* Van Duzee, 1921, *I. shulli* Knight, 1941, *I. silvosa* Knight, 1961, *I. sita* Van Duzee, 1921, *I. solani* (Heidemann), 1910. The only species of this genus not

restricted to North America is *I. sericans* whose range extends into eastern Siberia (Kulik 1965, Vinokurov 1979, Kerzhner 1988).

Several species of *Irbisia* have been reported from the crested wheatgrasses as well as other graminoid plants and, in fact, from other types of plants besides the grasses. Species of *Irbisia* often shift from grasses to other plants late in their adult stage, sometimes to crops of economic importance. Eggs of some bug species are placed in grass stems while other bug species have been reported to deposit their eggs in non-graminoid plants (Schwartz 1984). Before the genus was revised, references were often made only to the genus rather than to a particular species, although *I. pacifica* was often cited because it was abundant and distinctive in appearance. The revision by Schwartz (1984) placed the taxonomy of *Irbisia* upon stable ground.

Labops Burmeister, 1835, contains 12 species and occurs in both the Old and New Worlds (Carvalho 1958, Kerzhner 1988) with one species, *L. burmeisteri* Stål, present in both regions (Kulik 1965, Vinokurov 1979, Kerzhner 1988). Seven species are found only in North America. The currently accepted species of *Labops* occurring in North America are: *L. brooksi* Slater, 1954, *L. burmeisteri* Stål, 1858, *L. chelifera* Slater, 1954, *L. hesperius* Uhler, 1872, *L. hirtus* Knight, 1922, *L. tumidifrons* Knight, 1922, *L. utahensis* Slater, 1954, *L. verae* Knight, 1929. Of these, only *L. hesperius*, *L. hirtus*, and *L. utahensis* have been reported from crested wheatgrasses. The most economically important species is *L. hesperius*. The other two species of *Labops* may be important in more limited areas, especially *L. utahensis*.

MANAGEMENT CONSIDERATIONS

Many papers deal with different methods of coping with the damage caused to the grasses by species of *Irbisia* and *Labops*, depending chiefly on the geographic area.

While insecticide treatments have been used at different times and places in the past, emphasis has shifted towards cultural control, partly because of cost and partly because many compounds used previously are no longer available or registered. Further, the widespread use of pesticides has been deemphasized for environmental reasons. Nontarget organisms are receiving much greater attention, especially in seminatural settings such as rangelands.

The main management efforts seem to be in the timing of grazing and in the manipulation of the planting mixtures related to the natural vegetation. Pure stands of crested wheatgrass are more likely to sustain greater damage than range that maintains a diversity of species more nearly approximating original conditions (Spangler and MacMahon 1990). Increased efforts to breed resistant strains and to elucidate the nature of this resistance are occurring. Much, however, remains to be done in developing breeding programs for improving native grasses. The original wheatgrasses brought in were first located at a research station in Central Asia where they were being raised for selection for superior varieties in that area.

The consequences of introducing several non-indigenous grass species (*Agropyron* spp.) into western North America have been their widespread use as replacements or augmentations for native grass species, at times approaching monocultures. While this has improved the carrying capacity of many rangelands, it has often been at the expense of the native grasses, species often well adapted to particular localities throughout this vast portion of the continent. The diversity of native grass species found throughout this region attests to the selection and adaptation that occurred through time, resulting in well-adapted forms. Some of these grasses were unable to withstand the grazing pressures to which they have been subjected, and the introduced grasses seemed to hold the answer to increasing the

carrying capacity of these rangelands (Perry 1954).

As is often the case, planting a virtual monoculture within a highly diverse flora may create new problems. Expecting one or two species to replace a vast mosaic of grass species adapted over thousands of years to particular conditions may be unrealistic. For example, native insects whose populations were maintained at reasonable levels because of the diversity of grass species normally found in any given area often responded to this newly created monoculture by increasing in density.

Natural controls that helped maintain lower population levels of the insects that feed on native grasses may not have been able to sustain those lower levels because of the sudden abundance of new host plants. The increased densities of the insects, of course, reduced the very resources and benefits the plantings were supposed to provide. Many of the references included here document the differences in insect population levels between planted and unplanted rangeland.

Some obvious parallels exist between newly created insect problems on modified rangelands and more conventional agricultural practices. When native vegetation of any sort is converted to croplands, changes in the biota occur (Kogan and Lattin 1993). Monocultures do not resemble most natural vegetational patterns. Usually planted in high density for convenience of harvest, such artificial environments create conditions that often result in rapid build-up of pests, generally at population levels far above what might otherwise occur. Natural control mechanisms in the form of parasites and predators are usually rendered ineffective because the very situation that allowed these controls to function has been disrupted. A long-term consequence of the change to vast monocultures of crops of all types has been a gradual increase in reliance upon a variety of chemicals to provide the levels of control expected. After many years of this depen-

dency and the development of pesticide resistance and the impact of pesticides on the environment, we are again examining alternative approaches. The emergence of Integrated Pest Management (IPM) is gaining in popularity and in sophistication. It holds real promise in rangeland management where some semblance of native/natural conditions still exists in contrast to a cornfield, for example. With all of the various breeding programs involving the introduced crested wheatgrasses, one wonders what might have happened if similar efforts had been applied to our diverse native grass flora.

CONCLUSIONS

It is unlikely that the black grassbug/crested wheatgrass problem will ever be resolved completely. The non-indigenous grasses have been planted so widely that they are unlikely to be replaced or displaced. The native bugs are not likely to disappear either. They have been and continue to be well adapted to the grasslands of western North America. The presence of crested wheatgrasses simply provides additional resources and most likely supports higher population levels than existing undisturbed grasslands. Based on the bulk of the investigations reviewed for this publication, it appears that the most likely improvement will occur by moving away from monocultures. Bug populations should decrease as habitats become more heterogeneous. Increased resistance of some varieties of wheatgrasses seems likely to help (e.g. Levin 1973, Ling et al. 1985), as will careful attention to grazing pressures—especially when less than ideal climatic conditions follow heavy attack by the bugs. Increased attention to greater diversity of native grasses already adapted to local conditions provides yet another possibility; the best approach to ameliorating the problem appears to be an ecosystem approach to management rather than relying on only a few factors. It seems that the use of pesticides is

more and more unlikely for a variety of reasons. True integrated pest management may be the best approach to this complex problem (Watts et al. 1982).

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This bibliography is an annotated list of publications and reports describing the biology and documenting the occurrence of native black grass bugs on introduced crested wheatgrasses and other plants in North America. The time period covered concludes with December, 1993.

The list began with an early effort some years ago to bring together the literature on native black grass bugs. This early list was subsequently further developed by a comprehensive search of several bibliographic sources, either in print, CD-ROM, or online format. These sources included AGRICOLA, Bibliography of Agriculture, Biological Abstracts, Biological and Agricultural Index (formerly Agricultural Index), CAB Abstracts, Dissertation Abstracts, Index to the Literature of American Economic Entomology, Review of Agricultural Entomology (formerly Review of Applied Entomology Series A. Agricultural), and Zoological Record. All sources were searched from their beginning publication date. The need to search a variety of bibliographic sources to uncover entomological literature has been discussed by Deitz and Osegueda (1989).

The list of references cited in each article or report located in the literature search was checked to identify additional publications that were relevant to the scope of the bibliography. Several theses were located in the process which are included in the bibliography for completeness, but they have not been annotated.

Scientific names which are no longer valid have been corrected to conform with current taxonomic use.

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- Akingbohunge, A. E., J. L. Libby, and R. D. Shenefelt. 1973. Nymphs of Wisconsin Miridae, Hemip-

- tera: Heteroptera. University of Wisconsin, College of Agriculture and Life Sciences, Research Division. R. 2561. 25 pp. [The nymph of *Labops hirtus* is characterized. A diagnostic key to the nymphs of Wisconsin Miridae includes *Labops*.]
- Akingbohunge, A. E. 1974. Nymphal characters and higher classification analysis in the Miridae (Hemiptera: Heteroptera) with a subfamily key based on the nymphs. *Canadian Entomologist* 106: 687–694. [The genus *Labops* was included in a study on dorsal abdominal gland openings in the mirid nymphs. The opening is simple and has a sclerotized bar, a character shared by most of the Orthotylinae included in the study.]
- Anonymous. 1953. Outbreaks and new records. *FAO Plant Protection Bulletin* 2: 43–45. Rome. [*Irbisia brachycera* is reported (as *I. arcuata*) on *Agropyron intermedium* at the Experimental Station, Lethbridge, Alberta.]
- Anonymous. 1966. Wheatgrass bugs (*Labops* spp.). United States Department of Agriculture, Agricultural Research Service, Plant Protection Quarantine, Cooperative Economic Insect Report 16: 623–624. [The economic importance of *Labops hesperius* and *L. hirtus* in western United States is reviewed. Crested and intermediate wheatgrasses were injured along with other grasses. Life history, habits, distribution, and a description of *L. hesperius* are given. A guide to detecting bug damage to grasses is included.]
- Anonymous. 1977. Putting the stops on *Labops*. Oregon's Agricultural Progress. 21: 11–12. [The habits and damage caused by black grass bugs (*Labops hesperius*) in Oregon are reviewed.]
- Ansley, R. J., Jr. 1979. The influence of black grass bugs (*Labops hesperius*) and cattle on the vigor of crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.). M.S. thesis, Utah State University, Logan. 84 pp.
- Ansley, R. J. and C. M. McKell. 1982. Crested wheatgrass vigor as affected by black grass bug and cattle grazing. *Journal of Range Management* 35: 586–590. [Light to moderate populations (50–200 per m²) of black grass bugs (*Labops hesperius*) appeared to reduce plant vigor in a seeded monoculture of crested wheatgrass in Utah. Combined grazing by cattle and black grass bugs resulted in greater reduction in vigor than by the insects alone.]
- Araya, J. E. 1982. Studies of selected predators of black grass bugs (*Labops hesperius* Uhler and *Irbisia brachycera* Uhler) on ranges of Utah. M.S. thesis, Utah State University, Logan. 102 pp.
- Araya, J. E. and B. A. Haws. 1988. Arthropod predation of black grass bugs (Hemiptera: Miridae) in Utah ranges. *Journal of Range Management* 41: 100–103. [Two species of Nabidae, *Nabis alternatus* Parshley and *N. vanduzeei* Kirkaldy, were found to be effective predators on black grass bugs with prey size scaled to predator size. Six species of spiders were also found to feed on the bugs: *Xysticus cunctator* Thorell, *Misumenops lepidus* (Thorell), *M. celer* (Hentz), *Tibellus* sp., *Castianeira* sp., and *Tetragnatha* sp.]
- Araya, J. E. and B. A. Haws. 1991. Arthropod populations associated with a grassland infested by black grass bugs, *Labops hesperius* and *Irbisia brachycera* (Hemiptera: Miridae), in Utah, U.S.A. *FAO Plant Protection Bulletin* 39: 75–81. [*Nabis alternatus* and *N. vanduzeei* were reported to be important predators of *Labops hesperius* and *Irbisia brachycera*. A number of spiders were also recorded as predators of these two plant bugs including: *Xysticus cunctator*, *Misumenops lepidus*, *M. celer*, *Tibellus* sp., *Castianeira* sp., *Tetragnatha* sp., and *Metepeira foxi* Gertsch & Ivie. The value of these generalist predators is discussed. The authors suggest diversifying the plant species in the rangeland as a means of reducing the bugs' impact.]
- Armitage, H. M. 1952. Current insect notes. State of California, Department of Agriculture. *Bulletin* 41: 180–183. [*Labops hesperius* is reported on crested wheat and smooth brome grass from Plumas County, California.]
- Arnott, D. A. and I. Bergis. 1967. Causal agents of silver top and other types of damage to grass seed crops. *Canadian Entomologist* 99: 660–670. [The damage caused by different organisms that might result in silver top is reviewed. Miridae were included, but *Irbisia* and *Labops* are not mentioned specifically.]
- Babcock, J. M., L. K. Tanigoshi, E. A. Myhre, and R. S. Zack. 1993. Arthropods occurring on sweet white lupin and native lupins in southeastern Washington. *Pan-Pacific Entomologist* 69: 261–271. [*Labops hesperius* is reported from the native *Lupinus leucophyllus* Douglas in southeastern Washington. The bugs were found on the plants towards the end of May and remained until the plants dried out; they were not found on white lupine (*Lupinus albus* L.), a non-indigenous species grown as a rotational crop in the area.]
- Banks, N. 1910. Catalogue of the Nearctic Hemiptera-Heteroptera. American Entomological Society, Philadelphia. 103 pp. [The catalog lists early state records for *Irbisia brachycera*, *I. pacifica*, and *I. sericans*, and *Labops hesperius*. (For more recent information on distribution, see Schwartz 1984, Henry and Wheeler 1988.) (Note: *I. gilvipes* is now placed in the genus *Mecomma* Fieber.)]
- Blatchley, W. S. 1926. Heteroptera or True Bugs of Eastern North America. Nature Publishing Company, Indianapolis. 1116 pp. [*Labops hesperius* and *L. burmeisteri* are treated. Each species is de-

- scribed briefly and distribution records given. Blatchley states that he considers *L. hirtus* a synonym of *L. hesperius*.]
- Blatchley, W. S. 1928. "Quit-Claim" specialist vs. the making of manuals. Bulletin of the Brooklyn Entomological Society 23: 10-18. [The identity of *Labops hesperius* is noted.]
- Blatchley, W. S. 1934. Notes on a collection of Heteroptera taken in winter in the vicinity of Los Angeles, California. Transactions of the American Entomological Society 60: 1-16. [*Irbisia cuneomaculata* is described from Sunland, California. *Irbisia californica* was common in February and March on grasses and herbs.]
- Bliven, B. P. 1961. New species of *Irbisia* from California. Occidental Entomologist 1: 45-49. [Six species of *Irbisia* are described as new: *I. eurekae*, *I. paenulata*, *I. vestifica*, *I. gorgoniensis*, *I. tejonica*, and *I. silvosa*, all from California. (See Schwartz 1984 for synonymy.)]
- Bliven, B. P. 1963. New species of *Irbisia* from California II. Occidental Entomologist 1: 68-86. [Thirteen species of *Irbisia* are described as new, 12 from California and one from Arizona. Those described from California include: *I. umbratica*, *I. upupa*, *I. retrusa*, *I. incomperta*, *I. neptis*, *I. paulula*, *I. lacertosa*, *I. panda*, *I. limata*, *I. ustricula*, *I. inurbana*, and *I. serrata*. *Irbisia oreas* is described from Arizona. (See Schwartz 1984 for synonymy.)]
- Bohning, J. W. and W. F. Currier. 1967. Does your range have wheatgrass bugs? Journal of Range Management 20: 265-267. [*Labops hesperius* damaged crested wheatgrass throughout much of western North America. Some basic biological information is included. The question was raised as to whether this was a native insect species (it is—J.D.L.). Although 900 acres were sprayed with malathion in the Santa Fe National Forest in 1967, the bugs returned the following year.]
- Bowers, D. M. 1976. Insect consumption of seeded rangeland herbage in a selected area of Diamond Fork Canyon, Utah County, Utah. M.S. thesis, Utah State University, Logan. 45 pp.
- Bowers, D. M. and B. A. Haws. 1977. Impact of insect consumption of rangeland forage in Utah. Society of Range Management, 30th Annual Meeting, Abstract, p. 35. [Insects consumed 34% (2.8 AUM) of the total available forage of a study area seeded to crested wheatgrass in Utah County, Utah. Cattle consumed 28% (2.1 AUM) at the same site. These comparative figures were used to calculate losses from insects.]
- Brewer, P. S., W. F. Campbell, and B. A. Haws. 1979. How black grass bugs operate. Utah Science 40: 21-23. [The method of feeding by *Labops hesperius* is described. Photographs and photomicrographs of the bug and damage are included. Intermediate wheatgrass and Kentucky bluegrass were more attractive to the bugs than crested wheatgrass.]
- Burkhardt, C. C. 1974. Grass bug control in grass and wheat. University of Wyoming. Agricultural Experiment Station. Research Journal No. 82. 2 pp. [Damage to crested wheatgrass in eastern Wyoming by *Labops hesperius* is reported with bug densities reaching 100 per ft². A number of different compounds were applied to research test plots of grasses and winter wheat. Good control was achieved with a variety of compounds but many did not yet have label approval.]
- Burkhardt, C. C., J. M. Edwards, and L. E. Bennett. 1986. Chemical control of grass bugs on crested wheatgrass. University of Wyoming, Laramie. College of Agriculture. Annual Research and Extension Centers Progress Report No. 885. 170-172. [Seven insecticides were tested against *Labops hesperius* on crested wheatgrass in Wyoming; most gave 92-100% control on three and seven-day post treatment sampling.]
- Burmeister, H. C. C. 1835. Handbuch der Entomologie. Tome 2, Abtheil 1: i-xii, 1-400. T. Enslin, Berlin. [This paper contains the original description of *Labops* based upon *L. diopsis* Burmeister [a junior synonym of *Capsus sahlbergi* Fallén, monotypic (Henry and Wheeler 1988)].]
- Campbell, W. F., B. A. Haws, K. H. Asay, and J. D. Hansen. 1984. A review of black grass bug resistance in forage grasses. Journal of Range Management 37: 365-369. [Several mechanisms of resistance are discussed including trichome length, non-preference, tolerance, and antibiosis. The authors conclude that there is potential for breeding resistance to black grass bugs in range grasses.]
- Carvalho, J. C. M. 1958. Catalogo dos Mirideos do Mundo. Parte III. Subfamilia Orthotylinae. Arquivos do Museu Nacional, Rio de Janeiro, Brazil 47: 1-161. [Eleven species of *Labops* are reported from throughout the world, included are *Labops brooksi*, *L. burmeisteri*, *L. chelifera*, *L. hesperius*, *L. hirtus*, *L. nigripes* Reuter, *L. sahlbergi* Fallén, *L. setosus* Reuter, *L. tumidifrons*, *L. utahensis*, and *L. verae*. Relevant literature is referenced and distribution given.]
- Carvalho, J. C. M. 1959. Catalogo dos Mirideos do Mundo. Parte IV. Subfamilia Mirinae. Arquivos do Museu Nacional, Rio de Janeiro, Brazil 48: 1-385. [Fourteen species of *Irbisia* are reported from North America and the Soviet Far East: *Irbisia brachycera*, *I. californica*, *I. castanipes*, *I. cuneomaculata*, *I. elongata*, *I. fuscipubesces*, *I. molliques*, *I. nigripes*, *I. pacifica*, *I. paeta*, and *I. sericans*. (For the most recent documentation, see Schwartz 1984.)]

- Childs, L. 1914. Insect notes. California State Commission of Horticulture. Monthly Bulletin 3: 220. [*Irbisia brachycera* and *I. californica* (as *I. serican*, see Schwartz 1984, p. 234) are reported feeding on grain at Stanford University, causing considerable damage.]
- Cockerell, T. D. A. 1893. The entomology of the mid-alpine zone of Custer County, Colorado. Transactions of the American Entomological Society 20: 305–370. [The biogeography of the region and the impact of the topography, vegetation, and habitats on the insect fauna are discussed. *Irbisia brachycera* is reported from Westcliff, Colorado (as *Capus brachycorus* (sic!) Uhler).]
- Cockerell, T. D. A. 1910. Some insects from Steamboat Springs, Colo. II. Canadian Entomologist 42: 366–370. [*Irbisia brachycera* is reported from Steamboat Springs, Colorado.]
- Coombs, E. M. 1985. Growth and development of the black grass bug (*Labops hesperius* Uhler) in the State of Utah. M.S. thesis, Utah State University, Logan. 163 pp.
- Denning, D. G. 1948. The crested wheat bug. University of Wyoming, Agricultural Experiment Station. Circular No. 33. 2 pp. [*Labops hesperius* is reported damaging crested wheatgrass in Wyoming and affecting the palatability of the damaged hay to cattle.]
- Dickerson, G. W. 1978. Control of black grass bugs (*Labops hesperius* Uhler) in northern New Mexico. Journal of Range Management 31: 398–399. [Trichlorfon, malathion, and methylparathion were used to control *Labops hesperius* in improved wheatgrass pastures. All provided good control; untreated plots showed up to a 50% reduction in herbage yields.]
- Dillman, A. C. 1946. The beginnings of crested wheatgrass in North America. Journal of the American Society of Agronomy 38: 237–250. [The introduction of crested wheatgrass, *Agropyron cristatum*, into North America from Siberia, including sites of original plantings from the early seed importation, is reviewed in detail.]
- Downes, W. 1924. New records of Hemiptera from British Columbia. Proceedings of the Entomological Society of British Columbia 21: 27–33. [*Labops hirtus* is reported from Chilcotin, British Columbia.]
- Downes, W. 1927. A preliminary list of the Heteroptera and Homoptera of British Columbia. Proceedings of the Entomological Society of British Columbia 23: 1–22. [*Irbisia nigripes*, *I. brachycera* var. *solani* (probably *I. serrata*), and *I. sericans*, *I. pacifica* (as *Thyrillus pacificus*), *Labops hirtus*, *L. tumidifrons*, and *L. burmeisteri* are reported from British Columbia, Canada.]
- Drake, C. J. 1922. Heteroptera in the vicinity of Cranberry Lake. Syracuse University, New York State College of Forestry, Technical Publication No. 16: 54–86. [*Labops hirtus* is reported from New York, including both short- and long-winged forms.]
- Essig, E. O. 1915. Injurious and beneficial insects of California (Second edition). California State Commission of Horticulture. The Monthly Bulletin. Supplement 4. 541 pp. [*Irbisia brachycera*, reported as the black plant-bug, is a common insect in California attacking many cultivated crops and native plants. *Irbisia californica* (see Schwartz 1989, p. 263), reported as *Irbisia sericans*, the lesser black plant-bug, damaged barley, oats and wheat as well as other plants. *Irbisia pacifica*, reported as the pacific plant-bug, fed on grasses and grains, including barley, oats, and wheat.]
- Essig, E. O. 1926. Insects of Western North America. Macmillan Company, New York. 1035 pp. [Six species of *Irbisia* are included: *I. solani*, *I. brachycera*, *I. californica*, *I. mollipes*, *I. setosa*, and *I. sericans*. *Irbisia solani* was reported as moving into cultivated fields and gardens when the grasses dry up and attacking a wide variety of plants. *Irbisia californica* and *I. mollipes* attacked grasses and grains. *Irbisia pacifica* was reported from grasses and grain.]
- Essig, E. O. and W. M. Hoskins. 1944. Insects and other pests attacking agricultural crops. University of California, Agricultural Extension Service. Circular 87 (revised). 197 pp. [The black grass bug, *Irbisia solani*, and the California plant bug, *I. californica*, attacked grain in California. *Irbisia* spp. also attacked peaches and nectarines.]
- Fisher, E. M. and R. W. Every. 1969. Federal-State Cooperative Economic Insect Report. Oregon (week ending May 23, 1969). 1 p. [*Labops hesperius* adults damaged brome grass, intermediate wheatgrass, pubescent wheatgrass, and orchard grass in eastern Oregon. Most of the damaged grass was on soil bank land; some stands were as old as 10 years.]
- Foster, R. N., R. T. Staten, E. Miller, J. A. Henderson, J. B. Thernley, D. K. Sato, E. W. Huddleston, and R. G. Bullard. 1981. Malathion for control of black grass bugs. Insecticide and Acaricide Tests 6: 135–136. [Malathion (ULV) was applied at different concentrations on replicated 40 acre plots in New Mexico for control of *Labops hesperius* and *L. hirtus* on *Agropyron desertorum* (Fisch.) Schulten 1978. All treatments were highly successful.]
- Fuxa, J. R. 1975. Biological attributes and alteration of the habitat to manipulate populations of *Labops hesperius* Uhler (Heteroptera: Miridae). M.S. thesis, Oregon State University, Corvallis. 118 pp.
- Fuxa, J. R. and J. A. Kamm. 1976a. Effects of tem-

- perature and photoperiod on the egg diapause of *Labops hesperius*. *Environmental Entomology* 5: 505–507. [*Labops hesperius* diapauses as a well-developed embryo, normally overwintering in that stage. At least 60 days exposure to 3° to 9° C plus approximately 14 days incubation at 15° C are required for hatching to occur. No hatching occurred if the chilling occurred in August. Approximately 40% hatching occurred if the chilling was delayed until September or later. The combination of increasing temperatures and day length in early spring appears to regulate egg hatch, allowing the eggs to hatch at relatively cold temperatures, an ideal adaptation to early herbage growth of host grasses.]
- Fuxa, J. R. and J. A. Kamm. 1976b. Dispersal of *Labops hesperius* on rangeland. *Annals of the Entomological Society of America* 69: 891–893. [The adult population of *Labops hesperius* was analyzed at Vale, Oregon, in 1974; 43% were macropterous males, 53% brachypterous females, and only 4% macropterous females. Apparently the ovaries of macropterous females do not mature until the adults have completed their migratory phase of about three weeks. Dispersal capabilities were considered to be limited because of the high percentage of brachypterous females in the population. There was a positive correlation between old growth wheatgrass and bug density.]
- Gates, D. H. 1969a. ABC (another bug on crested)-problem. Oregon State University, United States Department of Agriculture, and Oregon Counties Cooperating. The *Grazier*. No. 127: 3. [*Labops hesperius* and *Irbisia* spp. are reported damaging wheatgrass in several localities in eastern Oregon.]
- Gates, D. H. 1969b. Black grass bug observations in Utah. Oregon State University, United States Department of Agriculture, and Oregon Counties Cooperating. The *Grazier*. No. 127: 5–6. [This report, taken from the Cooperative Economic Insect Report 16(25): 596, 1966, Plant Pest Control Division, Agricultural Research Service, United States Department of Agriculture, reviews several species of black grass bugs found in Utah: *Irbisia brachycera*, *Irbisia* spp., *Labops hesperius*, *L. hirtus*, and *L. utahensis*. Damage was reported on planted crested wheatgrass, intermediate wheatgrass, other wheatgrasses and miscellaneous grass species. *Labops* spp. caused more damage at higher elevations and *Irbisia* spp. at lower elevations. Barley was attacked in Sanpete County by *Irbisia* spp., as was rye in many areas of Utah. Seed damage to crested and intermediate wheatgrass was also common. It was felt that summer rains would result in additional grass growth, reducing the impact of the bugs' feeding.]
- Gates, D. H. 1969c. Wheatgrass bugs (*Labops* spp.). Oregon State University, United States Department of Agriculture, and Oregon Counties Cooperating. The *Grazier*. No. 127: 4–5. [This report was abstracted from the Cooperative Economic Insect Report, Plant Pest Control Division, Agricultural Research Service, United States Department of Agriculture. General economic importance of these bugs is reported from western United States where damage to crested and intermediate wheatgrass occurred. Distribution information by state and province (Canada) is given. Life history information is given and the bug briefly described.]
- Gibson, A. 1910. The entomological record, 1909. Entomological Society of Ontario, Fortieth Annual Report: 110–128. [*Labops burmeisteri* is reported from Ontario, Canada; this is the first published record of this native species in North America.]
- Gibson, A. 1913. The entomological record, 1912. Entomological Society of Ontario, Forty-third Annual Report: 113–140. [*Irbisia brachycera* and *I. sericans* are reported from the Queen Charlotte Islands, Canada.]
- Gillette, C. P. and C. F. Baker. 1895. A preliminary list of the Hemiptera of Colorado. (Colorado) State Agricultural College, Agricultural Experiment Station, Bulletin No. 31, Technical Series No. 1. 137 pp. [*Labops hesperius* is reported from several localities in Colorado. *Irbisia brachycera* and *I. pacifica* are also reported (as *Thyrillus brachycerus* and *T. pacificus*).]
- Gray, A. M. 1975. Nutritional quality and herbage production of intermediate wheatgrass (*Agropyron intermedium* (Host) Brauv.) when infested with black grass bugs (*Labops hesperius* Uhler). M.S. thesis, Utah State University, Logan. 42 pp.
- Hagen, A. F. 1976. Crested wheatgrass, *L. hesperius* control, 1975. Insecticide and Acaricide Tests 1: 102. [Several different chemicals, together with a control, were applied to plots in Scotts Bluff County, Nebraska. All treatments gave highly effective results.]
- Hagen, A. F. 1982. *Labops hesperius* (Hemiptera: Miridae) management in crested wheatgrass by haying: An eight-year study. *Journal of Economic Entomology* 75: 706–707. [Annual harvest of a crested wheatgrass field significantly reduced the populations of *Labops hesperius* compared to a similar field that was not harvested.]
- Hall, I. M. 1959. The fungus *Entomophthora erupta* (Dustan) attacking the black grass bug, *Irbisia solani* (Heidemann) (Hemiptera, Miridae), in California. *Journal of Insect Pathology* 1: 48–51. [This fungus caused an epizootic at Riverside, California. The fungus was previously known only from the mirids *Lygus communis* var. *novascotiensis*

- Knight and *Plagiognathus* sp. Illustrations of the infected *Irbisia* are included together with a general description of the appearance of infected bugs.]
- Hansen, J. D. 1986. Differential feeding on range grass seedlings by *Irbisia pacifica* (Hemiptera: Miridae). *Journal of the Kansas Entomological Society* 59: 199–203. [Eighteen range grasses were tested for feeding preference by *I. pacifica*. *Leymus cinereus* (Scrib. & Merr.) Love was the species most preferred and *Psathyrostachys juncea* (Fisch.) Nevski and *Agropyron fragile* (Roth) Candargy, the least preferred.]
- Hansen, J. D. 1987. Feeding site selection by *Irbisia pacifica* (Hemiptera: Miridae) on four cool-season western range grasses. *Journal of the Kansas Entomological Society* 60: 316–323. [Feeding sites by *I. pacifica* were examined on Great Basin wildrye, *Leymus cinereus* (Scrib. & Merr.) Love, a crested wheatgrass hybrid and a hybrid between quack grass and blue bunch wheatgrass. Feeding density was greatest at the leaf apex and least at the base.]
- Hansen, J. D. 1988. Field observations of *Irbisia pacifica* (Hemiptera: Miridae): Feeding behavior and effects on host plant growth. *Great Basin Naturalist* 48: 68–74. [The interaction of *I. pacifica* with intermediate wheatgrass, *Thinopyrum intermedium* (Host) Barkw. and D. R. Dewey, was examined in northern Utah. Egg hatch began in April; ovarian development was completed by mid-June. The second and third leaves were the preferred feeding sites.]
- Hansen, J. D., K. H. Asay, and D. C. Nielson. 1985a. Screening range grasses for resistance to black grass bugs *Labops hesperius* and *Irbisia pacifica* (Hemiptera: Miridae). *Journal of Range Management* 38: 254–257. [Three crested wheatgrasses and two hybrids between quack grass and blue bunch wheatgrass were tested for resistance to feeding by these mirids. No difference in feeding preferences was noted. Tolerance is suggested as a possible mechanism of resistance.]
- Hansen, J. D., K. H. Asay, and D. C. Nielson. 1985b. Feeding preference of a black grass bug, *Labops hesperius* (Hemiptera: Miridae), for 16 range grasses. *Journal of the Kansas Entomological Society* 58: 356–359. [Sixteen grass species and hybrids were tested for feeding preference by *L. hesperius*. *Dactylis glomerata* L., *Phalaris arundinacea* L. and *Pascopyrum smithii* (Rydb.) Love were among the least preferred and crested and intermediate wheatgrasses the most preferred.]
- Hansen, J. D. and R. S. Nowak. 1988. Feeding damage by *Irbisia pacifica* (Hemiptera: Miridae): Effects of feeding and drought on host plant growth. *Annals of the Entomological Society of America* 81: 599–604. [Green leaf area per tiller was reduced by two-thirds in intermediate wheatgrass, for Great Basin wildrye (GBWR), the reduction was one-half. Drought conditions further reduced green leaf area on bug-infested GBWR but did not damage the previously affected intermediate wheatgrass.]
- Hardee, D. D., H. Y. Forsythe, Jr., and G. G. Gyrisco. 1963. A survey of the Hemiptera and Homoptera infesting grasses (Gramineae) in New York. *Journal of Economic Entomology* 56: 555–559. [*Labops hirtus* is recorded from grass fields in New York.]
- Harling, J., J. M. Snyder, and D. M. Coletti. 1977. Insects collected from an alpine-sub alpine region in southeast British Columbia. *Journal of the Entomological Society of British Columbia* 74: 34–36. [*Irbisia nigripes* is reported from the Selkirk Mountains in southeastern British Columbia, Canada.]
- Harrington, W. H. 1892. Fauna Ottawaensis, Hemiptera. *Ottawa Naturalist* 6: 25–32. [*Labops hesperius* is reported from the vicinity of Ottawa, Canada, and the long-winged form noted as rare.]
- Haws, B. A. 1972. Preliminary report on black grass bug *Labops hesperius* Uhler. United States Department of Agriculture, Forest Service, Inter Mountain Region, Range Improvement Notes 17: 1–3. [The Black Grass Bug project at Utah State University was established in 1971. Full observations on the bug showed early seasonal growth of range grasses and concomitant development of early instar bugs, which were active at low air temperatures (22° F). There was evidence that considerable damage to the grass by bugs occurred early in the season.]
- Haws, B. A. (Compiler). 1978. Economic impacts of *Labops hesperius* on the production of high quality range grasses. Utah State University, Agricultural Experiment Station. Final Report to Four Corners Regional Commission. 267 pp. [The environmental impact of *L. hesperius*, upon range grasses, chiefly crested and intermediate wheatgrass, is discussed. Other arthropods, including some natural enemies of *L. hesperius*, are reported.]
- Haws, B. A. 1979. Something is eating more grass than our livestock. *Rangelands* 1: 135–138. [This popular account of range insects includes several references to *Labops hesperius* and its damage to grasses.]
- Haws, B. A. (Compiler). 1982a. An introduction to beneficial and injurious rangeland insects of the western United States. Utah State University, Utah Agriculture Experiment Station. Special Report 23. 64 pp. [This general introduction to the insects found on western rangeland includes many photographs of *Labops hesperius* and *Irbisia pacifica* and their damage. The role of *L. hesperius* as a rangeland pest is discussed.]

- Haws, B. A. (Compiler). 1982b. Rangeland improvement; Demonstration Project. FCRC No. 602-466-080-4. Final Report of Five States to the Four Corners Regional Commission (Arizona, Colorado, Nevada, New Mexico, Utah). Utah State University, Logan. 282 pp. [A summary of cooperative work involving Nevada, Utah, Colorado, New Mexico and Arizona on *Labops hesperius*, *L. hirtus*, *L. utahensis*, *Irbisia brachycera* and *I. pacifica* is included. Plantings of crested wheatgrass along highways were suggested to provide "bug free-ways" for dispersal of the insects.]
- Haws, B. A. 1986. The status of IPM strategies for controlling grass bugs infesting introduced grassland monocultures, pp. 67-72. In Onsager, J. A., ed., Integrated Pest Management on Rangeland. United States Department of Agriculture, Agricultural Research Service. ARS-50. [Strategies for managing grass bugs include chemical control, plant resistance, burning, grazing, planting heterocultures, and biological control. Future work on reducing the grass monocultures is suggested.]
- Haws, B. A. and G. E. Bohart. 1986. Black grass bugs (*Labops hesperius* Uhler) (Hemiptera: Miridae) and other insects in relation to crested wheatgrass, pp. 123-145. In Johnson, K. L., ed., Crested Wheatgrass: Its Values, Problems and Myths: Symposium Proceedings. Utah State University, Logan. [The insects, native and introduced, range grasses, and the problems of management strategies to minimize the impact of insect damage are reviewed. Basic biology of the bugs is compared to phenology of the wheatgrass. Many possible control strategies are discussed.]
- Haws, B. A., D. D. Dwyer, and M. G. Anderson. 1973. Problems with range grasses? Look for black grass bugs! Utah Science 34: 3-9. [Information on the recognition, distribution, life history of *Irbisia pacifica*, *Labops hesperius*, *L. hirtus*, and *L. utahensis*, their damage, and management and control is included.]
- Haws, B. A., C. M. McKell, and J. Malechek. 1976. Do insects affect the validity of basic assumptions of grazing management? Society for Range Management, 29th Annual Meeting, Abstract, p. 28. [Some reproductive structures of crested wheatgrass developed despite a heavy concentration *Labops hesperius* (900 per sweep). Undergrazed ranges had heavier bug infestations because of increased dead grass and plant debris, which provided sites for egg deposition.]
- Hayward, C. L. 1948. Biotic communities of the Wasatch chaparral, Utah. Ecological Monographs 18: 473-506. [*Irbisia brachycerus* is reported from the herb layer of the lower chaparral of the Wasatch Mountains, Utah.]
- Heidemann, O. 1900. Papers from the Harriman Alaska Expedition. XIII. Entomological Results (7): Heteroptera. Proceedings of the Washington Academy of Sciences 2: 503-506. [*Irbisia sericans*, originally described from Sitka, Alaska, is recorded from eight locations in Alaska during June and July in both macropterous and brachypterous forms. A collection record from near Hood River, Oregon, is included.]
- Heidemann, O. 1910. Description of a new capsid. Proceedings of the Entomological Society of Washington 12: 200-201. [*Irbisia solani* is described (as *Capsus solani*) from Walnut Creek, California, with other specimens from California, Washington, and Utah. It was found on *Lupinus* sp. in California and injured potato plants.]
- Henry, T. J. and A. G. Wheeler, Jr. 1988. Miridae, pp. 25-507. In Henry, T. J., and R. C. Foreschner, eds., Catalog of the Heteroptera, or True Bugs, of Canada and the Continental United States. E. J. Brill, Leiden. 958 pp. [Twenty-three species of *Irbisia* are included. Only a single species, *I. sericans*, extends from the Pacific Northwest into eastern Asia. Eight species of *Labops* are cataloged, including *L. burmeisteri*, a species known to occur in northern North America and west into the eastern Palearctic Region.]
- Hermes, W. B. 1926. An analysis of California's major entomological problems. Journal of Economic Entomology 19: 262-270. [*Irbisia solani* migrated from grass as it dried to feed on the California buckeye, *Aesculus californica* Nuttall. Droplets of plant sap exuding from the punctures made by the bugs were fed upon by bees.]
- Hewitt, G. B. 1975. Grass bugs may be present on your rangeland. Society for Range Management, International Mountain Section, Newsletter No. 1: 3. [This brief review of the presence of *Labops* and *Irbisia* on range grasses and grain includes a history of their occurrence and effect upon the vegetation. A chemical control method is cited from the publication by C. C. Burkhardt (1974).]
- Hewitt, G. B. 1980. Tolerance of ten species of *Agropyron* to feeding by *Labops hesperius*. Journal of Economic Entomology 73: 779-782. [Cultivars of ten different species and varieties of the wheatgrasses, *Agropyron* spp., were screened for feeding tolerance to *L. hesperius* and *Capsus simulans* Stål at Bozeman, Montana. Infested and non infested plants were compared for number of culms per plant, percentage of abnormal seed heads, seed production, seed weight, seed germination, forage production, and percentage leaf damage. Feeding reduced the number and weight of seeds, and the percentage of germination of most grass species. Silver top was recorded only in infested cages. Tall, slender, intermediate, and pubescent wheatgrasses appeared somewhat tolerant to grass bug feeding;

- however, grass bugs preferred introduced wheatgrasses over native vegetation.]
- Hewitt, G. B. and W. H. Burleson. 1975. Arthropods associated with two crested wheatgrass pastures in central Montana. *Journal of Range Management* 28: 301-304. [Two crested wheatgrass (*Agropyron desertorum*) (Fisch.) Schult.) pastures were surveyed for arthropods in 1972 and 1973. Although it was expected both *Irbisia* spp. and *Labops* spp. would be abundant, only 21 specimens of *Irbisia* and no *Labops* were collected during the two-year study.]
- Hewitt, G. B. and W. H. Burleson. 1976. An inventory of arthropods from three rangeland sites in central Montana. *Journal of Range Management* 29: 232-237. [Three sites in central Montana were sampled in 1972 and 1973: a mountain, foothill, and plains rangeland. Seven orders of arthropods formed the bulk of the material collected. *Labops hesperius* was the second most abundant insect at the mountain site but was not collected at the other two sites; *L. brooksi* was taken in small numbers at the foothill site.]
- Hewitt, G. B., E. W. Huddleston, R. J. Lavigne, D. N. Veckert, and J. G. Watts. 1974. Rangeland Entomology. Society for Range Management, Range Science Series No. 2. 127 pp. [This review of sucking insects of grasses and forbs in rangeland includes *Irbisia* spp. and *Labops* spp. and brief discussion of their damage, biology, and control.]
- Higgins, K. M. 1975. The effects of the black grass bug *Labops hesperius* Uhler, on several native and introduced grasses. M.S. thesis, Utah State University, Logan. 82 pp.
- Higgins, K. M., J. E. Bowns, and B. A. Haws. 1977. The black grass bug (*Labops hesperius* Uhler): Its effect on several native and introduced grasses. *Journal of Range Management* 30: 380-384. [Six introduced grass species were more susceptible to damage by *L. hesperius* than native range grasses. Slender and intermediate wheatgrasses and Kentucky bluegrass were the most susceptible.]
- Homan, H. W. 1977. *Labops* grass bug, *Labops utahensis*. University of Idaho, Cooperative Extension Service. Idaho's Insect Reporter, p. 33. [*Labops utahensis* caused minor damage to a grain field near Driggs, Idaho.]
- Horning, D. S., Jr. and W. F. Barr. 1970. Insects of Craters of the Moon National Monument, Idaho. University of Idaho, College of Agriculture, Miscellaneous Series No. 8. 118 pp. [*Irbisia pacifica* is reported from this area.]
- Jensen, F. 1971. Reseeding and *Labops*. United States Department of Agriculture, Forest Service, Inter Mountain Region. Range Improvement Notes 16: 6-9. [Severe damage to range grasses by *L. hesperius* is reported in Dixie National Forest, Utah, where the areas have been plowed or otherwise disturbed and then seeded with crested wheatgrass, intermediate wheatgrass, and smooth brome. Large numbers of *Labops* were found on giant wild ryegrass. Several treatments were used on the range prior to reseeding, plowing, cabling, and chaining. Pesticide control of *Labops* was ineffective; creation of a balanced plant community rather than a monoculture was recommended.]
- Jensen, F. 1973. Reseeding and *Labops*. Society for Range Management, 26th Annual Meeting Abstract, p. 23. [*Labops hesperius* inhabits much of the reseeded rangelands on the Dixie National Forest, Utah. Population densities and resulting damage are related to plant community diversity. Densities were greatest in plowed rangelands that had been seeded to virtual monocultures of crested wheatgrass, intermediate wheatgrass, or smooth brome. Planting for a more diversified plant community is suggested, including the conservation of native grasses.]
- Kamm, J. A. and J. R. Fuxa. 1977. Management practices to manipulate populations of the plant bug *Labops hesperius* Uhler. *Journal of Range Management* 30: 385-387. [Populations on wheatgrass increased with nitrogen fertilization; no response was shown to applications of phosphorus and potassium. Early curing of the herbage with paraquat, mechanical removal of the herbage, and heavy spring grazing all reduced bug populations in spring and summer. Grassbug survival is enhanced by pastures with adequate oviposition sites, winter protection, and habitat.]
- Kamm, J. A. and R. R. Robinson. 1974. *Labops*, a plant bug, on Oregon rangeland. Oregon State University, Extension Service, Fact Sheet 211. 2 pp. [*Labops hesperius* is reported on native rangeland seeded with introduced wheatgrasses in eastern Oregon. Many different grasses, introduced and native, are recorded as host plants. The general life history is described. One hundred and twenty bugs per ft² reduced the nutritive value of intermediate wheatgrass by 18% midway in the growing season. This loss decreased to 23% if the rangeland was reserved for fall pasture. Greatest losses occur during severe summer drought.]
- Kamm, J. A., F. A. Sneva, and L. M. Rittenhouse. 1978. Insect grazers on the cold desert biome. Proceedings of the First International Rangeland Congress, D. N. Hyder (ed.), Society for Range Management, Denver, Colorado, pp. 479-483. [Population levels of *Labops hesperius* increased in response to widespread planting of introduced wheatgrasses. Increased use of resistant grass varieties could have occurred if the pest potential of this bug had been recognized.]
- Kelton, L. A. 1959. Male genitalia as taxonomic char-

- acters in the Miridae (Hemiptera). Canadian Entomologist (Supplement 11) 91: 1–72. [This review of male genitalia structure in mirids includes *Irbisia pacifica*, *I. sericans*, *Labops hesperius*, *L. hirtus* and *L. sahlbergi*.]
- Kelton, L. A. 1980. The insects and arachnids of Canada. Part 8. The plant bugs of the Prairie Provinces of Canada. Heteroptera: Miridae. Agriculture Canada. Publication 1703. 408 pp. [This review of the mirids of west-central Canada includes a brief description of each species with distribution maps and host information. Keys are given to allow identification of each species. Some species (*Labops hirtus*) are illustrated with habitus drawings. The genus *Irbisia* (pp. 83–86) includes the four species found in the Prairie Provinces (*I. brachycera*, *I. elongata*, *I. fuscipubescens*, and *I. nigripes*). The genus *Labops* (pp. 189–194) includes *L. brooksi*, *L. hesperius*, *L. hirtus*, *L. tumidifrons*, and *L. verae*.]
- Kirkaldy, G. W. 1906. List of the genera of the pagliopodus Hemiptera-Heteroptera, with their type species, from 1758 to 1904 (and also of the aquatic and semi-aquatic Trochalopoda). Transactions of the American Entomological Society 32: 117–156. [This important paper lists the type species of the genera of several families, including *Irbisia* and *Labops*.]
- Knight, H. H. 1918. Synoptic key to the subfamilies of Miridae (Hemiptera-Heteroptera). Journal of the New York Entomological Society 26: 40–44. [Details of the claw of *Labops hesperius* are illustrated.]
- Knight, H. H. 1921. Scientific results of the Katmai expeditions of the National Geographic Society. XIV. Hemiptera of the family Miridae. Ohio Journal of Science 21: 107–112. [*Irbisia sericans* is reported from Katmai, Alaska, where it was abundant and feeding on rye grass. Described originally from Sitka, Alaska, it is the only species of *Irbisia* to occur in the Old World (Siberia).]
- Knight, H. H. 1922. The North American species of *Labops* (Heteroptera-Miridae). Canadian Entomologist 54: 258–261. [Three species are considered: *L. hesperius*, *L. hirtus*, and *L. tumidifrons*, the latter two described as new. *Labops hirtus* is described from New York with other specimens from across northern United States and southern Canada. *Labops tumidifrons* is described from British Columbia, Canada. Some notes are included on the taxonomic value of the shape of the male clasper.]
- Knight, H. H. 1923. Family Miridae (Capsidae), pp. 422–658. In Britton, W. E., ed., Guide to the Insects of Connecticut. Part IV. The Hemiptera or Sucking Insects of Connecticut. State of Connecticut, State Geological and Natural History Survey, Bulletin No. 34. 807 pp. [A brief description of *Labops hirtus* and state records from Maine, Massachusetts, and New York are given.]
- Knight, H. H. 1925a. Descriptions of a new genus and eleven new species of North American Miridae (Hemiptera). Canadian Entomologist 57: 89–97. [*Irbisia nigripes* is described as new from Troy, Idaho, with additional specimens from Alberta, British Columbia, Canada, and Montana.]
- Knight, H. H. 1925b. A list of Miridae and Anthocoridae from Alberta, Canada (Hemiptera). Canadian Entomologist 57: 181–182. [*Labops hesperius* is reported from Nordegg, Alberta, Canada, and *Irbisia nigripes* from Waterton Lakes in the same province.]
- Knight, H. H. 1926. *Capsus simulans* (Stål) and *Labops burmeisteri* Stål recognized from the Nearctic Region. (Hemiptera, Miridae). Canadian Entomologist 58: 59–60. [*Labops burmeisteri* is reported from the Abitibi Region of northern Ontario, Canada. This species was described originally from Siberia. Although there had been earlier records of this species from North America, Knight was unable to locate any specimens.]
- Knight, H. H. 1927. On the Miridae in Blatchley's "Heteroptera of Eastern North America." Bulletin of the Brooklyn Entomological Society 22: 98–105. [Blatchley's concept of *Labops hesperius*, which includes species variation associated with geographic distribution, is discussed.]
- Knight, H. H. 1928. Family Miridae, pp. 110–134. In Leonard, M. D., ed., A List of the Insects of New York. Cornell University, Agricultural Experiment Station, Memoir 101. 1121 pp. [Localities of *Labops hirtus* for the state of New York are listed.]
- Knight, H. H. 1929a. *Labops verae*, new species, with *Labopella*, *Nicholia* and *Pronotocrepis*, new genera of North American Miridae (Hemiptera). Canadian Entomologist 61: 214–218. [A new high-altitude, high-latitude species of *Labops*, *L. verae*, is described from Mt. Rainier, Washington, and Banff, Alberta.]
- Knight, H. H. 1929b. Rectifications for Blatchley's "Heteroptera" with the description of a new species (Hemiptera). Bulletin of the Brooklyn Entomological Society 24: 143–154. [The identity of the *Labops* species treated by Blatchley (1926) is clarified.]
- Knight, H. H. 1941a. New species of *Irbisia* Reuter (Hemiptera, Miridae). Bulletin of the Brooklyn Entomological Society 36: 75–79. [Three new species of *Irbisia* are described from western North America (*I. elongata*, *I. fuscipubescens* and *I. shulli*). Distributional information is included for each new species and for *I. brachycera*.]
- Knight, H. H. 1941b. The plant bugs, or Miridae of

- Illinois. Illinois Natural History Survey, Bulletin. Volume 22: 1–234. [No *Labops* species were reported from Illinois; *L. hirtus* is reported from Colorado, Maine, Massachusetts, Montana, New York, and Ontario, Canada.]
- Knight, H. H. 1968. Taxonomic review: Miridae of the Nevada Test Site and the western United States. Brigham Young University, Science Bulletin, Biological Services 9: 1–282. [This review of mirids found in western United States includes descriptions of many new species and keys for the identification of many of the included species. Five species of *Irbisia* are briefly discussed and keyed (*I. brachycera*, *I. elongata*, *I. nigripes*, *I. pacifica*, and *I. shulli*). Information is largely restricted to collection localities. *Labops hesperius*, *L. hirtus*, and *L. utahensis* are listed with state distribution records only.]
- Knight, J. B. 1982. An initial survey of the insects associated with five grassland sites in central Utah. M.S. thesis, Utah State University, Logan. 81 pp.
- Knight, J. B. 1986. Range insects—pests and beneficials, pp. 73–75. In Onsager, J. A., ed., Integrated Pest Management on Rangeland. United States Department of Agriculture, Agricultural Research Service. ARS-50. [A brief review of the pest insects found on rangeland, including Homoptera, Hemiptera, Lepidoptera, Diptera and Hymenoptera, is followed by general remarks on biological control agents, chiefly of weeds.]
- Knowlton, G. F. 1931. Notes on Utah Heteroptera and Homoptera. Entomological News 42: 68–72. [*Irbisia brachycerus* var. *solani* Heidemann and *I. pacifica* (as *Thyrillus pacificus*) are reported from several localities in Utah.]
- Knowlton, G. F. 1932. Notes on Utah Hemiptera. Canadian Entomologist 64: 166–167. [*Labops hirtus* is reported from Providence, Utah.]
- Knowlton, G. F. 1945. *Labops* damage to range grasses. Journal of Economic Entomology 38: 707–708. [*Labops tumidifrons* fed in large numbers on giant wild rye, *Elymus condensatus* Presl., in Utah. Other specimens were collected on bunch grass and large bunch grass at several sites in Utah and Idaho. *Labops hesperius* was collected on meadow grass and at several other localities in Utah on smooth broom. *Labops hirtus* was taken on range grasses in Utah and Idaho.]
- Knowlton, G. F. 1951. Bugs damage grass in Utah. Bulletin of the Brooklyn Entomological Society 46: 74–75. [*Irbisia pacifica* (as *Thyrillus pacificus*) damaged giant rye grass Timothy, blue grass brome, and several other grasses in Morgan County, Utah. Other Hemiptera found on the grasses were *Labops hirtus* and *Slaterocoris atritibialis* (Knight) (as *Strongylocoris atritibialis*.)
- Knowlton, G. F. 1955a. Hemiptera of Utah—records. Utah State Agricultural College, Extension Service, Mimeograph Series No. 140. 15 pp. [*Irbisia arcuata*, *I. brachycera*, *I. solani* and *Labops hesperius*, *L. hirtus*, and *L. utahensis* are reported from Utah.]
- Knowlton, G. F. 1955b. Some Hemiptera and Homoptera of Utah—1955. Utah State Agricultural College, Extension Service, Mimeograph Service No. 145. 9 pp. [*Irbisia elongata* is reported from Utah.]
- Knowlton, G. F. 1966a. Insect conditions in Utah—1966. Utah State University, Cooperative Extension, Entomology Mimeo Series No. 114. 4 pp. [Approximately 200,000 acres were damaged by *Labops hesperius*, *L. utahensis*, *Irbisia brachycera*, *I. shulli*, and *I. pacifica* in Utah during 1966.]
- Knowlton, G. F. 1966b. Grass bugs, range and crop pests in Utah. Utah State University, Cooperative Extension, Entomology Mimeo Series No. 119. 5 pp. [This brief general discussion of the extent and range of damage to grasses and crops in Utah by mirids gives detailed distributional information for 15 species including *Labops hesperius*, *L. hirtus*, *L. utahensis*, *Irbisia brachycera*, *I. pacifica*, and *I. shulli*.]
- Knowlton, G. F. 1967. Grass bugs: A serious range problem in 1966. Utah Academy of Sciences, Arts and Letters 43: 20–21. [Grass bugs extensively damaged crested wheatgrass, intermediate wheatgrass, giant rye grass, and other planted and native grasses in Utah. The species included *Irbisia brachycera*, *I. pacifica*, *I. shulli*, *Labops hesperius*, *L. utahensis*, *Leptopterna ferrugata* (Fallén), *Stenodema pilosipes* Kelton, *S. vicinum* (Provancher), and *Trigonotylus dohertyi* (Distant). At least 200,000 acres were damaged, especially at higher elevations. Wheat, barley, and rye were also damaged.]
- Knowlton, G. F. 1973. Some Hemiptera of Curlew Valley. Utah State University, Terrestrial Arthropod Series No. 5. 8 pp. [A partial list of the Hemiptera of the Utah portion of Curlew Valley includes records of *Irbisia brachycera* on crested wheat and giant rye grasses and *I. brachycerus solani* (probably *I. serrata*) (no hosts given) and *I. pacifica* on crested wheatgrass and giant ryegrass. *Labops hesperius* was reported from crested wheatgrass at Cedar Creek, Utah.]
- Knowlton, G. F. and F. C. Harmston. 1940. Utah insects. Hemiptera. Utah State College, Utah Agricultural Experiment Station, Mimeograph Series 200 (Technical). Part 5. 10 pp. [*Labops hesperius* and *L. hirtus* are reported from several localities in Utah as are *Irbisia brachycera*, *I. brachycera solani*, *I. mollipes*, *I. arcuata*, and *I. nigripes*.]
- Kumar, R., R. J. Lavigne, J. E. Lloyd, and R. E. Pfadt. 1976. Insects of the Central Plains Experiment

- Range, Pawnee National Grassland. University of Wyoming, Agricultural Experiment Station, Science Monograph 32. 74 pp. [*Labops hesperius* is reported from the Central Plains Experimental Range (Pawnee National Grasslands) in Colorado.]
- La Follette, R. A. 1915. Preliminary list of common Heteroptera from the Claremont-Laguna region. *Journal of Entomology and Zoology* 7: 123-129. [*Irbisia politus* Uhler is reported from Claremont, California and nearby localities. (This must be a mistake; there is no combination, *Irbisia politus* Uhler, and one species is described as "very dark olive green, legs yellowish brown.")]
- Lange, W. H., Jr. 1941. The artichoke plume moth and other pests injurious to the globe artichoke. University of California, Agricultural Experiment Station, Bulletin 653. 71 pp. [*Irbisia solani* is reported as damaging artichokes; the report is attributed to Tavernetti (1933).]
- Larochelle, A. 1984. Les punaises terrestres (Hémiptères: Geocoris) du Québec. *Fabriques, Supplément* 3. 1-513. [*Irbisia sericans*, *Labops hesperius*, *L. hirtus*, and *L. burmeisteri* are reported from Quebec, Canada. An extensive bibliography on the hemipteran fauna of Quebec is included with keys for identification. (The record for *I. sericans* has not been duplicated (Schwartz 1984, p. 263).)]
- Larochelle, A. and M. C. Larivière. 1979. Le genre *Labops* Burmeister du Québec, Canada (Heteroptera: Miridae): Repartition géographique, habitat et biologie. *Bulletin d'inventaire des insectes du Québec* 1(4): 61-67. [This review of *Labops* spp. found in the province of Quebec, Canada, includes *Labops burmeisteri* and *L. hirtus*. *Labops hesperius*, reported from Quebec by early authors, is removed from the faunal list because no specimens could be located to document its occurrence.]
- Leonard, M. D. (ed.). 1928. A list of the insects of New York. Cornell University, Agricultural Experiment Station. Memoir 101. 1121 pp. [*Labops hirtus* is reported from several localities in New York State.]
- Lindsay, H. G. 1970. A serious threat: Black grass bugs. *Utah Farmer*. August 6, 1970, p. 12. [This article discusses black grass bugs in Utah, especially *Labops* spp. Details on life history, damage, and possible chemical control methods are given and the need for research on this problem is stated.]
- Ling, Y. H. 1982. Scanning electron microscopic (SEM) studies on range grasses and their resistance to black grass bugs. M.S. thesis, Utah State University, Logan. 94 pp.
- Ling, Y. H., W. F. Campbell, B. A. Haws, and K. H. Asay. 1985. Scanning electron microscope (SEM) studies of morphology of range grasses in relation to feeding by *Labops hesperius*. *Crop Science* 25: 327-332. [Selected grass varieties were subjected to similar bug densities in rearing chambers. Results suggested that selecting clones of wheatgrasses with large trichomes should confer some resistance to this insect.]
- Loan, C. C. 1965. Life cycle and development of *Leiophron pallipes* Curtis (Hymenoptera: Braconidae: Euphorinae) in five mirid hosts in the Belleville district. *Proceedings of the Entomological Society of Ontario* 95: 115-121. [The braconid parasite *Leiophron pallipes* was reared from *Labops hirtus* near Belleville, Ontario, Canada. The parasite larva emerged from the adult bug and then pupated, spinning a silken cocoon. The adult wasp emerged the following year.]
- Loan, C. C. 1980. Plant bug hosts (Heteroptera: Miridae) of some euphorine parasites (Hymenoptera: Braconidae) near Belleville, Ontario, Canada. *Naturaliste Canadien* 107: 87-93. [The braconid parasite *Peristenus pallipes* (Curtis) was reared from *Labops hirtus* collected near Belleville, Ontario, Canada, as well as from four other mirid species.]
- Lockwood, S. 1933. Insect and mite scars of California fruits. California Department of Agriculture. *Monthly Bulletin* 22: 319-345. [*Irbisia solani* was suspected of causing scarring of peaches, especially in orchards close to grassy or weedy slopes. The bugs became very abundant in the orchards after the surrounding vegetation dried up.]
- Lockwood, S. 1937. Farm sanitation aids pest control. *California Cultivator* 84: 537, 557. [Black grass bugs (no scientific name given) are reported as a pest of cultivated crops, especially peaches, moving to these plants as the grasses dried up.]
- Lockwood, S. and E. T. Gammon. 1949. Incidence of insect pests. California Department of Agriculture. *Bulletin* 38: 190-203. [*Irbisia* sp. is reported cat-facing peaches, cherries, and plums in parts of Riverside County, California. DDT was used for control.]
- MacGillivray, A. D. and C. O. Houghton. 1903. A list of insects taken in the Adirondack Mountains, N.Y.—III. *Entomological News* 14: 262-265. [*Labops hesperius* is reported from the Adirondack Mountains of New York.]
- Malechek, J. C., A. M. Gray, and B. A. Haws. 1977. Yield and nutritional quality of intermediate wheatgrass infested by black grass bugs at low population densities. *Journal of Range Management* 30: 128-131. [Populations of *Labops hesperius* at 156 bugs per m² did not affect herbage yields of intermediate wheatgrass in Utah. Seed head production was reduced 56%, resulting in a slight in-

- crease in crude protein and a small decrease in cell content.]
- Markgraf, P. M. 1974. Effects of wheatgrass bug infestation on range grasses. Society for Range Management, 27th Annual Meeting. Abstract, p. 31. [*Labops hesperius* was studied on soil bank lands seeded to wheatgrasses in northeast Oregon. Feeding by mature nymphs and adults was heavy in May, reducing current annual growth of air-dry herbage by 13%. The quality of the resulting foliage was 5% less digestible. Although chemical control of the bugs is possible, resource management to reduce litter and straw accumulation was considered more economical.]
- McAtee, W. L. 1923. Hemiptera. In A biological survey of the Pribilof Islands, Alaska, Part II. Insects, arachnids, and chilopods. North American Fauna No. 46. p. 145. [*Irbisia sericans* is reported from the St. Paul Island and St. George Island, Alaska, from June to September.]
- McKendrick, J. D. and D. P. Bleicher. 1980. Observations of a grass bug on bluejoint ranges. Agroborealis 12: 15–18. [A native bluejoint reedgrass (*Calamagrostis canadensis* (Michx.) Beauv.) was damaged by *Irbisia sericans* near Homer, Alaska. The range of this bug includes parts of eastern Siberia and Alaska south to San Francisco, California. Evidence showed a negative correlation between insect damage and total nonstructural carbohydrates in the grass. The possibility of some resistance to insect damage because of silica in the grass was suggested. The bug was also reported from fireweed (*Epilobium angustifolium* L.).]
- Mills, H. B. 1939. Montana insect pests for 1937 and 1938. Montana State College, Agricultural Experiment Station, Bulletin 366. 32 pp. [*Labops hesperius* and *Conostethus* n. sp. were found on range grasses and winter wheat at sites in Montana. The number of bugs declined in late May and the wheat outstripped the injury. The range grasses attacked were *Koeleria cristata* (L.) Pers., *Poa secunda* Presl., *Stipa comata* Trin. and Rupt., *Stipa williamsi* Scrbn., and an unidentified species.]
- Mills, H. B. 1941. Montana insect pests 1939 and 1940. Montana State College, Agricultural Experiment Station, Bulletin 384. 28 pp. [*Labops hesperius* moved into wheat near Bozeman, Montana, causing mottling of the leaves.]
- Moore, G. A. 1944. A list of Hemiptera taken at Hudson Heights, Quebec. Canadian Entomologist 76: 40–44. [*Labops hesperius* is reported from Hudson Heights, Quebec. (Note: This identification is doubtful, see Laroche and Larivière (1979).)]
- Moore, G. A. 1950. Checklist of Hemiptera of the Province of Quebec. Naturaliste Canadien 77: 233–271. [*Labops hesperius* and *L. hirtus* are reported from Quebec; the record of *L. hesperius* is based on Van Duzee (1916c).]
- Osborn, H. 1893. Notes on the distribution of Hemiptera. Proceedings of the Iowa Academy of Sciences 1: 120–123. [*Labops hesperius* is reported from New Hampshire. This record almost certainly refers to *L. hirtus*.]
- Oshanin, B. 1912. Katalog der paläarktischen Hemipteren (Heteroptera, Homoptera-Auchenorrhyncha-und Psylloideae). R. Friedlander and Sohn, Berlin. 187 pp. [This catalog of the Old World Hemiptera includes the Heteroptera and part of the Homoptera. *Irbisia sericans* is reported from northern Siberia and the Nearctic Region. Four species of *Labops* are included: *L. setosus* from Siberia; *L. sahlbergi* from Scandinavia, northern and middle Russia and Siberia; *L. burmeisteri* from Siberia; and *L. nigripes* from Siberia and Mongolia. (*Labops burmeisteri* is also found in North America.)]
- Osman, D. H. 1979. The toxicity, metabolism and distribution of carbaryl in three species of *Labops* with and without piperonyl butoxide treatment (Hemiptera: Miridae). M.S. thesis, Utah State University, Logan. 85 pp.
- Osman, D. H. and W. A. Brindley. 1981. Estimating monooxygenase detoxification in field populations: Toxicity and distribution of carbaryl in three species of *Labops* grass bugs. Environmental Entomology 10: 676–680. [In tests of monooxygenase detoxification of carbaryl by field populations of *Labops hesperius*, *L. hirtus*, and *L. utahensis*, males were more susceptible than females. The three species differed in susceptibility, with *L. hesperius* the most tolerant and *L. utahensis* the most susceptible.]
- Ostlie, K. R. 1979. *Labops hesperius* Uhler, abundance and dispersal in relation to vegetation. M.S. thesis, Utah State University, Logan. 198 pp.
- Paraqueima, O. L. 1977. Some effects of different temperatures on the development of the black grass bug *Labops hesperius* Uhler, from the egg through the adult stage. M.S. thesis, Utah State University, Logan. 84 pp.
- Parshley, H. M. 1917. Fauna of New England. 14. List of the Hemiptera-Heteroptera. Occasional Papers of the Boston Society of Natural History 7: 1–125. [*Labops hesperius* is recorded from Maine, New Hampshire, Vermont, and Massachusetts. (Note: Henry and Wheeler (1988) suggest these records apply to *L. hirtus*.)]
- Parshley, H. M. 1919. On some Hemiptera from western Canada. University of Michigan. Occasional Papers of the Museum of Zoology. No. 71. 35 pp. [*Irbisia brachycerus solani* and *I. pacificus* (as *Thyrillus pacificus*) are reported from Vernon, British Columbia, Canada.]

- Parshley, H. M. 1921. A report on some Hemiptera from British Columbia. Proceedings of the Entomological Society of British Columbia. Systematic Series No. 18: 13–24. [*Labops burmeisteri* and *L. hesperius* are reported from Chilcotin, British Columbia.]
- Parshley, H. M. 1922. Report on a collection of Hemiptera-Heteroptera from South Dakota. South Dakota State College, Technical Bulletin No. 2. 22 pp. [*Irbisia brachycera* and *Labops hesperius* are reported from several localities in South Dakota.]
- Parsons, G. L., G. Cassis, A. R. Moldenke, J. D. Lattin, N. H. Anderson, J. C. Miller, P. Hammond, and T. D. Schowalter. 1991. Invertebrates of the H. J. Andrews Experimental Forest, Western Cascade Range, Oregon. V: An annotated list of insects and other arthropods. United States Department of Agriculture, Forest Service, Pacific Northwest Research Station, General Technical Report. PNW-GTR-290. 168 pp. [This report documents 3454 species of insects and other arthropods from an old-growth Douglas-fir forest in western Oregon, including *Irbisia cascadia* (as *I. inurbana* Bliven) and *I. serrata*, from grasses in open areas in the forest. *Irbisia cascadia* is distributed in the Coast and Cascade of Oregon and northern California, and *I. serrata* occurs throughout much of western North America.]
- Pepper, J. H. 1962. Montana insect pests, 1961 and 1962. 39th Report of the State Entomologist. Montana State College, Agriculture Experiment Station. Miscellaneous Publication. No. 4. 8 pp. [*Irbisia* sp. damaged intermediate wheatgrass in Montana.]
- Pepper, J. H., N. L. Anderson, G. R. Roemhild, and L. N. Graham. 1956. Montana insect pests 1955 and 1956. Montana State College, Agricultural Experiment Station, Bulletin 526. 27 pp. [The crested wheat plant bug, *Labops hesperius*, infested crested wheatgrass fields as well as wheat and barley. *Stenodema* sp. damaged tall wheatgrass and crested wheatgrass in Montana.]
- Pepper, J. H., J. P. Corkins, L. N. Graham, D. R. Merkley, and N. L. Anderson. 1953. Montana insect pests. 1951 and 1952. Montana State College, Agricultural Experiment Station. Bulletin 484. 34 pp. [The margins of winter and spring wheat fields were damaged by *Labops hesperius* moving from adjacent crested wheatgrass fields. Crested wheatgrass plantings were severely damaged at several locations in Montana and were often killed when the bug infestation was accompanied by grazing.]
- Pepper, J. H., J. P. Corkins, R. Schmiedeskamp, C. R. Hunt, N. L. Anderson, and J. C. Wright. 1951. Montana insect pests, 1949 and 1950. Montana State College, Agricultural Experiment Station. Bulletin 474. 35 pp. [*Labops hesperius* occurred throughout southern Montana where it severely damaged planted crested wheatgrass.]
- Pepper, J. H., G. R. Roemhild, and L. N. Graham. 1954. Montana insect pests 1953–1954. Montana State College, Agricultural Experiment Station, Bulletin 504: 1–27. [*Labops hesperius* damaged crested wheatgrass fields in Cascade and Chouteau Counties.]
- Pepper, J. H., G. R. Roemhild, and L. N. Graham. 1958. Montana insect pests, 1957 and 1958. 37th Report of the State Entomologist. Montana State College, Agricultural Experiment Station. Miscellaneous Publication No. 2. 19 pp. [The crested wheat plant bug, *Labops hesperius*, damaged grass in two Montana counties. *Leptopterna dolabrata* (as *Miris dolabratus*) damaged crested wheatgrass.]
- Pepper, J. H., G. R. Roemhild, and L. N. Graham. 1960. Montana insect pests, 1959–60. Montana State College, Montana Agricultural Experiment Station, Miscellaneous Publication No. 3. 11 pp. [*Irbisia* sp. damaged intermediate and crested wheatgrass grown for seed in Montana.]
- Perry, E. 1954. New ranges for old. Western Livestock Journal, 32 (July, 1954): 26–27, 39. [This article is a nontechnical review of the use of crested wheatgrasses in western United States.]
- Provancher, L. 1885–1890. Petite Faune Entomologique du Canada. Vol. III. Cinquieme Ordre les Hémiptères. Naturalist Canadien. 354 pp. [*Labops hesperius* is reported from Ontario, Canada.]
- Rees, N. E. and G. B. Hewitt. 1977. Effects of specific cultural practices on immediate rangeland arthropod populations. Montana State University, Agricultural Experiment Station. Bulletin 695. 38 pp. [Seven sites in northern Montana that had received different rangeland renovation treatments were sampled for insects for three years. Treatments included sagebrush removal, scalping, and interseeding. *Irbisia* sp. (probably *I. serrata*) was reported from four of the seven sites. Additional grass-feeding mirids reported included *Litomiris debilis* (Uhler), *Stenodema vicinum* (Provancher), and *Trigonotylus tarsalis* (Reuter).]
- Reuter, O. M. 1879. De Hemipteris e Siberia orientali nonnullis adnotationes criticae. Ofversigt Finska Vetenskaps-Societätens Förhandlingar 21: 42–63. [Reuter described the genus *Irbisia*, type *Leptomerocoris sericans* Stål, and stated that the genus was allied with *Orthocephalus* Fieber. Reuter also reported *Labops burmeisteri* from Siberia.]
- Reuter, O. M. 1890. Adnotationes Hemipterologicae. Revue d'Entomologique 9: 248–254. [The systematic position of *Irbisia* is noted.]
- Reuter, O. M. 1896. Dispositio generum palaearticorum divisionis Capsaria familiae Capsidae.

- Ofrersigt af Finska Vetenskaps-Societätens Förhandlingar 38: 156–171. [*Irbisia* is included in a key to the genera of Capsidae (Miridae) of the Palearctic Region. The genus *Thyrillus* is a synonym of *Irbisia*.]
- Schuh, R. T. 1975. The structure, distribution, and taxonomic importance of trichobothria in the Miridae (Hemiptera). American Museum of Natural History. Novitates No. 2585. 26 pp. [*Labops burmeisteri* and *L. hirtus* are included in a study of the systematic value of the trichobothria (sensory setae).]
- Schwartz, M. D. 1981. A revision of the black grass bug genus *Irbisia* Reuter (Heteroptera: Miridae). M.S. thesis, Oregon State University, Corvallis. 222 pp.
- Schwartz, M. D. 1984. A revision of the black grass bug genus *Irbisia* Reuter (Heteroptera: Miridae). Journal of the New York Entomological Society 92: 193–306. [This modern revision includes keys to 23 recognized species from throughout the range of the genus and synonyms of some names used previously. The genus is characterized and separated from related genera of Miridae. Each species is described and discussed in detail. Habitus drawings of *I. pacifica*, *I. knighti* and *I. cascadia* are included with morphological drawings of portions of each species. *Irbisia bliveni* and *I. cascadia* are described as new. Detailed information on host plant associations is included for each species as available.]
- Schwartz, M. D. and J. D. Lattin. 1983. *Irbisia knighti*, a new mirine plant bug (Heteroptera: Miridae) from the Pacific Northwest. Journal of the New York Entomological Society 91: 413–417. [*Irbisia knighti* is described from the Pacific Coast of British Columbia, Washington, Oregon and northern California. This species, which occupies a very narrow portion of the Vancouverian Zone, was found on *Agropyron repens* (L.) Beauv., *Festuca rubra* L., *Holcus lanatus* L., *Poa pratensis* L., *Poa* sp. and *Carex* sp.]
- Slater, J. A. 1950. An investigation of the female genitalia as taxonomic characters in the Miridae (Hemiptera). Iowa State College Journal of Science 25: 1–81. [Details of the sclerotized portions of the female genitalia of *Irbisia sericans*, *I. shulli*, *I. pacifica* (as *Thyrillus pacificus*), *Labops hesperius*, and *L. hirtus* are described and illustrated.]
- Slater, J. A. 1954. Notes on the genus *Labops*, Burmeister in North America, with the descriptions of three new species (Hemiptera: Miridae). Bulletin of the Brooklyn Entomological Society 49: 57–65, 89–94. [This revision includes descriptions of each species and a key to the species.]
- Slater, J. A. 1974. A preliminary analysis of the derivation of the Heteroptera fauna of the northeastern United States with special reference to the fauna of Connecticut. Connecticut Entomological Society, Memoirs, 25th Anniversary, New Haven, pp. 145–213. [A single species (*L. hirtus*) is reported in this biogeographical analysis of north-eastern Heteroptera. The genus *Labops* is suggested to have reached North America in post-Pleistocene times.]
- Slater, J. A. and R. M. Baranowski. 1978. How to Know the True Bugs (Hemiptera-Heteroptera). W. C. Brown Co., Dubuque, Iowa. 256 pp. [This book contains keys to the mirid genera of the United States, including *Labops* and *Irbisia*. An illustration of *L. hesperius* and a brief discussion of its appearance and distribution are included. Some western species of *Labops* are mentioned as rangeland pests.]
- Slosson, A. T. 1895. Additional list of insects taken in alpine region of Mt. Washington. Entomological News 6: 316–321. [*Labops hesperius* is reported from the alpine zone of Mt. Washington, New Hampshire.]
- Spangler, S. M. 1984. Arthropod faunas of reseeded rangelands: Effects of vegetation structure. M.S. thesis, Utah State University, Logan. 77 pp.
- Spangler, S. M. and J. A. MacMahon. 1991. Arthropod faunas of monocultures and polycultures in reseeded rangelands. Environmental Entomology 19: 244–250. [*Irbisia brachycera* and *Conostethus americanus* (Knight) were the dominant mirid species occurring in grass monocultures. They were present during the early stages of growth when the root reserves of carbohydrates were the lowest. Species richness was lowest in monocultures. Diversifying grass species mixes for reseeding is suggested as a means of reducing plant bug numbers and increasing their natural enemies.]
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- Stephens, G. M., III. 1982. The plant bug fauna (Heteroptera: Miridae) of grasses (Poaceae) of the Medicine Bow Mountains and Pole Mountain Ranger District, Wyoming. University of Wyoming, Agricultural Experiment Station, Science Monograph 43. 175 pp. [This analysis of the plant bug fauna found on grasses in southeastern Wyoming includes *Labops hesperius*, *L. hirtus* and *L. utahensis*. A brief description of the first two species is combined with information on host grasses, grass communities, and general ecological data.]
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- optera identification: A reference guide, with special emphasis on economic groups. *Journal of Natural History* 25: 1027–1066. [More than 350 references useful for identifying Heteroptera from around the world are provided.]
- Strickland, E. H. 1953. An annotated list of the Hemiptera (S.L.) of Alberta. *Canadian Entomologist* 85: 193–214. [Five species of *Irbisia* are reported from Alberta: *I. arcuata*, *I. brachycera*, *I. solani*, *I. nigripes* and *I. fuscipubescentes*. Two species of *Labops* are reported, *L. hesperius* and *L. verae*. Strickland listed *Labops hirtus* as a synonym of *L. hesperius*.]
- Sweet, H. E. 1930. An ecological study of the animal life associated with *Artemisia californica* Less, at Claremont, California. *Journal of Entomology and Zoology* 22: 57–70, 75–103, 121–151. [*Irbisia sita* is recorded from Claremont, California, from several different plant associations that included *Artemisia*. This early-spring species (March to May) was uncommon.]
- Tavernetti, A. A. 1933. Production of the globe artichoke in California. University of California, Berkeley. California Agricultural Extension Service, Circular 76. 24 pp. [*Irbisia solani* is reported as a pest of the globe artichoke in California, the bugs moving onto the crop when the host grasses dried up.]
- Thomas, D. B. and F. G. Werner. 1981. Grass feeding insects of the western ranges: An annotated checklist. The University of Arizona, Agricultural Experiment Station. Technical Bulletin No. 243. 50 pp. [Some host and distribution information is provided for *Irbisia brachycera*, *I. oreas*, *I. pacifica*, *I. serrata*, *I. shulli*, *I. solani*, *Labops hesperius*, *L. hirtus*, and *L. utahensis*. *Leptopterna ferrugata* fed on seed heads of *Agropyron* sp.]
- Todd, J. G. 1973. *Labops hesperius* Uhler: Biology and impact in Oregon rangelands (Hemiptera: Miridae). M.S. thesis, Oregon State University, Corvallis. 91 pp.
- Todd, J. G. 1974. Biology of the wheatgrass bug in Oregon rangelands. Society for Range Management. 27th Annual Meeting, Abstract, p. 31. [The life history of *Labops hesperius* was studied on rangeland seeded to intermediate wheatgrass in central Oregon (see Todd and Kamm 1974).]
- Todd, J. G. and J. A. Kamm. 1974. Biology and impact of a grass bug *Labops hesperius* Uhler in Oregon rangeland. *Journal of Range Management* 27: 453–458. [The biology of a univoltine grass bug *Labops hesperius* is outlined for a site in Baker County, Oregon. Winter was passed as an egg in grass straw, eggs hatched in late March, and the nymphs reached the adult stage by late April. About two weeks later, new eggs were deposited in dry grass from the previous year. The nutrient value of the new season's growth of intermediate wheatgrass was reduced about 18% half way through the season; the losses were reduced to 2% by the time the grass had matured. The effect of insect feeding on range productivity varied with rainfall, grazing period, and drought.]
- Uhler, P. R. 1871. A list of Hemiptera collected in eastern Colorado and northeastern New Mexico, by C. Thomas, during the expedition of 1869, pp. 471–472. In Hayden, F. V., Preliminary Report of the United States Geological Survey of Wyoming and Portions of Contiguous Territories. [*Labops hesperius* and *Irbisia pacifica* are reported without specific localities.]
- Uhler, P. R. 1872. Notices of the Hemiptera of the western territories of the United States, chiefly from the Surveys of Dr. F. V. Hayden, pp. 392–493. In Hayden, F. V., Preliminary Report of the United States Geological Survey of Montana and Portions of the Adjacent Territories 5: 392–493, United States Government Printing Office, Washington, D.C. [*Irbisia pacifica* (as *Rhopalotomus pacificus*) is described from Montana, and *I. brachycera* (as *Rhopalotomus brachycerus*) and *Labops hesperius* are described from Colorado and Canada (Lake Winnipeg and Great Bear Lake).]
- Uhler, P. R. 1876. List of Hemiptera of the region west of the Mississippi River, including those collected during the Hayden explorations of 1873. Bulletin of the United States Geological and Geographical Survey of the Territories 1: 267–361, plates 19–21. [*Irbisia pacifica* (as *Rhopalotomus pacificus*) is reported from Montana, Idaho, and California and *I. brachycera* (as *Rhopalotomus brachycerus*) is reported from California and Colorado. *Labops hesperius* is reported from Colorado, Montana, and Canada.]
- Uhler, P. R. 1877. Report upon the insects collected by P. R. Uhler during the explorations of 1875, including monographs of the families Cydnidae and Saldae, and the Hemiptera collected by A. S. Packard, Jr., M.D. Bulletin of the United States Geological and Geographic Survey of the Territories 3: 355–475, 765–801, plates 27–28. [*Labops hesperius* is reported from near Gray's Peak, Colorado.]
- Uhler, P. R. 1886. Check-list of the Hemiptera Heteroptera of North America. Brooklyn Entomological Society. 32 pp. [*Irbisia pacifica* (as *Capsus pacificus*), *I. brachycera* (as *Capsus brachycorus*), and *Labops hesperius* are listed all from the "western states."]
- Uhler, P. R. 1894. Observations upon the heteropterous Hemiptera of Lower California, with descriptions of new species. Proceedings of the California Academy of Sciences. Second Series 4: 223–295. [The genus *Thyrillus* is described to include

- Rhopalotomus pacificus* and *R. brachycerus*. (Note: *Thyrillus* Uhler is a synonym of *Irbisia* Reuter.) *Irbisia pacifica* is reported from Lower (Baja) California, southern California, San Francisco, southern Nevada, and Yakima, Washington. *Irbisia brachycera*, reported from Lower California, is considered common in California (state).]
- United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine Program. 1951–1975. Cooperative Economic Insect Report. Vol. 1–25. [This weekly series, listing site-specific occurrences of various economic and non-economic insects from throughout the United States, includes occasional references to *Labops* and *Irbisia*.]
- United States Department of Agriculture, Animal and Plant Health Inspection Service. Plant Protection and Quarantine Programs. 1976–1980. Cooperative Plant Pest Report. Vol. 1–5. [This series superseded the Cooperative Economic Insect Report cited above.]
- Usinger, R. L. 1934. Blood sucking among phytophagous Hemiptera. Canadian Entomologist 66: 97–100. [*Irbisia solani* bit a person in California and produced a small, red spot that persisted for a short time.]
- Van Duzee, E. P. 1889. Hemiptera from Muskoka Lake District. Canadian Entomologist 21: 1–11. [*Labops hesperius* is reported from an oat field along the Muskoka River, Canada.]
- Van Duzee, E. P. 1905. List of Hemiptera taken in the Adirondack Mountains, pp. 546–556. In Felt, E. P., 20th Report of the [New York] State Entomologist for 1904. New York State Museum Bulletin 97. [*Labops hesperius* is reported from Axton, New York, in the Adirondack Mountains.]
- Van Duzee, E. P. 1912a. A few days' work and play in Canada. Ottawa Naturalist 26: 68–70. [*Labops hesperius* is reported from Hull, Ontario, Canada.]
- Van Duzee, E. P. 1912b. Synonymy of the Provancher collection of Hemiptera. Canadian Entomologist 44: 317–329. [The identity of *Labops hesperius* in the Provancher collection is confirmed. (Note: the Provancher collection is located in Laval University, Quebec City, Canada.)]
- Van Duzee, E. P. 1914. A preliminary list of the Hemiptera of San Diego County, California. Transactions of the San Diego Society of Natural History 2(1): 1–57. [*Irbisia pacifica* and *I. brachycera* are reported from San Diego County; the latter species is considered the most common mirid in cultivated regions of southern California.]
- Van Duzee, E. P. 1916a. Synoptical keys to the genera of the North American Miridae. University of California Publications, Technical Bulletins, Entomology 1: 199–216. [The keys include *Irbisia* and *Labops*.]
- Van Duzee, E. P. 1916b. Notes on some Hemiptera taken near Lake Tahoe, California. University of California Publications, Technical Bulletins, Entomology 1: 229–249. [*Labops hesperius* is reported from Lake Tahoe.]
- Van Duzee, E. P. 1916c. Check list of the Hemiptera (excepting the Aphididae, Aleurodidae and Coccidae) of America, north of Mexico. New York Entomological Society, New York. 111 pp. [Distribution information for *Irbisia sericans*, *I. brachycera*, *I. solani*, *I. pacifica* (as *Thyrillus pacificus*), *Labops hesperius*, and *L. burmeisteri* is included.]
- Van Duzee, E. P. 1917a. Catalogue of the Hemiptera of America north of Mexico. University of California Publications, Technical Bulletins, Entomology 2: 1–902. [*Irbisia sericans*, *I. brachycera*, *I. pacifica* (as *Thyrillus pacificus*), *Labops burmeisteri*, and *L. hesperius* are included.]
- Van Duzee, E. P. 1917b. Report upon a collection of Hemiptera made by Walter M. Giffard in 1916 and 1917, chiefly in California. Proceedings of the California Academy of Sciences. Fourth Series 7: 249–318. [*Irbisia californica* (as *I. sericans*, see Schwartz 1984, p. 2–34) is reported from several localities in California. *Irbisia mollipes*, described as a variety of *sericans* from specimens near San Francisco, is now considered a valid species. *Irbisia pacifica* (as *Thyrillus pacificus*) is reported from California.]
- Van Duzee, E. P. 1921a. A study of North American grass-bugs of the genus *Irbisia*. Proceedings of the California Academy of Sciences. Fourth Series 11: 145–152. [Six new species of *Irbisia* are described from western North America: *I. arcuata* (a synonym of *brachycera*), *I. californica*, *I. castanipes*, *I. parta* (a synonym of *brachycera*), *I. setosa*, and *I. sita*. A key is included to the ten known species in the genus (*I. brachycera*, *I. mollipes*, *I. sericans*, and *I. solani*, plus the six new species). Distribution information is included with the original descriptions of the six new species and for *Irbisia mollipes*.]
- Van Duzee, E. P. 1921b. Insects of the Pribilof Islands, Alaska. Orthoptera, Neuroptera, Hemiptera and Lepidoptera. Proceedings of the California Academy of Sciences. Fourth Series 11: 193–195. [*Irbisia sericans* is reported from St. Paul Island and St. George Island.]
- Van Duzee, E. P. 1926. *Labops burmeisteri* Stål. Pan-Pacific Entomologist 2: 163. [*Labops burmeisteri* is recorded from the Adirondack Mountains of New York and comments are made on *L. hirtus*.]
- Vosler, E. J. 1913. A new fruit and truck crop pest (*Irbisia brachycerus* Uhler). California (State) Commission of Horticulture. Monthly Bulletin 2: 551–553. [*Irbisia solani* (as *Irbisia brachycera*, see

- Schwartz 1984, p. 281) injured garden crops and fruit in California. Damage to lettuce, radishes, onions, peaches and rhubarb is recorded. Weedy plants in uncultivated areas near the crops dried up, resulting in the bugs moving into crops.]
- Watts, J. G., E. W. Huddleston, and J. C. Owens. 1982. Rangeland entomology. Annual Review of Entomology 27: 283–311. [This broad overview includes a concise treatment of black grass bugs and other mirids.]
- Wheeler, A. G., Jr. and T. J. Henry. 1992. A Synthesis of the Holarctic Miridae (Heteroptera): Distribution, Biology, and Origin, with Emphasis on North America. Entomological Society of America, Thomas Say Foundation, Volume 15, Lanham, Maryland. 282 pp. [*Irbisia sericans* and *Labops burmeisteri* are discussed with information on distribution, host plants, habits, and zoogeography. Distribution maps in North America are included.]
- Windig, W., H. L. C. Meuzelaar, B. A. Haws, W. F. Campbell, and K. H. Asay. 1983. Biochemical differences observed in pyrolysis mass spectra of range grasses with different resistance to *Labops hesperius* Uhler attack. Journal of Analytical and Applied Pyrolysis 5: 183–198. [Range grass species and hybrids differing in susceptibilities towards feeding damage by *Labops hesperius* were examined by means of pyrolysis mass spectrometry. Clear correlations between pyrolysis patterns and susceptibility to insect damage were found. A possible attractive role of chloroplast components and a possible repellent role of phenolic moieties that might influence the feeding behavior of the grass bug are suggested.]

NOTES ABOUT THE OLD WORLD GENUS *HEXAMEROCERUS* REUTER
(HETEROPTERA: REDUVIIDAE: ECTRICHODIINAE)

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Abstract.—*Hexamerocerus* and a syntype of *H. punctatus* (Stål) are redescribed, *H. quadrimaculatus*, sp. nov. is described from Mashonaland, South Africa, and a key to the four species of the genus is given.

Key Words: Reduviidae, *Hexamerocerus*, *H. punctatus* redescription, *H. quadrimaculatus*, n. sp., key

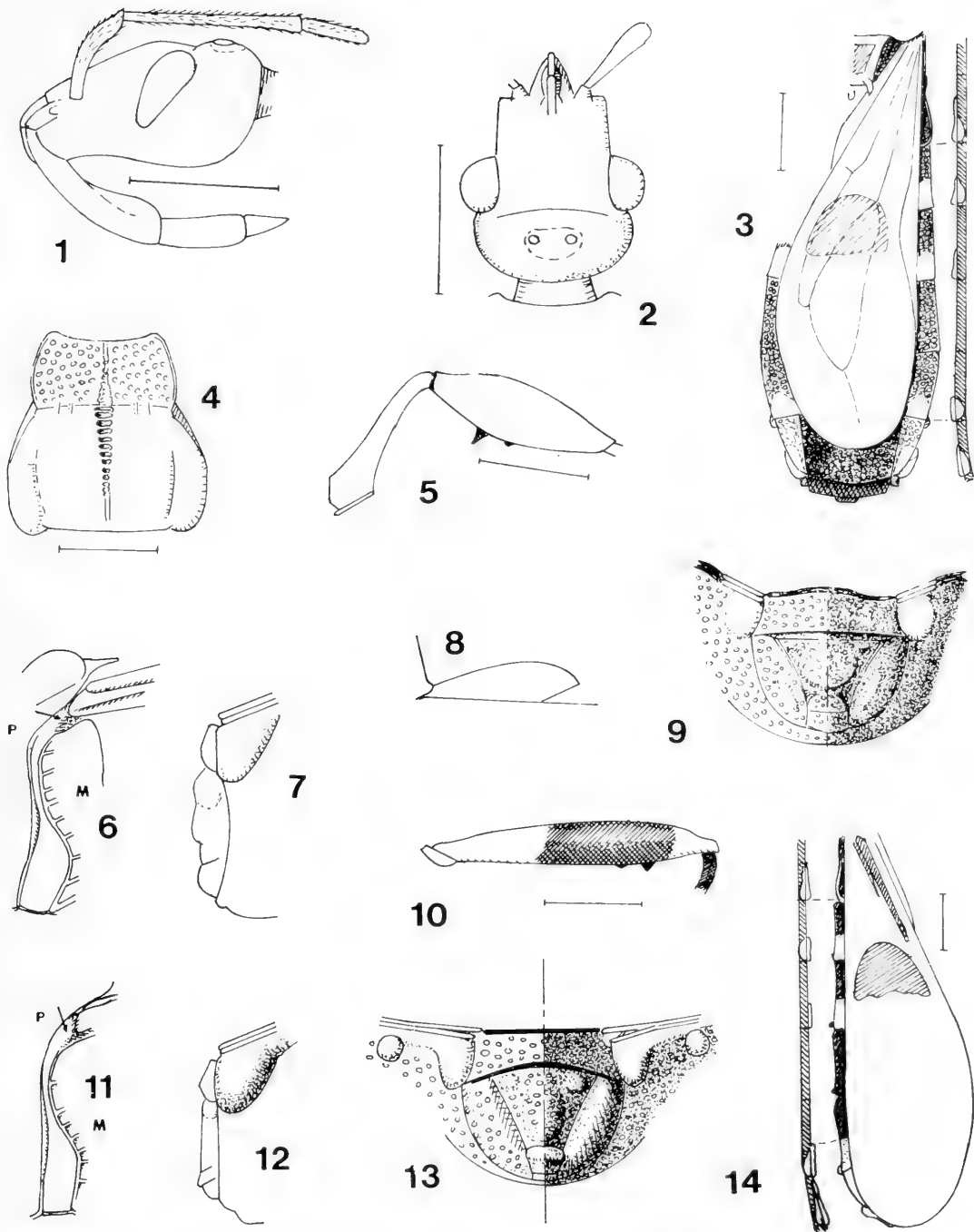
Reuter (1881) described the South African genus *Hexamerocerus* for the type species *H. nobilis* from Zanzibar. Thanks to Mrs. J. Margerison-Knight, from the British Natural History Museum, I was able to examine a female syntype of *H. punctatus*, describe a new species, and prepare the notes discussed below. Measurements are given in mm.

Hexamerocerus Reuter

Reuter 1881 (1883). 12: 306. Type *Hexamerocerus nobilis* Reuter 1881, 12: 307.

Body parallel-sided, narrow, not flattened; head finely and sparsely granulose, both lobes thinly corrugate, broader behind than in front of eyes, without ventrolateral pouches behind eyes; antennae six segmented, the first about half as long as head or second segment, second the longest, about twice as long as each of the last segments, all segments short, with fine decumbent setae, thickened; rostrum moderately thick, first segment almost as long as last two combined, slightly dilated apically; eyes relatively small, not reaching upper or lower margins of head. Thorax wider than long, without collar, anterior margin below dorsal

surface of anterior lobe; anterior lobe shorter than posterior lobe, coarsely punctate above and laterally, lateral margins carinate; posterior lobe transversely corrugate (only the corrugations in the mediolongitudinal impression illustrated in Fig. 4); median longitudinal sulcus of pronotum extending across transverse constriction just before base of posterior lobe; mesopleurae horizontally and metapleura vertically corrugate; mesosternum radially and metasternum transversely corrugate, the latter with a broad median depression; scutellum quadrangular, wider than long, two widely separated, short, converging prongs, on apex. Anterior femur incrassate, second slightly incrassate, third slightly thickening toward apex; pro- and mesotibia slightly expanded apically, both with spongy fossa on slanted apical surface; each femur ventrally with a postmedian toothlike spine following one or two small spines. Tarsi 3, 3, 3; third segment as long as first two combined; claws slightly expanded basally. Hemelytral surface smooth. Abdomen coarsely punctate dorsally and ventrally, slightly compressed laterally, parallel sided, connexivum exposed, apical connexival angles slightly produced as elevated, rounded angulations, sternal



Figs. 1–14. 1–9. *Hexamerocerus punctatus* (Stål), female syntype. 1, head, lateral view. 2, head, dorsal view. 3, hemelytron and connexivum, dorsal and lateral view, respectively; colors of hemelytron inverted. 4, pronotum, dorsal view. 5, anterior leg, external view. 6, evaporation area of mesopleural scent gland, lateral view, arrow: opening of gland, P: pronotum, M: mesopleuron. 7, external genitalia, lateral view. 8, scutellum, lateral view. 9, external genitalia, caudal view. 10–14. *Hexamerocerus quadrimaculatus*, n. sp., female holotype. 10, hind femur, external view. 11, evaporation area of mesopleural scent gland, lateral view. 12, external genitalia, lateral view. 13, external genitalia, caudal view. 14, hemelytron and connexivum, dorsal and lateral view respectively; colors of hemelytron inverted. All scale lines equivalent to 1.0 mm.

sutures crenulate; spiracles circular, each on a globose area.

Species with blackish-blue or black metallic bodies, apical half of some connexival segments yellow or pale orange, some species with small yellowish areas in different parts of body; hemelytra dull, usually with a grayish semicircular area and with or without a longitudinal fascia on corium; legs uniformly dark, polished or with base and apex of segments fulvous; anterior lobe of pronotum darker than posterior lobe. Basal and apical connexival segments with caudal halves yellow above and below, the middle segments with connexivum colored as corresponding sterna (Fig. 14).

Reuter considered *Hexamerocerus* close to *Labidocoris* Mayr, *Mendis* Stål, and *Cleptria* Stål. It can be separated from all African ectrichodiine genera by the narrow, metallic-blue body, a six-segmented antenna, the relatively thick rostrum with the first segment almost as long as last two combined, the coarsely punctured body, and the transversely corrugate posterior lobe of pronotum. Not mentioned before in the literature is a narrow, vertical evaporation area, probably associated with a scent gland, anteriorly on the mesopleura (Fig. 6). It differs from other pleural sclerites by its dull surface; in Fig. 6 the double lines in the surrounding sclerites represent carinae or corrugations. The opening of the gland is above, just below the beginning of the caudal extension of the posterior lobe of the pronotum (Fig. 6, arrow). A similar area occurs in at least some other ectrichodiine genera.

Hexamerocerus punctatus (Stål)

Figs. 1-9

Pirena punctata Stål, 1863, 3: 47, Caffraria.

Ectrichodia punctata: Walker, 1873, 8: 46.

Hexamerocerus punctatus: Bergroth, 1894, 38: 547.

Female.—Coloration metallic black: head, anterior lobe of pronotum laterally and dorsally, meso- and metapleurae, scutellum,

basal half of connexival segments II, III, IV, VI, and VII, connexival segment V, basal half of ventral connexival segments II, III, VI, and VII, thoracic sterna, and genital segments. Antenna brown; legs dark brown, tarsi pale brown. Caudal half of connexival segments mentioned above yellow (Fig. 3). Abdominal sterna metallic dark blue. Posterior lobe of pronotum metallic dark brown, a shade paler than legs. Hemelytra: clavus and corium, very dark red, membrane black; a gray, suboval transverse spot across on apex of corium; hemelytra reaching middle of last tergum.

Head (Figs. 1, 2).—Anterior lobe of pronotum dorsally and laterally grossly punctate (Fig. 4), lateral margin carinate; median longitudinal sulcus shallow and narrow along anterior half, on caudal half gradually broader and deeper, crossing over onto posterior lobe; median longitudinal sulcus relatively broad anteriorly, tapering to and ending before basal margin of lobe. Evaporation area of mesopleuron as in Fig. 6. Scutellum width 0.6, length 0.5, with discal quadrangular depression, slightly raised towards apex (Fig. 8). Legs: pro- and mesofemora incrassate (Figs. 5, 10), metafemur slightly thickening toward apex, slightly constricted apically; large spine on femora about $\frac{1}{5}$ to $\frac{1}{4}$ diameter of segment.

Head—length 1.40, width across eyes 1.02, width behind eyes 0.87, width in front of eyes 0.62, distance from anterior margin of eye to apex of antennophore 0.31, from anterior margin of eye to apex of head 0.62, from posterior margin of eye to base of posterior lobe 0.43, width of eye 0.19, interocular space 0.64, from interocular suture to apex of head 1.00, from interocular suture to base of posterior lobe 0.4, collum 0.18. Antennal segments: I, 0.62; II, 1.19; III, 1.0; IV, 0.5; V, 1.0, VI missing. Rostral segments: 1.0; 0.62; 0.4. Thorax length 1.93, width 2.12; anterior lobe—length 0.81, greatest width 1.50; posterior lobe—length 1.12, greatest width 2.12. Scutellum width 0.69, length 0.50. Legs; length and depth of

femora: 1.56×0.5 ; 1.68×0.5 ; 2.31×0.5 ; tibiae length: 1.36, 1.50, 2.01 (Figs. 5, 10). Length of abdomen 5.51, margins of connexival segments straight, greatest abdominal width at segment V, 2.62. External genitalia as in Figs. 7 and 9. Total length of body 10.30.

Syntype female, from Pt. Natal, SOUTH AFRICA; pin with: red-margined cardboard circle labeled "type"; blue-margined circle labeled "syntype"; cardboard label typed "*Ectrichodia punctata*"; handwritten label "*punctata* Stål"; in Natural History Museum, London.

Hexamerocerus quadrimaculatus,

n. sp. Maldonado

Figs. 10–14

Female.—Coloration dark metallic blue: head, anterior lobe of pronotum dorsally and laterally, meso- and metapleura, meso- and metasternum, abdominal sterna, and scutellum; abdominal tergites black; posterior lobe of pronotum brown, with a metallic bluish tinge. Antenna: segments I and II dark brown, III and IV black, others missing; rostrum dark brown. Legs: coxae brown, polished; trochanters pale brown; profemur polished dark brown, apex shortly ringed with stramineous; mesofemur: middle $\frac{2}{4}$ polished dark brown, apex and base fulvous; metafemur with same colors as mesofemur, as in Fig. 10; protibia: external surface with basal half and apex brown, preapical stramineous ring, internal surface with basal $\frac{3}{4}$ whitish, apical $\frac{1}{4}$ brown; mesotibia with both surfaces as protibia externally; metatibia brown, dark stramineous preapically. Tarsi pale brown. Hemelytra black, with grayish corial longitudinal stripe parallel to clavocorial suture, a gray, sub-hemispherical area at end of corium and over base of membrane (Fig. 14). Coloration of connexival segments: dorsal caudal halves of II narrowly, III, IV, VI, and VII entirely yellow; ventral caudal halves of II, III, IV narrowly, VI and VII entirely yellow, the last two fused above and below; spirac-

ular areas VI and VII yellow, apparently fused.

Head—length 1.62, width across eyes 1.16, width behind eyes 1.00, width in front of eyes 0.75, from anterior margin of eye to apex of antennophore 0.40, from anterior margin of eye to apex of head 0.89, from posterior margin of eye to base of posterior lobe of head 0.37, width of eye 0.19, interocular space 0.68, from interocular suture to apex of head 1.02, from same to base of posterior lobe of head 0.6, collum 0.19. Antennal segments: I, 0.75; II, 1.43; III, 0.62; IV, 0.4; V and VI missing. Rostral segments: 1.0; 0.75; 0.37. Thorax: length 2.29, greatest width 2.62, posterior margin slightly angularly produced; anterior lobe length 0.93, width 1.81; posterior lobe length 1.36, width 2.62; evaporation area of mesopleura as in Fig. 11. Scutellum width 0.87, length 0.68. Legs—femora length and depth: 1.81×0.5 ; 1.94×0.5 ; 3.06×0.5 . Tibiae lengths: 1.62, 1.87, 2.75. Hemelytra smooth; slightly surpassing apex of abdomen. Abdomen: margins of connexival segments slightly concave, length 6.77, greatest width at V segment 3.00 (Fig. 14). External genitalia as in Figs. 12 and 13. Total body length 11.06.

Holotype female, Mashonaland, SOUTH AFRICA; 1897, collector unknown; in Natural History Museum, London.

KEY TO THE SPECIES IN *HEXAMEROCERUS*

1. Corium of hemelytra with longitudinal fascia close and parallel to the clavocorial commissure (Fig. 14) 2
 Corium without such longitudinal fascia (Fig. 3) 3
2. Hemelytra and antennae black; dorsal connexival segments II, III, IV, VI, VII with caudal halves yellow to orange; ventral segments II, III, IV, VI, and VII colored similarly; small yellowish area near each mucron of scutellum, acetabulum, coxae, and first abdominal sternum; length 10.3; Zanzibar *H. nobilis* Reuter
 Antenna brown basally, gradually turning to black toward apex; hemelytra dull dark brown; yellow apical half of connexival segments II, III, IV, and yellow of VI and VII fused; body without small yellow areas; length 11.1; Mash-

- onaland, South Africa
 *H. quadrimaculatus*, n. sp.
 3. Legs black, base and apex of pro- and meso-
 femora luteus; hemelytra black; Mozambique
 *H. junodi* Distant
 Legs uniformly black; clavus and corium dark
 red, membrane black; 8.84 mm; South Africa
 *H. punctatus* (Stål)

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**PODALIA BOLIVARI (LEPIDOPTERA: MEGALOPYGIDAE): A HIGHLY
SEXUALLY DIMORPHIC NEOTROPICAL PEST**

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Abstract.—*Podalia bolivari* (Heylaerts) is unusual among the Megalopygidae in its extreme sexual dimorphism, as well as the male habitus. Association of the sexes is confirmed and the species is redescribed to allow its identification. Observations on the natural history of *P. bolivari* are given. Problems of generic concepts in Megalopyginae are discussed.

Key Words: Megalopygidae, Zygaenoidea, *Megalopyge*, palms, ferns

Podalia bolivari is unusual among the Megalopygidae in its extreme sexual dimorphism, as well as the male habitus. This has caused confusion in its classification and identification. Because this species can be a pest of cultivated palms and ferns in Colombia, we redescribe it here. The taxonomic portion of this paper was prepared by SEM and VOB, the natural history observations are by RVA.

The male was described by Heylaerts (1884) as *Pentophora bolivari*, but the female has been named three times (*Megalopyge pellucens* Dognin, 1912; *Unduzia gistinda* Dyar, 1914; and *U. phaule* Dyar, 1914). Dognin (1916) recognized the synonymy of *pellucens* and *phaule*, and Joicey and Talbot (1922, based on unpublished information from Dyar) synonymized *pellucens* and *gistinda*. Hopp (1926, 1935) recognized the association of the male and female, but other workers (unpublished notes in USNM) doubted the association because of the extreme dimorphism. We can now confirm the association, based on males and females reared together.

The sexual dimorphism of *Podalia bolivari* is the most extreme that we are aware of in Megalopygidae, both in size and wing shape (similar to, but more extreme than, dimorphism in *Phobetron* in the Limacodidae). Forewing lengths in male *bolivari* are 7–9 mm; female lengths are 17–22 mm. The usual dimorphism in megalopygids is that the largest males are slightly smaller than the smallest conspecific females. In addition to size, *bolivari* is strongly dimorphic in habitus. The females are fairly typical *Podalia* in appearance (although the wings are semitranslucent), but the males are very unusual for Megalopygidae. The males have narrow, hyaline wings, yielding the appearance of Zygaenidae, Psychidae, or Arctiidae such as small species of *Paracles* (Becker and Miller 1991); *Podalia bolivari* can be distinguished from most of these by the stalking of forewing veins R4 and R5.

This species can be a pest of palms and ferns in the vicinity of Medellín, Colombia. Gallego (1946) recorded *Podalia bolivari* as a pest of *Washingtonia* palms, and it is quite common on the introduced palm *Chrysal-*



Figs. 1, 2. *Podalia bolivari* wings: 1 (upper), male wing (USNM) (forewing length 9 mm); 2 (lower), female wing (USNM) (forewing length 19 mm); same specimen illustrated against both black and white backgrounds. Both sexes figured at same scale to show dimorphism.

idocarpus lutescens H. Wendl. (= areca palm or bamboo palm). It is also found on an ornamental fern, *Pteridium* sp., and *Cyperus diffusus* Vahl (Cyperaceae) on the Universidad Nacional de Medellín campus. Larvae develop much more slowly on *Cyperus* than *Pteridium*. Genty et al. (1978: 382–

383) noted *P. bolivari* as a secondary pest of oil palms.

All the species of Megalopyginae are currently placed in either *Megalopyge* Hübner or *Podalia* Walker (Hopp 1935), except for the enigmatic genus *Psychagrapha* Walker (transferred to Megalopyginae by Epstein

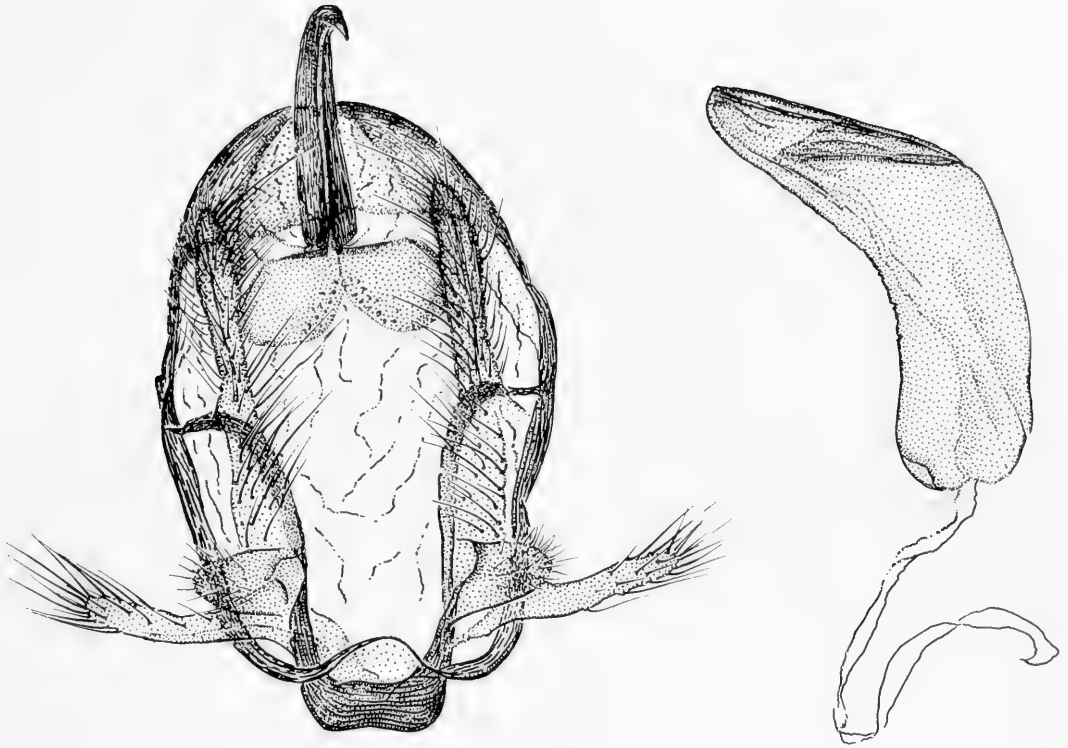


Fig. 3. *Podalia bolivari*, male genitalia (USNM 28024).

and Becker 1994: 313, Becker 1994). The generic classification of the subfamily needs revision (Miller 1994). Such a revisionary study may result in the lumping of all species into *Megalopyge* or the splitting of the subfamily into additional genera. The generic name *Unduzia* was proposed by Dyar (1914: 252), with *U. gistinda* as type species. We follow Hopp (1935) and Forbes (1942) in placing *bolivari* in *Podalia* until the generic classification of the subfamily can be revised.

REDESCRIPTION

Podalia bolivari (Heylaerts) Figs. 1–4

Pentophora bolivari Heylaerts, 1884: xli.
Hypogymna bolivari: Kirby, 1892: 490.
Unduzia bolivari: Hopp, 1926: 193.—Gallego, 1946: 455.—Morales, 1982: 168.

Podalia bolivari: Hopp, 1935: 1098, pl. 163g.—Forbes, 1942: 404.—Genty et al., 1978: 382–383.

Megalopyge pellucens Dognin, 1912: 171.

Unduzia pellucens: Dognin, 1916: 22.

Unduzia gistinda Dyar, 1914: 252.

Unduzia phaule Dyar, 1914: 252.

Diagnosis.—Male dark grey, with narrow, hyaline wings, yielding the appearance of Zygaenidae or Psychidae (Fig. 1). Female fairly typical of *Podalia* in appearance, but with semitranslucent wings; forewing with postmedial white spots (Fig. 2).

Adult male (Fig. 1).—Forewing length 7–9 mm. **Head:** Pale fuscous, densely hairy. Antennae dark grey, broadly bipectinate. **Thorax:** Dark grey dorsally, slightly paler ventrally. Densely covered with long hairs. Forewings sparsely covered with long narrow scales, dense only along wing margins;

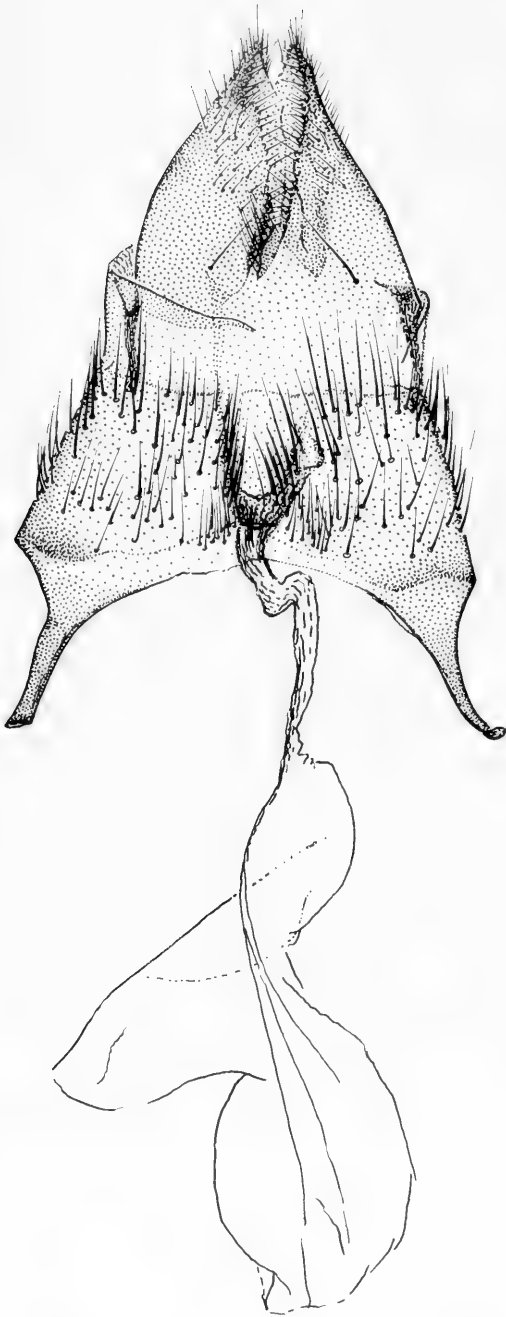


Fig. 4. *Podalia bolivari*, female genitalia (USNM 28162, paralectotype of *pellucens*).

scaling especially sparse in middle of wing, creating translucent appearance. Hindwings as in forewings, but densely scaled from CuP to posterior margin. Wings ventrally as dorsally, slightly paler. Legs dark grey. *Abdomen*: Dark grey, densely covered with long hairs. Genitalia as in Fig. 3.

Adult female (Fig. 2).—Forewing length 17–22 mm. Entire moth pale fuscous, covered with long hairs. *Head*: Densely hairy. Antennae narrowly bipectinate. *Thorax*: Densely hairy. Forewings pale fuscous, sparsely covered with long, curled hairs, resulting in appearance of undulating bands, translucent; postmedian line consisting of patches of elongate white hairs, one patch in each cell, midway between each vein after M2. Hindwings pale fuscous, more sparsely clothed than forewing. *Abdomen*: Pale fuscous, densely hairy. Genitalia as in Fig. 4.

Types.—Holotype male, ZMHB (*bolivari*); Lectotype female, here designated [lectotype bears Dognin's handwritten label "type," three paralectotypes bear "co-type"], USNM 29855 (*pellucens*); Lectotype female, here designated, USNM 16097 (*gistinda*); Holotype female, USNM 16098 (*phaule*). [all examined]

Type localities.—Venezuela, Mérida (*bolivari*); Venezuela, Mérida (*pellucens*); Panamá, Río Trinidad (*gistinda*); Venezuela, Mérida (*phaule*).

Hosts.—*Washingtonia filifera* (L. Linden) H. Wendl. (Gallego 1946: 455); *Elaeis guineënsis* Jacq. (Genty et al. 1978); *Cyperus diffusus* Vahl; *Chrysalidocarpus lutescens* H. Wendl. (USNM); *Pteridium* sp. (USNM). Gallego (1946: 455) also recorded *Washingtonia comunis* and *Washingtonia erecta*, but we have been unable to identify these taxa; they are not valid species of *Washingtonia*.

Immature stages.—Larvae densely hairy, reddish, up to 30 mm long (see below).

Flight period.—March, May, August, and December (in Panamá).

Distribution.—Panamá, Colombia, and Venezuela.

Material examined [by SEM and VOB].—10 males and 18 females. COLOMBIA: *Antioquia*: Medellín, [no date], F. L. Gallego M. (USNM), VIII-1985, “ex helecho” [reared from *Pteridium* sp.], J. A. Quiroz & F. Serna (USNM), X-1985, “en palma areca” [reared from *Chrysalidocarpus lutescens*], R. Velez (USNM); *Boyacá*: Muzo, 400–800 m, [no date], A. H. Fassl (USNM); PANAMA: Barro Colorado Island, 5-VIII-1940, N. S. Scrimshaw (MCZ), 10-XII-1934, M. Bates (MCZ); Cabima, 16–30-V-1911, A. Busck (USNM); Cano Saddle, V-[no year], R. C. Shannon (USNM); Río Trinidad, 15–31-III-1912, Busck (USNM, lectotype of *gistinda*), same but III-1912 (USNM, paralectotype of *gistinda*); VENEZUELA: *Mérida*: Mérida, [no date] (USNM, lectotype and 3 paralectotypes of *pellucens*), 1890 (USNM), [no date], S. Briceño (USNM, holotype of *phaule*).

Discussion.—Hopp (1926, 1935; repeated by Forbes 1942) mentions México, but we have not seen any specimens to confirm this distribution record. We have seen a single female from Perú ([Valle de] Canchamayo, I-VII-1901, W. Hoffmanns, BMNH), evidently the specimen noted by Hopp (1935), which might be *P. bolivari* but it differs slightly in coloration and venation.

We have examined the “type” male of *Podalia bolivari* in ZMHB, as did Hopp (1926). The original description implies that Heylaerts had only one specimen, so we consider this specimen the holotype. It is in good condition, except for lacking the abdomen (as noted in the original description) and right antenna. It bears a handwritten locality label “Merida/Hahnel.” Paul Hahnel collected in Venezuela from 1875–1879 (Horn and Kahle 1935: 102).

Podalia bolivari is most similar to *P. dyari* (Joicey and Talbot 1922: 302), known only from the female holotype (BMNH) from Ecuador (specific locality not known). The holotype of *dyari* is much larger than *bolivari*, with a forewing length of 27 mm. The wing shape is more pointed in *dyari*, with the

Table 1. Life cycle of *Podalia bolivari* on leaves of areca palm (*Chrysalidocarpus lutescens*) at 24°C and 67% R.H.

Life stage	Mean life span (days)	No. individuals observed
Egg	9	200±
Larvae		
Males	49–50	34
Females	65–70	33
Pupae		
Males	25–28	24
Females	21–26	23
Adults (males & females)	7	47

outer margin more oblique than in *bolivari*. The wings of *dyari* are also more transparent and the forewings lack the postmedial white spots, although this is hard to evaluate with only one specimen. We have not dissected the genitalia of *dyari*, as there is no morphological knowledge of megalopygid female genitalia for comparative evaluation (Fig. 4 in this paper is the first published illustration of a megalopygid female genitalia).

NATURAL HISTORY

Adult and eggs: Adults eclose at night under laboratory conditions. After emerging, both sexes show slow movements during the day but fly actively after dark. About 3 days after mating, the female lays a mass of eggs (close to 200 in each group), frequently deposited on its old cocoon. The eggs are very small, spherical and surrounded by masses of web. In the field, the egg masses are covered completely with pili-form scales from the female abdomen. Adults live about 7 days when fed on absorbent cotton soaked in a solution of honey (30%) and water (see Table 1).

Larvae and pupae: The larvae, soon after hatching from the eggs, start feeding on foliage of the host plants reported. The larvae are covered with a dense coat of fine, long, reddish hairs (figured by Genty et al. 1978:

382), show slow movements and prefer the underside of the leaves they feed on. The larvae have urticating setae beneath the long hairs that cause skin irritation. Last instar larvae reach about 3.0 cm long. Mature larvae seek hidden pupation sites on walls or similar surfaces close to their feeding site. The pupae can be easily sexed by the clearly larger size of the females.

Natural enemies: Egg parasites, *Telenomus* sp. (Hymenoptera: Scelionidae), were observed emerging from an egg mass collected on *C. diffusus*. A fly (possibly Tachinidae) was seen after emerging from a dead larva. Signs and symptoms similar to those of affliction with a viral disease have also been noticed in larvae.

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Research facilities for SEM and VOB were provided by the Smithsonian Institution (USNM), and the photographs were taken by Victor Kranz of the Smithsonian Institution. H. J. Hannemann loaned the type of *Podalia bolivari*. Additional specimens were borrowed from the Museum of Comparative Zoology, Harvard University (MCZ) and the Natural History Museum, London (BMNH). Isabella Forster translated Hopp's paper for us. D. R. Davis, M. E. Epstein, and N. L. Evenhuis reviewed the manuscript. L. Masner, Agriculture Canada, identified the parasitic wasp.

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THE IDENTITY AND SYNONYMY OF *NEPA FUSCA* LINNAEUS, 1758
(HETEROPTERA: NEPIDAE)

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Abstract.—The nomenclatural history of *Nepa fusca* Linnaeus, 1758 is reviewed. Usages by other authors of the name *Nepa fusca* are also reviewed, some of which refer to different species, and occasionally to Belostomatidae. The synonymy of *Nepa fusca* Linnaeus, 1758 and *Laccotrepes brachialis* Gerstaecker, 1873 is established (**New Synonymy**).

Key Words: Heteroptera, Nepidae, Belostomatidae, *Laccotrepes*, synonymy

Nepa fusca has remained an enigma ever since it was described by Linnaeus (1758). It has had a confusing nomenclatural history because of uncertainty as to both its identity and provenance, the latter variously attributed to America, Asia and Africa. Linnaeus (1758, 1767) gave "Habitat in Calidis regionibus" but in 1764 gave simply "Habitat—." Gmelin (1790) gave "Habitat in Indiae aquis . . .," Turton (1802) states that it "Inhabits East India," and Fabricius variously gave "Habitat in America" (1775), "Habitat in Americae meridionalis aquis" (1781), and "Habitat in Indiae orientali aquis" (1787, 1794, 1803).

Fabricius (1775) described *Nepa fusca* as "N. ecaudata, scutello rugoso, alis niveis" indicating that the specimen was belostomatid. He cites the third description of Linnaeus (1767), but gave "Habitat in America." He further gave "Duplo major N. cinerea: tota fusca, solis alis albis," leading Esaki (1926) to suggest that the species might be *Lethocerus (Benacus) griseus* (Say).

Fabricius (1787; same in 1794) described *Nepa fusca* differently, as "N. cauda biseta, scutello rugoso, alis niveis" clearly indicating that the species was a nepid. In both (Fabricius 1787, 1794) he listed Stoll 1780, pl. I, fig. I as a citation for *fusca*, but this

must have been a lapsus (cf. Esaki 1926) because this is not a figure of a nepid, but an American belostomatid (*Zaitha stollii* Amyot and Serville, 1843: 430; pl. I, fig. II may have been intended, which is a *Laccotrepes*. As further evidence that this was a lapsus on the part of Fabricius, Stoll, in his citations for pl. I, fig. I, gave "FABRICIUS Syst. Entom. pag. 691. Nepa 2. Rustica" (= Fabricius 1775) which is clearly an American belostomatid (but not the *Nepa rustica* of Fabricius 1787, 1794, 1803, which is synonymous with *Nepa plana* Sulzer, 1776, a belostomatid from India). On page 11, Stoll cited pl. I fig. II for *Nepa cinerea* Linnaeus, but on pages 35-36 he also cited it as illustrating his "*Scorpion-aquatique gris*" from Tranquebar and Coromandel (India). Amyot and Serville (1843) gave binominal names to most of Stoll's aquatic Heteroptera, but attributed his pl. I, fig. II solely to *Nepa cinerea*, and did not mention his "*Scorpion-aquatique gris*."

Ferrari (1888), on the other hand, attributed Stoll's "*Scorpion-aquatique noir de Tranquebar*" to *fusca*, with the citation as p. 29, tab. VIII, fig. 5, 1792, a German language edition of Stoll's original work (1780-88) which was printed in parallel Dutch and French; this citation refers to p. 35, tab. VII,

fig. V in the original. Amyot and Serville (1843) give this species in error as "*Nepa rubra* Linn.," later shown by Lundblad (1933) to pertain instead to *grossus* Fabricius (= *L. kohlii* Ferrari sensu Esaki, 1926).

Esaki (1926) studied the types of *fusca* in Uppsala, reviewed the works of Fabricius, and concluded that at least two of the Fabricius descriptions refer to other species. For instance the description of *Nepa fusca* by Fabricius in 1775 apparently refers to a belostomatid, and his 1803 description is of a species smaller than *Nepa cinerea*, or only about half the length of Linnaeus' types of *fusca*. Fabricius' 1794 description matches the Linnaean species more closely; at least it is approximately the same size. Esaki thought the latter might be Ferrari's (1888) *Laccotrephes kohlii*, but this species has since been synonymized with *Laccotrephes grossus* Fabricius, 1787, described next to *L. fusca* Fabricius, 1787 in the same work so this cannot be. Lundblad, however (1933: 23) has tentatively cited *L. fusca* Fabricius, 1787 as belonging to his *Laccotrephes occultus*, new name for "*Laccotrephes fuscus* auct. in coll. partim, non *Laccotrephes fuscus* Linné, 1758." Esaki did not mention Fabricius' "Species Insectorum" (1781) where he repeated the description from his "Systema Entomologiae" (1775) but gave the habitat as "Habitat in Americae meridionalis aquis," nor his "Mantissa Insectorum" (1787) wherein he gave the same description and provenance used in his "Entomologia Systematica" (1794).

Stål (1868: 135) studied the Linnaean types of *fusca* in Uppsala, and provided a redescription in Latin. Esaki (1926) also studied the Linnaean types of *fusca* in Uppsala, stated that the two specimens were both females with lengths of 31 and 33 mm, with caudal filaments of lengths $22.5 + X$ and $21 + X$ mm respectively, with apices of the caudal filaments broken (with "+ X" Esaki indicated that an unknown additional length of caudal filament once existed). No further description was given.

Fortunately Lundblad (1933) carefully restudied the Linnaean types of *Nepa fusca* and found that Esaki's (1926) examination had been cursory indeed. The types are both males, not females as Esaki had stated, and do not belong to any Asian species known to Lundblad. Lundblad dissected and figured the paramere of one male, and provided a dorsal habitus photograph of the unspread specimen, presumably also the one he dissected. This specimen is here designated as lectotype.

The key characters given by Lundblad are: interocular space about twice the width of an eye, low prosternal carina, shape of male paramere, size of body (See also Poisson 1949: 30–31). Lundblad gave the body length of the lectotype as 30 mm, the siphon as 22 mm. The photograph clearly shows the characteristic widened abdomen.

Poisson (1949) noted that the parameres of *Laccotrephes brachialis* closely match those of *Laccotrephes fuscus*, but he failed to formally equate the two species because he thought *fuscus* was an Asian species, from "l'Inde," citing Lundblad (1933) as the source for this provenance.

Gerstaecker described *Laccotrephes brachialis* from East Africa (from a locality given as "See Jipe"). He described the prosternal carina of *L. brachialis* as low and of even height all along its length except for the anterior tubercle, which is quite removed from the anterior margin; he gave the length of the body as 40 mm, the siphon 35 mm.

Poisson (1949: 30–31; 1965: 240) restricted *L. brachialis brachialis* to those specimens with a body length of 33–40 mm and the sides of the abdomen enlarged, and gave the distribution as West Africa, Uganda, Zaire, etc. He assigned those of 37–45 mm with the sides of the abdomen parallel to *L. brachialis oculatus* Montandon, known from Sierra Leone and Zaire. Poisson (1954) has also described a considerably smaller subspecies, *L. brachialis kazibae* from Zaire, with body length given as 23–30 mm. Because they all are said to occur in Zaire, the

status of these subspecies should be carefully scrutinized, for if any two are found together they must either be considered synonyms or separate species.

SYNONYMY

The evidence presented here leaves little doubt concerning the synonymy of *Nepa fusca* Linnaeus, 1758 and *Laccotrephes brachialis* Gerstaecker, 1873 (new synonymy). This species has three salient characteristics that in combination set it apart from any other *Laccotrephes* species: 1) The unique shape of the distal part of the male paramere, which is somewhat like a crochet hook. All three subspecies share this character to a degree but have other differences (see above). 2) The shape of the abdomen, slightly expanded just behind the middle. *Laccotrephes ampliatus* (Montandon) is similar in this regard, but is definitely broader than *L. brachialis*. 3) The unique shape of the prosternal carina. No other species I have examined (including most of the known species) has the odd characteristics of a low carina with an isolated anterior tumescence removed from the anterior margin.

The usage of the names *fusca* and *brachialis* are about equal in the literature, so it is difficult to make a case for suppression of the name *fusca*, particularly in view of the previous evidence for the synonymy given by both Lundblad (1933) and Poisson (1949). The only plausible explanation of why one of these authors did not formalize the synonymy must have been their apparent belief and mind-set that *fusca* was Oriental.

Laccotrephes fuscus (Linnaeus, 1758)

Nepa fusca Linnaeus, 1758: 440. Lectotype here designated.

Nepa fusca: Linnaeus, 1764: 166.

Nepa fusca: Linnaeus, 1767: 713.

Nepa fusca: Müller, 1774: 472.

Nepa fusca: Goeze, 1778: 173.

Nepa fusca: Olivier, 1811: 189. [in part]

Laccotrephes fuscus: Stål, 1868: 135. [redescription of Linnaean type]

Laccotrephes brachialis Gerstaecker, 1873: 422. New Synonymy

Laccotrephes brachialis: Montandon, 1914: 127.

Nepa fusca: Esaki, 1926: 179. [in part]

Laccotrephes fuscus: Lundblad, 1933: 22–23. [redescription of Linnaean type]

Laccotrephes brachialis: Poisson, 1949, 30, fig. 32A, B, C, fig. 33A, B.

Laccotrephes fuscus: Poisson, 1949: 31. [comparison with *L. brachialis*]

Laccotrephes brachialis: Poisson, 1954: 17, fig. 5A.

Laccotrephes brachialis: Poisson, 1965: 240, fig. 3C.

Laccotrephes brachialis: Linnavuori, 1971: 357.

References to *L. fusca* referring to other species:

Nepa fusca: Fabricius, 1775: 692. [belostomatid sp.; *Benacus griseus*?]

Scorpion-aquatique gris Stoll, 1780: 35–36. pl. I, fig. II. [*Laccotrephes griseus* (Guerin)?]

Nepa fusca: Fabricius, 1781: 333. [belostomatid sp.; = *fusca* Fabricius, 1775]

Nepa fusca: Fabricius, 1787: 277. [*Laccotrephes occultus* Lundblad?; not *L. grossa*, which was described in the same work.]

Nepa fusca: Gmelin, 1790: 2121. [*Laccotrephes occultus* Lundblad?; = *L. fusca* F., 1787.]

Nepa fusca: Fabricius, 1794: 62. [*Laccotrephes occultus* Lundblad?; = *L. fusca* F., 1787.]

Nepa fusca: Turton, 1802: 607. [*Laccotrephes occultus* Lundblad?; = *L. fusca* F., 1787.]

Nepa fusca: Fabricius, 1803: 107. [*Laccotrephes griseus* (Guerin)?]

Nepa fusca: Olivier, 1811: 189. [in part]

Nepa fusca: Ferrari, 1888: 184. [*Laccotrephes* sp.?; synonymy; redescription; nomen inquerendum]

Nepa fusca: Esaki, 1926: 179. [*Laccotrephes* spp.; in part]

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A REVIEW OF THE GENUS *STRIDULIVELIA* HUNGERFORD AND TWO
NEW SPECIES (HETEROPTERA: VELIIDAE) FROM
SOUTH AMERICA

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Abstract.—Two new species are described, *Stridulivelia ayacucho* from the Territorio Federal Amazonas of Venezuela and *S. anta* from Amazonas, Brazil. *Stridulivelia nama* (Drake 1957) is placed as a junior synonym of *S. tersa* (Drake & Harris 1941) (new synonymy). Habitat and distributional data and maps are given for the South American species along with a key to species of the nominate subgenus *Stridulivelia*.

Key Words: Heteroptera, Veliidae, *Stridulivelia*, new species, water strider, synonymy, key to subgenera, key to species, South America

Hungerford (1929) established the subgenus *Stridulivelia* for those members of the genus *Velia* Latreille 1804 that share a general facies that he characterized as follows: "The sides of the thorax are devoid of hair and sculptured with depressed figures. The middle legs are the longest. Two or more of the anterior ventral abdominal segments bear transverse grooves and all of the species, except *Velia cinctipes* Champion, 1898, are provided with a stridular patch on the hind femur and with a row of stridular pegs on the submargin of the abdomen." Polhemus (1976) elevated *Stridulivelia* to generic rank and later Polhemus (1979) established the subgenus *Aenictovelia* for the primarily Mesoamerican species that lack the stridulatory mechanism. The Mesoamerican species were revised by Drake and Menke (1962) and two additional species were added by Polhemus (1979) and Polhemus and Polhemus (1985); thus, the fauna of that region is adequately known. This contribution, therefore, deals only with the

South American species assigned to *Stridulivelia*—*S. (A.) cinctipes* (Champion); *S. (S.) alia* (Drake); *S. (S.) anta* Polhemus & Spangler, new species; *S. (S.) astralis* (Drake & Harris); *S. (S.) ayacucho* Polhemus & Spangler, new species; *S. (S.) quadrispinosa* (Hungerford); *S. (S.) raspa* (Hungerford); *S. (S.) stridulata* (Hungerford); *S. (S.) strigosa* (Hungerford); *S. (S.) tersa* (Drake & Harris); *S. (S.) transversa* (Hungerford). Of the five species in the subgenus *Aenictovelia*, only *Stridulivelia (A.) cinctipes* occurs in northern South America and Mesoamerica and is included in this study.

Both authors have made substantial collections of these insects in South America and we believe the taxonomy, habitat, and distribution of the South American members of *Stridulivelia (Stridulivelia)* are now reasonably well understood. This information and the synonymy are given for each species and a key to the species of *Stridulivelia (Stridulivelia)* is provided.

Paratypes of the new species are depos-

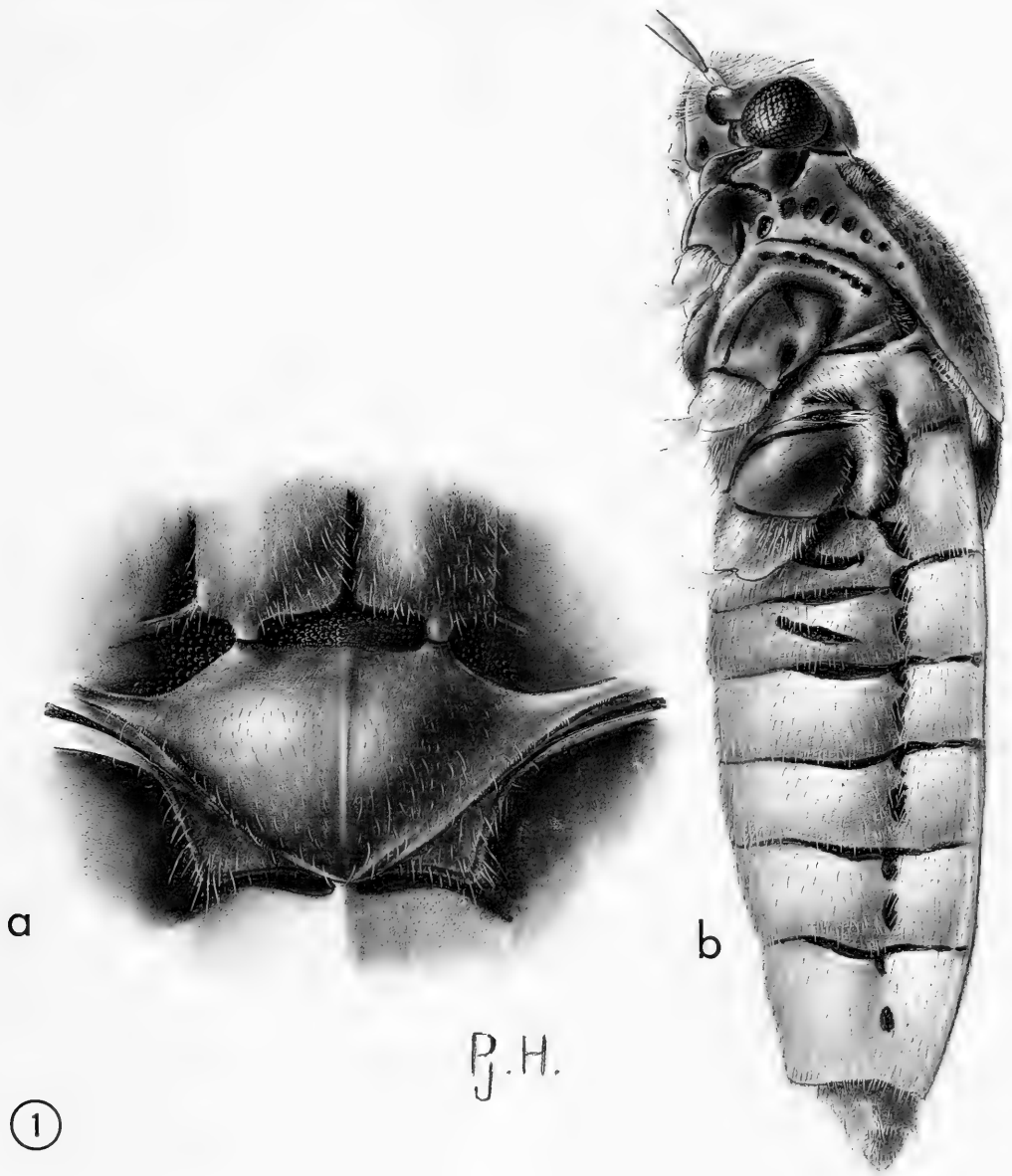


Fig. 1. *Stridulivelia (Aenictovelvia) epeixis* (Drake & Menke): a, metasternum and scent gland channels; b, body, lateral view (from Drake and Menke 1962)

ited in the U.S. National Museum of Natural History, Smithsonian Institution, Washington (NMNH) and, as material permits, paratypes will be deposited in the American Museum of Natural History, New York (AMNH) and the J. T. Polhemus Collection (JTPC).

Genus *Stridulivelia* Hungerford

Stridulivelia Hungerford, 1929: 55 (as subgenus of *Velia* Latreille, 1804).

Stridulivelia: Polhemus, 1976: 509 (raised to generic rank).

Aenictovelvia Polhemus, 1979: 46 (as subgenus of *Stridulivelia*).

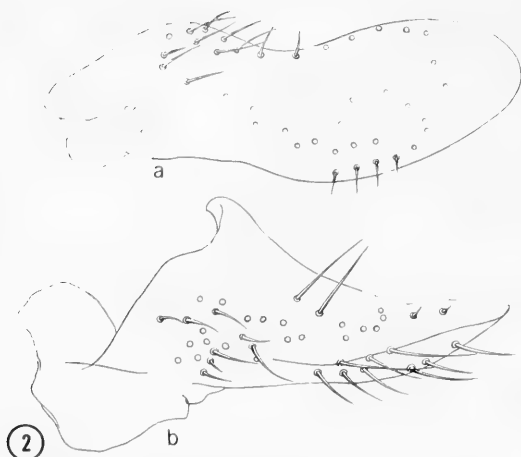


Fig. 2. *Stridulivelia* species, left parameres: a, *S. (Stridulivelia) tersa* (Drake & Harris); b, *S. (Aenictovelina) cinctipes* (Champion). (From Drake and Menke 1962)

Discussion: The genus *Stridulivelia* is restricted to the New World. Its Old World sister group is *Tetraripis*, a genus Andersen (1982) placed in the subfamily Rhagoveliinae on account of a swimming plume resembling that of *Rhagovelina*; however, *Tetraripis* has been transferred by D. A. Polhemus (in press) to the Veliinae by reason of the morphology of the scent gland channels (i.e. angled anteriorly in *Stridulivelia*; Fig. 1a), fore tibial grasping comb in females, and swimming plumes of a different nature than in *Rhagovelina*, representing parallelism in these pretarsal structures.

Stridulivelia Hungerford

KEY TO SUBGENERA

- Stridulatory apparatus present in both sexes, consisting of rastrate patch on hind femur and pegs or ridges on connexival margin. Claws slender, downcurving arolia slender. *Stridulivelia*
- Stridulatory apparatus absent in both sexes. Claws blade-like, downcurving arolia blade-like *Aenictovelina*

Discussion: The subgenus *Aenictovelina* is primarily Mesoamerican; however, *S. (A.) cinctipes* (Champion) occurs widely in

northern South America. This species and all others of the subgenus are easily distinguished from those of the subgenus *Stridulivelia* by the lack of stridulatory structures (Fig. 1b) and the complex (Fig. 2b) rather than simple (Fig. 2a) parameres. In the taxonomic treatment below, a key is given only for species of the subgenus *Stridulivelia*, which is restricted to South America including Trinidad.

Stridulivelia (Aenictovelina) cinctipes
(Champion)
Figs. 2b, 3

Velia cinctipes Champion, 1898: 143, pl. 9, fig. 9. (Type from Santarem, Brazil; in BMNH.)

Velia (Stridulivelia) cinctipes; Hungerford, 1929: 55.

Stridulivelia cinctipes; Polhemus, 1976: 509.

Stridulivelia (Aenictovelina) cinctipes; Polhemus, 1979: 46.

Material examined.—COLOMBIA: Antioquia: 4 ♂ micr., 4 ♀ micr., trib to Rio Claro, W of Doradal, CL 2406, 21.VII.1989, J. T. & D. A. Polhemus (JTPC); 1 ♂ micr., 1 ♂ macr., 2 ♀ macr., Quebrada Cristalina, 18 km W of Doradal on Hwy. 60, 350 m, water temp. 22.5°C, CL 2407, 22.VII.1989, J. T. & D. A. Polhemus (JTPC). GUYANA: Mazaruni-Potaro Dist.: 1 ♀ micr., Takatu Mtns., 6°15'N, 59°5'W, 3-10.XII.1983, P. Spangler, R. Faitoute (NMNH). VENEZUELA: Amazonas: 3 ♀ micr., 42 km S. Puerto Ayacucho, Tobogan, CL 2371, 19.I.1989, J. T. Polhemus (JTPC); 3 ♂ micr., 5 ♀ micr., 42 km S. Puerto Ayacucho, small trib to Caño Coromoto, at Tobogan, CL 2388, 26.I.1989, J. T. Polhemus (JTPC); 1 ♂ micr., tiny stream, trib to Rio Gavilan, nr. bridge, CL 2379, 23.I.1989, J. T. Polhemus (JTPC). Dist. Federal: 2 ♂ micr., 1 ♀ micr., Los Caracas, 19.I.1985, P. Spangler, R. Faitoute, W. Steiner, A. Conover (NMNH).

Known distribution (Fig. 3).—Brazil, Colombia, Costa Rica, Guatemala, Guyana,

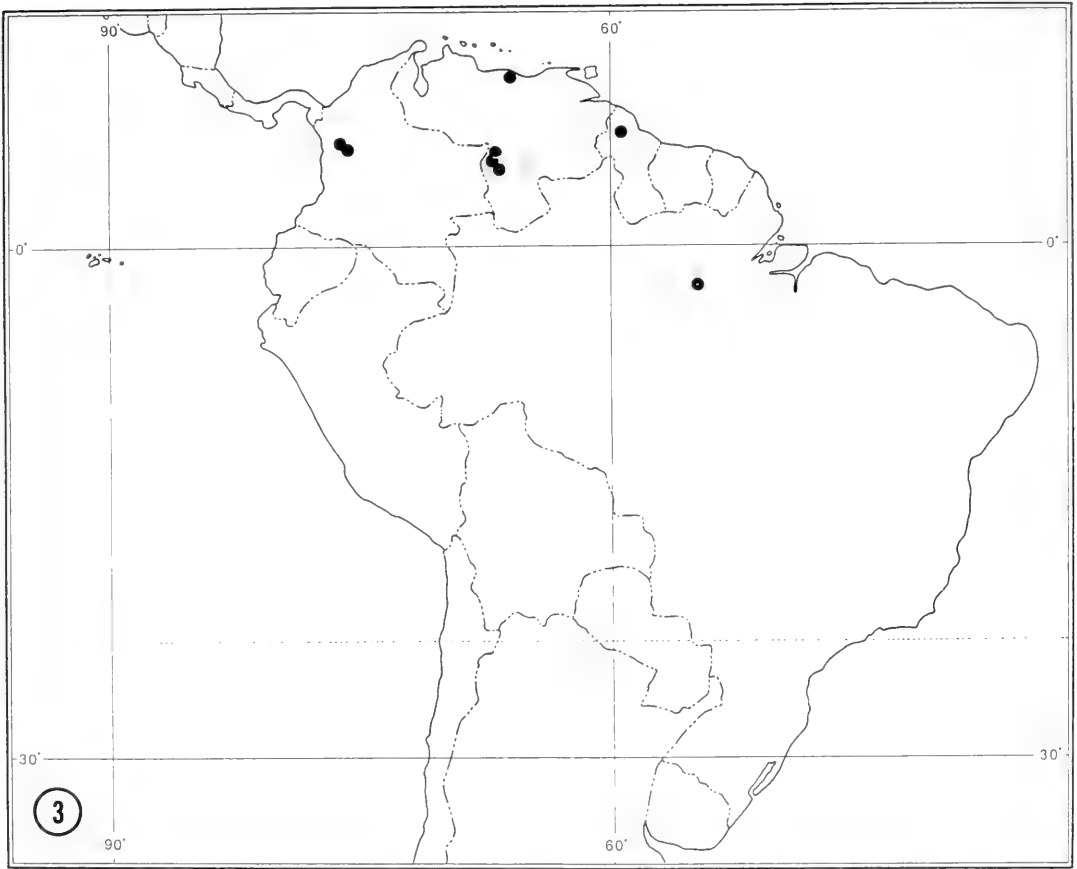


Fig. 3. *Stridulivelia (Aenictovelia) cinctipes* (Champion), known South American distribution.

Mexico, Panama, Venezuela. Only South American localities are plotted.

Discussion.—This predominantly micropterous species is easily distinguished from all other South American species of the genus by the lack of an evident stridulatory mechanism and the usual presence in males of a long stout spine on the hind trochanter. The length of this spine on the hind trochanter is extremely variable, essentially lacking in some specimens and extremely long in others. *Stridulivelia cinctipes* is common throughout Panama and Costa Rica, where we have collected many specimens; it was reported from Guatemala and Mexico by Drake and Menke (1962), but we have not seen specimens from Mexico.

Stridulivelia (Stridulivelia) Hungerford

KEY TO SPECIES

1. First five (visible) ventral abdominal segments with transverse glabrous grooves. (Male also has small groove on segment VI) *transversa* (Hungerford)
 First four or fewer ventral abdominal segments with transverse glabrous grooves 2
2. First four ventral abdominal segments with transverse glabrous grooves (female may have just a spot on segment IV; male has small groove on segment V, Fig. 18b) .. *tersa* (Drake & Harris)
 First three or fewer ventral abdominal segments with transverse glabrous grooves 3
3. Pronotal humeral angles spinose (Fig. 4a) ...
 *alia* (Drake)
 Pronotal humeral angles not spinose (Figs. 15a, 18a) 4

- 4. First two ventral abdominal segments with transverse glabrous grooves 5
 First three ventral abdominal segments with transverse glabrous grooves 6
- 5. Length of second antennal segment subequal to width of head across eyes (male) or at most 1.13 times greater (female). Male without a digitate process ventrally on first genital segment. Female without spine-like processes on posterior margin of abdominal tergite VII
 *ayacucho*, n. sp.
 Length of second antennal segment clearly greater than width of head across eyes; 1.22 (female) to 1.38 (male) times greater. Male with a digitate process ventrally on first genital segment. Female with two posteriorly directed spine-like processes on posterior margin of abdominal tergite VII *stridulata* (Hungerford)
- 6. Length of first antennal segment at least 1.5 times width of head across eyes. Body and legs long, slender *strigosa* (Hungerford)
 Length of first antennal segment no more than 1.2 times width of head width across eyes. Body stout, legs stout, hind femur incrassate 7
- 7. Length of first antennal segment about 1.2 times width of head across eyes. Males with pair of prominent projections ventrally on last abdominal segment. Stridulatory patch on hind femur with about 26–32 sharp pegs not organized in rows *anta*, n. sp.
 Length of first antennal segment equal to or less than width of head across eyes. Males with or without pair of prominent projections ventrally on last abdominal segment. Stridulatory patch on hind femur may or may not be organized in rows 8
- 8. Length of first antennal segment about 0.8 width of head across eyes. Males without pair of prominent projections ventrally on last abdominal segment. Female genital segment, in dorsal view, sharply triangular with length equal to basal width. Stridulatory patch on hind femur organized in about 17 rows of tiny spinulae *astralis* (Drake & Harris)
 Length of first antennal segment about equal to width of head across eyes. Males with pair of prominent projections ventrally on last abdominal segment. Female genital segment, in dorsal view, rounded or broadly triangular with length clearly less than basal width. Stridulatory patch on hind femur may or may not be organized in rows 9
- 9. Stridulatory patch on hind femur with about 40 sharp pegs not organized in rows; connexival margin with a row of fine vertical ridges. Male (ventrally) and female (dorsally) with prominent projections posteriorly on seventh abdominal segment . . . *quadrispinosa* (Hungerford)

Stridulatory patch on hind femur organized in about 17 rows of tiny spinulae; connexival margin with a thin row of tiny pegs. Male (ventrally) with prominent projections posteriorly on seventh abdominal segment; female (dorsally) without prominent projections posteriorly on seventh abdominal segment
 *raspa* (Hungerford)

Stridulivelia (Stridulivelia) alia
 (Drake)
 Figs. 4, 5

Velia alia Drake, 1957: 115 (Type from Bar-tica District, Guyana; in the National Museum of Natural History).
Stridulivelia alia; Polhemus, 1976: 509.

Material examined (all JTPC, unless noted).—BRAZIL: Amazonas: 6 ♂ micr., 2 ♂ macr., 4 ♀ micr., 1 ♂ macr., Reserva Ducke, 25 km NE of Manaus, Igarape de Anta, 60 m, water temp. 24.5°C, 25.VIII.1989, CL 2472, J. T. and D. A. Polhemus; 1 ♂ micr., 8 ♂ macr., 5 ♀ macr., Reserva Ducke, Igarape Barro Branco, nr. headquarters, 50 m, 27.VIII.1989, CL 2475, J. T. and D. A. Polhemus; 6 ♂ micr., 33 ♂ macr., 9 ♀ micr., 39 ♀ macr., forest stream at INPA forest management station, 98 km NW Manaus, 90 m, water temp. 25°C, 29 Aug. 1989, CL 2477, J. T. & D. A. Polhemus; 7 ♂ macr., 15 ♀ macr., stream near viewing tower, 90 km NW Manaus, 90 m, 29 Aug. 1989, CL 2478, J. T. & D. A. Polhemus; 29 ♂ micr., 26 ♀ micr., stream nr. Egler Reserve, 30.VIII.1989, CL 2479, J. T. and D. A. Polhemus. Para: 5 ♂ macr., 3 ♀ macr., Rio Xingu, camp, 52°22'W, 3°39'S, ca. 60 km S Altamira, 3.X.1986, P. Spangler, O. Flint (NMNH). GUYANA: 6 ♂ micr., 1 ♀ micro, 40 km S Georgetown, 4°29.9'N, 58°13.1'W, 13.IV.1994, P. J. Spangler, colln #27 (NMNH); 1 ♂ micro, 1 ♀ micro, 1 ♀ macr., Dubulay Ranch, 5°39.8'N 57°53.4'W, Warniabo River, 10.IV.1994, P. J. Spangler & R. Parris, colln #24 (NMNH). SURINAME: 1 ♂ macr., 1 ♀ macr., Zanderijsavanne, 4.IX.1969, SN 117B, N. Nieser; 1 ♀ micr., Coesewijn Project, 24.III.1970, SN 371, N. Nieser; 1 ♂ micr., 1 ♀ micr., Coesewijn Pro-

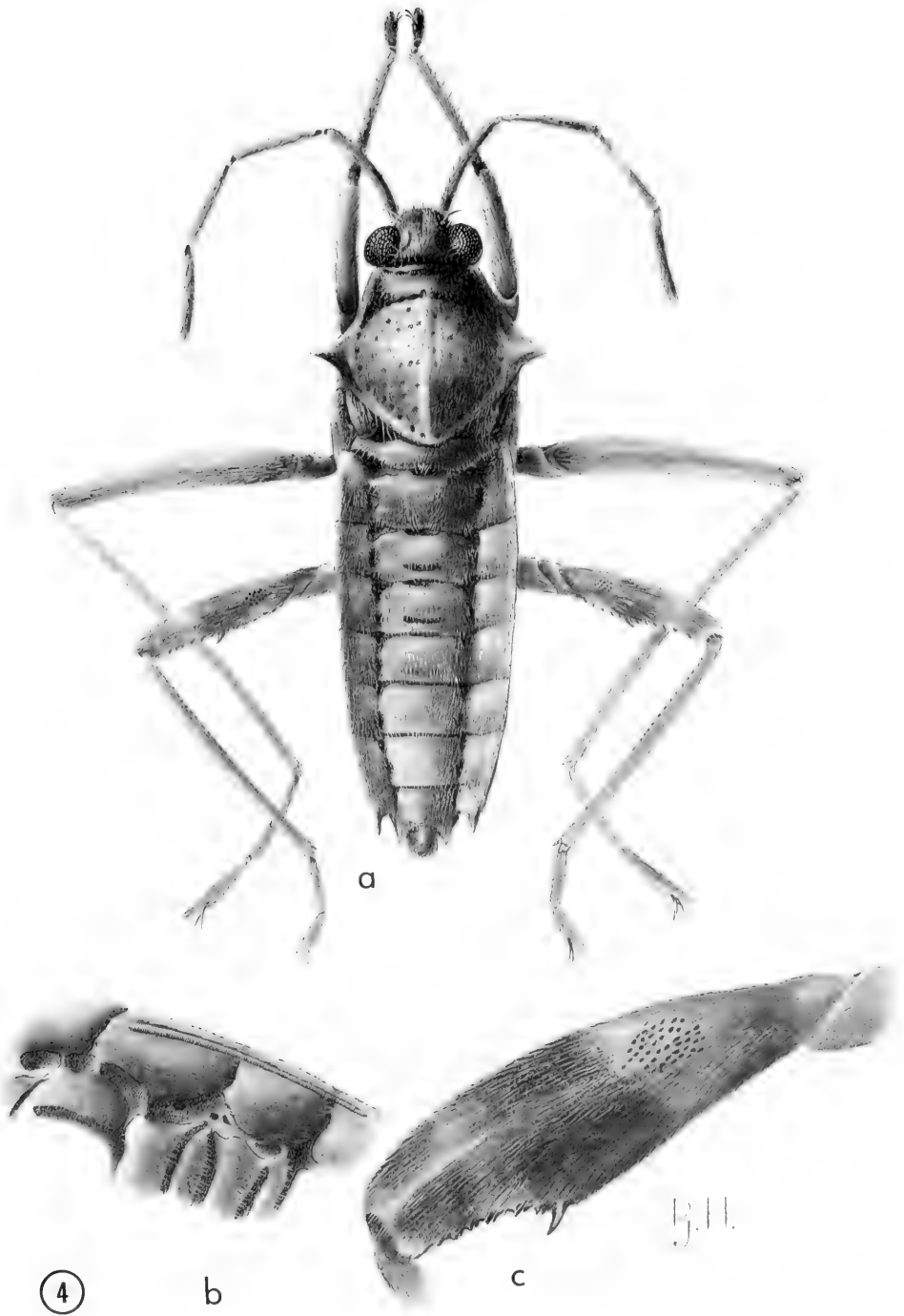


Fig. 4. *Stridulivelia (Stridulivelia) alia* (Drake): a, dorsal habitus, micropterous female; b, connexiva, lateral view, showing stridular file of fine vertical ridges; c, hind femur, showing stridular denticles.



Fig. 5. *Stridulivelia (Stridulivelia) alia* (Drake), known distribution.

ject, 3.III.1970, SN 368, N. Nieser; 1 ♀ macr., 1st streamlet, Hanover Rd., 4.VIII.1969, SN 061, N. Nieser; 1 ♂ micr., Troelikkreek, 18.XI.1969, SN 237, N. Nieser. VENEZUELA: Amazonas: 9 ♂ micr., 9 ♀ micr., small clear stream with sandy bottom, 0.5 km N of Alto Mavaca Base Camp, 2°1'30"N, 65°7'0"W, 228 m, water temp. 22°C, CL 8006, 4.II.1989, D. A. Polhemus; 2 ♂ micr., 1 ♀ micr., small shallow forest stream, trib to upper Rio Siapa, 1°43'N, 64°30'W, 635 m, water temp. 21.5°C, CL 8011, 8.II.1989, D. A. Polhemus.

Known distribution (Fig. 5).—Brazil, Guyana, Suriname, Venezuela.

Discussion.—*Stridulivelia alia* (Drake) is the most easily distinguished *Stridulivelia*

species because of the unique spines on the humeral angles of both sexes.

***Stridulivelia (Stridulivelia) anta*
Polhemus and Spangler, NEW SPECIES
Figs. 6–8**

Diagnosis.—*Stridulivelia anta*, new species, is most closely related to *S. quadrispinosa* (Hungerford 1929) and *S. alia* Drake. It differs from *S. quadrispinosa* by the smaller size, shorter antennae, fewer stridulatory pegs on the hind femur, and differently formed abdominal terminalia in both males and females. *Stridulivelia anta* is very similar to *S. alia* (Fig. 4) in body size, shape, coloration and stridulatory mechanism; however, *S. anta* is distinguished by the ab-

sence of large spines on the humeral angles, longer glabrous groove on male abdominal sternite IV, less tumid male genital segments, and male proctiger with much shorter and blunt lateral protuberances (Fig. 7). The female of *S. anta* is without spines protruding posteriorly from the first genital segment.

Description.—*Micropterosus male*: Length, mean = 4.09 mm (N = 10, min. 3.77, max. 4.50). Width, mean = 1.07 mm (N = 10, min. 1.00, max. 1.17).

Ground color orange brown, venter somewhat lighter. Pronotum anteriorly lighter, anterolaterally with prominent triangular silvery spots. Head light orange brown; tips of antennal tubercles, bucculae, anteclypeus yellowish; rostrum yellowish brown, distal segment black. Legs and antennae yellow to light brown, lighter ventrally; antennal segment 4 broadly lighter medially.

Head short, almost vertical anteriorly; bucculae prominent, short; rostral cavity closed behind; collar not prominent, set off by a few weak pits; length 0.39; width of eye/interocular space, 0.22/0.28. Pronotum long, humeri not prominent; weakly carinate on midline, carina evanescent anteriorly and posteriorly; with shallow pits, depressed part of each pit with several glabrous light reflecting facets; disc raised; posterior margin rounded at apex; length : width, 1.00 : 1.05. Micropterosus wing pads with silvery setae, reaching onto base of abdominal tergite I.

Dorsum clothed with short semi-erect pubescence and scattered longer setae. Abdominal tergites I, III–VI subequal in length (0.22–0.28), III, VII longer (0.33); connexival margins of II, III, and basal part of IV with a stridular file of fine vertical ridges (similar to those of *S. alia*, Fig. 4b); distal connexival spines acuminate, extending to distal part of first genital segment. Abdominal sternite II (first visible) medially carinate; VII modified, with stout tubercles posteroventrally; sternites II–IV with long,

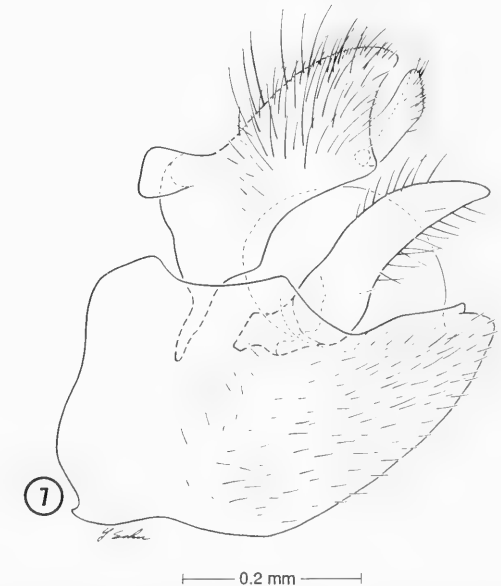
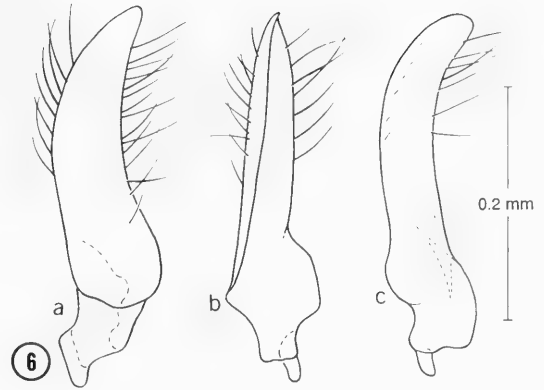


Fig. 6. *Stridulivelia (Stridulivelia) anta* Polhemus & Spangler, n. sp., male paramere: a, lateral view; b, anterior view; c, posterolateral view.

Fig. 7. *Stridulivelia (Stridulivelia) anta* Polhemus & Spangler, n. sp., male genital capsule, lateral view.

glabrous, transverse striae laterally, striae shorter on IV. Legs and antennae thickly clothed with short to moderate length setae; with scattered longer setae ventrally on all femora and tibiae. Posterior trochanters unarmed. Posterior femur tumid, denticulate ventrally, basally with a few scattered denticles increasing in length and frequency dis-



Fig. 8. *Stridulivelia (Stridulivelia) anta* Polhemus & Spangler, n. sp., known distribution.

tally, also with a stout tooth at distal $\frac{2}{3}$ followed by a distal row of small denticles; stridulatory patch small, dorsal, at basal $\frac{1}{4}$, consisting of 26–32 small but stout, black denticles not organized into rows (similar to those of *S. alia*, Fig. 4c). Posterior tibia ventrally with numerous denticles over entire length, not organized into rows; with a very large stout apical spur.

Antennal formula I:II:III:IV; 0.80:0.56:0.56:0.56. Claws long, slender, preapical; dorsal and ventral arolia slender, prominent. Measurements of legs as follows: Femur, tibia, tarsal-1, tarsal-2, tarsal-3 of male fore-leg, 0.97, 0.97, 0.06, 0.05, 0.22; middle-leg, 1.55, 1.66, 0.11, 0.61, 0.42; hind-leg, 1.56, 1.89, 0.06, 0.23, 0.39.

Male genital capsule as shown in Fig. 7.

Proctiger sculptured, with blunt lateral projections (Fig. 7). Paramere long, slender (Fig. 6).

Macropterous male: Length, mean = 4.42 mm (N = 3, min. 4.33, max. 4.50). Width, mean = 1.44 mm (N = 3, min. 1.44, max. 1.44). Similar in most respects to microppterous male, except pronotum longer and wider, broadly V-shaped posteriorly. Hemelytra chocolate brown, reaching to tip of abdomen; each with two (1 + 1) spots of silvery setae, one basally, the other along costal margin at basal $\frac{1}{3}$; distally with single median, light colored, V-shaped mark opening posteriorly, sometimes followed by light streak; basal half with scattered patches of short golden setae, absent medially and distally.

Micropterous female: Length, mean = 4.12 mm (N = 10, min. 4.00, max. 4.27). Width, mean = 1.14 mm (N = 10, min. 1.11, max. 1.17). Color and most structures as in male, except slightly broader. First genital segment truncate, with slight lateral posteriorly directed projections.

Macropterous female: Length, mean = 4.38 mm (N = 4, min. 4.22, max. 4.61). Width, mean = 1.44 mm (N = 4, min. 1.39, max. 1.50). Except for sex, similar to macropterous male.

Ecological notes.—At the type locality, *S. anta* was taken along with 5 other species of *Stridulivelia*—*S. alia* (Drake), *S. tersa* (Drake and Harris), *S. stridulata* (Hungerford), *S. strigosa* (Hungerford), and *S. transversa* (Hungerford); thus 6 of the 10 known species of this genus were collected at a single site. The type locality is a moderately sized, clear, headwater stream flanked with small springs and pools in the original rain forest of Reserva Ducke, a biotope located in low sandy hills.

Etymology.—The name *anta*, a noun in apposition, refers to the type locality, Igarape da Anta, in Reserva Ducke, Amazonas, Brazil.

Material examined.—Holotype, microppterous male: BRAZIL: Amazonas, Reserva Ducke, 25 km NE Manaus, Igarape da Anta, 60 m, water temp. 24.5°C., 25 Aug. 1989, CL 2472, J.T. & D.A. Polhemus (INPA).

Paratypes: BRAZIL: Amazonas: 9 ♂ micr., 11 ♀ micr., same data as holotype (JTPC, AMNH, NMNH); 8 ♂ micr., 9 ♀ micr., Reserva Ducke, 25 km NE Manaus, Igarape Barro Branco, 50 m, water temp. 23.5°C., 27 Aug. 1989, CL 2475, J. T. & D. A. Polhemus (JTPC); 3 ♂ macr., 4 ♀ macr., stream near viewing tower, 90 km NW Manaus, 90 m, 29 Aug. 1989, CL 2478, J. T. & D. A. Polhemus (JTPC); 2 ♂ macr., rainforest stream at INPA Forest Mgmt. Sta., 98 km NW Manaus, 90 m, 29 Aug. 1989, CL 2477, J. T. & D. A. Polhemus (JTPC). VENEZUELA: Amazonas: 2 ♂ micr., Cerro de la Neblina, white water str., 1 km S. Base-

camp, 0°50N, 66°10W, 140 m, 8.II.1985, W. E. Steiner, R. Holling (NMNH).

Known distribution (Fig. 8).—Brazil, Venezuela.

Stridulivelia (Stridulivelia) astralis
(Drake & Harris)

Fig. 9

Velia astralis Drake & Harris, 1938: 200 (Type from Matto Grosso, Brazil; in Museo de La Plata).

Stridulivelia astralis; Polhemus, 1976: 509.

Material examined (all JTPC, unless noted).—BRAZIL: Goias: 1 ♂ micr., 1 ♀ micr., 2 ♂ macr., 1 ♀ macr., 48 km S. Peixe, 1.VI.1956, F. Truxal. Matto Grosso: 1 ♂ micr., 1 ♀ micr., Capita Vasconcelos, on Rio Tuatuari, Up. Xingu Basin, 31.VII.1957, B. Malkin. PARAGUAY: Cordillera: 2 ♀ macr., Dist. Caacupe, Cabañas, 9.XII.1980, R. D. Cave (NMNH); 1 ♀ micr., Depto. Cordillera, Piribebuy, Rio Piribebuy, 3.V.1985, T. Bonace (NMNH). Central: 1 ♀ macr., Asuncion, 9.XI.1974, J. Sedlacek; 1 ♀ macr., Horqueta, 17.XII.1974, Alperdo Schulze.

Known distribution (Fig. 9).—Brazil, Paraguay.

Discussion.—*S. astralis* and *S. raspa* are small, stout-bodied, closely related species with a small, rastrate stridulatory patch on the hind femur. They may be distinguished by the characters given in the key.

Stridulivelia (Stridulivelia) ayacucho
Polhemus and Spangler, NEW SPECIES

Figs. 10–12

Diagnosis.—*Stridulivelia ayacucho*, new species, most closely resembles *S. quadrispinosa* (Hungerford) in size, general habitus, female abdominal terminalia, and most other features. However, the male of *S. ayacucho* lacks the paired protuberances found on abdominal sternite VII of *S. quadrispinosa* and the stridulatory patch on the hind femur is a rastrate area of parallel sclero-



Fig. 9. *Stridulivelia (Stridulivelia) astralis* (Drake & Harris), known distribution.

tized ridges unlike the patch of black denticles found on *S. quadrispinosa*.

Stridulivelia ayacucho is perhaps most closely related to *S. stridulata* (Hungerford) (Fig. 15b, c), as the stridulatory mechanisms are the same, as well as most other features. In *S. stridulata*, however, the abdomen is more strongly narrowed in both sexes (Fig. 15a); the males have longer upturned connexival spines, spatulate parameres, and a strong digitate process on the first genital segment (Hungerford, 1929, Figs. 3, 8), and the females have two long processes on abdominal tergite VIII (Fig. 15a).

Description.—*Micropterosus male*: Length, mean = 4.73 mm (N = 10, min. 4.38, max. 4.99). Width (across base of abdomen), mean = 1.32 mm (N = 10, min. 1.28, max. 1.39).

Ground color brown. Abdominal venter yellowish on each side of midline and along connexival margins. Pronotum anteriorly slightly lighter, anterolaterally without silvery spots; connexival margins yellowish. Head light brown; antennal tubercles lighter; rostrum yellowish brown, distal segment black. Legs and antennae yellow to light brown, lighter ventrally. Posterior femur with broad dark annulus just beyond middle and another distally. Antennal segment 4 light on distal $\frac{4}{5}$.

Head short, almost vertical anteriorly; bucculae prominent, short, rostral cavity closed behind; collar not prominent, set off by a few weak pits plus elongate transverse pit behind each eye; length 0.47; width of eye/interocular space, 0.28/0.28. Pronotum

long, humeri not raised; weakly carinate on midline, carina evanescent posteriorly; with shallow pits, depressed part of each with several glabrous light reflecting facets; disc raised; posterior margin rounded at apex, set off by row of pits; length : width, 1.22: 1.17. Micropterous wing pads with silvery setae, reaching onto base of abdominal tergite I.

Dorsum clothed with short, semi-erect pubescence and scattered, dark, erect, long setae. Abdominal tergites I–VI subequal in length (0.28–0.33), VII longer (0.39); connexival margins II–IV with stridular file of about 30 black, knob-like denticles (similar to that of *S. stridulata*, Fig. 15b); distal connexival spines long, acuminate, extending to middle of genital segments. Abdominal sternite II (first visible) medially carinate; VII modified, tumescent, tumescence abruptly terminating posteriorly; sternites II–III with long, glabrous, transverse striae laterally, located about midway between intersegmental sutures. Legs and antennae thickly clothed with short to moderately long setae; with scattered longer setae ventrally on all femora and tibiae. Posterior trochanters with 8–10 tiny black denticles. Posterior femur tumid, denticulate ventrally; with 2 ragged parallel rows of small denticles plus a few more distally, all subequal in size, except stout tooth at distal $\frac{2}{3}$ on anterior row; dorsally near base with long, broad stridulatory patch consisting of about 50 parallel sclerotized ridges; each ridge interrupted 7 to 20 times, ridges very thin and closely packed anteriorly, progressively coarser posteriorly, extending onto posterior face of femur (similar to that of *S. stridulata*, Fig. 15c). Posterior tibia ventrally with numerous denticles over entire length, mostly organized into 2 rows; with a stout apical spur.

Antennal formula I:II:III:IV; 1.10:0.89:0.69:0.61.

Claws long, slender, preapical; dorsal and ventral arolia slender, prominent. Measurements of legs as follows: Femur, tibia, tar-

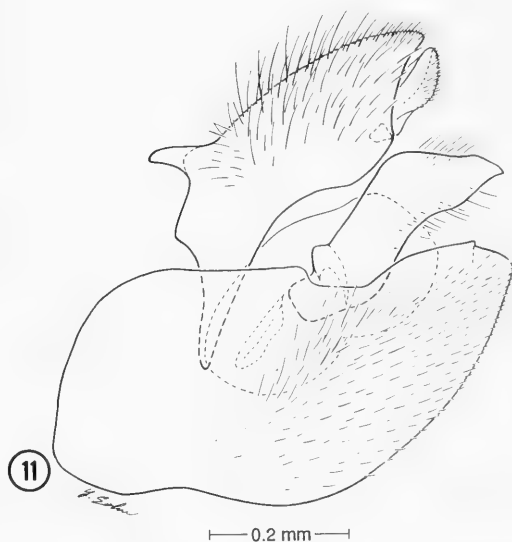
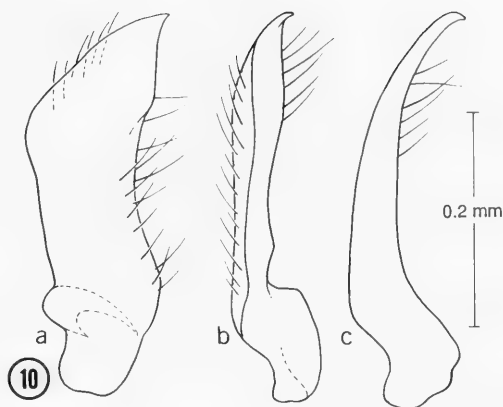


Fig. 10. *Stridulivelia (Stridulivelia) ayacucho* Polhemus & Spangler, n. sp., male paramere: a, lateral view; b, anterior view; c, posterolateral view.

Fig. 11. *Stridulivelia (Stridulivelia) ayacucho* Polhemus & Spangler, n. sp., male genital capsule, lateral view.

sal-1, tarsal-2, tarsal-3 of male fore-leg, 1.22, 1.22, 0.06, 0.05, 0.22; middle-leg, 1.89, 2.05, 0.06, 0.61, 0.50; hind-leg, 1.72, 1.83, 0.06, 0.39, 0.33.

Male genital capsule as shown in Fig. 11. Proctiger sculptured, with acuminate lateral



Fig. 12. *Stridulivelia (Stridulivelia) ayacucho* Polhemus & Spangler, n. sp., known distribution.

projections (Fig. 11). Paramere long, broad, blade-like (Fig. 10).

Macropterous male: Unknown.

Micropterous female: Length, mean = 4.93 mm (N = 10, min. 4.77, max. 5.16). Width (across base of abdomen), mean = 1.45 mm (N = 10, min. 1.39, max. 1.50). Color and most structures as in male, except slightly broader. First genital segment truncate; with prominent, acuminate, lateral, posteriorly directed projections.

Macropterous female: Length, mean = 5.30 mm (N = 2, min. 5.27, max. 5.33). Width (across humeral angles), mean = 1.78 mm (N = 2, min. 1.78, max. 1.78). Similar in most respects to micropterous female, ex-

cept pronotum longer and wider, broadly V-shaped posteriorly, caudally with short (0.14) posteriorly projecting digitate protuberance. Hemelytra chocolate brown, reaching to tip of abdomen; each with two (1 + 1) spots of silvery setae, one large triangular spot basally, another small spot along costal margin at basal $\frac{1}{3}$; distally with single median white almost circular mark, with small V-shaped notch posteriorly; with scattered patches of short golden setae basally, patches absent medially and distally.

Habitat data.—The type locality is a flowing stream in original forest, with alternating long pools and gravel bottomed riffles. The insects were taken from a low, partially

flooded cavity deeply hollowed out under a steep bank laced with tree roots.

Etymology.—The name *ayacucho*, a noun in apposition, refers to the city of Puerto Ayacucho, which is near the type locality.

Holotype, apterous male: VENEZUELA: Amazonas: 21 km S. Tobogan Jct. (53 km S of Pto. Ayacucho), "Missionary Stream," small river with alternating riffles and pools, CL 2375, 22.I.1989, J. T. Polhemus (NMNH).

Paratypes: BRAZIL: Para: 1 ♀ micr., Rio Xingu, camp, 52°22'W, 3°39'S, ca. 60 km S Altamira, 3.X.1986, P. Spangler, O. Flint (NMNH). GUYANA: 1 ♂ micr., Ishezt-Tun., Lat 2°N, 16 km E of Rupununi Riv., 1937, Terry-Hulden Exp. (JTTC). PARAGUAY: Paraguari: 3 ♂ micr., 4 ♀ micr., Cerro Acahay, Arroyo, 31.V.1985, T. Bonace (NMNH). PERU: Madre Dios: 1 ♂ micr., 1 ♀ micr., Parque Manu, Pakitza, 12°07'S, 70°58'W, 250 m, side pools of stream, colln. 39, 13.IX.1989, R. A. Faitoute (NMNH); 1 ♀ micr., Parque Manu, same, but stream, colln. 44, 17-18.IX.1989, R. A. Faitoute (NMNH). VENEZUELA: Amazonas: 5 ♂ micr., 10 ♀ micr., same data as holotype (JTTC); 1 ♀ micr., 6 km S. Tobogan Jct. (38 km S of Pto. Ayacucho), brook, CL 2374, 22.I.1989, J. T. Polhemus (JTTC); 4 ♂ micr., 10 ♀ micr., tiny stream, trib to Rio Gavilan, nr. bridge, CL 2379, 23.I.1989, J. T. Polhemus (JTTC); 2 ♀ micr., 16 km S Pto. Ayacucho, Puente Pulda, CL 2387, 26.I.1989, J. T. Polhemus (JTTC); 2 ♂ micr., 4 ♀ micr., small shallow forest stream, trib to upper Rio Siapa, 1°43'N, 64°30'W, 635 m, water temp. 21.5°C, CL 8011, 8.II.1989, D. A. Polhemus (JTTC, NMNH); 23 ♂ micr., 23 ♀ micr., small clear stream with sandy bottom, 0.5 km N of Alto Mavaca Base Camp, 2°1'30"N, 65°7'0"W, 228 m, water temp. 22°C, CL 8006, 4.II.1989, D. A. Polhemus (JTTC, NMNH); 1 ♂ micr., 1 ♀ micr., 39 km S Pto. Ayacucho, brook, 15.XI.1987, P. Spangler, R. A. Faitoute (NMNH).

Known distribution (Fig. 12).—Brazil, Guyana, Paraguay, Peru, Venezuela.

Stridulivelia (*Stridulivelia*)
quadrspinosa (Hungerford)

Fig. 13

Velia (*Stridulivelia*) *quadrspinosa* Hungerford, 1929: 52. (Type from Santarem, Brazil; in BMNH.)

Stridulivelia quadrspinosa; Polhemus, 1976: 509.

Material examined.—BOLIVIA: Beni: 2 ♂ micr., 2 ♀ micr., rainforest stream 40 km S of Rurrenabaque, nr. Monte Redondo Sawmill, CL 2511, 12.IX.1989, J. T. & D. A. Polhemus (JTTC). BRAZIL: Amazonas: 1 ♂ micr., Rio Crynyn, Missao, A 88-1, 12.I.1961, E. J. Fittkau (JTTC). Para: 2 ♀ micr., Rio Xingu, camp, 52°22'W, 3°39'S, ca. 60 km S Altamira, 3.X.1986, P. Spangler, O. Flint (NMNH). GUYANA: Lethem (30 km SE), 3°18'N, 59°39'W, Moco Moco River, 3.IV.1994, Paul J. Spangler, 1 ♀ micr. (NMNH). PERU: Loreto: 1 ♂ micr., 2 ♀ micr., stream near Napo Camp, CL 2459, 15.VIII.1989, J. T. & D. A. Polhemus (JTTC); 1 ♂ micr., 1 ♀ micr., small rainforest stream near Explorama Inn, CL 2465, 18.VIII.1989, J. T. & D. A. Polhemus (JTTC). VENEZUELA: Amazonas: 2 ♂ micr., 3 ♀ micr., 21 km S. Tobogan Jct. (53 km S of Pto. Ayacucho), "Missionary Stream," small river with alternating riffles and pools, CL 2375, 22.I.1989, J. T. Polhemus (JTTC); 3 ♂ micr., 3 ♀ micr., small clear stream with sandy bottom, 0.5 km N of Alto Mavaca Base Camp, 2°1'30"N, 65°7'0"W, 228 m, water temp. 22°C, CL 8006, 4.II.1989, D. A. Polhemus (JTTC).

Known distribution (Fig. 13).—Bolivia, Brazil, Guyana, Peru, Venezuela.

Discussion.—This species was described from Brazil. We have specimens from several localities matching the original description and figures given by Hungerford (1929), but the species seems to be uncommon.

In three small series from Loreto Dept., Peru, and Beni Dept., Bolivia, the males have the first genital segment more tumid ventrally and the females lack the strongly



Fig. 13. *Stridulivelia (Stridulivelia) quadrispinosa* (Hungerford), known distribution.

projecting spines on tergite VIII; otherwise these specimens match those from Venezuela and Brazil in every respect. For the present, these are considered as variant populations of *S. quadrispinosa*.

Stridulivelia (Stridulivelia) raspa
(Hungerford)

Fig. 14

Velia (Stridulivelia) raspa Hungerford, 1929: 51. (Type from Manacaparu, Amazonas, Brazil; in SEMC.)

Stridulivelia raspa; Polhemus, 1976: 509.

Material examined (all JTPC).—BRAZIL: Amazonas: 2 ♀ micr., Rio Madeira, Ig. (Igarape) Tres Casas, 10.XI.1941, S67, H. Sioli (JTPC); 2 ♀ micr., Rio Madeira, Ig.

Tres Casas, 12.XI.1941, S73, H. Sioli (JTPC).

Known distribution (Fig. 14).—Brazil.

Discussion.—This species has been found only in the lowlands west and south of Manaus, Amazonas, Brazil, and is one of eight *Stridulivelia* species now known from the vicinity of Manaus.

Stridulivelia (Stridulivelia) stridulata
(Hungerford)

Figs. 15, 16

Velia (Stridulivelia) stridulata Hungerford, 1929: 53. (Type from Guyane, Haut-Carsevenne; in Paris Museum.)

Stridulivelia stridulata; Polhemus, 1976: 509.



Fig. 14. *Stridulivelia (Stridulivelia) raspa* (Hungerford), known distribution.

Material examined (all JTPC unless noted).—BRAZIL: Amazonas: 4 ♂ micr., 4 ♀ micr., Reserva Ducke, 25 km NE of Manaus, Igarape da Anta, 60 m, water temp. 24.5°C, 25.VIII.1989, CL 2472, J. T. and D. A. Polhemus; 9 ♂ micr., 11 ♀ macr., Reserva Ducke, Igarape Barro Branco, nr. headquarters, 50 m, 27.VIII.1989, CL 2475, J. T. and D. A. Polhemus; 4 ♀ micr., forest stream at INPA forest management station, 98 km NW Manaus, 90 m, water temp. 25°C, 29 Aug. 1989, CL 2477, J. T. & D. A. Polhemus; 1 ♂ micr., 1 ♀ micr., Igarape Acará, 4 km SE of Ducke Reserve Hdq., 60 m, water temp. 24.5°C, 26 Aug. 1989, CL 2474, J. T. & D. A. Polhemus; 1 ♀ micr., Rio Cuieiras, Branquinho, 22.VII.1969, A 214-

1, E. J. Fittkau; 1 ♂ micr., 2 ♀ micr., Manaus, Ig. (Igarape) Gigante, 3.VII.1961, A 198-6, E. J. Fittkau (JTPC, ZSMC); 3 ♀ micr., Lago Salgado, Ig. S. Benedito, 15.IV.1948, A 223, H. Sioli (JTPC, ZSMC). SURINAME: 1 ♂ micr., Zanderijsavanne, Carolinakreek, 22.VIII.1969, SN 095, N. Nieser; 3 ♂ micr., 1 ♀ micr., Brokopondo, Kakaterekreek, 3.XI.1969, SN 216, N. Nieser; 1 ♂ micr., Saramacca, road to Saramacca-brug, 12 km W of jct. with rd. to Matta, 26.I.1970, SN 299, N. Nieser.

Known distribution (Fig. 16).—Brazil, French Guiana, Suriname.

Discussion.—This species is known only from the micropterous form (Fig. 15a). It is the largest *Stridulivelia* species known.

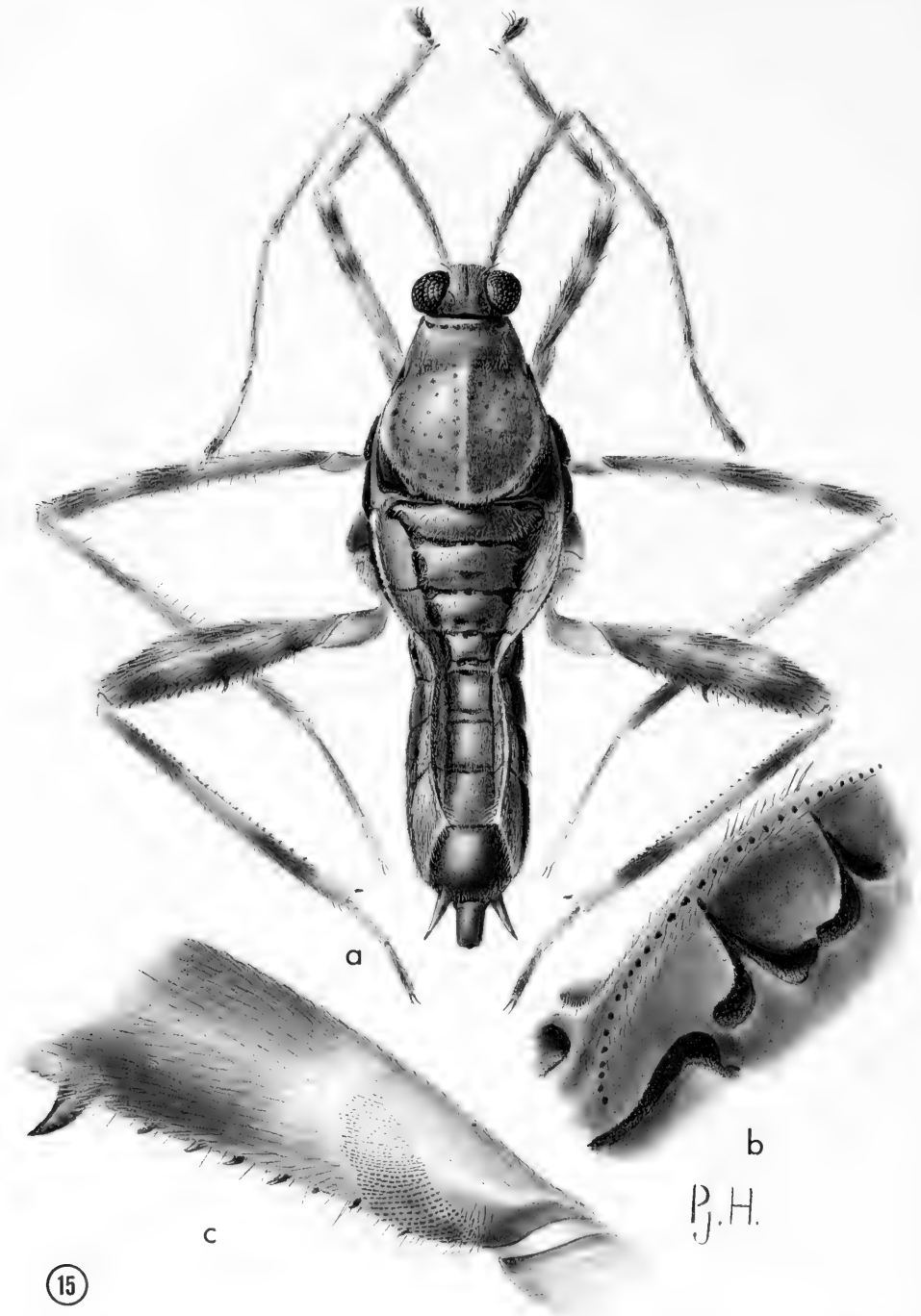


Fig. 15. *Stridulivelia (Stridulivelia) stridulata* (Hungerford): a, dorsal habitus, micropterous female; b, connexiva, lateral view, showing row of stridular denticles; c, hind femur, showing rastrate stridular structure.



Fig. 16. *Stridulivelia (Stridulivelia) stridulata* (Hungerford), known distribution.

Stridulivelia (Stridulivelia) strigosa
(Hungerford)

Fig. 17

Velia (Stridulivelia) strigosa Hungerford, 1929: 50. (Type from Guyane, Haut-Carvenne; in Paris Museum.)

Stridulivelia strigosa; Polhemus, 1976: 509.

Material examined (all JTPC, unless noted).—BRAZIL: Amazonas: 1 ♂ micr., 1 ♀ micr., Reserva Ducke, 25 km NE of Manaus, Igarape da Anta, 60 m, water temp. 24.5°C, 25.VIII.1989, CL 2472, J. T. and D. A. Polhemus; 10 ♂ micr., 4 ♀ micr., Reserva Ducke, 25 km NE Manaus, Igarape Barro Branco, 50 m, water temp. 23.5°C., 27 Aug. 1989, CL 2475, J. T. & D. A. Polhemus (JTPC); 1 ♂ macr., 1 ♀ micr., stream

near viewing tower, 90 km NW Manaus, 90 m, 29 Aug. 1989, CL 2478, J. T. & D. A. Polhemus; 3 ♂ micr., 1 ♀ micr., rainforest stream at INPA Forest Mgmt. Sta., 98 km NW Manaus, 90 m, 29 Aug. 1989, CL 2477, J. T. & D. A. Polhemus; 3 ♂ micr., 2 ♀ micr., Reserva Ducke, 25 km NE of Manaus, Igarape Acará, 26.VIII.1989, CL 2474, J. T. and D. A. Polhemus; 2 ♂ micr., 2 ♀ micr., stream nr. Egler Reserve, 30.VIII.1989, CL 2479, J. T. and D. A. Polhemus; 5 ♂ micr., 5 ♀ micr., Rio Negro, Igarape Barro Branco, 30.VII.1962, A 400, E. J. Fittkau (JTPC, ZSMC). Matto Grosso: 9 ♂ macr., 11 ♀ macr., Serra Roncador, 16-17.VIII.1965, A 558, E. J. Fittkau (JTPC, ZSMC). Para: 1 ♂ macr., Quellgebiet des Rio Xingu, Fließgewasser zwischen Goiana und Cuiaba, 5.IX.1965A

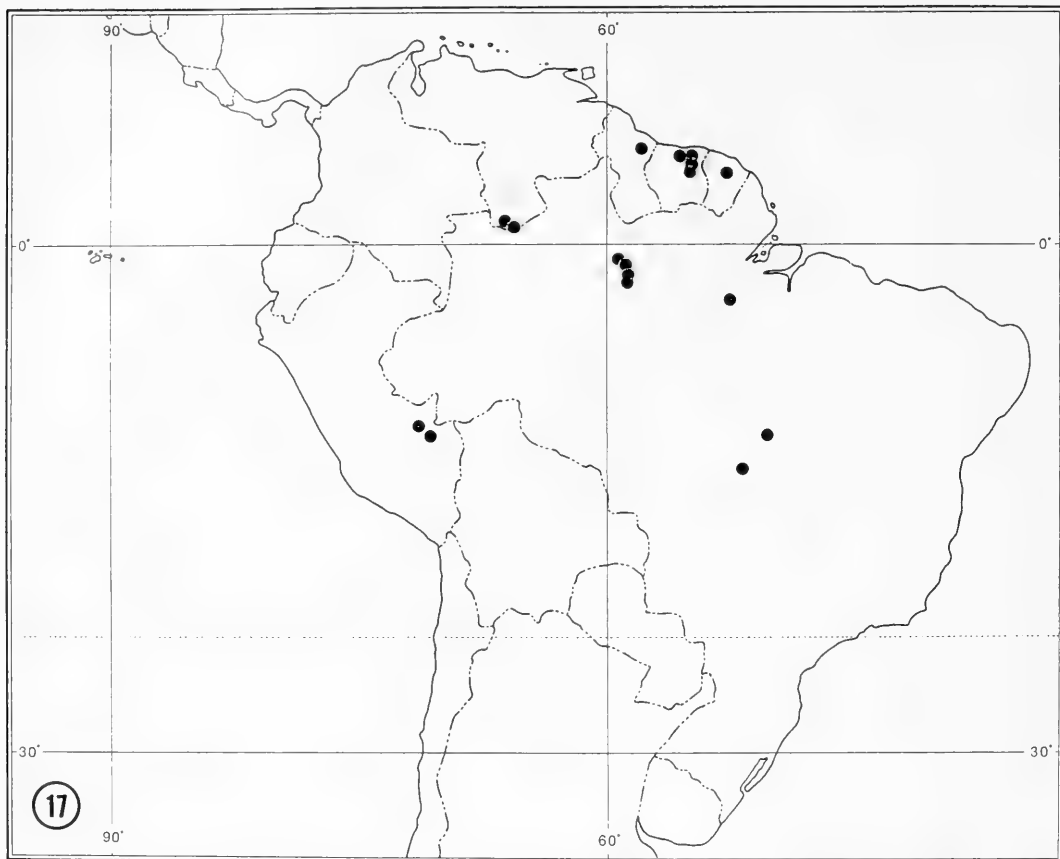


Fig. 17. *Stridulivelia (Stridulivelia) strigosa* (Hungerford), known distribution.

574-2, E. J. Fittkau (ZSMC); 2 ♂ macr., Rio Xingu, camp, 52°22'W, 3°39'S, ca. 60 km S Altamira, 3.X.1986, P. Spangler, O. Flint (NMNH). GUYANA: 15 ♂ micro, 10 ♀ micro, Dubulay Ranch, 5°39.8'N, 57°53.4'W, Warniabo River, 10.IV.1994, P. J. Spangler & R. Parris, colln #24 (NMNH). PERU: Madre Dios: 1 ♀ micr., Parque Manu, Pakitza, 12°07'S, 70°58'W, 250 m, side pools of stream, colln. 42, 16.IX.1989, R. A. Faitoute (NMNH). SURINAME: 1 ♂ micr., 1 ♀ micr., Zanderijsavanne, 1st trib. Colakreek crossing rd. to Matta, SN 116, N. Nieser; 1 ♂ micr., Zanderijsavanne, 28.VIII.1969, SN 099, N. Nieser; 1 ♂ micr., 3 ♀ micr., Zanderijsavanne, Carolinakreek, 22.VII.1969, SN 092, N. Nieser; 7 ♂ micr., 6 ♀ micr., Zanderijsavanne, 1st trib. Colakreek, 8.IX.1969, SN

127, SN 128, N. Nieser; 21 ♂ micr., 23 ♀ micr., 2 ♂ macr., Saramaca, 2nd trib. Troelikreek, 18.XI.1969, N. Nieser; 1 ♂ micr., Sabakoekreek, 29.VII.1965, SN 044, N. Nieser; 2 ♂ micr., 3 ♀ micr., Carolinakreek, 8.IV.1962, P. H. van Doesburg; 1 ♂ micr., Bosgivak, Creek, 29.XII.1950, Geiskes. VENEZUELA: Amazonas: 1 ♀ micr., Cerro de la Neblina, Basecamp, margins Rio Baria, 0°50'N, 66°10'W, 140 m, 20.II.1985, P. J. & P. M. Spangler, R. A. Faitoute, W. E. Steiner (NMNH); 2 ♀ micr., Cerro de la Neblina, same, but 1 km S of Basecamp (NMNH).

Known distribution (Fig. 17).—Brazil, French Guiana, Guyana, Peru, Suriname, Venezuela.

Discussion.—This long, slender species does not resemble any of the other species

of the genus except *S. tersa*, with which it forms a species pair. These species are distinguishable from each other by the complement of striae on the abdominal sternites as given in the key and the short dark region on the hind femur of *S. tersa* (Fig. 18a, c) as opposed to a longer, more diffuse, dark region in *S. strigosa*. They share a similar size and shape, large triangular silvery spots on the pronotum (Fig. 18a), an extensive covering of silvery setae on the base of the hemelytra of macropters, and large rastrate stridular patches on the slender hind femora; the stridular patches are only modestly thickened distally (Fig. 18c). *Stridulivelia strigosa* is usually micropterous.

Stridulivelia (Stridulivelia) tersa

(Drake & Harris)

Figs. 18, 19

Velia tersa Drake & Harris, 1941: 338. (Type from Trinidad, B.W.I.; in the National Museum of Natural History).

Velia nama Drake, 1957: 114. (Type from Quarto Ojos, Rio Piray, Dept. Santa Cruz, Bolivia; in the National Museum of Natural History) (New synonymy).

Velia (Stridulivelia) tersa; Drake & Menke, 1962: 415.

Stridulivelia tersa; Polhemus, 1976: 509.

Material examined (all JTPC, unless noted).—BOLIVIA: Beni: 1 ♂ micr., rainforest stream 40 km S of Rurrenabaque, nr. Monte Redondo Sawmill, CL 2511, 12.IX.1989, J. T. & D. A. Polhemus. La Paz: 3 ♂ micr., 9 ♀ micr., 3 km SE of Sapecho, CL 2515, 12.IX.1989, J. T. & D. A. Polhemus. Santa Cruz: 1 ♀ macr., Ichilo Prov., stream 10 km S Buena Vista, 380 m, 20.IX.1989, CL 2357, J. T. and D. A. Polhemus. BRAZIL: Amazonas: 1 ♀ macr., Reserva Ducke, 25 km NE of Manaus, Igarape da Anta, 60 m, water temp. 24.5°C, 25.VIII.1989, CL 2472, J. T. and D. A. Polhemus; 6 ♂ macr., 5 ♀ macr., Reserva Ducke, Igarape Acará, 26.VIII.1989, CL 2474, J. T. and D. A. Polhemus; 2 ♀ macr., Reserva Ducke, Igarape Barro Branco, nr.

headquarters, 50 m, 27.VIII.1989, CL 2475, J. T. and D. A. Polhemus; 3 ♂ macr., rainforest stream at INPA Forest Mgmt. Sta., 98 km NW Manaus, 90 m, 29 Aug. 1989, CL 2477, J. T. and D. A. Polhemus. MATTO GROSSO: 4 ♂ macr., 8 ♀ macr., Serra Roncador, 16-17.VIII.1965, A 558, E. J. Fittkau; 9 ♂ macr., 9 ♀ macr., Serra Roncador, nr. Acampamento Sarapé, km 125, 17.VIII.1965, A 559, E. J. Fittkau (JTPC, ZSMC). GUYANA: 1 ♂ macr., 1 ♀ macr., Karanambo, 18.IX.1957, R. McConnell. PERU: Loreto: 7 ♂ macr., 5 ♀ macr., stream near Napo Camp, CL 2459, 15.VIII.1989, J. T. & D. A. Polhemus; 7 ♂ macr., 6 ♀ macr., stream near Explorama Lodge, CL 2457, 14.VIII.1989, J. T. & D. A. Polhemus; 3 ♂ macr., 4 ♀ macr., small rainforest stream near Explorama Inn, CL 2465, 18.VIII.1989, J. T. & D. A. Polhemus. SURINAME: 1 ♂ micr., 5 ♂ macr., 4 ♀ macr., Zanderijsavanne, Carolinacreek, 22.VIII.1969, SN 092, N. Nieser; 1 ♀ micr., same but 18.VIII.1969, SN 080, N. Nieser; 1 ♀ macr., Coesewijn Project, Brokopondo, 9 km along Rd. to S. branch, 7.IV.1970, SN 402, N. Nieser. TRINIDAD: 1 ♂ micr., 27.X.1938, C. J. Drake. VENEZUELA: Amazonas: 1 ♂ micr., 2 ♀ macr., 39 km S. Puerto Ayacucho, brook, coll. 4, 15.XI.1987, P. J. Spangler & R. A. Faitoute (NMNH); 30 ♂ micr., 6 ♂ macr., 42 ♀ micr., 4 ♀ macr., 21 km S. Tobogan Jct. (53 km S of Pto. Ayacucho), "Missionary Stream," small river with alternating riffles and pools, CL 2375, 22.I.1989, J. T. Polhemus; 7 ♂ micr., 4 ♀ micr., 6 km S. Tobogan Jct., brook, CL 2374, 22.I.1989, J. T. Polhemus; 2 ♂ micr., 2 ♀ micr., Puente Pulda, 16 km S Pto. Ayacucho, CL 2387, 26.I.1989, J. T. Polhemus; 4 ♂ micr., 2 ♂ macr., 3 ♀ micr., 4 ♀ macr., 30 km S Pto. Ayacucho, Rio Paria Chico, CL 2372, 21.I.1989, J. T. Polhemus; 6 ♂ micr., 7 ♂ macr., 4 ♀ micr., 8 ♀ macr., stream, 0.1 km S of Tobogan-Coromoto Jct., CL 2383, 25.I.1989, J. T. Polhemus; 4 ♂ macr., 5 ♀ macr., 38 km N Pto. Ayacucho, CL 2386, 25.I.1989, J. T. Polhemus; 4 ♂ macr., 1 ♀ macr., small clear stream with sandy bottom, 0.5 km N of Alto

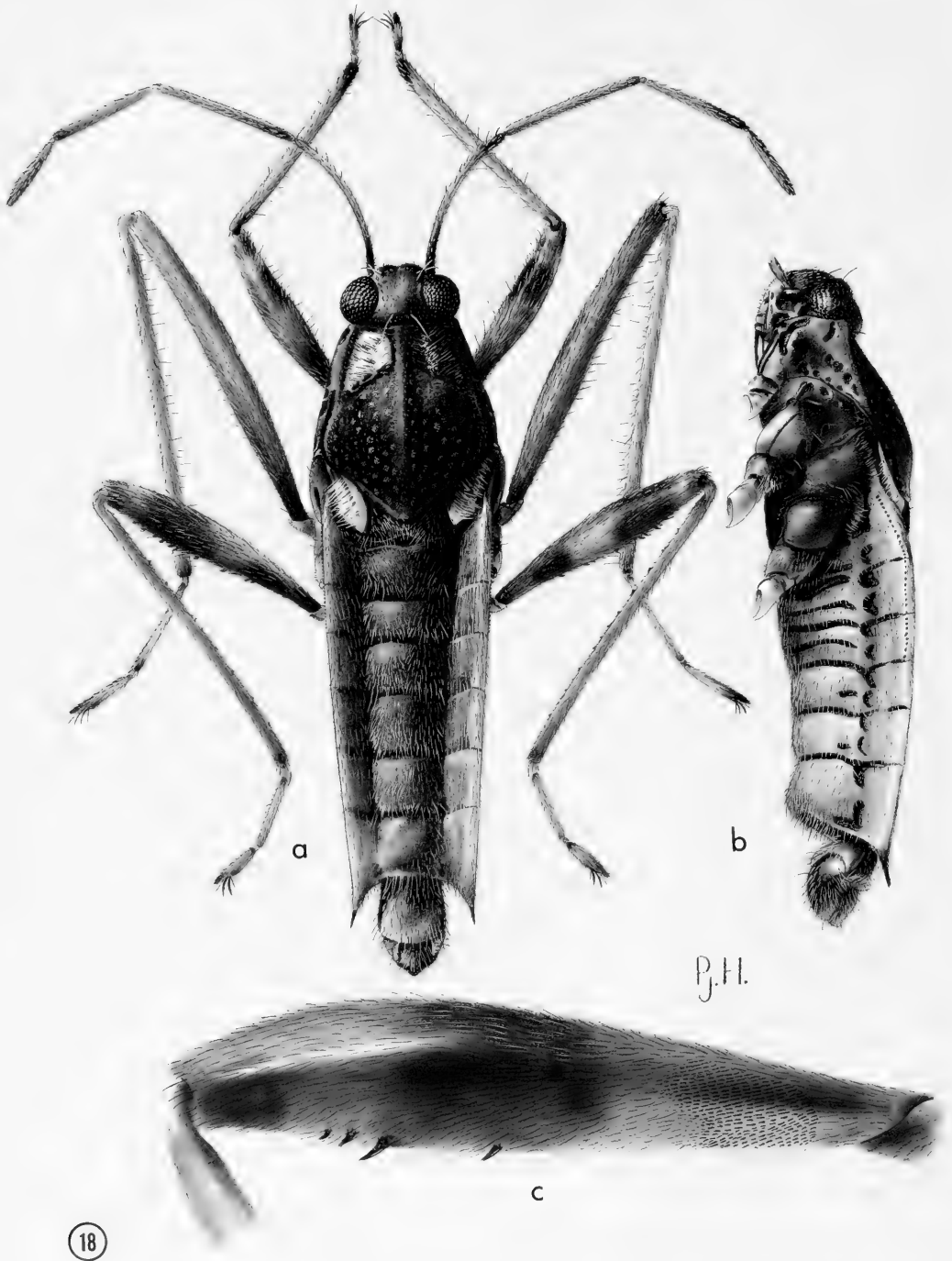


Fig. 18. *Stridulivelia (Stridulivelia) tersa* (Drake & Harris): a, dorsal habitus, micropterous male; b, body, lateral view, showing lateral abdominal glabrous grooves and stridulatory denticles on the connexivum; c, hind femur, showing basal rastrate stridular structure. (From Drake and Menke 1962)

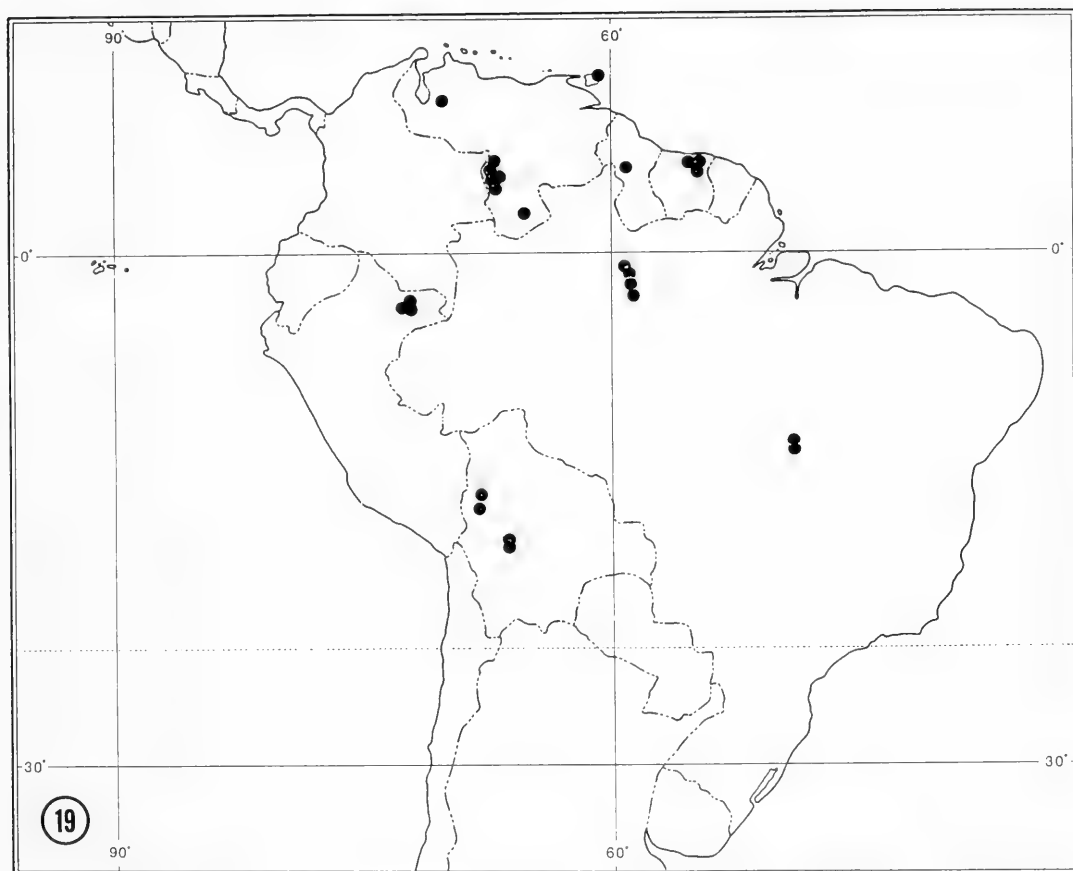


Fig. 19. *Stridulivelia (Stridulivelia) tersa* (Drake & Harris), known distribution.

Mavaca Base Camp, 2°1'30"N, 65°7'0"W, 228 m, water temp. 22°C, CL 8006, 4.II.1989, D. A. Polhemus. Prov. Unknown: 1 ♂ micr., 2 ♀ micr., Barinas, Rio Bocono, 13.IX.1957, B. Malkin.

Known distribution (Fig. 19).—Bolivia, Brazil, Guyana, Peru, Suriname, Trinidad, Venezuela.

Discussion.—The type of *S. tersa* is a micropterous male. This species is quite common in South America and we now have long series including both micropterous and macropterous forms; the macropterous morph is predominant. See comparative notes under *S. strigosa*.

The macropterous type of *S. nama* was compared with a macropterous male of *S.*

tersa by Dr. D. A. Polhemus who found it to be the same in every important respect. Drake (1957) stated in the description of *nama*: "Abdomen beneath with first three abdominal segments deeply transversely grooved on each side," which would be a key character distinguishing this species from *tersa*; however, the type of *nama* has these grooves on the first 5 (visible) abdominal segments, exactly as shown in the splendid figure of *tersa* given by Drake and Menke (1962, plate 1, fig. b; our Fig. 18b), and the stridulatory mechanism also is exactly the same. We recently collected specimens of *nama* from several localities in Bolivia very near the type locality, but when we could not distinguish these from *tersa*, and they



Fig. 20. *Stridulivelia (Stridulivelia) transversa* (Hungerford), known distribution.

matched the description of *nama* except for the abdominal grooves, we reverted to the types to establish the synonymy.

Stridulivelia (Stridulivelia) transversa
(Hungerford)
Fig. 20

Velia (Stridulivelia) transversa Hungerford, 1929: 54. (Type from Guyane, Haut-Car-sevenne; in Paris Museum.)

Stridulivelia transversa; Polhemus, 1976: 509.

Material examined (all JTPC).—BRAZIL: Amazonas: 11 ♂ micr., 11 ♀ micr., Reserva Ducke, 25 km NE of Manaus, Igarape da Anta, 60 m, water temp. 24.5°C,

25.VIII.1989, CL 2472, J. T. and D. A. Polhemus; 9 ♂ micr., 9 ♀ micr., Reserva Ducke, Igarape Barro Branco, nr. headquarters, 50 m, 27.VIII.1989, CL 2475, J. T. and D. A. Polhemus; 26 ♂ micr., 1 ♂ macr., 24 ♀ micr., 1 ♀ macr., forest stream at INPA forest management station, 98 km NW Manaus, 90 m, water temp. 25°C, 29 Aug. 1989, CL 2477, J. T. & D. A. Polhemus; 2 ♂ micr., 4 ♂ macr., 4 ♀ micr., 2 ♀ macr., stream near viewing tower, 90 km NW Manaus, 90 m, 29 Aug. 1989, CL 2478, J. T. & D. A. Polhemus; 9 ♂ micr., 7 ♀ micr., stream, nr. Egler Reserve, 30.VIII.1989, CL 2479, J. T. and D. A. Polhemus; 1 ♂ macr., Mont Alegre, Mulaba, 23.IX.1954, S303-6, H. Sioli; 1 ♀ macr., Lago

Salgado, Ig. (Igarape) Agua Dolce, 23.IV.1948, S225, H. Sioli; 1 ♂ micr., Rio Negro, Ig. (Igarape) Barro Branco, 30.VII.1962, A 400, E. J. Fittkau. SURINAME: 1 ♂ micr., 1 ♂ macr., 1 ♀ micr., Zanderijsavanne, 1st trib. of Colakreek crossing rd. to Matta, 19.IX.1969, SN 150, N. Nieser; 2 ♀ macr., 1st trib. of Colakreek, 8.IX.1969, SN 127, SN 128, N. Nieser; 1 ♂ micr., 1 ♀ micr., Coesewijn Project, 3.III.1970, SN 368, N. Nieser; 3 ♂ micr., 1 ♀ micr., 1st streamlet, Hanover Rd., 4.VIII.1969, SN 058, N. Nieser.

Known distribution (Fig. 20).—Brazil, French Guiana, Suriname.

Discussion.—This is the smallest and most delicate of the *Stridulivelia* species, easily distinguishable by its small size, small stridulatory patch on the hind femur, complement of transverse abdominal grooves, and strongly narrowed abdomen of the females.

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A NEW SPECIES OF *CENTISTES* FROM BRAZIL
(HYMENOPTERA: BRACONIDAE: EUPHORINAE) PARASITIZING
ADULTS OF *DIABROTICA* (COLEOPTERA: CHRYSOMELIDAE),
WITH A KEY TO NEW WORLD SPECIES

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Abstract.—A new species of euphorine braconid, *Centistes gasseni* Shaw from Brazil is described, diagnosed, and illustrated. This species is a koinobiont endoparasitoid of the adult stage of *Diabrotica*, and is currently being studied as a possible biocontrol agent for the *Diabrotica* pest-complex including the southern corn rootworm in North America. An identification key for the known *Centistes* species in the New World region is included. Three species, *C. agilis* (Cresson), *C. claripennis* (Ashmead), and *C. laevis* (Cresson) are newly recorded as occurring in Wyoming, representing new far western distribution records for these species.

Key Words: Braconidae, Euphorinae, Centistini, neotropical, biological control

The purpose of this paper is to describe a new species of *Centistes* parasitizing *Diabrotica* that was recently discovered in Passo Fundo, Rio Grande do Sul, Brazil. The new *Centistes* was reared from *Diabrotica speciosa* (Germar) in 1992 by Dirceu N. Gassen, of EMBRAPA-CNPT, Passo Fundo, working in collaboration with Robert F. W. Schroder, USDA-ARS, Insect Biocontrol Laboratory, Beltsville, Maryland. It is currently being studied by Dr. Schroder as a possible biocontrol agent for the *Diabrotica* pest-complex including the southern corn rootworm, *Diabrotica undecimpunctata howardi* Barber. *D. undecimpunctata* is a serious pest of corn and cucurbits in the southern United States, and *Diabrotica speciosa* is increasingly becoming a problem in Brazil. The new *Centistes* was imported to the United States in 1992 and has been successfully raised from *D. undecimpunctata* at the Maryland Department of Agriculture quarantine facility in Annapolis. A permit

was recently obtained for laboratory studies at the Beltsville Agriculture Research Center. Consequently, providing a scientific name for this species is critical at this point in time.

The genus *Centistes* is the most diversified lineage of the euphorine tribe Centistini (Shaw 1985). The Centistini can be most easily diagnosed by the broad first metasomal tergum with spiracles very near the front of the segment (Fig. 13) and the very smooth fused tergum 2 + 3 without a lateral fold or crease (Fig. 12). *Centistes* are the most common members of the centistine lineage with an extremely short, broad, and densely setose ovipositor sheath (Figs. 15, 16). A less obvious, but phylogenetically significant, character is the extreme reduction or complete absence of vein M beyond the Rs in *Centistes*. The genus is essentially worldwide in distribution, except for the Australian continent. Most of the described species are holarctic in distribution, but that

is probably only an artifact of poor sampling and lack of taxonomic revisions in the tropics. For example, while there is a total of six named *Centistes* species in North America (Shaw 1985), there are at least eight undescribed *Centistes* species occurring in Costa Rica alone (Shaw unpublished data). While no *Centistes* species have been described from South America, one closely related species has recently been named in the genus *Centistoides* (van Achterberg 1992). *Centistes* can be identified to genus using the keys of Shaw (1985), van Achterberg (1985, 1992), or Marsh et al. (1987). The tribe Centistini is defined by Shaw (1985) and van Achterberg (1985, 1992). The subfamily Euphorinae is defined by Shaw (1985) and can be identified using the keys of Shaw and Huddleston (1991) or Goulet and Huber (1993).

Descriptive terminology follows that of Shaw (1985, 1993) and Marsh et al. (1987). Terminology for microsculpture follows that of Harris (1979). Wing venation terminology is that of Goulet and Huber (1993). Scanning electron microscopy was done with a JEOL model 35CF SEM at an operating voltage of 25 kv. Specimens from this study are deposited at the University of Wyoming, Rocky Mountain Systematic Entomology Laboratory, Laramie (RMSEL), the United States National Museum of Natural History, Washington, D.C. (USNM), the Universidade Federal de Sao Carlos, Sao Paulo, Brazil (UFSC), and EMBRAPA-CNPT, Passo Fundo, Rio Grande do Sul, Brazil.

Centistes gasseni Shaw,

NEW SPECIES

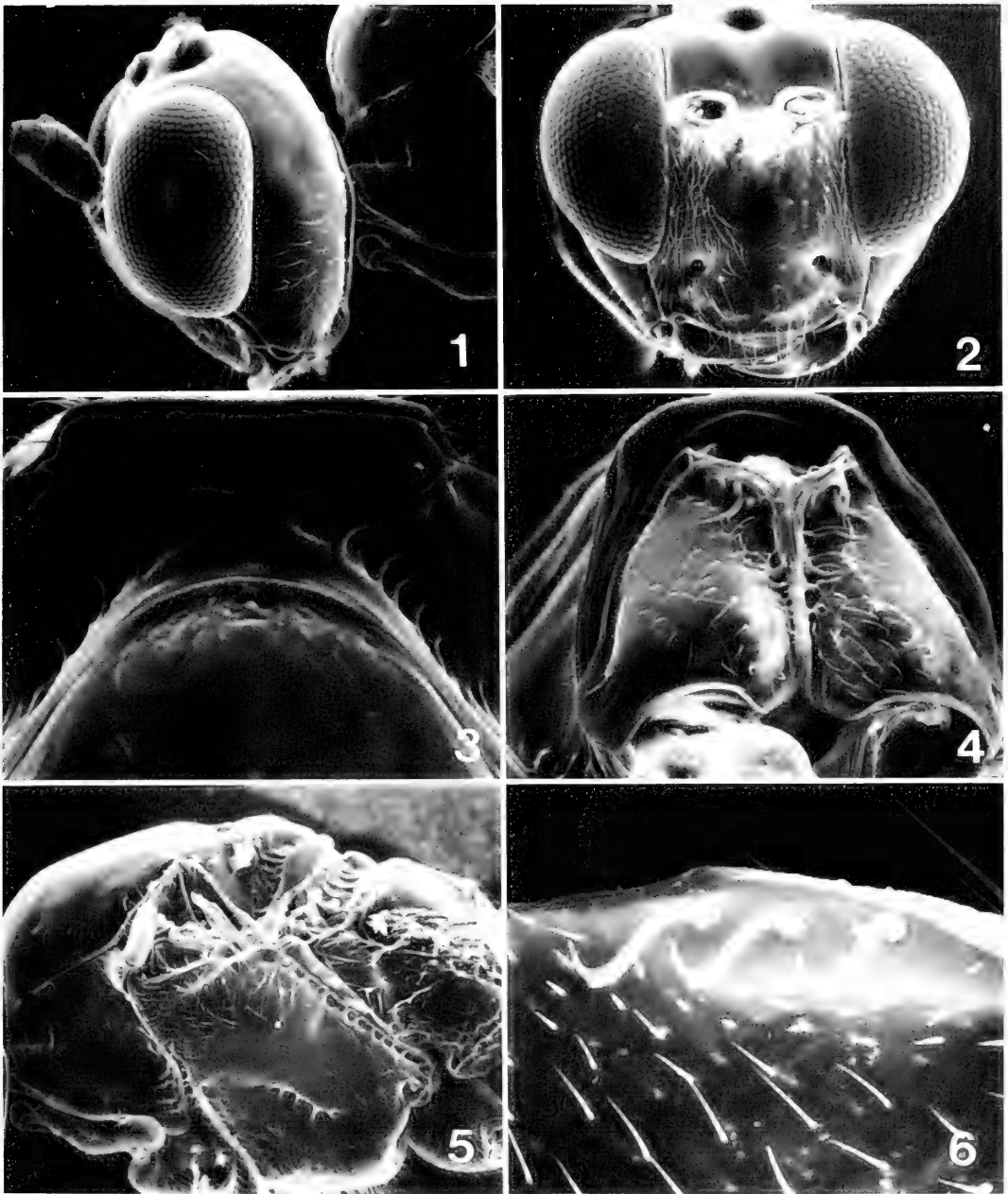
Figs. 1–18

Holotype female.—Body length 2.8 mm; forewing length 3.5 mm.

Head (Figs. 1, 2).—Shortest distance between eyes $1.28\times$ greater than clypeus width; face, clypeus, and gena evenly setose; frons, vertex, and temple smooth and devoid of setae; temple width $0.5\times$ eye width; eyes,

in anterior view, parallel and not converging ventrally; eye $1.61\times$ taller than wide, smooth, devoid of minute setae; scape cylindrical, $1.36\times$ longer than wide; pedicel compact, $0.88\times$ longer than wide; antenna with 26 flagellomeres; F1 $3.13\times$ longer than wide; F10 $2.86\times$ longer than wide; F26 $2\times$ longer than wide basally, terminating apically in a sharp point; malar space $0.22\times$ eye height, about equal to basal width of mandible; mandibles when closed overlapping for $0.6\times$ mandible length; mandible width basally $0.25\times$ mandible length, strongly narrowing apically; ocellar triangle equilateral, posterior margin of median ocellus slightly ahead of anterior margin of lateral ocellus; ocelli large, lateral ocellus separated from compound eye by distance $0.83\times$ ocellar width; occipital carina strong and complete, but situated very low on occiput, apex of occipital carina about level with midpoint of eye.

Mesosoma (Figs. 3–11).—With scattered large setae about same size as those on head posteriorly, except pronotum laterally, mesonotum, scutellum, central disc of mesopleuron, and dorsum of propodeum largely devoid of setae; pronotum rugose anteriorly, with a series of 5 shallow pronopes dorsomedially (Fig. 3); pronotal furrow foveate medially, smooth ventrally; prosterna with anterior and medial margins rugose, otherwise smooth, ending as smooth rounded flange over base of fore coxa (Fig. 4); mesonotum smooth, without any trace of notauli; mesopleuron mostly smooth, but with oblique foveate sternaulus and foveate posterior margin (Fig. 5); scutellar furrow bifoveate (Fig. 7); scutellar disc smooth; lateral subapical scutellar margins rugofoveolate; apex of scutellum minutely bifoveate; metanotum irregularly longitudinally costate, posterior rim narrow and smooth (Fig. 8); mesosternum anteriorly densely covered with erect setae; mesosternum and metasternum posteriorly obliquely costate (Fig. 11); propodeum clearly subdivided into anterior and posterior halves by a strong

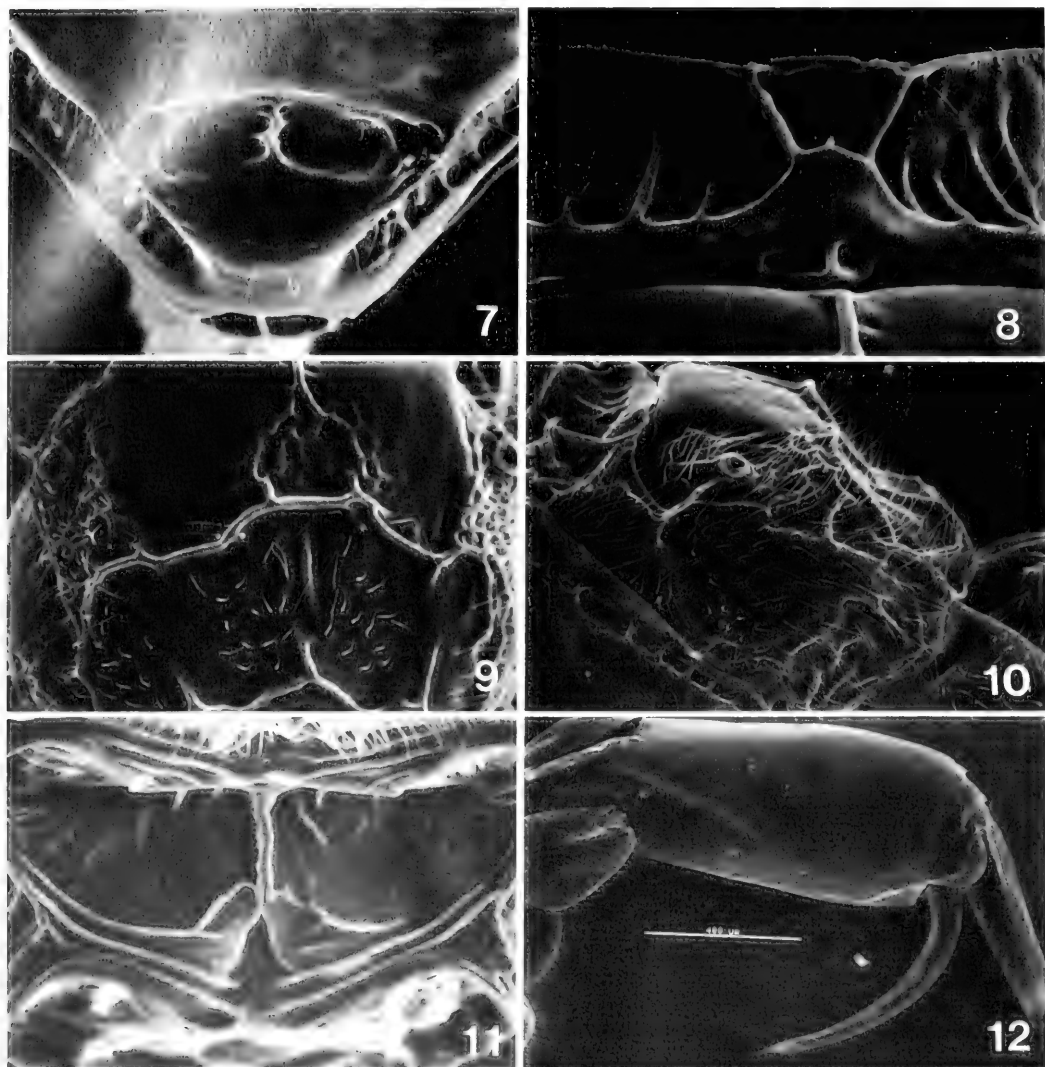


Figs. 1-6. *C. gasseni*. 1, Lateral view of head. 2, Anterior view of head. 3, Dorsal view of pronotum and anterior mesonotum. 4, Ventral view of pronotum, prosterna, and anterior coxal cavities. 5, Lateral view of mesosoma. 6, Dorsal view of anterior margin of hindwing and hamuli.

transverse carina, surfaces mostly smooth except medially and laterally rugulose (Figs. 9, 10).

Wings.—Venation as in Fig. 306 of Marsh

et al. (1987) except pterostigma $3.53 \times$ longer than maximum width; r-rs vein $0.66 \times$ as long as maximum width of pterostigma; length of marginal cell 2R1 along anterior

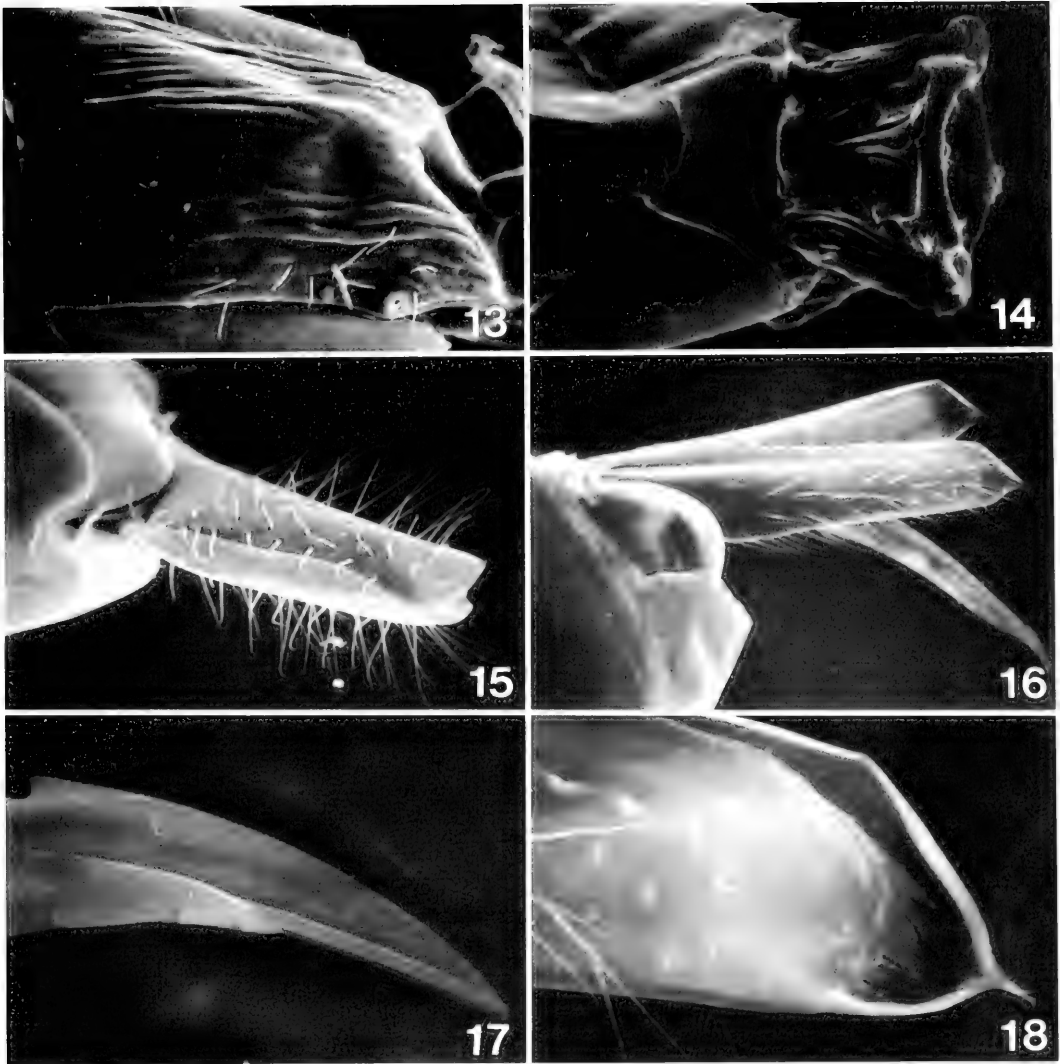


Figs. 7–12. *C. gasseni*. 7, Dorsal view of scutellum. 8, Dorsal view of metanotum. 9, Dorsal view of propodeum. 10, Lateral view of propodeum. 11, Ventral view of posterior mesosternum, metasternum, and associated coxal cavities. 12, Lateral view of metasoma.

wing margin equal to length of pterostigma; vein m-cu interstitial with vein Rs; vein M apically represented by a very short sclerotized stub; hindwing with 3 sinuate hamules (Fig. 12).

Legs.—Moderately setose throughout; surfaces smooth and shining, especially of coxae and femorae; coxae short and compact, fore and middle coxal lengths equal to

trochanter length; hind coxa longer, $1.8\times$ middle coxa length; hind femora length $5.4\times$ longer than maximum width; hind tibia length $9\times$ longer than maximum width, apical 30% moderately compressed in dorsal view; hind tibial spurs moderately long, $0.48\times$ as long as hind basitarsus; ratio of hind tarsomeres from basitarsus apically 48:26:22:16:24; tarsal claws large, simple.



Figs. 13–18. *C. gasseni*. 13, Dorsolateral view of first metasomal tergum. 14, Ventral view of first metasomal sternum. 15, Ventral view of apex of metasoma showing hypopygium and ovipositor sheaths with ovipositor retracted. 16, Lateral view of apex of metasoma showing hypopygium and ovipositor sheaths with ovipositor extended. 17, Lateral view of ovipositor apex. 18, Lateral view of ovipositor sheath apex.

Metasoma (Figs. 12–18).—Tergum 1 basally $0.63\times$ as wide as apical width, $1.7\times$ longer than apical width; spiracle of tergum 1 situated on lateral margin near basal quarter of segment; sculpture of tergum 1 longitudinally costate laterally, smooth medially and apically (Fig. 13); sternum 1 costate anteromedially, smooth posteriorly (Fig. 14); remainder of metasoma smooth and shin-

ing (Fig. 12); hypopygium deeply incised and laterally situated (Figs. 15, 16); ovipositor sheath short and broad, $3.2\times$ longer than basal width, densely setose (Figs. 15, 16), terminating in a sharp point formed from a fringe of dense setae (Fig. 18); dorsal and ventral edges of right ovipositor sheath wrapping over edges of left sheath; ovipositor smooth and saber-like, dorsal valve with

a deep subapical notch, ventral valve with 3 subapical curved incisions (Fig. 17).

Color.—Body bright orangish yellow except flagellum, compound eyes, ocelli, tips of tarsi, and ovipositor sheaths black; pedicel, mesonotum anteriorly and laterally, wing venation, apical $\frac{1}{3}$ of hind tibia, and remainder of hind tarsus dark brown; wing membrane infumated with light brown.

Variation.—Paratype females. Essentially as in holotype except body length 2.6–3.7 mm; forewing length 3.0–3.5 mm; 25–26 flagellomeres; color of compound eye varying from black to light gray; color of ocelli varying from black to light reddish brown; ocellar triangle varying from orange to dark brown or black; anterior and lateral mesonotal lobes varying from brown to black; ovipositor position varying from concealed to fully extended (as Fig. 12).

Paratype males.—As female except body length 2.6–3.5 mm; forewing length 2.5–3.0 mm; 24 flagellomeres; apex of metasoma from T3 beyond often infused with dark brown; parameres ovate with ventral margin somewhat flattened, orangish yellow, apically fringed with setae; aedeagus bilobate, smooth, yellowish white.

Host.—Originally reared from *Diabrotica speciosa* in Brazil. Reared in quarantine from the southern corn rootworm, *Diabrotica undecimpunctata howardi*.

Biology.—As far as known, all *Centistes* species are solitary koinobiont endoparasitoids of adult beetles, particularly the families Curculionidae, Chrysomelidae, Coccinellidae, Anthicidae, and Carabidae (Loan 1972, Shaw 1985). Only one other species, *Centistes (Syrhrizus) diabroticae* (Gahan), is recorded as parasitizing adult stages of the subtribe Diabroticina (Gahan 1922). That species attacks the striped cucumber beetle, *Acalymma vittatum* (F.). The only other named neotropical species, *Centistes epicaeri* Muesebeck, parasitizes a curculionid on coffee (Muesebeck 1958). Some *Centistes* have been reported to leap onto the host elytra (Gahan 1922) or grasp the host beetle

with their legs during oviposition (Loan 1964, 1972). The dense layer of mesosternal setae in *Centistes gasseni* may be an adaptation to similar host-mounting behavior. More complete reviews of euphorine biology are given by Shaw (1988, 1994) and Shaw and Huddleston (1991).

Discussion.—*Centistes gasseni* is a very distinctive species because of its bright orangish yellow coloration, and should not be confused with any of the other known *Centistes* species. The only other described neotropical species, *C. epicaeri*, has an entirely black body, more coarsely costate tergum 1, and has the posterior face of the propodeum subdivided by a median carina that is absent in *C. gasseni*. The other undescribed *Centistes* species that I've seen from the neotropics all have mostly black body coloration, and are mostly smaller in size. The other species that parasitizes chrysomelids, *C. diabroticae* varies in body color from black to orangish yellow, but is somewhat smaller (2.2 mm), has a distinctive median fovea on the mesopleuron that is absent in *C. gasseni*, and has most of the Rs+M vein absent basally, thus the 1R1 and 1M cells are confluent (these cells are completely separated by the Rs+M vein in *C. gasseni*). *C. gasseni* can be distinguished from other known *Centistes* in the New World by the key given below. This key treats all of the named New World *Centistes* as reclassified by Shaw (1985).

Material examined.—Holotype: female, Brazil, Rio Grande do Sul, Passo Fundo, July 1991, D. N. Gassen, reared from *Diabrotica speciosa*, (RMSEL). Paratypes: 2 females, 2 males, same data as holotype; 30 females, 22 males, lab reared, United States, Maryland, Annapolis, Maryland Department of Agriculture quarantine facility, em. May 1, 1993, R. Schroder, reared from *Diabrotica undecimpunctata howardi*; 11 females, 149 males, same data except em. June–July 1993, (RMSEL, USNM, UFSC, EMBRAPA-CNPT).

Etymology.—Named for the collector of

the type series, Mr. Dirceu N. Gassen, of EMBRAPA-CNPT, Passo Fundo, Rio Grande do Sul, Brazil.

KEY TO THE NEW WORLD SPECIES OF
CENTISTES HALIDAY

- 1. Forewing vein Rs+M greatly reduced or absent, thus cells 1R1 and 1M forming a single large confluent cell; mesonotum smooth and without any trace of notauli (subgenus *Syr-rhizus*) 2
- Forewing vein Rs+M complete, thus cells 1R1 and 1M completely separated; mesonotum variable, but notauli often indicated, as least anteriorly, by a groove or foveation 3
- 2(1). Forewing vein Rs+M entirely absent; mesonotum entirely smooth, without any trace of sculpture; mesopleuron smooth, without any trace of a sternaulus; body black; parasitoids of Anthicidae (*Notoxus*); New York south to Virginia, westwards to Wyoming *Centistes agilus* (Cresson)
- Forewing vein Rs+M partly present apically, at least with a distinct stub; mesonotum with a distinctive median fovea, but otherwise smooth; mesopleuron with a small but distinct foveate sternaulus, but otherwise smooth; body color variable, but often extensively marked with reddish to yellowish brown; parasitoids of Chrysomelidae (*Aca-lymma*); central United States (Illinois, Ohio, Missouri) *Centistes diabroticae* (Gahan)
- 3(1). Notauli foveate and distinct throughout the length of the mesonotum; metasoma sometimes with small tooth-like structures situated on sternum 5 (subgenus *Ancylocentrus*) 4
- Notauli distinct only anteriorly, indicated by smooth grooves, or absent; metasoma smooth, without small tooth-like structures situated on sternum 5 (subgenus *Centistes*) 5
- 4(3). Small species 3 mm or less in body size; propodeum areolate posteriorly; metasoma with small tooth-like structures situated on sternum 5; parasitoids of Curculionidae (*Sitona*); holarctic (northeastern Canada and Europe) *Centistes ater* (Nees) [= *C. excrucians* Haliday]
- Robust species 5 mm or greater in body size; propodeum coarsely rugose; metasoma without small tooth-like structures situated

- on sternum 5; parasitoids of Carabidae (*Amara*); eastern North America from Quebec south to Pennsylvania, westwards to South Dakota and Wyoming *Centistes laevis* (Cresson)
- 5(3). Body color mostly bright orangish yellow; ovipositor sheath terminating in a sharp point (Fig. 18); parasitoids of Chrysomelidae (*Diabrotica*); native to Brazil, introduced to the United States *Centistes gasseni* Shaw, NEW SPECIES
- Not as above; body color mostly black; ovipositor sheath blunt or rounded, not terminating in a sharp point 6
- 6(5). Mesonotum with notauli indicated by fine grooves; posterior face of the propodeum subdivided by a median carina; tergum 1 coarsely costate and nearly parallel-sided, only slightly wider posteriorly than basally; moderately large species 3-4 mm in body length; parasitoids of Curculionidae (*Epicauerus*) on coffee; El Salvador *Centistes epicaeri* Muesebeck
- Mesonotum smooth, notauli absent, posterior face of the propodeum not subdivided by a median carina; tergum 1 not so coarsely costate and about 1.5x wider posteriorly than basally; very small species 2 mm or less in body size; hosts unknown; central United States from Michigan south to Arkansas, Washington, D.C. westwards to Wyoming *Centistes claripennis* (Ashmead) [= *C. politus* (Ashmead)]

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NEW WESTERN NEARCTIC *SWELTSA*
(PLECOPTERA: CHLOROPERLIDAE)

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Abstract.—New species *Sweltsa resima*, *Sweltsa cristata*, *Sweltsa umbonata* and *Sweltsa adamantea* are described and compared with their closest relatives.

Key Words: Plecoptera, Chloroperlidae, *Sweltsa*, Nearctic

The following four new species of the stonefly genus *Sweltsa* Ricker (Plecoptera: Chloroperlidae) were discovered during examination of numerous collections of the genus from throughout western North America. Information on similarities and differences between each new species and the rest of its group accompanies descriptions in advance of publication of further revisionary studies.

Sweltsa, found in the eastern Palearctic and the Nearctic, is one of three genera in tribe Alloperlini of subfamily Chloroperlinae. They are small- to medium-sized, yellowish stoneflies with a dark abdominal stripe and distinct dark marks on head and nota. The genus is particularly recognized by the recurved epiproct that is composed of the basal bar, widened anteriorly into a cupped anchor, and the hinged, sculptured epiproct tip, extending anteriorly to a transverse ridge on deeply incurved tergum nine (Surdick 1985). The subgenital plate of the female is slightly convex and usually basically hexagonal.

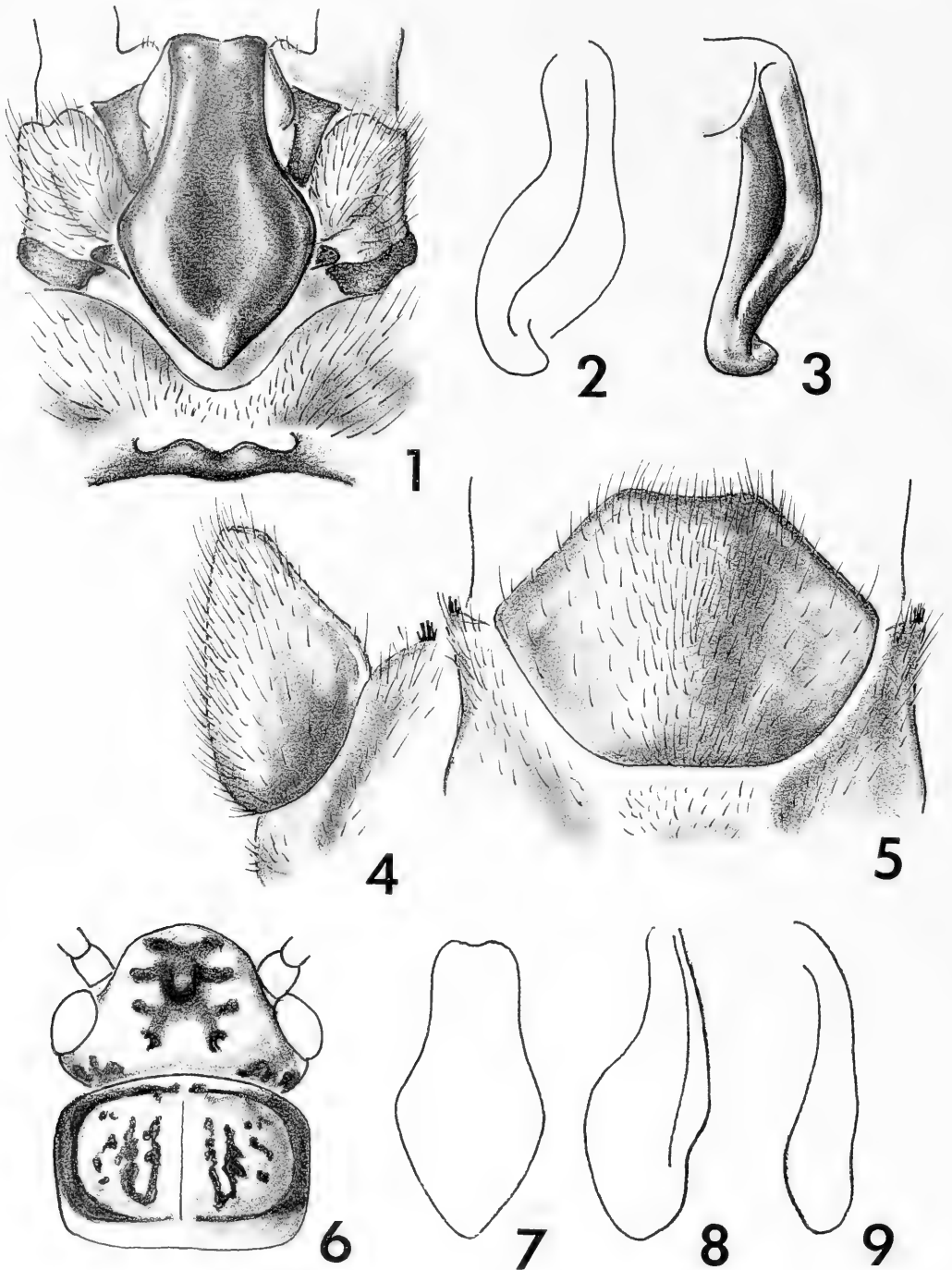
Surdick (1985) gives a key to Nearctic chloroperlinid genera and a list including western Nearctic *Sweltsa* species. Bauermann, Gaufin, and Surdick (1977) give a key to most Rocky Mountain and Pacific Northwest *Sweltsa* and Jewett (1960) gives one for most California *Sweltsa*.

Sweltsa resima, sp. nov.

Figs. 1-6

Adult.—General color darkly-marked tan in alcohol. Head with 3 dark ocellar rings, dark rugulae in dusky environs anterior to and adjacent to ocellar triangle and posterior to compound eyes. Pronotum with broad dark explanate margin, dark longitudinal rugulae, median longitudinal unmarked area one-fourth width of pronotum. Meso- and metanota dusky, each with dark recurrent scutoscutellar suture. Abdomen with dark median longitudinal stripe from tergum 1 to 8, single dark lateral stripes from segment 1 to 5, lateral pectens on segments 7, 8, 9. Macropterous; wings hyaline, dark-veined, representative of genus.

Male.—Body length 8 mm; forewing length 9 mm. Epiproct sclerotized, hinged, with tip extending anteriorly to prominent sclerotized deeply crenate transverse ridge on anterior of tergum 9. In dorsal aspect, epiproct tip lozenged, twice as long as wide; verge curved ventrad; median longitudinal furrow ending at recurved apex. In lateral aspect of epiproct tip, distal half of dorsal face declivent 45 degrees; apex recurved, conical; verso of furrow visible beneath verge. Basal anchor of epiproct broadly and deeply scoop-like, notched anteriorly; epiproct support structures otherwise repre-



Figs. 1-9. *Sweltsa resima*. 1, Male terminalia, dorsal aspect. 2, Epiproct tip, dorsolateral aspect. 3, Epiproct tip, lateral aspect. 4, Subgenital plate of female, lateral aspect. 5, Subgenital plate, ventral aspect. 6, Adult head and pronotum. *Sweltsa townesi*, epiproct tip. 7, Dorsal aspect. 8, Dorsolateral aspect. 9, Lateral aspect.

sentative of genus as are segment 9, hemiterga of segment 10. Aedeagus membranous.

Female.—Body length 9 mm; forewing length 9 mm. Subgenital plate dusky, entire, crudely hexagonal, as long as wide, based centrally on sternite 8, evenly hirsute with longer hairs posteromedially, distinguishable anteriorly by narrow membranous periphery; posterior half flap-like, extending over most of sternite 9; profile planate but distinctly elevated. Vagina membranous.

Material.—Holotype ♂, allotype ♀ (U.S. National Museum): California, Inyo Co., Whitney Portal 15-VI-1966 D. C. Rentz. Paratypes: 1 ♂, 1 ♀ (R. F. Surdick) California, Mono Co., Lee Vining Creek, Tioga Pass 15-VII-1979 R. W. Surdick; 2 ♂ (Brigham Young Univ.) California, Inyo Co., Coyote Crk. 11 mi. SSW of Bishop, 1000 ft. 4-VII-1986 D. Giuliani; 2 ♂, 2 ♀ (Brigham Young Univ.) California, Mono Co., Glass Crk. Meadows, Sierra Nevada, 9000 ft. 20-VII-1990 D. Giuliani; 1 ♂, 1 ♀ (Brigham Young Univ.) same locality 28-VI-1990 D. Giuliani; 1 ♂ (Brigham Young Univ.) California, Mono Co., White Mountains, Lone Tree Crk., 6400 ft. 23-VII-1985 D. Giuliani. Other material: 2 ♂, 2 ♀ (S. G. Jewett, Jr.) California, Inyo Co., Lone Pine 28-VII-1940 L. J. Lipovsky, R. H. Beamer.

Compared material.—*Sweltsa townesi*: holotype ♂, allotype ♀ (Illinois Natural History Survey); specimens from El Dorado, Nevada, Placer, Plumas, Sierra, Tehama, Tuolumne Cos., California (Brigham Young Univ., Field Museum of Natural History, A. R. Gaufin, R. E. Hill, S. G. Jewett, Jr., W. E. Ricker, Royal Ontario Museum, B. P. Stark, R. F. Surdick, Univ. of California at Riverside, Univ. of Kansas, U.S. National Museum).

Etymology.—The adjective *resima* means turned up and bent back and describes the tip of the epiproct.

Diagnosis.—This species is closely related to *Sweltsa townesi* (Ricker) 1952 (Figs. 7–9). cursorily, the dorsal aspects of the epiproct tips of the species look the same.

In lateral aspect, the differences are evident: the epiproct tip of *S. townesi* resembles a partially ballooned version of the epiproct tip of *S. resima* without the conical, up-turned apex. The subgenital plates of the species are similar. The pronota both bear a distinctive broad dark marginal ring.

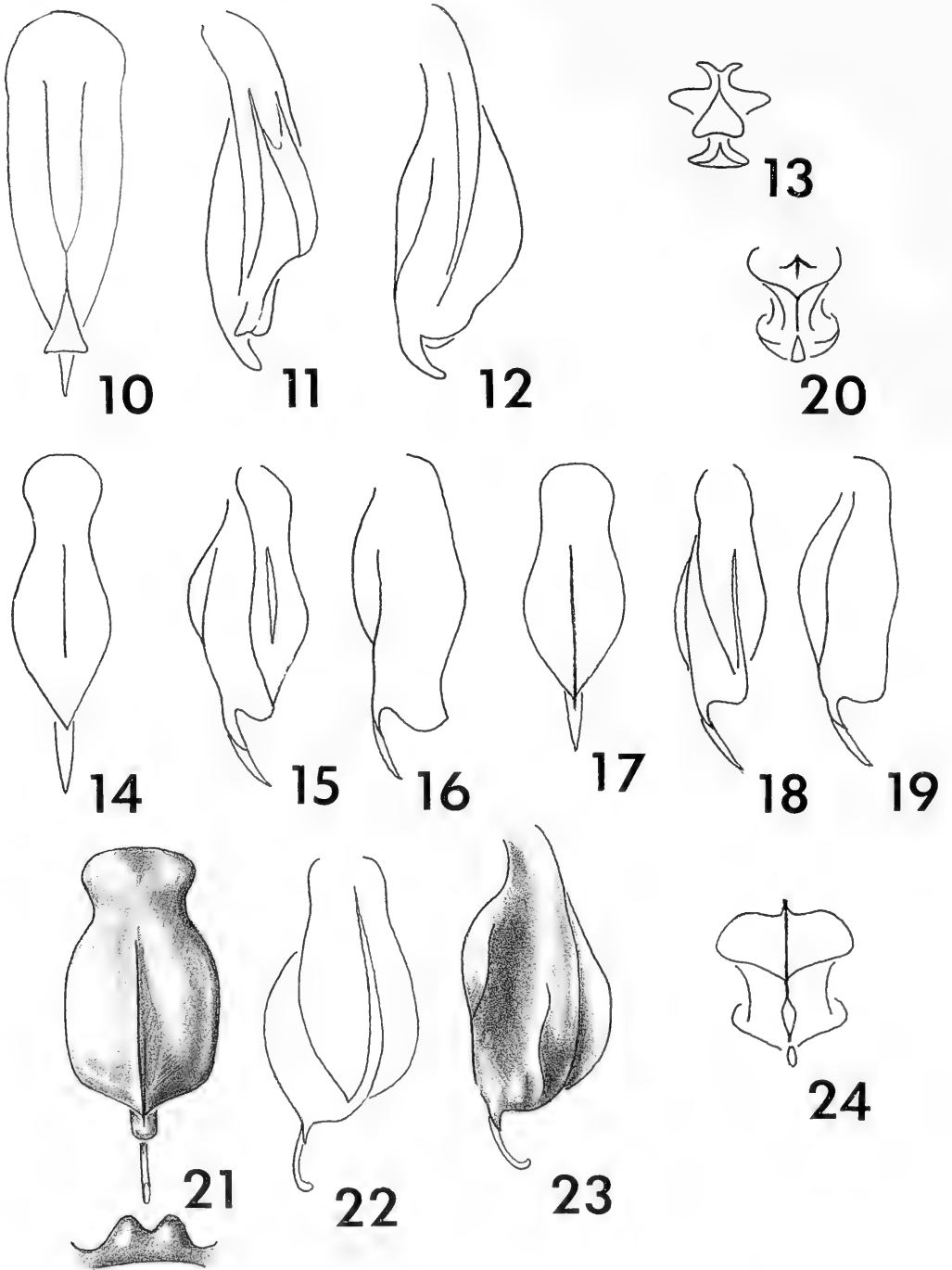
Sweltsa resima has been found on the Great Basin side of the Sierra Nevada south of the Mono Lake area. *Sweltsa townesi* has been found in the northern Sierra Nevada.

***Sweltsa cristata*, sp. nov.**

Figs. 21–24, 40, 42–44

Adult.—General color dusky-marked light tan in alcohol. Head with 3 dark ocellar rings, small dusky rugulae anterior to and adjacent to ocellar triangle and posterior to compound eyes. Pronotum with thin dark encircling line, thin dusky longitudinal rugulae. Meso- and metanota each with dark recurrent scutoscuteellar suture, dusky areas. Abdomen with dark median longitudinal stripe from tergum 1 to 8, single dusky lateral stripes from segment 1 to 3, lateral pectens on segments 7, 8, 9. Macropterous; wings hyaline, dusky-veined, representative of genus.

Male.—Body length 7 mm; forewing length 7.5 mm. Epiproct sclerotized, hinged, with tip deeply sculptured, crudely prismoid, extending anteriorly to deeply crenate transverse ridge on anterior of tergum 9. In dorsal aspect of epiproct tip, proximal three-fourths a slightly undulating horizontal elongately pandurate plane constricted to half width basad of median, obtuse-angulate distally, with greatest width half length; middle portion a barely visible projection of bulk, blunt distally, as long as wide; distal fourth filamentous. In lateral aspect, bulk of epiproct tip cuneate, appearing to intersect three-fourths of slightly declivent horizontal plane forming an arced dorsal crest one-fourth height of epiproct tip; slightly excurved anterior profile a continuation of crest; anteroventral filamentous projection slightly up-curved, colorless



Figs. 10-24. *Sweltsa gaufni*, epiproct tip. 10, Dorsal aspect. 11, Dorsolateral aspect. 12, Lateral aspect. 13, Frontal aspect. *Sweltsa albertensis*, epiproct tip, showing individual variation. 14, Dorsal aspect. 15, Dorsolateral aspect. 16, Lateral aspect. 17, Dorsal aspect. 18, Dorsolateral aspect. 19, Lateral aspect. 20, Frontal aspect. *Sweltsa cristata*, epiproct tip. 21, Dorsal aspect and center of transverse ridge of tergum 9. 22, Dorsolateral aspect. 23, Lateral aspect. 24, Frontal aspect.

beyond base. Bulk of epiproct tip concavo-concave; elliptical ventral surface nearly congruent to and aligned with horizontal plane, convex proximally, explanate laterally. Epiproct support structures, segment 9, hemiterga of segment 10 representative of genus. Aedeagus membranous with lightly sclerotized striate crudely square lamella bilobate apically, incurved to half length basally, recurved laterally.

Female.—Body length 8 mm; forewing length 8 mm. Subgenital plate dusky, crudely hexagonal, based centrally on sternite 8, distinguishable anteriorly by narrow membranous periphery; posterior half entire, flap-like, extending over most of sternite 9; middle third from base to apex convex, more hirsute than remainder; profile elevated, a flattened curve. Vagina membranous.

Material.—Holotype ♂, allotype ♀ (U.S. National Museum), paratype 1 ♂ (R. F. Surdick); Utah, San Juan Co., Johnson Crk., Tunnel 19 mi. N. of Blanding [no date] Mu-liak.

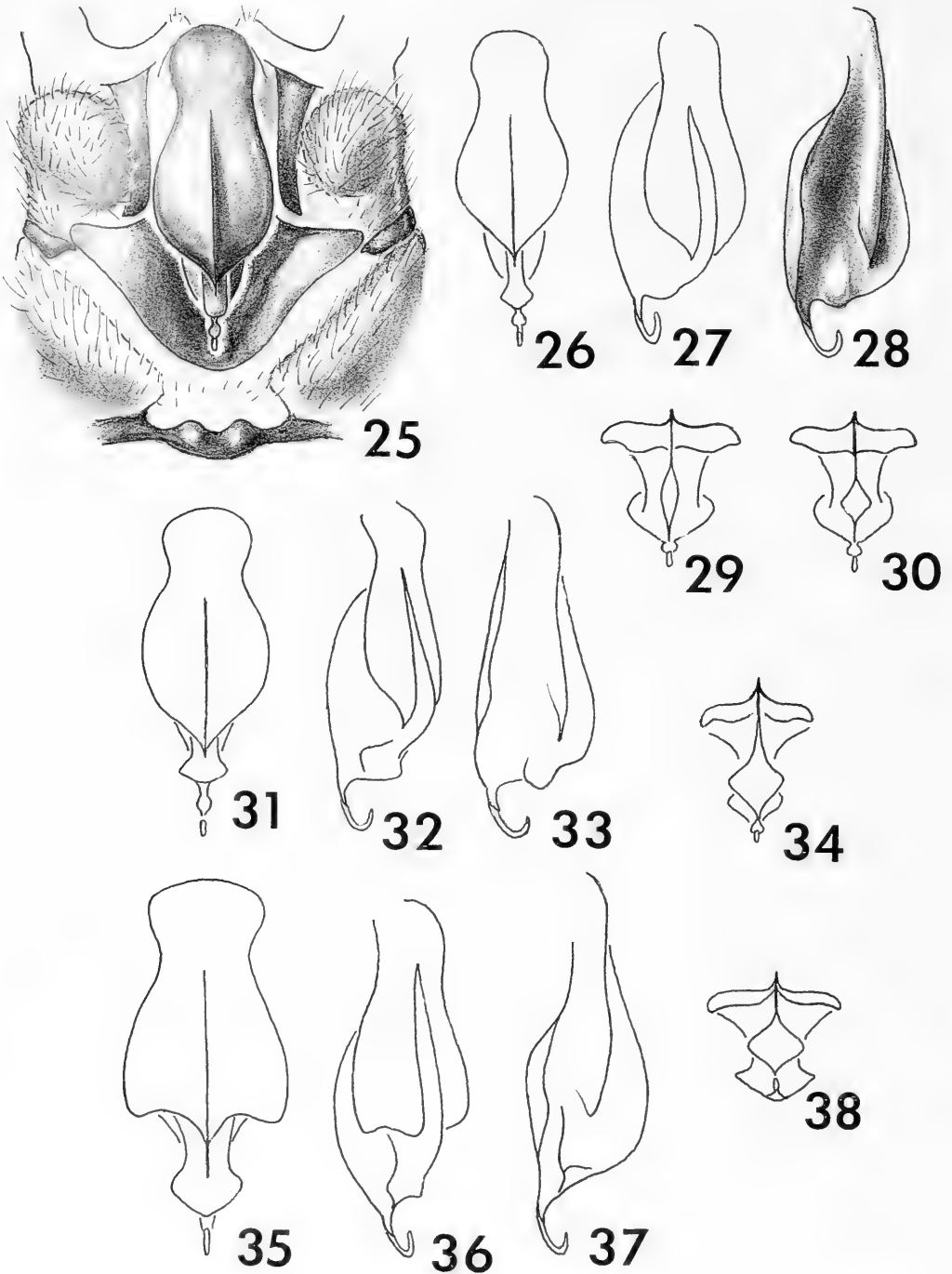
Compared material.—*Sweltsa gaufini*: holotype ♂, allotype ♀ (U.S. National Museum); hundreds of specimens from Idaho, Utah. *Sweltsa albertensis*: topoparatype ♀ (Illinois Natural History Survey); hundreds of specimens from Alberta, British Columbia, Idaho, Montana, Oregon, Wyoming. *Sweltsa lambda*: topoparatype 2 ♂, ♀ (Illinois Natural History Survey, U.S. National Museum); hundreds of specimens from Colorado, Idaho, Oregon, Utah, Wyoming. *Sweltsa hondo*: topoparatype ♂, ♀ (R. F. Surdick); 2 ♀ from New Mexico. (For above species, Brigham Young Univ., California Academy of Science, M. Cather, D. Dunster, Field Museum of Natural History, A. R. Gaufin, Illinois Natural History Survey, S. G. Jewett, Jr., Kansas State Univ., Lyman Museum, Montshire Museum of Science, Oregon State Univ., W. E. Ricker, Royal Ontario Museum, B. P. Stark, R. F. Surdick, Univ. of Kansas, Univ. of Minnesota, U.S. National Museum, Utah State Univ., Washington State Univ.)

Etymology.—The adjective *cristata* describes the crest on the epiproct tip.

Diagnosis.—*Sweltsa cristata* is most closely related to *Sweltsa lambda* (Needham and Claassen 1925) (Figs. 25–34, 41, 45–47), *Sweltsa hondo* Baumann and Jacobi 1984 (Figs. 35–38), *Sweltsa albertensis* (Needham and Claassen) 1925 (Figs. 14–20, 39) and *Sweltsa gaufini* Baumann 1973 (Figs. 10–13). All five species in the *Sweltsa lambda* group have a sclerotized leaflet on the aedeagus that is not found in other *Sweltsa* species. Their elaborately sculptured epiproct tips and their nearly identical female subgenital plates are variations on basic forms that are unique to the group even though similar in some ways to other *Sweltsa* relatives. The epiproct tips are basically concavo-concave rhombohedrons. The upper surface is a curved plane bisected by a longitudinal carina. The sides curve to meet anteriorly at a right or acute angle bearing a swelling or projection. And, a partially colorless filament extends anteriorly from the ventral surface.

In *S. gaufini*, found only in the Bear River area of the northern Wasatch Mountains of Idaho and Utah, the filamentous part of the epiproct tip is a short, slanted blade. The epiproct tip is more elongate than in the other species; the carina is a prominent double crest; the anterior angle bears an oblique hastate projection that is triangular in frontal aspect; the sides are deeply concave, and the ventral surface is half as wide as the dorsal plane. The leaflet on the aedeagus is longer than wide, lightly sclerotized and has rectangular lobes.

In *S. albertensis*, found in the Rocky Mountains of British Columbia, Alberta, Montana, Idaho and northwestern Wyoming, the filament is a long, slanted blade. The dorsal plane is concave and only slightly flanged; the carina is minor, either not reaching all the way to the anterior angle or continuing over the anterior angle, and there is no swelling on the anterior angle but the anterior profile is undercut. The sides are



Figs. 25-38. *Sweltsa lambda* from Wasatch Range, Virgin River drainage of Utah. 25, Male terminalia, dorsal aspect. 26, Epiproct tip, dorsal aspect. 27, Epiproct tip, dorsolateral aspect. 28, Epiproct tip, lateral aspect. 29, Epiproct tip, frontal aspect. 30, Epiproct tip, frontal aspect. *Sweltsa lambda* from Colorado, epiproct tip. 31, Dorsal aspect. 32, Dorsolateral aspect. 33, Lateral aspect. 34, Frontal aspect. *Sweltsa hondo*, epiproct tip. 35, Dorsal aspect. 36, Dorsolateral aspect. 37, Lateral aspect. 38, Frontal aspect.

shallowly concave and the ventral surface is nearly as wide as the dorsal plane and more convex than in the other species. The leaflet on the aedeagus is longer than wide but it is darkly sclerotized and each lobe is rounded.

Sweltsa cristata, *S. lamba* and *S. hondo* are more similar to each other than to either *S. gaufini* or *S. albertensis*. The dorsal plane of each epiproct tip is undulating and broadly pandurate; the carina is a single crest; the slight to prominent projection on the anterior angle is lenticular or diamond-shaped in frontal aspect; the filament is a curled extension on a blade-like base, and the leaflet on the aedeagus is about as long as wide. The middle of the transverse ridge on tergum nine looks like an acutely emarginate triangle in *S. gaufini* and *S. albertensis*. It is crenate in the other four species.

Characters of the epiproct tip and aedeagus distinctly separate *S. cristata* from *S. lamba* and *S. hondo* and indicate that the latter species are more closely related to each other than to *S. cristata*. The anterior part of the pandurate plane of the epiproct tip is nearly elliptical in *S. cristata*; slightly more pyriform and acuminate in *S. lamba*, and nearly triangular in *S. hondo*. The projection at the anterior angle of the bulk of the epiproct tip is minimal in *S. cristata* and visible as a slight swelling in frontal aspect. It is about one-fifth the length of the epiproct tip in the other two species. The ventral surface of the epiproct tip is nearly as wide as and aligned with the dorsal plane in *S. cristata*, but it is more anteriorly placed and narrower than the dorsal plane in the other two species.

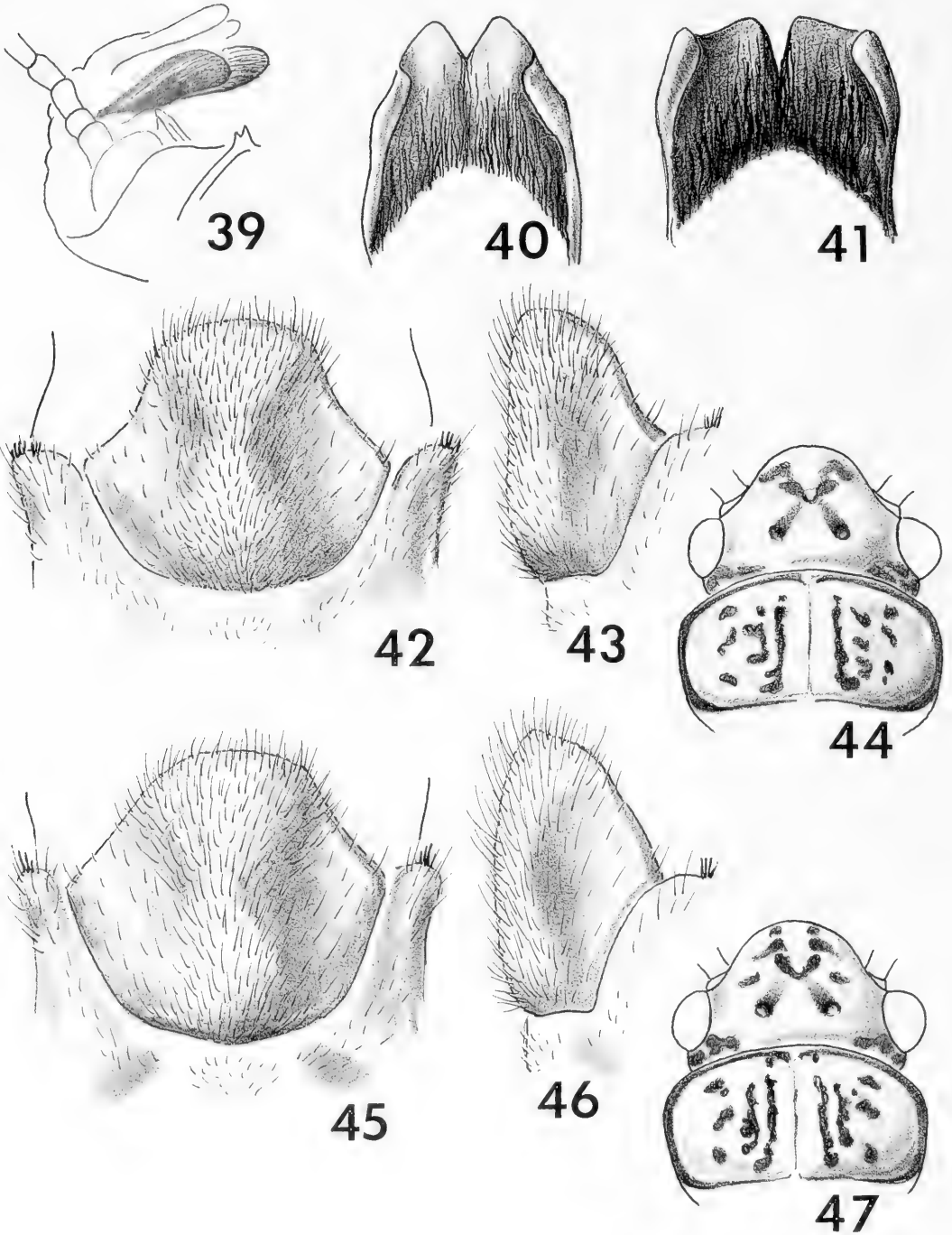
The leaflet on the aedeagus of *S. cristata* is slightly longer than in the other two species and the broader notch in its distal edge bisects it into two rounded lobes. The narrower notch in the leaflets of *S. lamba* and *S. hondo* has only slightly rounded shoulders and bisects a sinuate edge.

Sweltsa cristata has been found in southeastern Utah near Blanding. *Sweltsa lamba*

is a Rocky Mountain species or, more likely, a complex of two incipient or perhaps true species that exhibit considerable variety within and between populations, particularly in the shape and size of the anterior projection of the bulk of the epiproct tip. Utah populations found in the arc of highlands stretching from the Wasatch Mountains to the Virgin River drainage have an anterior projection that is less than half the width of the dorsal plane. In those northern populations the projection is parallel-sided in dorsal aspect and lenticular in frontal aspect (Figs. 25, 29) and in those populations from the Virgin River drainage, it is enlarged anteriorly and lozenged in frontal aspect (Figs. 26–28, 30). Populations from Oregon to Colorado have a projection that is about half to greater than half as wide as the dorsal plane. Again, in those northern populations, the projection is parallel-sided and in Colorado populations, it is enlarged anteriorly (Figs. 31–34). *Sweltsa hondo* has been found in the Sangre de Cristo Range of northcentral New Mexico and differs little from some southern Colorado populations of *S. lamba*.

KEY TO *SWELTSA* MALES WITH A
SCLEROTIZED LAMELLA ON THE
AEDEAGUS

1. Epiproct tip elongate in dorsal aspect with double longitudinal carina; front of bulk of epiproct tip hastate in dorsal aspect, triangular in frontal aspect; lamella on aedeagus longer than wide with rectangular lobes (Figs. 10–13) *gaufini*
 - Epiproct tip with dorsal pandurate plane, single longitudinal carina; front of bulk of epiproct tip parallel-sided or anteriorly swollen in dorsal aspect, lozenged or lenticular in frontal aspect or wedge-like; lamella on aedeagus longer than wide with excurved lobes or as long as wide 2
2. Dorsal plane of epiproct tip slightly concave with carina minor and not usually rising above concavity; front of bulk of epiproct tip perpendicular or slightly undercut in profile, wedge-like in frontal aspect; lamella on aedeagus longer than wide with excurved lobes (Figs. 14–20, 39) *albertensis*
 - Dorsal plane of epiproct tip slightly convex with carina a prominent crest; projected front



Figs. 39-47. 39, *Sweltsa albertensis*, male terminalia and aedeagus, dorsolateral aspect. 40, *Sweltsa cristata*, lamella of aedeagus. 41, *Sweltsa lamba*, lamella of aedeagus. *Sweltsa cristata*. 42, Subgenital plate of female, ventral aspect. 43, Subgenital plate, lateral aspect. 44, Adult head and pronotum. *Sweltsa lamba*. 45, Subgenital plate of female, ventral aspect. 46, Subgenital plate, lateral aspect. 47, Adult head and pronotum.

- of bulk of epiproct tip parallel-sided or anteriorly swollen in dorsal aspect, lozenged or lenticular in frontal aspect; lamella on aedeagus as long as wide 3
- 3. Projection of bulk of epiproct tip as long as wide and visible as slight swelling in dorsal aspect; ventral surface of epiproct tip as wide as and aligned with dorsal plane (Figs. 21-24) *cristata*
- Projection of bulk of epiproct tip longer than wide and about one-fifth length of epiproct tip in dorsal aspect; ventral surface of epiproct tip narrower than and staggered anteriorly to dorsal plane 4
- 4. Dorsal plane of epiproct tip pyriform and anteriorly acuminate (Figs. 25-34) *lamba*
- Dorsal plane of epiproct tip nearly triangular (Figs. 35-38) *hondo*

***Sweltsa umbonata*, sp. nov.**

Figs. 48-54

Adult.—General color dusky-marked pale tan in alcohol. Head with 3 dark ocellar rings, dusky rugulae anterior to and adjacent to ocellar triangle and posterior to compound eyes; posterior ocelli connected to anterior ocellus by diffuse dusky V-mark. Pronotum with thin dark encircling line, dusky longitudinal rugulae. Meso- and metanota each with dark recurrent scutocutellar suture. Abdomen with dark median longitudinal stripe from tergum 1 to 8, single dusky lateral stripes from segment 1 to 4, lateral pectens on segments 7, 8, 9. Macropterous; wings hyaline, dusky-veined, representative of genus.

Female.—Body length 11 mm; forewing length 11 mm. Subgenital plate slightly dusky, crudely hexagonal, umbonate, based centrally on sternite 8, two-thirds as long as wide, distinguishable anteriorly by narrow membranous periphery; posterior half flap-like, extending over most of sternite 9. Emargination on posterior of plate nearly quadrate with slight interior convexity; each consequent lateral flap thin, flat, trapeziform, narrowed posteriorly, one-fifth length of plate, half as wide as emargination, pointing posteromedial. Tumulus centered on triangular convexity that longitudinally spans middle third of plate prominent, de-

clivent anteriorly, steeply sloped laterally, precipitous posteriorly. Plate thickly hirsute on tumulus and anterior declivity with hairs longer, more posteriorly directed approaching summit; remainder sparsely hirsute with fine, pale hairs. Vagina membranous.

Male.—Body length 10 mm; forewing length 10 mm. Epiproct sclerotized, hinged, with tip extending anteriorly to prominent sclerotized shallowly crenate transverse ridge on anterior of tergum 9. In dorsal aspect, epiproct tip 9 times longer than wide, slightly widened at base and at two-thirds length, with distal quarter acuminate. In lateral aspect, epiproct tip 12 times longer than thick, parallel-sided, slightly cernuous at two-thirds length, with apex circular and slightly broader than remainder. Epiproct support structures, segment 9, hemiterga of segment 10 representative of genus. Aedeagus membranous.

Material.—Holotype ♀, allotype ♂ (U.S. National Museum), paratype 9 ♂, 7 ♀ (U.S. National Museum): California, Shasta Co., Fowlers Campground, McCloud R. 6-VI-1965 S. G. Jewett, Jr. Paratypes: 4 ♂, 2 ♀ (U.S. National Museum) California, Siskiyou Co., Mt. Shasta, head Sacramento R. 29-V-1967 S. G. Jewett, Jr.; 7 ♂, 4 ♀ (U.S. National Museum, R. F. Surdick) same locality 5-VI-1965 S. G. Jewett, Jr.; 2 ♂, 1 ♀ (U.S. National Museum) same locality 18-VI-1967 E. Evans.

Compared material.—See compared material of *Sweltsa adamantea*, sp. nov. below.

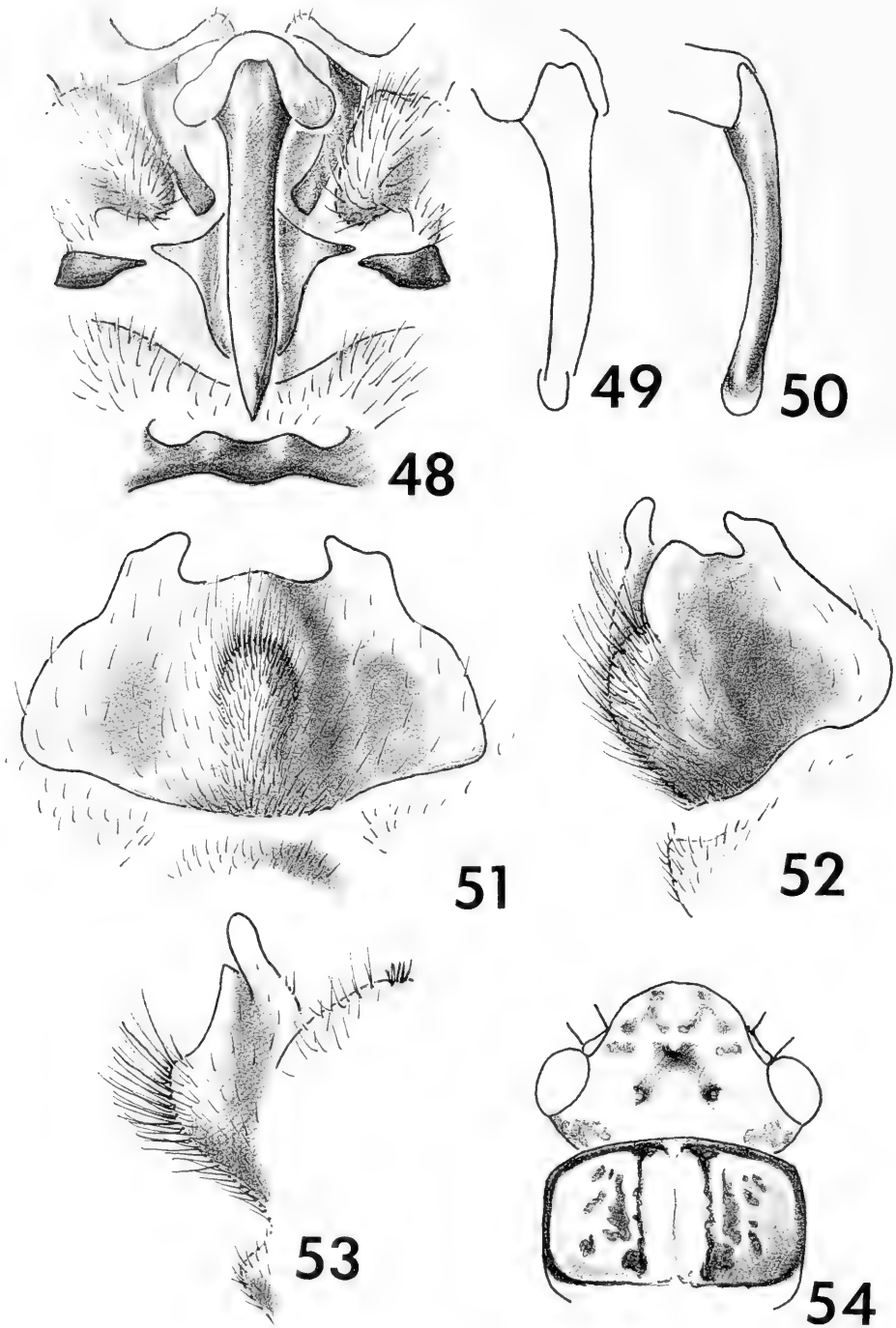
Etymology.—The adjective *umbonata* describes the distinctive appearance of the subgenital plate. The tumulus resembles a boss at the center of a shield.

Diagnosis.—See diagnosis of *Sweltsa adamantea*, sp. nov. below.

***Sweltsa adamantea*, sp. nov.**

Figs. 55-61

Adult.—General color darkly-marked tan in alcohol. Head with 3 dark ocellar rings, dark rugulae anterior to and adjacent to ocellar triangle and posterior to compound



Figs. 48-54. *Sweltsa umbonata*. 48. Male terminalia, dorsal aspect. 49. Epiproct tip, dorsolateral aspect. 50. Epiproct tip, lateral aspect. 51. Subgenital plate of female, ventral aspect. 52. Subgenital plate, ventrolateral aspect. 53. Subgenital plate, lateral aspect. 54. Adult head and pronotum.

eyes; most of frons, ocellar triangle and rugose areas dark. Pronotum with thin dark encircling line, dark longitudinal rugulae in dusky environs. Meso- and metanota dusky, each with dark recurrent scutoscuteellar suture. Abdomen with dark median longitudinal stripe from tergum 1 to 8, single dark lateral stripes from segment 1 to 3, lateral pectens on segments 7, 8, 9. Wings macropterous to brachypterous, hyaline, dark-veined, representative of genus.

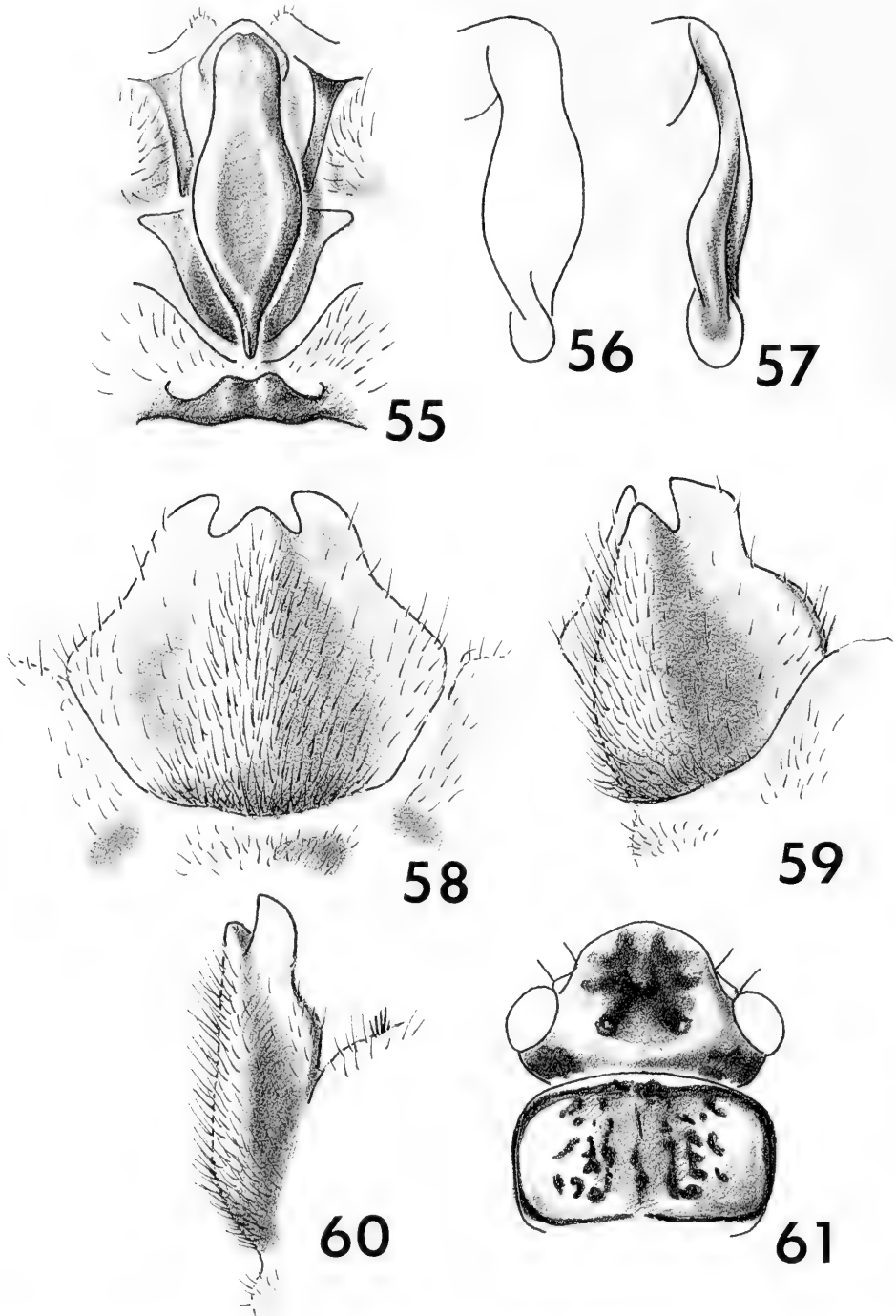
Male.—Body length 9 mm; forewing length of holotype 8 mm. Epiproct sclerotized, hinged, with tip extending anteriorly to prominent sclerotized, shallowly crenate transverse ridge on anterior of tergum 9. In dorsal aspect, epiproct tip thrice longer than wide, an elongate lozenge with obtuse angles rounded, surface slightly depressed centrally, verge curved ventrad; apex bluntly acute, compressed with dorsal edge appearing as short bisecting line. In lateral aspect, epiproct tip with thickness less than half width, slightly declivent and thickened medially; apex one-fifth epiproct tip length, a colorless crescent, paddle-like with vertical elliptical blade slightly broader than thickness of bulk of tip, arising anteromedially from dorsal and ventral surfaces of bulk. Epiproct support structures, segment 9, hemiterga of segment 10 representative of genus. Aedeagus membranous.

Female.—Body length 11 mm; forewing length 10 mm. Subgenital plate slightly dusky, crudely hexagonal, based centrally on sternite 8, almost as long as wide, distinguishable anteriorly by narrow membranous periphery; posterior half flap-like, extending over most of sternite 9. Emargination on posterior of plate bisected by slightly obtuse angular projection; each consequent lateral flap thin, flat, trapeziform, narrowed posteriorly, pointing posteromedial, one-sixth length of plate, one-third longer than interposed angle, half as wide as emargination. Median triangular convexity longitudinally spanning middle third of plate based anteriorly, terminated pos-

teriorly as angular projection, a plateau in profile, thickly hirsute; remainder of plate sparsely hirsute with fine hairs more numerous laterally. Vagina membranous.

Material.—Holotype ♂, allotype ♀ (U.S. National Museum), paratype 1 ♂, 1 ♀ (R. F. Surdick): Oregon, Yamhill Co., McMinnville, Peavine Ridge 8-VI-1948 K. M. Fender. Additional material: 1 ♂ (S. G. Jewett, Jr.) Oregon, Benton Co., Wren; 1 ♂ (U.S. National Museum) Washington, Grays Harbor Co., Humptulips.

Compared material.—*Sweltsa borealis*: lectotype ♀, cotypes (Museum of Comparative Zoology); hundreds of specimens from Alaska, Alberta, British Columbia, California, Colorado, Idaho, Montana, Oregon, Utah, Washington, Wyoming, Yukon. *Sweltsa fidelis*: lectotype ♀, cotypes (Museum of Comparative Zoology); hundreds of specimens from Alberta, British Columbia, California, Colorado, Idaho, Montana, Oregon, Washington, Wyoming, Yukon. *Sweltsa revelstoka*: holotype ♀, allotype ♂ (W. E. Ricker); hundreds of specimens from Alberta, British Columbia, Montana, Oregon, Washington, Wyoming. (Above species, Brigham Young Univ., California Academy of Science, M. Cather, D. Dunster, A. R. Gaufin, Field Museum of Natural History, R. E. Hill, Illinois Natural History Survey, S. G. Jewett, Jr., Michigan State Univ., Montshire Museum of Science, Oregon State Univ., W. E. Ricker, Royal Ontario Museum, B. P. Stark, R. F. Surdick, Univ. of Alberta, Univ. of British Columbia, Univ. of Kansas, Univ. of Minnesota, Univ. of Montana, Univ. of Nebraska, U.S. National Museum, Utah State Univ., Washington State Univ., R. Wisseman.) *Sweltsa continua*: lectoallotype ♀, cotypes (Museum of Comparative Zoology); specimens from Los Angeles, Riverside, San Bernardino, San Diego Cos., California (Brigham Young Univ., California Academy of Science, Field Museum of Natural History, S. G. Jewett, Jr.). *Sweltsa californica*: holotype ♂ (California Academy of Science); specimens from



Figs. 55-61. *Sweltsa adamantea*. 55, Epiproct and center of transverse ridge on tergum 9, dorsal aspect. 56, Epiproct tip, dorsolateral aspect. 57, Epiproct tip, nearly lateral aspect. 58, Subgenital plate of female, ventral aspect. 59, Subgenital plate, ventrolateral aspect. 60, Subgenital plate, lateral aspect. 61, Adult head and pronotum.

Butte, Placer Cos., California (California Academy of Science, R. E. Hill).

Etymology.—The adjective *adamantea* describes the rhomboid dorsal aspect of the epiproct tip.

Diagnosis.—*Sweltsa umbonata* and *S. adamantea* are closely related to *Sweltsa borealis* (Banks) 1895 (Figs. 62–65), *Sweltsa fidelis* (Banks) 1920 (Figs. 66–70), and *Sweltsa revelstoka* (Jewett) 1955 (Figs. 71–74). All these western Nearctic species have a similarly elongate, club-like or slightly flattened epiproct tip and an emarginate, approximately hexagonal female subgenital plate. They have a median convexity on the subgenital plate that either does not extend posteriorly as far as the emargination or does not project beyond the lateral flaps formed by the emargination. In the latter case, the projected portion, whether acute, obtuse or slight, is about twice as broad as a lateral flap.

Sweltsa continua (Banks) 1911 (Figs. 75–79, 85) and *Sweltsa californica* (Jewett) 1965 (Figs. 80–84, 86) also have an emarginate subgenital plate and are included in the *Sweltsa borealis* group but are more distantly related. Both species have a broad median convexity on the subgenital plate that projects beyond the lateral flaps, a distinctly sculptured epiproct tip and a pronounced median dark stripe on the pronotum.

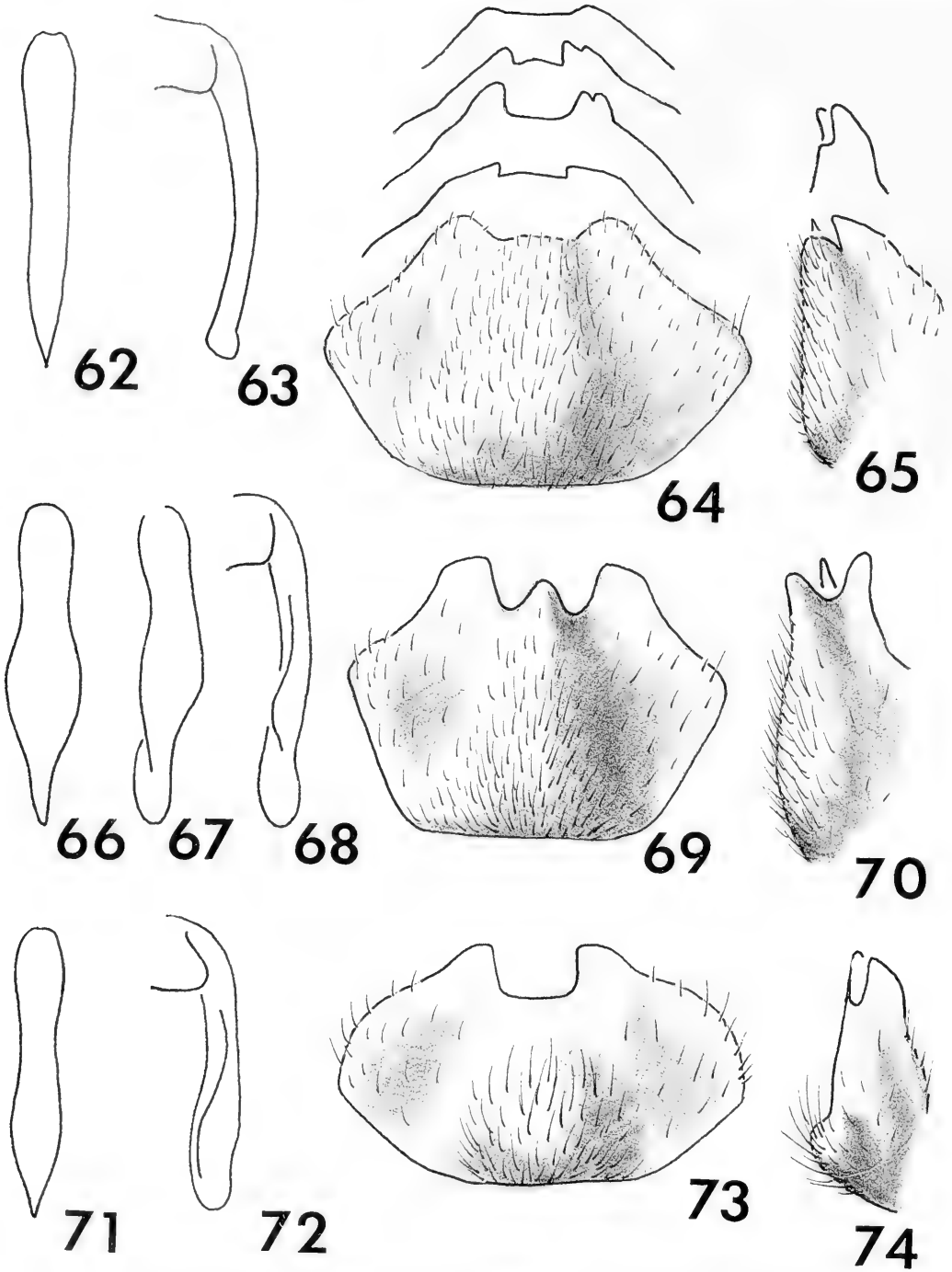
The five species that include *S. umbonata* and *S. adamantea* differ from each other in the shapes of the median convexity and lateral flaps of the subgenital plate, in the setation of the subgenital plate, in the location and width of the widest or flattest part of the epiproct tip, and in the prominence of the compressed apex of the epiproct tip. Some species have a consistent color pattern that can be an aid in determining them.

The subgenital plate of all five species bears a triangular convexity on the middle third. In *S. borealis*, *S. fidelis* and *S. adamantea*, the convexity is shallow and plateau-like in profile but it obviously swells

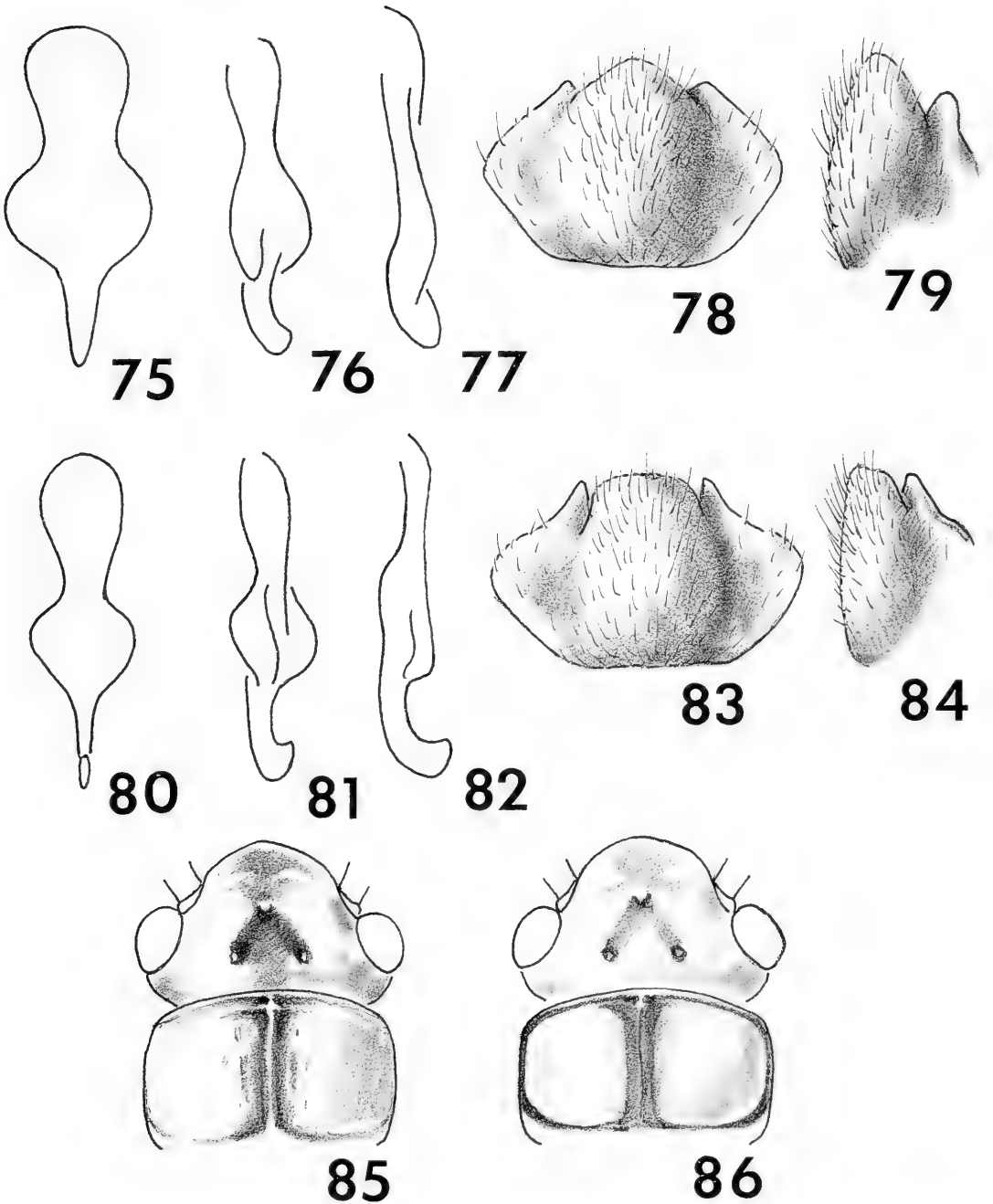
above the sparsely haired lateral thirds that terminate in the thin flaps flanking the emargination. The convexity, or at least its anterior two-thirds, is more hirsute than the remainder of the plate. In *S. borealis*, the convexity is usually only slightly projected as a small curve or very obtuse angle in the emargination between the lateral flaps. In *S. fidelis* and *S. adamantea*, the convexity is usually slightly deeper than in *S. borealis* and, projecting between the flaps as a nearly right angle, extends half as to almost as far as the flaps extend. In *S. umbonata*, the convexity itself is not pronounced and it projects in the emargination as a slight broad curve. But, there is a prominent boss on the center of the convexity. The boss and the anterior of the convexity where it slopes down from the boss is thickly hirsute with long hairs. In *S. revelstoka*, the convexity is usually pronounced but reaches posteriorly from the base to only about midway on the plate so it does not project in the square emargination. It is thickly hirsute with long hairs.

In *S. borealis*, the lateral flaps that flank the emargination of the subgenital plate are usually more circular or square than trapeziform and are often slightly notched or scalloped. They range from small out-curves on the posterior margin of the plate to distinct flaps one-fifth the length of the plate. Their shape and length often differ within and between populations. As a pair, they occasionally exhibit asymmetry and aberrations of shape or development. In *S. fidelis* and *S. adamantea*, the flaps are trapeziform, often point posteromedially and constitute about one-fifth the length of the plate. In *S. revelstoka*, the flaps, although also trapeziform and about one-fifth the length of the plate, do not arise as distinctly from the lateral margins of the plate. This gives the plate the appearance of an oblate hexagon with rounded angles and with a prominent, round-shouldered, square notch in its posterior margin.

In all five species, the epiproct tip is to



Figs. 62-74. *Sweltsa borealis*. 62, Epiproct tip, dorsal aspect. 63, Epiproct tip, lateral aspect. 64, Subgenital plate of female and variations, ventral aspects. 65, Subgenital plate and variation, lateral aspects. *Sweltsa fidelis*. 66, Epiproct tip, dorsal aspect. 67, Epiproct tip, dorsolateral aspect. 68, Epiproct tip, lateral aspect. 69, Subgenital plate of female, ventral aspect. 70, Subgenital plate, lateral aspect. *Sweltsa revelstoka*. 71, Epiproct tip, dorsal aspect. 72, Epiproct tip, lateral aspect. 73, Subgenital plate of female, ventral aspect. 74, Subgenital plate, lateral aspect.



Figs. 75-86. *Sweltsa continua*. 75, Epiproct tip, dorsal aspect. 76, Epiproct tip, dorsolateral aspect. 77, Epiproct tip, lateral aspect. 78, Subgenital plate of female, ventral aspect. 79, Subgenital plate, lateral aspect. *Sweltsa californica*. 80, Epiproct tip, dorsal aspect. 81, Epiproct tip, dorsolateral aspect. 82, Epiproct tip, lateral aspect. 83, Subgenital plate of female, ventral aspect. 84, Subgenital plate, lateral aspect. 85, *Sweltsa continua*, adult head and pronotum. 86, *Sweltsa californica*, adult head and pronotum.

some extent flattened for most of its length and compressed at its partly colorless tip. In *S. borealis*, it is one-tenth to one-eighth as wide and as thick as long, only barely flattened anywhere along its length, slightly declivent, and nearly parallel-sided with its apical quarter acuminate in dorsal aspect. Its apex is rounded in profile and as thick as or slightly thicker than the bulk of the epiproct tip. Its shape differs within and between populations. The epiproct tip of *S. umbonata* is similar to that of *S. borealis*, but it increases slightly in width at two-thirds its length, is more declivent and has an apex slightly larger in profile.

In *S. fidelis*, *S. revelstoka* and *S. adamantea*, the epiproct tip is wider and slightly thicker with a more pronounced apex than in the above two species. It widens and narrows along its length. Because the compressed apex arises from the dorsal and ventral surfaces, the epiproct tip resembles a large horizontal rhomboidal disk intersected on its apex by a small vertical elliptical disk for half the diameter of the small disk. In *S. fidelis*, the epiproct tip reaches its greatest width, almost one-fourth its length, at about three-fifths its length. Its sides are slightly incurved from base to widest part and it is acuminate beyond. In *S. revelstoka*, the epiproct tip reaches its greatest width, about one-sixth its length, at three-fourths its length. Its sides are also slightly incurved from base to widest part and it is acuminate beyond. In *S. adamantea*, the epiproct tip reaches its greatest width, about one-third its length, at about half its length. Its sides are slightly incurved only adjacent to the base; beyond that, its sides are slightly excurved and it ends acutely.

Sweltsa borealis is usually the largest of the Chloroperlinae and macropterous but its body length and wing length differ within and between populations. The crenulations on the transverse ridge are often comparatively very shallow. *Sweltsa revelstoka*, although other macropterous, commonly exhibits different degrees of brachyptery. The

S. adamantea examined are macropterous and brachypterous. *Sweltsa fidelis* is usually macropterous and the *S. umbonata* examined are macropterous.

Sweltsa borealis differs, sometimes greatly, in adult coloration and distinctness of color pattern within and between populations. But, whether pale or dark overall, the rugulae of the head and pronotum are darkened, the posterior ocelli are usually connected to the anterior ocellus by a dark V and the pronotum is ringed by a dark line. *Sweltsa umbonata*, *S. revelstoka* and *S. adamantea* are usually darkly and distinctly colored in the same pattern as *S. borealis*. In *S. revelstoka* and even darker *S. adamantea*, however, a broad dark area on the head usually extends from the ocellar triangle to the clypeus. *Sweltsa fidelis* differs in coloration within and between populations but it is usually pale overall. The rugulae are barely noticeable or darkened, the ocelli are usually not connected by a dark V and the dark ring on the pronotum is often interrupted, forming a pair of lateral crescents.

Sweltsa borealis is a common, wide-ranging species. It has been found from Alaska to New Mexico and to California. *Sweltsa fidelis* ranges from Alaska to Utah and to California and *S. revelstoka* ranges from Alberta and British Columbia to Wyoming and Oregon. *Sweltsa adamantea* has been found in areas of the Coast Ranges of northern Oregon and Washington. *Sweltsa umbonata* has been found in the Mount Shasta area of California between the southern Cascade Range and northern Sierra Nevada.

KEY TO NEARCTIC *SWELTSA* WITH THE
SUBGENITAL PLATE OF THE
FEMALE EMARGINATE

1. Median longitudinal dark stripe on pronotum; in dorsal aspect, epiproct tip narrowed to less than basal width at one-third length, abruptly widened to wider than base in middle third then abruptly and sharply acuminate; median convexity on female subgenital plate projecting posteriorly between emargination to or beyond

- apices of lateral flaps where it is at least half width of posterior margin of plate 2
- Median longitudinal area of pronotum pale; in dorsal aspect, epiproct tip nearly parallel-sided, slightly widened or gradually widened to up to twice basal width then gradually tapered to apex or acuminate; median convexity on female subgenital plate either not extending posteriorly as far as emargination or not extending beyond apices of lateral flaps where it is less than half width of posterior margin of plate 3
- 2. Dark ring encircling pronotum; apex of epiproct tip up-curled, hook-like; median convexity of subgenital plate blunt, extending slightly beyond apices of lateral flaps (Figs. 80-84, 86) *californica*
- No dark ring encircling pronotum; apex of epiproct tip up-curved, blunt; median convexity of subgenital plate rounded, extending beyond apices of lateral flaps (Figs. 75-79, 85) *continua*
- 3. Epiproct tip nearly parallel-sided, acuminate distally; lateral flaps of subgenital plate more square or rounded 4
- Epiproct tip widened somewhere along its length, acuminate or acute distally; lateral flaps of subgenital plate more trapeziform 5
- 4. Median convexity of subgenital plate with prominent central hirsute boss (Figs. 48-54) .. *umbonata*
- Median convexity of subgenital plate without a boss (Figs. 62-65) *borealis*
- 5. Median convexity of subgenital plate prominent, reaching from base to midway on plate; epiproct tip reaching greatest width at about three-fourths its length (Figs. 71-74) .. *revelstoka*
- Median convexity of subgenital plate extending length of plate and projecting as an obtuse angle in the emargination between the lateral flaps; epiproct tip reaching greatest width at about three-fifths or one-half its length 6
- 6. Epiproct tip reaching its greatest width, almost one-fourth its length, at about three-fifths its length; epiproct tip acuminate with sides slightly incurved; ocelli usually not connected by dark V (Figs. 66-70) *fidelis*
- Epiproct tip reaching its greatest width, almost one-third its length, at about half its length; epiproct tip acute apically with sides slightly excurved; ocelli connected by dark V and dark area reaching to clypeus (Figs. 55-61) *adamantea*

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I am grateful to M. S. Kelley of the Museum of Comparative Zoology, N. Adams and O. S. Flint, Jr. of the U.S. National Museum, R. W. Baumann of Brigham Young University, S. G. Jewett, Jr. and A. R. Gaufin for their assistance and loan of specimens and to all the museums and collectors noted in the text.

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NOTES ON THE *MINDARUS* SPP. (HOMOPTERA: APHIDIDAE) OF
NORTH AMERICA WITH DESCRIPTIONS OF TWO NEW SPECIES

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Abstract.—A background of the biology and taxonomy of *Mindarus* spp. in North America is presented. A previously unused character, wax gland plates on apterous adult female morphs, has been found to be relatively conservative and useful for discriminating between species. An extensive study of specimens from western North America and Europe suggests that *M. abietinus* Koch, a European aphid to which most specimens have been assigned, may not be present in the western Nearctic. Two species, *Mindarus kinseyi*, n. sp. living on *Abies concolor* and *M. remaudierei*, n. sp. living on *Abies religiosa*, are described. The distribution of *M. victoria* Essig is extended to California and Idaho where it lives on *A. concolor*.

Key Words: Aphididae, *Mindarus*, aphid, new species

Aphids of the genus *Mindarus* are mon-
oecious, needle feeders on *Abies*, *Keteleeria*
or *Picea*. In this holarctic genus are five fos-
sil and five extant species. Heie (1967) dis-
cusses the living species in relation to the
fossils and provides a key to eight species.

The literature reports three species from
North America: *Mindarus abietinus* Koch,
M. obliquus (Cholodkovsky) and *M. victoria*
Essig. *Mindarus obliquus* lives on *Picea* and
the latter two live on *Abies*. Because of the
morphological similarity between *obliquus*
and *abietinus* they have been identified pri-
marily on the basis of the host on which
they were collected. Robinson and Chen
(1969) found differences between the chro-
mosomes of *Mindarus* from *Picea* and those
from *Abies*, and Carter and Eastop (1973)
found it possible to separate *Mindarus* col-
lected in Britain from these two hosts by
plotting the number of sensoria on the third
antennal segment against the length of the
segment. *Mindarus victoria* has been re-

corded only from *Abies grandis* in the type
locality, Vancouver Island, British Colum-
bia, Canada (Smith and Parron 1978).

The life cycle of *Mindarus abietinus* is
reduced in number of generations and rel-
atively simple. The fundatrices produce ei-
ther alate sexuparae or apterous viviparae
that produce only sexuparae. These second
and third generation sexuparae produce
males and oviparae which mate and by early
summer eggs have been deposited on the
host. A period of 9-10 months is spent in
the egg stage. The biology and seasonal his-
tory of *M. abietinus* has been studied in de-
tail by Varty (1966, 1968). This cycle has
been common to all species studied until
recent work by Ehler and Kinsey (in press)
who found that *Mindarus* living on *Abies*
concolor on the west slope of the Sierra Ne-
vada, most particularly pest populations in
the United States Forest Service Nursery in
Placerville, California, had a life cycle and
biology which clearly did not match any

published for *M. abietinus* (Nüsslin 1900, Varty 1966, 1968). This aphid is described below.

DATA COLLECTION

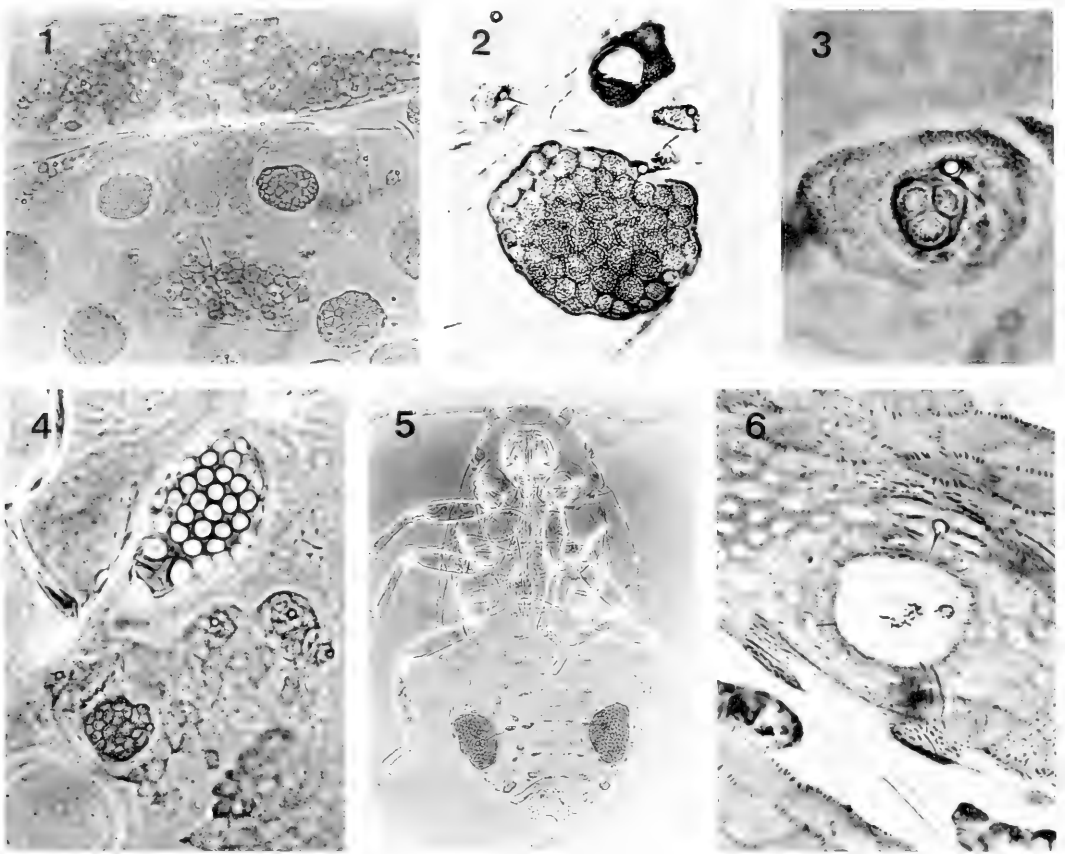
Hundreds of specimens have been provided by Marvin Kinsey (Department of Entomology, University of California, Davis) taken from *Abies concolor* in the Sierra Nevada. In addition he has reared clones from fundatrices through several generations, collecting good series from these clones. Approximately 1500 slides, each containing a minimum of two aphids, have been prepared from this material. Additional specimens were borrowed from several museums.

Measurements were taken of body, wing, hind tibia, antennal segments III, IV, V, VI base and VI process terminalis, ultimate rostral segment, second hind tarsus and counts were made of secondary sensoria on antennal III and IV of alatae, setal counts were made on cauda, ultimate rostral segment, first hind tarsus, subgenital plate, abdominal tergite VIII and scape. The distribution of wax gland plates was recorded on apterous female morphs. Measurements were made with the use of a drawing tube on a Zeiss® microscope extending out over a Zidas® digitizing pad. With this system it is possible to make measurements accurate to three decimal places using a 16× or greater objective.

Wax gland plates (WGP) have not previously been used to discriminate between species of *Mindarus*. They are found on fundatrices, apterae, oviparae and nymphs. They are irregularly shaped, heavily sclerotized plates ranging from circular to oval on which are located groups of cells (Fig. 1). The structure of these cells under high magnification is very regular, appearing much like a sieve (Fig. 2). Foottit and Richards (1993) call these cells "margined cribriform discs" and WGP "clusters of emarginate cribriform discs." Sometimes the plate is only lightly sclerotized (especially in ovi-

parae) but a cluster of closely associated clearly defined cells will still define WGP in such cases. The number of cells in a WGP can vary from one to over a hundred (Fig. 3). Each gland is accompanied by a setae which is located on the anterior half of its margin. Wax gland plates may be found on the head, thorax, abdomen and subanal plate. Typically there are a pair on the front of the head and a pair on the anal plate. Those on the thorax and abdomen may be assigned to paired marginal, dorsolateral and submedian lines (terminology for these lines after Foottit and Richards 1993). In slide-mounted specimens the lateral line often appears to be ventral. These can be expressed as a formula which is maximally 6.6.6:6.6.6.6.6.6.4. The first three numbers refer to number of WGP on the thoracic segments and the later seven refer to the WGP on the first seven abdominal segments. Unless otherwise indicated a 2 means that there are 2 marginal WGP present, a 4 means that there are 2 marginal and 2 dorsolateral WGP, and a 6 means that there are 2 marginal, 2 dorsolateral and 2 submedian WGP on that segment. No specimens have been seen with more than 4 WGP on abdominal segment VII. WGP on the prothorax are usually easy to see and appear to be located on the head due to the fusion of head and prothorax in *Mindarus* (Fig. 4). Diagrammatic representations of the wax gland distribution on various species is shown in Fig. 7. Although there is intraspecific variation, within a range, the distribution patterns seem to hold. The formula for *M. victoria* is almost invariant on specimens seen from several locations in California and British Columbia taken over several years.

Oviparae have two large wax producing structures located on the abdominal venter (Fig. 5). These have somewhat different structure than WGP in that the entire surface, with the exception of a central pore, is glandular with fine lines creating a matrix of cells of variable shape.



Figs. 1-6. 1, Abdominal tergites V, VI and VII of *M. kinseyi* aptera showing wax gland plates with distinct sclerotized outer ring. 2, High magnification of wax gland plate of aptera of *M. kinseyi* showing sieve-like structure within cells. Siphuncular pore and associated sclerite shown at top of photo. 3, A small wax gland plate containing only three cells. 4, Wax gland plate on prothorax posterior to eye of *M. kinseyi* aptera. 5, Ovipara of *M. kinseyi* showing paired ventral wax glands found on abdominal venter of all *Mindarus* oviparae. 6, Abdominal tergite VI of *M. kinseyi* alata showing membranous wax gland completely embedded in sclerite. Note adjacent glandular areas.

Most of the sclerotization on the dorsum of the body in both apterae and alatae contains less organized glandular areas usually surrounding a seta. These areas are most likely wax producing glands without the discrete structure of the WGP's discussed above.

Although present in alatoid nymphs, wax gland plates as described above are not present in alatae. On the abdomen of alatae at the locations where WGP's would be expected in apterae, there are membranous areas with a dark central spot and a seta (Fig. 6). In some cases under high magni-

fication fine radial lines can be seen around the central spot. The submedian pair of these membranous areas is often embedded in the posterior edge of the sclerotic bands on each tergite (Fig. 8). The dorsolateral and marginal rows are indicated only by the darkened pore and associated seta and are often very difficult to see. Since alatae have some abdominal wax, usually appearing as transverse bands, and these structures are located where WGP's are in nymphs and apterae, it may be that they are wax producing glands. I have been unable to find a name for these

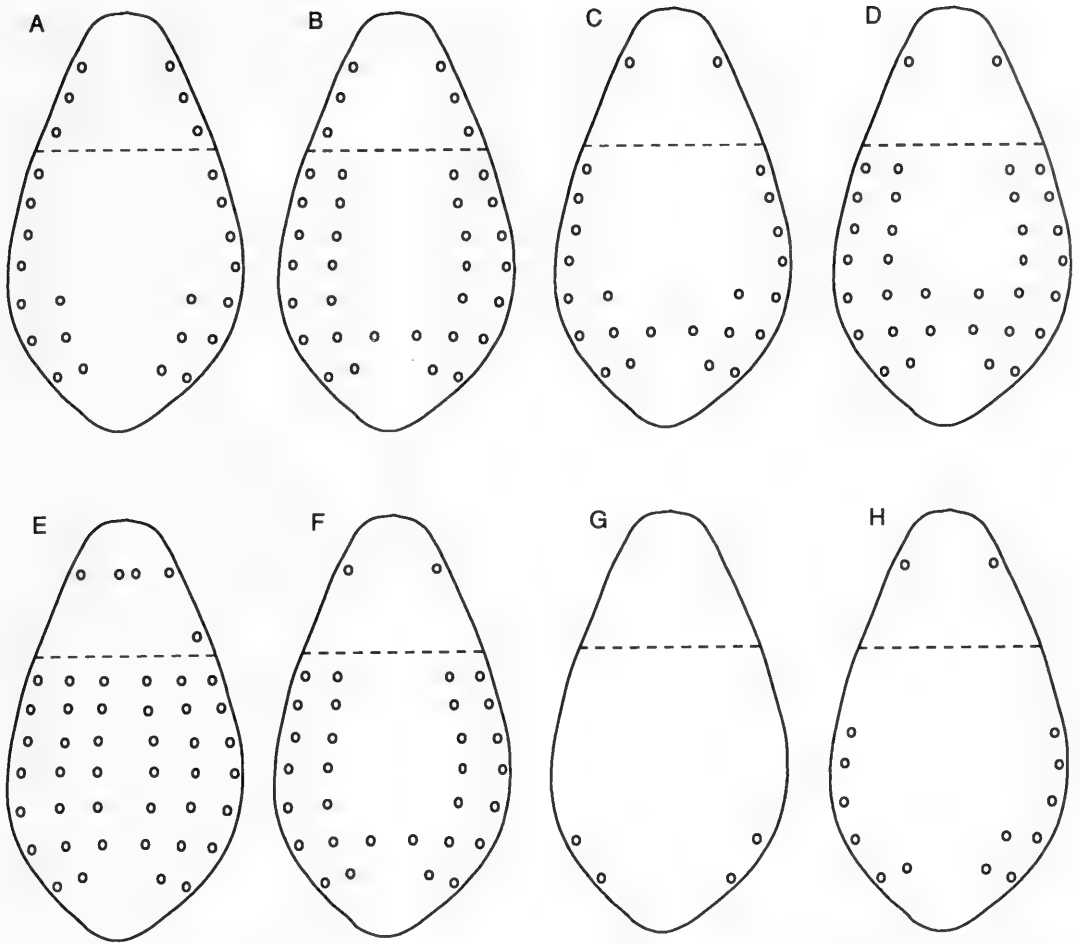


Fig. 7. Diagrammatic representation of apterous morph of *Mindarus* showing paired marginal, dorsolateral and submedian lines of wax gland plates as observed in the following species: A & B, minimum and maximum distribution seen on *M. kinseyi* fundatrices; C & D, minimum and maximum distribution seen on *M. kinseyi* apterae; E, distribution seen on *M. remaudierei* apterae; F, distribution seen on *M. victoria* apterae; G & H, minimal and maximal distribution seen on *M. abietinus* apterae.

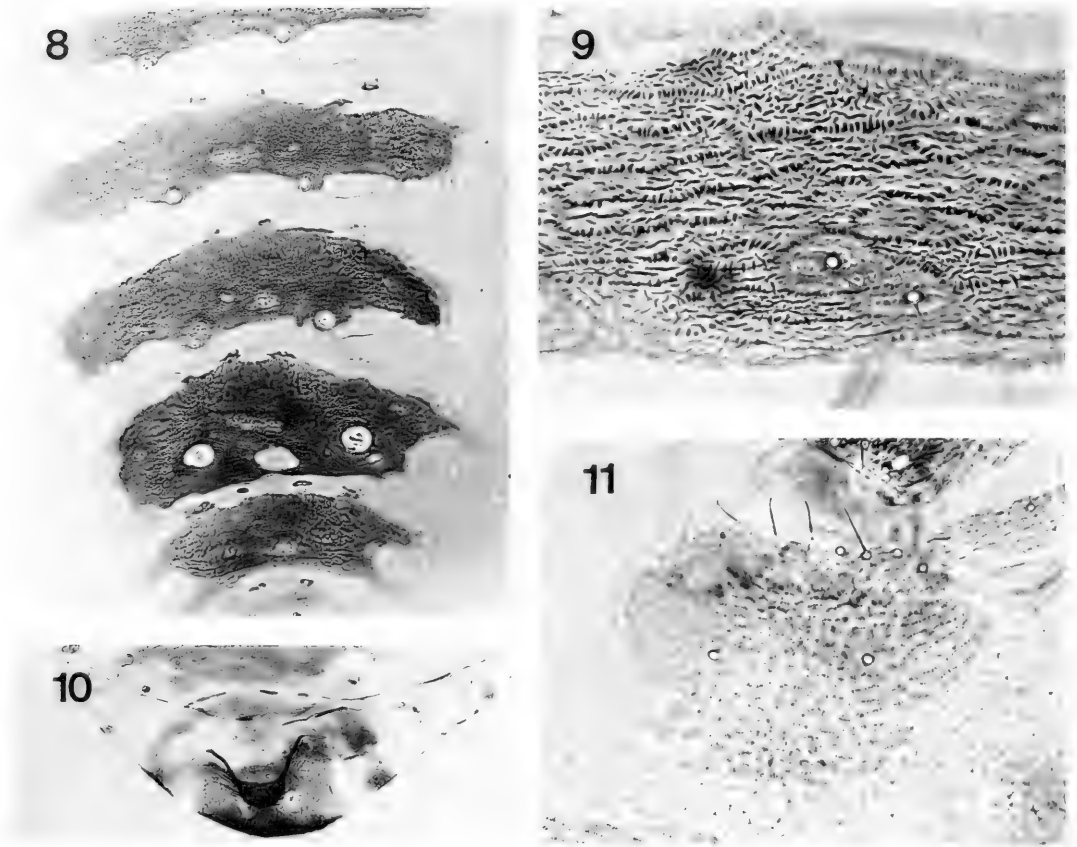
structures so will call them membranous wax glands (MWGs).

Mindarus Koch 1857

Detailed generic descriptions are given in Heie (1980) and Foottit and Richards (1993) and will not be repeated here. *Mindarus* is the only genus in the subfamily Mindarinae. It is separated from most other aphids by the presence of ventral wax glands in oviparous females and the pterostigma in alatae

extends to the tip of the wing. Males and oviparae are mostly much smaller than viviparous morphs. In apterous morphs there is no visible separation between the head and prothorax. Eyes in fundatrices, oviparae and males consist only of triommatidia while apterae have compound eyes.

Only two named species, *Mindarus japonicus* Takahashi (1931) and *M. keteleerifoliae* Zhang and Zhong (1984), have not been recorded from North America and will not be covered in this paper.



Figs. 8-11. 8, Abdomen of *M. kinseyi* alata showing maximum level of sclerotization and also membranous wax glands associated with posterior edge of sclerites on anterior segments. 9, Dorsal abdominal sclerite of *M. kinseyi* alata showing irregular transverse sculpturing. 10, Cauda shape and size typical of *M. kinseyi* alata. 11, Subgenital plate of *M. kinseyi* alata showing paired setae located on approximate midline of plate.

Mindarus abietinus Koch

Except for *Mindarus victoria*, specimens of *Mindarus* from *Abies* spp. in North America have been identified and referred to as *M. abietinus*. Based on the morphology of the alatae there is little reason to doubt this. A comparison of the fundatrices and apterae suggests otherwise. Apterae and fundatrices from Europe have a limited distribution of wax gland plates. Dr. G. Remaudière (Museum National D'Histoire Naturelle, Paris) and Dr. R. Blackman (Natural History Museum, London) kindly examined additional fundatrices and apterae in their collection, and confirm this general

pattern of reduction in WGP's in *M. abietinus*. The formula for WGP's ranged from 0.0.0:0.0.0.0.0.2.2 to 0.0.0:0.0.2.2.2.3.4. Dr. Remaudière has two apterae from Greece with two "very small" WGP's on the prothorax which have the formula 2.0.0:0.0.0.2.2.2.2. This is in considerable contrast to the patterns seen in fundatrices and apterae from North America (Fig. 7). I have examined several hundred fundatrices and apterae from multiple years, hosts, distributions and elevations and have yet to find one without at least one pair of lateral WGP's on the prothorax and, with the exception of one specimen, all have a complete paired lateral line on the first seven abdominal seg-

ments. The paucity of apterae of *abietinus* in European collections is also in contrast to the abundance of apterae here. With the exception of the aphids studied by Varty (1966, 1968) the number of offspring of the fundatrices (based on collections I have made and those sent to me) which are apterous is significant, reaching nearly 100% in some cases. Much additional work needs to be done but I believe that none of the material I have seen, at least from western North America, is *M. abietinus*.

***Mindarus kinseyi*, n. sp.**

Fundatrix

Color in life: Pale green, mature specimens covered with filamentous wax, especially laterally and posteriorly. Color of fundatrices and other forms from Ehler and Kinsey (in press).

Morphology: Apterous. Eyes only triommatidia, however some specimens examined that are considered fundatrices have a few facets in addition to the triommatidia. Body oval, enlarging gradually from head to abdominal segment IV then rounding to caudal region. Head, scape and pedicel smooth, antennal segments III–VI with gradually increasing density of spiculate imbrications. Head and prothorax fused. Rostrum reaching abdominal segment II, ultimate rostral segment gradually tapering to tip with convex sides. Dorsum of thorax and abdomen smooth with sclerotized areas appearing granular, on posterior segments with irregular transverse lines of spicules. Trochanters and femora fused, joint indicated only by a slight ventral crease. Legs smooth through femora, tibiae lightly spiculate on distal half, second tarsal segment with spiculate imbrications. Cauda slightly raised, transverse ridge. Subgenital plate with spiculate imbrications. Without siphunculi. Setation: Setae very sparse, and short (<0.015 mm). Dorsal setae on a sclerite or edge of a gland. Ultimate rostral segment with 0–2 accessory setae. Cauda with 2 setae. Subgenital plate with 2 setae on

anterior margin and 7–14 scattered along posterior, some specimens with 2 additional setae on midline of plate.

Sclerotization (Fig. 12): Intensity of sclerotization varies from pale to medium tan. Head with one central sclerite covering middle of vertex and front but not reaching antennal sockets or eyes. Antennae with scape, pedicel, V and VI and distal 1/3 of segment IV darker than segment III and basal 2/3 of IV. Paired sclerites on prothorax extend onto posterior of head, mesad of triommatidia. Prothorax with two pairs of small submedian sclerites. Meso- and meta-thorax, and abdominal tergites I–III (IV) each with a row of small, irregularly shaped sclerites. Abdominal tergites (IV), V–VII with sclerotized areas which are highly varied in size and usually extending across mid-dorsal line especially on the latter two segments. Tergite VIII with a narrow sclerotic band most often divided into a median and two lateral sections. Cauda, subanal plate and subgenital plate lightly sclerotized. Legs more or less evenly sclerotized throughout.

Wax gland plates: Formula ranging from 2.2.2:0.2.2.2.2.4.4 to 2.2.2:4.4.4.4.4.6.4 (Fig. 7A & B).

Size: Summary of measurements given in Table 1.

Apterae and alatae are divided into two categories in the description below. These categories, based on date of collection, roughly correspond to observed differences in biology noted between spring and later generations of both morphs (Ehler and Kinsey in press).

Aptera (second and third generation)

Description and measurements based on specimens collected in May and June.

Color in life: Body pale green covered with a light wax pulverulence which increases with age. Posterior and lateral areas of abdomen can be covered with long wax filaments extruded from wax glands.

Morphology: Compound eyes present. Body enlarged gradually from narrow head

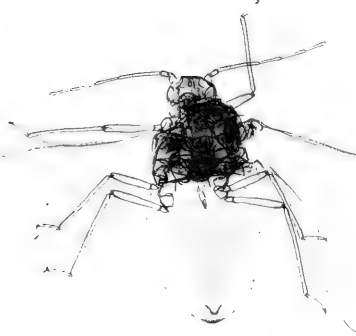
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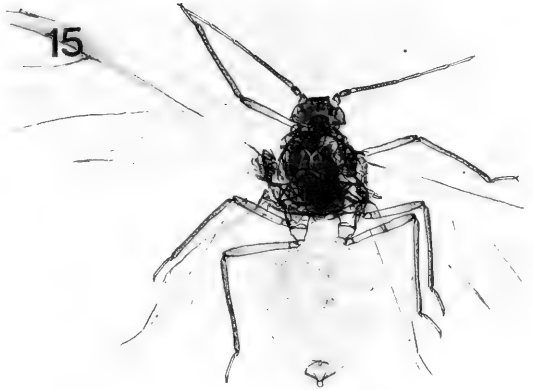
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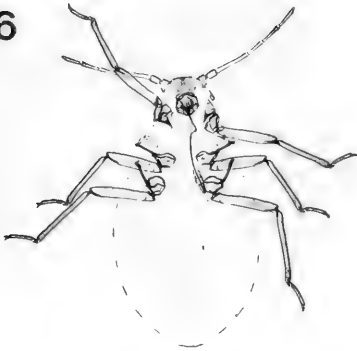
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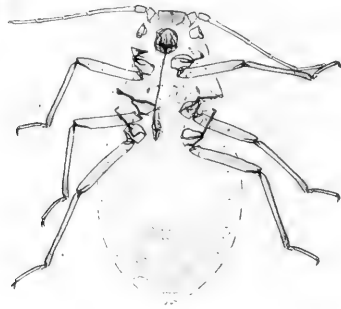
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Figs. 12-17. 12, Fundatrix of *M. kinseyi*. 13, Aptera of *M. kinseyi* showing close to maximum level of sclerotization. 14, Alata of *M. kinseyi* showing a moderate level of sclerotization. 15, Alata of *M. victoria*. 16, Fundatrix of *M. victoria*. 17, Aptera of *M. victoria*.

to mid abdomen rounding smoothly to blunt caudal region; dorsum smooth with faint network of spiculate lines on abdominal tergite VIII. Head and thorax fused, ap-

pearing as one unit. Rostrum reaching abdominal segment III, ultimate rostral segment gradually tapering to blunt tip. Antennae six-segmented without secondary

sensoria, scape and pedicel smooth, flagellum increasingly spiculose distally. Legs smooth, second tarsi with light spiculose imbrications. Cauda slightly elevated, transversely elongate. Siphunculi small rimmed pores sometimes surrounded by a small sclerotic area. Subgenital plate usually rugose and always spiculate. Setation: Setae on body sparse, and short (<0.015 mm). Dorsal setae all on a sclerite or on the edge of a gland. Ultimate rostral segment with 2 accessory setae, rarely 1 or 0. Subgenital plate with 2 setae near middle of anterior margin and (5) 8–14 scattered along posterior margin. Some specimens with an additional smaller pair in the middle of the plate or an additional smaller setae on either side of the middle pair on the anterior margin.

Sclerotization (Fig. 13): On body from medium to light tan. Head with wide, parallel sided, median sclerite covering vertex and front, median suture indicated on both vertex and front. Irregularly shaped sclerotic areas on posterior of head and prothorax. Sclerites on meso- and metathorax and tergites I and II small, scattered across segment in an irregular line, gradually increasing in size on tergites III and IV and tergites V–VII each with transverse band; tergite VIII with narrow band divided into submedian and two lateral sections. Scape and pedicel concolorous with central head sclerite, distal tip of III and $\frac{1}{3}$ of IV slightly darkened, V and VI darker than head. Legs evenly tanned, coxae and trochanters lighter.

Wax gland plates: Formula commonly ranging from 2.0.0:2.2.2.2.4.5.4 to 2.0.0:4.4.4.4.6.6.4 (Fig. 7C & D). One specimen seen without a complete paired marginal line of glands and one specimen seen with thoracic formula 2.2.2.

Size: Summary of measurements given in Table 1.

Alata (second and third generation)

Descriptions and measurements based on specimens collected in May and June.

Color in life: Body light to medium green, shiny in recently molted adults becoming covered with a light pulverulence in mature specimens.

Morphology: Head clearly separate from narrow prothorax, ocelli on vertex located on anterior-mesal margin of compound eyes, ocellus on front located at base of indistinct median suture. Rostrum reaching to abdominal segment II, ultimate rostral segment with slightly convex sides gradually tapering to rounded tip. Antennae six-segmented with 8–23 (mean = 14.5, var. = 6.6) secondary sensoria on segment III and 0–4 (mean = 1.9, var. = 0.7) on segment IV, scape pedicel and III smooth, IV–VI with spiculose imbrications. Abdomen gradually widening from pterothorax to abdominal segment V then tapering to more pointed abdomen than apterae, prothorax and membranous areas of dorsum smooth, dorsal lobes of pterothorax with reticulate sculpturing, sclerotized bands on abdominal segments I–VII with irregular transverse sculpturing (Fig. 9). Legs smooth except for anterior surface of femora and second tarsi which have spiculose imbrications. Siphunculi rimmed pores, rarely absent, sometimes surrounded by a small sclerite. Cauda rugose, subtriangular with rounded tip, usually wider than long (Fig. 10). Subgenital plate spiculose. Setation: On body sparse as in apterae and very short (<0.01 mm). Abdominal segments with a row of setae on the sclerotic band. Setae on tibiae $<$ half tibial diameter. Ultimate rostral segment with 2, rarely 1 or 0, accessory setae. Subgenital plate usually with 2 large setae located near midline and 8–15 scattered along posterior margin (Fig. 11). Some specimens with a second smaller pair between midline and posterior group or one on each side of median pair.

Sclerotization (Fig. 14): Head and pterothorax heavily sclerotized, prothorax pale. Scape and pedicel concolorous with head and darker than flagellum which is evenly sclerotized. Coxae and trochanters pale, femora gradually darkening distally, tibiae

Table 1. Measurements for *Mindarus* spp. For each character the range is given, the mean is in boldface followed by the variance. The n values for each morph vary because on some of the specimens certain characters were not measurable. Length of antennal segment VI is not separated into base and process terminalis for the oviparae and males. All measurements are in mm.

	Body	Wing	Hind Tibia	Antennal Segments	
				III	IV
<i>M. kinseyi</i>					
Fundatrices	1.42-1.80		0.253-0.431	.115-.198	0.054-0.096
n = 17-23	1.62 , 0.009		0.306 , 0.003	0.149 , 0.000	0.073 , 0.000
Apterae					
May-June	1.35-2.27		0.319-0.560	0.174-0.332	0.087-0.170
n = 116-119	1.84 , 0.027		0.468 , 0.002	0.275 , 0.001	0.136 , 0.000
July-Sept.	1.09-2.14		0.292-0.577	0.155-0.330	0.074-0.168
n = 129-131	1.56 , 0.042		0.416 , 0.003	0.243 , 0.001	0.118 , 0.000
Alatae					
May-June	1.28-2.90	1.61-3.47	0.453-0.925	0.195-0.475	0.102-0.242
n = 199-212	2.08 , 0.115	2.58 , 0.160	0.704 , 0.008	0.356 , 0.002	0.187 , 0.001
July-Nov.	1.02-2.83	1.30-3.28	0.346-0.864	0.173-0.439	0.098-0.231
n = 154-156	1.79 , 0.090	2.26 , 0.147	0.601 , 0.010	0.307 , 0.002	0.169 , 0.001
Oviparae	0.074-1.00		0.131-0.196	0.040-0.066	0.016-0.043
n = 68-69	0.88 , 0.002		0.161 , 0.000	0.051 , 0.000	0.031 , 0.000
Males	0.52-0.66		0.126-0.174	0.050-0.090	0.029-0.051
n = 35-36	0.60 , 0.001		0.150 , 0.000	0.065 , 0.000	0.040 , 0.000
<i>M. remaudierei</i>					
Apterae	2.01-2.34		.510-.550	0.295-0.314	0.107-0.127
n = 4	2.16 , 0.019		0.528 , 0.000	0.302 , 0.000	0.116 , 0.000
Alatae	2.05-3.00	2.91-3.48	0.706-0.851	0.449-0.510	0.171-0.210
n = 15	2.43 , 0.063	3.23 , 0.033	0.808 , 0.002	0.490 , 0.000	0.192 , 0.000
<i>M. victoria</i>					
Fundatrices	1.67-2.20		0.382-0.565	0.207-0.312	0.108-0.169
n = 40	1.96 , 0.018		0.512 , 0.001	0.274 , 0.000	0.140 , 0.000
Apterae	1.76-2.47		0.537-0.688	0.287-0.415	0.158-0.218
n = 32-33	2.08 , 0.031		0.620 , 0.002	0.368 , 0.001	0.187 , 0.000
Alatae	1.67-2.85	2.13-3.52	0.562-0.870	0.333-0.484	0.168-0.260
n = 47-50	2.36 , 0.070	3.01 , 0.106	0.785 , 0.005	0.419 , 0.001	0.218 , 0.000
Oviparae	1.11-1.94		0.307-0.494	0.159-0.307	0.076-0.152
n = 39-40	1.53 , 0.033		0.410 , 0.002	0.241 , 0.001	0.119 , 0.000
Males	0.769-0.889		0.226-0.275	0.091-0.139	0.051-0.064
n = 11	0.808 , 0.001		0.252 , 0.000	0.114 , 0.000	0.058 , 0.000

and tarsi evenly sclerotized. Abdominal tergites I-VII with transverse bands, decreasing in size on anterior segments. Tergite VIII with narrow band which is sometimes incomplete forming a median and two marginal sections. Cauda and anal region darker than unevenly sclerotized subgenital plate.

Membranous wax glands: The most common arrangement seen is two on abdominal segment VI within the sclerotic band and two on segment VII that are not contained completely within the band. Fig. 8 shows the maximum development of these glands in spring alatae.

Table 1. Extended.

V	Antennal Segments		Ultimate Rostral Seg.	Second Hind Tarsus	Antennal Flagellum
	VI base	VI pt			
<i>M. kinseyi</i>					
0.083–0.108 0.092 , 0.000	0.091–0.114 0.101 , 0.000	0.020–0.030 0.026 , 0.000	0.048–0.070 0.057 , 0.000	0.102–0.137 0.118 , 0.000	0.386–0.540 0.440 , 0.002
0.095–0.168 0.136 , 0.000	0.092–0.152 0.127 , 0.000	0.024–0.039 0.032 , 0.000	0.051–0.080 0.069 , 0.000	0.128–0.194 0.168 , 0.000	0.484–0.832 0.706 , 0.005
0.087–0.174 0.127 , 0.000	0.088–0.168 0.122 , 0.000	0.023–0.042 0.031 , 0.000	0.051–0.083 0.066 , 0.000	0.119–0.199 0.159 , 0.000	0.336–0.873 0.638 , 0.007
0.124–0.243 0.192 , 0.001	0.110–0.203 0.158 , 0.000	0.023–0.043 0.032 , 0.000	0.058–0.087 0.071 , 0.000	0.125–0.227 0.187 , 0.000	0.554–0.150 0.925 , 0.111
0.114–0.231 0.178 , 0.001	0.104–0.190 0.149 , 0.000	0.021–0.040 0.031 , 0.000	0.056–0.081 0.067 , 0.000	0.125–0.208 0.172 , 0.000	0.513–1.076 0.834 , 0.011
0.032–0.063 0.050 , 0.000	0.071–0.099 0.082 , 0.000		0.034–0.049 0.044 , 0.000	0.057–0.077 0.067 , 0.000	0.160–0.267 0.214 , 0.000
0.036–0.069 0.050 , 0.000	0.073–0.104 0.086 , 0.000		0.030–0.039 0.033 , 0.000	0.056–0.071 0.064 , 0.000	0.198–0.303 0.241 , 0.001
<i>M. remaudierei</i>					
0.150–0.166 0.157 , 0.000	0.141–0.158 0.146 , 0.000	0.031–0.040 0.36 , 0.000	0.088–0.096 0.091 , 0.000	0.157–0.179 0.168 , 0.000	0.732–0.805 0.757 , 0.001
0.197–0.240 0.218 , 0.000	0.162–0.190 0.174 , 0.000	0.031–0.042 0.037 , 0.000	0.087–0.102 0.093 , 0.000	0.172–0.193 0.183 , 0.000	0.930–1.164 1.098 , 0.004
<i>M. victoria</i>					
0.119–0.192 0.168 , 0.000	0.117–0.190 0.164 , 0.000	0.021–0.029 0.025 , 0.000	0.060–0.078 0.072 , 0.000	0.141–0.219 0.198 , 0.000	0.576–0.857 0.772 , 0.003
0.187–0.231 0.207 , 0.000	0.173–0.207 0.190 , 0.000	0.022–0.034 0.028 , 0.000	0.070–0.083 0.077 , 0.000	0.207–0.247 0.234 , 0.000	0.850–1.079 0.980 , 0.003
0.186–0.276 0.237 , 0.000	0.166–0.242 0.209 , 0.000	0.026–0.041 0.032 , 0.000	0.067–0.085 0.077 , 0.000	0.184–0.266 0.234 , 0.000	0.879–1.247 1.116 , 0.007
0.099–0.183 0.147 , 0.000	0.127–0.205 0.170 , 0.000		0.061–0.079 0.068 , 0.000	0.140–0.199 0.178 , 0.000	0.478–0.830 0.676 , 0.000
0.079–0.093 0.085 , 0.000	0.115–0.135 0.124 , 0.000		0.040–0.047 0.045 , 0.000	0.108–0.127 0.121 , 0.000	0.364–0.402 0.381 , 0.000

Size: Summary of measurements given in Table 1.

Aptera

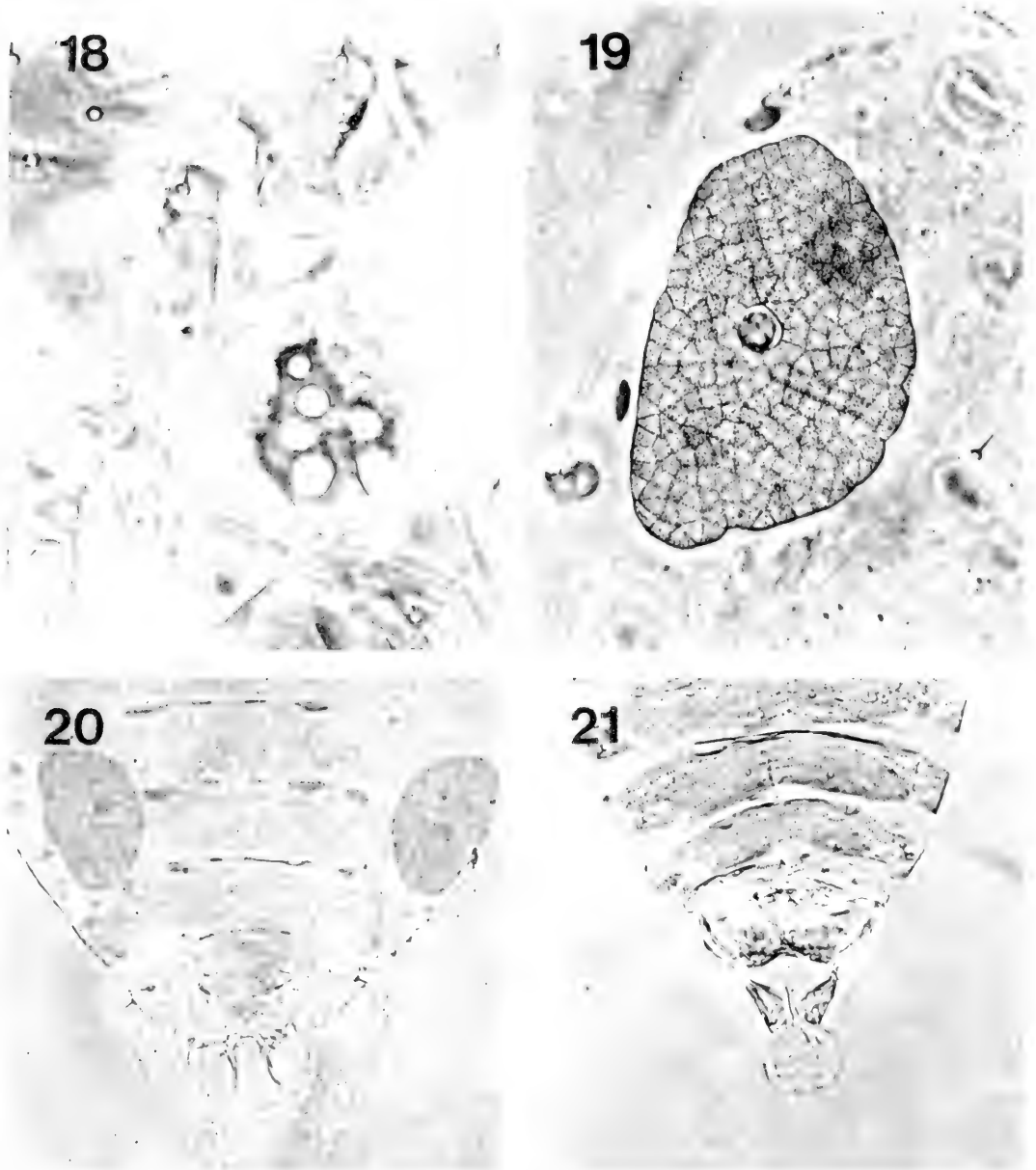
(late season viviparae and sexuparae)

It is not possible to discriminate morphologically between those apterae that pro-

duce viviparous offspring and those producing sexuales. Description and measurements made from specimens collected July through November.

Color in life: Similar to spring apterae.

Morphology: Similar to spring apterae. Eye size is highly variable in this group.



Figs. 18-21. 18, Compound eye of *M. kinseyi* aptera showing reduction in facets common in summer apterae. 19, Magnification of ventral wax gland of *M. kinseyi* ovipara showing combination of mostly triangular and square cells. 20, Genital structure of *M. kinseyi* ovipara. 21, Genital structure of *M. kinseyi* male.

There seems to be a general decrease in number of facets as the season progresses. Not all specimens exhibit this but late summer apterae with only a few facets in addition to the triommatidia are common (Fig.

18). Siphuncular pores generally without a sclerite. Setation: As in spring apterae.

Sclerotization: Pattern of sclerotization similar to the apterae described above, however, there is a gradual reduction in size and

intensity of tanning of sclerites as the summer progresses. Specimens collected during the winter show increased darkness and size of sclerites so this variability may be in part a function of temperature. In the most reduced form the entire body is almost completely pale with only the wax glands visible on the abdomen. Sclerites are first lost on anterior segments then bands on tergites V, VI and VII begin to disintegrate into individual pale sclerites, finally becoming very small and almost invisible.

Wax gland plates: Formula ranging from 2.0.0:2.2.2.2.4.6.4 to 2.0.0:4.4.4.4.4.6.4.

Size: Summary of measurements given in Table 1.

Alata

(late season viviparae and sexuparae)

It is not possible to discriminate morphologically between those alatae that produce viviparous offspring and those that produce sexuales. Descriptions and measurements made from specimens collected July through November.

Color in life: Similar to spring alatae.

Morphology: Similar to spring alatae. There is a gradual decrease in size of alatae throughout the season (Table 1). Siphuncular pores may not have an associated sclerite, sometimes absent. Setation: As in spring alatae.

Sclerotization: This group shows tremendous range of presence and intensity of sclerotization. Specimens developing in July and August range from the sclerotization of spring alatae to a point where virtually none of the sclerotic bands on the abdominal segments are visible and the pterothorax and appendages are pale. Specimens collected in September through February are more likely to show sclerotization intensity of spring generations. This seasonal variation in sclerotization is similar to that seen in apterae.

Wax glands: Wax production areas appear to be associated with sclerites and since the sclerites are greatly reduced or absent the amount of glandular area on the dorsum

appears to be much reduced in some specimens. The paired MWGs on abdominal segments VI and VII are usually not contained within the sclerotized bands.

Size: Summary of measurements given in Table 1.

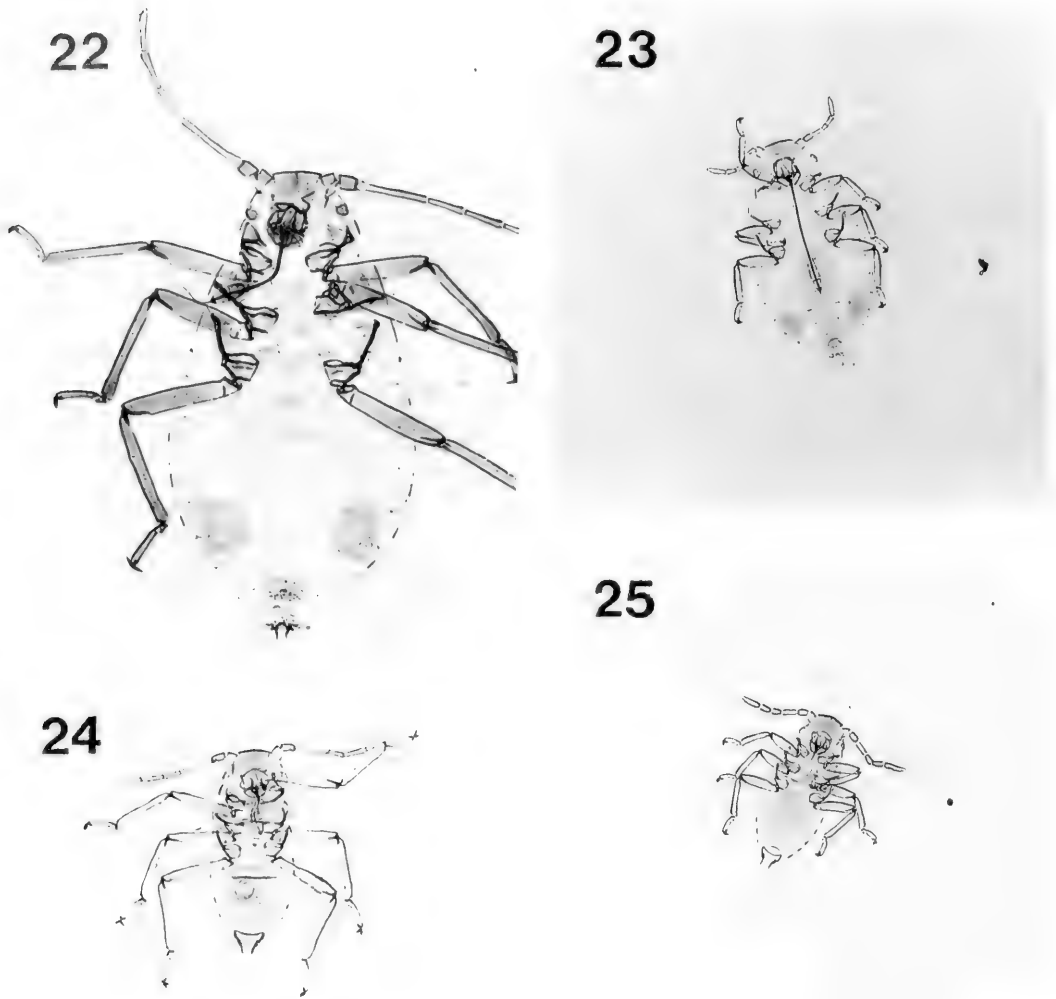
Ovipara

Color in life: Entire body yellow to gold. Not as covered with wax as are other apterous morphs.

Morphology: Apterous. Eyes only triommatidia. Body elongate oval appearing parallel sided from mesothorax to abdominal segment V, dorsum smooth with faint spiculate lines visible on posterior abdominal segments. Head and prothorax fused, appearing as one unit. Rostrum reaching abdominal segment IV, ultimate rostral segment blunt with slightly convex sides. Antennae six-segmented without secondary sensoria, segments I–IV smooth, V and VI with a few spiculate imbrications. Cauda only slightly elevated. Siphuncular pores absent. Hind tibia with (1) 2–8 (11) scent plaques (Fig. 23). A modified genital structure present (Fig. 20) consisting of a base and two posteriorly directed arms. Setation: Much reduced as in apterae. Ultimate rostral segment with 2 sometimes 1 or 0 accessory setae. Subgenital plate with 6–10 setae along posterior margin, 2 near anterior margin.

Sclerotization (Fig. 23): Head with median parallel-sided sclerite extending over vertex and front but not enclosing base of antennae or triommatidia. Median suture visible on front but not vertex. Front with a pair of wax gland plates. Antennae with scape, pedicel, segments V and VI somewhat darker than head, III and IV pale. Legs evenly sclerotized and only slightly darker than antennae. Hind tibiae with 4–13 irregularly shaped scent plaques. No dorsal sclerites visible on thorax or abdomen. Cauda light tan. Subgenital plate at most lightly sclerotized, indicated by setal arrangement.

Wax gland plates: Formula ranging from



Figs. 22–25. 22, Ovipara of *M. victoria*. 23, Ovipara of *M. kinseyi*. 24, Male of *M. victoria*. 25, Male of *M. kinseyi*.

2.2.2:0.2.2.2.2.3.4 to 2.2.2:2.4.4.4.4.6.4 more variable than in fundatrices and apterae. When present on the first abdominal tergite the two glands are in the dorsolateral line, not the marginal as in apterae. Two large, asymmetrical glands on the abdominal venter (Fig. 5) produce elongated, straight wax filaments which protrude from the glands perpendicular to the body. These glands are granular in appearance and have a lattice like substructure creating numerous

triangular and square cells (Fig. 19). There is also a central pore in which (0) 2–4 (5) cells are visible.

Size: Summary of measurements given in Table 1.

Male

Color in life: Entire body blue to blue green.

Morphology: Apterous. Eyes only triommatidia. Small, elongate oval body almost

parallel sided from mesothorax to abdominal segment V. Head and prothorax fused, appearing as one unit. Rostrum reaching mesocoxae, ultimate rostral segment short, blunt with convex sides. Antennae 6 segmented with secondary sensoria on segments IV (1–2), V (1–3) and VI (2–4); segments I–IV (I–III) smooth, (IV) V–VI with some spiculose imbrications. Trochanter-femoral joint fused, indicated only by faint suture. Legs smooth throughout. Thoracic sclerites smooth, abdominal sclerites increasingly spiculose on posterior segments. Cauda not developed but indicated by two setae. Siphuncular pores absent. A genital structure present (Fig. 21). Setation: Very reduced. Ultimate rostral segment without accessory setae.

Sclerotization (Fig. 25): Head sclerotized throughout, thoracic and abdominal segments each with wide transverse band. Scape and pedicel, distal $\frac{1}{2}$ of III, IV, V and VI concolorous with head. Legs evenly dark throughout and only slightly darker than body.

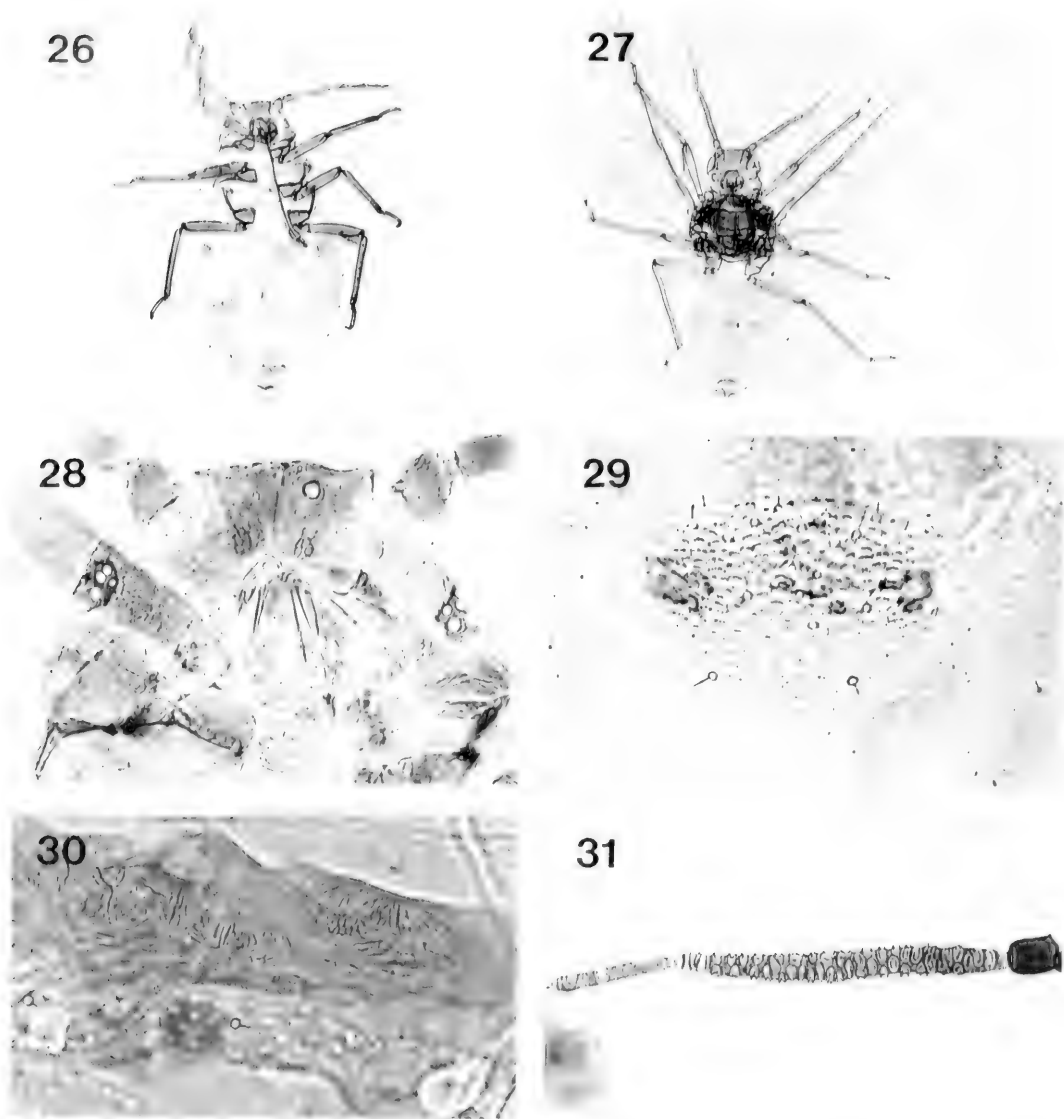
Wax glands: No glandular areas observed.

Size: Summary of measurements given in Table 1.

Types: Holotype, morphotypes and all paratypes collected on *Abies concolor* in California by Marvin Kinsey unless otherwise noted. Holotype: Aptera, top specimen circled on slide #92-63-12 with three other apterae. *Abies concolor*, USFS Nursery, Placerville, Eldorado County, California, 14 June 1992, M. Kinsey, deposited at the Illinois Natural History Survey, Champaign, Illinois. Morphotypes: Fundatrix, Cold Springs, Toulumne County, 18 June 1992, M. Kinsey & D. Voegtlin (top specimen circled on slide #92-55-22 with one aptera); alata, Westpoint, Calaveras County, 24 June 1991 (on slide #92-6-1 with aptera); ovipara and male, USFS Nursery, Placerville, Eldorado County, 7 June 1992 (circled on slide #92-61-40 with one other male and ovipara); all deposited at INHS. Paratypes: Ca-

laveras County: Sonora, 26 June 1991, 10 ap., 20 al.; 3 July 1991, 2 fund. West Point, 24 June 1991, 12 ap., 13 al.; 10 July 1991, 5 ap., 19 al. Eldorado County: Camino, 15 May 1990, 5 ap., 1 al., 13 June 1991, 20 ap., 10 al.; 11 September 1990, 16 ap., 18 al. Morgan, 6 June 1991, 10 fund., 16 ap., 15 al. USFS Nursery, Placerville, 24 August 1989, 22 ap., 22 al., L. Ehler; 30 August 1989, 19 ap., 14 al., L. Ehler; 21 June 1990, 11 ap., 11 al.; 30 July 1990, 12 ap., 12 al.; 28 August 1990, 5 ap., 19 al.; 11 September 1990, 12 ap., 8 al.; 28 August 1991, 6 ap., 18 al.; 2 October 1991, 12 ap., 12 al. Sly Park, 25 June 1991, 16 ap., 16 al.; 10 July 1991, 6 ap., 10 al. 40 km S. E. of Sly Park, Eldorado Nat. For., 7 July 1992, 3 ap., 26 al., 12 ovip., 12 male. Plumas County: Grey Eagle, 7 July 1991, 4 ap., 5 al. Siskiyou County: Mt. Shasta, 20 June 1991, 3 ap., 3 al. Tulare County: Peppermint Camp Ground, nr. Johnsondale, 17 June 1992, 2 fund., 4 ap., 29 al., 3 ovip., 3 male, M. Kinsey & D. Voegtlin. Sequoia Kings Canyon N. P., 27 July 1992, 11 ap., 14 al. Toulumne County: Yosemite Institute, 18 June 1992, 7 al., M. Kinsey & D. Voegtlin. Cold Springs, 18 June 1992, 2 fund., 22 ap., 21 al., 5 ovip., 1 male, M. Kinsey & D. Voegtlin. Hardin Flat, 18 June 1992, 2 fund., 5 ap., 16 al., 2 ovip., 4 male, M. Kinsey & D. Voegtlin. Strawberry, 19 June 1992, 2 fund., M. Kinsey & D. Voegtlin. Paratypes will be deposited at the following museums: United States National Museum, Beltsville; The Natural History Museum, London; Museum National D'Histoire Naturelle, Paris; Canadian National Museum, Ottawa, all remaining slides are on deposit at INHS.

Discrimination: The biology of this species separates it from all other *Mindarus* species. Fundatrices and apterae can easily be separated from *M. abietinus* by the WGP's (see discussion of *M. abietinus* above). Many alatae have more than one sensoria on antennal segment IV, a condition uncommon in *M. abietinus* but common in *M. obliquus*. The tremendous variabilities in size and



Figs. 26–31. 26, Holotype of *M. remaudierei*. 27, Morphotype of *M. remaudierei*. 28, Head of *M. remaudierei* aptera showing few eye facets in addition to the triommattidion. 29, Subgenital plate of *M. remaudierei* aptera showing paired setae on anterior margin and cluster of setae at midplate. 30, Dorsal abdominal sclerite of *M. remaudierei* aptera showing paired setae on anterior margin and cluster of setae at midplate. 31, Antennal segments III and IV of *M. remaudierei* alata showing large number of secondary sensoria on III.

pigmentation of the alatae make it virtually impossible to separate this morph from *M. abietinus* or *M. obliquus*.

Etymology: This species is named after Marvin Kinsey whose careful observations

and field work detailed much of the biology of this species (Ehler and Kinsey in press) and who collected and reared the majority of specimens on which this description is based.

Mindarus remaudierei, n. sp.

Aptera

Color in life: Not seen alive.

Morphology: Body oval, increasing in width to abdominal segment IV then rounding to caudal region. Eyes only a few facets in addition to the triommatidia (Fig. 28). Head, scape and pedicel smooth, spiculose imbrications gradually increasing from antennal segments III–VI. Two of the four apterae seen with one secondary sensoria on antennal segment III but they have no other indications of alatoidity such as small wing buds and large compound eyes. Rostrum reaching abdominal segment II, ultimate rostral segment with gradually tapering slightly convex sides and rounded tip. Head and prothorax fused, smooth as is the remainder of the dorsum. Legs smooth to second tarsi which have spiculose imbrications. Subgenital plate spiculose. Cauda slightly elevated. Siphuncular pore rimmed. Setation: Very sparse and short <0.015 mm. Ultimate rostral segment with 2 accessory setae; cauda with 2 setae; subgenital plate with 20–23 setae arranged with 2 on the anterior half, from 2–6 in the central area and 14–17 along the posterior edge.

Sclerotization (Fig. 26): Head with front and much of vertex sclerotized, enclosing antennal sockets but not eyes. Irregular pale sclerotic band extending across prothorax and abdominal segment VIII. Remainder of dorsum clear. Antennae slightly darker than head with only basal $\frac{1}{3}$ – $\frac{1}{2}$ of segment III lighter. Legs medium brown, darker than antennae with base of femora and trochanters paler. Cauda and subanal plate only slightly darkened. Subgenital plate with irregular dark areas.

Wax gland plates: Formula ranging from 4.0.0:5.6.6.6.6.6.4 to 4.0.1:6.6.6.6.6.6.4 (Fig. 7E). Without a distinct sclerotized ring around each plate. The four on the prothorax are on the submedian and marginal lines. Three of the four specimens have an additional WGP on the vertex.

Size: Summary of measurements given in Table 1.

Alata

Color in life: Not seen in life.

Morphology: Head smooth with area on vertex posterior to eyes with longitudinal ridges. Antennal scape, pedicel and III smooth, IV–VI imbricated, most imbrications on segments IV and V without spicules, those on VI spiculose. Antennal segment III with 45 to 54, and segment IV with 1–5 secondary sensoria (Fig. 31). Pterothorax rugose. Anterior surface of femora and second tarsi with spiculose imbrications, remainder of legs smooth. Non-sclerotized regions of the abdomen smooth. Sclerotic bands on abdominal segments with limited sculpturing, much less than seen in other *Mindarus* spp. (Fig. 30). Siphuncular pore usually surrounded with a small, pale sclerotized area. Cauda subtriangular with rugose knob at tip, wider than long. Subgenital plate spiculose. Setation: Sparse and short <0.015 mm. Tibial setae < $\frac{1}{2}$ diameter of tibiae. Ultimate rostral segment with 2 accessory setae. Cauda with 2 setae. Subgenital plate with 15–21 setae, 2–4 on anterior half, 0–3 near the middle and 11–15 scattered along the posterior edge.

Sclerotization (Fig. 27): Head, scape, pedicel and antennal segment III light amber, IV–VI evenly colored and paler. Pterothorax darker than head. Legs evenly colored, concolorous with head. Bands on abdominal tergites pale, not extending across segment and not visible on some specimens. Cauda and anal plate concolorous with head. Subgenital plate with irregular dark areas usually confined to posterior half.

Membranous wax glands: When sclerotic bands are visible on the abdomen the paired submedian line of MWGs is embedded in the posterior edge of these sclerites on abdominal segments I–VI.

Size: Summary of measurements given in Table 1.

Types: Holotype: Apteran, right hand specimen indicated on slide with one other apteran and one nymph (Fig. 26). Taken on *Abies religiosa*, Selva Obscura, 2870 m, Puebla, Mexico, 5 June 1983, A. L. Munoz, collection #265. Morphotype: Alata, same data as holotype (Fig. 27). Paratypes: 14 alatae and 3 apterae on 12 slides all with same data as holotype. Holotype, morphotype, and paratypes (nine alatae and one apteran) deposited in the collection of the Museum National D'Histoire Naturelle, Paris. Four paratypes (two alatae and two apterae) deposited in the collection of the Illinois Natural History Survey, one paratype (alata) sent to each of the following: United States National Museum, Beltsville, the Canadian National Collection, Ottawa and the Natural History Museum, London.

Discrimination: The apterae can be distinguished from all other *Mindarus* species by the WGP formula on the thorax. The number of secondary sensoria on antennal segment III, 45–54, in the alatae is greater than known for any other *Mindarus* species.

Etymology: This species is named after Dr. George Remaudière in recognition of his dedication to the study of aphids and his contributions to our knowledge of this most interesting group. He has been of considerable assistance in this study as well as many others.

Mindarus victoria Essig

Prior to this paper, this species has not been reported since Essig's original description of specimens from Vancouver Island, British Columbia, on *Abies grandis* (Essig 1939). Collections from the Sierra Nevada, Mt. Shasta in northern California and Idaho on *Abies concolor* all contained specimens of *M. victoria*. This is a considerable range extension, however, its use of *Abies concolor* is not surprising given that *A. concolor* and *A. grandis* are considered to be closely related and hybridize easily.

The description given by Essig is accurate

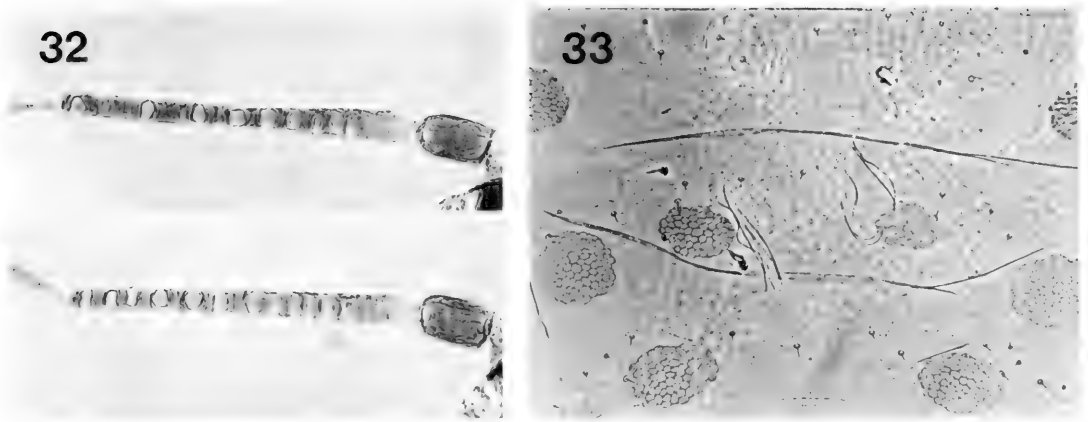
so no new description will be given here but a summary of measurements made during this study is included in Table 1. Essig used the count of secondary sensoria to separate *M. victoria* from other species. This character is unreliable in that it overlaps *M. kinseyi* and *M. obliquus*. *Mindarus victoria* can be separated from other North American *Mindarus* by the following combination of characters. In alatae, the second hind tarsal segment >0.22 mm, sclerotic bands on abdomen very pale not enclosing membranous wax glands and the secondary sensoria on antennal segment III often not parallel sided, rather appearing as irregular polygons especially on the distal half of the segment (Fig. 32). In apterae the dorsum is free of sclerotization, length of second hind tarsal segment >0.20 mm and wax gland plates are large and lack a distinct outer sclerotized ring (Fig. 33), WGP formula is 2.0.0:4.4.4.4.4.6(5).4 (Fig. 7F). The oviparae are much larger than seen in any other species (compare Figs. 22 and 23) and mounted specimens have been seen with as many as five eggs.

Mindarus obliquus (Cholodkovsky)

I have examined only a limited number of specimens labeled as *M. obliquus*. The few apterae seen have a WGP formula similar to *M. kinseyi* so they are easily separated from *M. abietinus*. The alatae are small and often have more than one secondary sensoria on antennal segment IV. In these characters it overlaps with *M. kinseyi*, however, its host specificity (Carter and Eastop 1973) and differences in chromosomes (Robinson and Chen 1969) make it clear that it is distinct from the species feeding on *Abies* spp. At present there is no morphological basis for distinguishing between apterae or alatae of *M. obliquus* and *M. kinseyi*.

DISCUSSION

Heie (1967) noted that the Asian species *M. japonicus* Takahashi overlaps in counts



Figs. 32, 33. 32, Antennal segment III from two alatae of *M. victoria* showing distinct polygonal shape of sensoria, especially on distal half of segment. 33, Abdomen of aptera of *M. victoria* showing wax gland plates without a distinct outer sclerotized ring.

of secondary sensoria with *M. abietinus* and suggested that they are only isolated geographical populations of the same species. I think there is little to be gained from this concept. Detailed studies such as that carried out by Ehler and Kinsey (in press) and additional morphological examination will undoubtedly reveal distinct biological and morphological differences between populations of *Mindarus* which are great enough to warrant specific standing. Additional work on the *Mindarus* spp. in North America needs to be done and is in progress. This study has focused primarily on western North America but I have collected and examined material from the eastern half of the country and the Rocky Mountain region. Much of this material shows distinctive wax gland patterns which need to be verified with collections over several years from a variety of elevations and locations.

Unfortunately the prospects for accurate identification of trap collected alate *Mindarus* are not good. Limits of variation will have to be developed from material which can be associated with identifiable apterae. Eventually it may be possible to develop discriminant functions for alatae. Unfortunately the abbreviated life cycle of most

of the species makes gathering this material a long term project.

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THE NEW WORLD GENUS *CHROMOLEPIDA* COLE
(DIPTERA: THEREVIDAE: THEREVINAE)

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Abstract.—Species of the genus *Chromolepida* Cole are confined to western North American and northern South America. The species are revised, a phylogeny is hypothesized, and a key to the species is provided. Two species from México, *Chromolepida clavitibia* Webb and Irwin and *C. nigra* Webb and Irwin, are described as new to science.

Key Words: Diptera, stiletto flies, Therevidae, *Chromolepida*, New World revision, phylogeny, species keys, descriptions, distributions

This paper is the fifth of a series (Webb and Irwin 1988, Webb and Irwin 1991a, b, c) revising the species of the genera treated in the monograph of the Nearctic genera of Therevidae. A key to the species of *Chromolepida* Cole is provided along with species descriptions and distributions.

The morphological terminology used for the male terminalia was originally defined and described by Lyneborg (1968) and subsequently modified by Lyneborg (1972, 1976, 1978) and Irwin (1977a, b). The female terminalia terminology was defined and described by Irwin (1976). Other morphological features are described with terminology set out in the "Manual of Nearctic Diptera" (McAlpine 1981). The range for each setal count is followed by the mode. Setal counts were taken from the left side of the specimen and from the entire posterior margin of the scutellum.

Each specimen was assigned a unique THEREVIDAE/M. E. IRWIN/SPECIMEN number. This number is used to associate the ecological and label data with a given specimen, and when referred to herein, is printed in italics. The data are intended to be incorporated into an auto-

mated data management system originally designed by Rauch (1970).

To conserve space and include as much information as possible about each specimen, a format adopted from Irwin (1983) is used in the "Specimens Examined" section of each species. Many of the terms used there were defined by Stuckenberg and Irwin (1973). In the presentation of repetitive locality data, a semicolon terminates one series of specimens and signals the beginning of the next, thus, data not repeated in a series are the same as those of preceding series.

PHYLOGENETIC RELATIONSHIPS

The genus *Chromolepida* belongs to the *Cyclotelus* group of therevids, along with *Cyclotelus* Walker, *Ozodiceromya* Bigot, and an undescribed genus from Chile. This group is characterized by rather bulbous gonocoxites. The black, glossy calli on the face ventral to the antennal bases and the appressed, iridescent, silver green scales on the thorax and abdomen separate *Chromolepida* as a monophyletic genus within this group.

The cladogram (Fig. 1) represents the relationship we hypothesize for the five spe-

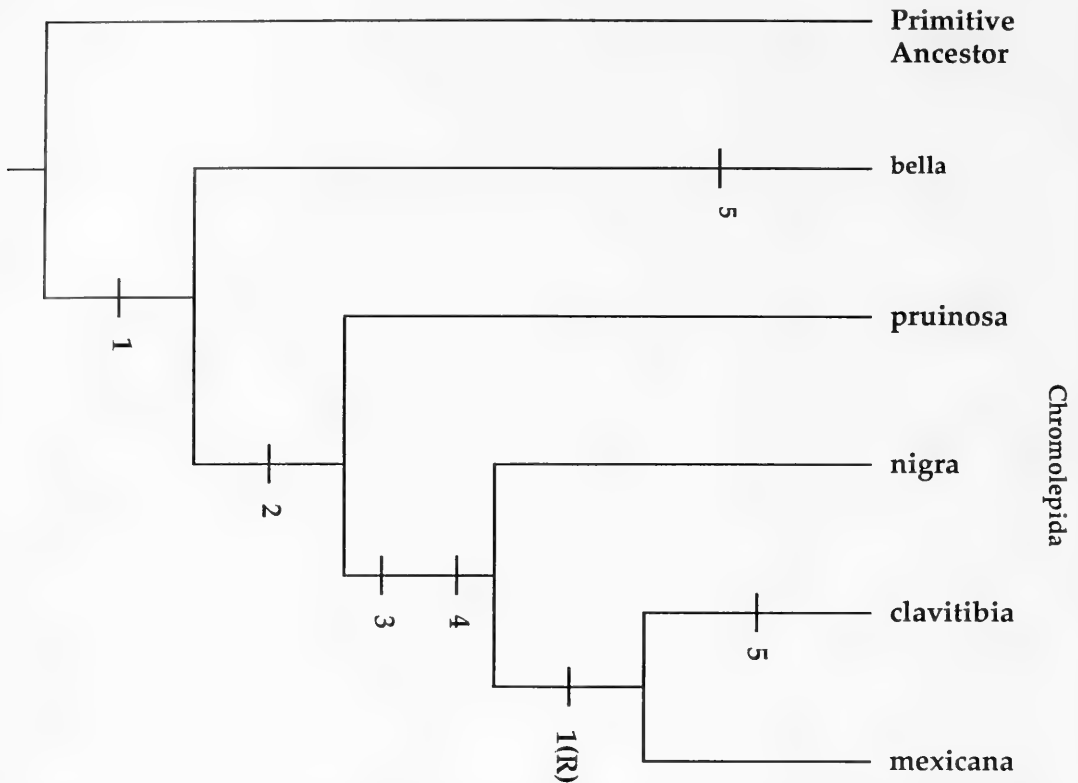


Fig. 1. Cladogram showing the hypothesized phylogeny of the species of *Chromolepida*. Numbers on the branches refer to apomorphic alternatives of characteristics listed in Table 1. (R) indicates a reversal in a character state.

cies of *Chromolepida* based on characteristics given in Table 1. Although no hypothesized generic-level phylogeny has been attempted for the Therevidae, our work to date strongly suggests that the *Cyclotelus* group is more derived than members of the genus *Phycus* (*Phycus* group) and the genus *Dialineura* (*Thereva* group). The determination of the plesiomorphic condition, then, was based on an examination of the characteristics found in New World species of *Dialineura* and *Phycus*.

In these genera, the plesiomorphic condition for Characters 1, 4, and 5 was found in all species. Character 2. The plesiomorphic state of a narrow, simple gonostylus was found in most species. Only in the one species of *Dialineura* was a lateral projection found. Character 3. The anterior

margin of the male dorsal apodeme of the aedeagus generally has a single transverse attachment to the anterior margin of the hypoproct. Only in *Phycus frontalis* is the dorsal apodeme bifurcate, forming a double attachment to the hypoproct.

The character matrix is given in Table 2. A heuristic search of this matrix using PAUP (Version 3.1.1, Swofford 1993) resulted in a single tree of seven steps (consistency index = 0.714, retention index = 0.750). This cladogram was rooted from a hypothetical ancestor possessing the primitive state of all characteristics.

Chromolepida bella formed a clade possessing a simple gonostylus (Fig. 4) without a lateral projection, although it does possess the most specialized and distinctive distiphallus which is more elongate and re-

Table 1. Character states for *Chromolepida*.

Plesiomorphic	Apomorphic
1. Female frontal setae present	Female frontal setae absent
2. Male gonostylus simple	Male gonostylus with lateral projection
3. Male dorsal apodeme truncate or slightly emarginate anteriorly	Male dorsal apodeme deeply emarginate anteriorly
4. Male ventral apodeme truncate or slightly emarginate anteriorly	Male ventral apodeme pointed, extended anteriorly
5. Endophallus simple	Endophallus recurved

curved than all other species of *Chromolepida*. This species currently ranges from California to southern Washington, east to Idaho, northern Utah, and Nevada.

Chromolepida pruinosa formed a southern, neotropical clade separated from *C. bella* by the possession of a lateral projection on the male gonostylus and from *C. nigra*, *C. clavitibia*, and *C. mexicana* in retaining the more primitive characteristics of the male dorsal and ventral apodemes of the aedeagus. It currently ranges from Guyana to Colombia, north to Nicaragua.

Chromolepida nigra, *C. clavitibia*, and *C. mexicana* form a clade defined by the male dorsal apodeme of the aedeagus being deeply emarginate anteriorly and the anterior apodeme of the aedeagus being pointed and extended anteriorly. These species are centered in Mexico and the southwestern United States with *C. nigra* found in southern Mexico, but not sympatric with *C. pruinosa*. *Chromolepida clavitibia* and *C. mexicana* form the final clade based on the presence of frontal setae in the females of both species. *Chromolepida clavitibia* apparently

separated from *C. mexicana* and is currently restricted to the southern tip of Baja California de Sur, with *C. mexicana* ranging from northern Mexico to southern California, Arizona, New Mexico, western Texas, and southern Colorado, but not sympatric with *C. bella*.

Chromolepida may be separated from other Nearctic therevids by using the keys to the genera of Nearctic Therevidae in Irwin and Lyneborg (1981a, b). No key to the genera of Neotropical Therevidae is available at this time; however, all species of *Chromolepida* have a pair of shiny, black, raised calli on the upper face below the antennal bases, which is unique to species of this genus.

Chromolepida Cole

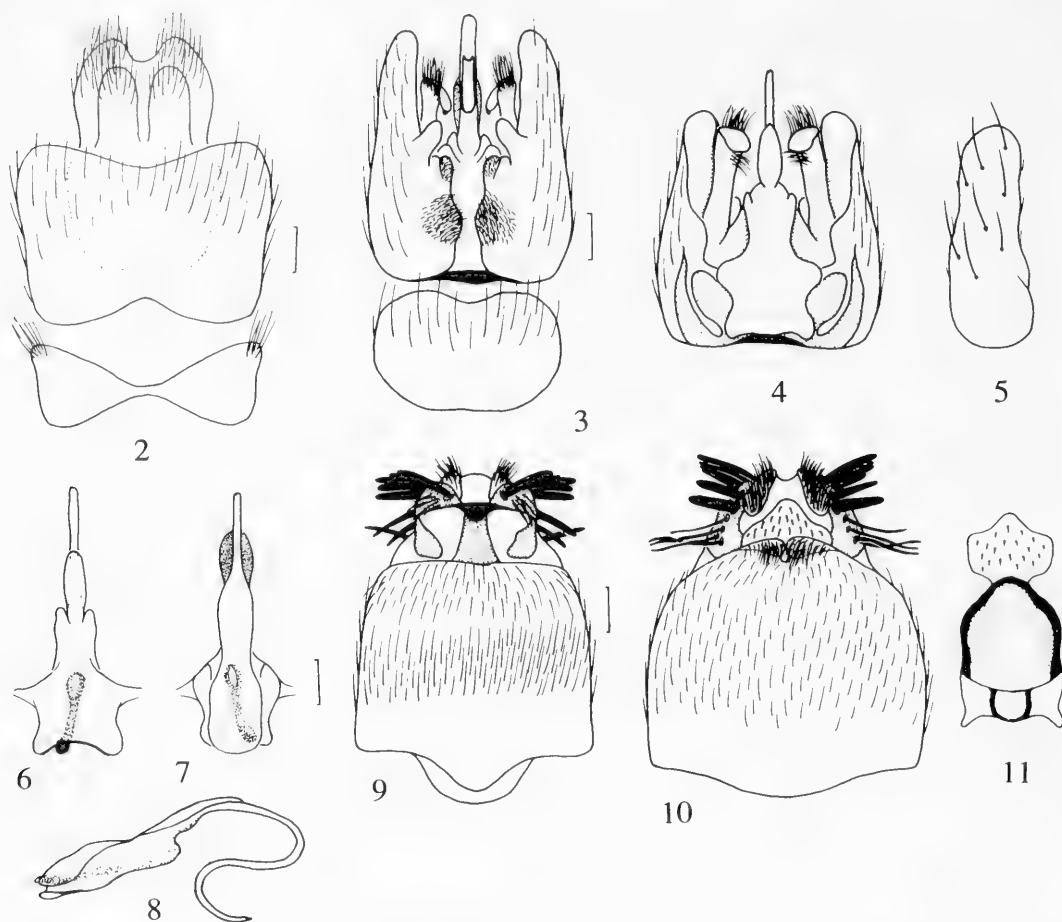
Chromolepida Cole (1923: 23). Type species: *Psilocephala pruinosa* Coquillett (1904: 91) by original designation.

Derivation of name.—*chroma* (Greek) = color; *lepido* (Greek) = scale.

Diagnosis.—*Chromolepida* is a member of the *Cyclotelus* group of therevid genera. Beyond *Chromolepida*, this group includes *Cyclotelus* Walker, *Ozodiceromya* Bigot, and an undescribed genus from Chile. Species in this group of genera can be characterized by the following: middle coxae without setae on posterior surface; male gonocoxites often strongly fused ventrally, forming a rather compact capsule; dorsal apodeme of male aedeagus weakly to strongly joined to internal dorsal portion of gonocoxite (= par-

Table 2. Character matrix for *Chromolepida*.

Taxa	Character matrix				
	1	2	3	4	5
<i>Chromolepida bella</i>	2	1	1	1	2
<i>Chromolepida clavitibia</i>	1	2	2	2	2
<i>Chromolepida mexicana</i>	1	2	2	2	1
<i>Chromolepida nigra</i>	2	2	2	2	1
<i>Chromolepida pruinosa</i>	2	2	1	1	1



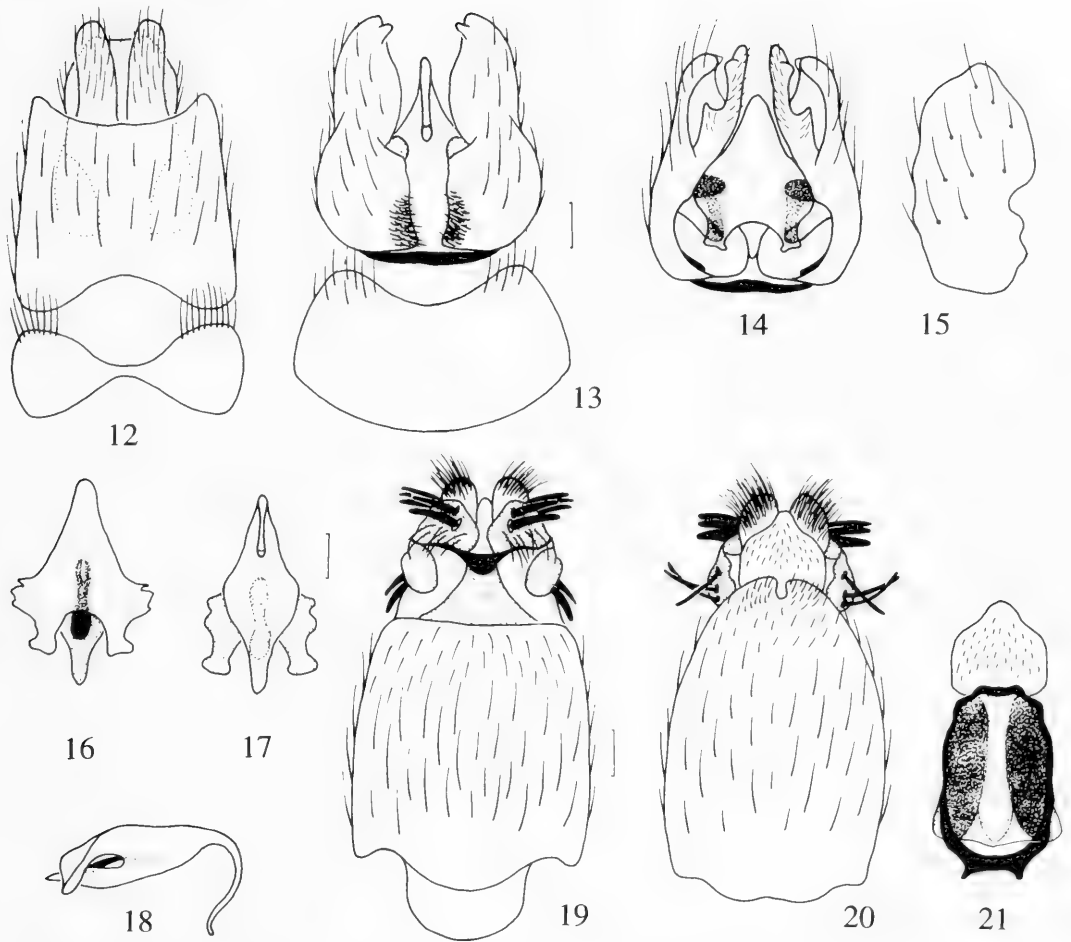
Figs. 2-11. *Chromolepida bella* (9177, 9179) 2. Male tergite 8, epandrium, cercus, and hypoproct, dorsal view. 3. Male sternite 8, gonocoxites and gonostylus, ventral view. 4. Male gonocoxites and gonostylus, dorsal view. 5. Male gonocoxite, lateral view. 6. Male aedeagus, dorsal view. 7. Male aedeagus, ventral view. 8. Male aedeagus, lateral view. 9. Female terminalia, dorsal view. 10. Female terminalia, ventral view. 11. Female furca, dorsal view. Scale = 0.1 mm, unless otherwise indicated.

amer process); male hypandrium small or absent; male gonocoxites usually strongly fused with lateral margins of epandrium; posterior parameral processes composed of pair of nonarticulated projections; and male distiphallus of aedeagus often curved, extending posteroventrally beyond gonocoxites. *Chromolepida* is separated from the other genera of the *Cyclotelus* group in having a pair of shiny, black, raised calli on the face just below the antennal bases, and the thorax and abdomen clothed with ap-

pressed iridescent silver green scales in addition to normal setae.

Small to medium-sized flies.

Description of male and female.—*Head*: Eyes of male holoptic, ommatidia on ventral third smaller; eyes of female dichoptic, all ommatidia of similar size; antenna (Fig. 42), length 0.9–1.7 times head length; scape cylindrical; pedicel cylindrical to ovate; flagellum awl-shaped, tapered apically; style subapical, two-segmented, including minute apical spine; frons in female (Fig. 52)

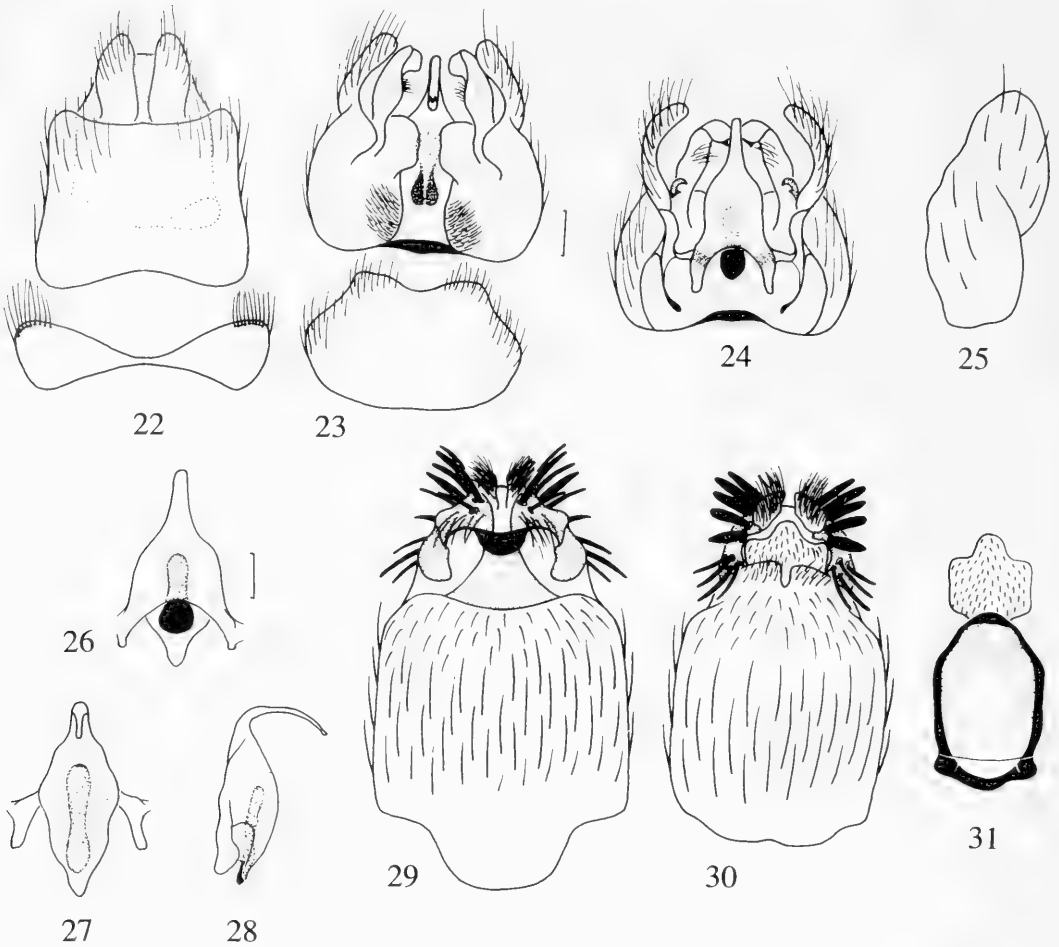


Figs. 12–21. *Chromolepida clavitibia* (8812, 8805) 12. Male tergite 8, epandrium, cercus, and hypoproct, dorsal view. 13. Male sternite 8, gonocoxites and gonostylus, ventral view. 14. Male gonocoxites and gonostylus, dorsal view. 15. Male gonocoxite, lateral view. 16. Male aedeagus, dorsal view. 17. Male aedeagus, ventral view. 18. Male aedeagus, lateral view. 19. Female terminalia, dorsal view. 20. Female terminalia, ventral view. 21. Female furca, dorsal view. Scale = 0.1 mm, unless otherwise indicated.

broad, lateral margins convergent dorsally; frontal calli glossy, with distinct area of black pile dorsolateral to antennal bases; parafacial broad with enlarged, glossy parafacial calli; maxillary palpus one-segmented (Fig. 43), cylindrical to slightly clavate, rounded apically. Setae of two types (filiform, and appressed, iridescent, silver green scale-like), scattered filiform on female frons; short, filiform on antenna, abundant, filiform on maxillary palpus, absent on eyes, parafacial, clypeus and generally on male frons. Genal

setae white, filiform and silver green scale-like, ventral projection of gena with concentration of short, black, filiform setae. Macrosetae thick, filiform, moderately long, scattered on apex of scape.

Thorax: Macrosetae: np 3–4, sa 1, pa 1, dc 0, sc 4. Postpronotal lobe concolorous with thorax. Vittae indistinct. Setae of 2 types: filiform, on prosternum, mesonotum, propleuron, anepisternum, and dorsal third of katepisternum, and appressed, iridescent, silver-green scale-like on mesonotum, pro-

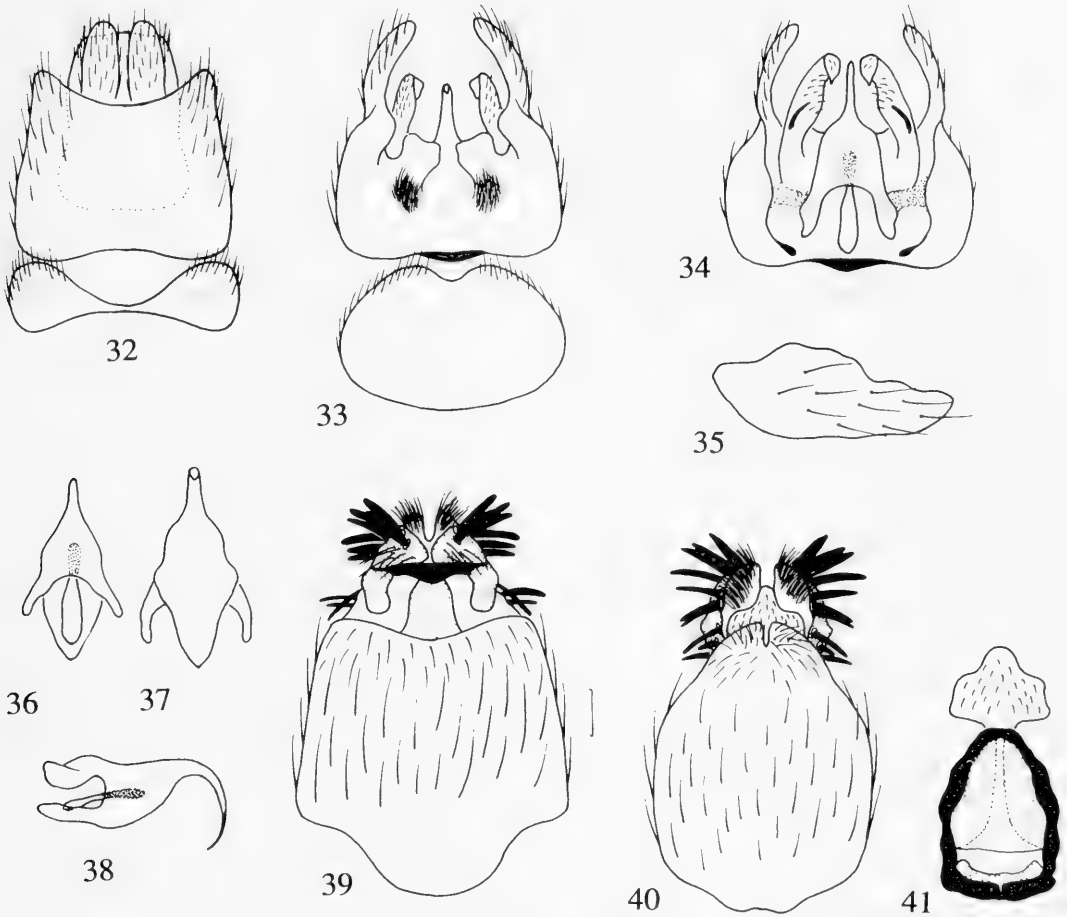


Figs. 22-31. *Chromolepida mexicana* (8814, 9025) 22. Male tergite 8, epandrium, cercus, and hypoproct, dorsal view. 23. Male sternite 8, gonocoxites and gonostylus, ventral view. 24. Male gonocoxites and gonostylus, dorsal view. 24. Male gonocoxite, lateral view. 26. Male aedeagus, dorsal view. 27. Male aedeagus, ventral view. 28. Male aedeagus, lateral view. 29. Female terminalia, dorsal view. 30. Female terminalia, ventral view. 31. Female furca, dorsal view. Scale = 0.1 mm, unless otherwise indicated.

pleuron, anepisternum and dorsal third of katepisternum, absent on remaining pleural sclerites. Wing (Fig. 44) hyaline to opaque, often patterned; veins generally pale brown; pterostigma indistinct to brown; setulae absent; length of R_4 0.8-1.3 times R_5 ; length of cell r_4 1.7-4.0 times width; veins M_1 , M_2 , and M_3 originate separately from apical margin of discal cell; cell m_3 open; discal cell acute basally; cell cup closed with short petiole; m-cu/r-m subequal. Legs. Coxae moderately long. Setae of two types: fili-

form, and appressed, iridescent, silver-green scale-like, on anterior half of fore and middle coxae and over entire hind coxa, over entire femora, filiform on tibiae. Macrosetae dark brown, apical, 2 on fore and middle coxae, 3 on hind coxa.

Abdomen: Rather narrow, gradually tapering from base to apex, male dorsum flattened, female dorsum convex. Setae filiform, appressed, iridescent, silver green scale-like or lanceolate. Male terminalia (Figs. 2-8, 12-18, 22-28, 32-38, 42-51).



Figs. 32–41. *Chromolepida nigra* (8815, 9239) 32. Male tergite 8, epandrium, cercus, and hypoproct, dorsal view. 33. Male sternite 8, gonocoxites and gonostylus, ventral view. 34. Male gonocoxites and gonostylus, dorsal view. 35. Male gonocoxite, lateral view. 36. Male aedeagus, dorsal view. 37. Male aedeagus, ventral view. 38. Male aedeagus, lateral view. 39. Female terminalia, dorsal view. 40. Female terminalia, ventral view. 41. Female furca, dorsal view. Scale = 0.1 mm, unless otherwise indicated.

Tergite 8 large, about as wide as epandrium, posterior deeply emarginate. Sternite 8 somewhat reduced, posterior emarginate. Epandrium about two-thirds as long medially as wide, posterolateral corners rounded; cercus free, well sclerotized, ending before or slightly beyond hypoproct; hypoproct attached to membranous subepandrial plate, which extends anteriorly and attaches to anterior margin of aedeagal dorsal apodeme. Hypandrium greatly reduced, narrow. Gonocoxite bulbous, sides broad in lateral view; in ventral view, gonocoxite with medial

patch of short setae. Parameral apodeme reduced. Gonostylus elongate, with or without lateral projection. Aedeagus attached to parameres and gonocoxites; a long, weak, membranous bridge stretching from distal corners of dorsal apodeme to midsection of paramere and a stronger attachment between ventral lobes of gonocoxites and ventral surface of aedeagus; distiphallus sclerotized, variable; ventral apodeme extends parallel to dorsal apodeme, anterior margin variable; ejaculatory apodeme about as long as ventral apodeme, slender. Female ter-

minalia (Figs. 9–11, 19–21, 29–31, 39–41, 53–55). Tergite 8 subrectangular, longer than wide, with broadly concave posterior margin; setae black, elongate, scattered. Tergite 9+10 fused, with strong acanthophorites. Cercus triangular, membranous, with numerous, fine, short setae projecting posteriorly. Sternite 8 large, longer than wide; posterior emarginate; setae black, elongate, scattered. Sternite 9 greatly modified, invaginated above sternite 8 to form internal sclerotized furca which is closed anteriorly; ventral surface of furca covered with lightly sclerotized membrane. Sternite 10 membranous, subtriangular with short, thick setae.

Immature stages.—Unknown.

Biology.—Adults of *Chromolepida* have been collected from flowers of a variety of plants, a reseeded range, a fen area, oak-chapparral habitats, and coastal dunes.

Distribution (Figs. 56–58).—*Chromolepida* has been collected from South America (Guyana, Venezuela, Colombia) and in North America from Costa Rica to the state of Washington and eastward to Utah, Colorado and western Texas.

KEY TO SPECIES OF *CHROMOLEPIDA*

- 1. Halter dark brown 2
- Halter yellow 4
- 2. Femora dark reddish brown to black 3
- Femora dark yellow ... *mexicana* Cole (females)
- 3. Fore tibia distinctly clavate
... *clavitibia* Webb and Irwin, n. sp. (males and females)
- Fore tibia cylindrical
... *nigra* Webb and Irwin, n. sp. (females)
- 4. Wing membrane without apical band; male distiphallus elongate, distinctly recurved (Fig. 8); male gonostylus lacking lateral projection (Fig. 4); male frontal setae absent
... *bella* Cole (males and females)
- Wing membrane (Fig. 44) with smoky brown

- to black apical band; male distiphallus short to moderately long, if recurved, only slightly (Figs. 18, 28, 38, 51); male gonostylus with lateral projection (Figs. 14, 24, 34, 47); frontal setae black 5
- 5. Costal and subcostal cells of wing dark yellow; male distiphallus short, sinuate (Fig. 51) ...
... *pruinosa* (Coquillett) (males and females)
- Costal and subcostal cells of wing hyaline; distiphallus elongate, bent at right angle to plane of aedeagus (Figs. 28, 38) 6
- 6. Gonocoxite in lateral view (Fig. 25) with distal half broad; length of fore femur to length of scape 2.4 ± 0.2 ; length of fore tibia to length of scape 2.5 ± 0.2 ; length of hind femur to length of scape 3.5 ± 0.4
... *mexicana* Cole (males)
- Gonocoxite in lateral view (Fig. 35) with distal half reduced, tapered apically; length of fore femur to length of scape 1.7 ± 0.2 ; length of fore tibia to length of scape 1.8 ± 0.2 ; length of hind femur to length of scape 2.4 ± 0.3 ...
... *nigra* Webb and Irwin, n. sp. (males)

Chromolepida bella Cole

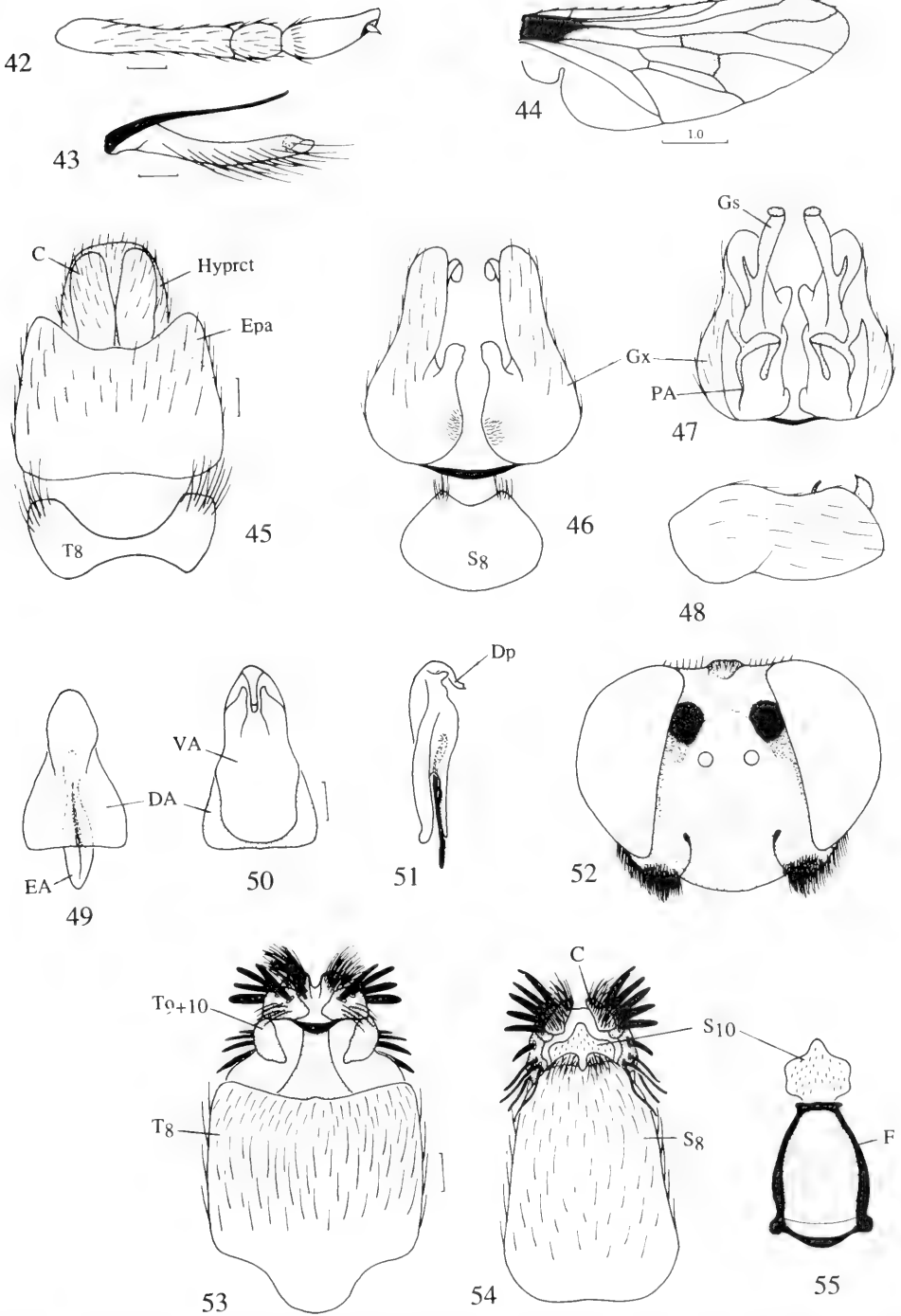
Chromolepida bella Cole (1923: 24); Cole (1965: 350); Irwin and Lyneborg (1981a: 260).

Derivation of name.—*bellus* (Latin) = beautiful.

Diagnosis.—Females of *Chromolepida bella*, like *C. nigra* and *C. pruinosa*, lack frontal setae. The species is separated from *C. nigra* in having the wing membrane pale yellow, concolorous; the anterior margin of the dorsal apodeme of the male aedeagus truncate; and the females have yellow halteres and femora. *Chromolepida bella*, unlike *C. pruinosa*, has pale yellow, concolorous wing membranes; the male gonostylus lacks a lateral projection; and the male distiphallus is elongate and sinuate.

Redescription of holotype male (9177).—Body length 4.0 mm.

Figs. 42–55. *Chromolepida pruinosa* (9218, 8316) 42. Male antenna, lateral view. 43. Male maxillary palpus, lateral view. 44. Male wing, dorsal view. 45. Male tergite 8, epandrium, cercus, and hypoproct, dorsal view. 46. Male sternite 8, gonocoxites and gonostylus, ventral view. 47. Male gonocoxites and gonostylus, dorsal view (aedeagal complex removed). 48. Male gonocoxite, lateral view. 49. Male aedeagus, dorsal view. 50. Male



aedeagus, ventral view. 51. Male aedeagus, lateral view. 52. Female head, frontal view. 53. Female terminalia, dorsal view. 54. Female terminalia, ventral view. 55. Female furca, dorsal view. Abbreviations: Cercus (C); Distiphallus (Dp); Dorsal apodeme (DA); Ejaculatory apodeme (EA); Epandrium (Epa); Furca (F); Gonocoxite (Gx); Gonostylus (Gs); Hypoproct (Hyprct); Parameral apodeme (PA); Sternite 8 (S_8); Sternite 10 (S_{10}); Tergite 8 (T_8); Tergite 9+10 (T_{9+10}); Ventral apodeme (VA). Scale = 0.1 mm, unless otherwise indicated.

Head: Length 0.8 mm. Ocellar tubercle dark reddish brown, silver pruinose; setae dark reddish brown. Eyes dull reddish brown; medial margin rounded. Frons dark reddish brown, glossy, with lateral silver pile and black dorsal pile, dorsal pile becoming silver dorsally. Antenna dark reddish brown, pruinose; setae dark reddish brown; macrosetae dark brown; length of antenna 1.4 times head length; length of scape 0.75 mm, 9.3 times width, 4.4 times length of pedicel; length of pedicel 0.11 mm, 1.1 times width; length of flagellum 0.34 mm, 3.4 times width, 0.4 times length of scape; length of basal stylomere 0.05 mm. Parafacial dark reddish brown, glossy with silver pile along lateral margins. Maxillary palpus pale brown; length 0.28 mm, 2.8 times width; setae pale yellow.

Thorax: Macrosetae: np 3. Dark reddish brown, pruinose. Postpronotal setae white, filiform and scale-like. Prosternal setae white. Pleura dark reddish brown, pruinose, anepisternum and ventral half of katepisternum glossy; setae white, filiform, scattered on propleuron and dorsal half of katepisternum, pale yellow, filiform, over entire anepisternum, scale-like over propleuron, anepisternum, and dorsal half of katepisternum. Scutellum dark reddish brown; setae white, filiform, and scale-like. Laterotergite dark reddish brown, pruinose; setae dark white to pale yellow, filiform. Wing. Length 3.2 mm, 2.7 times width; pale yellow, opaque; pterostigma indistinct. Halter dark yellow, stalk darker. Legs. Coxae dark reddish brown, pruinose. Femora dark yellowish brown. Fore tibiae dark reddish brown, middle and hind tibia dark yellowish brown. Tarsi dark brown. Coxal and femoral setae white, filiform and scale-like; tibial setae dark reddish brown.

Abdomen: Dark reddish brown; setae white, filiform, more abundant laterally than dorsally, and white, appressed, lanceolate, more abundant along posterior margins. Terminalia (Figs. 2–8). Dark yellow. Sternite 8 moderately reduced, posterior margin slightly concave. Gonostylus lacks lateral

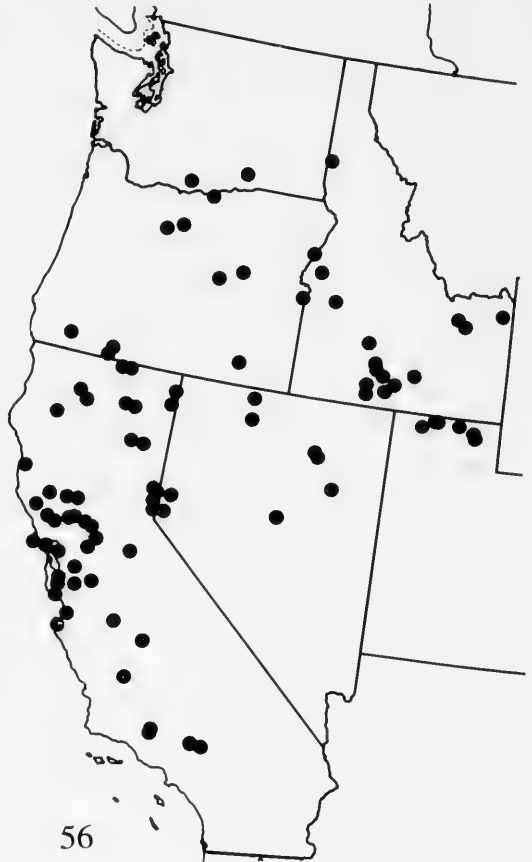


Fig. 56. The distribution of *Chromolepida bella* in the western United States.

projection. Dorsal apodeme of aedeagus broad anteriorly, wider than ventral apodeme, anterior slightly emarginate; distiphallus elongate, sinuate.

Variation in males: Body measurements for males are provided in Table 3. Considerable variation in coloration was noted between the holotype and most males of this species. Specimens in the San Francisco area and from Inglenook Fen appeared to be smaller and more slender in size than specimens inland from the coastal dune habitats where the holotype was collected. Head. Antenna reddish brown, pruinose, paler on basal half of scape; setae reddish brown. Maxillary palpus dark reddish brown. In one specimen (9045), a few frontal setae were noted at base of antenna. Wing. Membrane

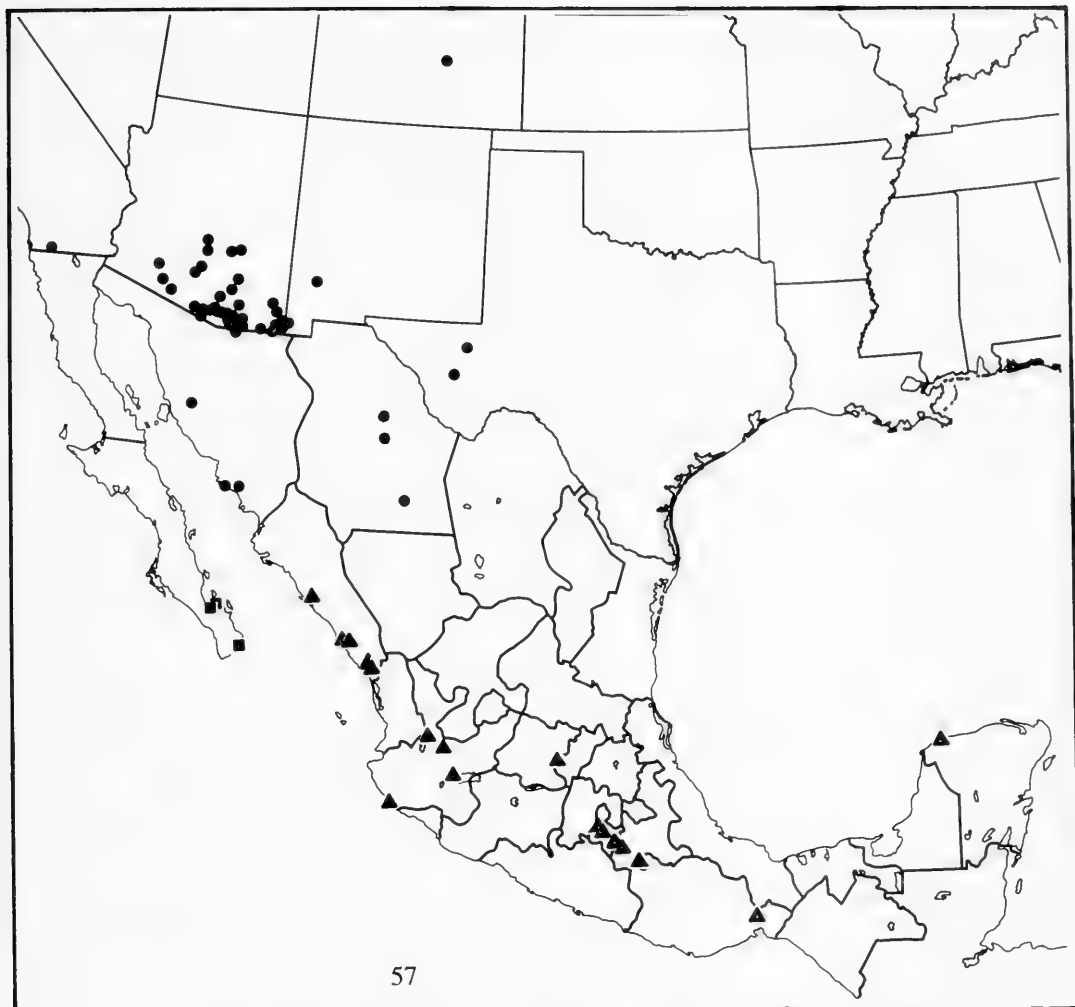


Fig. 57. The distribution of *Chromolepida clavitibia* (Squares), *C. mexicana* (Circles) and *C. nigra* (Triangles) in the southwestern United States and México.

pale yellow. Halter dark yellow. Legs. Femora dark reddish brown, apical half dark yellow. In one specimen (9037), the legs were entirely dark reddish brown, subshiny. Abdomen. Tergite 1 dark reddish brown, tergites 2–8 dark yellow; setae white, lanceolate, dense dorsally on tergites 1–3. Terminalia. The contour of the lateral margin of the epandrium varies from specimen to specimen.

Description of female.—Similar to male with following exceptions. Body measurements for females given in Table 3.

Head: Frons dark reddish brown, glossy dorsad of antennal bases, with dark gray pile lateral to antennal bases with silver, medial, pruinose band and a circular area of black pile dorsolateral to antennal bases; setae absent.

Thorax: Macrosetae: np 3. Setae white, elongate, with scattered reddish brown setae. Legs. Femora dark yellowish brown, becoming dark reddish brown basally on middle and hind femora.

Abdomen: Dark yellowish brown, subshiny; setae dark reddish brown, filiform

Table 3. Morphometric variation in the species of *Chromolepida* (N = 10 except N = 4 for *C. clavathia* males and females). The range (mm) and ratio for each measurement are followed by the mean.

	<i>bella</i>	<i>bella</i>	<i>clavathia</i>	<i>clavathia</i>	<i>mexicana</i>	<i>mexicana</i>	<i>nigra</i>	<i>nigra</i>	<i>nigra</i>	<i>pruinosa</i>	<i>pruinosa</i>
Male											
Body length (excluding antenna)	4.0-5.8	5.2	5.2-5.3	5.30	4.5-6.2	5.6	4.7-6.0	5.1	5.7-7.7	6.6	
Wing length	3.0-4.0	3.5	3.8-4.0	3.9	3.3-4.3	3.9	3.5-4.3	3.8	4.2-5.0	4.6	
Wing length/width	1.9-3.1	2.7	2.5-3.3	3.0	2.7-3.1	2.9	2.8-3.1	3.0	2.7-3.3	3.0	
Head length	0.60-1.00	0.75	0.8-0.88	0.84	0.75-1.02	1.02	0.78-0.98	0.87	0.82-0.96	0.89	
Antenna/head length	1.1-1.8	1.4	1.30	1.3	0.8-1.2	1.0	1.0-1.4	1.3	1.1-1.3	1.1	
Scape length	0.48-0.96	0.75	0.56-0.58	0.57	0.33-0.52	0.46	0.47-0.74	0.55	0.48-0.66	0.56	
Scape length/width	4.8-13.7	9.3	5.6-5.8	5.7	3.7-5.8	4.7	4.7-9.3	6.1	3.9-5.5	4.7	
Scape length/pedicel length	5.1-11.1	7.5	4.7-5.6	5.0	3.3-4.8	4.2	3.9-5.3	4.5	4.2-6.0	5.5	
Pedicel length	0.07-0.13	0.10	0.10-0.12	0.12	0.07-0.15	0.11	0.12-0.16	0.14	0.10-0.12	0.1	
Pedicel length/width	0.8-1.3	1.0	1.0-1.2	1.2	0.8-1.5	1.1	1.1-1.6	1.4	0.7-1.2	0.8	
Flagellum length	0.27-0.37	0.32	0.38-0.46	0.41	0.27-0.42	0.36	0.35-0.40	0.38	0.34-0.36	0.35	
Flagellum length/width	2.7-3.5	3.1	3.5-4.6	4.0	2.7-4.0	3.5	3.2-3.5	3.3	2.4-3.4	2.9	
Flagellum length/scape length	0.3-0.7	0.4	0.7-0.8	0.7	0.6-0.9	0.8	0.5-0.7	0.6	0.5-0.7	0.6	
Stylomere length	0.02-0.08	0.05	0.04	0.04	0.03-0.06	0.05	0.04-0.06	0.05	0.06	0.06	
Maxillary palpus length	0.28-0.82	0.50	0.46-0.52	0.49	0.30-0.52	0.44	0.37-0.56	0.47	0.42-0.60	0.49	
Maxillary palpus length/width	2.8-6.3	5.1	5.8-6.5	6.1	3.2-7.4	5.4	4.8-8.5	6.5	4.2-8.0	6.1	
Length of fore femur					1.0-1.4	1.2	1.1-1.2	1.1			
Length of fore femur/length of scape					1.8-2.8	2.4	1.4-2.4	1.7			
Length of fore tibia					1.0-1.5	1.3	1.1-1.3	1.2			
Length of fore tibia/length of scape					2.0-3.1	2.5	1.5-2.4	1.8			
Length of hind femur					1.4-2.3	1.8	0.8-1.6	1.6			
Length of hind femur/length of scape					2.9-4.4	3.5	2.0-3.3	2.4			

Table 3. Continued.

	<i>bella</i>	<i>bella</i>	<i>clavatibia</i>	<i>clavatibia</i>	<i>mexicana</i>	<i>mexicana</i>	<i>nigra</i>	<i>nigra</i>	<i>pruinosa</i>	<i>pruinosa</i>
Female										
Body length (excluding antenna)	5.5-8.2	6.8	7.0-8.2	7.6	6.5-8.0	7.1	5.3-7.3	6.5	6.3-8.4	7.5
Wing length	3.5-4.8	4.2	4.5-5.3	4.9	3.1-5.0	4.6	3.8-4.7	4.4	4.2-5.2	4.8
Wing length/width	2.5-3.3	2.9	2.8-3.5	3.1	2.9-3.6	3.1	2.8-3.5	3.0	2.9-3.4	3.2
Head length	0.62-0.94	0.85	0.88-1.02	0.94	0.92-1.08	0.98	0.78-0.92	0.88	0.9-1.1	1.0
Antenna/head length	1.2-1.7	1.4	1.3-1.5	1.4	0.9-1.3	1.1	1.4-1.7	1.5	1.1-1.5	1.2
Scape length	0.56-0.78	0.66	0.70-0.80	0.74	0.49-0.68	0.57	0.60-0.90	0.77	0.65-0.84	0.74
Scape length/width	4.4-6.7	5.6	5.3-6.7	5.9	4.3-7.0	5.5	5.0-7.5	6.5	3.4-6.1	4.4
Scape length/pedicel length	4.3-5.7	5.1	4.4-5.3	4.9	3.4-6.1	4.4	3.3-5.6	4.9	6.2-7.5	6.6
Pedicel length	0.12-0.18	0.13	0.14-0.18	0.15	0.08-0.16	0.13	0.14-0.18	0.16	0.09-0.15	0.13
Pedicel length/width	0.9-1.4	1.1	1.0-1.5	1.2	0.8-1.5	1.1	1.1-1.5	1.4	0.9-1.6	1.2
Flagellum length	0.36-0.44	0.41	0.40-0.44	0.42	0.37-0.44	0.4	0.38-0.45	0.41	0.33-0.40	0.36
Flagellum length/width	2.8-3.5	3.2	2.5-3.7	3.1	2.8-3.9	3.2	2.7-3.2	3.0	2.6-3.3	2.7
Flagellum length/scape length	0.5-0.7	0.6	2.9-3.7	3.3	0.6-0.9	0.7	0.5-0.6	0.5	0.5-0.6	0.5
Stylomere length	0.06-0.10	0.08	0.04	0.04	0.03-0.05	0.04	0.04	0.04	0.03-0.04	0.04
Maxillary palpus length	0.34-0.54	0.43	0.52-0.58	0.54	0.38-0.52	0.45	0.48-0.54	0.51	0.38-0.59	0.46
Maxillary palpus length/width	3.4-6.0	5.0	5.2-7.3	5.7	3.7-6.0	4.7	6.0-6.8	6.4	4.0-7.6	5.3



Fig. 58. The distribution of *Chromolepida pruinosus* in Nicaragua, Costa Rica, Colombia, Venezuela, and Guyana.

and scale-like. Terminalia (Figs. 9–11). Sternite 8 (Fig. 10) with posterior margin bilobed medially. Furca (Fig. 11) subrectangular; length 0.5 mm; anterior margins broadly rounded; posterior margin biconcave; lateral margins sinuate.

Variation in females.—In specimen (9047) scutellum with 5 macrosetae. In specimen (9036) femora dark reddish brown, apical half of fore and middle femora dark yellow. Specimens in the San Francisco area and from Inglenook Fen appeared to be smaller and more slender in size than specimens collected inland and away from coastal dunes.

Seasonal activity and distribution

In the specimens examined, adults were collected between 16 April and 27 September. The following plant taxa have been recorded as sources from which specimens were collected: *Achillea Millefolium* L., *Apocynum* sp., *Atriplex* sp., *Daucus pusillus* Michx., *Descurainia Sophia* (L.) Webb, *Lactuca pulchella* (Pursh) DC., *Lupinus* sp., *Phacelia ciliata* Benth. Specimens have also been collected from a reseeded range, fen areas, an oak-chapparral zone, and in flight and light traps. *Chromolepida bella* have

been collected from southern California to southeastern Washington eastward into Utah and Nevada (Fig. 56).

Specimens examined

Type material.—The holotype male of *Chromolepida bella* Cole (U.S. Museum of Natural History, Type No. 25929) (M. E. Irwin Therevidae Specimen Number 9177) was collected near San Francisco, California on 6 June 1920 by F. R. Cole.

Other material.—UNITED STATES. CALIFORNIA. Fox Valley, 8-VII-1935, J. Schuh, 1 ♀ (FSCA). Alameda County: Midway Road, 16-VIII-1957, W. W. Middlekauff, 1 ♀ (UCB); Arroyo Mocho, Mines Road, 28 km NE Livermore, 18-VI-1967, P. H. Arnaud, 1 ♂ (CAS); Berkeley, 27-V-1933, G. E. Bohart, 1 ♀ (UCB); 22-V-1907, M. A. Cazier, 2 ♂ (AMNH); Patterson Reserve, Del Valle Lake, 20-VIII-1973, J. Powell, 3 ♀ (UCB). Calaveras County: Big Trees, 7-VI-1931, E. C. Van Dyke, 1 ♀ (CAS). Contra Costa County: 6-VI-1912, 1 ♀ (UCB); 11-VIII-1982, D. G. Denning, 1 ♀ (CAS); Orinda Village, San Pueblo Ridge below Eureka Peak, 10-VIII-1969, E. I. Schlinger, 1 ♀ (MEI), oak-chapparral zone; Lafayette, 25-VI-1984, E. I. Schlinger, 1 ♀ (UCB); Mount

Diablo, 16-VII-1933, R. H. Beamer, 1 ♂ (SEM); Danville, 10-VIII-1949, F. X. Williams, 1 ♂ (UCB); 11-VIII-1951, 2 ♀ (UCB); Clayton, 20-VI-1992, E. I. Schlinger 1 ♀ (MEI); 15-VII-1992, 2 ♀ (MEI). Fresno County: Silver Creek, 16 km W Mendota, 10-VI-1962, P. F. Torchio, 1 ♀ (OSM); Selma, 4-VI-1929, R. L. Usinger, 1 ♂ 1 ♀ (UCB). Kern County: Lost Hills, 13-VI-1957, P. Opler, 1 ♀ (UCB); 16 km W Kramer Junction, 16-IV-1974, J. Wilcox, 1 ♀ (CAS). Lake County: Bogg's Lake, 10 km SSE Kelseyville, 838 m, 20-VIII-1966, P. H. Arnaud, 2 ♂ (CAS). Lassen County: Susan River Camp, 9-VII-1949, A. T. McClay, 1 ♂ (UCD); 10-VII-1949, 1 ♂ (UCD); Bridge Creek Camp, 12-VII-1954, R. C. Bechtel, 1 ♂ 1 ♀ (MEI); 40 km S Adin, 20-VI-1963, J. Wilcox, 1 ♂ (UCB). Los Angeles County: 27 km E Gorman, 16-IV-1962, J. A. Litsinger, 1 ♀ (UWisc); Chuchapate Ranger Station, 22-V-1959, E. I. Schlinger, 2 ♀ (UCD); Palmdale, 1-V-1968, J. Powell, 2 ♂ (MEI, UCB). Marin County: 3 km N Point Reyes light, 4-VI-1956, A. M. Barnes, 1 ♂ (UCB); Lagunitas, 11-V-1924, E. C. Van Dyke, 1 ♂ (UCB); 25-VI-1924, E. H. Nast, 1 ♂ 1 ♀ (UCB). Mendocino County: Alpine Lake, 4-VIII-1955, C. D. MacNeil, 1 ♂ (UCB); Inglenook Fen, fen area, 9–15 m, 13-VI-1973, E. I. Schlinger, 2 ♂ 2 ♀ (MEI, UCB); Inglenook Fen, dunes, 6–24 m, 21-VII-1972, P. A. Rauch, 2 ♀ (MEI); Inglenook Fen Reserve, Ten Miles dunes, 24-VI-1982, M. Buegler, 1 ♂ (MEI), on sand dunes. Modoc County: 24 km E Cedarville, 3-VII-1935, J. Schuh, 2 ♀ (CSU, FSCA); Newell, 31-VII-1963, J. Schuh, 1 ♀ (UCB), on *Lactuca pulchella*. Monterey County: near Pacific Grove, 8-VII-1935, J. Schuh, 1 ♀ (UCM); U. N. Lanham 1 ♀ (UCM); Arroyo Seco, 21-V-1955, D. Ribble, 1 ♂ (SEM); Arroyo Seco Camp, 11-V-1958, R. M. Bohart, 1 ♂ (UCD). Napa County: Oakville, 55 m, 6-IX-1970, P. H. Arnaud, 7 ♂ 2 ♀ (CAS, INHS). Nevada County: Sagehen Creek, near Hobart Mills, 25-VI-1954, J. A. Powell, 2 ♂ (UCB); 5-VII-1962, M. E. Irwin, 2 ♂ 2 ♀ (MEI). Placer County: Carnelian Bay, Lake Tahoe, 13-VI-1959, R. M. Bohart, 2 ♂ 3 ♀ (INHS, UCD); 24-VI-1973, 2 ♂ (INHS, UCD); 8-VII-1955, 2 ♂ 3 ♀ (UCD). Sacramento County: Galt, 27-VII-1952, E. I. Schlinger, 1 ♀ (UCD); Sacramento, 1-VIII-1955, E. A. Kurtz, 1 ♀ (UCD). San Francisco County: San Francisco, 21-V-1922, C. L. Fox, 1 ♂ (UCB); sand dunes; 23-V-1927, 2 ♂ (CAS); 13-V-1960, D. C. Rentz, 3 ♂ 1 ♀ (CAS); 14-V-1960, 2 ♂ (CAS); 6-VI-1920, E. P. Van Duzee, 4 ♂ 1 ♀ (MCZ, UCB, USNM); San Francisco, Laguna Puerca, 11-V-1960, J. Powell, 2 ♀ (UCB); 16-V-1960, 9 ♂ 3 ♀ (INHS, UCB, UCD); 24-V-1961, 1 ♂ (UCB); 13-VI-1961, W. E. Ferguson, 1 ♂ (UCB); 14-VI-1960, G. I. Stage, 2 ♀ (UCB); San Francisco, Golden Gate Park, 6-VI-1920, F. R. Cole, 9 ♂ 2 ♀ (ANSP, CNC, MCZ, UCB, UMinn, USNM); 9-VI-1922, 2 ♂ 2 ♀ (MEI, UCB); 15-VI-1921, 4 ♂ (MEI, UCB); Golden Gate Dunes, 25-VI-1931, C. H. & D. Marrin, 2 ♂ (OSU); Lobos Creek, 10-V-1979, J. Powell, 5 ♂ 3 ♀ (UCB); Stanford University, 21-VI-1910, 1 ♂ (USNM). Santa Clara County: 11 km S San Antonio Ranger Station, 27-VI-1953, G. A. Marsh, 1 ♀ (UCB); 11 km S San Antonio Ranger Station, 27-VI-1953, G. A. Marsh, 1 ♀ (UCB); San Jose, 6-VIII-1956, D. Ribble, 1 ♀ (SEM); Smith Creek Ranger Station, 640 m, 20-21-VII-1968, P. H. Arnaud, 1 ♀ (CAS). Santa Cruz County: Felton, Santa Cruz Mountains, 91–152 m, 20-25-V-1907, Bradley, 5 ♂ 5 ♀ (CU). Shasta County: 21 km NW McArthur, 3-VI-1964, J. Schuh, 1 ♂ (UCB), on *Apocynum* sp.; Jones Valley, Shasta Lake, 25-VIII-1959, W. G. Iltis, 1 ♂ 1 ♀ (UCD). Sierra County: Sattley, 13-VII-1962, R. M. Bohart, 2 ♀ (INHS, UCD); 26-VI-1964, 6 ♂ 1 ♀ (INHS, UCD); 26-VI-1964, M. E. Irwin, 10 ♂ 4 ♀ (INHS, MEI, UCD), swept from pasture of blooming *Daucus pusillus*; 28-VI-1964, M. E. Irwin, 1 ♂ (UCD); 26-VI-1964, C. R. Kovacic, 6 ♂ (UCD); Sierra Valley, 3-VII-1980, L. S. Kimsey, 1 ♂ (UA, UCD). Siskiyou County:

- 10 km S Macdoel, 2-VII-1956, J. Schuh, 1 ♂ 1 ♀ (UCB). Solano County: Solano Lake, 14-V-1971, E. E. Grissell, 1 ♀ (UCD). Sonoma County: Windsor, 3-VIII-1956, A. M. Barnes, 1 ♂ (INHS); Cloverdale, 24-VIII-1953, E. I. Schlinger, 1 ♀ (UCB). Stanislaus County: Del Puerto Canyon, Frank Rains Park, 335 m, 27-IX-1969, P. H. Arnaud, 1 ♀ (CAS). Trinity County: Hayfork, 22-V-1973, J. Chemsak, 1 ♀ (INHS, UCB); 23-V-1972, 2 ♂ 1 ♀ (MEI, UCB), flight trap; Mountain Meadow Ranch, head of Coffee Creek, 1555 m, 8-10-VII-1969, C. Slobodchikoff, 1 ♂ (UCB); W. G. Goodman, 1 ♂ (UCD); Hayfork Ranger Station, 22-V-1973, J. Chemsak, 3 ♂ 4 ♀ (MEI, UCB), light trap. Ventura County: Wagon Road Number 2 Campground, 29 km WSW Gorman, 1585 m, 4-VII-1968, P. H. Arnaud, 1 ♂ (CAS); Lockwood Valley near Stauffer Post Office, 5-V-1959, P. D. Hurd, 1 ♂ (UCB), on *Phacelia ciliata*; 7-V-1959, 1 ♂ (UCB), on *Descurainia Sophia*; 3-V-1959, C. W. O'Brien, 2 ♂ 2 ♀ (UCB), on *Phacelia ciliata*; J. Powell, 1 ♂ (UCB). Yolo County: 13 km NW Winters, 10-VIII-1959, J. Fowler, 1 ♀ (UCD); 6 km SW Dunnigan, 8-IX-1959, 1 ♀ (UCD), light trap; Rumsey, 6-VIII-1955, E. A. Kurtz, 1 ♀ (UCD); Davis, 30-VI-1936, R. M. Bohart, 2 ♀ (UCD); 11-VII-1936, 2 ♀ (UCD); 3-VIII-1955, 2 ♂ (UCD); 14-VIII-1969, 1 ♀ (UA); 11-VIII-1982, D. G. Denning, 1 ♂ (CAS); 25-V-1962, M. E. Irwin, 1 ♀ (MEI); 27-V-1962, 1 ♀ (MEI); 4-VIII-1962, 1 ♂ 2 ♀ (MEI); 11-VIII-1962, 2 ♀ (MEI, UCD); 4-VI-1965, C. R. Kovacic, 1 ♂, 4-VII-1965, 1 ♂ (UCD); 18-V-1950, A. T. McClay, 2 ♀ (UCD); 9-VI-1950, 2 ♀ (UCD); 22-VII-1956, 4 ♀ (UCD); 20-VIII-1955, 2 ♂ (UCD); 21-VIII-1955, 2 ♀ (UCD); 28-VIII-1955, 2 ♂ (UCD); 2-IX-1956, 2 ♂ (INHS, UCD); 8-VIII-1953, W. D. McClellan, 2 ♂ (UCD); 18-VIII-1964, F. D. Parker, 2 ♀ (UCD); 26-IX-1965, 2 ♀ (INHS, UCD); 16-VII-1952, E. I. Schlinger, 2 ♂ (UCD); 17-VII-1959, 2 ♂ (UCD); 15-VII-1962, R. O. Schuster, 8 ♂ 4 ♀ (UCD); 23-IV-1959, F. E. Strong, 2 ♂ (UCD); 21-VI-1959, 1 ♂ (UCD); 29-VI-1959, 1 ♂ (UCD); 8-VIII-1959, 4 ♂ (UCD), light trap; 10-VIII-1959, 2 ♂ (UCD); 23-VIII-1959, 2 ♂ 2 ♀ (UCD), light trap. IDAHO. Eastern Idaho, 11-VII-31, D. E. F., 1 ♂ (USNM). Boise County: 14 km E Garden Valley, 3-VII-1979, M. W. Hanks, 2 ♂ (UIda). Camas County: 16 km NW Hill City, 15-VII-1967, A. R. Gittins, 1 ♂ 1 ♀ (UIda), *Lupinus* sp. Fremont County: 11 km NW Anthony, 16-VII-1965, R. L. Westcott, 2 ♀ (UIda). Gooding County: Wendell, 9-VI-33, Norta-Salsola, 1 ♂ (USNM); Bliss, 1000 m, 1-VI-1926, R. W. Haegele, 2 ♀ (UIda). Jefferson County: 7 km NW Terreton, 25-VII-1957, W. F. Barr, 2 ♀ (UIda). Latah County: Idlers Rest Creek near Moscow, 12-VII-1964, R. L. Westcott, 2 ♀ (UIda). Minidoka County: Adelaide, 14-VI-1929, 3 ♂ (UIda). Oneida County: Stone Reservoir, 31-V-1969, G. F. Knowlton, 1 ♂ (USU); Pocatello Valley, 11-VI-1973, G. F. Knowlton, 1 ♂ (USU); 3.2 km S Roy Summit, 17-VII-1972, G. F. Knowlton, 1 ♀ (USU). Owyhee County: 21 km S Grasmere, 7-VII-1969, A. R. Gittins, 2 ♀ (UIda); 27 km S Grasmere, 7-VII-1968, A. R. Gittins, 2 ♀ (UIda), *Achillea Millefolium*. Twin Falls County: Castleford, 28-VI-28, 1 ♀ (USNM); Castleford, Sophia #3, 15-VI-34, 1 ♀ (USNM); Roseworth, 16-VII-1963, O. O. Fillmore and G. B. Hewitt, 2 ♂ (UIda); 11 km S Kimberly, 8-VI-1967, M. A. Brusven, 2 ♀ (UIda); Hollister, 13-VI-1931, D. E. Fox, 2 ♂ (MEI, UCD); 26-VI-1931, D. E. Fox, 1 ♂ (UCD). Valley County: Camp Creek, South Fork Salmon River, 14-VI-1966, W. F. Barr, 2 ♀ (UIda). Washington County: Midvale, 782 m, 20-VI-1926, R. W. Haegele, 2 ♂ (UIda). NEVADA. Elko County: Carlin, 25-VI-1935, R. H. Beamer, 5 ♂ (INHS, SEM); 8 km NE Lamoille, 19-VI-1958, R. C. Bechtel, 2 ♂ (MEI, UCD); Harrison Summit, Ruby Mountain, 2208 m, 28-VI-1960, R. E. Blackwelder, J. C. Downey, 2 ♂ 2 ♀ (UCD); 11 km S Carlin, 27-VI-1955, J. C. Downey, 2 ♂ 1 ♀ (UCD); Wells, 12-VII-1911, J. M.

Aldrich, 1 ♀ (USNM). Humboldt County: Orovada, 14-VII-1962, F. D. Parker, 2 ♂ 2 ♀ (UCD); Winnemucca, 23-V-1960, T. R. Haig, 2 ♂ (UCB). Lander County: Austin Summit, 2255 m, 27-VI-1962, L. R. O'Brien, 2 ♀ (UCB) Ormsby County: Ormsby, 6-VII-, Baker, 1 ♂ (USNM); Carson City, 26-VII-1929, E. P. Van Duzee, 1 ♂ 2 ♀ (CAS, UCB). Washoe County: Reno, 19-V-1963, R. C. Bechtel, 2 ♀ (UCD); Patrick, 16-VI-1964, J. E. Slanky, 2 ♀ (MEI). OREGON. Critterion, 2-VII-1935, R. H. Beamer, 2 ♂ (SEM). Baker County: Sparta, 3-VII-1922, E. C. Van Dyke, 1 ♀ (UCB). Gilliam County: 3 km W Arlington, 29-VII-1964, J. W. MacSwain, 7 ♀ (MEI, UCB). Grant County: Seneca, 11-VII-1935, J. Schuh, 1 ♂ (CSU); Keerin's Ranch, Izee, 25-VI-1935, J. Schuh, 1 ♀ (FSCA). Harney County: Antelope Mountain, 11-VII-1931, D. K. Frewing, 1 ♀ (OSM); Roaring Spring Ranch, Steens Mountains, 1370 m, 7-VII-1927, H. A. Scullen, 1 ♂ (OSM). Josephine County: 6 km E Grants Pass, 17-VII-1969, R. L. Westcott, 1 ♂ (OSDA). Klamath County: Klamath Falls, 13-V-1924, C. L. Fox, 1 ♂ (MEI); 21-VII-1973, J. Schuh, 1 ♀ (FSCA); Worden, 1-VII-1935, R. H. Beamer, 2 ♀ (INHS, SEM); Algoma, Klamath Falls, 18-VII-1955, J. Schuh, 2 ♂ (UCB); 21-VIII-1973, 1 ♀ (FSCA). Malheur County: 3 km S Vale, 28-V-1969, K. Gordon, 1 ♀ (OSDA), reseeded range. Wasco County: Shaniko, 17-VII-1935, J. Schuh, 1 ♀ (FSCA); 13 km N Warm Springs, 2-VI-1968, K. Goeden, 1 ♂ (OSDA). UTAH. Lampo, 22-V-1932, G. V. Knowlton, 1 ♂ (SEM); 31-V-1939, 1 ♀; Locomotive Spring, 9-VI-1930, 1 ♂ (AMNH), *Atriplex* sp. Box Elder County: Snowville, 24-VI-1931, G. F. Knowlton, 1 ♀ (USU); 5-VI-1934, W. L. Thomas, 1 ♀ (USU); 8 km W Snowville, 6-VI-1969, G. F. Knowlton, 1 ♀ (USU); Bothwell, 22-VI-1938, D. E. & H. T. Hardy, 1 ♀ (USU). Cache County: Hyrum, 22-VI-1938, D. E. Harax, W. P. Nye, 1 ♀ (INHS); Logan, South Farm, 9-VII-1948, B. A. Haws, 1 ♂ (USNM). WASHINGTON. Ben-

ton County: 3 km W West Richland, 7-VI-1973, N. E. Woodley, 1 ♀ (WSU). Klickitat County: 40 km N Goldendale, 26-VI-1969, R. L. Westcott, 1 ♀ (UIda).

Chromolepida clavitibia
Webb and Irwin, NEW SPECIES

Derivation of name.—*clava* (Latin, female) = club; *tibia* (Latin) = shinbone.

Diagnosis.—Males of *Chromolepida clavitibia* differ from the males of all other species of *Chromolepida* in having dark brown halteres, dark reddish brown to black femora, and the fore tibia distinctly clavate. Females of *Chromolepida clavitibia*, like *C. nigra*, have dark brown to black halteres and femora. The species is separated from *C. nigra* in having the fore tibia distinctly clavate.

Description of holotype male (8812).—Body length 5.3 mm.

Head: Length 0.9 mm. Ocellar tubercle black, pruinose; setae black, filiform. Eyes dark reddish brown; medial margin rounded. Frons with medial callus dark reddish brown, glossy, dorsal and lateral pile silver; setae black, filiform. Antenna black, pruinose; setae black, filiform, short; macrosetae black; length of antenna 1.3 times head length; length of scape 0.56 mm, 5.6 times width, 4.7 times length of pedicel; length of pedicel 0.12 mm, 1.2 times width; length of flagellum 0.46 mm, 4.6 times width, 0.8 times length of scape; length of stylomere 0.04 mm. Parafacial dark reddish brown, glossy with silver pile along lateral margins. Maxillary palpus black; length 0.46 mm, 5.8 times width; setae white, filiform.

Thorax: Macrosetae: np 3. Black, pruinose; setae white and dark brown filiform and silver-green scale-like. Postpronotal setae white filiform and silver-green scale-like. Prosternal setae white filiform. Pleura dark reddish brown to black, pruinose, with posterior three-fourths of anepisternum glossy; setae pale yellow filiform on propleuron, anepisternum and dorsal third of katepi-

meron, silver-green scale-like on anepisternum and dorsal third of katapisternum. Scutellum black, pruinose; setae silver lanceolate in band across posterior margin. Laterotergite black, subshiny; setae white to pale yellow filiform. Wing. Length 4.0 mm, 3.3 times width; opaque, pale yellow, pale smoky black band across wing apex and apex of discal and posterior basal cells; pterostigma pale brown. Halter brown. Legs. Coxae dark reddish brown to black, pruinose. Femora dark reddish brown to black, subshiny. Tibiae dark reddish brown; fore tibia distinctly clavate. Tarsi dark reddish brown. Coxal setae white filiform and silver-green scale-like; femoral setae white filiform and silver-green scale-like; tibial setae dark reddish brown filiform.

Abdomen: Tergites 1–2 dark brown, pruinose, tergites 3–8 yellowish orange, subshiny; dorsal setae white lanceolate, densely appressed over tergites 1–2 and medially on tergite 3, lateral setae pale yellow filiform and silver-green scale-like. Terminalia (Figs. 12–18). Yellowish orange, subshiny. Sternite 8 moderately reduced, posterior margin moderately concave. Gonostylus with short basilateral projection. Dorsal apodemes of aedeagus broad, anterior margin deeply concave; ventral apodeme broad, anterior margin pointed; distiphallus elongate, sinuate.

Variation in males: Body measurements for males are provided in Table 3.

Description of female.—Similar to male with following exceptions. Body measurements for females given in Table 3.

Head: Frons black, pruinose with medial callus dark reddish brown, subshiny, with dorsolateral circle of black pile and narrow band of white pile lateral to antennal bases; setae black.

Thorax: Macrosetae: np 3. Wing. Pale smoky brown, margin of veins darker; pterostigma dark brown.

Abdomen: Dark reddish brown to black, subshiny; dorsal setae white, lanceolate, across posterior margin of tergites 1–3, lat-

eral setae pale yellow filiform and silver-green scale-like on tergites 1–2. Terminalia (Figs. 19–21). Sternite 8 (Fig. 20) with posterior margin bilobed. Furca (Fig. 21) subrectangular; length 0.34 mm; posterior and anterior margins truncate; lateral margins parallel.

Seasonal activity and distribution

In the specimens examined, adults were collected during April, October, and December. *Chromolepida clavitibia* has been collected only from the southern tip of Baja California Sur, México (Fig. 57).

Specimens examined

Type material.—The holotype male of *Chromolepida clavitibia* (deposited in the California Academy of Sciences, Type No. 17029, on permanent loan from the University of California, Riverside) (M. E. Irwin Therevidae Specimen Number 8812) was collected at Los Frailes, Baja California Sur, MEXICO, by E. M. Fisher, on 25-26-IV-1975.

Other material.—ALLOTYPE: In copulo with holotype, same data as holotype (CAS). PARATYPES: MEXICO. Baja California Sur. Los Frailes, 25-26-IV-1975, E. M. Fisher, 2 ♂ 2 ♀ (INHS, UCR); 16 km NW La Paz, 6-X-1941, Ross, Bohart, 1 ♂ (CAS); La Paz, 19-XII-1973, W. Middlekauff, 1 ♀ (UCB).

Chromolepida mexicana Cole

Chromolepida mexicana Cole (1923: 460); Cole (1965: 350); Irwin and Lyneborg (1981a: 260).

Derivation of name.—*mexicana* = of or from México.

Diagnosis.—Males of *Chromolepida mexicana*, like *C. nigra*, have the distiphallus elongate and bent at a right angle to the plane of the aedeagus. The males differ from *C. nigra* in having the apical half of the gonocoxite broad in lateral view. Fe-

males of *Chromolepida mexicana*, like *C. clavitibia* and *C. nigra*, have dark brown to black halteres. The females are separated from *C. clavitibia* and *C. nigra* in having the femora dark yellow.

Redescription of holotype female (9025).—Body length 7.0 mm.

Head: Length 1.0 mm. Ocellar tubercle dark reddish brown, pruinose; setae black. Eyes dull reddish brown; medial margin rounded. Frons dark reddish brown, with glossy callus dorsad of antennal bases, pruinose over remainder of frons, with silver, lateral pile and circular area of black pile dorsolateral to callus; setae black, scattered. Antenna reddish brown, pruinose; setae dark reddish brown; length of antenna 1.2 times head length; length of scape 0.66 mm, 6.6 times width, 4.4 times length of pedicel; length of pedicel 0.15 mm, 1.5 times width; length of flagellum 0.39 mm, 3.9 times width, 0.6 times length of scape; length of stylomere 0.04 mm. Parafacial dark reddish brown, glossy with silver pile along lateral margins. Maxillary palpus dark reddish brown; length 0.48 mm, 4.8 times width; setae white, filiform.

Thorax: Macrosetae: np 3. Dark brown; setae white, filiform, short, scattered scale-like. Postpronotal setae white and scale-like. Prosternal setae white. Pleura dark reddish brown, pruinose, anepimeron glossy; setae white, filiform, on propleuron, anepisternum and dorsal third of katepisternum and silver, scale-like over entire anepisternum and dorsal third of katepisternum. Scutellum dark reddish brown, pruinose; setae white, lanceolate, in broad band across posterior margin. Laterotergite dark reddish brown; setae dark white. **Wing**. Length 4.7 mm, 3.1 times width; opaque, pale smoky brown with apical band, apex of discal and posterior basal cells, and along posterior margin of wing pale brown; pterostigma brown. Halter dark brown. **Legs**. Coxae dark reddish brown, pruinose. Femora dark yellow, subshiny. Fore tibia dark reddish brown, middle and hind tibiae dark yellow,

subshiny. Tarsi dark reddish brown. Setae white, filiform and, scale-like setae on fore coxa and femora, dark reddish brown, filiform on tibiae.

Abdomen: Dark reddish brown, subshiny; dorsal setae scale-like, and silver, appressed, lanceolate across posterior margin tergites 1–4, lateral setae white, filiform on tergites 1–2. Terminalia (Figs. 29–31). Sternite 8 (Fig. 30), posterior margin with deep central notch; apical fourth of sternite flattened. Furca (Fig. 31) subrectangular; length 0.4 mm; posterior and anterior margins broadly rounded; lateral margins parallel.

Variation in females: Body measurements for females are provided in Table 3. Thorax. Macrosetae: np 2-3, 3, sa 1, pa 1, dc 0, sc 4.

Description of male.—Similar to female with following exceptions. Body measurements for males given in Table 3.

Head: Ocellar tubercle dark reddish brown. Frons dark reddish brown, glossy, with silver pile dorsad and laterad. Maxillary palpus dark brown, pruinose.

Thorax: Macrosetae: np 3-4, 4. Vittae faintly separated by gray pruinose areas. Wings. Hyaline to pale yellow with apical band and apex of discal and posterior basal cells pale smoky brown; pterostigma slightly darker than membrane. Halter pale yellow, stalk darker yellow. Legs. Tibiae dark brown, pruinose. Length of fore femur to length of scape 1.8–2.9, 2.4 ± 0.2 (N = 30); length of fore tibia to length of scape 2.0–3.1, 2.5 ± 0.2 (N = 30); length of hind femur to length of scape 2.4–4.4, 3.5 ± 0.4 (N = 30).

Abdomen: Tergites 1–4 dark reddish brown, tergites 5–8 dark yellowish orange; setae white, filiform and dense, silver, lanceolate, appressed dorsally on tergites 1–4. Terminalia (Figs. 22–28). Dark yellowish orange. Sternite 8 moderately reduced, posterior margin slightly concave. Gonostylus with lateral hook-like projection. Dorsal apodeme of aedeagus broad anteriorly, anterior margin deeply emarginate, ventral apodeme attenuate, pointed anteriorly; dis-

tiphallus moderately long, bent at right angle to plane of aedeagus.

Seasonal activity and distribution

In the specimens examined, adults were taken from 31 January to 29 September. Specimens have been collected on *Acacia* sp., *Baccharis* sp., *B. glutinosa* Pers., *Bailleya* sp., *B. pleniradiata* Harr. and Gray, *Chenopodium album* L., *Euphorbia albomarginata* T. and G., *Happlopapus tenuisectus* (Greene) Blake, *Lepidium Thurberi* Woot., *Senecio* sp., *Solanum* sp., swept alfalfa, and from a dry wash. *Chromolepida mexicana* has been collected from northern México north to Arizona, southern California, central Colorado, southwestern New Mexico, and western Texas (Fig. 57).

Specimens examined

Type material.—The holotype of *Chromolepida mexicana* Cole (CAS) (M. E. Irwin Therevidae Specimen Number 9025) was collected at Guaymas, Sonora, México, on 10 April 1921 by E. P. Van Duzee.

Other material.—MEXICO. Chihuahua: 14.4 km W El Sueco, 1-VII-1972, R. Manga, T. Sluss, 1 ♂ (USNM); Chicuhua, 13-VII-1938, L. J. Lipovsky, 1 ♂ (SEM); 24 km S Camargo, 1310 m, 6-IX-1962, R. H. & E. M. Painter, 1 ♂ (KSU). Sonora: Nogales, 28-III-1950, 1 ♂ (USNM); 19 km N Ciudad Obregon, 24-IV-1961, R. H. & E. M. Painter, 1 ♀ (KSU); 132 km N Hermosillo, 7-II-1964, M. E. Irwin, 1 ♀ (MEI); Guaymas, 10-IV-1921, E. P. Van Duzee, 1 ♀ (CAS). UNITED STATES. ARIZONA. Southern Arizona, 30-VII-1959, F. M. Hull, 3 ♂ 1 ♀ (CNC). Cochise County: 32 km W Benson, 4-IX-1968, D. R. Miller, J. E. Lauck, 1 ♀ (UCD); Peloncillo Mountains, 16 km E Apache, 5-VIII-1972, R. F. Denno, K. Yeargan, J. R. Benedict, 1 ♂ (UCD); Carr Peak, Huachuca Mountains, 16-VIII-1966, R. L. Westcott, 2 ♀ (UIda); Douglas, 23-III-1933, W. W. Jones, 1 ♀ (UCB); 2-IV-1933, 1 ♀ (UCB); 2 km E Wilcox, 26-VII-1973, J. D. Pinto, 1 ♀ (UCR), *Chenopodium album*; 8 km E Lowell, 15-VIII-1958, P. M. Marsh,

1 ♀ (UCD); Chiricahua Mountains, 5-IX-1947, D. J. & J. N. Knull, 1 ♀ (UA); Southwest Research Station, 8 km W Portal 28-IX-1965, V. D. Roth, 1 ♀ (MEI); 16 km E Sierra Vista, 15-IX-1974, A. E. & M. M. Michelbacher, 1 ♀ (UCB), *Happlopapus tenuisectus*; 4.8 km E Douglas, 1-IX-1984, R. M. Bohart, 1 ♀ (UCD); 5 km E Douglas, 1216 m, 12-VIII-1962, H. A. Scullen, 1 ♂ 1 ♀ (OSU); San Bernardino Ranch, Douglas, 1143 m, -VIII-, F. H. Snow, 3 ♂ 1 ♀ (INHS, SEM); 48 km NE Douglas, 1417 m, 1-VIII-1946, H. A. Scullen, 1 ♂ (OSU); Skeleton Canyon, 10 km SE Apache, 1-IX-1958, E. G. Linsley, 1 ♂ (UCB); 7 km W Montezuma Pass, 9-IX-1965, C. W. O'Brien, 1 ♂ (UCB); Bruno Canyon, Chiricahua Mountains, 1525 m, 28-VIII-1965, G. R. Ballmer, 1 ♂ (UCR); 4 km NE Portal, 30-VIII-1959, E. G. Linsley, 1 ♂ (UCB), *Acacia* sp.; 3 km NE Portal, 2-4-VIII-1960, M. A. Cazier, 1 ♀ (AMNH); 17-IX-1961, 1 ♀ (AMNH); 6 km E Portal, Chiricahua Mountains, 13-VIII-1965, G. R. Ballmer, 1 ♂ (UCR); 11 km E Portal, 23-VIII-1963, M. A. Cazier, 1 ♂ (UCB); 13-VIII-1962, J. Wilcox, 1 ♀ (UCB); 18-IX-1962, 1 ♂ 2 ♀ (UCB); Wilcox, 2-VIII-1975, J. D. Pinto, 1 ♂ (UCR); 18-VIII-1958, R. M. Bohart, 1 ♀ (UCD); 14-IX-1935, F. H. Parker, 1 ♂ (USNM); Huachuca Mountains, 1 ♀ (USNM); 12-VIII-1950, D. J. & J. N. Knull, 2 ♂ 1 ♀ (OSM); San Bernadino Ranch, 1145 m, F. H. Snow, 1 ♀ (SEM); 15.4 km N Apache, 14-VIII-1959, E. G. Linsley, 1 ♀ (UCB); 6 km S Apache, 1-IX-1959, H. E. Evans, 1 ♀ (CU), *Baccharis glutinosa*; 8 km S Apache, 11-VIII-1958, P. D. Hurd, 1 ♀ (UCB); 8 km SW Apache, 1311 m, 12-VIII-1959, H. E. Evans, 1 ♀ (CU), *Baccharis glutinosa*; 19-VIII-1959, E. G. Linsley, 1 ♀ (UCB), *Baccharis* sp.; 14 km N Apache, 14-VIII-1959, E. G. Linsley, 2 ♀ (UCB); 21 km SW Apache, 24-VIII-1980, J. G. Rozen, 1 ♂ (AMNH); 2 km E Apache, 9-VIII-1973, J. G. Ehrenfeld, 2 ♀ (AMNH), *Euphorbia albomarginata*; 10-VIII-1973, J. G. Ehrenfeld, 1 ♀ (AMNH), *Euphorbia albomarginata*; Portal, 1525 m, 7-IX-1959, H. E. Evans, 1 ♂, 1 ♀ (CU). Gila County: base of Pinal

- Mountains, -III-, D. K. Duncan, 1 ♂, 1 ♀ (FSCA); Mendoza Canyon, west slope Coyote Mountains, 1-VIII-1968, M. L. Lindsey, 1 ♂ (UA); Globe, 15-III-1936, F. H. Parker, 1 ♀ (UA); 25-III-1938, 2 ♂ (USNM); 2-IV-1935, 1 ♂ 1 ♀ (INHS, USNM); 5-IV-1935, 3 ♂ 3 ♀ (INHS, UA, USNM, WSU); 8-IV-1935, 1 ♀ (UA); 21-IV-1937, 1 ♀ (UA). Maricopa County: Cañon Lake, 2-IX-1935, F. H. Parker, 1 ♂ (USNM); Kyrene, 20-VI-1956, G. D. Butler, 1 ♀ (UA); Theba, 2-VIII-1954, G. D. Butler, 1 ♂ 1 ♀ (INHS, UA), swept alfalfa; Chandler, 26-V-1955, G. D. Butler, 3♀ (UA), swept alfalfa; 2-VIII-1955, O. L. Barnes, 2♂ 1♀ (UA), swept alfalfa. Pima County: Baboquivari Mountains, 28-IV-1935, F. H. Parker, 1 ♂ (USNM); Santa Rita Range Reserve, 1219 m, 12-VIII-1949, F. Werner, W. Nutting, 1 ♂ (USNM), mesquite-desert grassland; Santa Cruz Village, Cobabi Mountains, 945 m, 10-12-VIII-1916, 1 ♀ (CNC); Sasabe, 15-II-1997, O. Peck, 1 ♂ 5 ♀ (ASU, CNC, USU); Peña Blanco, Arivaca, 3-IX-1963, E. R. Burdien, 1 ♀ (USNM); Quijotoa, 28-VIII-1927, 1 ♂ (USNM); 48 km E Quijotoa, 28-29-VIII-1927, 1 ♀ (CU); Santa Catalina Mountains, 19-VIII-1968, R. M. Bohart, 1 ♀ (UCD); 26 km E Tucson, -III-1935, J. A. Griswold, 1 ♀ (MCZ); 76 km SW Tucson, 20-III-1961, R. H. & E. M. Painter, 1 ♀ (KSU), on flowers of *Baileya* sp.; Tucson, 5-III-1964, G. Danila, 1 ♂ 1 ♀ (USNM); 28-III-1967, D. M. Wood, 1 ♀ (CNC); 25-III-1956, G. D. Butler, 1 ♀, swept alfalfa; 28-VIII-, F. M. Carpenter, 1 ♀ (MCZ); 29-IX-1940, E. L. Peterson, 1 ♀ (UA); south of Tucson, 25-III-1970, O. R. Taylor, 1 ♀ (SEM); Madera Canyon, 18-VIII-1963, V. L. Vesterby, 2 ♀ (MEI, UCD); 2-IX-1973, L. Bezark, M. Ebertz, C. Katayama, 1 ♀ (UCB); Schaeffer Cañon, Baboquivari Mountains, 1573-1676 m, 18-IX-1924, R. & H., 1 ♂ (ANSP); 16 km NW Tucson, 732 m, R. H. & E. M. Painter, 1 ♂ (KSU); Baboquivari, 19-VII-1932, R. H. Beamer, 1 ♂ (SEM); 35 km E Ajo, 610 m, 31-III-1965, Bollinger, 2 ♂ (ASU, OSU); Rincon Mountains, 19-IX-1937, R. S. Beal, 1 ♂ (UA); Continental, 22-III-1956, F. W. Werner, G. D. Butler, 1 ♂ 1 ♀ (INHS, UA), swept alfalfa; Sierrita Mountains, 915-1220 m, 10-VIII-1924, A. A. Nichol, 1 ♂ (UA); Brown's Canyon, Baboquivari Mountains, 18-VIII-1956, G. D. Butler, F. G. Werner, 2 ♂ 1 ♀ (UA); 21-VIII-1957, C. W. O'Brien, 1 ♂ (UA); Summerhaven, Santa Catalina Mountains, 2345 m, 20-VIII-1934, I. Moore, 1 ♀ (SDNHM); 5 km N Madera Canyon, 10-VIII-1979, G. Forbes, 1 ♀ (NMSU), in mesquite wash; 2 km W Robles Junction, 26-VII-1973, E. M. Fisher, 2 ♂ 2 ♀ (UCR); Box Canyon, 25-VIII-1975, L. Bezark, G. Nishida, C. Kitayama, B. Tilden, 1 ♀ (UCB); 10-VIII-1977, D. K. Faulkner, 1 ♂ (SDNHM). Pinal County: Aravaipa Canyon, 9-IX-1986, F. Parker, T. Griswold, 1 ♀ (USU); Coolidge, 19-VII-1956, C. Williams, 1 ♂ (INHS); Casa Grande, 26-V-1955, G. D. Butler, 2 ♂ (UA), swept alfalfa; 20-VI-1956, 1 ♂ (UA), swept alfalfa; Oracle, 1370 m, 11-VIII-1950, R. S. Beal, 1 ♂ (UCB); 25-VIII-1934, I. Moore, 1 ♂ 1 ♀ (SDNHM). Santa Cruz: Parkers Ranch, Santa Rita Mountains, 1981 m, 21-VII-1937, H. Ruckes, 1 ♀ (USNM); 19 km N Nogales, 1-VIII-1966, C. R. Kovacic, 1 ♀ (UCD); Santa Rita Range Reserve, 1219 m, 12-VIII-1949, F. G. Werner, W. Nutting, 1 ♂ (USNM), mesquite-desert grassland; 8 km E Nogales, 1-IX-1970, G. E. & R. M. Bohart, 1 ♂ 1 ♀ (UCD, USU); Santa Rita Mountains, 6-IV-1937, W. Benedict, 1 ♂ 2 ♀ (SEM); 1-VIII-1941, R. H. Beamer, 1 ♂ (SEM); Calabasas, 9.6 km W Nogales, 1-VIII-1961, F. G. Werner, W. Nutting, 1 ♂ (INHS); Madera Canyon, 12-VIII-1965, D. N. Harrington, 1 ♂ (MEI); 3 km SW Patagonia, 9-III-1963, J. C. Bequaert, 1 ♀ (UA); Patagonia Mountains, 7-VIII-1950, D. J. & J. N. Knull, 1 ♂ (OSM); Patagonia, 22-III-1956, G. D. Butler, F. G. Werner, 1 ♀ (WSU), *Senecio* sp.; 19-IV-1956, G. D. Butler, 1 ♀ (UA), swept alfalfa; 2-VIII-1924, E.P. Van Duzee, 1♀ (UCB); 5-VIII-1937, R. S. Beal, 1♂ (UA); 5 km W Sonoita, 15-VIII-1966, R. L. Westcott, 1 ♂, 1 ♀ (UIda). Yavapai County: Cottonwood, 29-II-1978, R. C. Miller, 1 ♂ (UCD). CALIFORNIA. San Diego County:

Campo, 18-VII-1940, R. H. Beamer, 1 ♂ 1 ♀ (INHS). COLORADO. El Paso County: Foster Ranch, T15S R65W Sec 23 N½, 1737 m, F. M. Brown, 1 ♀ (CSU). NEW MEXICO. Grant County: Silver City, 10-III-1934, R. T. Kellog, 3 ♂ 2 ♀ (MEI, OSM). Hidalgo County: Skeleton Canyon, Rodeo, 10-VIII-1955, R. R. Dreisbach, 1 ♂, Skeleton Canyon, 16-VIII-1968, J. B. Heppner, 1 ♂ 1 ♀ (MEI), sweeping *Lepidium Thurberi*; 4 km N Rodeo, 23-VIII-1958, E. G. Linsley, 1 ♀ (UCB), *Baileya pleniradiata*; Rodeo, 1219 m, 21-VIII-1958, P. M. Marsh, 1 ♂ 2 ♀ (MEI, UCD); 28-VIII-1959, H. E. Evans, 1 ♂ 3 ♀ (CU, USNM); 31-VIII-1951, 1 ♂ (USNM); 5-IX-1959, 1 ♀ (CU); 5 km NW Rodeo, 16-IX-1960, M. A. Cazier, 1 ♂ (AMNH); 2 km N Rodeo, 29-VII-1959, E. G. Linsley, 2 ♂ (UCB); 16-VIII-1963, M. A. Cazier, Mortenson, 1 ♂ 1 ♀ (MEI); Cotton City, 19-VIII-1979, R. M. Bohart, 1 ♀ (UCD). TEXAS. Jeff Davis County: Fort Davis, 22-VI-1947, R. H. Beamer, 1 ♀ (INHS). Reeves County: Texas A & M Research Station, Pecos, 17-VIII-1976, S. J. Merritt, 1 ♀ (TAMU), sweeping *Solanum* sp.

***Chromolepida nigra* Webb and Irwin,
NEW SPECIES**

Derivation of name.—*nigra* (Latin) = black.

Diagnosis.—Males of *C. nigra*, like *C. mexicana*, have the distiphallus moderately long and curved and the costal and subcostal cells of the wing hyaline. The males are separated from *C. mexicana* in having the distal half of the gonocoxite reduced and tapered apically in lateral view. Females of *Chromolepida nigra*, like *C. mexicana* and *C. clavitibia*, have dark brown to black halteres. The females may be separated from *C. mexicana* in having the femora dark brown to black and from *C. clavitibia* in having the fore tibia cylindrical rather than distinctly clavate.

Description of holotype male (8815).—Body length 4.7 mm.

Head: Length 0.9 mm. Ocellar tubercle black, pruinose; setae black. Eyes dark reddish brown; medial margin rounded. Frons with medial callus black, glossy, surrounded by narrow band of silver pile; setae dark brown. Antenna dark brown, pruinose; setae black; length of antenna 1.3 times head length; length of scape 0.7 mm, 7.9 times width, 4.7 times length of pedicel; length of pedicel 0.15 mm, 1.4 times width; length of flagellum 0.37 mm, 3.4 times width, 0.5 times length of scape; length of stylomere 0.06 mm. Parafacial dark reddish brown, glossy with silver pile along lateral margins. Maxillary palpus dark reddish brown, pruinose; length 0.37 mm, 7.4 times width; setae white.

Thorax: Macrosetae: np 3. Black, pruinose; pronotal setae pale yellow, filiform and scale-like. Postpronotal setae pale yellow, filiform and scale-like. Prosternal setae white. Pleura dark reddish brown, pruinose; setae white, filiform on propleuron, anepisternum and dorsal third of katepisternum, and scale-like on propleuron, anepisternum, and dorsal third of katepisternum. Scutellum black; setae silver, lanceolate, in band across posterior margin. Laterotergite dark reddish brown, subshiny; setae pale yellow. Wing. Length 3.6 mm, 2.9 times width; dark yellow, opaque, with smoky brown apical band, and at apex of discal and posterior basal cells; pterostigma absent. Halter yellow. Legs. Coxae, tibiae, and tarsi dark reddish brown, pruinose; femora dark yellow, base dark reddish brown, subshiny. Length of fore femur 1.2 mm, 1.6 times length of scape; length of fore tibia 1.2 mm, 1.7 times length of scape; length of hind femur 1.5 mm, 2.1 times length of scape. Setae white, filiform, and scale-like on coxae and femora; dark reddish brown, filiform on tibiae.

Abdomen: Tergites 1–3 dark reddish brown, pruinose; tergites 4–7 yellowish orange, subshiny; dorsal setae silver, lanceolate on tergites 1–3, lateral setae white, filiform on tergites 1–2 and scale-like.

Terminalia (Figs. 32–38) yellowish orange, subshiny. Sternite 8 moderately reduced, posterior margin slightly concave. Gonostylus with lateral hook-like projection. Dorsal apodeme of aedeagus broad anteriorly, anterior edge deeply emarginate, ventral apodeme large, attenuate, pointed anteriorly; distiphallus moderately long, bent at right angle to plane of aedeagus.

Variation in males: Body measurements for males are provided in Table 3. Length of fore femur to length of scape 1.4–2.4, 1.7 ± 0.2 (N = 20); length of fore tibia to length of scape 1.5–2.4, 1.8 ± 0.2 (N = 20); length of hind femur to length of scape 2.0–3.3, 2.4 ± 0.3 (N = 20). In some males the posterior margin of sternite 8 is more deeply emarginate than normal; the lateral projection on the gonostylus is generally slender, although it is short and hook-like in some specimens; and in specimen (8825) the anterior margin of the ventral apodeme of the aedeagus is broadly rounded, rather than attenuated and pointed.

Description of female.—Similar to male with following exceptions. Body measurements for females given in Table 3.

Head: Ocellar tubercle dark reddish brown, pruinose; setae dark brown. Frons with medial callus black, glossy, with dorsolateral circle of black pile and narrow band of silver pile lateral to antennal bases; setae absent. Maxillary palpus dark reddish brown to dark brown, pruinose.

Thorax: Macrosetae: np 3. Dark brown to black, pruinose; setae white and black, filiform, short and scale-like. Pleura dark reddish brown, subshiny, propleuron, kat-episternum, and meron pruinose. Wing. Pterostigma brown. Halter black. Legs. Dark reddish brown, pruinose.

Abdomen: Dark reddish brown, subshiny; dorsal setae silver, lanceolate, across posterior margin of tergite 1, lateral setae white, filiform on tergites 1–2 and scale-like. Terminalia (Figs. 29–31). Sternite (Fig. 30) with narrow, deep median notch posteriorly. Furca (Fig. 31) oval length 0.38 mm;

posterior margin truncate; anterior margins rounded; lateral margins curved.

Seasonal activity and distribution

In the specimens examined, adults were collected throughout the year, only from the southern half of México (Fig. 57).

Specimens examined

Type material.—The holotype male of *Chromolepida nigra* Webb and Irwin (deposited in the Illinois Natural History Survey) (M. E. Irwin Therevidae Specimen Number 8815) was collected 34 km E Villa Union on 1 February 1964 by M. E. Irwin.

Other material.—PARATYPES: MEXICO. Hidalgo: Zimpan, 8-VII-1968, M. W. Wasbauer, J. E. Slansky, 1 ♀ (UCD). Jalisco: Jocotepec, 12-13-III-1972, R. Lavigne, 1 ♀ (UWyo); 19-III-1972, R. Lavigne, 1 ♀ (UWyo); Chamela, 26-30-IX-1985, F. D. Parker, T. L. Griswold, 1 ♀ (USU); 18 km SE Tequila, 20-XII-1963, M. J. Tauber, C. A. Toschi, 1 ♀ (UCB); Plan de Barrancas, 24-III-1962, F. D. Parker, 2 ♀ (UCD). Morelos: Cañon de Lobos, Yautepec, 1219 m, 7-III-1959, H. E. Evans, 2 ♀ (CU); Xochicalco Pyramid, 29-III-1962, F. D. Parker, L. A. Stange, 2 ♂ (MEI, UCD); Yautepec, 28-III-1962, F. D. Parker, L. A. Stange, 1 ♂ (UCD). Oaxaca: 37 km S Matias Romero, 6-IV-1962, F. D. Parker, 1 ♂ (MEI). Puebla: 5 km NW. Petlalcingo, 2-IV-1962, L. A. Stange, 1 ♀ (UCD); 4-III-1972, F. D. Parker, D. R. Miller, 11 ♂ 46 ♀ (INHS, MEI, USNM); 14 km W Izucar de Matamoros, 16-IX-1972, W. Hanson, J. Poff, 1 ♂ (MEI). Queretaro: Alvarado [Queretaro], 15-II-1954, R. R. Dreisbach, 1 ♀ (MEI). Sinaloa: 18 km N Culiacán, 20-V-1962, F. D. Parker, 1 ♀ (UCD); 34 km E Villa Union, 1-II-1964, E. I. Schlinger, 1 ♀ (UCR); 87 km S Culiacán, 185 m, 23-IV-1969, M. E. Irwin, 1 ♂ (MEI), dry wash; 21 km N Mazatlan, 30-I-1964, M. E. Irwin, 1 ♂ (MEI); 24 km S Villa Union, 31-I-1964, 1 ♀ (MEI); 31 km S Villa Union, 31-I-1964, M. E. Irwin, 2 ♂ (MEI). Yucatán:

Puerto Sisal, 25-VII-1964, J. C. & D. Palister, 1 ♀ (AMNH).

Chromolepida pruinosa (Coquillett)

Psilocephala pruinosa Coquillett (1904: 91):

Irwin and Lyneborg (1981a: 260).

Chromolepida pruinosa (Coquillett); Irwin and Lyneborg (1981a: 260).

Derivation of name.—*pruina* (Latin) = hoarfrost, rime.

Diagnosis.—The males of *Chromolepida pruinosa*, like *C. mexicana* and *C. nigra*, have black frontal setae, the wing membrane with brown to black band across apex of wing and apex of discal and posterior basal cells and the gonostylus with a lateral projection. The males of *C. pruinosa* can be separated from *C. mexicana* and *C. nigra* in having the costal and subcostal cells of the wing dark yellow and the distiphallus very short. Females of *Chromolepida pruinosa*, like *C. bella*, have dark yellow halteres. The females may be separated from *C. bella* in having a smoky brown to black band across the apex of the wing and the apex of the discal and posterior basal cells.

Redescription of holotype male (9218).—Body length 5.7 mm.

Head: Length 0.9 mm. Ocellar tubercle black, pruinose; setae black. Eyes dark reddish brown; medial margin sinuate. Frons with medial callus black, glossy, dorsal and lateral pile silver; setae black. Antenna (Fig. 42) dark yellowish brown, flagellum dark brown; setae black; length of antenna 1.1 times head length; length of scape 0.5 mm, 5.0 times width, 4.2 times length of pedicel; length of pedicel 0.12 mm, 1.2 times width; length of flagellum 0.34 mm, 2.8 times width, 0.7 times length of scape; length of stylomere 0.06 mm. Parafacial black, glossy with silver pile along lateral margins. Maxillary palpus (Fig. 43) black; length 0.46 mm, 5.8 times width; setae white.

Thorax: Macrosetae: np 3. Dark black, subshiny; setae dull yellow, filiform and scale-like. Postpronotal setae white, filiform

and scale-like. Prosternal setae white. Pleura black, glossy, propleuron and posterior two-thirds of katepisternum pruinose; setae whitish yellow, filiform on propleuron, anepisternum and dorsal third of katepisternum, scale-like on propleuron, anepisternum, and dorsal third of katepisternum. Scutellum black, posterior margin pruinose; setae silver, appressed, lanceolate in band across posterior margin. Laterotergite black, subshiny; setae white. Wing (Fig. 44). Length 4.2 mm, 3.2 times width; pale yellow, with smoky brown to black apical band, basal fourth of cell r_5 , and apex of discal and posterior basal cells smoky brown, costal and subcostal cells dark yellow; anterior veins dark yellow, posterior veins brown; pterostigma pale brown. Halter dark yellow. Legs. Coxae black, pruinose. Femora dark yellow, subshiny. Tibiae dull brown. Tarsi dark brown. Setae white, filiform and scale-like setae on coxae and femora, dark reddish brown, filiform on tibiae.

Abdomen: Tergites 1–5 black, tergites 6–8 dark yellow, subshiny; dorsal setae white, lanceolate, dense, appressed over tergites 1–5, lateral setae white, filiform and scale-like. Terminalia (Figs. 45–51). Dark yellowish brown, subshiny. Sternite 8 moderately reduced, posterior margin moderately concave. Gonostylus with thin lateral projection. Dorsal apodemes of aedeagus broad anteriorly, anterior margin truncate; ventral apodeme broad, anterior margin broadly rounded, anterolateral border with ventral projection; distiphallus short, reduced, sinuate.

Variation in males: Body measurements for males are provided in Table 3.

Description of female.—Similar to male with following exceptions. Body measurements for females given in Table 3.

Head: Ocellar setae absent. Frons (Fig. 52) with black, subshiny, medial callus with dorsolateral circle of black pile and narrow band of white pile lateral to antennal bases; setae absent. Parafacial callus broader than in male.

Thorax: Macrosetae: np 3. Wing. Membrane pale, opaque brown, much darker than in males.

Abdomen: Black, subshiny; dorsal setae whitish gray, filiform across posterior margin of tergites 2–3, black, filiform, moderately long on tergites 4–8 black, and scale-like on tergites 1–3, lateral setae white, filiform on tergites 1–3, black, filiform on tergites 3–8. Terminalia (Figs. 53–55). Sternite 8 (Fig. 54) rather long and narrow, posterior margin with deep median notch posteriorly. Furca (Fig. 55) subrectangular; length 0.38 mm; posterior and anterior margins broadly rounded; lateral margins rounded.

Seasonal activity and distribution

In the specimens examined, adults were collected from 8 October to 6 May with the majority of specimens collected during February, March, and April. Specimens have been collected on bean leaves, but most specimens were collected by Malaise traps. *Chromolepida pruinosa* has been collected from Nicaragua south to Colombia and east to Guyana (Fig. 58).

Specimens examined

Type material.—The holotype male of *Psilocephala pruinosa* Coquillett (U.S. Museum of Natural History, Type No. 7795) (M. E. Irwin Therevidae Specimen Number 9218) was collected at Granada, Nicaragua by Baker.

Other material.—COLOMBIA. Magdalena. 3 km E Santa Marta, 1-VIII-1973, P. A. Rauch, 1 ♀ (MEI); Santa Marta, 8-X-1971, G. E. Bohart, 1 ♀ (INHS). COSTA RICA. Alajuela. Bijagua, 7-III-1991, F. D. Parker, 1 ♀ (DEI). Guanacaste. 10 km SW San Miguel, 21-II-1991, D. W. Webb, M. E. Irwin, 11 ♂ 16 ♀ (CSDA, CSIRO, DZSA, FMNH, INHS, INIA, IOC, LACM, MEI, MPM, MSU, NSDA, PSU, SDNHM, UBC, UCVM); 22-II-1991, 20 ♂ 19 ♀ (CNC, DZSA, EEA, IML, INHS, IOC, LMM, MEI, UG, UNLP, WSU); 23-II-1991, 6 ♂ 16 ♀ (INHS,

MEI); 25-II-1991, F. D. Parker, 1 ♀ (INHS); 26-II-1991, 1 ♀ (INHS); 27-II-1991, 2 ♂ 2 ♀ (INHS); 28-II-1991, 3 ♂ 1 ♀ (INHS); 1-III-1991, 1 ♂ 1 ♀ (CSDA, INHS); 10-III-1991, 6 ♂ 9 ♀ (CNC, FMNH, INHS, MEI); 12-III-1991, 1 ♂ 1 ♀ (INHS, INIA); 13-III-1991, 3 ♂ 5 ♀ (BMH, CSDA, INHS, IRSN, NHW, NMP, NRS, PAS, UG); 14-17-III-1991, 8 ♂ 7 ♀ (ASU, BMNH, BYU, INHS, MCZ, MNH, MNHN, NMB, SMN, UTA, UZM, ZIR); 18-III-1991, 1 ♂ 1 ♀ (UCM, UCR); 19-20-III-1991, 6 ♂ 3 ♀ (AMNH, ASU, BYU, CAS, CU, MCZ, NMB, UCM, UTA); 21-22-III-1991, 7 ♂ 4 ♀ (ANSP, CAS, INHS, UCB, UCR, Uida, UWisc); 23-24-III-1991, 3 ♂ 2 ♀ (INHS, OSM, SEM, UA); 25-27-III-1991, 8 ♂ 4 ♀; 29-III-1991, 1 ♂ 4 ♀ (FSCA, INHS, IowaSU, KSU, NMSU, OSDA, OSU, TAMU, UA, UCYM, UMinn, UWyo); 31-III-1991, 2 ♂ 8 ♀ (CUS, FSCA, INHS, IowaSU, KSU, NMSU, OSDA, SEM, UCVM); 1-IV-1991, 3 ♀ (EI, INHS, RNHL); 2-IV-1991, 3 ♂ 1 ♀ (DEI, DSIR, MNHN, NMP); 3-IV-1991, 2 ♂ (IRSN, PAS); 4-5-IV-1991, 1 ♂ 3 ♀ (BMNH, CSIRO, INHS, MNH); 6-IV-1991, 1 ♂ 1 ♀ (MMB, NRS); 7-IV-1991, 1 ♂ 1 ♀ (RNHL, SMN); 8-12-IV-1991, 1 ♂ 2 ♀ (EI, UTI, ZSI); 15-IV-1991, 1 ♂ 1 ♀ (AMS, MMB); 17-IV-1991, 1 ♀ (IAS); 19-IV-1991, 3 ♂ 1 ♀ (AMS, IAS, KIK, ZIR); 19-20-III-1991, 1 ♀; 22-IV-1991, 2 ♀ (KUK, UZM); 24-IV-1991, 1 ♂ (ZSI); 2-V-1991, 1 ♂ (UTI); Palo Verde National Park, 34 km SW Cañas, 2-II-1984, S. A. Cameron, 1 ♀ (SEM); South of Cañas, 26-31-I-1989, W. L. Rubink, 3 ♂ 5 ♀ (USU); 1-3-II-1989, 2 ♂ 1 ♀ (USU); 9-14-II-1989, 4 ♂ 3 ♀ (INHS, USU); 7-10-III-1989, 1 ♂ 1 ♀ (INHS, USU); 21-25-I-1989, F. D. Parker, 2 ♂ 4 ♀ (INHS, USU); 25-31-I-1989, 5 ♂ 1 ♀ (INHS, USU); 9-14-II-1989, 3 ♂ 8 ♀ (INHS, USU); 16-20-II-1989, 4 ♂ 4 ♀ (INHS, USU); 22-24-II-1989, 2 ♂ 1 ♀ (USU); 25-II-8-III-1989, 1 ♀ (USU); 25-28-II-1989, 1 ♀ (INHS); 1-5-1989, 1 ♂ 2 ♀ (INHS, USU); 7-10-III-1989, 3 ♂ 2 ♀ (USU); 18-22-III-1989, 1 ♀ (USU); 4-6-V-1989, 2 ♀ (INHS); La Taboga Forest Reserve, 9 km SW Cañas, 17-27-II-

1987, W. L. Rubink, 3 ♂ 3 ♀ (INHS, USU); 18-20-III-1987, 1 ♀ (USU); 17-27-II-1987, 1 ♂ 9 ♀ (INHS, USU); 14 km S Cañas, 11-31-I-1990, F. D. Parker, 1 ♂ 1 ♀ (INHS, USU); 1-11-II-1990, 10 ♂ 5 ♀ (INHS, USU); 15-22-I-1990, 1 ♀ (USU); 15-24-II-1990, 1 ♀ (INHS); 1-12-III-1990, 1 ♀ (DSIR); South Cañas Experiment Station, 8-18-III-1988, F. D. Parker, 1 ♂ 1 ♀ (USU); E. J. N. Agricultural Station, 11 km S Cañas, 11-31-I-1990, F. D. Parker, 1 ♀ (USU); 14-III-1990, 1 ♀ (USU); 10 km S, 10 km W Cañas, Taboga 10° 19' N, 85° 09' W, 3-12-II-1967, 1 ♀ (USU); Hacienda La Pacifica, 6 km N Cañas, 20-21-III-1987, R. W. Thorp, 1 ♀ (UCD); 22-23-III-1987, 1 ♂ 1 ♀ (UCD). San Jose. Escazu, 24-30-I-1988, F. D. Parker, 1 ♂ 1 ♀ (USU); 1-7-II-1988, 4 ♂ 4 ♀ (INHS, USU); 7-14-II-1988, 2 ♂ 7 ♀ (INHS, USU); 14-21-II-1988, 1 ♀ (USU); 22-II-3-III-1988, 3 ♂ 1 ♀ (USU); 3-III-1988, 1 ♂ (USU); 4-7-III-1988, 1 ♂ 3 ♀ (USU); 8-18-III-1988, 2 ♀ (USU); 21-27-III-1988, 1 ♀ (BMH); 19-24-III-1988, 1 ♀ (USU); 26-III-1988, 1 ♀ (USU); 29-III-3-IV-1988, 1 ♂ 3 ♀ (INHS, USU); 1-8-IV-1988, 1 ♂ 5 ♀ (INHS, USU); 4-10-IV-1988, 1 ♂ 2 ♀ (USU); 11-18-IV-1988, 1 ♀ (USU); 16-18-IV-1988, 1 ♂ (USU); 19-24-IV-1988, 1 ♀ (USU); 25-30-IV-1988, 1 ♂ 12 ♀ (INHS, USU); 2-13-V-1988, 4 ♀ (INHS, USU); 23-26-VI-1989, 1 ♂ 3 ♀ (USU); 8-II-1987, G. E. Bohart, 1 ♀ (USU); San Pedro de Montes de Oca, -V-1987, M. Garcia, 1 ♀ (INHS); San Antonio de Escazu, -IV-1987, W. Everhard, 1 ♀ (INHS). GUYANA. Upper Rupupanni, -II-III-, Ogilvie, 1 ♀ (MCZ). NICARAGUA. Granada, Baker, 1 ♂ (USNM); La Calera, Managua, 13-III-1964, L. Saenz, 1 ♀ (USNM), on bean leaves. VENEZUELA. Aragua: Pozo Diablo Creek, Maracay, 500 m, 10-IV-1961, M. Gelbez, 1 ♀ (UCVM); El Limón, 450 m, 24-IV-1963, E. Osuma, 1 ♂ (MEI); Puerto de Cata, 10-11-VI-1976, A. S. Menke, D. Vincent, 1 ♂ 2 ♀ (MEI, USNM); 2 km N Ocumero de La Costa, 12-VI-1976, A. S. Menke, D. Vincent, 1 ♂ (USNM). Guarico: 12 km S Calabozo, 6-12-II-1969, P. & P. Spangler, 2 ♀

(USNM), blacklight. Zulia: 6 km W La Concepción, 18-VI-1976, A. S. Menke, D. Vincent, 1 ♂ (USNM); Carrasquero, 15-VI-1976, A. S. Menke, D. Vincent, 1 ♀ (USNM).

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NOTE

Lectotype Designations for Two Lace Bugs
Described from the United States
(Heteroptera: Tingidae)

At the request of J. Péricart, who is preparing the Tingidae chapter for the upcoming *Catalogue of Palaearctic Heteroptera*, the National Museum of Natural History collection at the Smithsonian Institution was searched for the available specimens in the type series of two species that were described from the United States but have since proven to be junior synonyms of Old World Species. To be able to maintain the format of the new catalog, it is necessary to designate a lectotype for each of these two species names.

Leptobyrsa explanata Heidemann (1908, Proceedings of the Entomological Society of Washington 10: 105) [a junior synonym of *Stephanitis rhododendri* Horvath, 1905, Annales Historico-Naturales Musei Nationalis Hungarici 3: 567, synonymy by Champion, 1916, Entomologist' Monthly Magazine 52: 207]. The original description included reference to "several specimens, male and female . . ." from several eastern United States localities, and then followed with a paragraph "Type (Rock Creek, D.C., July 6, 1987, female and male.—No. 9909, U.S.National Museum." Here the assumption is made that Heidemann intended to separate his series into two sorts of types, the two Rock Creek specimens to have dominance. Accordingly, the male labeled "Rock Creek, D.C. 6-7-97"; "O. Heidemann Collector"; "*Leptobyrsa explanata* Heidem. on *Kamia* [sic] *latifolia* [with O.H. in lower left corner]"; and "TYPE No. 9909" is here designated the lectotype. The type number label was added by persons unknown. Heidemann's interpretation of the date must be accepted because he wrote that label.

The remaining members of the type series found in the collection are designated as paralectotypes and include specimens labeled: 1 ♀, same collecting data as lectotype; 1 ♂, "8690 on *Rhododendron maximum*" "Kovcona, N.C., Sanderson, July 29-99"; 1 ♂, 1 ♀, "7531 Hopk., W. Va." "Tibbs Run, Dellslow, W. Va." 1 ♂, 1 ♀; 1 ♀, Black Mts., N.C. VI/24" "Beutenmuller, Am. Mus. Nat. Hist., N.Y." Several other specimens at hand have the same localities reported with the original description but have different dates.

Sphaerocysta Peckhami [sic] Ashmead (1887, Entomologica Americana 3: 155), a junior synonym of *Galeatus spinifrons* (Fallén) (1807, Monographia cimicum Sveciae, page 38); to synonymy under *Galeatus angusticollis* Reuter, 1874, by Drake and Ruhoff (1961, Bulletin of the Southern California Academy of Sciences 60: 163), then the latter species was made a junior synonym of *Galeatus spinifrons* by Drake and Ruhoff (1962, Studia Entomologica 5: 490). The two specimens referred to in the original description are present. The male, here designated lectotype, is labeled "Milwaukee, Wis."; "Collection Ashmead"; "Type"; "Galeatus (*Sphaerocysta*) Peckhami Ash."; "TYPE No. 9910 U.S.N.M." The first two labels are in print, the next two are in Ashmead's handwriting, and the "TYPE No." label was added subsequently by an unknown person. The second specimen, a female here made a paralectotype, has the two labels in print, "Milwaukee, Wis." and "Collection Ashmead" and labeled "Type" in Ashmead's handwriting.

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Richard C. Froeschner, *Department of Entomology, MRC-105, National Museum of Natural History, Washington, D.C. 20560.*

NOTE

Heinrichiessa sanpetella Neunzig (Lepidoptera: Pyralidae) is an
Inquiline in Juniper Midge Galls (Diptera: Cecidomyiidae)

Imbricate midge galls we collected from western juniper (*Juniperus occidentalis* Hook.) in Oregon (Grant Co., Mount Vernon, elev. 1370 m, XI-1992) and "fruit"-like midge galls from alligator juniper [*Juniperus osteosperma* (Torr.)] in Arizona (Pinal Co., Oracle, elev. 1700 m, V-1993) contained larvae of a moth recently described and known from only five specimens collected in central Utah, *Heinrichiessa sanpetella* Neunzig (1990. The Moths of America North of Mexico, fasc.15.3: 98) (Pyralidae: Phycitinae). Heretofore the host plant of larvae of this lepidopteran was unknown. Our records extend the moth's known range from the Utah type locality 900 km northwest to central Oregon and 800 km south to Arizona.

The Oregon artichoke-like galls are presumably generated by larvae of a *Walshomyia* sp., and probably undescribed (Gagné 1989. The Plant-Feeding Gall Midges of North America. Cornell University Press, Ithaca). Three other *Walshomyia* spp. are implicated by Gagné in formation of "fruit"-like juniper galls, but he gives no Arizona records and none from alligator juniper. The

inquilinous *H. sanpetella* larvae, found in approximately 20% of the Oregon galls and 4% of the Arizona galls, do not coexist with conspecifics nor with (solitary) gall maker midge larvae. They overwinter as larvae and pupate in early spring.

Vouchers of all life stages of this lepidopteran are held by F.F.P. at Ohio State University, Columbus.

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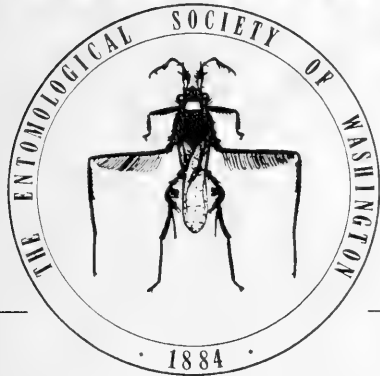
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PROCEEDINGS

of the

ENTOMOLOGICAL SOCIETY of WASHINGTON



PUBLISHED
QUARTERLY

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OF WASHINGTON

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FOREWORD

Beginning students of miridology soon learn that the Carvalho "Catalog of the Miridae of the World" is the bible of their science. Long before we ever met José, we knew him through his hundreds of papers, keys to the genera of the world, but, most of all, through his indispensable world catalog. Before Carvalho, the mirid literature had grown enormously over the previous century and a half and was inaccessible to most researchers, except for a few specialists (e.g. H. H. Knight and E. Wagner), who de-

scribed large numbers of taxa in many small, scattered papers. The appearance of the Carvalho catalog opened up a new era in mirid research, providing new students a quick grasp of the world literature.

Scientists such as José Carvalho come along only once in a great while. His more than 500 published papers and descriptions of nearly 400 genera and more than 2000 species reflect an unusual enthusiasm and self determination. To put things in a little better perspective, José described more spe-



Fig. 1. Heteropterists in attendance at XV International Congress of Entomology, Washington, D.C., 1976. [top row, left to right] Reece I. Sailer. José C. M. Carvalho. John D. Lattin. Peter D. Ashlock. Merrill H. Sweet. Cecil L. Smith. B. Jane Harrington. Alfred G. Wheeler, Jr. James A. Slater. [bottom row] René H. Cobben. Joseph C. Schaffner. Randall T. Schuh. Thomas J. Henry. Ryuichi Matsuda. Harry Brailovsky.

cies of Miridae than are known for all of Canada and the United States. Perhaps just as remarkable are José's numerous activities outside of mirid research. He held many offices and positions—from President of the International Congress of Entomology to Director of the National Museum of Natural History in Rio de Janeiro. One only has to read about his diverse extracurricular activities (see articles in this volume by his wife Milza and brother Marcio) to be in awe of this man's accomplishments.

We first met José at the 1976 International Congress of Entomology held in Washington, D.C. (Fig. 1), where he became president-elect for the 1980 congress scheduled for Kyoto, Japan. Despite his many accomplishments, this renowned scientist had time to talk to two beginning students and share with us his vast knowledge and enthusiasm for Miridae. Throughout the years since that meeting, we grew to admire José for his seemingly endless desire to make the Miridae better known. In 1985, he hosted one of us (TJH) for six weeks in Brazil. His hospitality and help in making arrangements to collect and visit various Brazilian museums made this trip wonderfully pleasant and productive. That time spent with José made it easy to see how focused he was on his science.

In 1992, we were reminiscing about our careers in entomology and our modest beginnings in miridology, when José Carvalho's name came up. We realized José had been publishing on Miridae for more than 50 years and would turn 80 in June of 1994. That afternoon, we decided to organize a Festschrift in his honor. Unfortunately, it took us a little longer than we anticipated, and sadly he is not here to receive this collection of papers written in his honor (José died October 21, 1994). This volume is therefore dedicated to his memory and his great accomplishments.

We thank all of the authors who contributed papers for this occasion. We are especially appreciative of Milza Carvalho, Marcio Carvalho, and S. P. Fiuza Ferreira for their personal tributes to José. Their articles allow us to see more into the man behind the scientist. We also are grateful to Iara Maria Carvalho for her help in coordinating correspondence, editing, and obtaining photographs for the introductory articles, and to the Entomological Society of Washington for allowing us to devote this entire issue of the *Proceedings* to the memory of Dr. José Candido de Melo Carvalho.

Thomas J. Henry
A. G. Wheeler, Jr.

JOSÉ CANDIDO DE MELO CARVALHO—A WIFE'S VIEW

MILZA CARVALHO

Rio de Janeiro, Brazil

Thomas J. Henry asked me to write a paper for the volume honoring José. After 54 years of marriage, I wondered if I could do justice to him. He was a person of many accomplishments and numerous facts certainly have been left out of this writing. What I have written only touches on his outstanding and productive career. Letters from his grandmother (1923) and from his father, which we still keep today, aided me in recalling much about his early years. Also his personal letters (1938-1973) helped me recall certain details of his scientific career.

José was born on June 11, 1914, on a farm named Saint Joséph in Conceicao Aparecida Village (the popular name was Barro Preto=Black Mud), a District of Carmo do Rio Claro City in the southern part of Minas Gerais. His parents and grandparents were farmers, and his mother died when he was 5 years old. His father married again some years after. José was raised among eight brothers and sisters. He spent his childhood on the farm, where he learned to love nature, animals and, in particular, insects. An oxcart driver and fisherman named Sebastiao Pereira, who worked at the farm, was his idol. They used to go together to the virgin forests existing then to watch wild animals and take native honey.

José obtained his primary (elementary) education from Lady Lia (Teacher Lia) at the Diocesano School in Minas Gerais. His father had in his library the "Natural History of Buffon," which José loved and read; undoubtedly, this book contributed to his interest in zoology. He attended Champagnat High School in Franca, Sao Paulo, and during this time, he lived with his uncle

Antonio Candido de Melo Carvalho. There he traveled from the farm to school, carrying his briefcase and books by horse. In high school, he read a lot of "Tesouro da Juventude = Youth's Treasure," an encyclopedia containing facts and curiosities of the world in general, which had a big influence on him.

By 1930, a great recession occurred in Brazil and the situation for farmers, including his father, became very bleak. Under the advice of his grandmother and stepmother, his father decided to enroll him at the Viçosa Agricultural and Veterinary University to study agriculture and learn more about modern farming methods. After finishing this program in 1933, he returned to the farm to work with his father for two years before again entering school at Viçosa to pursue studies in Veterinary Science. There, José was greatly influenced by Ruy Gomes de Morais, a parasitologist, and Joao Moojen, a zoologist. During this time he entered sports, participating in Brazilian and South American championships. In 1936 he took his talents to Paris, representing Brazil in the Youth Olympic Games and won 4th place in the pentathlon.

He finished his degree in 1938. During these years he specialized in studying ticks with Henrique de Beaufort Aragao at the Oswaldo Cruz Institute. The first year after graduating, he taught at Viçosa and during one of the visits to our hometown, he went to my father's farm to instruct the local people on how to control some dangerous ants that were plaguing the plantation. In 1939, we married after a long friendship.

In August 1940, José received a schol-

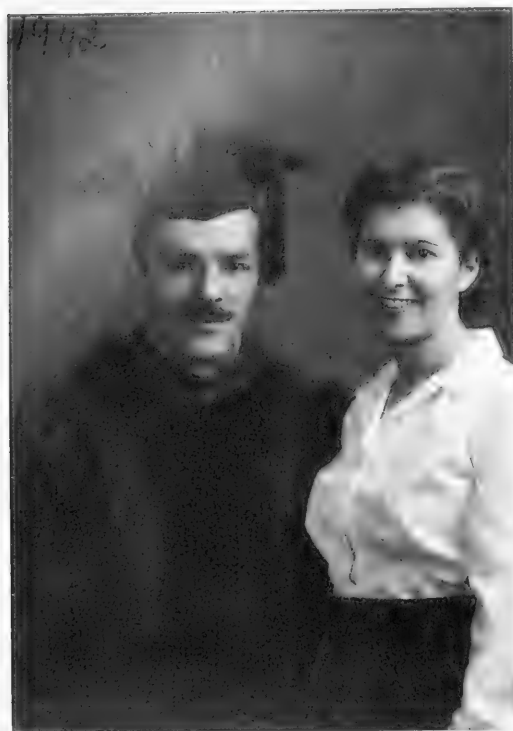


Fig. 1. José and Milza Carvalho, Iowa State College, Ames, Iowa, 1942.

arship to the University of Nebraska. We traveled to the United States in a cargo ship that carried only a few passengers. It was a hard trip lasting 28 days, with stops at many port cities along the Brazilian and Venezuelan coasts. We arrived in New York and took a Greyhound bus to Nebraska. Mrs. Snipes (the mother of Dr. Snipes, a well-known professor from Viçosa) was waiting for us. She arranged for an apartment to rent and gave us a basket full of "Brazilian" and American food, including types we had never seen before. I'll never forget her kindness. Soon José met with his major Professor, Dr. Harold Manter, a parasitologist. José brought some birds stuffed with straw to give to the university and specimens of Gordiacea, which were to become his graduate research group.

During our stay in Nebraska (1 year) José received from Burbank, California, a letter

that had great influence on his life. It was from the ex-director from Viçosa University, Dr. John B. Griffing, who said "To nearly all of my friends from Viçosa University I advise not to bother about degrees or even grades, but in your case the advice is different. You have the rare gift of research and scholarship, so I do hope that the way may be opened for you to take both the Master's and Ph.D. also. This would enable you to gain much more international recognition for your future in Brazil."

From Nebraska we moved to Ames, Iowa, to pursue graduate work at Iowa State College (2 years). José met Drs. Carl J. Drake, Harry H. Knight, and Halbert M. Harris. During this time, he received only \$100 a month. An encounter with Dr. Knight, who claimed that he could not identify a bug, left José despaired. Dr. Drake came to his rescue, however, and borrowed some Miridae from the Carnegie Museum in Pittsburgh. As a result, José's first mirid paper was with Dr. Drake. From then on, the Miridae became his life-long pursuit. He successfully defended his thesis on the genus *Eimeria*, under parasitologist Ellery Becker.

Life during José's graduate years are still vivid. I remember Homecoming Day and all the ceremonies at Iowa State. I also remember the day that the United States declared war on Japan.

Finally it came time for us to return to Brazil. On the way, we stopped in Florida to visit Dr. P. H. Rolfs, the founder of Viçosa University. It was difficult to get transportation to Brazil, especially because of World War II then in progress, but we managed to get tickets on a Chilean ship that sailed from New Orleans to Valparaiso, Chile, crossing through the Panama Canal. The return was made by convoy, with our ship sailing in the middle. We had to stay in collective and separate rooms. We weren't allowed to listen to the radio or make noises and at night no lights or cigarettes were allowed because of the bombing threat. On the way, the ship stopped in Guayaquil,



Fig. 2. José Carvalho with Kamaiuná children, Xingú, Pará, Brazil, 1947.

Lima, and Arica. At Arica the ship stopped for eight days, so we traveled to La Paz and returned to Arica before resuming. Arriving in Valparaiso, we crossed the Andes to Montevideo, and then completed the last part of our trip by train to Sao Paulo. The whole trip lasted three months and 11 days. During this long and sometimes difficult trip José managed to visit several museums and meet with zoologists.

Back to Viçosa, José taught zoology, biology, and animal parasitology. Life was quiet. During this time he received from the United States a letter stating that "You are being considered for a position as a Commissioned Officer in the Army." This news made him very happy, although, of course, as a Brazilian citizen, he could not accept. In 1946 we moved to Rio de Janeiro, where José became a zoologist at the National Mu-

seum of Natural History. He was motivated to work hard by the lack of a good library, adequate collections, and, above all, by the lack of well-trained staff members. During this time, he received an invitation to become a researcher at the North Agronomic Institute, and from Dr. Melo Barreto to take a zoologist's position at the Rio de Janeiro Zoo (a position he accepted and kept until 1952).

Our daughter, Iara, was born in 1947. Two years later, José ventured on an expedition to the Rio Negro (Amazon Region). We were unable to accompany him on this trip because the region was too wild and primitive. Other expeditions to the Amazon Region followed: in 1950 to the Javari, Itacoari, and Jurua rivers, and in 1952 to Paru de Leste River. He traveled extensively throughout

the Amazon Region, collecting many bugs and studying zoology.

In 1949, he was elected a member of the Brazilian Academy of Science. That same year, he traveled to England to study with W. E. China at the British Museum (Natural History). Again Iara and I weren't able to follow because life was hard so soon after World War II. In Europe he visited many museums and researchers in Austria, Belgium, France, Germany, Italy, Portugal, Scandinavia, and Switzerland. He attended the International Congress of Entomology in Amsterdam and published with Eduard Wagner. Back in Brazil in August 1951, he was offered by O. Monte's widow the chance to buy her husband's well-known tingid collection, which, of course, he purchased.

He worked at the Museum in Rio with bugs until 1953 when he received a Fellowship from the Guggenheim Memorial Foundation to work on his world catalog in the United States. Iara and I were able to accompany him on this trip. We traveled on a ship from the Moore McCormick Company, which was much more comfortable than our previous trip in 1940 (only 15 days this time) from Rio de Janeiro to New York. In Washington, José worked with Dr. Reece I. Sailer at the National Museum of Natural History. He also met Harry G. Barber, and Drs. Dave A. Young and R. E. Snodgrass. From Washington, we traveled to Ames, Iowa, where José worked with Dr. Knight for one year and then to Berkeley, California, where he worked with Dr. Robert L. Usinger for a few months. Iara attended school in Ames and Berkeley. She learned to read and write first in English, then in Portuguese. During this time, we crossed by car, visiting such National Parks as Yellowstone, Yosemite, and the Grand Canyon. José studied his bugs, visited museums, and worked with other zoologists the whole time. We spent the final months of 1954 back in Washington, D.C., where José was occupied with activities linked to the completion of his World Mirid Catalog and research with

Reece Sailer on Pentatomidae. That Christmas, we bought our first TV set. In March 1955, we took another Moore McCormick ship back to Brazil.

In June 1988, José began cooperative work with the Amazon National Institute for Research and became Director of the Goeldi Museum in Belem, Para for several months. Soon after, he was appointed Director of the National Museum in Rio de Janeiro, a position he held for two terms, six years all together. The Museum was already old at that time and in much need of repair. José was instrumental in the Museum's renovation and the creation of many new and innovative exhibits. He continued to publish many more papers and made numerous other expeditions to the interior of Brazil to collect bugs.

In 1972, the Brazilian Foreign Affairs Ministry chose José to represent Brazil at the World Conference on Environment in Stockholm. In January 1973, we traveled to College Station, Texas, where José worked with Dr. J. C. Schaffner at Texas A & M University. In late 1973, he received an invitation from Dr. D. F. Waterhouse to work at the Division of Entomology, CSIRO, in Canberra, and again José and I traveled afar. We had an exciting trip, visiting museums and the major cities of Australia. In 1978, he was elected President of the Brazilian Academy of Zoology and, from 1980–1984, he served as President of the International Congress of Entomology, held in Kyoto, Japan. As a result of all this travel, he earned the nickname of "globetrotter" from his colleagues!

Among his other activities were: Director of the Museum Paraense E. Goeldi (1954–1955); Director of the National Museum (1955–1961); Naturalist Museum (1946–1984); Brazilian Foundation for Conservation of Nature (1966–1969, 1979–1984); National Research Council (1962–1964); Brazilian Institute for Development of Forestry (1961–1964); Federal Council of Culture (1974–1985); Zoological Garden (1946–

1972); Permanent Commission for the International Congresses of Entomology (1951–1980), President (1980–1984); Association of Tropical Biology (1965–1967); International Union of Conservation of Nature (1963–1970, 1976–1981); and Group for Studies on Environment of the Vale do Rio Doce Company (1980–1991). He was made an honorable member of the Zoological Society of London, the Royal Entomological Society, and the International Congresses of Entomology, as well as many other societies. In addition, more than 45 animals—either species or genera—were named after him.

After such a demanding career and many trips, not to mention some aging, his heart began to give him problems. In September of 1982, we flew to Cleveland, Ohio, for an operation on the mitral valve of his heart. For José, this was only a minor setback and,

upon recovery, he started to work again as hard as ever.

In Brazil, 70 is the mandatory retirement age for government employees, so in 1984 he retired. José was able to maintain his research office at the museum where he continued working every day. In 1989, he developed a blood clot in the right leg, but he recovered quite well after surgery and continued working at the Museum. In 1992, he broke his femur, which left him in a wheel chair. Even so, he continued working at home every day with his bugs, microscope, and correspondence to scientists around the world until October 21, 1994.

I can say that it was very special to have shared my life with such an intelligent and capable husband. His willingness to help students and people, and his determined way of working and studying greatly enriched my life.

THE MAKING OF AN ENTOMOLOGIST

MARCIO ANTONIO DE CARVALHO

Belo Horizonte, Brazil

The following is an outline of the early years and family life of José Candido de Melo Carvalho, as remembered by me, with the aid of relatives (stepmother: Candida Vilela Carvalho (1892-); half brothers: Bolivar (1923-) farmer, Cassio (1925-) farmer, and Marcio (1936-) commercial pilot; half sisters: Mariana (1924-) farmer's wife, Gilda (1927-) farmer's widow, Lucia (1929-) retired teacher) and his own notes. It is with great pleasure that we present this information on such an accomplished man and good brother.

We believe the report that follows is an accurate description of what we know about José. Some topics may be hard for conservationists to appreciate, but these activities occurred in the 1920s in an aggressive environment where such things were different than they are today.

José, best known by family and friends as Zezinho (Joseph or Joe), was born on June 11, 1914. He was the first of two sons from the first marriage of our father. His mother, Ano, died prematurely in 1919, leaving five-year-old José and three-year-old Mauricio (1916-1973). Father married again in 1922, giving José six step brothers and sisters. The family was large, with uncles from both sides numbering 26.

A description of the environment near José's home is necessary to understand his interest in nature. The area where our family of European descent settled was in the farmlands of Carmo do Rio Claro in Minas Gerais, approximately 230 miles NW of Rio de Janeiro, Brazil. This area, with mild irregular topography at an altitude of about 2300 ft, was developed during the 1800s and consists of partially cut semitropical

forests. People in this part of the world were wise enough to preserve some untouched parts of forests as reserves. Unfortunately, devastation came after 1945. Our grandfathers used the land for mixed cultivation and grazing cattle. The climate in this region is very mild with temperatures varying mostly between 60° and 80°F. The dry winters during May, June, and July have occasional lows around 30°F, with some frost, but they are absolutely snow free. The rainy season occurs from October to March with a maximum temperature of 90°F. Because of this climate and location, the vegetation is rich and the wildlife plentiful. Before 1945, you occasionally heard of farmers losing cattle to attacks by jaguars. Snakes were common, including rattlesnakes, urutu, jararaca, and corals. As a consequence, snakebites were common. We hunted deer, paca, (*coelogenys paca*), water-hogs, and other animals. There are also many different birds, and the rivers, streams, and marshes were plentiful with fish and caimans.

Nearly all of the goods we needed were produced locally on our farms. As a result, it was necessary for us to import only a few things such as salt, sugar, basic tools, some clothing, and medicine. Our main transportation was by horse and mule. For transporting cargo, we had two large big-wheeled wooden carts, each pulled by six to twelve oxen. Our farm had an orchard and garden that also included medicinal plants and flowers.

We raised cows for milk and sheep for wool; we also had oxen, horses, mules, and donkeys to sell and for work around the farm. Our father had an ass that had only a single eye and, thus, gave him the name



Carvalho family in Rio de Janeiro, 1985. José Carvalho (back), Milza (second row, left), daughter Iara Maria (second row, right), granddaughter Lilian (front row, left), grandson Leonardo (front row, right).

Camoes (after the famous one-eyed Portuguese Poet). Our primary crop was coffee, followed by maize, rice, beans, cotton, sugarcane, and others. The houses were masonry and quite large to accommodate our sizable families.

Hard work was the norm for everyone, including young children. Riding horses was a natural part of country life. Chores included gathering eggs, helping handle the bullocks and shepherding, caring for livestock, and helping raise the crops.

Our grandfathers were a great influence in the education of our family. In our city we had a good nun's college that taught the ladies to become teachers. But the boys had to travel quite a distance to the best high school. Our father and uncles provided considerable knowledge of the sciences, language, music, and religion. In our home we had a bookshelf containing books on varied subjects, including "Natural History" by Buffon that José began reading at an early age. He received a good perspective from his uncles too, who we visited regularly. On Christmas, New Years, Easter, and "City Dedication Day" everyone went to the city for religious activities. This was a good opportunity to visit with cousins and other relatives. Of course the farms had many em-

ployees, and we usually had one of them as a special friend. One of José's first teachers of botany and zoology was such a man, Sebastiao Pereira, our father's "ox cart man." He knew a great deal about nature, particularly the forest, and taught him much about the life there. Nearly every Sunday, they went hunting, fishing, looking for honey, and observing vegetation, birds, and animal signs. This knowledge, besides provoking José's interests, proved particularly important for him later as a researcher, when he went on to explore by himself large areas of the Amazonian forest, as well as other parts of the world. At this time, however, José was being raised to become a farmer.

No doubt José was born a man of great intellect and strong body (6 ft). This was apparent later by his success at college and accomplishments as an athlete. Somehow he remembered having received supplemental feeding on mare and donkey milk as a child. José was quite precocious, and he learned to walk unassisted at seven months. At age three, our father had confidence enough to allow him to go alone on horseback from our farm to the city, a distance of more than 15 miles. A cousin of the same age remembers him finding a bird's nest on a visit to an uncle's farm. He was so young that his coordination wasn't well developed and he inadvertently stepped on the nest. After a few tears, he went on to examine the broken eggs and offspring. After their mother's death, José and Mauricio were cared for between 1919 and 1922 by their aunt Mariana, who became extremely devoted to them. That aunt and another one lived on farms in another city 100 miles away. There José became better acquainted with 16 of his cousins.

After their father's marriage to our mother, they returned to the farm to get to know the new family. Our mother, still alive today at 102 years, and the two stepsons became great friends. Our mother's immediate response to what José was like as a young boy, was "Very good boy, never teased (Nunca Amolou), very good." At that

time, the region received mail by railroad that was about 30 miles away. From the train station a postman delivered the mail by donkey to our city and farms. One of José's first jobs was going to an uncle's farm every other day to bring correspondence and newspapers.

As we described earlier, the area where we lived was rich in wildlife. Needless to say, some parts of it were dangerous because of the high concentrations of venomous snakes. Snakebites were a serious problem, so these parts of the farm were forbidden to the children. One of the forbidden places was a stream (Ribeirao), about a half mile from the farmhouse where the banks were covered with high vegetation and where snakes were particularly abundant. Well, José was a good boy, but one day when our father was away, José went fishing at the brook despite all warnings. He caught a good string of fish and returned to the farmhouse. Unfortunately for José, he and his father arrived together and, no doubt, the fish went flying in all directions. But as an indication of his determination, after the consequences of the encounter subsided, José picked up the fish one by one, went to the kitchen, and asked his stepmother to "please fry these fish for me!"

Until he went to high school, José helped with farm work, learning well his probable future profession as a farmer. He remembers the first Ford car that arrived in the region in 1923. In the late 1920s, dad bought a car, named Oakland. The real political power in small cities of our country was the priest (vigario), a position ranked even above the mayor. After José finished elementary school, dad, convinced that his son should become a priest, sent 8-year-old José to seminary (1923–1924). The life there was of course devoted to religious studies and hard discipline from early morning to bedtime. José, however, didn't like the new life. During his second year at the seminary, he developed an intestinal infection and his health was affected to such a degree that dad went to see him. Looking at his son's situ-

ation, the old man's heart softened to the extent that he changed his plans and sent him to public high school in a city near an uncle's farm. The time in the seminary did instill discipline and patience in José, and resulted in a good basic high school education.

In 1930, our state and the state where José and Mauricio attended high school, were adversaries in national politics and the situation progressed to an armed revolution. Uncle Antonio sent his best employee Alfredo on horse back to rescue Joe and brother Mauricio and bring them back to the farm's safety. They fled well before daybreak and remained at the farm until the armed conflict ceased.

When José was in high school, the economic horizon on our father's farm was bright and great investments were made in coffee culture and mechanical processing. Then came the effects of the world economic crisis in the late 1920s that severely affected dad's plans. Farmers were obligated by the government to burn part of their coffee production to keep prices level. Mother and grandmother knew José needed a better education, and convinced dad to send him to the Agriculture and Veterinary school in the city of Viçosa. José was only 15 but minimum age was 16, so father had to lie about his age to get him admitted. [This Vicosa School, now a facility of Minas Gerais State University, was created in 1927 under a grant from the U.S. Government under the supervision of Professor Peter Henry Rolfs, a U.S. citizen]. There José studied, learned, worked, and practiced sports with great energy and enthusiasm and graduated at the head of his class. After graduation, he returned to help his father and work on the farm he inherited from his mother. He and brother Mauricio often competed to see which one could carry the biggest load of coffee. Both were able to handle around 200 lbs. José was always interested in wildlife, and he frequently recruited his sisters to help hold different animals—from rattlesnakes to bats. He often helped exterminate ant

nests for the neighbors. Mother remembers she didn't like caterpillars and the time she asked José to remove a tobacco plant from a grassy area she used for drying clothes. Moments later José came back with several caterpillars in the palm of his hand and said "Look, they won't harm you. See, I can even put one on my tongue." We also remember a collection of 21 rattlesnakes in a room of his farm; they were eventually donated to a laboratory to make vaccines.

The effects of the depression persisted, so in 1934 José decided to go back to school at Viçosa and with great effort passed the examinations to get into veterinary school. A new stint of hard work began, coupled with success in athletics to the point of being selected to represent Brazil in the 1936 Olympic Games in Berlin. However, while training, José pulled a muscle that eliminated him from competition. His "globetrotter" career began in 1937, when he participated in an international university invitational in Paris, where he won fourth place in pentathlon. Sports aside, he still managed to find time to visit the museums in Paris.

His student and athletic career at Viçosa ended in 1938 with graduation. While at school, he became interested in parasitology and zoology. In January 1939 he went to Rio de Janeiro to pursue research on ticks and the protozoans they transmitted. In February, he returned to Viçosa as a teacher and researcher. His first scientific work, published in 1939, was initiated as a student in 1937 and dealt with protozoans of *Rana catesbiana* Shaw.

The diversity of people José knew as a boy and teenager gave him a great facility for making friends with everyone from Indians in Amazon jungle to world VIPs. One of the best things that happened to José was the marriage to Milza Freire, the daughter of a farmer from our city in October 1939. This well-educated, charming, and petite woman proved to be a great companion for José. Following their marriage, our father died prematurely in November at age 57.

Remarkable to us was his travel to the United States in 1941 just before World War II, the result of a scholarship he received from Viçosa for his teaching and dedication to research. He went to the University of Nebraska in Lincoln for his M.S. Because of his many new friends and his own research efforts, he was admitted to the Ph.D. program at then Iowa State College in Ames. For his dissertation, he studied parasites of rabbits. His athletic training served him well, and rumors began to circulate that he could run down and catch cottontails and jack-rabbits. This story was published in the university newspaper, and soon the football and other athletic coaches were after him to join various university teams. However, he declined (he later claimed he could catch only young rabbits), preferring to concentrate on his studies instead. In 1943 he received his Ph.D. (thesis #689). Impressed on his mind was the quote at the University's library: "You shall know the truth and the truth shall make you free."

In May 1943, José and Milza returned to Brazil after a complicated trip through Panama and along the west coast of South America (because of German subs in the Atlantic) to Chile. From there, they traveled by train to Buenos Aires and home.

From then on, José's professional career soared and he went on to hold numerous important positions, including the directorship at the National Museum of Natural History in Rio de Janeiro and the presidency of the XVI International Congress of Entomology, held in Kyoto, Japan. But these are the years best conveyed by his wife Milza. Even at 80 years, José, in company with Milza, his daughter Iara, a granddaughter Lilian, and a grandson Leonardo (the latter two of which are law students) continued to work with his insects on a daily basis until his death on October 21, 1994. Sometime before, he said to me "A hundred years, the maximum one can expect to live, is too short a time to accomplish everything."

JOSÉ C. M. CARVALHO: A STUDENT'S REMEMBRANCE

PAULO SÉRGIO FIUZA FERREIRA

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It was in 1966, the beginning of my scientific career, that I had the opportunity to meet Dr. José C. M. Carvalho at the National Museum of Natural History, Rio de Janeiro, Brazil.

I vividly remember the first day we met. Dr. Carvalho was working in his office when I arrived to express my interest in studying Heteroptera. I presented to him my modest notes on the reduviid *Arilus carinatus* (Forster) that I had raised from eggs to adults in a small shoe box. He apparently appreciated the efforts of a sixteen-year-old high school boy trying to understand the amazing world of insects because he opened his laboratory and invited me to study Heteroptera under his supervision. It was not easy for Dr. Carvalho to get approval for me to work there—only college students were allowed in the Museum. After considerable effort, he convinced the administration to make an exception. Even so, some of the more conservative people still did not approve.

Financial support was another problem we encountered. I was more interested in learning about bugs than worried about money, but Dr. Carvalho was concerned, for he knew that I was from a modest family that could not pay my way. His solution was to pay me out of his own resources until I entered the University. After that I was able to obtain assistantships from the gov-

ernment by working on our cooperative projects.

From 1966 until October 1973, I worked almost every day with Dr. Carvalho, becoming more and more entomologically mature and learning much about his scientific philosophy. Under the tutelage of this hard-working, honest, and patient man, I transformed from a modest high school student to a young man with the opportunity to pursue a career in entomology. From our close relationship over the years, I grew considerably, and Dr. Carvalho became more like a second father to me, rather than just an advisor.

I worked with him on nearly 30 papers, and we were still cooperating on various projects concerning Neotropical Miridae before his death. These papers and the other activities we shared, as well as his introductions to national and international scientists, were very important in promoting my professional life. These experiences opened numerous opportunities for cooperative work with other researchers, and eventually led to my M.S. (Universidade Federal do Paraná) and Ph.D. (Texas A&M University) degrees, and a staff position at the Universidade Federal de Viçosa.

I was very fortunate to have known Dr. Carvalho, who became my best friend and colleague. I will miss him greatly.

**LOULUCORIS, A NEW GENUS, AND TWO NEW SPECIES OF ENDEMIC
HAWAIIAN PLANT BUG (HETEROPTERA: MIRIDAE: ORTHOTYLINAE)**

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Abstract.—The new endemic Hawaiian orthotyline genus *Loulucoris*, is diagnosed and described to accommodate two new species: *Loulucoris kidoi*, the type species of the genus, associated with the fan palm, *Pritchardia* (Arecaceae), on the island of Hawai'i, and *Loulucoris cinygmiscus* from the island of O'ahu.

Key Words: Insecta, Miridae, plant bug, Hawaii

The Hawaiian plant bug fauna (Heteroptera: Miridae) is remarkable in the unusual autapomorphies displayed by the endemic genera, and in its overall species richness. Although a handful of new species have been added in recent years (Carvalho 1952, Carvalho and Usinger 1960, Gagne 1968, Asquith 1993), the fauna is still largely undescribed and the Miridae certainly represent the most speciose group of Heteroptera in Hawai'i (Howarth 1990). The tribal and generic placement of Hawaiian taxa, however, is still largely based on the dated works of Kirkaldy (1902, 1904) and Zimmerman (1948b), with minor reassessments by Carvalho (1957–1960) and Schuh (1974).

The subfamily Orthotylinae in Hawai'i is presently represented by the endemic genera *Sarona* Kirkaldy, *Kalania* Kirkaldy, *Sulamita* Kirkaldy, *Pseudoclerada* Kirkaldy, *Nesidiorchestes* Kirkaldy, and endemic species in the widespread genus *Orthotylus* Fieber. In this paper I describe a new endemic genus and two new species in the subfamily Orthotylinae. Terminology of the genitalia follows that of Slater (1950) and Asquith (1991). Types and paratypes are deposited in the Bishop Museum, Honolulu (BPBM),

and the American Museum of Natural History, New York (AMNH).

This paper is dedicated to José Carvalho in honor of his unequalled knowledge and productivity in the taxonomy of the Miridae.

***Loulucoris* Asquith, NEW GENUS**

Diagnosis.—Recognized by its delicate form (Fig. 1); vertical, triangular head with subpedunculate eyes (Figs. 2, 3); shallow, median longitudinal sulcus and short transverse carina on vertex; weakly flattened posterolateral margins of pronotum; reddish spot on the cuneus.

Description.—*Male:* Macropterous; general coloration greenish yellow to pale brown; dorsal surface smooth to faintly shagreened, shining; dorsal vestiture with moderately long, inclined, dark setae; abdominal venter with long, pale setae. *Head:* Triangular in frontal view (Fig. 2), vertical (Fig. 3), width greater than height; vertex slightly concave, dorsal texture shagreened, with shallow, wide, median longitudinal sulcus and short indistinct transverse carina; carina separating anterior shagreened surface from posterior polished area; three or four

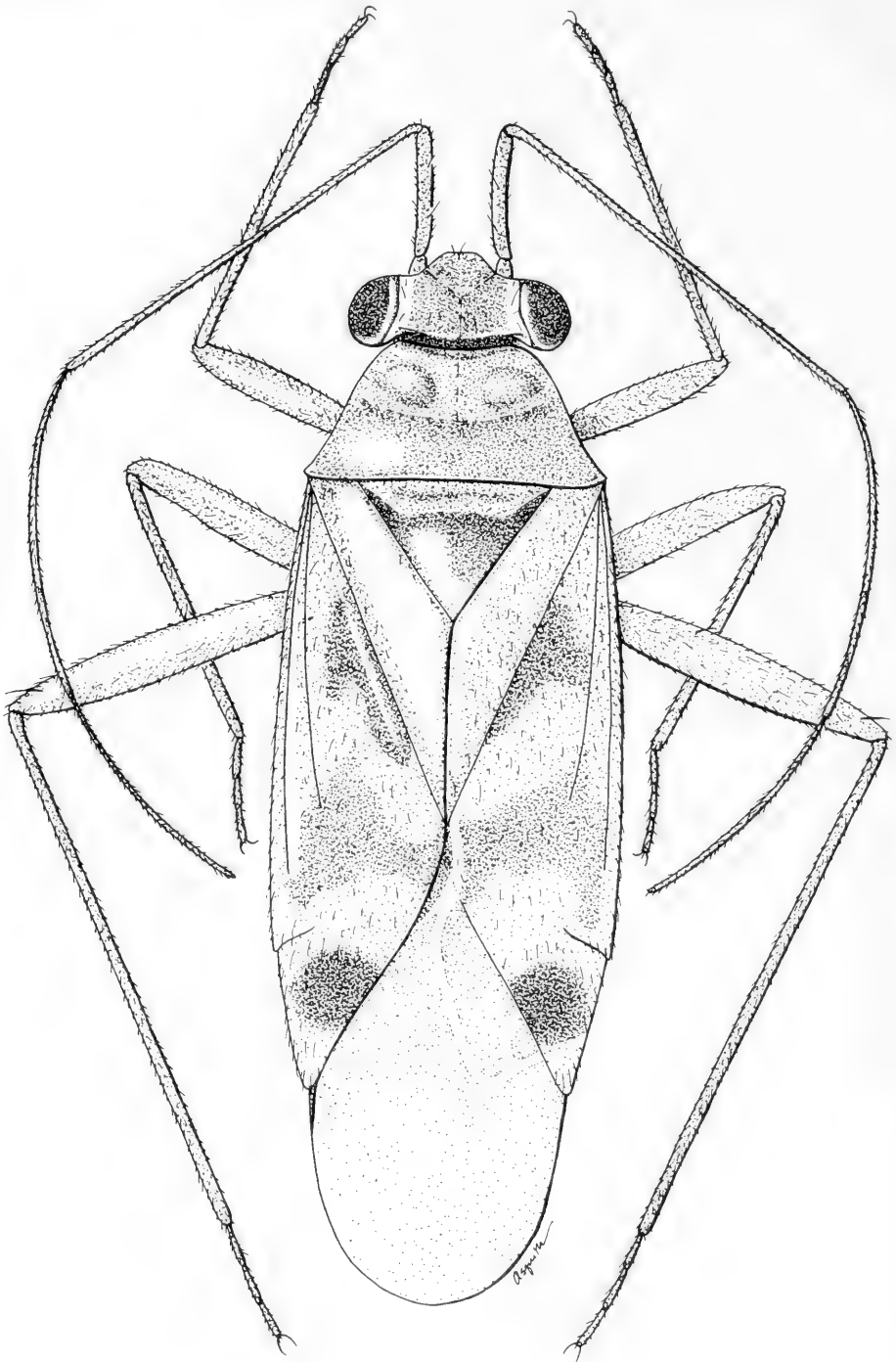


Fig. 1. *Loulucoris kidoi*, male dorsal habitus male.

erect, black setae along inner margin of eyes; frons prominent, extending only slightly anterior of antennal fossae, anterior surface highly polished; tylus flat, vertical, slightly depressed at junction with frons; juga vertical, flat, triangular; lora vertical, flat, rectangular; eyes subpedunculate, extending above vertex and occupying half of head height in lateral view, produced posterior well past occiput, weakly emarginate along posteroventral margins; antennae inserted at lower third of eyes, fossa separated from eyes by one third its diameter; antennal segment I weakly expanded basally, length slightly longer than width of vertex, with three or four erect, bristlelike setae on medial surface, all surfaces sparsely covered with short, inclined, dark setae; segment II linear, with short, inclined setae; segments III and IV linear, with short, inclined setae interspersed among longer, suberect setae. *Pronotum*: Trapezoidal in dorsal view, wider than long; flat to weakly sloping transversely; anterior margin straight; lateral margins straight to weakly sinuous, posterior halves weakly but thickly carinate; anterior angles broadly rounded; posterior angles sharp; posterior margin broadly and shallowly concave; calli weakly convex, reaching lateral and anterior margins, separated medially by shallow sulcus; mesoscutum broadly exposed, length one third of scutellum length; scutellum flat to weakly convex; metathoracic scent gland as in Fig. 4. *Hemelytra*: Subhyaline, subparallel sided, widest at middle; claval vein elevated for entire length; radial vein elevated along basal half; cuneus twice as long as broad, with a large reddish spot occupying most of surface; membrane lightly suffused with fuscous, more heavily on distal half; inner cell of membrane longer than length of cuneus but not extending past distal margin of cuneus. *Legs*: Color greenish yellow; femora slightly flattened, tapered distally and basally, with short, inclined, dark setae; fore femora with row of longer, erect, bristlelike setae on ventral surface; tibiae with short,

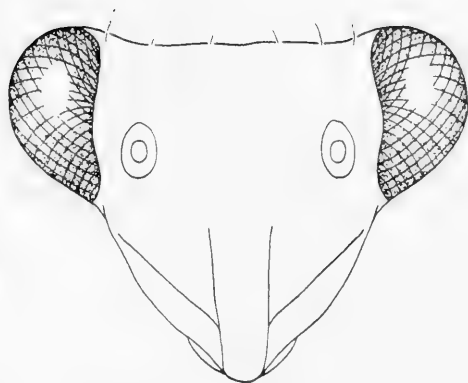


Fig. 2. *Loulucoris kidoi*, anterior view of head.

inclined, simple setae; meso- and metatibiae with additional longer, semierect setae and several rows of minute spinulae; each tarsal segment slightly longer than segment immediately basad; claws strongly curved, thickened basally, pulvilli small, distal margins angulate, parempodia convergent (Fig. 5).

Genitalia (Fig. 6): Genital capsule moderately large, broadly conical in ventral view, only slightly wider than long; and two anteromedially directed flanges supporting the parameres; aperture vertical, large, subcircular. Left paramere short, L-shaped; with dorsomedially curved ventral process. Right paramere elongate, narrow, strongly curved medially. Vesica with one or two long, thick sclerotized spiculae.

Female: Macropterous. Similar to male in color, vestiture, and structure except slightly broader. *Genitalia* (Fig. 7): Sclerotized rings small, widely separated; lateral sclerotized area folded dorsomesally. Posterior wall consisting of a single saddle-shaped structure (J structure of Slater 1950) with lateral margins strongly folded ventromesally (K structure of Slater 1950).

Etymology.—From the Hawaiian word, *loulou* (fan palm) and the Greek, *coris* (bug); referring to the host plant of the type species; gender masculine.

Type species.—*Loulucoris kidoi*, new species.



Fig. 3-5. *Loulucoris kidoi*. 3, Lateral view of head; 4, Ostiole and evaporative area of metathoracic scent gland; 5, Pretarsus, left claw missing.

Distribution.—Hawaiian Islands.

Discussion.—*Loulucoris* is not known to occur outside Hawai'i and it is not similar to any of the other endemic Hawaiian Or-

thotylini (Zimmerman 1948b, Schuh 1974). In general habitus it is somewhat similar to *Cyrtorhinus* Fieber, that is represented in Hawai'i by the introduced *C. fulvus* Knight

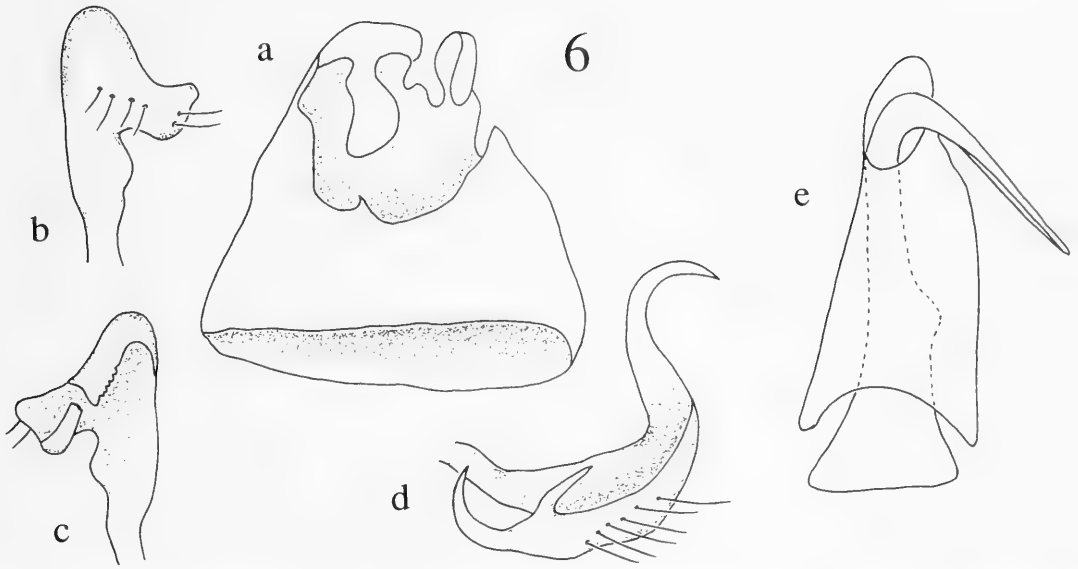


Fig. 6. a-e. Male genitalia of *Loulucoris kidoi*. a, Genital capsule, dorsal view; b, left paramere, lateral view; c, left paramere, medial view; d, right paramere, posterior view; e, theca and spicula, dorsal view.

and *C. lividipennis* Reuter. *Loulucoris* is easily distinguished from *Cyrtorhinus* by its triangular and vertical head. The strongly bent and thickened tarsal claws in *Loulucoris*, compared to the narrow, weakly curved claws of *Cyrtorhinus* (Carvalho and Southwood 1955), also suggest that the two taxa are not closely related.

Loulucoris appears to be related to species from the Indo-Pacific presently placed in the genus *Zanchius* Distant. These species also display the delicate body form; vertical head; narrow, apically furcate right paramere, and the medially folded, apicodorsal angle of the left paramere found in *Loulucoris*. The Pacific *Zanchius* species, including *Zanchius carolinensis* Carvalho, *Z. fragilis* Usinger, *Z. piperi* Usinger, and several undescribed species, also have thickened spiculae on the vesicae. Members of the genus *Zanchius*; however, and the "Zanchius group" of genera, lack sclerotized spiculae (Schuh 1974). The presence of vesical spiculae in *Loulucoris* and the Indo-Pacific "Zanchius" place them in the "Orthotylus group" of genera as defined by Schuh (1974).

A more extensive analysis of characters will be required to define strict synapomorphies that unite *Loulucoris* and the Pacific "Zanchius" species.

Loulucoris differs from the Indo-Pacific "Zanchius" by its subpedunculate and posteriorly produced eyes, and the median longitudinal sulcus. The flattened lateral pronotal margins and posterior carina on the vertex are found in some but not all species of Pacific "Zanchius." In addition, both species of *Loulucoris* have a distinct reddish spot in the middle of the cuneus, which I have not seen in any Pacific "Zanchius" species.

The relationships and biogeographic origins of several of the endemic Hawaiian mirid genera like *Sulamita* Kirkaldy, *Pseudoclerada* Kirkaldy and *Kalania* Kirkaldy may remain obscure because of highly autapomorphic fascies. *Loulucoris*, however, if shown to be clearly united with the Pacific "Zanchius" species, would be another confirmed Indo-Pacific derivative in the Hawaiian mirid fauna, along with *Opuna sharplanus* (Kirkaldy) (Schuh 1984).

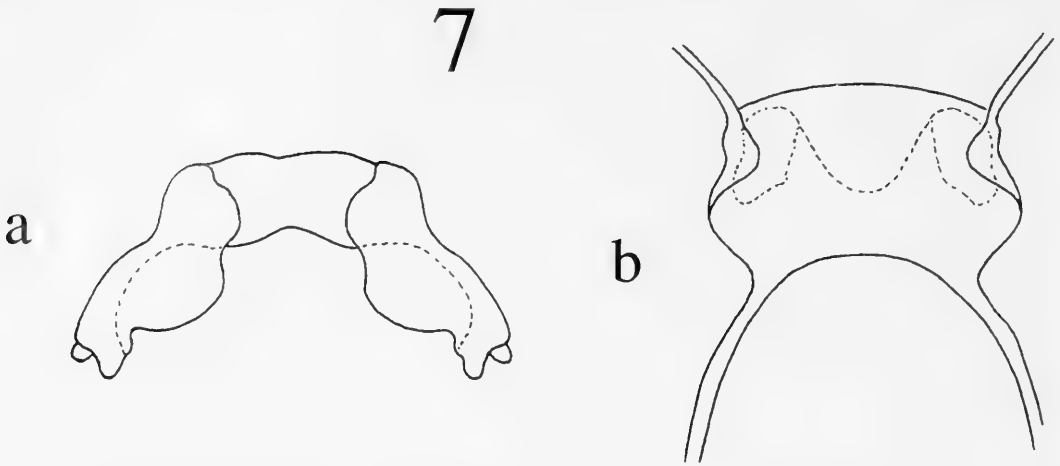


Fig. 7. a-b. Female genitalia of *Loulucoris kidoi*. a, posterior wall, anterior view; b, posterior wall, posterior view.

***Loulucoris Kidoi* Asquith,
NEW SPECIES**

Diagnosis.—Distinguished from the other known species by its overall darker coloration; short, acuminate tergal process on the right dorsolateral margin of the male genital capsule; the erect, basal process of the right paramere; found only on the island of Hawai'i.

Description.—*Male* ($n = 6$): Length 3.18–3.31 mm; pale greenish yellow coloration, dorsal vestiture with inclined, dark setae. *Head*: Width 0.73–0.74 mm; vertex 0.39–0.41 mm; head brown, vertex and area bordering eyes paler, three or four erect, black setae along medial border of eyes; dorsal surface shagreened, anterior area of frons polished; tylus, and juga pale yellow, surfaces polished, lora yellow distally, red on basal half; antennal segment I 0.46–0.54 mm, greenish yellow; segment II 1.47–1.52 mm, greenish yellow basally, yellowish brown distally; segment III 1.25–1.35 mm, yellowish brown; segment IV 0.60–0.64 mm, yellowish brown; rostrum reaching or just surpassing mesocoxae, color yellow, apex black. *Pronotum*: Length 0.32–0.35 mm, posterior width 0.83–0.88 mm; uniformly brown, occasionally darker at middle of

posterior disk; mesoscutum brown; scutellum brown, apex pale; dorsal half of thoracic pleura dark reddish brown; venter pale greenish yellow. *Hemelytra*: General coloration greenish yellow, suffused with large areas of brown on clavus, and basal and distal areas of corium; cuneus greenish yellow with large, reddish spot; membrane slightly suffused with fuscous, less so basally. *Legs*: Coxae and trochanters yellow; femora, tibiae and tarsi uniformly greenish yellow. *Genitalia*: Dorsal margin of genital capsule with short, acuminate tergal process on right side; posteroventral margin with deep socket for left paramere; supporting flange for right paramere broadly spatulate (Fig. 6a). Left paramere with broad area of apicodorsal edge serrate and folded medially (Fig. 6c). Right paramere narrow, elongate, evenly curved medially, apex narrowed, acuminate and curved dorsally (Fig. 6d), with large, erect, distally recurved process near base; smaller, basally recurved, dorsal process near apex. A single, thick spicula present, strongly recurved basally, spatulate distally (Fig. 6e).

Female ($n = 4$): Macropterous. Color and size similar to male, except usually darker and slightly longer and wider; length 3.40–3.46 mm; width of head across eyes 0.75–

0.76 mm; width of vertex 0.43–0.44 mm; antennal segment I 0.47–0.48 mm; segment II 1.40–1.48 mm; segment III 1.38 mm; segment IV 0.45–0.47 mm; length of pronotum 0.35–0.37 mm; posterior width of pronotum 0.87–0.90 mm.

Etymology.—Named for my colleague and good friend Michael Kido, University of Hawaii, Kauai Research Center, who first collected specimens of this species.

Holotype ♂, HAWAIIAN ISLANDS: HAWAII: Stainback Hwy., 2.VIII.1991, ex *Pritchardia* sp., (A. Asquith & M. Kido). (BPBM). **Paratypes.** 8 ♂, 2♀ HAWAIIAN ISLANDS: HAWAII: Stainback Hwy., 2.VIII.1991, ex *Pritchardia* sp., (A. Asquith & M. Kido). (BPBM, AMNH). **Additional specimens:** Same data as type series, 1 ♂, 2 ♀, all dissected, 2 nymphs (BPBM).

The type series was collected from attached but dead leaves of *Pritchardia beccariana* Rock. Adults and nymphs were found deep in the leaf folds in association with psocids, although predation was not observed.

***Loulucoris cinygmiscus* Asquith,
NEW SPECIES**

Diagnosis.—Distinguished from *Loulucoris kidoi* by its paler coloration; a red, dorsomedial, longitudinal stripe on the head of males; a large tergal process on the left dorsolateral margin of the male genital capsule, and the absence of the erect basal process on the right paramere; found only on the island of O'ahu.

Description (n = 1).—**Male:** Length 3.35 mm; pale, straw yellow coloration, dorsal vestiture with inclined, pale setae. **Head:** Width 0.70 mm; vertex 0.38 mm; head yellow, median sulcus reddish brown, erect setae bordering eyes gold to brown; dorsal surface shagreened, anterior surfaces polished; tylus, lora, juga pale yellow, surfaces highly polished; antennal segment I 0.48 mm, pale yellow; segment II 1.33 mm, pale yellow, slightly darker on distal half (antennal segments III and IV missing from specimen);

rostrum reaching to mesocoxae, yellow, apex fuscous. **Pronotum:** Length 0.36 mm, posterior width 0.85 mm; pale yellow, anterior angles reddish brown; mesoscutum and scutellum straw yellow, apex of scutellum cream; ventral margins of thoracic pleura reddish brown; venter yellow. **Hemelytra:** General coloration pale, brownish yellow, weakly suffused with pale brown basally on clavus and corium; cuneus pale yellow with large reddish spot; membrane translucent. **Legs:** All segments uniformly yellow. **Genitalia:** Dorsal margin of genital capsule with long, stout tergal process on left side; posteroventral margin entire, socket for left paramere absent; supporting flange for right paramere erect, narrowed, and recurved apically (Fig. 8a). Right paramere narrow, elongate, apex bifurcate, with two, narrowed, acuminate arms; basal process absent (Fig. 8c). Left paramere with folded area of apicodorsal angle small, serrate (Fig. 8b). Vesica with two elongate spiculae, ventral spicula weakly sinuate and flattened distally (Fig. 8d).

Female (n = 1): Macropterous. Size similar to male. General coloration yellow, tinged with green; reddish areas on thoracic pleura indistinct; lacking longitudinal reddish stripe on vertex. Length 3.61 mm; width of head 0.73 mm; vertex 0.39 mm; antennal segment I 3.61 mm; segment II 1.26 mm; segment III 1.09 mm; segment IV 0.70 mm.

Etymology.—From the Greek, *cinygm* (phantom), referring to the few occasions this species has revealed itself to collectors.

Holotype ♂, HAWAIIAN ISLANDS: O'AHU: Castle Trail, 2000 ft., 28.XI.1937, Beating, (E. C. Zimmerman). (BPBM). **Paratype** ♀, HAWAIIAN ISLANDS: O'AHU: Waikane, 22.X.1947, (E. C. Zimmerman). **Additional specimens:** HAWAIIAN ISLANDS: O'AHU: Halawa Valley, 11.I.1994, ex *Pritchardia*, (A. Asquith) 1 ♂, 2 nymphs, (BPBM).

An endemic genus with species found only on O'ahu and Hawai'i would be an unusual pattern within the Hawaiian insect fauna

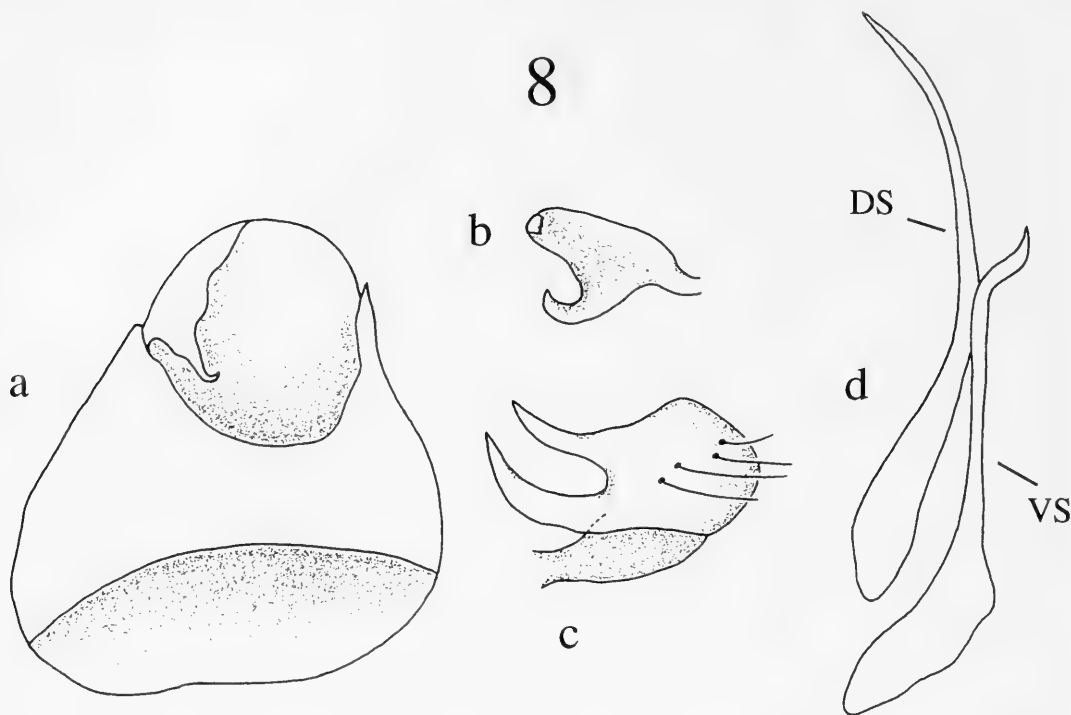


Fig. 8. a-d. *Loulucoris cinymiscus*, male genitalia. a, genital capsule, dorsal view; b, left paramere, medial view; c, right paramere, posterior view; d, vesical spiculae. (DS = dorsal spicula, VS = ventral spicula.)

(Zimmerman 1948a); therefore, it is highly likely that there are additional species of *Loulucoris* on other islands. With the both of the known species collected exclusively from *Pritchardia*, the fidelity of *Loulucoris* to fan palms seems likely. The genus *Pritchardia* (Arecaceae) is restricted to tropical Pacific islands, with 19 endemic Hawaiian species (Wagner et al. 1990). The Pacific "*Zanclus*" species have not been recorded from palms, but are known from *Marattia* (Marattiaceae), *Piper* (Piperaceae), *Cyrtandra* (Gesneriaceae) and *Ficus* (Moraceae). *Pritchardia* hosts several other endemic Hawaiian insects with various degrees of association. The psyllid genus *Megatrioza* Crawford, for example, is restricted to fan palms in Hawai'i (Uchida and Beardsley 1988), while *Nesodryas swezeyi* Zimmerman (Homoptera: Delphacidae) occurs on *Pritchardia* on Hawai'i and *Nesodryas frey-*

cinetiae Kirkaldy (Pandanaceae) is associated with *Freycinetia arborea* Gaud. on O'a-hu (Zimmerman 1948c).

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NEW GENUS AND NEW SPECIES OF COLPURINI
(HETEROPTERA: COREIDAE) FROM THE PHILIPPINE REPUBLIC

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Abstract.—One new genus (*Carvalhygia*) and three new species (*C. carvalhoi*, *C. milzae*, and *C. nigra*) collected in the Philippine Republic are described in the tribe Colpurini (Coreidae). Habitus view illustrations and drawings of the male and female genitalia are provided to help distinguish these taxa.

Key Words: Insecta, Heteroptera, Coreidae, Colpurini, new genus, new species, Philippine Republic

Only three genera and ten species of Colpurini have been described from the Philippine Republic. The genus *Hygia* Uhler contains three subgenera: *Colpura* Bergroth with two species (*obscuricornis* (Stål) and *pallidicornis* (Stål)), *Microcolpura* Breddin with one species (*denticollis* (Bergroth)), and *Sphinctocolpura* Breddin with five species (*dentifer* (Stål), *maculipes* (Stål), *obscuripes* (Stål), *pictipes* (Stål) and *punctipes* (Stål)). The genus *Homalocolpura* Breddin includes one species (*sorbax* Bergroth) and the genus *Typhlocolpura* Breddin has one species (*vulcanalis* Bergroth).

The present paper adds one new genus and three new species. Three features of this new genus are the reduced to absent postocular tubercle, the reduced hemelytra that exhibit a coleopteroid condition, and the absence of ocelli.

The following abbreviations are used for the institutions cited in this paper: BMNH (The Natural History Museum, London, England); UNAM (Instituto de Biología, Universidad Nacional Autónoma de México, México D.F.); and USNM (U.S. Na-

tional Museum of Natural History, Washington, D.C.).

All measurements are given in millimeters.

This paper is written in honor of the late Dr. José Candido Melo Carvalho, in recognition of his voluminous and seminal contributions on the Miridae of the world, as well as on other groups of animals and key papers on ethnical South American groups. His distinguished and productive career has long served as an example of excellence.

***Carvalhygia* Brailovsky, NEW GENUS**

Diagnosis.—*Carvalhygia* Brailovsky, new genus is similar and closely related to *Lygaeopharus* Stål and *Typhlocolpura* Stål. These three genera share several characters: ocelli reduced or absent, tylus apically globose and truncated, antenniferous tubercle unarmed, hemelytral membrane reduced, and the female abdominal sternite VII with plica and fissura.

Carvalhygia is easily distinguished because it is the only known genus in the tribe Colpurini with the postocular tubercle ex-

tremely reduced to absent, eyes globose, slightly protuberant and the paratergite IX thick and folded downward.

Carvalhygia exhibits the frontal angles of pronotum rounded, not exposed or produced forward as short or long conical teeth, buccula with a sharp middle projection, and femora armed. These are characters that may or may not be present in other genera, making the combination unique to this new genus. In *Lygaeopharus* the frontal angles are produced forward as long conical teeth, the femora are unarmed and the buccula entirely rounded, without sharp middle projection; in *Typhlocolpura* the frontal angles are produced forward as long conical teeth, the femora could be armed or unarmed, and the buccula always with a sharp middle projection.

Generic description.—Head: Longer than wide, pentagonal and dorsally flat or slightly depressed; tylus unarmed, apically globose, extending anteriorly to and laterally higher than juga; jugum unarmed, thickened and shorter than tylus; antenniferous tubercle unarmed, quadrate, robust, apex truncated; side of head in front of eye unarmed and obliquely straight; antennal segment I robust, thickest, slightly curved outward, shorter than head; segments II and III cylindrical and slender; segment IV fusiform; segment II the longest, segment IV the shortest and III longer than I; ocelli absent; posterior pit between eyes deep and diagonally excavated; eyes globose, slightly protuberant, and based on an hypothetical line the upper margin is raised above the vertex and frontal area; postocular tubercle extremely reduced to absent; buccula rounded, elevated, short, not projecting beyond antenniferous tubercle, with a sharp middle projection; rostrum reaching posterior third of abdominal sterna III or IV; rostral segment I reaching posterior margin of the gula.

Thorax.—Pronotum wider than long, trapeziform and bilobed; anterior lobe longer than posterior lobe, each margin convexly rounded, emarginated and moderately ele-

vated; collar wide; frontal angles rounded, not exposed or produced forward as short conical teeth; humeral angles rounded, not exposed; posterolateral border obliquely straight and posterior border straight or slightly concave; calli slightly convex, never separated along midline by longitudinal furrow; posterior margin without a transverse ridge. Anterior lobe of metathoracic peritreme elevated and reniform, posterior lobe sharp, small.

Legs.—Ventral surface of femora armed with two subdistal short spines and few more scattered along ventral surface; tibiae cylindrical and sulcate.

Scutellum.—Triangular, flat, wider than long or as long as wide; apex acute.

Hemelytra.—Coleopteroid; clavus and corium fused; wings do not overlap but meet along the midline; membrane reduced to a small flap, leaving the posterior abdominal terga exposed.

Abdomen.—Connexival segments strongly elevated; posterior angle of each connexival segment complete, not extending on a short spine; abdominal sterna with medial furrow, projecting to anterior third of sternite IV or V.

Integument.—Body surface rather dull. Head, pronotum, scutellum, clavus, corium, thorax, abdomen, and exposed parts of genital segments of both sexes with circular grayish-white farinose punctures and each punctuation with short, decumbent golden or silvery bristlelike setae; antennae, legs, and abdominal sterna with few long, erect setae; antennae and legs minutely granulate.

Male genitalia.—Genital capsule simple and globose; posteroventral edge entire, transversely straight, with lateral angles rounded (Fig. 3).

Female genitalia.—Abdominal sternite VII with plica and fissura; plica triangular, reaching middle third of sternite VII; gonocoxae I with dorsal third closed and ventral third opened, slightly triangular and with the external apical angle globose; paratergite VIII short, square, with visible spiracle; par-

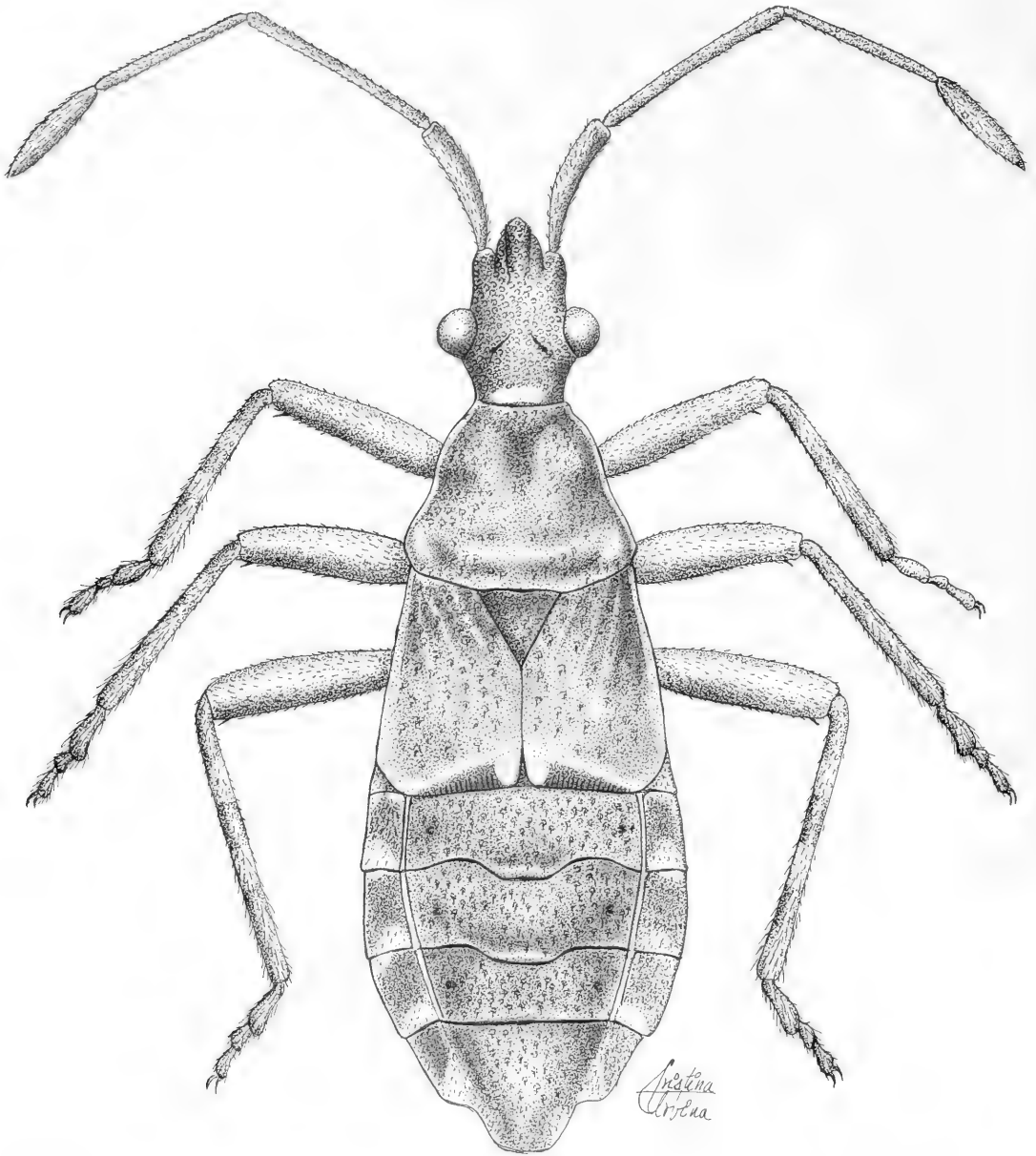


Fig. 1. Dorsal view of *Carvalhygia carvalhoi*, ♂.

atergite IX longer than VIII, rectangular, entirely thick and folded downward (Figs. 4–6).

Etymology.—I am pleased to name this new genus for Dr. José Candido Melo Carvalho, distinguished Brazilian hemipterist, in recognition of his splendid contributions to the sciences. Gender feminine.

Type species.—*Carvalhygia carvalhoi* Brailovskiy, new species.

***Carvalhygia carvalhoi* Brailovskiy,**
NEW SPECIES
Figs. 1, 3–5

Description.—Measurements: Male: Head length 2.12; interocular space 1.20;

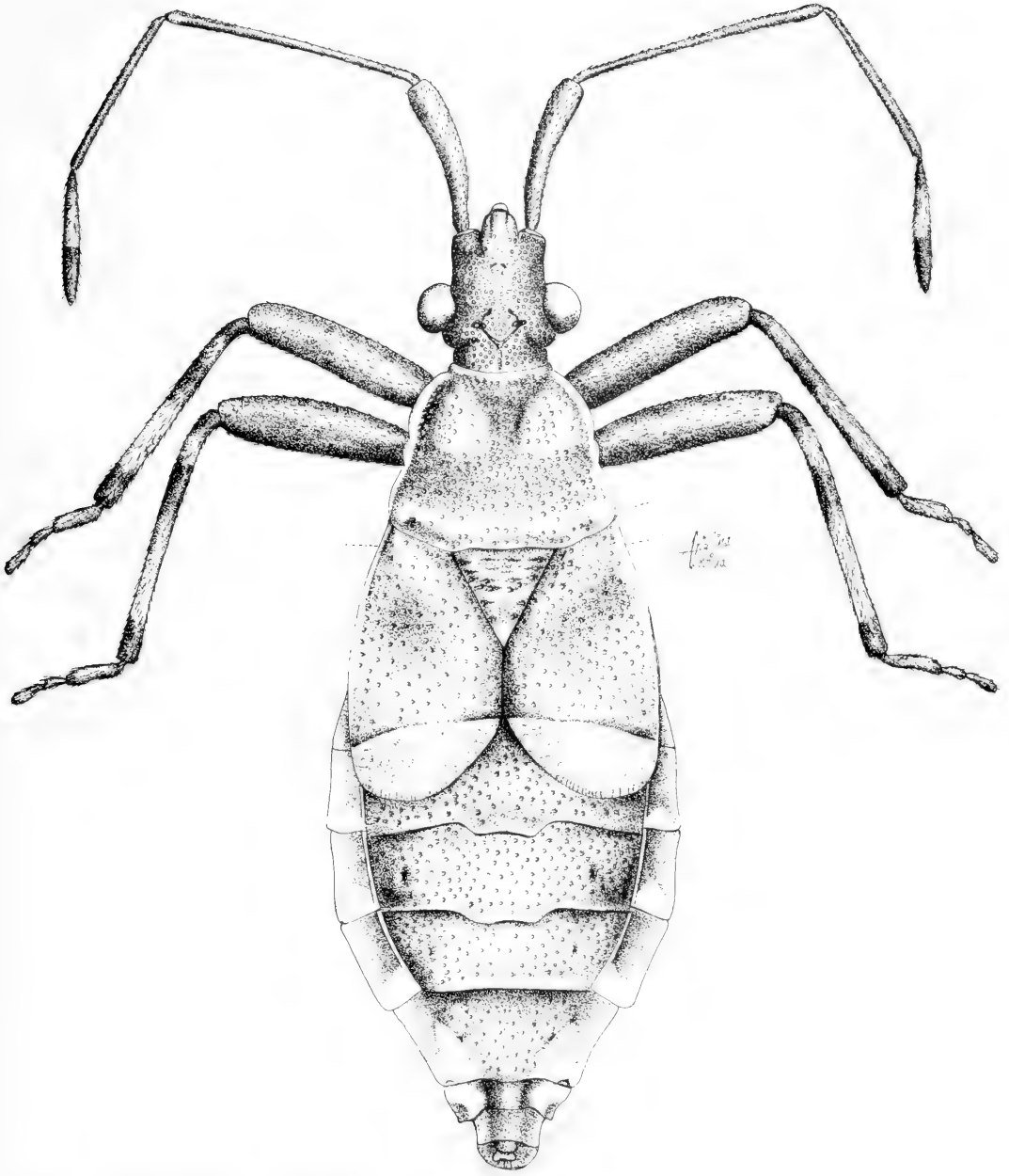
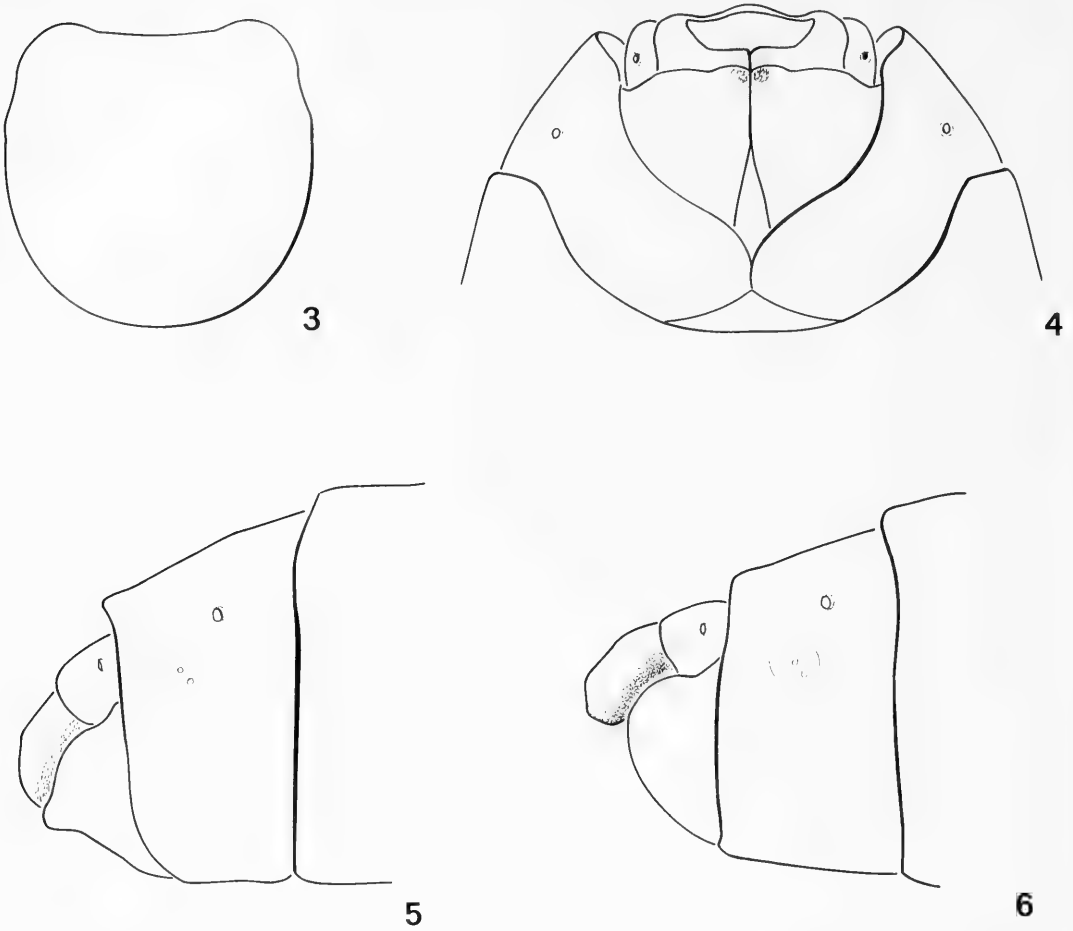


Fig. 2. Dorsal view of *Carvalhygia milzae*, ♀.

width across eyes 2.08; preocular distance 1.24; length antennal segments: I, 1.64; II, 2.40; III, 1.96; IV, 1.52. Pronotum: Total length of anterior lobe 1.26; total length of posterior lobe 0.88; total width of anterior lobe 2.28; total width of posterior lobe 2.84.

Scutellar length 1.04; width 1.12. Total body length 10.95.

Female.—Head length 2.28; interocular space 1.24; width across eyes 2.24; preocular distance 1.36; length antennal segments: I, 1.76; II, 2.76; III, 2.04; IV, 1.64.



Figs. 3-6. 3-5. *Carvalhygia carvalhoi*. 3. Male genital capsule in caudal view. 4-5. Female genital plates. 4. Caudal view. 5. Lateral view. 6. Female genital plates in lateral view of *Carvalhygia milzae*.

Pronotum: Total length of anterior lobe 1.16; total length of posterior lobe 1.00; total width of anterior lobe 2.56; total width of posterior lobe 3.20. Scutellar length 1.36; width 1.44. Total body length 12.10.

Male.—Dorsal coloration black with red brown reflections on posterior third of pronotum, clavus, and corium; antennal segments I to IV pale to dull orange; anterolateral margin of pronotum and costal margin of corium dull orange to chestnut brown; hemelytral membrane dark brown with inner portion creamy yellow; connexival segments III to VII red brown with posterior margin yellow; abdominal terga black with

lateral margin of VII yellow. Ventral coloration black with following areas orange, with or without chestnut reflections: rostral segments I to IV, anterior and posterior lobe of metathoracic peritreme and pleural margins of the abdominal sternites IV to VII; coxae black, trochanters yellow with chestnut reflections, femora dull orange with basal joint yellow, tibiae dull orange with two diffuse yellow rings, one subbasal, other one near middle, and tarsi dull orange with chestnut reflections.

Male.—Rostrum reaching middle or posterior third of abdominal sternite IV; scutellum wider than long; hemelytral mem-

brane reduced and reaching middle third of abdominal tergite IV.

Female.—Coloration: Similar to male. Connexival segments VIII and IX red brown with posterior margin yellow; abdominal terga VIII and IX black. Gonocoxae I black with internal apical angle yellow; paratergite VIII and IX red brown with anterior third yellow. Genital plates. Paratergite IX conspicuously folded downward (Figs. 3–5).

Variation.—The type material exhibits some color variation on most specimens: 1, antennal segment I red brown with basal third yellow; 2, antennal segment IV red brown; 3, femora red brown with dull orange reflections; 4, pleural margins of abdominal sterna III to VII red brown with dull orange reflections.

Type material.—Holotype: ♂, Philippine Republic, Sibuyan Island, Col. Baker (without additional data) (USNM). Paratypes: 3 ♂♂, 5 ♀♀, Philippine Republic, Sibuyan Island, Col. Baker (without additional data) (USNM, UNAM and BMNH).

Etymology.—I am pleased to name this new species after the late Dr. José Candido Melo Carvalho.

Carvalhygia milzae Brailovsky,

NEW SPECIES

Figs. 2, 6

Description.—Measurements: Female: Head length 2.20; interocular space 1.22; width across eyes 2.16; preocular distance 1.30; length antennal segments: I, 1.96; II, 3.12; III, 2.32; IV, 1.64. Pronotum: Total length of anterior lobe 1.12; total length of posterior lobe 0.96; total width of anterior lobe 2.16; total width of posterior lobe 2.64. Scutellar length 1.22; width 1.22. Total body length 12.00.

Female.—Dorsal coloration: Head and anterior lobe of pronotum dark red brown; posterior lobe of pronotum bright orange red; scutellum, clavus and corium dull orange red, with apical margin of corium mostly dark brown; connexival segments III to IX pale orange brown with posterior mar-

gin yellow; abdominal terga red brown; antennal segment I bright orange; segment II dull orange with basal third pale yellow; segment III dull orange and IV dark brown with subbasal yellow ring; collar, anterolateral margin of pronotum, apex of scutellum, and costal margin of corium bright to pale orange with yellow reflections; hemelytral membrane pale yellow. Ventral coloration: Head and prothorax dark red brown; mesothorax, metathorax, abdominal sternite and genital plates pale red brown; rostral segment I yellow and segments II to IV bright chestnut orange; coxae and femora bright orange red; trochanters yellow; protibiae pale orange with two yellow rings one subbasal, other one near middle; mesotibiae pale orange with yellow reflections; tarsi pale orange with yellow reflections (posterior leg absent); anterior and posterior lobe of metathoracic peritreme bright yellow with orange reflections; pleural margin of abdominal sternite III to VII, posterior edge of abdominal sternite IV to VII, and internal apical angle of gonocoxae I yellow.

Rostrum reaching anterior third of abdominal sternite IV; scutellum as long as wide; hemelytral membrane reduced and reaching posterior third of abdominal tergite IV. Genital plates. Paratergite IX slightly folded downward (Fig. 6).

Type material.—Holotype: ♀, Philippine Republic, Panay Mt. (Madaas), Col. W. Schultze (without additional data) (BMNH).

Etymology.—Named for Milza, Carvalho's wife and indefatigable partner.

Carvalhygia nigra Brailovsky,

NEW SPECIES

Fig. 7

Description.—Measurements: Female: Head length 2.04; interocular space 1.22; width across eyes 1.86; preocular distance 1.16; length antennal segments: I, 1.72; II, 2.52; III, 2.00; IV, absent. Pronotum: Total length of anterior lobe 1.12; total length of posterior lobe 0.72; total width of anterior lobe 1.88; total width of posterior lobe 2.40.

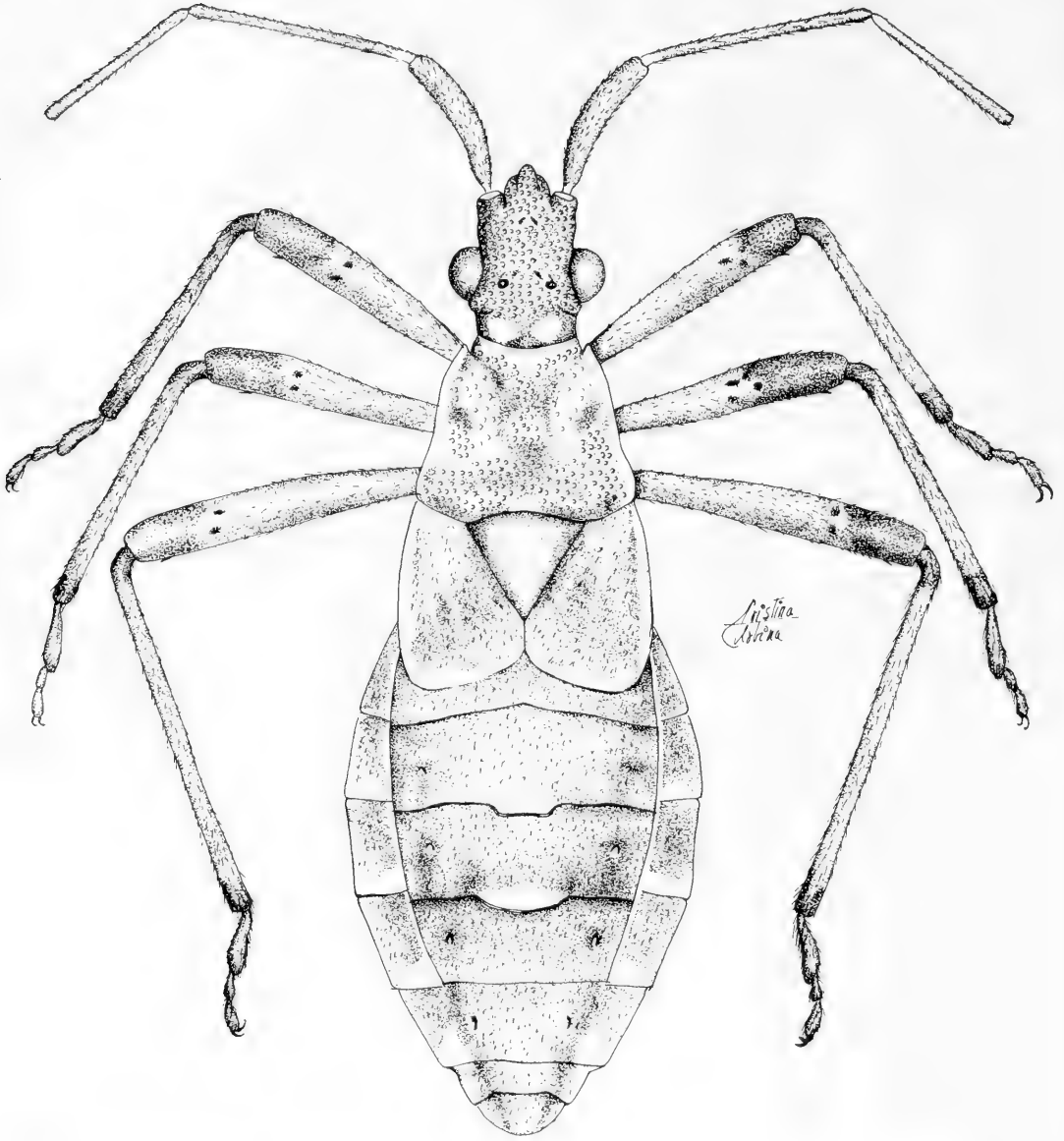


Fig. 7. Dorsal view of *Carvalhygia nigra*, ♀.

Scutellar length 1.00; width 1.08. Total body length 11.00.

Female.—Dorsal coloration black with following areas pale dirty yellow: anterolateral margin of pronotum and costal margin of corium; antennal segment I dark red brown, segments II and III dull orange with basal third yellow; segment IV absent; hemelytral membrane dirty yellow; connex-

ival segments III to IX red brown with posterior margin yellow; abdominal terga black with intersegmental scars IV-V and V-VI pale orange yellow. Ventral coloration black with following areas yellow, with or without chestnut reflections: rostral segments I to IV, anterior and posterior lobe of metathoracic peritreme, and posterior margin of pleural margins of abdominal sternite IV to

VII; gonocoxae I black with internal apical angle yellow; paratergite VIII and IX black with upper margin yellow; coxae black; trochanters yellow; femora yellow, densely covered with dark red brown discoidal spots and with posterior third or posterior half with spines dark red brown; tibiae yellow with basal join and apical third dark red brown; tarsi yellow with chestnut reflections.

Rostrum reaching posterior third of abdominal sternite III; scutellum wider than long; hemelytral membrane extremely reduced and reaching middle third of abdominal tergite III. Genital plates. Paratergite IX slightly folded downward.

Type material.—Holotype: ♀, Philippine Republic, Mindoro, Baco River, January–February 1910, J.J. Mounsey (BMNH).

Etymology.—From the Latin *nigra*, meaning black.

KEY TO THE KNOWN SPECIES OF
CARVALHYGIA

- 1. Hemelytral membrane dark brown with inner portion creamy yellow (Fig. 1)
..... *carvalhoi* Brailovsky, new species
- Hemelytral membrane entirely yellow (Figs. 2, 7) 2
- 2. Hemelytral membrane extremely reduced, reaching middle third of abdominal tergite III; rostrum reaching posterior third of abdominal sternite III; profemora and mesofemora yellow, with posterior third or posterior half, as well as several discoidal spots, dark red brown; scutellum wider than long
..... *nigra* Brailovsky, new species

- Hemelytral membrane never extremely reduced, reaching posterior third of abdominal tergite IV; rostrum reaching anterior third of abdominal sternite IV; profemora and mesofemora uniformly bright orange red; scutellum as long as wide *milzae* Brailovsky, new species

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**A RECLASSIFICATION AND PHYLOGENY OF THE TERMATOPHYLINI
(HETEROPTERA: MIRIDAE: DERAECORINAE), WITH A TAXONOMIC
REVISION OF THE AUSTRALIAN SPECIES, AND A
REVIEW OF THE TRIBAL CLASSIFICATION OF
THE DERAECORINAE**

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Australia.

Abstract.—The genera of Termatophylini are described, including two new genera, *Democoris* and *Kundakimuka*, from Australia. A key is given to the termatophyline genera. The type species of all the genera are described, and six new species of Australian termatophyline, *Kundakimuka carvalhoi*, *K. queenslandica*, *Democoris lugens*, *D. leptocytus*, *Termatophylum melaleucaae* and *T. weiri*, are described. A key is given to the Australian termatophyline species. The tribe is re-defined on the basis of the short first labial segment, the presence of antero-lateral pronotal setae, and the exposed metathoracic spiracle. The genera *Conocephalocoris*, *Hesperophylum* and *Teratomiris* are removed from the Termatophylini and placed in the Deraeocorini. A cladistic analysis of the Termatophylini is provided on the basis of 29 morphological characters. The sister-group relationships are discussed and the characters are reviewed. Characters of the pterothoracic pleura, particularly the metathoracic spiracle and the scent efferent system of the metathoracic glands are extensively utilized in this study. These characters are also discussed for other suprageneric groups of Miridae. The tribal classification of the Deraeocorinae is reviewed, and it is concluded that none of the other tribes are adequately defined. It is also firmly established that the termatophyline are mirids, and that any similarity with the Anthocoridae is due to convergence.

Key Words: Heteroptera, Miridae, Deraeocorinae, Termatophylini, revision, phylogeny, new genera, new species, Australia

The Termatophylini have had a labile position within the classification of the Cimicomorpha, varying from family status (Reuter 1910, Wagner 1970), as a subfamily within the Anthocoridae (Reuter 1884a, b) and Miridae (China and Myers 1929), and more recently as a tribe of the mirid subfamily Deraeocorinae (Carvalho 1952, 1955a, 1957). Mention has been made of their salient similarity with some members of the Anthocoridae (Schuh 1976). Curiously, after Carvalho (1952) placed them in

the Deraeocorinae, there has been little dispute as to their monophyly nor their familial or subfamilial position. This view is supported in this work despite the present conclusion that the previous tribal definition, based primarily on a porrect head, neither holds for the tribe, nor is exclusive for other Deraeocorinae.

This work was initiated by the receipt of a box of mirid specimens from the Museum and Art Galleries of Northern Territories, amongst which, one specimen of a terma-

tophyline from Smith Point, near Darwin, brought forth the question, "why is this mirid so like an anthocorid?" This exaggerated specimen has gigantic hind femora, somewhat like those found in members of the Halticini (Miridae: Orthotylinae). Aside from this apomorphy, the similarity of its overall facies with anthocorids is striking, and the absence of ocelli and presence of a hemelytral membrane cell, suggested an alternative taxonomic arrangement. Characters of the male genitalia and the presence of femoral trichobothria strongly support the placement of the termatophyline within the Miridae. The anthocorid-like features, however, provided the impetus for making an analysis of the termatophyline, mindful of present definitions of the Miridae, Anthocoridae and other cimicomorphan families (Schuh and Stys 1991).

In this work I also support the placement of the termatophyline in the Deraeocorinae, but in redefining them as a monophyletic tribe, I have discovered that the other deraeocorine tribes are presently inadequately defined. I have given a commentary on the characters presently used in these classifications and suggest alternative characters, particularly of the pterothoracic pleura. In particular I have introduced a morphological comparison of the metathoracic spiracular opening and the scent efferent system of the metathoracic glands in the Miridae, to reappraise previous characters, such as the basally cleft claws, primarily used to place the termatophyline within the Deraeocorinae.

An invitation to provide a contribution to a Festschrift for Dr. José Carvalho, rendered this idea into its present form. The Termatophylini have not been previously recorded from Australia. In accumulating all the Australian termatophyline material it was clear that not all termatophyline were anthocorid-like, which led me to study the Australian fauna, redescribe the genera worldwide, including a checklist of species, phylogenetic definition and position of the

termatophyline, and a cladistic analysis of the genera. José Carvalho's contributions on the Miridae, including the Australian fauna, remains unparalleled. Cassis and Gross (in press) report that Carvalho described more than half of the Australian mirid fauna. He had also commenced numerous projects on the Australian Miridae, and much of the termatophyline material in this work has passed through his hands, including *Democoris lugens* n. gen. and n. sp. I have provided a dedication to him by naming the unique Smith Point species in his honour, under the new generic name, *Kundakimuka*.

In this work I have recognized eight genera and 30 species of Termatophylini. The genus *Democoris* is restricted to south temperate Australia. The genera *Kundakimuka* and *Termatophylum* Reuter are broadly distributed in the Eastern Hemisphere, including Australia. *Termatophyllella* Carvalho, *Termatophylidea* Reuter and Poppius, *Termatophyloides* Carvalho are restricted to the Western Hemisphere. *Termatophylina* Carvalho is restricted to the Oriental region. *Arygrotelaenus* Reuter and Poppius is restricted to the Middle East. I have provided a key to the world genera, which is based entirely on external characters, and a key to all known Australian species. In redefining the Termatophylini I have transferred *Conocephalocoris* Knight, *Hesperophylum* Reuter and Poppius and *Termatomiris* Ghauri to the Deraeocorini.

MATERIALS AND METHODS

About 110 specimens of termatophyline were examined in this study. This material was borrowed from the Natural History Museum, London and the National Museum of Natural History, Smithsonian Institute, Washington, and the major collections found within Australia. The specimens of the type specimens were examined. No males of *Arygrotelaenus elegans* Reuter and Poppius were available for examination. The generic definitions incorporate observa-

tions of most termatophyline species. Not all species of *Termtophylum* and *Termtophylidea* were examined, but the descriptions in the literature were sufficient to confidently retain within them all previously assigned species.

The male genitalic characters were examined on temporary mounts in glycerin, using both a Zeiss SR Stereomicroscope and a Leitz Laborlux S Compound microscope. The line drawings were prepared using a camera lucida. Scanning electron micrographs were made from dried museum specimens, using a Cambridge S120 microscope.

TAXONOMIC CHARACTERS

The morphological terminology used in this work is derived from various sources. Many of the terms used for somatic characters are now conventional, following the modern works of authors such as Schuh (e.g. 1984). Some original interpretation was involved in my treatment of the forewing, the pterothoracic pleura and the male genitalia.

In this work I introduce the use of comparative morphology of the pterothoracic pleura, particularly the condition of the metathoracic spiracle and the scent efferent system of the metathoracic scent glands. The homologies are partly derived from Carayon (1971) and Staddon (1979) for the Heteroptera, and Larsen (1945) and Southwood (1953) for the Miridae. The junction of the mesepimeron and metepisternum contains in some Miridae, a visible opening of the metathoracic spiracle (Figs. 57, 65). Its position and associated structures are both phylogenetically and taxonomically significant (Cassis 1984, Cassis in preparation). The external cuticular component of the metathoracic scent glands yields a wealth of systematic characters. The terminology of this system remains greatly confused, and requires standardization across the Heteroptera. Staddon (1979) has referred to this system as the scent efferent system, which I have adopted in this work. His nomen-

clature of the scent efferent system components has not proven as useful, and I have preferred to use a translation of some of the terminology of Carayon (1971). I refer to the gutterlike channel which emerges from the ostiole as the peritreme. This structure is usually tongue-like and extends to the lateral margins of the metepisternum. Under light microscopy it often appears shiny, whereas under scanning electron microscopy it is usually covered with microsetae. The peritreme is surrounded by highly dissected cuticle, which has a granulate appearance and is referred to as the evaporative areas. The evaporative areas are composed of numerous components, and in this work I refer chiefly to the evaporative caps, which are raised and flattened. The characters of the scent efferent system are labeled in Figs. 57, 119 and 123. I have included in the *Phylogenetic* analysis section below an evaluation of these characters in other Miridae.

The forewing venation of the termatophyline has been used extensively in this work, both as diagnostic and phylogenetic characters. The terminology and homology of the heteropteran forewing has been partly resolved by Tanaka (1926), Wootton and Betts (1986), and Betts (1986). Carver et al. (1991) refer to the posterior margin of the embolium in the Miridae as the R+M vein, whereas Knight (1941) considered this to be the costal vein. I accept the former interpretation and concur with Betts (1986) that the vein anterior to the R+M vein is the subcostal vein, which is evident in some Miridae. In this work I refer to the groove posterior to R+M vein as the median flexion line. Knight (1941) referred to this groove as the radial vein, but its appearance suggests a flexion line, rather than a tracheate vein. Its position, posterior to the posterior margin of the embolium, eliminates its interpretation as a radial (or R+M) vein. The median flexion line cannot be interpreted as the CuA vein, which according to Betts (1986), is an uninterrupted vein,

parallel and adjacent to the claval furrow. The vein of the clavus is referred to as the first anal vein by Betts (1986), which I have adopted in this work, and is synonymous with the claval vein of Knight (1941). Other workers, such as Davis (1961), have produced venational terminologies for the Heteroptera, but it is beyond the scope of this paper to contrast in detail the various systems. The characters of the forewing are labeled in Fig. 47.

The morphology of the male genitalia of the Deraeocorinae has received little attention. Kelton (1959) gave a comparative morphological account, and reported considerable diversity in form throughout the subfamily. He stated that the most distinctive features included the flexible ductus seminis, and the bulbous spiculate processes of the membranous vesica. Schwartz (1987) in a review of Mirinae and Deraeocorinae male genitalia suggested that the secondary gonopore was of critical importance, and that it differed in the two subfamilies. He reported that the secondary gonopore of the Deraeocorini terminated adjacent and usually basad of the membrane, and that the aperture is large and opens into a depressed trough, often with associated serrate sclerotized plates. He also stated that the secondary gonopores in the other Deraeocorinae tribes were smaller than those found in the Deraeocorini. Schwartz (1987) reviewed the terminology of the vesical processes used in previous works (Kelton 1959, Clayton 1982, Stonedahl 1983), suggesting that they were too simplified. Stonedahl (1988) differentiated two types of vesical processes in the mirine genus *Phytocoris* Fallén, as follows: (1) sclerotized processes (equivalent to the ribbonlike strap of Schwartz (1987)) which originate at or near the level of the gonopore, which is sometimes continuous or associated with the basal sclerite (originating basad to the secondary gonopore and not present in the Deraeocorinae examined), and variously attached to the membranous sac; (2) lobal

sclerites (Schwartz 1987) which originate at or distally on the membranous lobes, and as simple outgrowths of the membrane cuticle (equivalent to spicules or spiculae of other authors).

Stonedahl and Cassis (1991) in a revision of the deraeocorine genus *Fingulus* Distant described the male genitalia, and reported homologies and terminologies that have apparent general value in the Deraeocorinae, including the Termatophylini. They described the male genitalia of *Fingulus* as possessing a basal tubular, sclerotized skirt surrounding the distal region of the ductus seminis, a simple secondary gonopore, and a distal multilobed membranous sac with lobal sclerites and/or fields of spines. They found no evidence of sclerotized processes or basal processes.

In the Termatophylini the ductus seminis terminates at the base of the membranous component of the vesica (Figs. 111–118), as reported for the Deraeocorini by Schwartz (1987). The secondary gonopore is small, simple and undifferentiated, as is found in *Fingulus*. Aside from the genus *Termatophylidea*, the gonopore is associated with a differentiated basal portion of the membranous sac, which can be recognized as a V or U-shaped cavity marked by compact fields of spines (Figs. 111–113, 115–118), and is here referred to as the gonoporal cavity. It is difficult to ascertain in the Termatophylini whether the sclerites which are associated with the gonoporal cavity are lobal sclerites (Figs. 111–113, 115–118), or represent a unique type of vesical process. They are clearly outgrowths of the membranous cuticle, but are never found on the periphery of the membranous lobe. This could not be clarified because of the limited material available for examination. In the Termatophylini, the vesica is small and appears to be unilobed, and does not show any obvious inflation as is evident in other Deraeocorinae and Mirinae. I have tentatively referred to these processes as lobal sclerites pending further study. The distal regions of

the membranous sac often have fields of spines (Figs. 111, 116–118).

The vesica of *Termtophylidea* is unlike any other termtophyline, in possessing a sclerotized process connected to the base of the ductus seminis and extending to near the apex of the membranous lobe. It also lacks any obvious gonoporal cavity and there are no lobal sclerites or fields of spines. This is reminiscent of the condition found in the dicyphine genus *Singhalesia* China and Carvalho and in some species of *Hyaliodes* Reuter. The latter genus and *Termtophylidea* are superficially similar, but are clearly differentiated on characters of the head and the pterothoracic spiracle, and the presence of a sclerotized process in both genera is considered to be independently derived. Stonedahl (personal communication) has indicated that the sclerotized process is also present in the clivinemines, *Ambracius* Stål and *Bothynotus* Fieber.

PHYLOGENETIC METHODS

The phylogenetic relationships of the termtophyline genera were examined using cladistic methods (Wiley 1981). The cladogram was produced, using in tandem, the computer software HENNIG86 and CLADOS. These programs are designed for producing cladograms of minimal length, and the manipulation of the character data. The character data matrix was built in a text editor and transferred to HENNIG86, where tree building algorithms were applied to the input file. The final result was produced by using the Branch and Bound option, where the data were treated in a stepwise manner. Choice between multiple trees of equal length was made by reweighting characters according to the rescaled consistency index.

The characters were coded as either binary or multistate characters. Most of the multistate characters were ordered, except for characters 4, 23 and 27 (see Table 2), which were coded as non-additive, because there was no evidence of transformation series. Character state polarization was

achieved through outgroup comparison. The selection of outgroups was made difficult by current deficiencies in the tribal classification of the Deraeocorinae (Akingbohunge 1974, 1978, Stonedahl and Cassis 1991). At present six tribes are recognized; Clivinemini, Deraeocorini, Saturniomirini, Hyaliodini, Surinamellini and Termtophylini. A selection of genera from each of the tribes, aside from the ant-mimetic Surinamellini, were initially included in the analysis, to examine the distribution of characters throughout the Deraeocorinae. This produced cladograms with low consistency indices, and the outgroups were then restricted to two members of the Clivinemini (*Ambracius* and *Bothynotus*), and the genera *Conocephalocoris* and *Hesperophylum*, which previously had been included in the Termtophylini. The last two genera show many similarities with the Termtophylini, as presently defined, particularly in the head and hemelytral structure, and are considered as sister-groups. The Clivinemini genera were also included in adherence to multiple outgroup principles (Maddison et al. 1984), and were selected above other deraeocorines because of some structural similarities with termtophylines, particularly in the form of the callosite region of the pronotum. Genera of the Hyaliodini (*Annona* Distant and *Hyaliodes* Reuter), initially included in the analysis, are similar to some *Termtophylini*, particularly the genus *Termtophylidea*, but were excluded because they provided no additional clarification to any of the character state trees. The male genitalic characters were not examined in any of the outgroups because of a lack of specimens. Stonedahl (personal communication) provided information on the male genitalia of some of the outgroup taxa.

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HISTORICAL REVIEW

The first termatophyline, *Termatophylum insigne*, was described by Reuter (1884a), who recognized this species as unique, and erected a new subfamily, the Termatophylina, of Anthocoridae for it. He diagnosed the group on the basis of the four-segmented labium, including the short first segment, the absence of ocelli, hemelytral structure, lack of a hamus in the hindwing, and the three-segmented tarsi. He distinguished it from another anthocorid subfamily, the Microphysina, on hemelytral and

tarsal characters. Reuter (1884b) in his monograph of the anthocorids, recognized three subfamilies, Anthocorina, Microphysina and Termatophylina, and provided a key to the subfamilies, differentiating the two latter subfamilies from the Anthocorina by the four-segmented labium. Subsequently, Reuter (1910) in his review of the systematics of the Miridae, recognized the termatophylines as a family, separating them from the mirids by the presence of an embolium. Poppius (1910) supported the family status, in describing a new *Termatophylum* species from the Ethiopian Region.

Reuter and Poppius (1912) in the only previous comprehensive paper on the termatophylines retained the suprageneric group as a family, giving a detailed description, and distinguishing them from the Anthocoridae. They made mention of the porrect head and the short first labial segment, but erroneously concluded that the pretarsi lacked arolia (= parempodia). Schuh (1976) in a review of the mirid pretarsus has shown that setiform and fleshy parempodia are homologous. Early European workers, such as Reuter and Poppius (1912), regarded fleshy parempodia as the only true "arolia," and their conclusion that termatophylines lack "arolia" is a misinterpretation of setiform parempodia. Reuter and Poppius (1912) described three new genera, *Arygrotelaenus*, *Hesperophylum* and *Termatophylidea*, and seven new species. They also included a key to the four known termatophyline genera. Parshley (1923) described the family, largely repeating Reuter and Poppius' (1912) diagnosis, but curiously suggested that termatophyline genitalia were "much as in the Anthocoridae."

China and Myers' (1929) seminal paper on the classification of the cimicoid families, reappraised the relationships of the termatophylines, and placed them within the Miridae. They concluded that apart from the anthocorid-type head and the short first labial segment, the termatophylines were conclusively mirids, and treated them as a subfamily. They indicated that the porrect

head condition occurs in the Cylapinae, and noted its similarity to termatophylines. Carvalho (1951, 1952) analyzed the position of the termatophylines, and concluded that they were a tribe of Deraeocorinae on the basis of the basally cleft claws and setiform parempodia. He differentiated them from other deraeocorines by the porrect head, large eyes, short antennae, and small body size. Carvalho (1955a) provided a key to the termatophyline genera, recognizing seven genera, *Hesperophylum*, *Termatophylidea*, *Arygrotelaenus*, *Conocephalocoris*, *Termatophyllella*, *Termatophyloides* and *Termatophylum*. He distinguished the genera mostly on head and pronotal characters, and the short antennae.

Aside from Wagner (1970), who retained the termatophylines as a family, no subsequent author has deviated from the tribal placement of this group within the Deraeocorinae. Other works mostly include descriptions of new genera and species. Carvalho (1955b) described new taxa from the Neotropical region, recognizing two new genera, *Termatophyloides* and *Termatophyllella*, from Central America, and two new species of *Termatophylidea*. Miyamoto (1965) gave detailed descriptions of two new termatophylines from Japan, providing adequate genitalic and habitus illustrations. Maldonado (1970) reviewed the distinctive genus *Termatophylidea*, describing three new species, with a key to all known species. Carvalho (1988) described a new genus, *Termatophylina*, from India, and gave illustrations of the male genitalia. Linnavuori (1974) described a new species of *Termatophylum* from Nigeria, and gave a key to the African species. Poppius (1910, 1915), China (1929), Usinger (1935), Carvalho (1983) and Ren (1983) described the other species.

BIOLOGY

The little that is known of the biology of Termatophylini suggests that the species are predators (Callan 1975). In Table 1 the biological information that is known is listed,

including prey and plant associations. This information was taken from the literature and label data. Myers (1935) was the first to report termatophylines as predators, describing *Termatophylidea pilosa* as an important predator of the cacao thrips, *Selenothrips rubrocinctus* (Giard), a serious pest of cacao in the tropical parts of the Neotropical region. Callan (1943, 1975) and van Doesburg (1964) recorded other *Termatophylidea* species as predators of thrips. Both *T. maculata* and *T. opaca* are also predators of the cacao thrips, and Callan (1975) reported that the former species also feeds on the larvae of the grass thrips, *Calliothrips insularis* (Hood). There are indications that other termatophylines feed on moth larvae. *Kundakimuka queenslandica* feeds on the xyloryctine moth, *Xylorycta luteotactella* (Walker), which feeds on a paperbark species, *Melaleuca integrifolia*. I have examined specimens of *Termatophylina indiana* from the Natural History Museum, which has the label data: "associated with larval galleries of *Lamida moncusalis*," which suggests that termatophylines may commonly feed on moth larvae.

The termatophylines are found in a variety of habitats, including flowers, foliage and moth larval galleries. Five termatophyline species, *Kundakimuka queenslandica*, *Termatophyloides pallipes*, *T. pilosulus*, *Termatophylidea maculata* and *T. opaca*, have been found on leaves, with the last two species restricted to the underside of leaves (van Doesburg 1964, Callan 1975). Two species of *Termatophylum*, *T. hikosanum* and *T. melaleucae*, have been collected from flowers. Van Doesburg (1964) reported that *T. opaca* and its prey were found under fine spider webs. The association of *Termatophylina indiana* with moth larval galleries, suggests that termatophylines may be commonly encountered in sheltered microhabitats. The prey of *Kundakimuka queenslandica*, *Xylorycta luteotactella*, is also known to live in small tunnels, which the moth bores in the branches of their food plant (Common 1990). Also of interest is the fre-

quency with which termatophyline are found at light. Five species of the genera *Kundakimuka*, *Termtophylidea* and *Termtophylum* have been taken at light or in light traps. This suggests that the termatophyline are nocturnal predators. This hypothesis is morphologically supported by the presence of very large eyes, with enlarged ommatidia. There is no evidence of *Termtophylina indiana* being collected at light, which is the only termatophyline taxon that does not have enlarged ommatidia, and the eyes are of moderate size.

Termtophyline are known from a wide variety of plants. They have been recorded from three monocot families, the Gramineae, Musaceae and Orchidaceae, and seven dicot families, the Anacardiaceae, Betulaceae, Bombacaceae, Compositae, Leguminosae, Myrtaceae and Sterculiaceae (Table 1). The association of termatophyline with monocots is restricted to the Neotropical genera *Termtophyllella*, *Termtophylidea* and *Termtophyloides*. There is no apparent overall pattern of plant association in the termatophyline, with some species having multiple plant associations, and *Termtophylidea opaca* known from both a monocot and dicot. Some sympatric termatophyline taxa are found on the same plant genera: *Arygotelaneus simoni* and *Termtophylum insigne* are both known from *Acacia* species, and *Kundakimuka queenslandica* and *Termtophylum melaleuca* are known only from *Melaleuca* species.

SYSTEMATICS

Tribe Termtophylini

Termtophylina: Reuter 1884b: 167; Reuter 1884a: 218 (subfamily of Anthocoridae).

Termtophylidae: Reuter 1910: 70 (family status); Poppius 1910: 56; Reuter and Poppius 1912: 2 (diagnosis); Reuter 1912: 52 (key; diagnosis); Parshley 1923: 665 (description); Wagner, 1970: *** (footnote).

Termtophylinae: China and Myers 1929: 97 (subfamily of Miridae).

Termtophylini: Carvalho 1951: 133 (tribe of Deraeocorini); Carvalho 1952: 32, 42, 43, 50 (checklist); Carvalho 1955a: 22 (generic key); Carvalho 1957: 34 (catalogue).

Diagnosis.—The Termtophylini are best diagnosed by the short first labial segment (Figs. 19–20) which does not extend beyond the posterior margin of the bucculae. The head is moderately (Figs. 11, 14, 16, 17) to strongly porrect (Figs. 12, 13, 15, 18), with the apex of the clypeus in lateral view terminating above or at level of the antennifers (Figs. 11–18). Unlike any other Deraeocorinae the metathoracic spiracle is external (= visible) as an oval or lanceolate opening, usually bounded by evaporative bodies on the dorso-caudal arm of the dorsal margin of the mesepimeron (Figs. 65, 67, 68). The pronotum has antero-lateral projecting setae on the anterior angles of the callosite region (Figs. 32–34).

Description.—Macropterous, either smooth or coriaceous; ovoid (Fig. 1), elongate-ovoid (Fig. 2), or parallel-sided; mostly with rows of punctures on pronotum (Figs. 31, 33, 34, 38–42) and hemelytra (Figs. 47, 51–56); sparse to dense cover of setiform vestiture, rarely intermixed with adpressed, flattened scalelike setae. **Head:** moderately (Figs. 11, 14, 16, 17) to strongly (Figs. 12, 13, 15, 18) porrect; elongate (Figs. 4, 5, 7, 10) or transverse (Figs. 3, 6, 8, 9); vertex rounded, flattened, or narrowly bicompressed, posterior margin sometimes weakly carinate; frons moderately to strongly narrowed in front, barely to weakly declivent; clypeus short, weakly to moderately declivent, terminating above (Figs. 12, 13, 15) or at level of antennifers (Figs. 11, 14, 16, 17, 18) in lateral view; bucculae usually short and terminating caudally at or just beyond antennifers, most often very narrow, with lateral margins either subparallel (Figs. 20, 22, 23), weakly to moderately arcuate (Figs. 19, 21, 26) sometimes strongly

Table 1. List of prey, habitats and habits, and plant associations of Termatophylini species.

Ternatophylini Species	Ternatophylini Prey	Habitats and Habits	Plant Association	Reference
<i>Arygrotalaenus simoni</i>		at light	<i>Acacia</i> sp. [Leguminosae]	Linnavuori 1975, 1989 label data
<i>Kundakimika carvalhoi</i>		sweeping herbs		Miyamoto 1965 label data
<i>Kundakimika pallipes</i>	<i>Xylorycta luteotactella</i> [Lepidoptera]	on foliage	<i>Melaleuca integrifolia</i> [Myrtaceae]	
<i>Kundakimika queenslandica</i>			Orchidaceae	Carvalho 1955b
<i>Ternatophylidella fulvovides</i>		at light	<i>Pachira insignis</i> [Bombacaceae]	Maldonado 1970
<i>Ternatophylidella brunnea</i>		at light		Maldonado 1970
<i>Ternatophylidella constricta</i>		at light	<i>Theobroma cacao</i> [Sterculiaceae], <i>Anacardium occidentale</i> [Anacardiaceae]	Maldonado 1970
<i>Ternatophylidella hyalina</i>	<i>Selenothrips rubrocinctus</i> [Thysanoptera]	on underside of leaves		Callan 1943, 1975
<i>Ternatophylidella maculata</i>	<i>Calliothrips insularis</i> [Thysanoptera]		<i>Alnus acuminata</i> [Betulaceae]	Uisinger 1935
<i>Ternatophylidella ocellata</i>	<i>Selenothrips rubrocinctus</i> [Thysanoptera]	on underside of leaves	Gramineae	Callan 1975
<i>Ternatophylidella opaca</i>	<i>Selenothrips rubrocinctus</i> [Thysanoptera]	?gregarious	<i>Vernonia brachiata</i> [Compositae]	Carvalho 1955b
<i>Ternatophylidella pilosa</i>		associated with larval galleries of <i>Lamida monocusalis</i> [Lepidoptera]		van Doesburg 1964, Callan 1975
<i>Ternatophylidella indiana</i>	<i>Selenothrips rubrocinctus</i> [Thysanoptera]	on tree blossom	Orchidaceae <i>Musa</i> sp. [Musaceae]	Myers 1935, Callan 1975
<i>Ternatophylidella pilosulus</i>		on herbs		label data
<i>Ternatophylidella hikosamum</i>		on racemes at light in rainforest	<i>Acacia</i> sp. [Leguminosae]	Carvalho 1955b
<i>Ternatophylidella insignis</i>		at light in rainforest	<i>Melaleuca integrifolia</i> , <i>M. quinquenervia</i> [Myrtaceae]	Miyamoto 1965
<i>Ternatophylidella melaleuca</i>		at light in rainforest		Linnavuori 1989 label data
<i>Ternatophylidella weiri</i>				label data

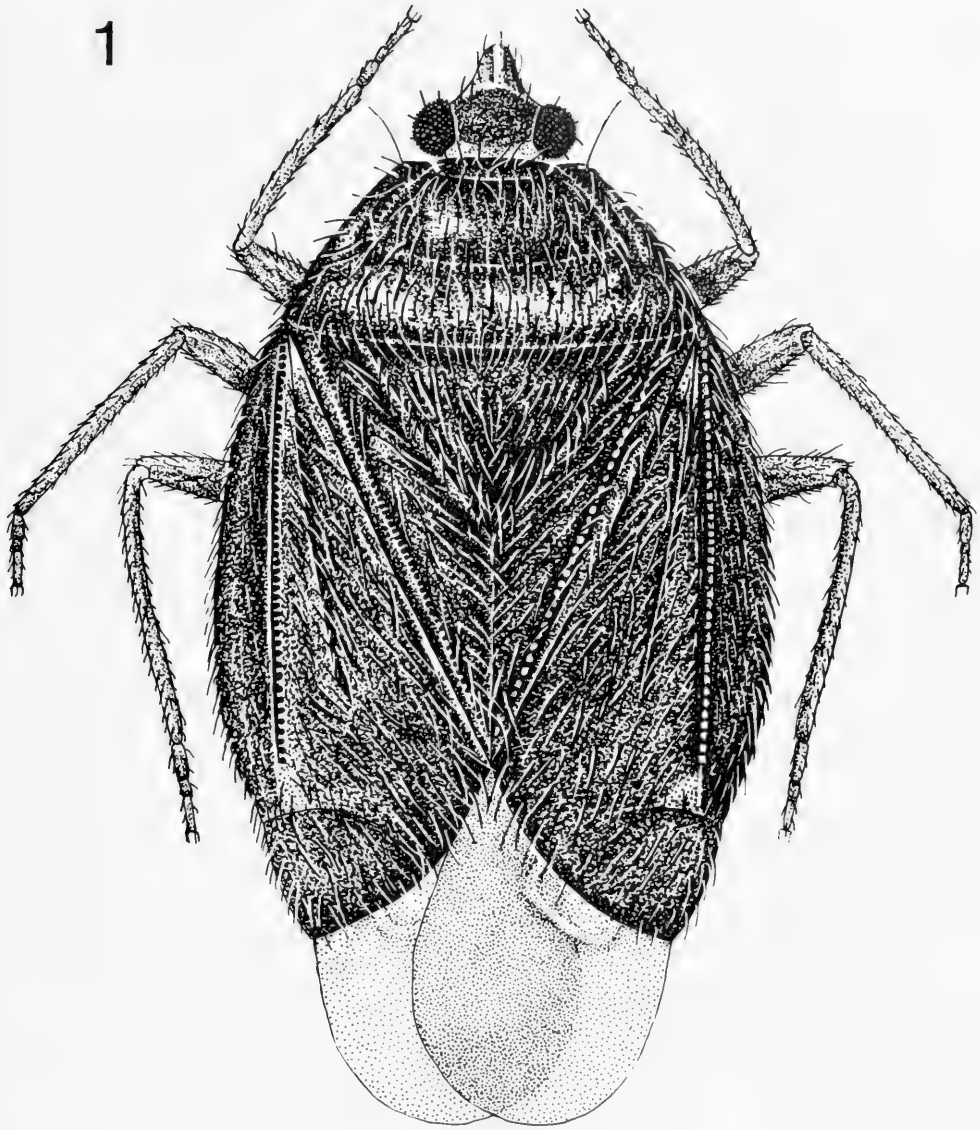


Fig. 1. *Democoris lugens*, dorsal habitus of female.

arcuate (Fig. 24), and in one case extremely broad, laterally almost contiguous with antennifers, with margins also explanate (Fig. 25); gula elongate, narrow (Figs. 22, 23) to moderately broad (Figs. 19, 20, 21, 24), concave (Figs. 19, 20, 22–26) to weakly convex (Fig. 21), often with transverse ridges, margins rarely carinate, sometimes with rows of setae on lateral margins, rarely with a

dense matt of whitish, microsetae (Figs. 22, 23). *Eyes*: moderately sized (Figs. 12, 13, 15, 17, 18) to very large (Figs. 11, 14, 16), most often contiguous, or nearly so, with pronotal collar, rarely removed; ommatidia usually very large, rarely small (Fig. 13), with short to elongate setiform interocular setae (Figs. 11–14). *Antennae*: inserted below midheight of eyes; usually short; mostly

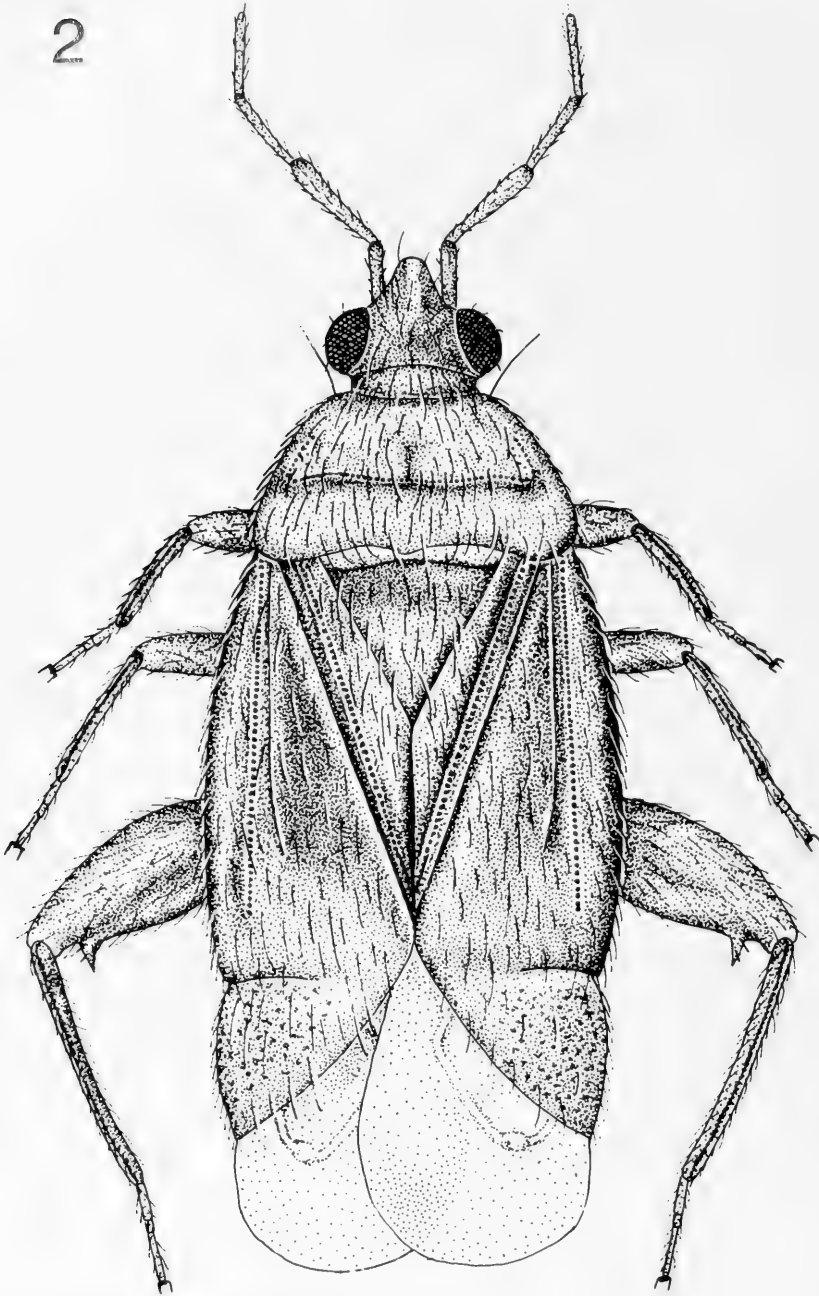
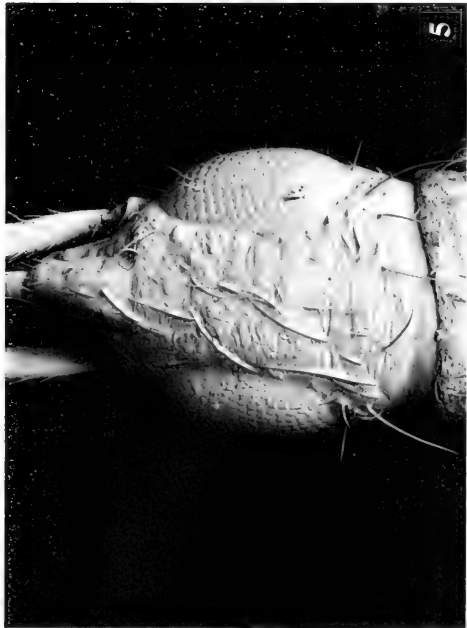


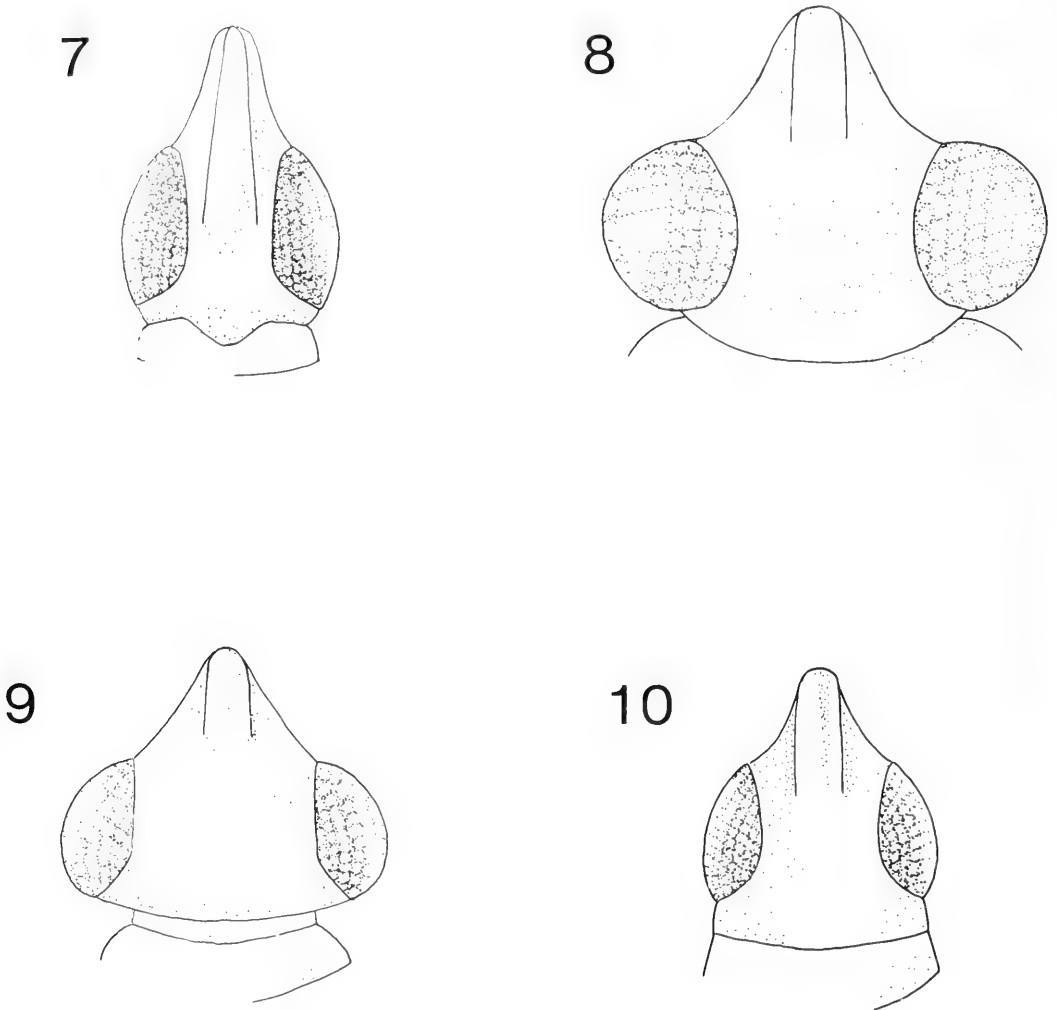
Fig. 2. *Kundakimuka carvalhoi*, dorsal habitus of male.

with AIII and AIV thinner than AI and AII; with setiform vestiture, usually longer than width of segments, rarely intermixed with minute, flattened, adpressed setae on AII;

AI usually short, barely surpassing apex of clypeus, rarely moderately surpassing tip of clypeus in females, moderately to greatly thickened; AII usually longest segment, usu-



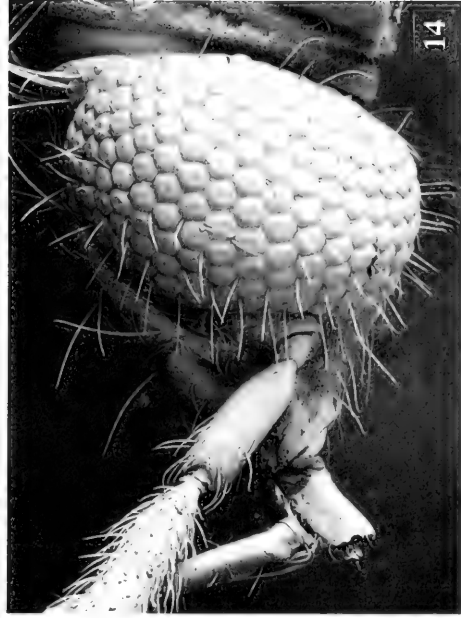
Figs. 3–6. Dorsal view of head. 3, *Kundakimuka queenslandica*, male. 4, *Termatophylidea* sp., female. 5, *Termatophylina indiana*, female. 6, *Termatophylina melaleuca*, male; c = clypeus, v = vertex.



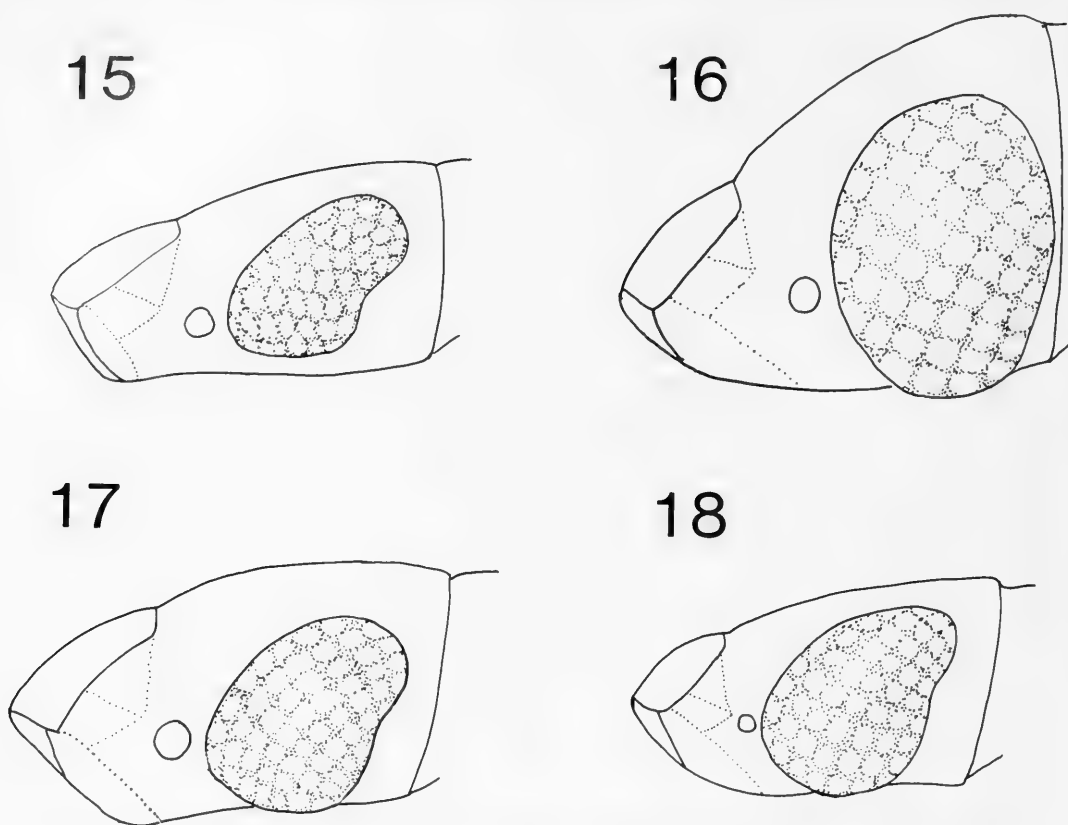
Figs. 7–10. Dorsal view of head. 7, *Arygrotelaenus elegans*, female. 8, *Democoris lugens*, female. 9, *Termatophylella fulvoides*, male. 10, *Termatophyloides pilosulus*, male.

ally cylindrical and weakly incrassate apically (Figs. 27–29), sometimes fusiform and swollen in males (Fig. 30), and if so, only incrassate in females; AIII cylindrical, either subequal in length to AII to much shorter; AIV weakly fusiform, subequal in length to shorter than AIII. *Labium*: inserted terminally on head, above or at the antennifers in lateral view (Figs. 11–14), slender, sometimes fragile, usually reaching apices of forecoxae, at most posterior margin of mesosternum; LI very short and narrow, never surpassing posterior margin of

bucculae (Figs. 19, 20); LII usually longest segment. *Pronotum*: tripartite, subtrapezoidal (Figs. 31–34, 39–42); lateral margins linear, weakly to strongly divergent posteriorly; flattened (Figs. 31, 43), evenly tumid (Fig. 40), or biconvex with callosite and disc regions separated by deep incision (Figs. 32, 46); pronotal collar rounded, moderately elongate (Figs. 31–34, 39–42), width variable reaching midwidth of eyes to maximum eye width, posterior margin marked by a shallow to deep groove, which is punctate (Figs. 31, 33, 34, 35, 40, 42) or non-



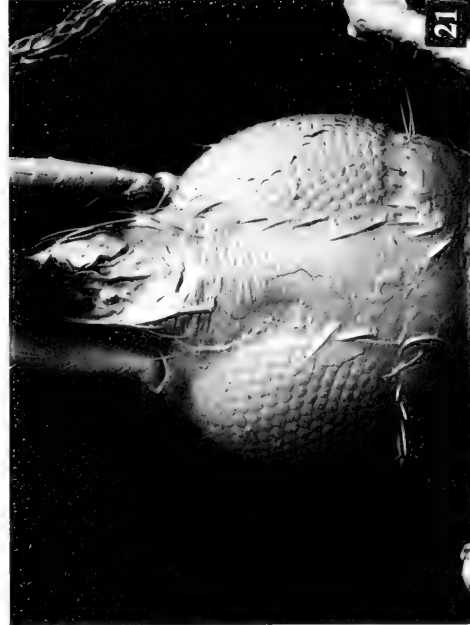
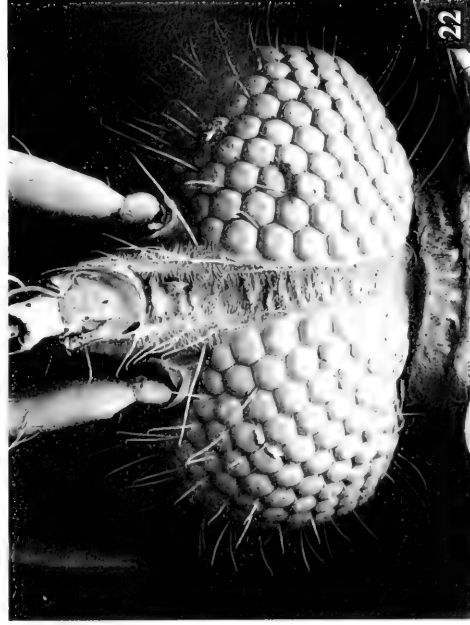
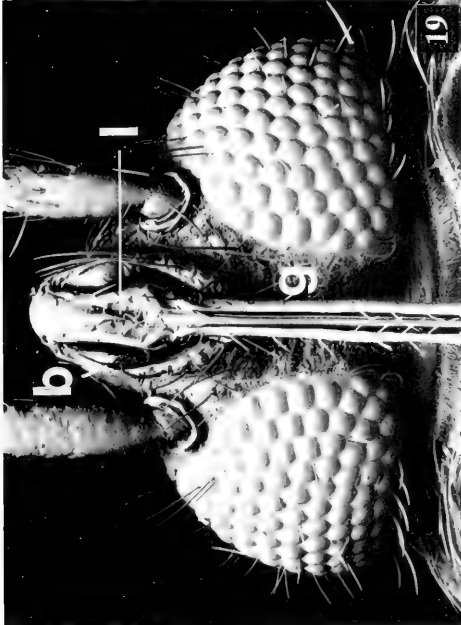
Figs. 11-14. Lateral view of head. 11, *Kundakimika queenslandica*, male. 12, *Termatophylina indiana*, female. 13, *Termatophylina indiana*, female. 14, *Termatophylum melaleuca*, male; b = bucculae; c = clypeus; a = antennifers.



Figs. 15–18. Lateral view of head. 15, *Arygrotelaenus elegans*, female. 16, *Democoris lugens*, female. 17, *Teratophylella fulvoides*, male. 18, *Teratophyloides pilosulus*, male.

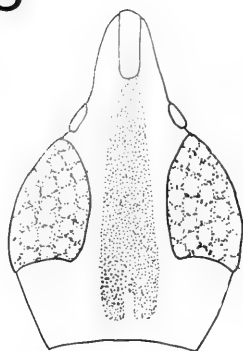
punctate (Figs. 32, 39, 41); callosite region separated by a shallow to deep transverse groove, submarginally directed anteriorly, usually meeting pronotal collar (Figs. 31–34, 39–42), groove usually punctate (Figs. 31, 33–35, 40, 41, 42) rarely with conical, tumid processes (Figs. 32, 36), sometimes callosite region demarcated along midline by a short row of punctures (Figs. 37, 42), with calli clearly separated; antero-lateral pronotal setae, placed dorsad to tergopleural suture, and either anterior to posterior to propleural suture; disc usually longer than callosite region, sometimes subequal in length, rarely shorter, most often obliquely raised above callosite region, posterior margin truncate, or weakly bisinuate. *Scutellum*: triangular, flattened to moderately rounded, sometimes with lateral margins

punctate; anterior margin rarely with small tubercles (Fig. 38). *Hemelytra*: margins parallel-sided to strongly arcuate (Fig. 1), usually not greatly extending laterally beyond posterior angles of pronotum, rarely much broader; clavus nearly always with a punctate anal vein (Figs. 47, 51–56), sublaterally placed, rarely anal vein as a sinuate groove (Figs. 49, 50); embolium either narrow (Figs. 48, 51, 54, 55, 56), usually less wide than length of pronotal collar, to very broad, subequal to or greater than length of pronotal collar (Figs. 47, 52, 53); corium mostly with a punctate R+M vein (Figs. 47, 51–56), variable in length, from midlength of corium to just anterior to cuneal fracture, either shorter (Figs. 51, 56) or longer than medial flexion line (Figs. 47, 48, 52–55), sometimes median flexion line very short (Fig. 49); me-

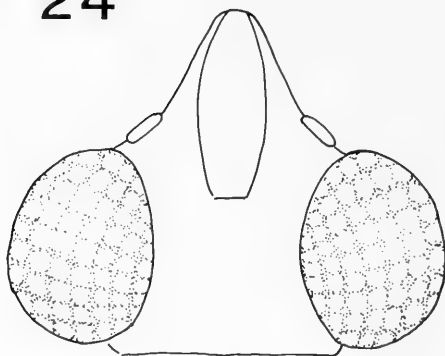


Figs. 19–22. Ventral view of head. 19, *Kundakimuka queenslandica*, male. 20, *Termatophylidea* sp., female. 21, *Termatophylina indiana*, female. 22, *Termatophylum melaleuca*, male; b = bucculae; g = gula; 1 = first labial segment.

23



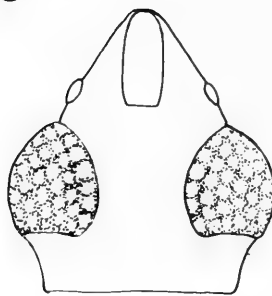
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25



26



Figs. 23–26. Ventral view of head. 23, *Arygrotelaenus elegans*, female. 24, *Democoris lugens*, female. 25, *Termatophylella fulvoides*, male. 26, *Termatophyloides pilosulus*, male.

dial flexion line mostly subparallel, and weakly divergent posteriorly to R+M vein, or strongly divergent from origin; cuneus mostly as long as wide; membrane either hyaline, translucent or opaque, concolorous or with bicolored pattern; usually glabrous, rarely with dense cover of microsetae; membrane with one cell, very narrow (Figs. 52, 53) to broad (Figs. 48, 54), subelliptical to subquadrate; membrane vein sometimes obscure (Fig. 51), often with an indistinct swelling subcaudally adjacent to cuneus. *Thoracic pleura*: tergo-pleural suture usually

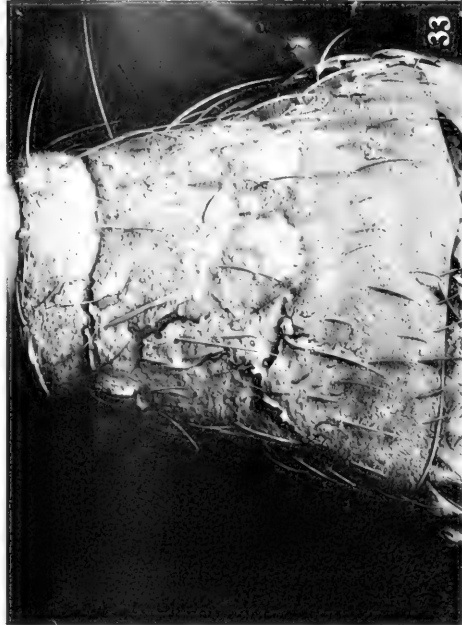
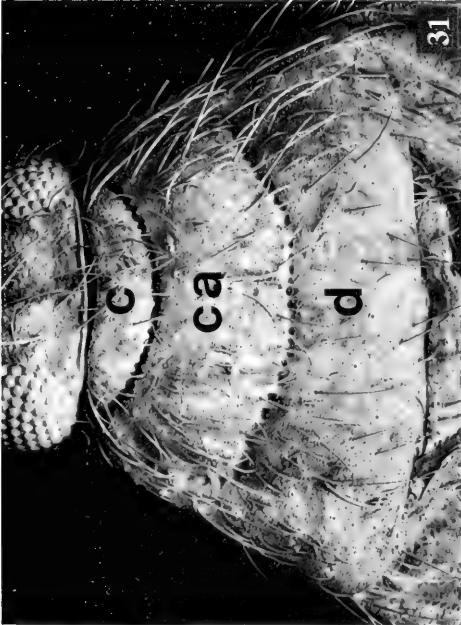
distinct as a groove anterior to propleural suture (Figs. 43–46), posteriorly evident as a weak depression, sometimes as a pit above propleural suture; propleural suture most often distinct, sometimes obscure; proepisternum short, subtriangular or subquadrate, explanate; proepimeron large, subtriangular, strongly depressed mesally, sometimes with one or two pits (Figs. 44, 46); mesepimeron usually polished, rarely rugose, variable, either short and subquadrate (Figs. 57, 60, 61–64), or large and elongate (Figs. 58, 59), with dorsal margin an-

gulate, and dorso-caudal arm bearing an oval to lanceolate spiracular opening (Figs. 65, 66, 67), or recessed and not visible in lateral view (barely visible in latero-caudal view) (Fig. 68), spiracle nearly always bounded by evaporative areas (Figs. 65, 67, 68), in one case absent (Fig. 66), ventral margin of mesepimeron often obscure, at most as a weak depression, sometimes with vestiture; metepisternum bipartite, with a well developed metathoracic gland scent efferent system (Figs. 57–64, 69–72), tumid, occupying about half of the segment, often dorsally contiguous with the mesepimeric evaporative areas (Figs. 57, 59, 63, 64), sometimes separated (Figs. 60–62), peritreme usually placed on mid-length of scent efferent system (Figs. 58, 70, 60, 72, 61) sometimes just caudad of mid-line (Figs. 57, 69, 62, 63, 64), rarely along posterior margin of metepisternum (Figs. 59, 71), peritreme tongue-like (Figs. 69, 70) or finger-like (Fig. 72), mostly polished, with microsetae, mostly straight, rarely weakly arcuate dorsally (Figs. 62, 64), often with posterior margin raised above plane of evaporative areas, rarely with apex raised; evaporative bodies either elongate (Figs. 73, 74, 76) or subquadrate (Fig. 75), caps mostly widely separated; remainder of metepisternum depressed relative to scent efferent system, margins rounded. *Legs*: usually of moderate length, rarely elongate; metatrochanters rarely with minute spine (Fig. 83); femora mostly fusiform, rarely elongate and cylindrical, with metafemora rarely greatly enlarged (Fig. 83), and armed with spinelets (Figs. 81–82) or large spine distally on the ventral surface (Figs. 83–84); three or four ventral mesofemoral and four to six ventro-subdistal metafemoral trichobothria (Figs. 77–80), intermixed with moderate to sparse cover of semierect setiform vestiture; tibiae mostly cylindrical, sometimes weakly subquadrate, sometimes with rows of spinelets (Figs. 86–88), rarely without rows of spines (Fig. 85), always with moderate to sparse cover of semiadpressed setiform ves-

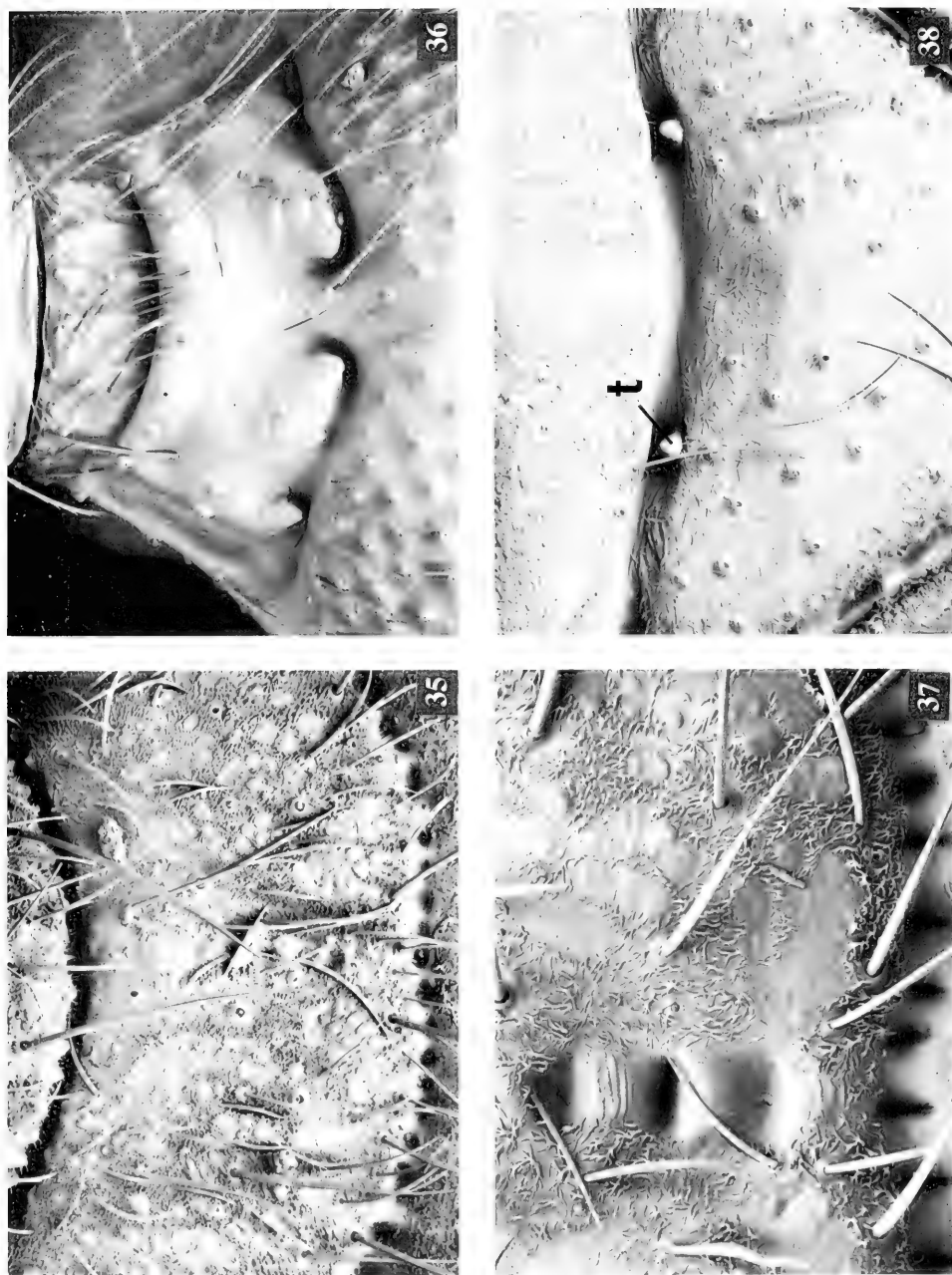
ture, foretibiae always with a well-developed tibial comb; tarsi cylindrical, with TI and TII subequal in length, TIII longest segment, always with semiadpressed setiform vestiture; pretarsus with basally toothed claws, mostly with setiform parempodia (Figs. 90, 96, 91, 97, 92, 98), sometimes parempodia flattened and ribbonlike (Figs. 89, 95, 93, 99, 94, 100), rarely weakly flattened with apices expanded, without pulvilli or pseudopulvilli. *Abdomen*: depressed, very broad, shiny, anthocoridlike, usually with regular distribution of semiadpressed semierect setae, often intermixed with elongate trichobothrialike setae laterally on terminal segments, abdomen rarely narrow and cylindrical. *Male genitalia*: genital capsule small, conical (Fig. 101), genital opening dorso-caudal (Fig. 102), small, narrow, ventral margin carinate, obliquely raised from left to right; tergite X large, mostly free, rarely partially fused to left dorsal margin of genital opening; left paramere (Figs. 103–110) placed in a weak excavation of ventro-sinistral corner of genital opening (Fig. 101), sensory lobe very small, with a few sensory hairs on outer margin, shaft arcuate, in resting position at 45° to ventral margin of genital opening (Fig. 102), directed dextrally, apex of shaft either spatulate (Figs. 106, 109) or evenly tapered (Figs. 103–105, 107, 108, 110); right paramere very small, apically tapered, placed in ventro-dextral corner of genital opening; aedeagus directed sinistrally in resting position, crossing shaft of left paramere; phallosome straplike, apically dissected, sclerotized, broadly connate with vesica and connected basally to phallobase by a thin membrane; vesica (Figs. 111–118) with one membranous lobe; ductus seminis terminating at base of lobe, without liplike sclerotized secondary gonopore, usually with gonopore opening into a gonoporal cavity, marked by a U or V-shaped field of spines; usually without sclerotized process (Figs. 111–113, 115–118), present in one genus (Fig. 114); lobal sclerites usually mesally placed, and linear



Figs. 27-30. Second antennal segment. 27, *Kundakimuka queenslandica*, male. 28, *Termatophylina indiana*, female. 29, *Termatophylum metaleuca*, male. 30, *Termatophylina indiana*, female.

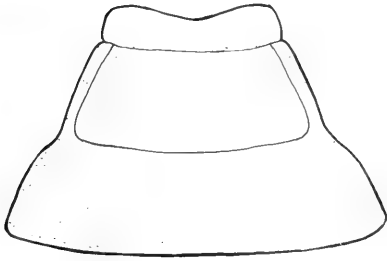


Figs. 31-34. Dorsal view of pronotum. 31, *Kundakimuka queenslandica*, male. 32, *Termatophylina indiana*, female. 33, *Termatophylina indiana*, female. 34, *Termatophylum melaleuca*, male; c = collar; ca = callosite region; d = disc region, s = antero-lateral pronotal seta.

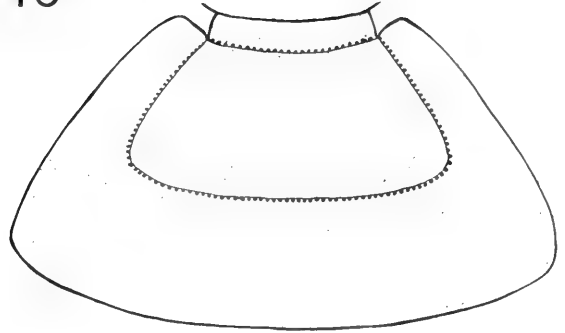


Figs. 35-38. Higher magnification of punctations and processes on posterior margin of pronotal collar and callosite region (Figs. 35-37); processes on anterior margin of scutellum (Fig. 38). 35, *Kundakimuka queenslandica*, male. 36, *Termtatophylidea* sp., female, anterior margin of pronotum. 37, *Termtatophylidea* sp., female, processes of pronotum. 38, *Termtatophylidea* sp., female, anterior margin of callosite region. t = tubercle.

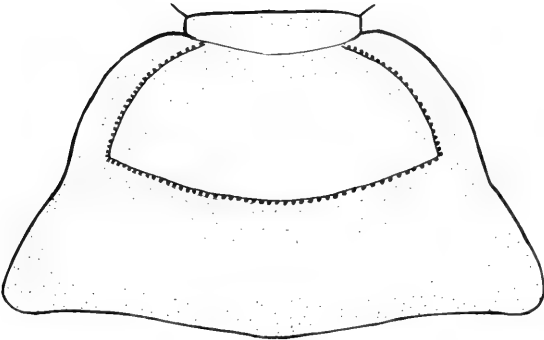
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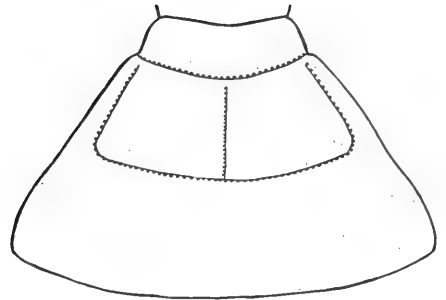
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42



Figs. 39–42. Dorsal view of pronotum. 39, *Arygotelaenus elegans*, female. 40, *Democoris lugens*, female. 41, *Termatophyllella fulvoides*, male. 42, *Termatophylloides pilosulus*, male.

to sublinear (Figs. 112, 113, 115) or sickle-shaped (Figs. 111, 116–118), and basally connected to apex of gonoporal cavity; apex of membranous lobe sometimes with fields of spines (Figs. 111, 116–118).

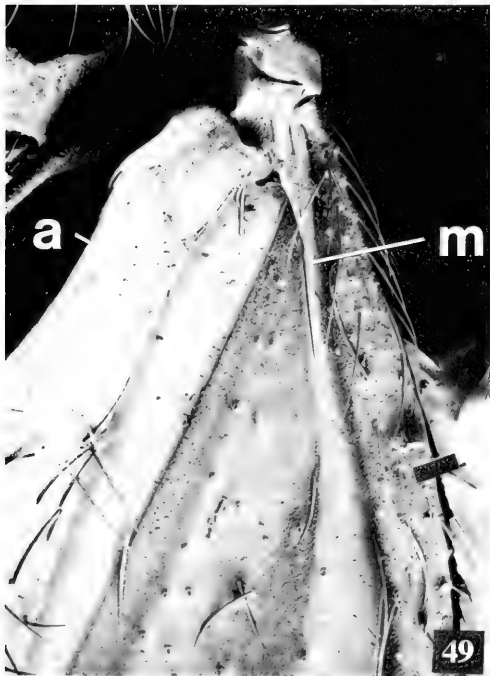
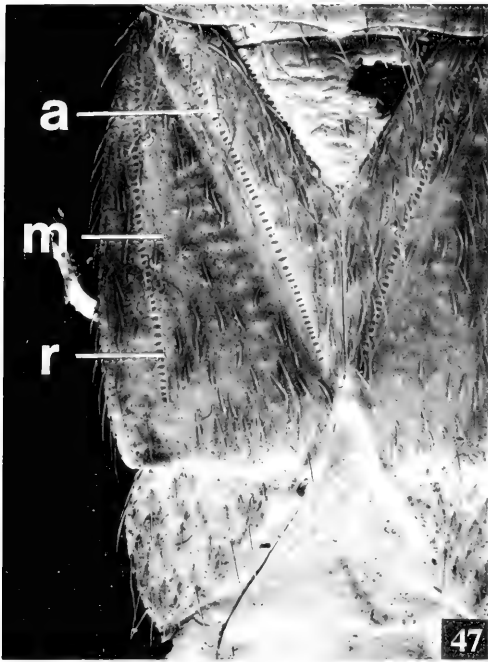
CHECKLIST OF THE
TERMATOPHYLINI OF THE WORLD

- Arygotelaenus* Reuter and Poppius, 1912
elegans Reuter and Poppius, 1912
 Egypt
simoni Reuter and Poppius, 1912
 Middle East, Sudan
- Democoris* Cassis n. gen.
lugens Cassis n. sp.
 Australia

- leptocytus* Cassis n. sp.
 Australia
- Kundakimuka* Cassis n. gen.
carvalhoi Cassis n. sp.
 Australia
pallipes (Miyamoto, 1965) nov. comb.
 Japan
- queenslandica* Cassis n. sp.
 Australia
- Termatophyllella* Carvalho, 1955
fulvoides Carvalho, 1955
 Mexico
- Termatophylidea* Reuter and Poppius, 1912
brunnea Maldonado, 1970
 Puerto Rico

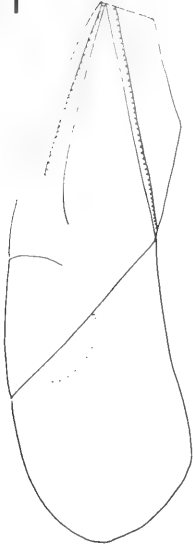


Figs. 43-46. Lateral view of pronotum. 43, *Kundakimika queenslandica*, male. 44, *Termatophylidea* sp., female. 45, *Termatophylina indiana*, female. 46, *Termatophyllum melaleuca*, male. pe = proepisternum; ps = propleural suture; p = proepimeron; tp = tergopleural suture.

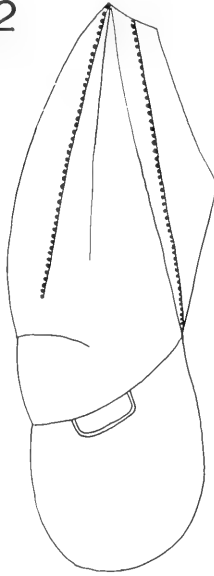


Figs. 47-50. Hemelytral characters. 47, *Kundakimuka queenslandica*, male, hemelytra. 48-50, *Termatophylidea* sp., female. 48, hemelytron. 49, anterior aspect of corium and clavus. 50, serrate anal vein of clavus. a = anal vein; m = median flexion line; r = R+M vein.

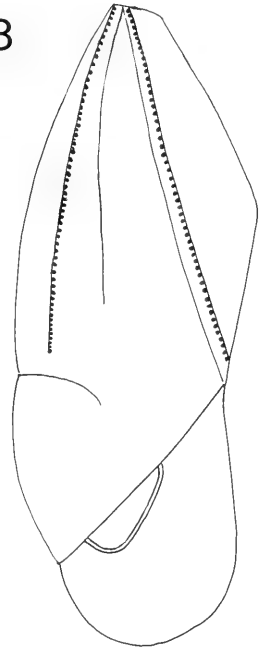
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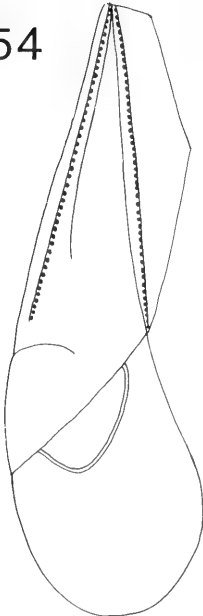
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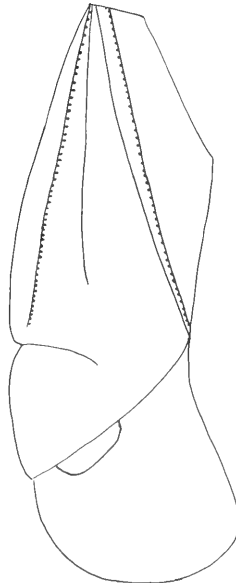
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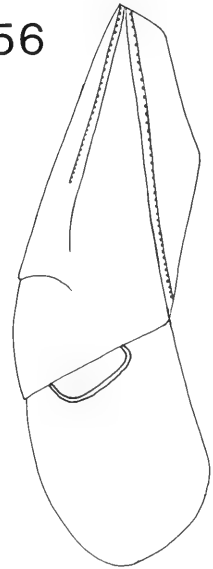
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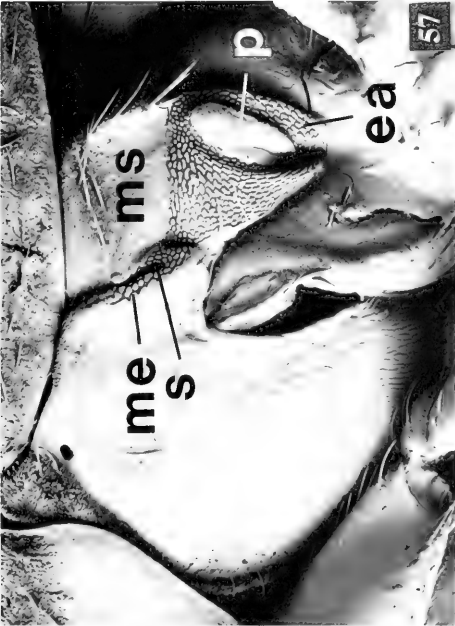
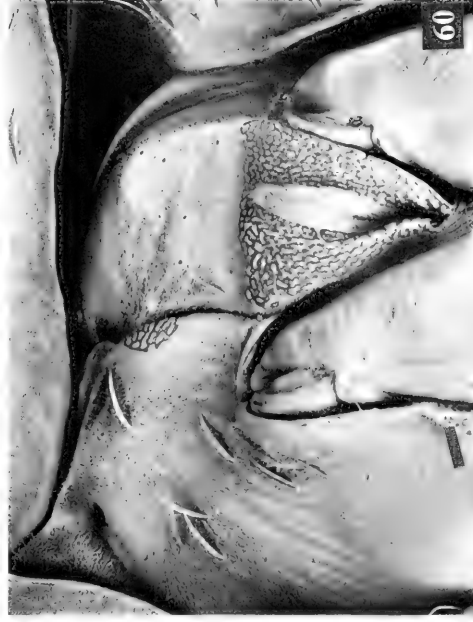
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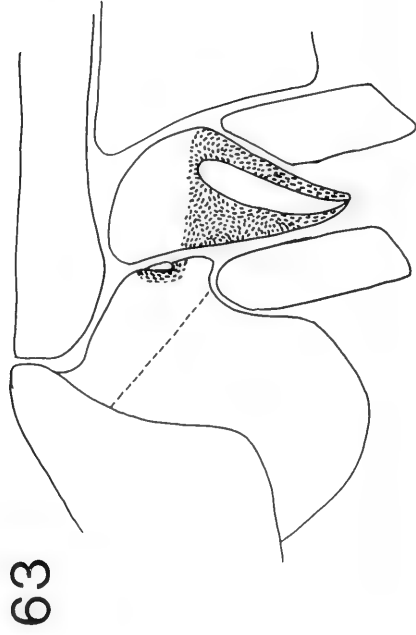
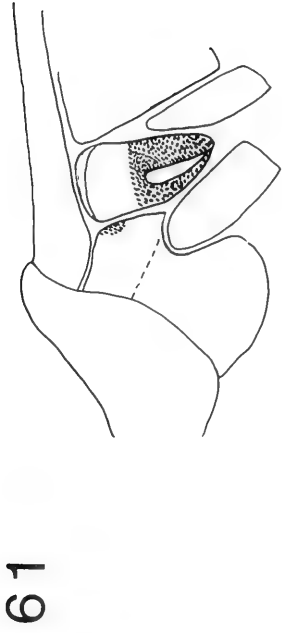
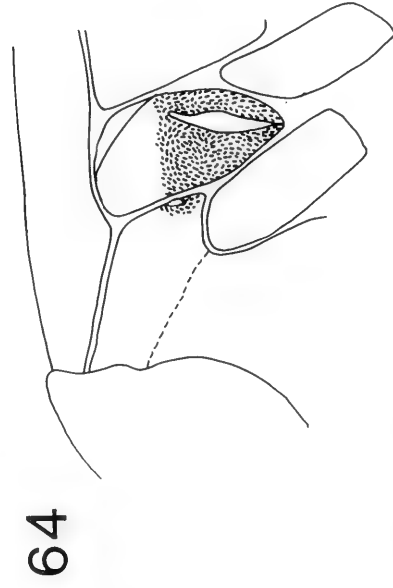
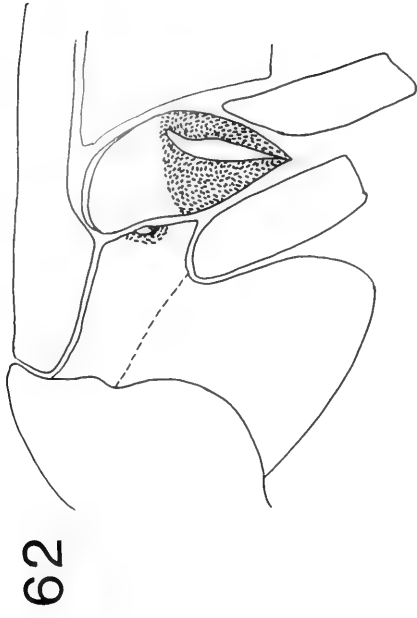
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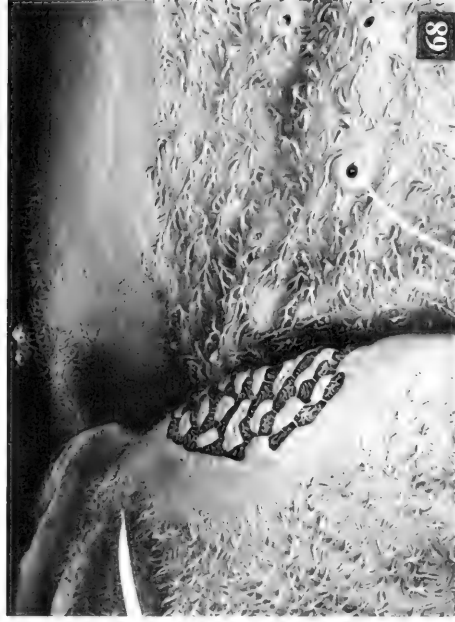
Figs. 51-56. Hemelytra. 51, *Arygotelaenus elegans*, female. 52, *Democoris lugens*, female. 53, *Termatophyella fulvoides*, male. 54, *Termatophylina indiana*, male. 55, *Termatophyloides pilosulus*, male. 56, *Termatophylum insigne*, male.



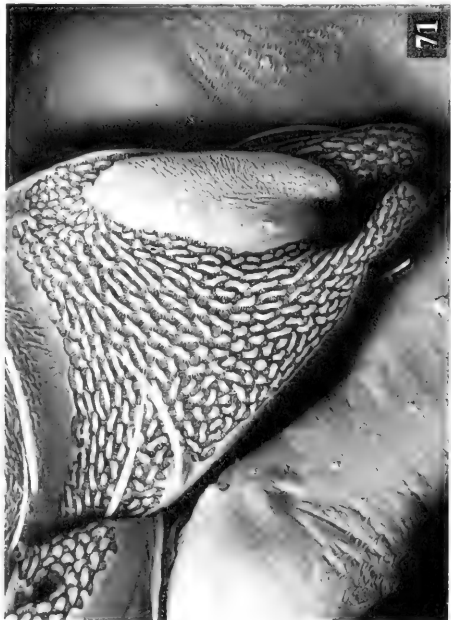
Figs. 57-60. Pterothoracic pleura. 57, *Kundakimika queenslandica*, male. 58, *Termatophylina indiana*, female. 60, *Termatophylina melaleuca*, male. ea = evaporative areas; me = mesepimeron; ms = metepimeron; p = peritreme; s = metathoracic spiracle.



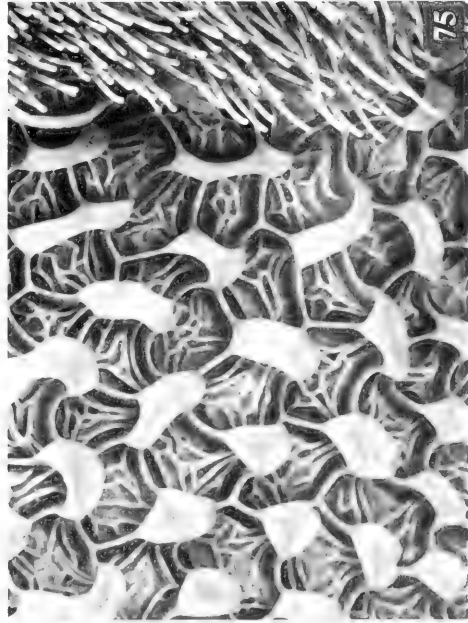
Figs. 61-64. Pterothoracic pleura. 61, *Arygrotaelaenus elegans*, female. 62, *Democoris lugens*, female. 63, *Termatophylloides fulvoides*, male. 64, *Termatophylloides pilosulus*, male.



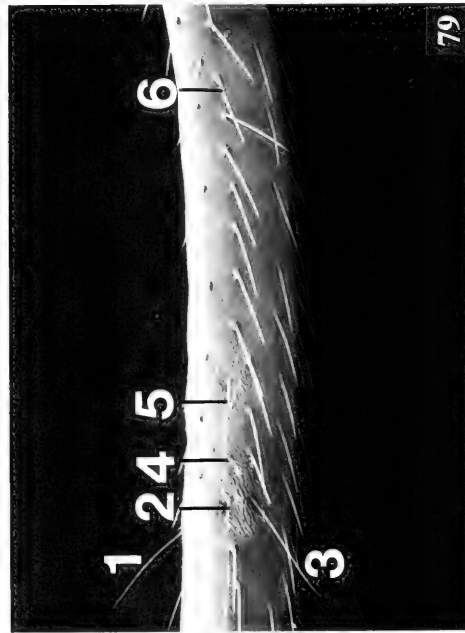
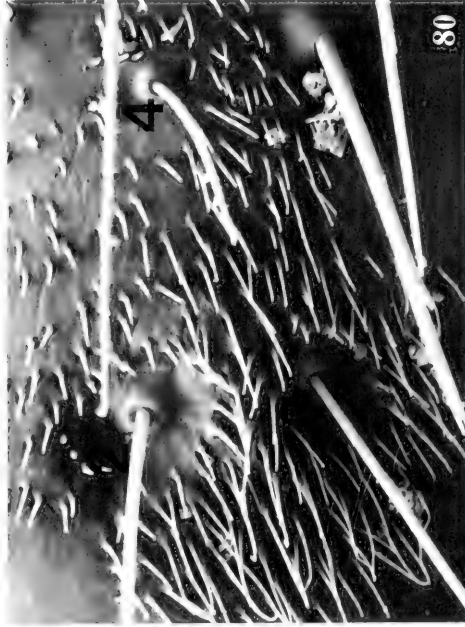
Figs. 65-68. Mesepimeron and metathoracic spiracle. 65, *Kundakimuka queenlandica*, male. 66, *Termatophylidea* sp., female. 67, *Termatophylina indiana*, female. 68, *Termatophylum melaleuca*, male. s = metathoracic spiracle.



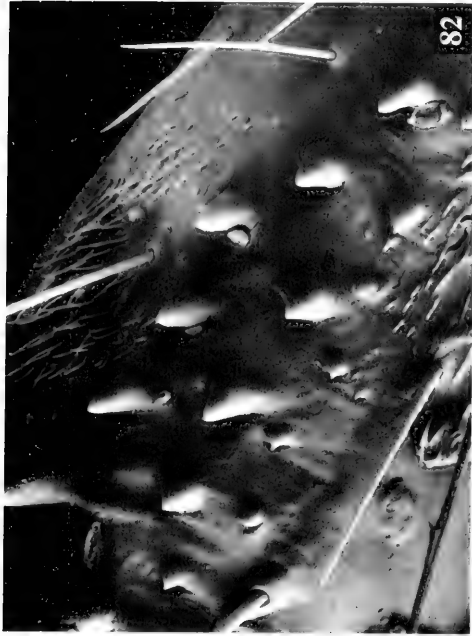
Figs. 69-72. Scent efferent system of metathoracic glands. 69, *Kundakimuka queenlandica*, male. 70, *Termatophyllina indiana*, female. 71, *Termatophyllum melaleuca*, male. p = peritreme.



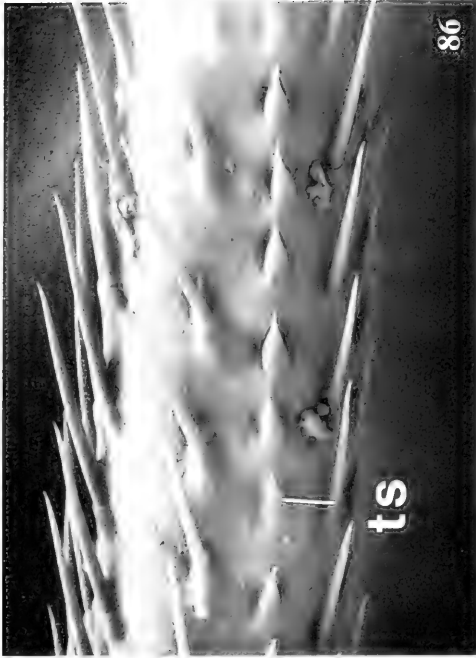
Figs. 73-76. Higher magnification of peritreme and scent efferent system. 73, *Kundakinuka queenslandica*, male. 74, *Termatophylidea* sp., female. 75, *Termatophylina indiana*, female. 76, *Termatophylum melaleucac*, male. ec = evaporative caps.



Figs. 77-80. Metathoracic trichobothria. 77, *Kundakimika queenslandica*, male. 78, *Termatophyllum insigne*, male. 79, 80, *Termatophyllum insigne* sp., female; numbers refer to position of trichobothria.



Figs. 81-84. Spines on metamora of *Kundakimika* species. 81, *Kundakimika carvalhoi*, male. 82, *Kundakimika carvalhoi*, male, higher magnification of spine. 83, *Kundakimika queenslandica*, male. 84, *Kundakimika queenslandica*, higher magnification of rows of spines.



Figs. 85-88. Spinature of tibiae. 85, *Arygrotaelaenus elegans*, female. 86, *Termatophyllyidea* sp., female. 87, *Kundakimuka queenlandica*, male. 88, *Kundakimuka carvalhoi*, male. ts = tibial spine.

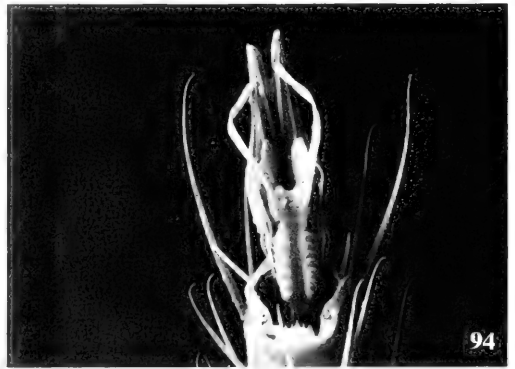
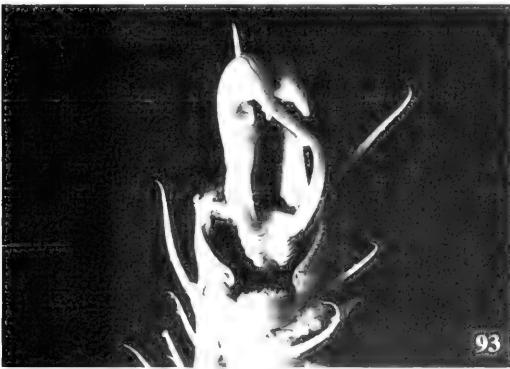
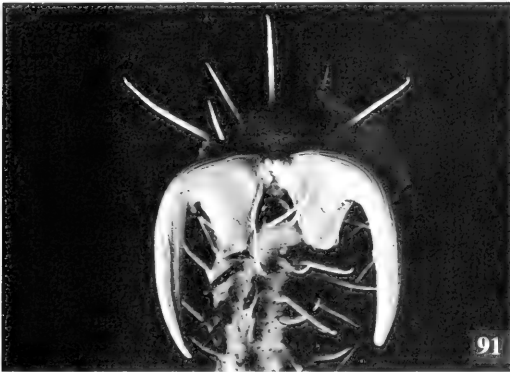
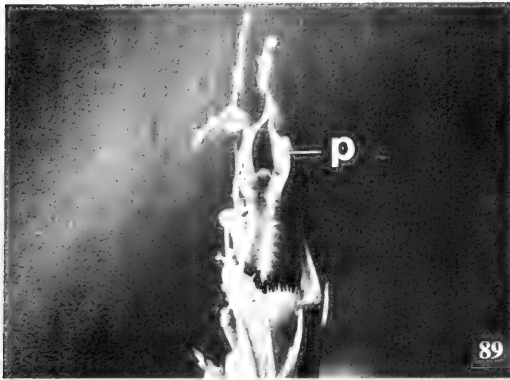
<i>constricta</i> Maldonado, 1970	Venezuela
<i>hyalina</i> Maldonado, 1970	Venezuela
<i>maculata</i> Usinger, 1935	Caribbean, Central America
<i>ocellata</i> Carvalho, 1955	Costa Rica
<i>opaca</i> Carvalho, 1955	Guyana, Surinam
<i>pilosa</i> Reuter and Poppius, 1912	Caribbean, Central America
<i>Termatophylina</i> Carvalho, 1988	
<i>indiana</i> Carvalho, 1988	India
<i>Termatophylodes</i> Carvalho, 1955	
<i>pilosulus</i> Carvalho, 1955	Guatemala
<i>Termatophylum</i> Reuter, 1884	
<i>grande</i> Reuter and Poppius, 1912	India
<i>hikos anum</i> Miyamoto, 1965	Japan
<i>insigne</i> Reuter, 1884	Middle East, Sudan
<i>melaleuca e</i> Cassis n. sp.	Australia
<i>montanum</i> Carvalho, 1983	Brazil
<i>nigrum</i> Poppius, 1910	Kenya
<i>obscurum</i> Reuter and Poppius, 1912	Sri Lanka, Indonesia
<i>ochraceum</i> Reuter and Poppius, 1912	India
<i>orientale</i> Poppius, 1915	Taiwan
<i>rhea</i> Linnavuori, 1974	Nigeria
<i>turneri</i> China	South Africa
<i>weiri</i> Cassis n. sp.	Australia
<i>yunnanum</i> Ren, 1983	China

KEY TO GENERA

1. Dorsum without rows of punctures on pronotum (Fig. 32) and hemelytra (Fig. 48) *Termatophylidea* (Neotropical region)
- Dorsum with punctures on pronotum (Fig. 31), and R+M and anal vein (Fig. 47) 2
2. Body with rows of flattened scalelike setae on pronotum and hemelytra *Argyrotelaenus* (Middle East, Sudan)
- Body without rows of flattened scalelike setae on pronotum and hemelytra, with setiform hairs only, rarely intermixed with scattered, flattened, scalelike setae 3
3. Eyes removed from collar by more than width of second antennal segment *Termatophylina* (India)
- Eyes contiguous with collar or removed by less than width of second antennal segment 4
5. Punctate R+M vein shorter than medial flexion line (Fig. 51) 6
- Punctate R+M vein longer than medial flexion line (Fig. 47) 7
6. Posterior margin of pronotal collar punctate (Figs. 31, 35); males with swollen, fusiform second antennal segment (Fig. 30) *Termatophylum* (Eastern Hemisphere, Brazil)
- Posterior margin of pronotal collar not punctate (Figs. 32, 36); males with cylindrical second antennal segment, weakly incrassate apically (Fig. 27) *Termatophylodes* (Guatemala)
7. Bucculae extremely broad and explanate, laterally almost reaching antennifers (Fig. 25) *Termatophylella* (Mexico)
- Bucculae moderately broad with margins weakly arcuate (Fig. 19) 8
8. Body ovoid, extremely broad (Fig. 1), with embolium wider than interocular distance; pronotum extremely tumid; metafemora not swollen *Democoris* (Australia)
- Body elongate to elongate-ovoid (Fig. 2), embolium not wider than interocular distance; pronotal disc obliquely raised above callosite region in lateral view (Fig. 43); metafemora greatly swollen (Fig. 83) *Kundakimuka* (Australia, Papua New Guinea, Japan, India, Hawaii)

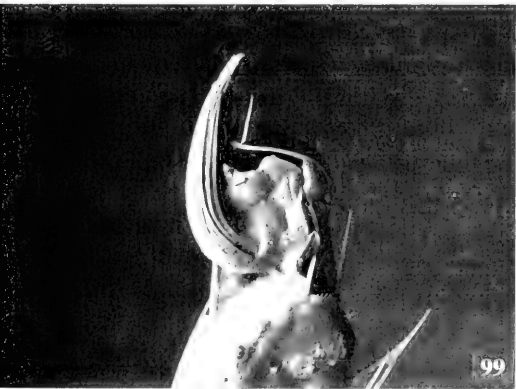
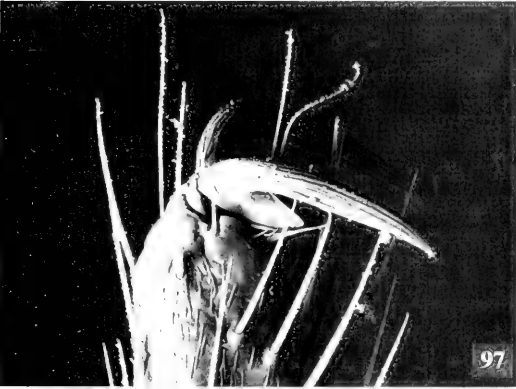
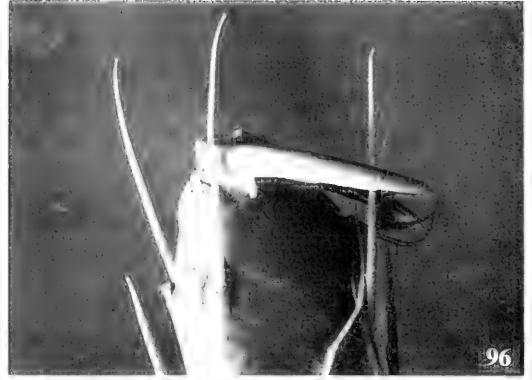
KEY TO AUSTRALIAN SPECIES OF TERMATOPHYLINI

1. Body ovoid, extremely broad (Fig. 1); pronotum tumid 2
- Body elongate to elongate-ovoid (Fig. 2); pronotum not tumid 3



Figs. 89-94. Ventral view of pretarsus. 89, *Arygotelaenus simoni*, male. 90, *Kundakimuka queenslandica*, male. 91, *Termatophylidea* sp., female. 92, *Termatophylina indiana*, female. 93, *Termatophylum insigne*, male. 94, *Termatophylum melaleucaae*, male. p = parempodia.

- | | | | |
|---|-------|--|----------------------------------|
| 2. Clypeus reddish; dorsum with elongate semi-erect setae | | <i>Democoris lugens</i> | |
| - Clypeus dark brown; dorsum with short semiadpressed setae | | <i>Democoris leptocytus</i> | |
| 3. R+M vein longer than medial flexion line (Fig. 47) | | | 4 |
| | | - R+M vein shorter than medial flexion line (Fig. 51). | 5 |
| | | 4. Metafemora with a large ventro-subdistal spine (Figs. 83, 84) | |
| | | - Metafemora with rows of short, black spines (Figs. 81, 82) | |
| | | | <i>Kundakimuka queenslandica</i> |



Figs. 95–100. Lateral view of pretarsus. 95, *Arygotelaenus simoni*, male. 96, *Kundakimuka queenslandica*, male. 97, *Termatophylidea* sp., female. 98, *Termatophylina indiana*, female. 99, *Termatophylum insignis*, male. 100, *Termatophylum melaleucaae*, male.

- 5. Hemelytral membrane yellowish, concolorous; apex of left paramere pointed (Fig. 110) *Termatophylum weiri*
- Hemelytral membrane patterned, mostly dark brown; apex of left paramere spatulate (Fig. 109) *Termatophylum melaleucaae*

GENERIC AND SPECIES DESCRIPTIONS

Arygotelaenus Reuter and Poppius

Arygotelaenus Reuter and Poppius 1912: 14; Carvalho 1952: 50 (list), Carvalho



Figs. 101–102. Pygophore of *Kundakimuka queenlandica*, male. 101, lateral view. 102, dorso-caudal view. lc = left clasper.

1955a: 22 (key), Carvalho 1957: 35 (catalogue), Stichel 1956: 176 (description).

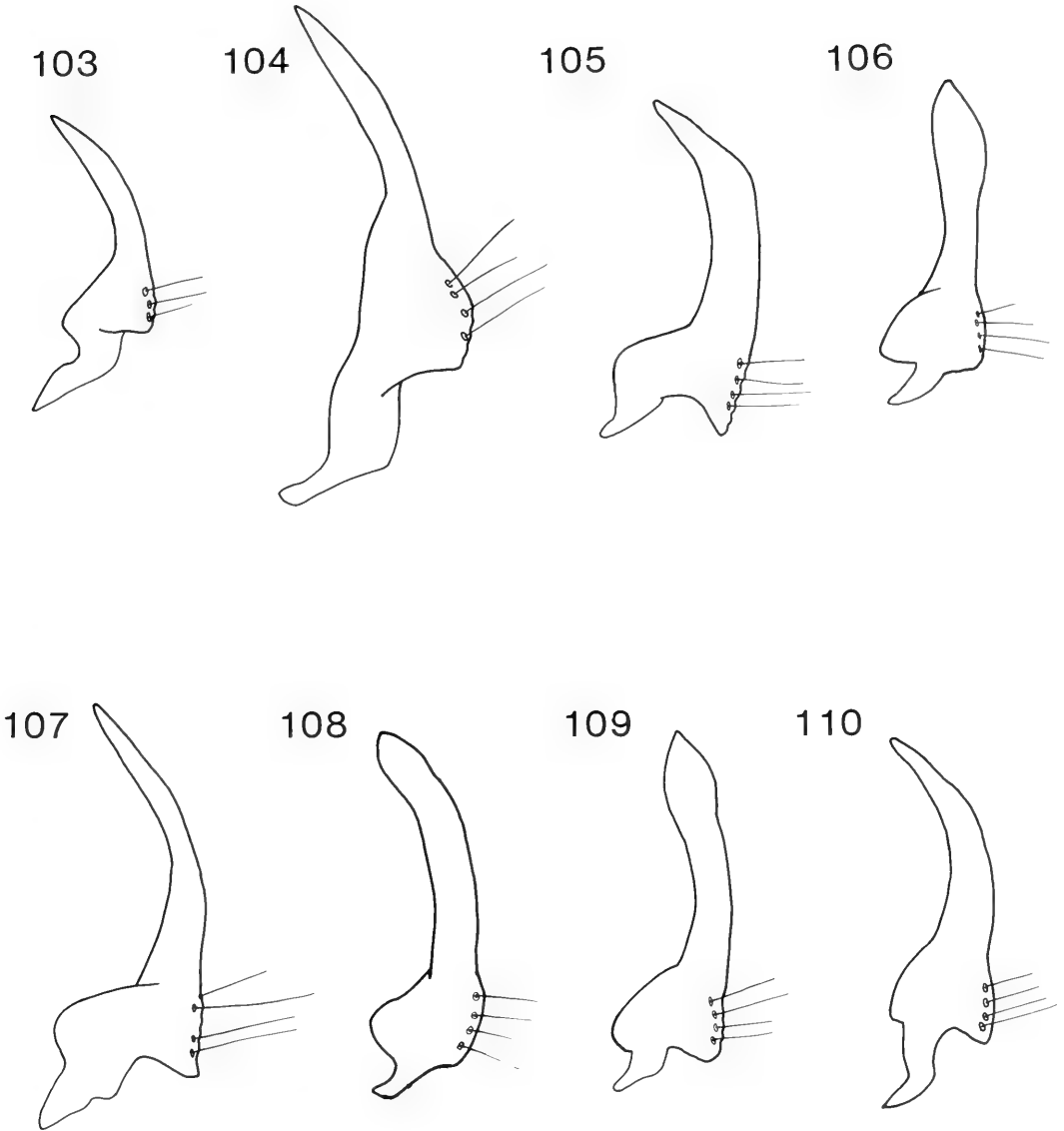
Figures.—7, 15, 23, 39, 51, 61, 85, 89, 95, 103, 111.

Type species.—*Arygotelaenus elegans* Reuter and Poppius, 1912, by original designation.

Diagnosis.—*Arygotelaenus* is recognized by the flattened scalelike setae on the head and pronotum. It is most similar to *Termtophylum*, with the male second antennal segment swollen and fusiform in both genera. The vestiture of the male second antennal segment is also similar, with setiform, semierect setae, intermixed with flattened, scalelike setae. The antennae of the females differs in the two genera, with the first antennal segment greatly thickened in *Arygotelaenus* species. Unlike *Termtophylum* (Fig. 31), the posterior margin of the pronotal collar and callosite region are not punctate in *Arygotelaenus* (Fig. 39).

Description.—Parallel-sided; coriaceous; rows of punctures on anal and R+M veins (Fig. 51); longitudinal rows of silvery, flattened scalelike setae on head, pronotum, hemelytra and thoracic pleura, intermixed with very sparse distribution of setiform vestiture. *Head*: strongly porrect (Fig. 15), elongate (Fig. 7); vertex and frons narrowly bilaterally compressed, with an indistinct row of flattened scalelike setae, lateral margins

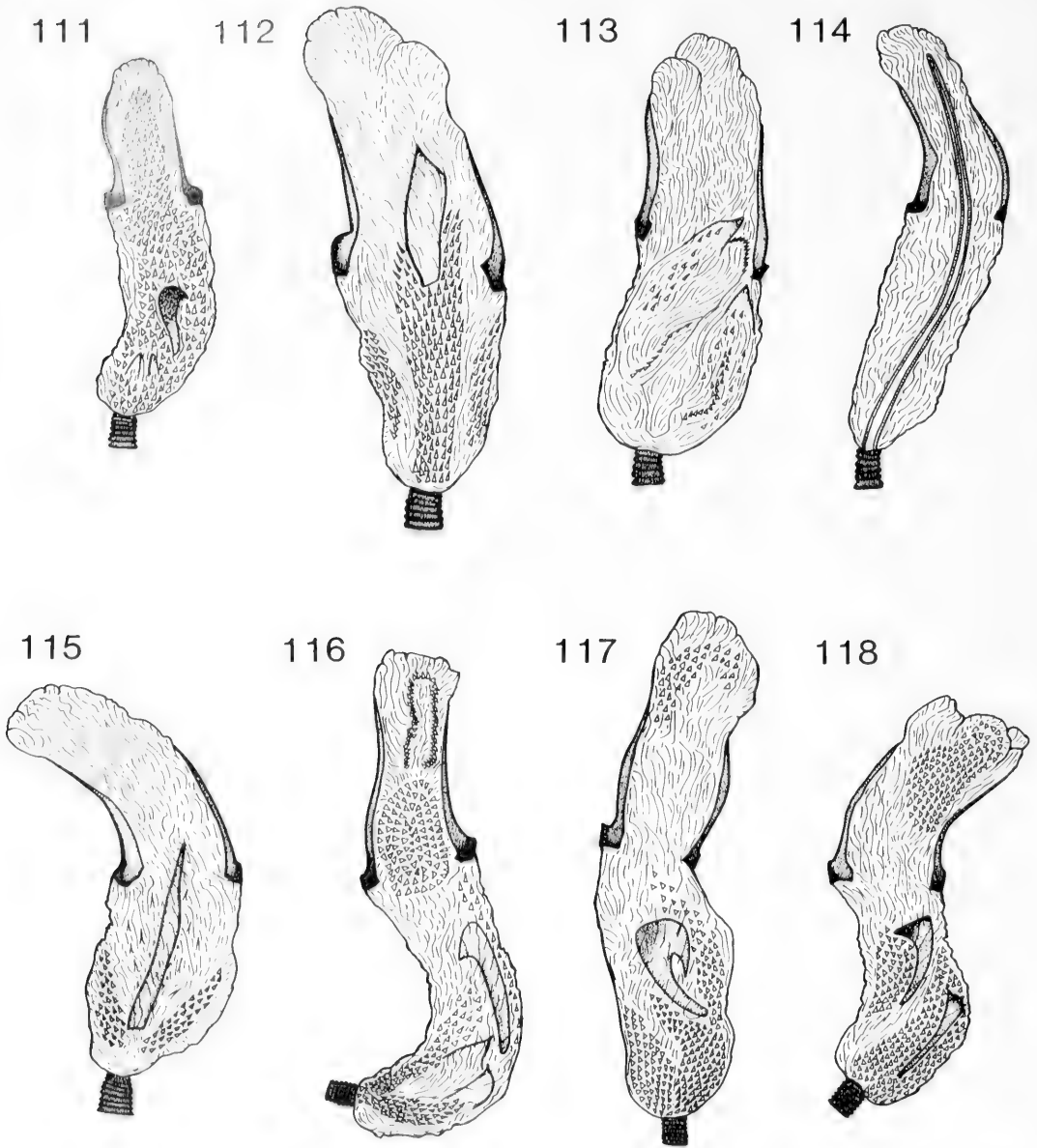
strongly declivent, almost vertical; posterior margin of head carinate; frons barely declivent; clypeus weakly declivent, terminating above antennifers (Fig. 15); lateral margins of bucculae weakly arcuate (Fig. 23); gula elongate, narrow, weakly concave, margins not carinate, with a dense matt of whitish microsetae (Fig. 23). *Eyes*: moderately sized, almost contiguous with pronotal collar, separated by a distance less than the width of the second antennal segment; ommatidia large, interocular setae absent. *Antennae*: short; AI greatly swollen in females, thicker than AII; AII weakly incrassate distally in females, subequal in width to AIII; AII fusiform and swollen in males, thicker than AI; AIII and AIV thin, short, subequal in length, combined length subequal to AII length. *Labium*: barely reaching apices of forecoxae; LII longest segment. *Pronotum*: (Fig. 39) lateral margins moderately divergent; with four longitudinal rows of flattened scalelike setae, on lateral margins, and either side of the midline; collar broad, extending to lateral margins of eyes, posterior margin delimited by a shallow, nonpunctate groove; callosite region marked by a transverse and sublateral nonpunctate groove, with midline weakly to moderately, transversely rugose, calli not distinctly separated, pronotal antero-lateral setae absent; disc subequal in length to callosite region, strongly rounded, obliquely raised above



Figs. 103–110. Left clasper of male, lateral view. 103, *Arygrotelaenus simoni*. 104, *Democoris leptocytus*. 105, *Kundakimuka queenslandica*. 106, *Teratophylidea pilosa*. 107, *Teratophylina indiana*. 108, *Teratophylum insigne*. 109, *Teratophylum melaleucaae*. 110, *Teratophylum weiri*.

callosite region, posterior margin truncate. *Scutellum*: weakly declivent, lateral margins not punctate. *Hemelytra*: (Fig. 51) narrow, barely extending beyond posterior angles of pronotum; lateral margins subparallel; anal vein punctate; embolium narrow, width less than length of pronotal collar; weakly punctate R+M vein short, barely

surpassing mid-length of corium, medial flexion line longer than R+M vein, about $\frac{2}{3}$'s length of corium, subparallel to R+M vein, and barely divergent posteriorly, region between veins marked by a row of flattened setae; cuneus longer than wide, lateral margins almost linear; membrane opaque, with color pattern, mesally brown and lat-



Figs. 111–118. Vesica, dorsal view. 111, *Arygrotelaenus simoni*. 112, *Democoris leptocyctus*. 113, *Kundakimuka queenslandica*. 114, *Teratophylidea pilosa*. 115, *Teratophylina indiana*. 116, *Teratophylum insigne*. 117, *Teratophylum melaleucaae*. 118, *Teratophylum weiri*.

erally pale; without microsetae; membrane cell subquadrate, broad; membrane vein indistinct, without subcaudal swelling. *Thoracic pleura*: (Fig. 61) tergopleural suture distinct above propleural suture, sometimes marked by a row of flattened scalelike setae;

proepisternum subtriangular; proepimeron without pits; mesepimeron short, subquadrate, dorsal margin strongly arcuate, dorso-caudal arm with an oval spiracular opening, with evaporative area, ventral margin marked by a depression and a row of flat-

tened scalelike setae, submesally with a row of flattened scalelike setae; metepisternum scent efferent system occupying half of segment; peritreme mesally placed, tongue-like, parallel-sided, not raised above plane of evaporative areas, evaporative bodies mostly subquadrate, remainder of metepisternum with numerous flattened scalelike setae. *Legs*: moderately long; coxae of moderate length; femora fusiform; femoral trichobothria not distinct in available specimens; tibiae cylindrical, without rows of spinelets, with moderate distribution of stiff, semi-adpressed setae; parempodia flattened, ribbonlike (Figs. 89, 95); *Abdomen*: broad, anthocoridlike, venter semipolished. *Male genitalia*: genital capsule minute, conical; left paramere (Fig. 103) very small, sensory lobe minute, with a few sensory hairs, shaft evenly arcuate, tapered apically; vesica (Fig. 111) with membranous lobe, gonoporal cavity present, basally with a pair of weakly sclerotized lobal sclerites, apex of membranous lobe with fields of spines.

Distribution.—Egypt, Yemen, Sudan, Israel, Saudi Arabia, Iraq.

Remarks.—*Arygotelaenus* contains two very similar species confined to the Middle East and the Sudan. The genus was described by Reuter and Poppius (1912) for the Egyptian species, *A. elegans*. They erroneously indicated that the membrane cell is obsolete, and although it is greatly reduced in both *Arygotelaenus* species, the membrane vein is visible. *Arygotelaenus* species are the most colorful of the termatophylines, and are mostly dark with highly contrasting pale markings on the scutellum and hemelytra. Aside from Stichel's (1956) redescription of the genus and species, little else has been published on these taxa. Linnavuori (1975, 1980, 1989) noted their presence throughout the Middle East and indicated that *A. simoni* is found in association with *Acacia* species.

Arygotelaenus is the sister taxon of *Termatophylum*, and is separated from it by the presence of rows of flattened scalelike

setae on the head and pronotum. Some species of *Termatophylum*, such as *T. insigne*, have setae of this type, but they are scattered, and never produced into rows. The head structure is also different, with the head of *Arygotelaenus* species elongate and strongly porrect, whereas the head in *Termatophylum* species is mostly transverse and less porrect. The vertex and frons in *Arygotelaenus* are narrowly bilaterally compressed, and raised dorsally above the eyes, which occurs to a lesser extent in *Termatophylum turneri*. *Arygotelaenus* is also differentiated from *Termatophylum*, by the smaller eyes, the lack of interocular setae, and the absence of punctations on the posterior margins of the collar and callosite region, and along the midline of the callosite region.

Arygotelaenus elegans Reuter and Poppius

Arygotelaenus elegans Reuter and Poppius 1912: 14, Linnavuori 1951: 104 (description), Carvalho 1952: 50 (type species), Carvalho 1957: 35 (catalogue), Wagner 1963: 484 (description), Linnavuori 1975: 6 (Sudan), Linnavuori 1980: 15 (Sudan; biogeography).

Figures.—7, 15, 23, 39, 51, 61, 85.

Syntypes.—UZMH. Type locality: Deschehena, Egypt. Not examined.

Specimens examined.—Egypt, 1912–24, H12 (NHM; 2 females).

Diagnosis.—This species is very similar to *Arygotelaenus simoni*, but can be differentiated from it by minor color differences in the hemelytra, and the relative length of the second antennal segment, which is a little longer than the first antennal segment in *A. elegans*, and shorter in *A. simoni*.

Description.—Female. Small, length 2.17–2.23, width 1.13–1.24, mostly dark brown, with yellow markings on hemelytra, and scutellum mostly yellow. *Head*: length 0.45–0.48, width 0.33–0.34, interocular distance 0.14–0.15, dark brown. *Eyes*: black tinged with red. *Labium*: length 0.80, reach-

ing apex of forecoxae, yellow, reaching apices of forecoxae; LII longest segment, reaching posterior margin of head; LIII reaching middle of forecoxae. *Antennae*: length 0.24, dark brown; AII length 0.25–0.27, basally dark brown, remainder yellow; AIII length 0.14–0.18, yellow; AIV length 0.14–0.16, yellow. *Pronotum*: length 0.47, posterior width 0.66–0.70. *Scutellum*: anterior half brown, remainder yellow. *Hemelytra*: clavus dark brown; corium with anterior half yellow, remainder dark brown; length of R+M vein half of corial length; medial flexion line almost reaching cuneal fracture; cuneus dark brown; membrane opaque, mesal brown band, laterally whitish. *Legs*: uniformly yellow.

Males not available.

Remarks.—Reuter and Poppius' (1912) original description adequately separated this species from *A. simoni*, primarily on the basis of color differences. Linnavuori (1951) redescribed the species without figuring the male genitalia. Stichel (1956) and Wagner (1963) gave detailed descriptions of the external characters of this species. Linnavuori (1975) listed the species from Egypt. Linnavuori (1980) listed *A. elegans* from the desert zone of the Saharan region.

The coloration, size and shape of the two *Arygotelaenus* species are similar and further study is needed to clearly differentiate the two *Arygotelaenus* species. The minor differences in the antennal segment lengths needs to be confirmed with additional material. No males of *A. elegans* were available for this study and a comparison of the male genitalia of the two species is necessary to confirm the separation of these taxa.

Democoris Cassis n. gen.

Figures.—1, 8, 16, 24, 40, 52, 62, 104, 112.

Etymology.—*demos* (Greek)—fat; *koris* (Greek)—bug.

Type species.—*Democoris lugens* Cassis n. sp.

Diagnosis.—This genus is recognized by the broad, ovoid body and the extremely

tumid pronotum. Both species have a finger-like peritreme, with its apex weakly arcuate and raised above the plane of the evaporative areas.

Description.—Ovoid, extremely broad (Fig. 1); coriaceous, weakly rugo-punctate; with rows of punctures on pronotum (Fig. 40), scutellum, R+M and anal veins (Fig. 53); dorsum with dense distribution of moderate sized to elongate, semiadpressed or semierect, pale setae. *Head*: transverse (Fig. 8), moderately declivent (Fig. 16), posterior margin carinate; vertex weakly to strongly rounded; frons strongly narrowed in front; clypeus moderately declivent, barely reaching antennifers in lateral view; lateral margins of bucculae moderately arcuate (Fig. 24); gula moderately broad, weakly concave, with transverse ridges, margins not carinate, with a few elongate, semierect, pale setae. *Eyes*: very large; contiguous with pronotal collar (Fig. 16), covering most of the lateral aspect of the head; ommatidia large, with short or elongate, interocular setae. *Antennae*: short; with moderate cover of semiadpressed setae; AI not thickened; AII weakly incrassate distally; AIII cylindrical; AIV not present on available specimens. *Labium*: reaching apices of forecoxae; LII longest segment. *Pronotum*: (Fig. 40) lateral margins moderately to weakly divergent posteriorly; moderately to extremely tumid, not biconvex; collar narrow, at most reaching mid-width of eyes, posterior margin marked by a deep groove with a few separated deep punctures; callosite region marked by an arcuate, transverse and sublateral, punctate groove, without any midline groove, callosite region tumid; pronotal antero-lateral setae moderately elongate, antierad to propleural suture; disc subequal in length to callosite region; declivent posteriorly, posterior margin truncate. *Mesonotum*: small, barely visible from above, strongly declivent. *Scutellum*: flattened with lateral margins marked by row of punctures. *Hemelytra*: (Fig. 52) extremely broad, extending beyond posterior angles of pronotum (Fig. 1); lateral margins strong-

ly arcuate; anal vein punctate; embolium very broad, much wider than the length of the pronotal collar; R+M vein punctate, elongate, almost reaching cuneal fracture; medial flexion line shorter than R+M vein, about $\frac{2}{3}$'s length of corium, weakly divergent from R+M vein; cuneus length subequal to width; membrane translucent, dusty, concolorous, without microsetae; membrane cell narrow to very narrow, vein indistinct, with a posterior, subcaudal, obscure thickening. *Thoracic pleura:* (Fig. 62) tergopleural suture indistinct, weakly depressed; propleural suture distinct; proepisternum subquadrate; proepimeron without pits; mesepimeron large, broad, subtrapezoidal, anterior half flattened, posterior half tumid, dorsal margin strongly angulate, dorso-caudal arm with an oval spiracular opening, with evaporative areas, ventral margin marked by a weak, arcuate depression; metepisternum scent efferent system occupying about half of segment, not contiguous with mesothoracic evaporative areas; peritreme mesally placed, narrow, fingerlike, with apex tapered, weakly arcuate, and raised above the plane of the evaporative areas, remainder of metepisternum with a few short, adpressed whitish setae. *Legs:* moderately long; coxae large, elongate; femora elongate, subcylindrical; four mesofemoral and six metafemoral trichobothria; tibiae cylindrical, without rows of spinelets, with stiff, semiadpressed setae; pretarsus with setiform parempodia. *Abdomen:* broad, anthocoridlike, venter polished. *Male genitalia:* genital capsule minute, conical; left paramere (Fig. 103) moderately large, sensory lobe weakly expanded, with a few sensory hairs, shaft evenly arcuate, tapered apically; vesica (Fig. 112) with membranous lobe, gonoporal cavity present, with large, mesal, sublinear lobal sclerite, tapered apically.

Distribution.—Australia.

Remarks.—*Democoris* is morphologically atypical in comparison with most termatophyline genera. It contains two species confined to the arid and dry mediterranean

environs of South Australia. As yet nothing is known of the biology of the two included species. This genus is similar to the Middle American genus *Termatophylella*, but can be separated from it by differences of the bucculae and the peritreme. The bucculae in *Democoris* are moderately broad, with the margins arcuate, whereas in *Termatophylella*, the bucculae are greatly enlarged, with the margins, greatly enlarged, explanate, and laterally almost extending to the antennifers. The peritreme of *Democoris* is also distinct, being very narrow and fingerlike, with the apex strongly tapered, projected away from the body, and above the plane of the evaporative areas. In *Termatophylella* the peritreme is tongue-like, quite broad, with the posterior margin weakly raised along its length, as is typical of a number of other termatophyline genera. These differences support the present separation of the two genera. Dorsally these genera could be confused, both having an enlarged, somewhat tumid pronotum. All the species are broad, with the embolium particularly broad; however, the body length of *Termatophylella fulvoides* is significantly smaller than the two *Democoris* species. The rows of punctures on the pronotum, and anal and R+M veins are very similar in both genera. Generally in both genera the membrane cell is narrow, and this is particularly so for *T. fulvoides* and *D. leptocytus*.

Democoris is the sister taxon of the clade containing *Arygrotelaenus* and *Termatophylum* (Fig. 131), and is related to these taxa on the basis of the recessed metathoracic spiracle and the reduced scent efferent system. *Democoris* also has a close relationship with the genus *Kundakimuka*, although saliently the two genera are dissimilar. *Democoris* contains oval species, with the pronotum greatly tumid, whereas in *Kundakimuka* the body is elongate to elongate to elongate-ovoid. *Democoris* also differs from *Kundakimuka* by the following characters; the narrow membrane cell, the metathoracic spiracle recessed and not visible in lateral view, the evaporative areas of the mesepi-

meron and metepisternum not contiguous, the peritreme positioned on the midline of the scent efferent system, and the parempodia setiform and not expanded apically.

Democoris lugens Cassis n. sp.

Figures.—1, 8, 16, 24, 40, 52, 62.

Etyymology.—*lugens* (latin)—dark.

Holotype.—Female. Mitcham. S[outh] Aust[ralia], 17-i-1981, at light, R.V. Southcott (SAMA).

Other specimens examined.—Paratype: Female. South Australia: Barossa (SAMA).

Diagnosis.—*D. lugens* is distinguished from *D. leptocytus* by the extremely broad body, and the dense distribution of elongate semierect, whitish setae. The clypeus is reddish-orange, as opposed to the fuscous clypeus of *D. leptocytus*.

Description.—Female. Large, length 4.10–4.55, width 2.11–2.30, extremely broad, uniformly fuscous, with dense cover of long semierect, whitish setae. *Head*: length 0.49–0.58, width 0.72–0.73, interocular distance 0.28, vertex fuscous; frons strongly narrowed in front of antennifers, reddish-orange; clypeus reddish-orange; maxillary and mandibular plates reddish-orange. *Eyes*: black tinged with red, with elongate, erect, pale interocular setae. *Antennae*: AI short, length 0.22, yellow; AII weakly incrassate apically, length 0.53, mostly yellow, with bases and apices weakly embrowned; AIII shorter than AIV, length 0.28, yellow; AIV length 0.36, yellow. *Labium*: length 1.06, barely surpassing forecoxae; LII reaching midpoint of collar; LIII reaching beyond midpoint of forecoxae. *Pronotum*: strongly tumid, lateral margins moderately divergent; length 0.78–0.96, posterior width 1.67–1.82; pronotal antero-lateral setae elongate. *Mesonotum*: barely visible, fuscous. *Scutellum*: fuscous. *Hemelytra*: embolium extremely broad, almost as wide as interocular distance; membrane short, translucent, with obscure embrownment, with one small, narrow membrane cell (Fig. 52), width subequal to embolium width, vein with obscure

fuscous markings. *Legs*: coxae brown with apices yellow; trochanters yellow; femora brown, with apices yellow, dorsal margins with short adpressed, pale setae, ventral margins with elongate, semierect, pale setae, with four mesofemoral trichobothria and six metafemoral trichobothria; tibiae yellowish, with dense distribution of strong, straight, semiadpressed, pale setae; tarsi yellowish.

Male unknown.

Remarks.—This species is the largest of all the known termatophylines, over 4 mm, and a quarter again the length of its congener. This spectacular species is only known from two female specimens from the Adelaide area and the Barossa Valley of South Australia. Its broad and tumid body is diagnostic for the genus, and the species is clearly distinguished by color characteristics and the vestiture of the dorsum.

Democoris leptocytus Cassis n. sp.

Figures.—104, 112.

Etyymology.—*lepto* (Greek)—narrow; *kyto* (Greek)—cell.

Holotype.—Male: South Australia: Mt Davies, 11 Nov[ember] 1963, at light, collectors P. Aitken and N. B. Tindale (SAMA).

Diagnosis.—*D. leptocytus* is readily identified by the very narrow membrane cell, and can be differentiated from its congener by other characters given in the diagnosis of *D. lugens*.

Description.—Male. Small, length 2.95, width 1.60, broad, uniformly fuscous, with dense cover of medium sized, semiadpressed, whitish setae. *Head*: length 0.42, width 0.64, interocular distance 0.25, vertex fuscous, with posterior margin yellow; frons fuscous; clypeus orange-brown; maxillary and mandibular plates orange-brown. *Eyes*: black with reddish tinge on inner margins, ommatidia large, with interocular setae small, barely surpassing maximum height of ommatidia. *Antennae*: AI length 0.22, yellow, with a few semiadpressed setae; AII length 0.33, weakly incrassate api-

cally, mostly yellow, with an indistinct embrownment basally, with moderate cover of semiadpressed, pale setae; AIII length 0.21, yellowish-brown, with a moderate cover of semiadpressed, pale setae. *Labium*: mostly yellow, length 0.54, reaching apices of forecoxae; LII reaching proxyphus; LIII reaching midlength of forecoxae. *Pronotum*: moderately tumid, callosite region more so than disc, lateral margins weakly divergent, setae thickened along lateral margins; uniformly fuscous; length 0.61, posterior width 1.96; callosite region more so than disc; pronotal antero-lateral setae moderately sized; posterior margin strongly truncate. *Hemelytra*: clavus, embolium and cuneus mostly fuscous, apex of clavus with a small yellow marking, and an indistinct red marking above cuneal fracture, corium orange brown; membrane opaque, yellowish-brown, membrane cell very narrow, about as wide as the length of the pronotal collar, vein dark brown and indistinct. *Legs*: short; coxae dark, shiny brown; femora mostly dark brown with apices yellow; trichobothria not clear in type specimen; tibiae light yellowish-brown. *Male genitalia*: left paramere (Fig. 104); vesica (Fig. 112).

Female unknown.

Remarks.—The male genitalia of this species is very simple, and unlike other termatophylines, does not have large basal spicules. This species which is only known from one male specimen is not considered to be conspecific with *D. lugens*, known from two female specimens, because of its larger size, more tumid shape of the latter species, and the different vestiture. The two species are restricted to South Australia, with *D. leptocytus* confined to the arid northwest corner of the state, and *D. lugens* found in the Mediterranean zone of South Australia.

Kundakimuka Cassis n. gen.

Figures.—2, 3, 11, 19, 27, 31, 35, 43, 47, 57, 65, 69, 73, 77, 81, 82, 83, 84, 87, 88, 90, 96, 101, 102, 105, 113.

Eytomology.—*kunda* (Larrickia)—big,

kimuka (Larrickia)—leg. Derived from the Larrickia aboriginal language, which is the predominate language group of the tropical parts of the Northern Territory.

Type species.—*Kundakimuka carvalhoi* Cassis n. sp.

Diagnosis.—*Kundakimuka* is characterized by the flattened pronotum (Fig. 31), the setiform parempodia which are weakly flattened apically (Figs. 90, 96), and the enlarged metafemora, which have either a large subapical spine (Figs. 81, 82), or small bristlelike spinelets (Figs. 83, 84) on the ventral surface. This genus is somewhat similar to *Termatophylum*, however, the punctate R+M is shorter than the medial flexion line vein in the latter (Fig. 56), and longer in *Kundakimuka* (Fig. 47).

Description.—Elongate to elongate-ovoid (Fig. 2), moderately dorso-ventrally flattened, with rows of punctures on pronotum, and anal and R+M veins, moderate cover of long semierect, pale setae. *Head*: transverse (Fig. 3), weakly porrect (Fig. 11); vertex rounded; frons moderately declivent; clypeus strongly narrowed in front, strongly declivent, barely reaching antennifers; bucculae margins moderately arcuate (Fig. 19); gula moderately broad, weakly concave, weakly transversely rugose. *Eyes*: very large, covering most of lateral aspect of head, contiguous with pronotal collar (Fig. 11); ommatidia large, with elongate, interocular setae. *Antennae*: short; AI fusiform, not swollen; AII weakly incrassate apically (Fig. 27); AIII and AIV slender, narrower than preceding segments. *Labium*: reaching between the foretrochanters and midpoint of mesosternum; LII longest segment. *Pronotum*: (Fig. 31) broad, strongly flattened; lateral margins moderately divergent posteriorly; collar narrow, extending to mid-width of eyes, posterior margin delimited by deep, nonpunctate groove; callosite region marked by a transverse and sublateral sinuate, punctate groove (Fig. 36), indistinct near posterior margin of pronotal collar, with a short punctate groove along midline from pos-

terior margin, pronotal antero-lateral setae elongate, antierad to propleural suture; disc region flattened, subequal in length to callosite region, posterior margin weakly bisinuate. *Mesosternum*: short, visible from above, flattened. *Scutellum*: flattened, lateral margins with a short row of deep punctures. *Hemelytra*: (Fig. 47) moderately broad, just wider than posterior angles of the pronotum (Fig. 2); anal vein punctate; embolium moderately broad, wider than length of pronotal collar; R+M vein punctate, elongate, almost reaching cuneal fracture; medial flexion line elongate, just short of R+M vein, weakly divergent posteriorly; cuneus as long as wide; membrane translucent, embrowned, concolorous; membrane cell subquadrate, broad; membrane vein with a subcaudal thickening. *Thoracic pleura*: (Fig. 57) tergopelural suture anteriorly distinctly grooved, posteriorly weakly depressed (Fig. 43); proepisternum subquadrate; propleural suture distinct; proepimeron without pits; mesepimeron narrow, V-shaped, dorsal margin strongly angulate, dorso-caudal arm with a lanceolate spiracular opening (Fig. 65), with evaporative area, ventral margin marked by a weak depression, and a few elongate, semi-erect setae; metepisternum scent efferent system large (Fig. 69), occupying about half of the segment, contiguous with metathoracic evaporative areas; peritreme (Fig. 73) placed just caudad of midline of scent efferent system, weakly dorso-caudally projected, broad, tongue-like, with either apex tumid and raised above plane of evaporative areas, or apex tapered and posterior margin weakly raised above evaporative areas, either ending before or sometimes just dorsally beyond evaporative areas; remainder of metepisternum short, depressed, with a few semi-erect, pale setae; metepimeron raised, narrow. *Legs*: moderately long; coxae broad, moderately long, weakly separated; metatrochanters sometimes with short spine subdistally (Fig. 83); femora fusiform, with metafemora greatly enlarged each with

large subdistal ventral spine (Figs. 83, 84), or moderately enlarged with rows of recumbent, bristlelike spines (Figs. 81, 82), four mesofemoral and six metafemoral trichobothria (Fig. 77); tibiae cylindrical to weakly arcuate, with four rows of minute spinelets (Figs. 87, 88), intermixed with semi-erect stiff setae; parempodia weakly flattened and expanded apically; pretarsus (Figs. 90, 96) with claws strongly cleft basally, parempodia setiform, and apically flattened; *Abdomen*: broad, anthocoridlike, venter, semipolished. *Male genitalia*: genital capsule small, with tergite X partially fused to the dorsal margin of the genital opening; left paramere (Fig. 105) small with a very small sensory lobe, and a narrow straplike shaft, evenly arcuate, and tapered apically; vesica (Fig. 113) with membranous lobe, with weakly spiculate gonoporal cavity, with broad ill-defined lobal sclerite.

Distribution.—Australia, Papua New Guinea, Japan, India, Hawaii.

Remarks.—*Kundakimuka* is a distinct genus found in the eastern Indo-Pacific, where new species require description, and one species, closely allied to *K. queenslandica*, has broadly spread. The Japanese species *K. pallipes* has been transferred to *Kundakimuka* from *Termtophyloides* on the basis of the head structure (see Remarks section of *Termtophyloides* for discussion). The two Australian species described below are the only species critically evaluated in this work. *Kundakimuka* is externally similar to *Termtophylum*, but can be distinguished from it by numerous characters, including differences in the length of the R+M vein, the shape of the second antennal segment, the punctuation of the pronotum, characters of the pterothoracic pleura, metafemora, pretarsi, and male vesica. The male second antennal segment in *Kundakimuka* is weakly incrassate apically, but is always fusiform and swollen in *Termtophylum* species. The metathoracic spiracle in *Kundakimuka* is exposed, and the associated evaporative areas are contiguous with those

of the scent efferent system of the metepisternum. In *Termtophylum* species the spiracle is recessed, with the opening not visible, and the evaporative areas are not contiguous with those of the metepisternum. The pretarsi of the two genera show some similarity, with the parempodia flattened in *Termtophylum*, and only apically flattened in *Kundakimuka*. The lobal sclerites of the two genera are markedly different; in *Kundakimuka* they are obscure, and in *Termtophylum* they are sickle-shaped.

***Kundakimuka carvalhoi* Cassis n. sp.**

Figures.—2, 83, 84, 88.

Eytomology.—This species is named after José Carvalho, in honor of his contributions to world miridology.

Holotype.—Male. Smith Point, N[orthern] T[erritory], 3-viii-1982, C. Wilson and S. Collins, ex light trap, registration no. 8592 (NTMAG).

Diagnosis.—This species can be separated from all other termtophylinae by the greatly expanded metafemora, each with a large, ventro-subdistal triangular spine (Figs. 83, 84) and the short subdistal spine on each of the metatrochanters (Fig. 83).

Description.—Male. Small, length 2.40, width 1.01, strongly dorso-ventrally flattened; uniformly yellowish-brown, smooth, with moderate cover of long semierect, golden setae. *Head*: length 0.29, width 0.46, interocular distance 0.19. *Eyes*: black with reddish tinge. *Antennae*: uniformly yellowish; AI weakly fusiform, length 0.13, less than interocular distance, with a few semierect setae; AII, length 0.33, with semiadpressed golden setae; AIII, length 0.20, cylindrical, with adpressed, short setae, and semierect setae; AIV, length 0.13, weakly fusiform, setation as AIII. *Labium*: length 0.84, reaching midpoint of mesosternum; LII and LIII subequal in length, LII reaching proxyphus, LIII reaching proxyphus, LIII reaching apices of forecoxae. *Pronotum*: strongly flattened, length 0.43, posterior width 0.82, with uniform distribution of semierect

setae; antero-lateral pronotal setae elongate, inserted dorsad of tergopleural suture and anteriorly of propleural sulcus. *Thoracic pleura*: peritreme dorsally tumid, raised above and extending just dorsally beyond evaporative areas. *Scutellum*: yellowish-brown, lighter posteriorly, lateral margins without punctures. *Hemelytra*: uniformly yellowish brown, with R+M and anal veins fuscous, membrane faintly embrowned. *Legs*: metatrochanters each with a short, subdistal spine (Fig. 83); fore and mesofemora fusiform, not expanded; metafemora, greatly expanded, about 2.5 × wider than preceding femora, with a very large, ventral, triangular spine (Figs. 83, 84), apex of metafemora expanded into a cuplike opening; with four mesofemoral and six metafemoral trichobothria; tibiae weakly arcuate, dorsal face with lateral row of closely pressed sclerotized teeth (Fig. 88), ventral face with row of scattered sclerotized teeth, foretibiae with well-developed ventral tibial comb; pretarsal claws with strong basal teeth, and weakly flattened setiform parempodia, each weakly expanded at apex. *Male genitalia*: genital capsule minute, conical; left paramere small, weakly arcuate.

Female unknown.

Distribution.—Northern Territory (known only from type locality).

Remarks.—*Kundakimuka carvalhoi* differs from *K. queenslandica* in color, with the former having a concolorous, pale yellowish-brown color, and the latter species being dark brown with lighter markings on the dorsum. The peritreme of the two species also differs with the type species having the apex weakly tumid and raised, and extending beyond the dorsal margin of the evaporative areas, whereas in *K. queenslandica* the peritreme is only weakly raised along its posterior margin, and terminates ventrad of the dorsal margin of the evaporative areas. The peritremes are similar in placement; just posteriad of the midwidth of the scent efferent system, and dorso-caudally directed. The metafemora in the two Australian *Kundakimuka* species are enlarged, but particularly so in *K. carvalhoi*, with each having an enlarged, subdistal spine.

Kundakimuka queenslandica Cassis n. sp.

Figures.—3, 11, 19, 27, 31, 35, 43, 47, 57, 65, 69, 81, 82, 87, 90, 96, 101, 102, 105, 113.

Eytomology.—The species name refers to the State of Queensland distribution.

Holotype.—Male. Maryborough, Queensland, 18-IV-1973, D.A.I. N3700 13277, C.I.E. coll[ection] A.6716 13277 (QDPI).

Other specimens examined.—Paratypes: QLD: Maryborough, 18-IV-1973, D.A.I., N3700, suspected predator of *Neodrepta luteodactella* (Lepidoptera) larva on *Melaleuca integrifolia* (Myrtaceae) (NHM: 3 males, 2 females; QDPI: 1 male, 1 female); QLD: Gympie, Lagoon Pkt, 4-VII-1968, D.A.I., numerous preying on larvae of *Neodrepta luteodactella* on *Melaleuca integrifolia* foliage, N3106 (NHM: 2 males, 2 females); QLD: Bauple, (CSR), 1-VII-1974, with *Neodrepta luteodactella* on *Melaleuca integrifolia*, N3852 (QDPI: 2 females, 1 male).

Diagnosis.—Distinguished from other *Kundakimuka* species by the presence of small spines on the ventral surface of the meso- and metafemora.

Description.—Male. Small, length 2.33–2.82, width 0.98–1.36, moderately dorso-ventrally flattened, mostly dark brown, with a few yellowish-orange markings on the dorsum, and a moderate cover of long, semi-erect, golden setae. *Head*: length 0.34–0.46, width 0.49–0.53, interocular distance 0.23–0.24, mostly brown with clypeus, maxillary and mandibular plates yellowish brown. *Eyes*: mostly reddish with fuscous tinge. *Antennae*: AI length 0.14–0.16, proximal half yellowish-brown, distal half yellow, AII length 0.34–0.37, weakly incrassate apically, yellow; AIII length 0.22–0.24, yellow; AIV length 0.22–0.24, brown. *Labium*: length 0.88–1.20, reaching between apices of forecoxae and foretrochanters. *Pronotum*: moderately flattened, length 0.48–0.54, posterior width 0.82–0.96, mostly brown, with a yellowish marking on midline of pronotal disc. *Thoracic pleura*: peritreme short of dorsal margin of evaporative areas, polished orange dark brown, slightly raised above evaporative areas.

Mesonotum: brown with distinct reddish markings on each side of midline. *Scutellum*: brown laterally, with an indistinct reddish-yellow to yellowish marking along posterior half of midline. *Hemelytra*: mostly brown, lighter brown to yellowish-brown on anterior parts of corium, embolium, and cuneal fracture, membrane mostly dusty brown, sometimes mesally pale and translucent. *Legs*: forefemora mostly yellow, sometimes with a dorso-proximal infuscation; mesofemora and metafemora fuscous with apices yellow, ventral margins with indistinct rows of very short, recurved, black spines (Figs. 81, 82), metafemora moderately incrassate, four mesofemoral and six metafemoral trichobothria; tibiae cylindrical with four rows of minute, closely pressed sclerotized, fuscous teeth (Fig. 87); pretarsal claws (Figs. 90, 96) strongly cleft basally, with setiform parempodia, apically flattened (Fig. 90). *Genitalia*: tergite X as a U-shaped process, connate apically with dorsal margin of genital opening; left paramere (Fig. 105); vesica (Fig. 113).

Female. Similar to male in structure and color. Length 2.79–3.04, width 1.30–1.39. *Head*: length 0.36–0.37, width 0.54–0.60, interocular distance 0.54–0.60. *Antennae*: AI length 0.14–0.16, AII length 0.36–0.38, AIII length 0.23–0.24, AIV length 0.22–0.23. *Labium*: length 0.98–1.02. *Pronotum*: length 0.58–0.60, posterior width 1.06.

Remarks.—*K. queenslandica* is somewhat similar to *Termtaphylum* species in color and texture, and in coastal Queensland where these species are sympatric, differentiating the two genera requires careful examination. In such cases the relative lengths of the R+M vein and medial flexion line veins easily distinguishes the two genera, with *Termtaphylum* species having a short R+M vein.

Specimens of *Kundakimuka* from India, Papua New Guinea and Hawaii have been received from the Natural History Museum which are very similar to *K. queenslandica*. They possess spiculate ventral surfaces of the meso- and metafemora. Adam Asquith (personal communication) has indicated that the termtaphyline found in Hawaii is a recent

introduction. It is possible that the specimens from India and New Guinea could also be introductions, and that this species may be adventitious in other areas of the Indo-Pacific. At present these specimens are not considered to be conspecific with *K. queenslandica*.

All specimens of *Kundakimuka queenslandica* have been recorded from *Melaleuca integrifolia* (Myrtaceae), which also harbors *Termatophyllum weiri*. The label data on these specimens indicates that *K. queenslandica* feeds on the lepidopterous larvae of *Neodrepta luteotactella*.

Termatophylella Carvalho

Termatophylella Carvalho 1955b: 643; Carvalho 1955a: 22 (key), Carvalho 1957: 35 (catalogue)

Figures.—9, 17, 25, 41, 53, 63.

Type species.—*Termatophylella fulvoides* Carvalho 1955, by original designation.

Diagnosis.—*Termatophylella* is recognized by the greatly enlarged bucculae (Fig. 9), with the lateral margins explanate, and almost reaching the antennifers when viewed ventrally.

Description.—Ovoid, with rows of punctures on transverse groove of pronotum, anal and R+M veins; sparse cover of short, semiadpressed setae. *Head*: transverse (Fig. 9), strongly porrect (Fig. 17); vertex strongly convex; frons declivent, rounded, wide; clypeus short, weakly declivent, terminating above antennifers; bucculae greatly enlarged, and widely separated, explanate, and almost contiguous with antennifers (Fig. 25), longer than first labial segment; gula elongate, narrow, weakly convex, lateral margins carinate, with transverse ridges, with a row of soft, moderately long, semierect setae. *Eyes*: large, almost contiguous with pronotal collar, distance less than the width of the second antennal segment; ommatidia large, with short, interocular setae. *Antennae*: short; AI fusiform, not swollen; AII weakly incrassate distally; AIII subequal in length to AII, longer than AIV. *Labium*: reaching apices of forecoxae; LIV longest segment.

Pronotum: (Fig. 41) biconvex; lateral margins weakly carinate; collar narrow, reaching mid-width of eyes, posterior margin delimited by a deep nonpunctate groove; callosite region tumid, marked by a postero-transverse and sublateral punctate groove, with a faint, nonpunctate impression along midline, pronotal antero-lateral setae not present in available specimens; disc shorter in length than callosite region, rounded, posterior margin truncate. *Mesonotum*: large, declivent, visible from above. *Scutellum*: weakly rounded, lateral margin not punctate. *Hemelytra*: (Fig. 53) broad, extending well beyond lateral margins of pronotum; embolium broad, width greater than length of pronotal collar; anal vein punctate, elongate, almost reaching cuneal fracture; medial flexion line long, almost $\frac{3}{4}$'s of length of corium, shorter than R+M vein, strongly divergent to R+M vein; cuneus very large, longer than wide; membrane translucent, dusty, concolorous; without microsetae; membrane cell very narrow; membrane vein indistinct, without subcaudal thickening. *Thoracic pleura*: tergopleural suture distinct anteriorly; proepisternum subquadrate; proepimeron without pits; mesepimeron (Fig. 63) moderately sized, rugose, dorsal margin moderately angulate, dorso-caudal arm with a short lanceolate spiracular opening, with evaporative area, ventral margin marked by a weak depression; metepisternum scent efferent system (Fig. 63), occupying about half of the segment, not contiguous with metathoracic evaporative areas; peritreme submarginal to posterior margin of segment, dorsally dorso-caudally projected, tongue-shaped, weakly tumid at dorsal end, weakly raised above plane of evaporative areas; evaporative bodies mostly with rounded appearance; remainder of metepisternum weakly depressed. *Legs*: moderately long; coxae elongate; femora fusiform; three mesofemoral and four metafemoral trichobothria; tibiae cylindrical, with stiff, semiadpressed setae, without rows of spinelets; parempodia setiform. *Abdomen*: broad, anthocoridlike, venter semipolished. *Male genitalia*: left paramere at right angles to ventral margin of genital

opening, straplike with a very small sensory lobe. Male aedeagus not examined.

Remarks.—*Teratophylella* is a monotypic genus restricted to Mexico. This genus is known from only two specimens. I did not examine the internal male genitalia of *T. fulvoides* pending the collection of more material of this species. Carvalho (1955a) distinguished *Teratophylella* from other teratophylines by the transverse head, however, this character also occurs in *Democoris* and *Kundakimuka*. The genus shows numerous similarities with the Australian endemic genus *Democoris*, but can be distinguished by characters of the bucculae and the peritreme of the scent efferent system (see *Democoris* Remarks section). *Teratophylella* is the sister genus of the clade containing *Kundakimuka* + *Democoris* + *Arygotelaenus* + *Teratophylum*, and is united with this group by the presence of the enlarged eyes, which are contiguous with the posterior margin of the pronotum.

Teratophylella fulvoides Carvalho

Teratophylella fulvoides Carvalho 1955b: 644; Carvalho 1957: 35 (catalogue).

Figures.—9, 17, 25, 41, 53, 63.

Holotype.—Male. Mexico Br. Tex. 69391, 7/III/1950, 329, on orchid plants (USNM; type seen).

Other specimens examined.—Mexico, State of Vera Cruz, 3-20-1962, Jackson coll[ection], ex bromelads (USNM; male).

Diagnosis.—This species is clearly differentiated from other Western Hemisphere teratophylines by the very narrow membrane cell (Fig. 53). The enlarged bucculae distinguishes it from all teratophylines.

Description.—Male. Small, length 2.26–2.51, width 1.24–1.30, mostly dark brown, with sparse cover of short semiadpressed, pale setae. *Head*: porrect, rounded, longer than wide, length 0.38, width 0.49–0.52, interocular distance 0.24–0.28, mostly dark reddish-brown, posterior margin and mandibular plate orange-brown, apex of clypeus red. *Eyes*: red, with short interocular setae, barely surpassing

maximum height of ommatidia. *Antennae*: short, AI length 0.20 brown, fusiform; AII length 0.32, basally narrower than AI, weakly incrassate apically, yellow; AIII length 0.24, mostly yellow, weakly embrowned apically; AIV length 0.34, yellow, weakly fusiform. *Labium*: length 0.96, reaching mesocoxae; LI barely reaching posterior margin of bucculae; LII reaching proxyphus; LIII short of apices of forecoxae; LIV longest segment. *Pronotum*: uniformly fuscous; length 0.64, posterior width 0.94. *Mesonotum*: mostly fuscous, with reddish tinge. *Scutellum*: fuscous. *Hemelytra*: embolium reddish-brown; clavus and corium dark brown; membrane translucent, yellowish, cell narrow, subequal in width to length of pronotal collar, vein brown. *Legs*: femora dark brown, four meso- and six metafemoral trichobothria; tibiae mostly yellowish-brown, basally dark brown; tarsi yellow. *Abdomen*: dark brown. *Male genitalia*: genital capsule small, conical, mostly dark brown, tergite X orange brown; left paramere small, orange-brown, sensory lobe minute, shaft weakly arcuate, spatulate. Female unknown.

Remarks.—This species is known from orchids and bromelads (Table 1), however, this information probably represents sitting records, and does not indicate true host plant records. More material is needed to fully describe this species, and field studies are needed to establish its hosts and habits.

Teratophylidea Reuter and Poppius

Teratophylidea Reuter and Poppius 1912: 2, 5, Usinger 1935: 271 (note), Carvalho 1952: 50 (list), Carvalho 1955a: 22 (key), Carvalho 1957: 35 (catalogue), Maldonado 1970: 119 (taxonomic history; species key), Callan 1975: 389–391 (biology).

Figures.—4, 12, 20, 28, 32, 36, 38, 44, 48, 49, 50, 58, 66, 70, 74, 79, 80, 86, 91, 97, 106, 114.

Type species.—*Teratophylidea pilosa* Reuter and Poppius 1912 by monotypy.

Diagnosis.—*Teratophylidea* is characterized by glassy, broad hemelytra, with the em-

bolium enlarged. Unlike any other termatophyline, they do not have rows of punctations on the pronotum (Figs. 32, 36) and hemelytra (Fig. 48), and the anal vein of the clavus is present as a serrate groove (Figs. 49, 50). They also do not possess evaporative areas surrounding the metathoracic spiracle (Fig. 66), and they have a small pit along the anterior margin of the metepisternum (Fig. 58).

Description.—Elongate-ovoid to ovoid, mostly smooth with pronotum granulate; without rows of punctures on dorsum (Figs. 32, 48), with moderate cover of elongate, semierect, pale setae, arising from pronounced bases, intermixed with microsetae on hemelytra. **Head:** elongate (Fig. 4) strongly porrect (Fig. 12); vertex weakly rounded, postocular margins either subparallel or moderately convergent posteriorly, posterior margin very weakly carinate; frons moderately narrowed; clypeus subhorizontal, terminating above antennifers; bucculae short, margins subparallel (Fig. 20); gula moderately broad, weakly concave, distinctly transversely rugose, without any distinctive vestiture. **Eyes:** small to moderately sized, separated from anterior margin of pronotal collar by a distance equal to or greater than width of second antennal segment; ommatidia large, with elongate, interocular setae. **Antennae:** moderately sized, subcylindrical, with AI, AIII and AIV subequal in length, and AII 3× to 4× longer than other segments; AI not thickened; AII thickest segment, incrassate apically (Fig. 28); AIII and AIV fusiform. **Labium:** reaching between apices of forecoxae and midlength of mesosternum. **Pronotum:** (Figs. 32, 36, 44) biconvex; lateral margins strongly divergent posteriorly; pronotal collar narrow (Fig. 32), extending to mid-width of eyes, marked posteriorly by a deep nonpunctate groove; callosite region marked by a deep, nonpunctate, transverse and sublateral groove (Fig. 36), incomplete mesally, with or without tubercles either side of midline contiguous with the posterior margin of the callosite region, mostly smooth, with a few setae restricted to the midline and below the posterior margin of pronotal collar; antero-lateral pronotal setae

caudad of propleural suture; disc longer than callosite region, mostly with a granular appearance, with elongate, semierect setae with distinct raised bases, posterior margin weakly bisinuate. **Mesonotum:** visible from above, declivent, sometimes with a dense matt of whitish microsetae. **Scutellum:** lateral margins not punctate, sometimes with tubercles just caudad of anterior margin (Fig. 38). **Hemelytra:** (Figs. 48–50) hyaline; broad, widest caudad of midlength of corium; lateral margins strongly arcuate; anal vein sinuate (Figs. 48, 49), nonpunctate, region laterad of vein with dense matt of microsetae; embolium narrow, thickened; R+M vein not punctate, almost reaching cuneal fracture; corium broad, mostly glassy, sometimes with darker markings, weakly to moderately setate, setae with tuberculate, sometimes embrowned bases; medial flexion line either obscure and short or obsolete; cuneus either as long as wide, or usually longer than wide; membrane transparent to translucent, usually concolorous; with dense matt of microsetae; membrane cell large, subquadrate; membrane vein with subcaudal thickening. **Thoracic pleura:** tergopleural suture indistinct (Fig. 44), sometimes marked by a subanterior pit, remainder as a very weak depression; propleural suture indistinct, usually marked by a pit; proepisternum subquadrate; proepimeron usually with a subanterior pit; mesepimeron elongate (Fig. 58), usually smooth and shiny, dorsal margin weakly angulate, with narrow, lanceolate spiracular opening on dorso-caudal arm of dorsal margin (Fig. 66), without evaporative areas, lined with microsetae, ventral margin as a weak depression; metepisternum with reduced scent efferent system (Fig. 58), occupying about 1/3 of the segment, not reaching metathoracic spiracle, dorsal margin usually emarginate, peritreme (Fig. 70) tongue-like, broad, along midwidth of scent efferent system, dorsally directed, short of dorsal margin of scent efferent system, not raised dorsally or along posterior margin, above evaporative areas; evaporative bodies widely separated, caps mostly elongate (Fig. 74), much longer than wide, remainder of segment weakly depressed,

anterior margin carinate, with a pit dorsad of dorsal margin of scent efferent system. *Legs*: elongate, cylindrical; coxae elongate; femora elongate and narrow, with four mesofemoral and six metafemoral trichobothria (Figs. 79, 80), with moderately dense distribution of elongate, semierect setae; tibiae elongate and narrow, cylindrical, with rows of spinelets (Fig. 86), intermixed with elongate, semiadpressed setae; pretarsus (Figs. 91, 97) with claws greatly thickened basally, apically strongly arcuate, parempodia setiform, not flattened apically. *Female abdomen*: broad. *Male abdomen*: sub-cylindrical. *Male genitalia*: genital capsule small, conical; left paramere minute (Fig. 106), with small sensory lobe, and shaft weakly arcuate, broad, and weakly enlarged apically; vesica (Fig. 114) with narrow membranous lobe, with a sclerotized process, directly connected to the termination of the ductus seminis, and almost reaching apex of vesica, no gonoporal cavity, lobal sclerites or fields of spines.

Remarks.—*Termatophylidea* is restricted to the Caribbean, Central America, and northern South America. *Termatophylidea* is atypical of most termatophyline in not having punctate rows on the pronotum and hemelytra. It is superficially similar to Deraeocorinae: Hyaliadini because of the glassy, broad hemelytra, however the head structure is markedly different. The head of *Termatophylidea* is strongly porrect like all other termatophyline. This genus is confidently retained in the Termatophylini because of the short first labial segment and the presence of antero-lateral pronotal setae. Aside from the nonpunctate dorsum it differs from other termatophyline most markedly in the form of the metathoracic spiracle and the male aedeagus. The spiracle lacks any surrounding evaporative areas, although the opening is exposed as in most termatophyline. The male genitalia are atypical for termatophyline in possessing a sclerotized process, which is connected to the apex of the ductus seminis. This is reminiscent of the male genitalia of some Hyaliadini (Kelton 1959), and suggests a possible relationship between the hyaliadini and the termatophyline. The present description of *Termatophylidea* is based

on observations of *T. maculata*, *T. opaca*, and *T. pilosa*, and an undescribed species from Mexico, and the descriptions of other species by Carvalho (1955a) and Maldonado (1970). Callan (1975) has reviewed the biology of *Termatophylidea* species, and reports that *T. pilosa*, *T. maculata* and *T. opaca* are noted predators of thrip pest species.

Termatophylidea pilosa Reuter and Poppius

Termatophylidea pilosa Reuter and Poppius 1912: 5 (n. sp.), Usinger 1935: 271 (note), Myers 1935: 22 (biology), Carvalho 1952: 50 (list), Carvalho 1955b: 647 (description), Carvalho 1957: 36 (description), Maldonado 1970: 125 (key), Callan 1975: 389–391 (biology).

Figures.—106, 114.

Syntypes.—Male and female specimens. Mandeville, Jamaica (as Jamaica), IV/1906, [E.P.] Van Duzee (UZMH; not examined).

Specimens examined.—Jamaica, J. G. Myers, 1933 #3515, Brit. Mus. 1933-400 (NHM; male).

Diagnosis.—*Termatophylidea pilosa* is recognized by the embrowned markings on the clavus and corium. The male vesica is distinctive (Fig. 114), possessing a sclerotized process, however the male genitalia of no other *Termatophylidea* species has been examined.

Description.—Male. Small, length 3.10, width 1.20, uniformly yellow with hemelytra mostly transparent, with sparse cover of semi-erect, pale elongate setae. *Head*: extremely porrect, rounded, length 0.52, width 0.46, interocular distance 0.20; postocular margins tumid; clypeus with lateral margins tinged with red; maxillary and mandibular plates yellow, tinged with red. *Eyes*: black, tinged with red, moderately sized. *Antennae*: AI length 0.24, with a few elongate, semiadpressed setae, yellow, with slight reddish tinge, AII length 0.70, uniformly and weakly swollen, with dense distribution of elongate, semiadpressed pale setae, uniformly yellow; AIII and AIV missing in available specimen. *Labium*: length 1.14, reaching just beyond the apices of the forecoxae; LII elongate, about twice length of

LIII. *Pronotum*: length 0.54, posterior width 0.82; mostly yellowish, with grooves and lateral margins embrowned and polished, with moderate distribution of elongate, semierect setae. *Scutellum*: moderately rounded, yellow, with a few elongate, semierect setae, with two minute processes on either side of the midline, just caudad of anterior margin. *Hemelytra*: mostly transparent with clavus and meso-caudal aspect of corium weakly embrowned; embolium thickened, with moderate distribution of semierect, elongate setae; corium with a few scattered semierect, elongate setae; membrane vein weakly tinged with red. *Legs*: uniformly yellow; femora very long, narrow, with moderate distribution of semiadpressed setae; tibiae elongate, cylindrical, with four rows of minute spines, with dense distribution of semiadpressed setae. *Abdomen*: not broad, subcylindrical, venter yellowish and brown laterally, with sparse distribution of elongate, semierect setae. *Male genitalia*: left paramere (Fig. 106); vesica (Fig. 114).

Female not available.

Remarks.—*Termatophylidea pilosa* has received some attention in the literature because it is a predator of the economic pest, the cacao thrips, *Selenothrips rubrocinctus*. Myers (1935) and Callan (1975) gave details of the biology of this species (see Biology section). Carvalho (1955b) redescribed this termatophylina species, and also recorded it from Central and South America. Usinger (1935) made a comparison of this species with *T. maculata*, and included a habitus illustration of the male of the species. Maldonado (1970) in a review of *Termatophylidea*, gave a key to species, and distinguished *T. pilosa* mainly on color characteristics.

Termatophylina Carvalho

Termatophylina Carvalho 1988: 235.

Figures.—5, 13, 21, 29, 33, 45, 54, 59, 67, 71, 75, 92, 98, 107, 115.

Type species.—*Termatophylina indiana* Carvalho, 1988: 235, by original designation.

Diagnosis.—*Termatophylina* is diagnosed by the narrow body and elongate appendages.

It has numerous other apomorphies including the peritreme positioned on the posterior margin of metepisternum (Fig. 59) and the eyes distantly removed from the pronotum (Figs. 5, 13). The pronotum is similar to *Kundakimuka*, but the head is much longer in *Termatophylina*.

Description.—Elongate, parallel-sided, dark brown, coriaceous, with rows of punctures on pronotum (Fig. 33), and anal and R+M veins (Fig. 54), with moderate cover of elongate, pale, semierect setae. *Head*: elongate (Fig. 5), porrect (Fig. 13); vertex rounded, posterior margin not carinate; frons short; clypeus large, weakly declivent, terminating above antennifers; bucculae moderately large, wide, lateral margins arcuate (Fig. 21), posteriorly extending just beyond antennifers; gula elongate, moderately wide, weakly convex, weakly transversely rugose. *Eyes*: removed from the pronotum by a distance subequal to length of pronotal collar, moderately large; ommatidia small, with a few elongate, interocular setae. *Antennae*: relatively long, longer than head and pronotum combined; all segments cylindrical and narrow, AII cylindrical (Fig. 29). *Labium*: elongate and slender, reaching posterior margin of mesosternum; LII elongate reaching posterior margin of head; LIII longest segment, reaching midpoint of forecoxae. *Pronotum*: (Fig. 33) weakly flattened, subtrapezoidal; collar rounded, moderate length, broad, almost extending to lateral margins of eyes, posterior margin marked by a moderately deep, impunctate groove; callosite region marked by a sinuate, transverse, weakly punctate groove; antero-lateral pronotal setae elongate, dorsad of tergo-pleural suture and anterior to propleural sulcus; disc region weakly rounded, subequal in length to callosite region, posterior margin weakly excavate on either side of midline. *Mesonotum*: relatively long and visible from above, weakly declivent. *Scutellum*: weakly flattened, not punctate. *Hemelytra*: (Fig. 54) narrow, barely surpassing posterior angles of pronotum; clavus broad with a punctate anal vein; embolium narrow, a little wider than width of first antennal segment; corium with an elongate, punctate R+M vein, about $\frac{3}{4}$

length of corium, subequal in length to a weakly divergent medial flexion line; cuneus slightly longer than wide; membrane with a moderately wide membrane cell. *Thoracic pleura*: tergopleural suture mostly distinct (Fig. 45), mesally obscure placed at midheight of eyes; propleural suture distinct; proepimeron subquadrate, explanate; proepisternum subquadrate, depressed; mesepimeron elongate (Fig. 59), broad, dorsal margin angulate, dorso-caudal arm bearing a lanceolate spiracular opening (Fig. 67), with evaporative bodies, ventral margin of mesepimeron marked by a depression; metepisternum with a well-developed scent efferent system (Fig. 71), dorsal margin contiguous with evaporative areas of mesepimeron; peritreme almost contiguous with posterior margin of metepisternum, tongue-shaped, posterior margin raised above evaporative areas; evaporative bodies subquadrate to elongate (Fig. 75); remainder of metepisternum weakly depressed, dorsally with elongate setae. *Legs*: all segments elongate, cylindrical; femora narrow, with four mesofemoral and six metafemoral trichobothria; pretarsi (Figs. 92, 98) with narrow, strongly C-shaped claws, weakly cleft basally, parempodia short and setiform. *Abdomen*: moderately broad, venter semipolished. *Male genitalia*: genital capsule small, conical; left paramere (Fig. 107) moderately large, sensory lobe weakly tumid, with a few sensory hairs, shaft, narrow, evenly arcuate, tapered apically; vesica (Fig. 115) with membranous lobe, gonoporal cavity present, with large, mesal, narrow, linear lobal sclerite.

Distribution.—India and Malaysia.

Remarks.—Carvalho (1988) described this genus from India, suggesting that it was closely allied to *Termtophyllum*. From my investigations it is evident that *Termtophyllum* differs considerably from *Termtophyllum*, particularly in the head structure, with the former having an elongate head and the eyes greatly removed from the pronotal collar. Unlike any other termtophyline, *Termtophyllum* has very small ommatidia. The scent efferent system is also distinctive, with the peritreme running

along the posterior margin of the metepisternum. The pronotal grooves are also reduced, with the degree of punctation minimal, and unlike in *Termtophyllum*, the posterior margin of the pronotal collar is not punctate. *Termtophyllum* also contains an undescribed species from West Malaysia. This species is represented by two specimens in the Natural History Museum (London). This species is larger than *T. indiana*, but its overall facies are very similar to the type species.

Termtophyllum indiana Carvalho

Termtophyllum indiana Carvalho 1988: 236 (n. sp.).

Figures.—5, 13, 21, 29, 33, 45, 54, 59, 67, 71, 75, 92, 98, 107, 115.

Holotype.—Male. India: Calicut University, Madras, Suchitra collection, Nov[ember] 1987—Jan[uary] 1988 (NHM; not seen).

Specimens examined.—India: Kerala, Calicut Univer[sity] Campus, 22-II-1984, S. A. George, C.I.E.A. 15860 (NHM; male, 2 females).

Diagnosis.—*Termtophyllum indiana* is distinguished from an undescribed *Termtophyllum* species by its smaller size, and the shape of the lobal sclerite of the male genitalia (Fig. 115).

Description.—Male. Moderate size, length 2.73, width 0.74, mostly dark brown, with head lighter, and reddish and yellowish tinges on hemelytra, with moderate distribution of elongate, semiadpressed, golden setae. *Head*: elongate, length 0.53, width 0.42, interocular distance 0.18, vertex mesally medium brown, laterally yellow, maxillary and mandibular plates yellow; clypeus yellowish to yellowish-brown. *Eyes*: reddish-black. *Antennae*: with a moderate cover of semierect setae; AI length 0.22, yellow, sometimes proximally embrowned; AII length 0.55, yellow; AIII length 0.38, proximally more yellowish, distally reddish-brown; AIV length 0.24, reddish-brown. *Labium*: length 1.24. *Pronotum*: dark brown, with elongate, erect to semierect, golden setae, antero-lateral pronotal setae dorsad of tergopleural

suture, and anteriad of propleural suture. *Hemelytra*: mostly dark brown, embolium light brown, R+M vein reddish, cuneal fracture and antero-lateral margins of cuneus yellowish with reddish tinge; membrane dark brown, with dense cover of microsetae. *Legs*: mostly yellow, with meso and metafemora with subapical reddish tinge. *Male genitalia*: left paramere (Fig. 107); vesica (Fig. 115).

Female. Similar to male in structure, color and vestiture. Length 3.07–3.10, width 0.84–0.90. *Head*: length 0.52–0.69, width 0.43–0.46, interocular distance 0.17–0.21. *Antennae*: AI length 0.24; AII 0.50–0.54; AIII length 0.36–0.37, AIV 0.24–0.31. *Labium*: length 1.29–1.44.

Distribution.—India.

Host association.—Associated with the larval galleries of *Lamida moncusalis* Walker (Lepidoptera: Pyralidae).

Remarks.—Carvalho (1988) described *T. indiana*, and included a habitus illustration, and detailed figures of the male genitalia. His illustration of the male vesica indicates the presence of a sclerotized process. In my dissections the sclerite was not connected to the apex of the ductus seminis, and appeared to be associated with a gonoporal cavity as in most other termatophyline, and is therefore considered to be a lobal sclerite.

Termatophyloides Carvalho

Termatophyloides Carvalho 1955b: 641 (n. gen.), Carvalho 1955a: 36 (key), Carvalho 1957: 36 (catalogue).

Figures.—10, 18, 26, 42, 55, 64.

Type species.—*Termatophyloides pilosulus* Carvalho, 1955, by monotypy.

Diagnosis.—*Termatophyloides* is separated from other termatophyline by a combination of characters, and does not contain a single autapomorphy. Like *Termatophyllum*, the callosite region of this genus has a longitudinal row of punctures along the midline. It can be separated from *Termatophyllum* by the elongate, punctate R+M vein, which is longer than the median flexion line in *Termatophyloides*.

Description.—Ovoid; coriaceous; rows of punctures on pronotum (Fig. 42), anal vein and R+M veins (Fig. 55); moderate distribution of semierect, elongate setae. *Head*: elongate (Fig. 10), porrect (Fig. 18); vertex rounded; frons declivent, rounded; clypeus short, weakly declivent, terminating above antennifers; bucculae short, margins weakly arcuate (Fig. 26), not surpassed by first labial segment; gula elongate, narrow, weakly concave, lateral margins carinate, with transverse ridges, and a row of soft, moderate-sized, semierect setae adjacent to eyes. *Eyes*: large, almost contiguous with pronotal collar, distance less than the width of the second antennal segment; ommatidia moderately large; elongate interocular setae. *Antennae*: short; AI subcylindrical; AII weakly incrassate distally, AIII subequal to AII length, longer than AIV; AIII and AIV weakly fusiform. *Labium*: reaching apices of forecoxae; LII longest segment. *Pronotum*: (Fig. 42) weakly biconvex; lateral margins moderately divergent; collar broad, almost reaching lateral margins of eyes, separated from callosite region by a deep, nonpunctate groove, callosite region marked by a postero-transverse and sublateral, punctate groove, and punctate groove along midline; pronotal antero-lateral setae caudad of propleural suture; disc weakly biconvex, longer than callosite region, posterior margin truncate. *Mesonotum*: barely visible from above, strongly declivent. *Scutellum*: flattened, lateral margin not punctate. *Hemelytra*: broad, extending well beyond lateral margins of pronotum; lateral margins arcuate; anal vein punctate; embolium broad, subequal to pronotal collar length; punctate R+M vein short, only slightly surpassing $\frac{2}{3}$ length of corium; medial flexion line much longer, and strongly divergent from the R+M vein; cuneus as long as wide; membrane translucent, dusty concolorous, without microsetae; membrane cell moderately broad, subelliptical, with a weak expansion subcaudally. *Thoracic pleura*: tergopleural suture distinct anteriad to propleural suture; proepisternum subquadrate, granulate; proepimeron weakly rugose, without pits; mesepimeron (Fig. 64) moderately short, broad,

with dorsal margin strongly angulate, dorso-caudal arm of margin with a lanceolate, spiracular opening with evaporative areas, ventral margin marked by a weak depression, and a row of elongate, anteriorly directed, semiadpressed setae; metepisternum scent efferent system (Fig. 64) occupying about half of the segment, contiguous with metathoracic evaporative area; peritreme submarginal to posterior margin of segment, dorso-caudally projected, tongue-shaped, almost reaching dorsal margin of evaporative areas, not raised above plane of evaporative area; evaporative bodies mostly rounded, remainder of metepisternum depressed, with elongate, semiadpressed setae. *Legs*: moderately sized; coxae elongate; femora fusiform; three mesofemoral and four meta-femoral trichobothria; tibiae cylindrical, not slender, with four rows of spinelets, and stiff, semiadpressed setae; pretarsi with basally toothed claws and setiform parempodia. *Abdomen*: broad, semipolished. *Male genitalia*: genital capsule small, genital opening small; left paramere at right angles to ventral margin of genital opening, shaft broad. Male aedeagus not examined.

Remarks.—Carvalho (1955b) described *Termtophyloides* from a single female specimen from Mexico. Carvalho (1955a) distinguished this genus from other termtophylinines by the presence of a transverse punctate groove along the posterior margin of the callosite region, elongate pubescence, and the labium extending to the apex of the forecoxae. None of these characters are exclusive to *Termtophyloides*, and can no longer be considered diagnostic for the genus. A lack of material does not allow an examination of the male genitalia, however the genital capsule and the left paramere, indicate a close relationship with the other Central American genus *Termtophylla*. Miyamoto (1965) in describing a new species, *T. pallipes*, from Japan, indicated numerous differences from the type species, particularly in head structure. I have moved *T. pallipes* to *Kundakimuka*, on the basis of the similar head structure, although the presence of a punctate groove along the midline of the

callosite region of this species is consistent with the present diagnosis of *Termtophyloides*.

Termtophyloides pilosulus Carvalho

Termtophyloides pilosulus Carvalho 1955b: 643 (n. sp.), Carvalho 1957: 36 (catalogue).

Figures.—10, 18, 26, 42, 55, 64.

Holotype.—Female. Mexico: Tamazunchale, San Luis Potosi, 30-XII-1948, coll[ector] Insp[ector] Leary, Laredo Tex[as], 49529, on orchids (USNM, 62946; type seen).

Other specimens examined.—Mexico on orchids, 10-10-1953, Brownsville, Tex[as] (USNM, male).

Diagnosis.—This species is recognized by the dark coriaceous body, the presence of a punctate groove along the midline of the callosite region, and the elongate R+M vein.

Description.—Male. Small. Length 2.17, width 1.20, mostly black, with elongate, semiadpressed vestiture. *Head*: conical, small, a little longer than wide, length 0.41, width 0.37, dark brown, with reddish tinge, particularly on apex of clypeus, and maxillary and mandibular plates. *Eyes*: red, removed from pronotal collar by a distance equal to width of second antennal segment, ommatidia of moderate size. *Antennae*: very small, mostly cylindrical, with a moderate distribution of pale, semiadpressed setae; AI small, a little thickened, length 0.13, dark brown; AII weakly expanded distally, mostly yellow, apex with a weak reddish tinge, length 0.24; AIII mostly yellow, with an apical red annulus, length 0.14; AIV red, length 0.14. *Labium*: yellow, small, reaching midlength of forecoxae; LII reaching midlength of eyes, longest segment; LIII reaching proxyphus. *Pronotum*: uniformly black, antero-lateral setae dorsad of tergo-pleural suture, and anterior of propleural suture. *Legs*: coxae mostly dark brown, apices with reddish tinge; trochanters reddish; femora mostly dark brown, sometimes with obscure reddish tinge, apices yellow; tibiae yellow; tarsi yellow, TIII with obscure embrownment, longest segment. *Abdomen*: dark brown, broad, anthocoridlike, ven-

ter with regular, moderately distributed, elongate, adpressed, pale setae, posterior segments with a few elongate, erect setae, particularly laterally. *Male genitalia*: see generic description.

Female. Similar to male in color, shape and vestiture. Length 2.17, width 1.10. *Head*: length 0.40, width 0.34, interocular distance 0.16. *Pronotum*: length 0.40, posterior width 0.84. *Antennae*: AI length 0.14; AII length 0.24; AIII length 0.16; AIV length 0.16. *Pronotum*: length 0.40, posterior width 0.84.

Remarks.—This species, like *Teratophyllella fulvoides*, has been taken on orchids, which probably represents a sitting record. It was intercepted in quarantine in Texas, USA. More material is needed for examination to firmly establish the relationships of this species.

Teratophylum Reuter

Teratophylum Reuter 1884a: 218 (n. gen.), Reuter 1884b: 167 (description), Reuter and Poppius 1912: 3, 5 (key; description), Carvalho 1952: 50 (list), Carvalho 1955a: 23 (key), Stichel 1956: 175 (key), Carvalho 1957: 36 (catalogue).

Figures.—6, 14, 22, 30, 34, 37, 46, 56, 60, 68, 72, 76, 80, 93, 94, 99, 100, 108, 109, 110, 116, 117, 118.

Type species.—*Teratophylum insigne* Reuter, 1884 by monotypy.

Diagnosis.—*Teratophylum* is separated from other teratophylines by the abbreviated punctate R+M vein (Fig. 56), which is shorter than the medial flexion line. The midline of the callosite region has a punctate groove (Figs. 34, 37) in *Teratophylum*, which is not the case in the saliently similar species of *Kundakimuka* (Figs. 31, 35). Also, the posterior margin of the callosite region of *Teratophylum* is punctate (Fig. 34), which is not the case in the phylogenetically related genus *Arygrotaelaenus* (Fig. 39).

Description.—Elongate to elongate-ovoid; semipolished to weakly coriaceous; with rows of punctures on anal and R+M veins (Fig. 56), pronotum (Fig. 34) and scutellum, with

sparse to moderate cover of semierect, pale setae. *Head*: transverse (Fig. 6) weakly porrect (Fig. 14); vertex weakly to moderately rounded, posterior margin weakly carinate; frons weakly declivent; clypeus moderately declivent, terminating above antennifers; lateral margins of bucculae subparallel (Fig. 22), terminating caudally at midpoint of antennifers; gula elongate, narrow, concave, with transverse ridges, and matt of microsetae (Fig. 22). *Eyes*: very large, covering the lateral aspect of the head, almost touching pronotum (Fig. 14), separated by a distance less than the width of the second antennal segment, ommatidia large, with short to elongate, interocular setae. *Antennae*: short to moderately long, with semiadpressed setae, in males intermixed with flattened, scalelike, adpressed setae on AII; AI short, weakly thickened; AII swollen and fusiform in male (Fig. 30), cylindrical and weakly incrassate subapically in females, AIII cylindrical, AIV weakly fusiform, not swollen. *Labium*: reaching between apices of forecoxae and apex of mesosternum; LII longest segment. *Pronotum*: (Figs. 34, 37, 46) lateral margins strongly divergent, weakly to moderately biconvex; collar rounded, not wide, barely reaching midwidth of eyes, posterior margin marked by a deep punctate groove; callosite region (Fig. 34), marked by a transverse and sublateral, punctate groove, and a short, midline, punctate groove (Fig. 37); calli separated and moderately tumid antero-lateral pronotal setae anterior of propleural suture; disc longer than callosite region, moderately raised above callosite region in lateral view, posterior margin truncate. *Mesonotum*: short to very short, visible from above. *Scutellum*: flattened to weakly rounded, lateral margins each with a row of punctations, rarely along entire length. *Hemelytra*: (Fig. 56) not broad, barely surpassing posterior angles of pronotum, margins subparallel to weakly arcuate; anal vein punctate; embolium narrow, mostly less wide than width of second antennal segment of male; punctate R+M vein, usually surpassing midlength of medial flexion line, rarely beyond, sometimes with punctations less deep and dis-

tinct than punctures of anal vein and pronotum; medial flexion line elongate, almost reaching cuneal fracture, not strongly divergent from R+M vein, subparallel anteriorly; cuneus as wide as long; membrane translucent to opaque with a bicolored pattern, usually pale anteriorly and brown posteriorly, membrane cell large, subquadrate, vein somewhat indistinct, sometimes thickened subcaudally. *Thoracic pleura*: tergopleural suture distinct anteriorly (Fig. 46); proepisternum, subtriangular; proepimeron with a pit ventro-mesally placed; mesepimeron (Fig. 60) broad, dorsal margin strongly angulate, dorso-caudal arm with a small band of evaporative areas, spiracular opening (Fig. 68) not visible, recessed, ventral margin of mesepimeron marked by a depressed line; metepisternum scent efferent system (Fig. 60) occupying almost half of segment, not contiguous with evaporative areas of mesepimeron, with peritreme at midlength or just posteriad of mid-length of evaporative areas, peritreme (Fig. 72) weakly depressed, lanceolate and narrow, to moderately broad and tonguelike, not raised dorsally or posteriorly above plane of evaporative areas; evaporative bodies variable, mostly elongate (Fig. 76), remainder of segment weakly depressed with a few semierect, pale setae. *Legs*: moderately long; femora fusiform, not greatly swollen; four mesofemoral and six metafemoral trichobothria; tibiae cylindrical, without any rows of spinelets, with stiff, semiadpressed pale setae; pretarsi (Figs. 94, 100) with claws strongly cleft basally, and angulately C-shaped, with short, flattened, ribbonlike parempodia. *Abdomen*: broad, polished, with moderate distribution of soft, semiadpressed setae; *Male genitalia*: genital capsule conical (Fig. 101, 102); genital opening small; left paramere (Figs. 108–110) with a very short sensory lobe, with a few short, erect, pale setae, shaft arcuate, sometimes evenly tapered apically, sometimes broader and spatulate apically; vesica (Figs. 116–118) with a membranous lobe, with a gonoporal cavity, and one or two sickle-shaped, lobal sclerites, apex of membranous lobe with fields of spines.

Remarks.—*Termatophylum* is the most diverse genus of the termatophyline, and presently contains 13 species, of which, all except one, are confined to the Old World, particularly the tropical and subtropical regions. *Termatophylum montanum* was described from Brazil by Carvalho (1983) but has not been examined in this study. Reuter (1884a) first described the genus for a species from Egypt. Reuter and Poppius (1912) provided a detailed redescription of the genus and listed diagnostic characters for *Termatophylum* in a key to the known genera. They separated *Termatophylum* and *Arygrotelaenus* primarily on the presence of hairy eyes in the former genus, which remains a valuable distinguishing character. Carvalho's (1955a) generic key to the termatophyline did not contain any significant diagnostic characters, and incorrectly stated that the pronotum did not have rows of punctures behind and between the calli. *Termatophylum* is now clearly recognized by the punctuation of the pronotum and characters of the pterothoracic pleura and male genitalia. The biology of *Termatophylum* is poorly known with host plant records known for *T. insigne* and *T. melaleuca* (see Table 1 and Biology section).

Termatophylum insigne Reuter

Termatophylum insigne Reuter 1884a: 218 (n. sp.), Reuter 1884b: 168 (description), Reuter and Poppius 1912: 7, 9 (key, description), Carvalho 1952: 50 (type species), Stichel 1956: 175 (description), Carvalho 1957: 36 (catalogue), Linnavuori 1974: 3, 4 (diagnosis; species key), Linnavuori 1975: 6 (Egypt; host plant), Linnavuori 1980: 15 (Sudan), Linnavuori 1989: 29 (Yemen).

Figures.—93, 99, 108, 116.

Holotype.—Female. Egypt (as Aegyptus) (?UZMH; not seen).

Specimens examined.—Sudan: Kordofan, Tendelti-Umm Ruwaba, 25-1-1963, R. Linnavuori (NHM; male); Sudan: N[orthern] Prov[ince] Ed Dammer-Shendi 1-XI-1962, R. Linnavuori (NHM; male); Sudan: Khartoum, junction of Niles, 23-1-1966, P.

Štys collector (AM; female); Sudan: Khartoum, Sunt Forest, 19-11-1965, P. Štys collector (AM; 3 males; female); Sudan: Khartoum, Burri, 10-1965, P. Štys collector (AM; female); Sudan: Khartoum, Burri, 10-12-1965, Williams collector (AM; male).

Diagnosis.—*Termtophylum insigne* is distinguished by the color pattern of the dorsum; mostly brown, with yellowish markings. The male left paramere (Fig. 108) and the vesica (Fig. 116) are also distinctive for the species.

Description.—Male. Small, parallel-sided, length 2.33–2.64, width 0.84–0.93, mostly yellowish-brown, with brown and yellow markings, hemelytra opaque, with sparse cover of semiadpressed, short, golden setae. *Head*: uniformly brown, with uniform distribution of short, whitish, adpressed setae, moderately porrect, length 0.43–0.48, width 0.53–0.56, interocular distance 0.14–0.17; maxillary and mandibular plates yellowish-brown, sometimes with reddish; gula yellow. *Eyes*: reddish-black, with moderately elongate, interocular setae. *Antennae*: AI short, length 0.14–0.17, barely passing apex of clypeus, yellow, with a few semiadpressed setae; AII length 0.39–0.44, fusiform, uniformly swollen, proximal half to two-thirds yellow, distal half to third brown, sometimes with reddish tinge, particularly at apex, with moderate cover of flattened, adpressed, scalelike, whitish setae, intermixed with elongate, semiadpressed setae; AIII cylindrical, much narrower than AII, length 0.22–0.24, yellow, with moderately sized semiadpressed, pale setae AIV weakly fusiform, length 0.14–0.17, vestiture as AIII. *Labium*: slender but not fragile, reaching apices of forecoxae, length 0.98–1.00, LII longest segment but only slightly longer than LIII. *Pronotum*: with sparse cover of moderately long, semi-erect, pale setae; collar yellowish-brown, laterally more brown; callosite region yellowish-brown, with grooves and lateral regions darker brown; disc uniformly brown. *Mesonotum*: barely visible from above. *Scutellum*: anterior half brown, posterior half yellow to yellowish-brown, with sparse cover of semierect, moderately sized, pale setae. *Hemelytra*: with sparse cover of

semiadpressed, moderately sized, pale setae on clavus, embolium, corium and cuneus; clavus yellowish brown, with inner margins darker; embolium R+M vein short, about $\frac{3}{4}$ length of medial flexion line, R+M vein only weakly punctate, mostly yellowish, posteriorly embrowned; corium with anterior $\frac{2}{3}$'s laterad of medial flexion line vein yellow to yellowish-brown, remainder brown, except for indistinct yellow marking mesally above cuneal fracture; cuneus antero-laterally yellow, remainder brown; membrane with vein embrowned, membrane patterned, mostly brown, with two indistinct yellow markings posteriad of cuneus, without any apparent microsetae. *Thoracic pleura*: proepisternum proximally brown, distally yellow, proepimeron proximally brown, distally yellow; proxyphus uniformly yellow. *Legs*: moderately sized, mostly yellow with distal half of metafemora shiny brown; metafemora almost $1.5\times$ longer than mesofemora; tibiae and tarsi yellow. *Abdomen*: broad, anthocoridlike, brown, shiny. *Male genitalia*: left paramere (Fig. 108); vesica (Fig. 116) with a sickle-shaped lobal sclerite, and two ill-defined, basal lobal sclerites.

Female similar to male in color, shape and vestiture. Length 2.67–2.79, width 0.86–0.96. *Head*: length 0.45–0.49, width 0.52, interocular distance 0.16–0.18. *Antennae*: AI length 0.15–0.16, uniformly dark brown; AII cylindrical, weakly expanded distally, yellow; AIII length 0.24, yellow; AIV length 0.16–0.18, yellow. *Labium*: length 0.94–0.96. *Pronotum*: length 0.59–0.60, posterior width 0.82–0.88.

Remarks.—This species is broadly distributed in the Middle East, including the Sudan, and is known to inhabit *Acacia* (Linnavuori 1975). Reuter (1884a) briefly described the species from a single female specimen. Reuter and Poppius (1912) gave a detailed description of the species, including the male, and differentiated it from other *Termtophylum* species, primarily on color characteristics. Stichel (1956) briefly described the species, and Linnavuori (1974) gave a detailed diagnosis, including structural and color features. The majority of *Termtophylum* species are differentiated on

external color characters, and a study of the male genitalia is necessary to confirm the validity of these species.

Teratophylum melaleuca Cassis n. sp.

Figures.—6, 14, 22, 30, 34, 37, 46, 56, 60, 68, 72, 76, 94, 100, 108, 109, 117.

Eytomology.—This species is named after its host-plant genus association.

Holotype.—Male. QLD: 19:18.2S 146:49.1E, Townsville, Oonoonba Kennan St[reet] 19 May 1993, L. M. Brown, NQMqn93028.PO41-042, ex *Melaleuca quinquenervia* (AM).

Specimens examined.—Paratypes: QLD: 19:18.2S 146:49.1E, Townsville, Oonoonba Kennan St[reet], 19 May 1993, L. M. Brown, NQMqn93028.PO41-042, ex *Melaleuca quinquenervia* (AM; 1 male; 2 females); QLD: Heathlands, 11:45S 142:35E, 18 August 1992, J. Cardale, P. Zborowski, at light (ANIC; male); QLD: 18:07.9S 145:55E, 21.8 km S Tully, Double Barrel C[ree]k Swamp, 11 May 1993, J.K. Balciunas, NQMMqn93026.P099, ex *Melaleuca quinquenervia* (AM; female).

Diagnosis.—*Teratophylum melaleuca* is distinguished by the bicolored hemelytral membrane. It is also differentiated from its close relative, *T. weiri*, by the spatulate apex of the left paramere (Fig. 109), and the single lobal sclerite (Fig. 117).

Description.—Male. Small, length 2.51–2.73, width 0.96–1.02, parallel-sided, mostly dark brown, with moderate cover of pale, semierect setae. *Head*: length 0.38–0.48, width 0.51–0.53, interocular distance 0.12–0.15, vertex and frons mostly dark brown to black, clypeus, maxillary and mandibular plates dark brown, sometimes with reddish tinge. *Eyes*: reddish-dark brown. *Antennae*: with moderate cover of semierect setae, less so on AI; AI length 0.16–0.18, dark brown, with moderate to strong reddish tinge; AII length 0.36–0.41, mostly dark brown with reddish tinge, sometimes with base yellow, also with short flattened, scalelike setae; AIII length 0.23–0.24, dusty yellow; AIV length 0.21–0.24, dusty yellow. *Labium*: length 0.96–1.08, yellow, LII

longest segment, reaching base of forecoxae, LIII reaching apex of forecoxae, LIV reaching posterior margin of mesosternum. *Pronotum*: dark brown to black, grooves darker, posterior margin with a minute, pale yellowish band; length 0.49–0.58, width 0.84–0.86. *Scutellum*: flattened, mostly dark brown to black, apex with yellow marking. *Hemelytra*: color variable, mostly with clavus and cuneus dark brown to fuscous, embolium reddish-brown to brown, with corium brown, but darker mesally, but sometimes hemelytra lighter brown, with clavus and corium with reddish tinge, and lateral aspect of corium almost translucent, medial flexion line and R+M veins usually darker; R+M vein occupying $\frac{3}{4}$ to $\frac{5}{8}$ of corium, medial flexion line more than $\frac{1}{2}$ of corium; membrane with moderate cover of pale microsetae, bicolored, with anterior half pale to translucent, remainder pale to medium brown, anterior margin of darker areas V-shaped, cell moderate size, mostly pale, with vein weakly raised, and caudal half embrowned, and weakly thickened caudo-laterally. *Legs*: mostly yellow. *Genitalia*: left clasper (Fig. 109) with apex of shaft spatulate; vesica (Fig. 116), with one sickle-shaped lobal sclerite.

Female similar to male in shape but more elongate-ovoid; color similar, in some specimens hemelytra sometimes more uniformly dark brown, with lighter markings along cuneal fracture; vestiture similar to males. Length 2.63–3.04, width 1.10–1.20. *Head*: length 0.48–0.49, width 0.52–0.54, interocular distance 0.16–0.17. *Antennae*: AI length 0.19–0.24, dark brown to fuscous; AII length 0.37–0.43, weakly incrassate apically, proximal $\frac{2}{3}$ yellow, remainder dark brown to fuscous, sometimes with reddish tinge; AIII length 0.24–0.26, dusty yellow; AIV length 0.21–0.22, dusty yellow. *Labium*: length 1.02–1.08. *Pronotum*: length 0.48–0.50, posterior width 0.90–0.94.

Remarks.—This species is easily recognized by the patterned hemelytral membrane. The description of this species is based on specimens from northern Queensland, however, numerous specimens from southern Queensland, acquired after the observational phase of

this work, appear to be conspecific, which suggests that the species is broadly distributed in the coastal region of the State. This needs to be confirmed by examination of the male genitalia.

Termatophylum weiri Cassis n. sp.

Figures.—110, 118.

Eytomology.—This species is named after the collector Tom A. Weir, of the Australian National Insect Collection, CSIRO, Canberra.

Holotype.—Male. QLD: 15.47S 145.17E, Moses C[ree]k, 4 km N by E of Mt. Finnigan, 14–16 October 1980, T. Weir (ANIC).

Other specimens examined.—Paratypes: QLD: 15.47S 145.17E, Moses C[ree]k, 4 km N by E of Mt. Finnigan, 14–16 October 1980, T. Weir (ANIC; 1 male; 2 females); QLD: Cairns district, F. P. Dodd (SAMA; female).

Diagnosis.—*Termatophylum weiri* is recognized by the unicolorous hemelytral membrane, the evenly tapered apex of the left clasper (Fig. 110), and the vesica with two lobal sclerites.

Description.—Male. Small, length 2.29–2.33, width 0.85–0.90, parallel-sided, mostly light brown, with sparse cover of elongate, semiadpressed pale setae. *Head*: length 0.36–0.40, width 0.46–0.52, interocular distance 0.12, vertex fuscous, clypeus, maxillary and mandibular plates reddish-brown. *Eyes*: fuscous, with a reddish tinge. *Antennae*: AI length 0.14–0.15, not thickened, yellowish-brown, with a few erect, pale setae; AII length 0.38–0.40, yellowish-brown, with moderate cover of erect, brown, elongate, bristlelike setae, and short, flattened, adpressed pale setae; AIII length 0.22–0.24, cylindrical, narrow, yellow, with moderate cover of elongate, semierect, pale setae; AIV length 0.16–0.17, narrow, weakly fusiform, with moderate cover of elongate, semierect, pale setae. *Labium*: length 0.88–0.96, reaching beyond midlength of mesosternum; LII longest segment, reaching midlength of forecoxae; LIII reaching beyond apices of forecoxae. *Pronotum*: subtrapezoidal, mostly yellowish-brown; collar light yellowish-brown; callosite region yellowish-brown, but darker

than pronotal disc and collar; pronotal disc yellowish-brown. *Scutellum*: brown, with anterior half with fuscate tinge, lateral margins with weak punctations. *Hemelytra*: clavus yellowish-brown, with darker embrownment particularly along anal vein; corium yellowish brown, R+M vein punctations not deep, not embrowned, barely surpassing midlength of medial flexion line, setal bases fuscous; membrane yellowish, translucent, without any color pattern, membrane cell large, subquadrate, vein weakly embrowned. *Genitalia*: left clasper (Fig. 110) with apex of shaft evenly tapered; vesica (Fig. 117) with two sickle-shaped lobal sclerites.

Female. Similar to male in structure and color. Length 2.17–2.29, width 0.93–0.96. *Head*: length 0.38, width 0.46, interocular distance 0.12–0.14. *Antennae*: AI length 0.16, AII length 0.36, weakly incrassate apically; AIII length 0.22–0.24; AIV length 0.18–0.19. *Labium*: length 0.89–0.96. *Pronotum*: length 0.50–0.53, posterior width 0.78–0.82.

Remarks.—There is some doubt as to whether the female from Moses Creek, QLD, is conspecific with the holotype male from the same locality, as it is considerably darker. The female from the Cairns district is saliently very similar to the holotype male, particularly in the lighter coloration.

GENERA REMOVED FROM THE
TERMATOPHYLINI

Conocephalocoris Knight, 1927

Conocephalocoris Knight 1927: 141 (n. sp.),
Carvalho 1952: 53 (list), Carvalho 1955a:
22 (key), Carvalho 1957: 35 (catalogue).

Type species.—*Conocephalocoris nasicus*
Knight, 1927, by monotypy.

Specimen examined.—USA: Utah, Wash-
ington Co., Leeds Canyon, 28 July 1965, W.
J. Hanson collector (Utah State University;
male).

Remarks.—*Conocephalocoris* was originally
described in the Deraeocorini by Knight (1927),
which was followed by Carvalho (1952). Car-
valho (1955a) transferred the genus to the Ter-

matophylini, presumably on the basis of the elongate, porrect head. His diagnosis of the Termatophylini refers to the short antennae, but in *Conocephalocoris* the antennae are elongate, with the second segment extremely long and thickened. Carvalho (1957) retained its position within the Termatophylini in his world catalogue.

Conocephalocoris cannot be retained in the Termatophylini, as presently defined. There is little doubt that it is similar to termatophylini, in possessing rows of punctures on the pronotum, and R+M and anal veins. However, these characters are present in numerous other Deraeocorinae, particularly the Hyaliodini. The head of *Conocephalocoris* is porrect, but this has evidently been independently derived in the termatophylini, and some Deraeocorini genera, such as *Conocephalocoris*, *Eurychlopterella* Reuter, *Hesperophylum* and *Teratomiris*. *Conocephalocoris* has interocular setae, which has not been observed in any other non-termatophyline Deraeocorinae, and is present in all termatophylini, except *Arygrotelaenus*.

The short first labial segment, not surpassing the posterior margin of the bucculae, is the most critically defining character for the Termatophylini. In *C. nasicus* the first labial segment far surpasses the bucculae. The pterothoracic pleura of this species are different to the termatophylini, with the dorsal margin of the mesepimeron almost linear, carinate, and without an exposed spiracular opening, or associated evaporative areas. The peritreme of the scent efferent system of the metepisternum is spoutlike, and greatly raised above the evaporative areas, and is unlike any Termatophylini. The pronotum *C. nasicus* has an indistinct callosite region, but is not bounded posteriorly and sublaterally by a deep groove.

Numerous other characters of *C. nasicus* are not present in other termatophylini, and these include: 1) clavus with an incomplete punctate anal vein, and a punctate longitudinal groove, antero-mesally placed; 2) hemelytra much longer than abdomen; 3) membrane with two cells; 4) labium extremely elongate, reaching last ab-

dominal segment; 4) absence of antero-lateral pronotal setae.

Stonedahl (personal communication) is presently reviewing the North American genera *Conocephalocoris*, *Eurychlopterella* and *Hesperophylum*, and has indicated support for my conclusions. It is unknown at present whether these genera, and genera such as *Teratomiris*, form a monophyletic group, which are defined by having a porrect head.

Hesperophylum Reuter and Poppius, 1912

Hesperophylum Reuter and Poppius 1912: 3, 16 (n. gen.), Knight 1941: 64, 74 (key), Carvalho 1952: 50 (list), Carvalho 1955a: 22 (key), Carvalho 1957: 35 (catalogue).

Type species.—*Hesperophylum heidemanni* Reuter and Poppius, 1912, by monotypy.

Remarks.—*Hesperophylum* was described in the Termatophylini by Reuter and Poppius (1912), predominantly on the basis of the porrect head. This North American monotypic genus is removed from the Termatophylini on the same basis as *Conocephalocoris*; it has an elongate first labial segment which extends far beyond the bucculae. It also differs from termatophylini by the following characters: 1) flattened second antennal segment; 2) callosite region not demarcated posteriorly by a groove; 3) anal vein reduced to posterior half of clavus; 4) labial segment elongate, surpassing apices of metacoxae; 5) presence of two membrane cells; 6) absence of antero-lateral pronotal setae.

Teratomiris Ghauri, 1975

Teratomiris Ghauri 1975: 615.

Type species.—*Teratomiris probosciodocoris* Ghauri, 1975, by original designation.

Specimen examined.—Female. QLD: Lankelly, B. Gray, ii-vii-1972 (NHM; paratype).

Remarks.—Ghauri (1975) described this Australian taxon in the Termatophylini,

primarily because of the porrect head. He indicated that it was similar to the mirine genus *Proboscidoris* Reuter, but was clearly a member of the Deraeocorinae on the basis of the basally cleft claws and setiform parempodia. *Teratomiris* is removed from the Termatophylini, because of the elongate first labial segment, and transferred to the Deraeocorini.

Teratomiris differs from termatophylines by the following characters: 1) first labial segment longer than bucculae; 2) ommatidia small; 3) absence of interocular setae; 5) absence of antero-lateral pronotal setae; 6) pronotum bipartite; 7) without rows of punctures on pronotum and hemelytra; 8) two membrane cells; 9) dorsal margin of mesepimeron not angulate; 10) metathoracic spiracle not exposed; 11) mesepimeron without evaporative areas; 12) peritreme dorsally expanded and raised.

PHYLOGENY OF THE GENERA OF TERMATOPHYLINI

The 29 characters and the 68 character states utilized in this analysis are those of head, eyes, labium, antennae, pronotum, scutellum, hemelytra, pterothoracic pleura, parempodia and male genitalia. The character and character state descriptions are presented in Table 2, and the data matrix for outgroups and Termatophylini is given in Table 3. One cladogram of 66 steps (Fig. 131) was produced, with a consistency index of 0.59 and a retention index of 0.69. The character state changes for the ancestral nodes and terminal taxa are given in Table 4. The following discussion of sister-group relationships is based on the character state changes at the designated ancestral nodes. Discussion is restricted to synapomorphic characters, except for Node 9, which is only supported by homoplasious characters.

Node 9.—The sister-group relationship of *Hesperophylum* and *Conocephalocoris* + Termatophylini is based on the following characters: elongate head (1-1) and the porrect head (9-2). Both characters are labile

within the Termatophylini, and other Deraeocorinae, not included in this analysis. The elongate head state is found in the basal genera of the Termatophylini, and the apomorphic genus *Arygrotaenus*, in which it is independently derived. The porrect head has been ascertained by the degree of declivity of the clypeus, which is also variable within the Termatophylini. Both these head characters are partially correlated, however in *Termatophyloides*, the clypeus is moderately declivent and the head is elongate. The porrect head is found in other Deraeocorini, such as *Teratomiris* and *Eurychilopterella*, and my analysis suggests that this character state has independently arisen often in the Deraeocorinae. From this it is evident that previous definitions of the Termatophylini (Carvalho 1955a), based on the porrect head, are artificial, and therefore, *Conocephalocoris* and *Hesperophylum* are removed from the Termatophylini.

Node 8.—The sister-group relationship of *Conocephalocoris* and the Termatophylini is based on the following synapomorphies: interocular setae present (8-1) and the absence of a sclerotized process (28-1). The presence of interocular setae is diagnostic for all termatophylines, except for *Arygrotaenus*, where the lack of setae is interpreted as a secondary loss. The presence of interocular setae appears to be widespread within the Miridae, however in most of the Deraeocorinae, the eyes appear to lack these setae, and *Conocephalocoris* is the only non-termatophyline Deraeocorinae examined which has interocular setae. The examination of the male genitalia outside of the termatophylines has been limited in this study, and the significance of the sclerotized process is not understood.

Node 7.—The Termatophylini are defined as a monophyletic group in this analysis by the following synapomorphies: short first labial segment (3-1), the presence of antero-lateral pronotal setae (12-1) and the condition of the metathoracic spiracle (21-1). The first labial segment is extremely ab-

Table 2. Characters and character states used in cladistic analysis of Termatophylini genera.

1) Head shape	0 = transverse, 1 = elongate
2) Bucculae shape	0 = parallel-sided, 1 = moderately arcuate, 2 = strongly arcuate
3) Labial segment I	0 = longer than bucculae, 1 = as long as bucculae
4) Gula vestiture	0 = without microsetae, 1 = with microsetae on lateral margins, 2 = with dense matt of microsetae
5) Eye size	0 = large, 1 = very large
6) Eye position	0 = removed from pronotal collar by distance greater than AII width, 1 = contiguous with pronotal collar
7) Ommatidia size	0 = small, 1 = large
8) Interocular setae	0 = absent, 1 = moderately distributed, 2 = densely distributed
9) Clypeus	0 = vertical, 1 = moderately distributed, 2 = densely distributed
10) Male AII shape	0 = cylindrical, incrassate apically, 1 = fusiform and flattened, 2 = fusiform and swollen
11) Male AII vestiture	0 = setiform only, 1 = setiform intermixed with flattened scale-like setae
12) Antero-lateral pronotal setae	0 = absent, 1 = present
13) Pronotal collar	0 = posterior margin not punctate, 1 = punctate
14) Callosite region	0 = posterior margin not punctate, 1 = punctate
15) Callosite region	0 = midline without groove, 1 = with punctate groove
16) Scutellum	0 = lateral margins not punctate, 1 = punctate
17) R+M vein	0 = longer than median flexion line, 1 = equal to or shorter than median flexion line
18) Hemelytral membrane	0 = concolorous, 1 = bicoloured
19) Membrane cell	0 = broad, 1 = narrow
20) Mesepimeron shape	0 = elongate, 1 = broad
21) Metathoracic spiracular opening	0 = not evident, pleura separated, 1 = visible as a lanceolate/oval opening, 2 = not visible, recessed
22) Scent efferent system evaporative areas	0 = contiguous with mesepimeric evaporative areas, 1 = not contiguous with mesepimeric evaporative areas
23) Peritreme	0 = anterior to midwidth of evaporative areas, 1 = at midwidth of evaporative areas, 2 = caudad of midwidth of evaporative areas, 3 = along posterior margin of metepisternum
24) Parempodia	0 = setiform, 1 = setiform, apex weakly flattened, 2 = flattened, ribbon-like
25) Male genital opening	0 = left margin without tubercle, 1 = left margin with tubercle
26) Gonoporal cavity	0 = absent, 1 = present
27) Lobal sclerites	0 = absent, 1 = elongate, 2 = sickle-shaped
28) Sclerotized process	0 = present, 1 = absent
29) Vesica apex	0 = without fields of spines, 1 = with fields of spines

breviated in the Termatophylini, and terminates caudally at the posterior margin of the bucculae. This condition has not been reported in any other Miridae, nor any other Deraeocorinae examined in the course of this study. The first labial segment in the Miridae is the most robust of all the segments, and greatly surpasses the posterior margin of the bucculae, and usually reaches the posterior margin of the head. Schuh and Stys (1991) in a cladistic review of the Cimicomorpha indicate that the elongate first

labial segment is a synapomorphy for the Miroidea, and that the short to absent first labial segment is in the ground plan for the Cimicomorpha. The short first labial segment of the Termatophylini is undoubtedly of independent origin, and cannot be presently supportive of any alternative taxonomic arrangement of the tribe, outside of the Miroidea. Curiously, despite there being no doubt about the carnivorous habit of the Termatophylini (Callan 1975), their labium is extremely slender and fragile. The strong-

Table 3. Character matrix of four outgroups, eight termatophyline genera and 29 characters. Missing data = ?.

	00000000111111111222222222
	12345678901234567890123456789
<i>Ambracius</i>	020000000000000000000000?100?000
<i>Bothynotus</i>	0200000000000000100000?100?000
<i>Hesperophylum</i>	120000002100000100000?10????
<i>Conocephalocoris</i>	120000012000100100000?000?011
<i>Arygrotelaneus</i>	10120110221100011101211211211
<i>Democoris</i>	02111112100111010011211001110
<i>Kundakimuka</i>	02111112100111010001102101010
<i>Termatophyllella</i>	0211011110010101001110200????
<i>Termatophylidea</i>	101100112001000000001?1000000
<i>Termatophylina</i>	11100001200101001000103001110
<i>Termatophyloides</i>	1111001110010111000110200????
<i>Termatophylum</i>	01121112121111111101211211211

ly robust and elongate first labial segment of *Conocephalocoris* and *Hesperophylum* supports their removal from the Termatophylini. The presence of antero-lateral pronotal setae appears to be unique to the Termatophylini, and is very similar in form to that found in some Anthocoridae, but

must be considered to be independently derived.

The condition of the metathoracic spiracle has undoubted phylogenetic value in the Miridae (Cassis 1984, Cassis in preparation). The spiracular opening in the Termatophylini is clearly visible, although sometimes recessed (Node 8), and is unlike that in any other Deraeocorinae. In the Termatophylini the dorso-caudal arm of the dorsal margin of the mesepimeron is highly modified, with the posterior angle recurved cephalically, and subsiding below the dorsal margin, at times partially fused with the anterior margin of the metepisternum. The spiracular opening in termatophylines, except in *Termatophylidea*, is bounded by evaporative bodies, which presumably function as a barrier to allosomes from entering the respiratory system. In other Deraeocorinae, such as *Deraeocoris* (Fig. 122), *Hyaliodes* (Fig. 120) and *Trilaccus* (Fig. 121), the mesepimeron and metepisternum are confluent, and the spiracular opening is assumed to be intersegmental, deeply recessed, and not visible or differentiated, as in the Termatophylini. Also, the dorso-caudal arm of the dorsal margin of the mesepimeron of these non-termatophylines is not angulately recurved and recessed, and there is no evidence of evaporative areas.

Table 4. List of character state changes at ancestral nodes and terminal taxa for Figure 131.

9:	1-1, 9-2
8:	8-1, 28-1
7:	2-1, 3-1, 12-1, 16-0, 21-1
6:	4-1, 7-1
5:	9-1, 14-1, 16-1, 20-1, 23-2
4:	1-0, 2-2, 6-1
3:	5-1, 8-2, 13-1
2:	21-2, 22-1, 23-1, 27-1
1:	2-1, 4-2, 10-2, 11-1, 17-1, 18-1, 24-2, 25-1, 27-2, 29-1
<i>Ambracius</i>	16-0
<i>Hesperophylum</i>	10-1
<i>Conocephalocoris</i>	13-1, 23-0, 29-1
<i>Termatophylina</i>	14-1, 17-1, 23-3, 27-1
<i>Termatophylidea</i>	2-0, 26-0, 28-0
<i>Termatophyloides</i>	15-1
<i>Termatophyllella</i>	19-1
<i>Kundakimuka</i>	24-1
<i>Democoris</i>	19-1
<i>Termatophylum</i>	15-1
<i>Arygrotelaneus</i>	1-1, 2-0, 5-0, 8-0, 9-2, 13-0, 14-0

In *Bothynotus* (Fig. 119) (Clivinemini) evaporative bodies are present on the ventro-caudal angle of the mesepimeron, and there is evidence that the dorsocaudal arm is recurved and subsided. However, the pleura are clearly separated in *Bothynotus*, which is suggestive of a different character state to the Termatophylini, and similar to that found in *Conocephalocoris* and *Hesperophylum*.

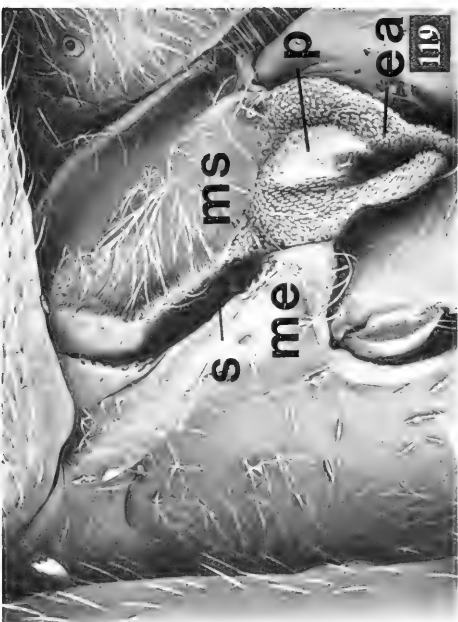
The structure of the mesepimeron, and particularly the metathoracic spiracle is very similar to that found in the Dicyphini (Fig. 123), and somewhat similar to the Phylinae (Fig. 126) and Orthotylinae (Fig. 125). This form of the spiracular opening cannot be considered to be plesiomorphic for the Miridae, because of its absence in the plesiomorphic subfamilies Isometopinae (Fig. 128) and Cylapinae (Fig. 129), and is considered to be an important synapomorphy for the Termatophylini, and elsewhere in the Miridae. The striking similarity of the spiracular opening in the Termatophylini and Dicyphini is suggestive of a close relationship between these tribes. This has been previously suggested by Cobben (1968) whose examination of the termatophylinae, *Termatophylidea opaca*, indicated similarities with the Dicyphini in the aero-micropylar structure of the eggs. More generally Wagner (1955) considered the Dicyphini as a sister taxon to the Deraeocorinae, primarily on the basis of the male genitalia. However, on the basis of the pretarsal structure (Schuh 1976), the Termatophylini are considered to belong to the Deraeocorinae, and the relationship of the Dicyphini to the Deraeocorinae requires examination, and is beyond the scope of this work.

Node 6.—*Termatophylina* in this analysis is the most plesiomorphic of the termatophylines, on the basis of the small, flattened ommatidia. The remainder of the termatophylines form a clade of seven genera on the basis of the enlarged and convex ommatidia (7-1) and the presence of microsetae on the lateral margins of the gula (4-1).

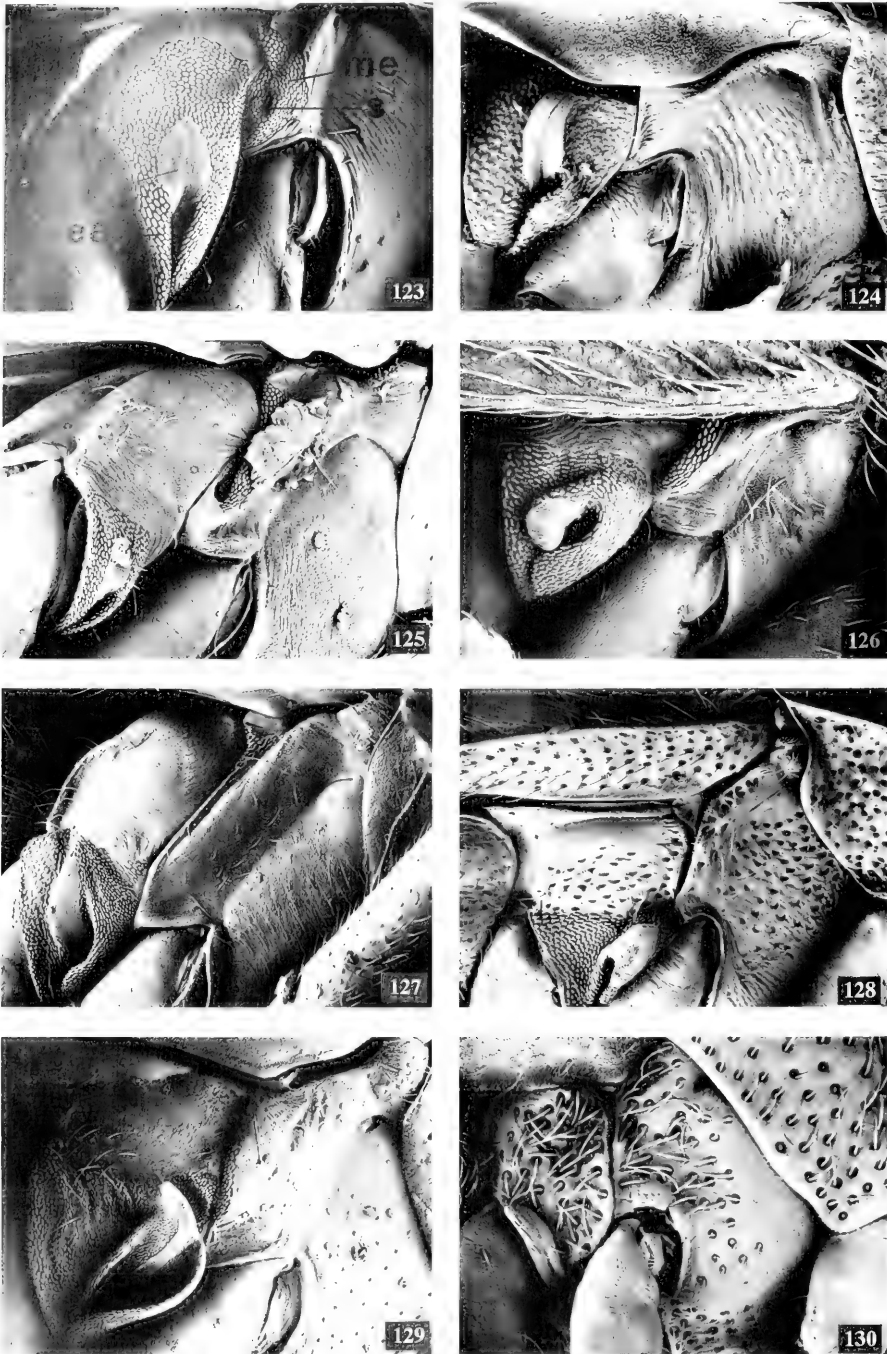
The presence of enlarged ommatidia has not been examined in other suprageneric group of Miridae and its importance requires further examination. The gula of termatophylines is usually weakly concave, with transverse ridges, and this clade is characterized by the occurrence of microsetae on the gula, which are absent in *Termatophylina*.

Node 5.—This clade is represented basally by the Western Hemisphere genera *Termatophylodes* and *Termatophylella*, and the four Old World genera *Kundakimuka*, *Democoris*, *Termatophylum* and *Arygrota laenus*. It is defined by the following synapomorphies: the broad mesepimeron (20-1) and the peritreme posteriad to midwidth of the scent efferent system (23-2). The broad mesepimeron is correlated to the strongly angulate dorsal margin (Figs. 57, 60). In *Termatophylina* (Fig. 59) and *Termatophylidea* (Fig. 58) the dorsal margin of the mesepimeron is weakly arcuate, which is more typical for other Deraeocorinae, where the dorsal margin of the mesepimeron is almost linear to very weakly arcuate (Figs. 119-122). The angulate dorsal margin of the mesepimeron is rarely encountered in the Miridae, occurring in the Eccritotarsini (Fig. 130). This character state exists in other non-mirid cimicomorphans, such as the Anthocoridae (Fig. 124). The dorsal margin of the mesepimeron is fundamentally different in the Dicyphini (Fig. 123), Orthotylinae (Fig. 125) and Phylinae (Fig. 126), where the evaporative areas bridge to the postalare, producing a dissected dorsal margin.

The position of the scent efferent system peritreme in relation to the evaporative areas has some phylogenetic value in some of the mirid suprageneric groups. In the Isometopinae (Fig. 128) the peritreme is contiguous with the anterior margin of the metepisternum, and in the Eccritotarsini (Fig. 130) it is situated on the posterior margin of the metepisternum. This character shows variability within some mirid suprageneric groups, such as Termatophylini. In the most basal termatophylinae, *Termatophylina*, the



Figs. 119–122. Pterothoracic pleura of non-termatophyline Deraeocorinae, lateral view. 119, *Bothynotus* sp. (Clivinemini). 120, *Hyaliodes* sp. (Hyaliodini). 121, *Trilaccus* sp. (Saturniomirini). 122, *Deracocoris* sp. (Deraeocorini). ca = evaporative areas; me = mesepimeron; ms = metepimeron; p = peritreme; s = metathoracic spiracle.



Figs. 123–130. Pterothoracic pleura of Anthocoridae and non-deraecorine Miridae. 123, *Dicyphus* sp. (Bryocorinae: Dicyphini). 124, *Temnostethus* sp. (Anthocoridae). 125, undetermined orthotyline species. 126, undetermined phylinae species. 127, undetermined mirine species. 128, undetermined isometopine species. 129, *Cylapus* sp. (Cylapinae). 130, undetermined ecclitotarsine species. ea = evaporative areas; me = mesepimeron; ms = metepisternum; p = peritreme; s = metathoracic spiracle.

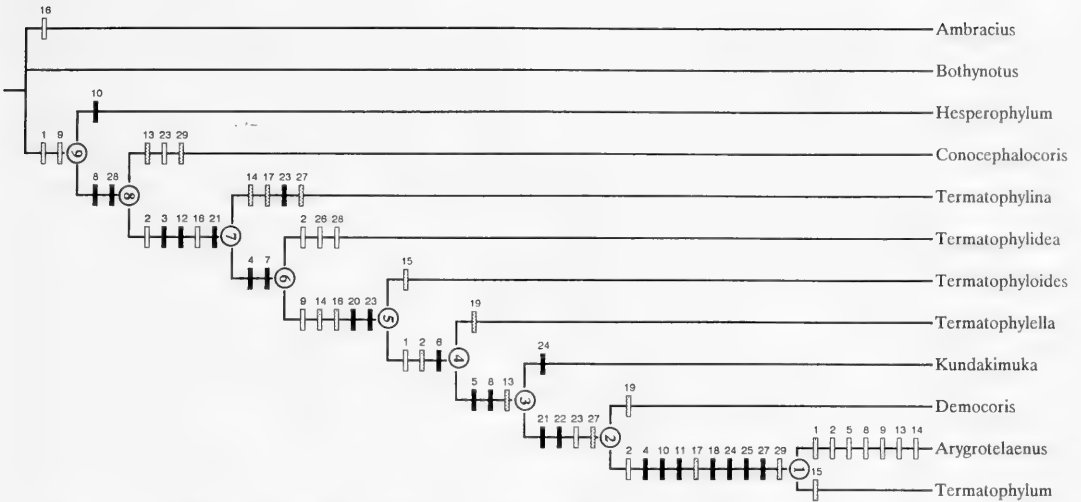


Fig. 131. Cladogram depicting phylogenetic relationships of the genera of Termatophylini. Black bars = synapomorphies; stippled bars = homoplasious forward; white bars = homoplasious reversal).

peritreme is contiguous with the posterior margin of the metepisternum (Figs. 59, 71). The peritreme caudad of the midwidth of the scent efferent system occurs in the three most basal genera of Node 5, and is reversed (23-1) for the clade of Node 2.

Node 4.—This clade of five genera (*Termatophylella* + *Kundakimuka* + *Democoris* + *Arygrotelaenus* + *Termatophylum*) is defined by the following synapomorphy: the eyes contiguous with the pronotal collar (6-1). This character is partly correlated to very large eye size, however, in *Termatophylella* the eyes (6-0) are not as large, but are still contiguous with the pronotal collar (Fig. 9).

Node 3.—This clade of four genera (*Kundakimuka* + *Democoris* + *Arygrotelaenus* + *Termatophylum*) is defined by the following synapomorphies: very large eyes (5-1) and densely distributed interocular setae (8-2). In this clade the genera have the eyes occupying almost the entire lateral aspect of the head, with the entire posterior margin contiguous with the collar in lateral view. The interocular setae are densely distributed in this clade, and are nearly always greatly elongate, greatly surpassing the maximum height of the ommatidia.

Node 2.—This clade of three genera (*Democoris* + *Arygrotelaenus* + *Termatophylum*) is defined by the following synapomorphies: the metathoracic spiracular opening recessed (21-2), and the scent efferent system not contiguous with the mesepimeric evaporative areas (22-1). In these genera the metathoracic spiracular opening is not visible when the pleura are observed in lateral view (Figs. 60, 68) and its presence is indicated by a short band of evaporative areas. In postero-lateral view, the spiracle is observed as a small, recessed opening, which is most obvious in *Democoris*, and is very small in *Termatophylum* and *Arygrotelaenus*. In many mirids the evaporative areas of the mesepimeron and metepisternum are contiguous. The scent efferent system, however, is often reduced, and in this clade, the separation of the two evaporative areas is considered phylogenetically significant.

Node 1.—The sister-group relationship of *Termatophylum* and *Arygrotelaenus* is strongly supported by the following synapomorphies: the gula with dense matt of microsetae (4-2), the male second antennal segment fusiform and swollen (10-2), the male second antennal segment with seti-

form and flattened scalelike setae (11-1), the parempodia broadly flattened and ribbonlike (24-2), the hemelytral membrane bicolored (18-1), the left margin of the male genital opening with a small tubercle (25-1), and the lobal sclerites sickle-shaped (27-2).

The vestiture of the gula of this clade is characterized by a dense matt of microsetae (Figs. 22, 23), occupying the entire region. This is somewhat variable in *Teratophyllum*, but is found in the type species, *T. insigne*. The vestiture of the male second antennal segment of *Arygrotelaenus* and *Teratophyllum* is composed of setiform, semierect setae, intermixed with flattened, scalelike setae (Fig. 30). This does not occur in any other termatophyline, and is possibly correlated with the presence of flattened, scalelike setae in *Arygrotelaenus* and some species of *Teratophyllum*. The flattened, ribbonlike parempodia of *Arygrotelaenus* (Figs. 89, 95) and *Teratophyllum* (Figs. 93, 94, 99, 100), represents the first reported variation of the deraeocorine setiform parempodial type, and strongly supports the sister-group relationship of these two genera. These parempodia retain longitudinal striations which also supports their derivation from a setiform type. Schuh (1976) has indicated that in the Miridae the lamellate type has been derived from the setiform type, and this case is evidence that this has occurred in the Miridae on more occasions than previously thought. This clade is supported by two male genitalic characters. The most significant of these is the presence of sickle-shaped lobal sclerites (Figs. 111, 116-118), whereas in all other termatophyline the lobal sclerites are linear, with the apex often tapered.

DISCUSSION

I conclude that the Termatophylini belong to the Deraeocorinae, which are presently defined by the presence of basally cleft claws, and the presence of setiform parempodia. Schuh (1976) supported the

monophyly of the Deraeocorinae on the basis of the pretarsal structure, and also indicated that most deraeocorines have a polished and punctate pronotum, and a tendency towards reduction in femoral trichobothrial numbers. The deraeocorine pretarsus, however, remains the only synapomorphy for the subfamily, and no additional support has been gained from my observations of the pterothoracic pleura. Despite the existence of some variation in the parempodia in the termatophyline, with *Arygrotelaenus* and *Teratophyllum* having flattened parempodia, other characters do not strongly support an alternative taxonomic arrangement. The similarity of the Dicyphini and Termatophylini metathoracic spiracle is out-weighed by the great differences in their pretarsal structure. The male genitalia of the Termatophylini is consistent with those of other Deraeocorinae (Kelton 1959), although the secondary gonophore appears to be considerably reduced. The parameres are strongly asymmetrical, with the right paramere minute, which is again reminiscent of the Dicyphini, although this condition also occurs in other Deraeocorinae, such as the Hyaliiodini and Clivinemini.

Schuh (1976), Akingbohunge (1974, 1978), and Stonedahl and Cassis (1991) pointed to the inadequacies of the definitions of the deraeocorine tribes. Akingbohunge (1974) made an analysis of various genera of Hyaliiodini, and supported Knight (1943) in considering them as a subfamily, primarily on the presence of an anal tube. However, he recognized two groups within the hyaliiodines, in which one group did not contain the anal tube, and no other character presented as a synapomorphy for the group. The glassy appearance of the hemelytra in many Hyaliiodini strongly resembles the condition in the termatophyline *Teratophylidea*, which is superficially similar to *Hyaliodes*, although the heads are very different. The hemelytra of the hyaliiodines and termatophyline are similar

in structure, with the R+M and anal veins punctate in many of the genera of both tribes. This also occurs in other deraeocorines including *Conocephalocoris*, *Eurychlopterella* and *Hesperophylum*, and some Clivinemini. The expanded embolium is also shared by the former two tribes, although it is somewhat reduced in some termatophylines, such as *Arygrotelaenus*, *Termatophylum* and *Termatophylina*. It is clear that the glassy hemelytra and enlarged embolium are not sufficient characters for defining the Hyaliiodini (Carvalho 1955b), and the tribe remains without a reasonable diagnosis.

The Clivinemini were defined by Carvalho (1952, 1955a) as having the "pronotum with an impressed line running from [the] antero-lateral corner to the posterior margin of [the] calli." This is also the case in the Termatophylini, with the line sometimes marked by a row of punctures. This groove demarcates the callosite region, which is generally much shorter in the Clivinemini than in the Termatophylini. There appears to be little character support for the definition of the Clivinemini as a suprageneric group. I have indicated that the mesepimeron and metepisternum are widely separated in the clivenemines, but this also occurs in some Deraeocorini, and thus does not define the tribe exclusively.

Carvalho (1952) erected the Saturniimirini as a deraeocorine tribe on the basis of characters of the pronotum, eyes, and hemelytral membrane. He indicated that the pronotum was constricted anteriorly, but this is variable within the tribe, as pointed out by Akingbohungebe (1978), and in my examination of a number of undescribed saturniimirines from Australia. Carvalho (1952, 1955a) also indicates that the calli are large and fused, which is mostly true within the tribe but also occurs in some Clivinemini and some Termatophylini. The one-celled membrane is variable within the Saturniimirini, and Akingbohungebe (1974) and Schuh (1976) have indicated that this character has little taxonomic value in the

Miridae. Curiously, the one-celled membrane is invariant in the Termatophylini. Carvalho (1952) reported that the eyes of saturniimirines are semistylate, which appears to be consistent in all members of the tribe examined. At present it is difficult to evaluate this character because not enough material within the remainder of the subfamily was available for examination.

Carvalho (1952, 1955a) defined the Deraeocorinae chiefly on the basis of absent characters. His key couplet read as follows: "pronotum not constricted anteriorly; calli not prominent and fused; neither are eyes semistylate; membrane usually with two cells." It is obvious that this definition does not provide any diagnosis or synapomorphy for the nominate tribe of the Deraeocorinae. Stonedahl and Cassis (1991) suggested that the tribe was paraphyletic, and was basically a taxon that contains the genera that could not be placed within the more narrowly defined tribes. They established the sister-group relationship of the Deraeocorinae genera *Angerianus* and *Fingulus*, and suggested that a broad survey of the male genitalia would possibly enlighten the situation. I did not have any material of Surinamelini, and cannot comment on the definition of this tribe.

It is evident that aside from the present definition of the Termatophylini, no other deraeocorine tribe can be established as a monophyletic group. Undoubtedly, suprageneric groups occur within the other deraeocorines, such as the anal tube bearing Hyaliiodini, but a thorough analysis of the genera is required to provide a useful classification.

The similarity of a few Termatophylini, such as *Kundakimuka* and *Termatophylum*, with some Anthocoridae is undoubtedly due to convergence. The most striking similarities include the abbreviated first labial segment, the short antennae, with the third and fourth segments greatly reduced, and the presence of large, forward projecting setae, on the antero-lateral corners of the pronotum.

tum. However, termatophyline possess femoral trichobothria, a mirid-type pretarsus, the hemelytral membrane with a closed cell, and typical mirid male genitalia. There is also no evidence that any of the termatophyline have copulatory organs associated with traumatic insemination, typical of most Cimicoidea. The similarities that do exist between the termatophyline and anthocorids have obviously evolved independently, and there is no reason to remove the Termatophylini from the Deraeocorinae.

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REVIEW OF THE NEW WORLD LACE BUG GENERA
ACANTHOCHEILA STÅL AND *CARVALHOTINGIS* NEW GENUS
(HETEROPTERA: TINGIDAE)

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Abstract.—*Acanthocheila* Stål is revised and redefined with removal of the new genus *Carvalhotingis*. Of the 16 species formerly cataloged in *Acanthocheila*, 8 are retained but reduced to 7 with 1 new synonymy: *A. abducta* White, *A. armigera* Stål (= *A. nigrescens* Drake and Bondar), *A. dira* Drake and Hambleton, *A. exquisita* Uhler, *A. sigillata* Drake and Bruner, *A. spinicosta* Van Duzee, and *A. thaumana* Drake and Cobben. The other 8 species are transferred to *Carvalhotingis* and reduced to 5 with the following new combinations and new synonymies: *C. comitis* Drake, *C. hollandi* Drake (= *comentis* Drake, = *denieri* Monte, = *rustica plana* Drake, = *rustica rustica* Monte), *C. nexa* Drake, *C. tumida* Drake, and *C. visenda* Drake and Hambleton. Keys to the 2 genera and their species are included.

Key Words: Heteroptera, Tingidae, New World, new genus, new species, new synonymies, key

In honor of the memory of a long time friend and colleague—José Candido de Melo Carvalho—and in recognition of his many fine contributions to the study of biology, the following new genus, *Carvalhotingis*, is named after him.

My attempts to divide the currently cataloged lace bug tribe Tingini into groups of genera based on external characters revealed that some of the accepted genera are actually composite, encompassing more than one genus. The present paper deals with one of them by dividing *Acanthocheila* Stål into two genera.

The genus *Acanthocheila* was cataloged by Drake and Ruhoff (1965) with sixteen species and one “variety”; the distributions given below are mostly from that catalog, but include subsequently encountered country records indicated by an asterisk.

Until now *Acanthocheila* was recognized among American tingid genera by the combination of the uniseriate paranotum whose free margin bears a row of long (almost as long as or longer than width of an eye), stout spines, plus the costal margins being parallel for a short distance from the base and thence widened.

However, my studies of other structures showed this definition included two genera: the second is here described as a new genus *Carvalhotingis*. Initially this separation was suggested by the presence or absence of occipital spines (Figs. 1, 2); then additional contrasting characters were found. The two genera show different structure of the subantennal plate on the side of the head: in *Carvalhotingis* (Fig. 4) that plate is a simple, narrow strip passing vertically next to the eye and not approaching the side of the head:

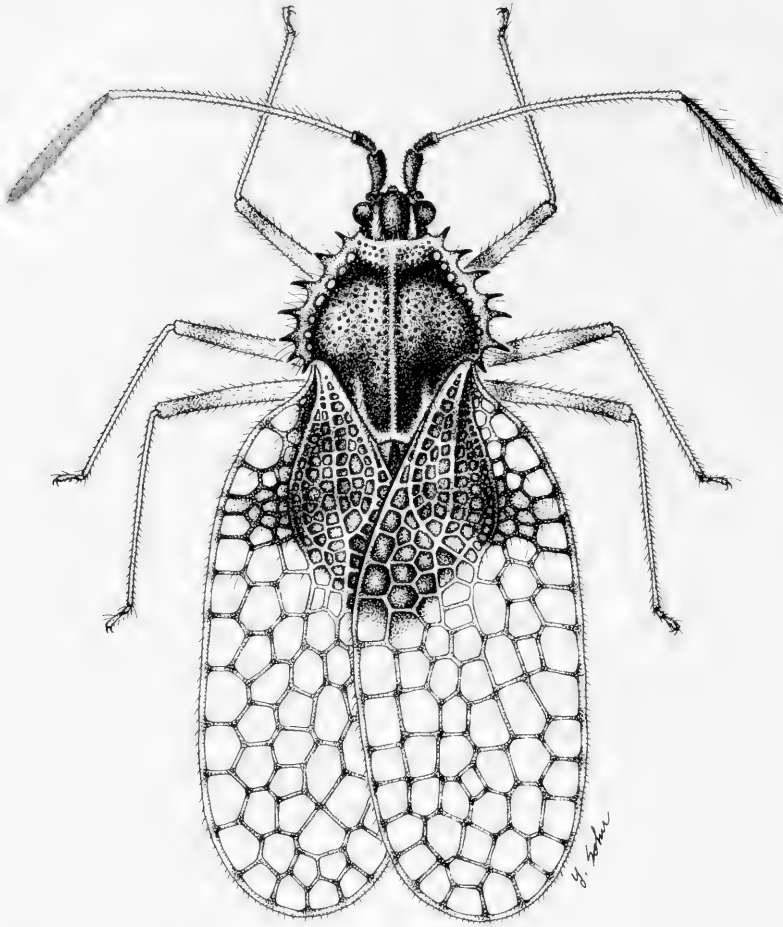


Fig. 1. *Acanthocheila armigera* (Stål). Natural length 3.7 mm.

in *Carvalhotingis* (Fig. 4) that plate is a simple, narrow strip passing vertically next to the eye and not approaching the margin of the clypeus, while in *Acanthocheila* (Fig. 3) that plate has its anterior margin convexly expanded forward to almost or quite reach the margin of the clypeus. Modifications of the bucculae further support the separation: all species of *Acanthocheila* have the anterior ends of the bucculae incurved anterior to the clypeus and, except in *A. sigillata* Drake and Bondar, in contact with each other beyond the clypeus (Fig. 3). In *A. sigillata* the anterior ends of the bucculae are distinctly incurved anterior to the clypeus but

they do not meet; in contrast, the bucculae in *Carvalhotingis* are parallel and do not reach the apex of the clypeus (Fig. 4).

In both genera there were serious problems in defining and separating certain of the described species—hence, it was necessary to synonymize several of them.

These two genera may be conveniently separated by the following couplet:

Head with prominent occipital spines. Bucculae strongly incurved beyond apex of clypeus
 *Acanthocheila* Stål
 Head without occipital spines (Caution: the long hairs may sometimes be matted in groups and look

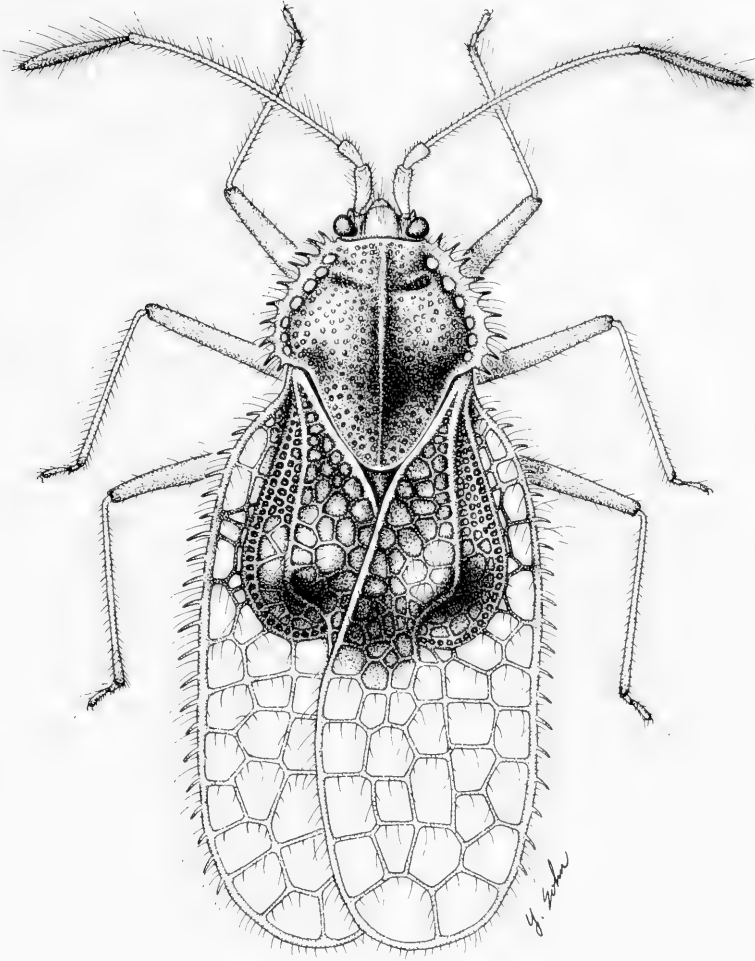


Fig. 2. *Carvalhotingis tumida* (Drake). Natural length 4.0 mm.

like spines). Bucculae parallel, not incurved anteriorly *Carvalhotingis*, new genus

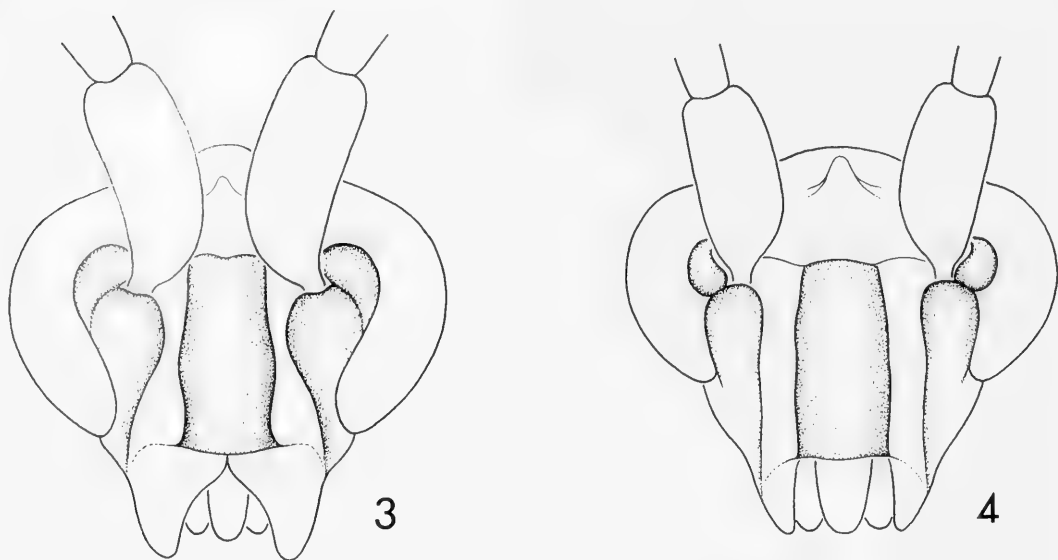
Genus *Acanthocheila* Stål
(Figs. 1, 3, 5)

Monanthia (*Acanthocheila*) Stål, 1858: 61.
Type-species:—*Monanthia* (*Monanthia*)
Stål, designated by Van Duzee, 1916: 26.
Acanthochila [sic].—Stål, 1872: 127.

Diagnosis.—As defined and keyed above.
Characters.—Length, 2.4–5.0 mm. Dorsal surface with few fine hairs or none. Macropterous; hemelytral axes subparallel to

diverging, apices moderately to strongly separated.

Head.—Short, with 2–3 cephalic spines: occipital spines elongate, each reaching at least to base of antennal tubercle; with or without anteromedian spine or tubercle; supraclypeals always absent. Eyes a little less to slightly more than half as wide as interocular space. Bucculae anteriorly surpassing, incurved, and, except in *A. sigillata*, contiguous beyond apex of clypeus. Labium nearly or quite reaching meso-metasternal suture. Antennal segment I three-fourths to subequal to interocular width, almost twice



Figs. 3, 4. 3. *Acanthocheila armigera*. Anterior view of head showing bucculae incurved and contiguous anterior to clypeus, and convex anterior margin of subantennal plate. 4. *Carvalhotingis tumida*. Anterior view of head showing widely separated bucculae, and straight anterior margin of subantennal plate.

as long as II, III thinnest. Subantennal plate convex anteriorly, nearly or quite reaching margin of clypeus (Fig. 3).

Pronotum.—Without cysts; median carinae low, reaching transverse anterior margin of pronotum, virtually without cells. Lateral carinae absent or represented by weak to vague calloused lines on posterior projection. Paranotum narrow to moderately broad, uniseriate, with marginal row of 5–10 long, stout, tapering spines. Posterior pronotal projection extending to basal third or midlength of discoidal area, acutely triangular, converging to a broadly truncated or distinctly emarginate apex.

Hemelytron.—Except for oblique basal part of costal area, nearly flat. Discoidal area, except at apex, distinctly separated from sutural area; with 2–5 cells across widest part. Subcostal area faintly convex, horizontal, with 2–6 rows of cells, outermost row of cells sometimes narrowed and delimited by thickened veins. Costal margin convex to concave on basal fourth; margin with 0–3 small spines on basal seventh, or with a row

of distinct spines extending from base to beyond apex of discoidal area. Costal area with 1–3 rows of cells. Hypocosta uniseriate and distinct for only a short distance at base, becoming obsolete before midlength of abdomen.

Peritreme variable, elevated and transversely auriculate to obsolete. Metapleural flange a narrow, transverse, single row of cells. Sternal laminae present on all three sterna; on prosternum parallel, on mesosternum distinct to very weak, widely separated near base, ventral margin with or without a premedian, distinct angulation; on metasternum low but distinct, outwardly convex, apically more or less approaching each other. Abdomen basoventrally convex.

Type species.—*Monanthia (Acanthocheila) armigera* Stål, designated by Van Duzee 1916: 26.

Known geographic distribution.—The known range of this essentially Neotropical genus is from Argentina north through South and Central America, and the West Indies

to southern Texas and the southern tip of Florida.

Comments.—All species of the genus as here constituted, except *A. abducta* White (*A. dira* Drake and Hambleton known only from female holotype), show some sexual dimorphism in the subcostal area: Females have it noticeably wider than it is in the males and usually have one or more additional rows of cells; females are darker and more strongly marked than males.

Other variations in range of color of individuals are also evident. The pronotum may vary from yellowish tan to virtually black. The hemelytra may vary from virtually colorless, with a few parts of veins lightly embrowned, to having most of the cells in the discoidal and subtending subcostal areas dark brown. In the latter case the brown color extends almost or quite to the costa as a broad band across the basal third of the costal area. Within the band crossing the costal area the cells are usually much reduced in size and form more rows than are evident basal to or beyond the band. The first two antennal segments may be deep black, brown, or pale yellow; accompanying this, the apical two thirds of each femur may be decidedly darkened.

The presence (Fig. 5) or absence of the premedian angulation on the lower margin of the mesosternal lamina is especially interesting when correlated with the distribution of the several species. All but one of those species with such an angulation are continental forms from South and Central America, including *A. armigera*, which ranges north into the southern United States and onto the Antilles. Those species without such an angulation appear restricted to the Bahamas and the West Indies, including *A. exquisita* Uhler which was described from Key West, Florida (perhaps it was an introduction there), but subsequently found to inhabit the Bahamas. The exception to the above generalizations is the more recently described *A. thaumana* Drake and Cobben which does have such an angulation but ap-

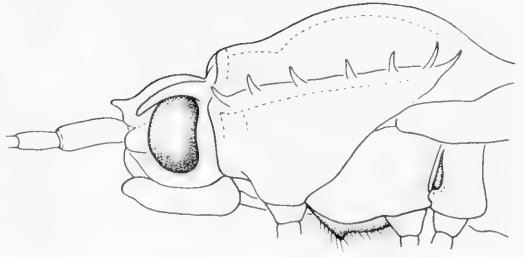


Fig. 5. *Acanthocheila armigera*. Lateral view showing small angulation on mesosternal carina.

pears restricted to the Leeward Islands of St. Eustatius and St. Martin.

The specimens that run to *armigera* in the following key to species vary in several and perplexing ways. This variability was recognized and, in part, described by Champion (1897: 28) and some subsequent authors. Several of these variations may be present or absent in a series with identical label data or may be found in different combinations, sometimes on the two sides of the same specimen. At this time the significance of these variations is not evident. But recognition of them as simply "variations," leads to the conclusion that *A. armigera* must be the senior synonym of *A. nigrescens* Drake and Bondar, new synonymy; further study may prove otherwise.

It might be helpful to comment on some of these variations. The paranotum may terminate at the anterior margin of the collar or conspicuously project cephalad; its 7–11 marginal spines may be equally spaced or variously separated. Most specimens with the simple row of spines on the margin of the paranotum also have the head showing a distinct angulation or a small but evident spine anterodorsally (best seen in profile); in contrast, those specimens with the anterior 2–3 paranotal spines crowded together usually have the anterodorsal outline of the head (in profile) smoothly decurved, but sometimes they show a distinct angulation. These combinations of differences may be evident on specimens in a series bearing the same label data, or the paranotal spine num-

ber and arrangement may differ on the two sides of one individual. None of these patterns show any association with geography.

The lateral discal carinae may be absent, or may show a trace of the posterior ends as a vaguely calloused longitudinal ridge projecting anteriorly from the lateral margin of the pronotum's posterior projection (Fig. 1).

These variations do not appear to be sufficiently constant and contrasting to use for separating *A. armigera* into two or more species.

LIST OF ACANTHOCEILA SPECIES

- Acanthocheila abducta* White
- Acanthocheila abducta* White, 1879: 485.
- Acanthocheila kahavalu* Kirkaldy, 1905: 216. Synonymized by Drake and Ruhoff, 1965: 56.
- Known distribution: Bolivia, Brazil, Peru.
- Acanthocheila armigera* (Stål)
- Monanthia (Acanthocheila) armigera* Stål, 1858: 61.
- Monanthia (Acanthocephala) spinuligera* Stål, 1858: 61. Synonymized by Monte, 1938: 128.
- Acanthochila (sic) armigera*. — Stål, 1873: 127.
- Acanthocheila nigrescens* Drake and Bondar, 1932: 88. NEW SYNONYMY.
- Known distribution: Argentina, Bolivia, Brazil, Colombia, Costa Rica*, Cuba, Ecuador, El Salvador*, Guatemala, Haiti, Honduras, Jamaica, Mexico, Panama, Peru, Puerto Rico, Trinidad, Venezuela, United States of America.
- Acanthocheila dira* Drake and Hambleton
- Acanthocheila dira* Drake and Hambleton, 1945: 359.
- Known distribution: Guatemala
- Acanthocheila exquisita* Uhler
- Acanthocheila exquisita* Uhler, 1889: 143.
- Known distribution: Bahamas. United States of America.
- Acanthocheila sigillata* Drake and Bruner

Acanthocheila sigillata Drake and Bruner, 1924: 147.

Known distribution: Cuba.

Acanthocheila spinicosta Van Duzee

Acanthocheila spinicosta Van Duzee, 1907: 20.

Known distribution: Dominican Republic, Haiti, Jamaica, Puerto Rico, St. Thomas (Virgin Islands).

Acanthocheila thaumana Drake and Cobben

Acanthocheila thaumanni Drake and Cobben, 1960: 71.

Known distribution: St. Eustatius, St. Martin (Virgin Islands).

KEY TO SPECIES OF ACANTHOCEILA

- 1. Costa with a series of strong spines reaching to or beyond apex of discoidal area 2
- Costal area with no spines or with 1–3 confined to basal seventh 4
- 2. Midline of head with tubercle or a strong, projecting, tapering spine above base of clypeus 3
- Midline of head with no tubercle or spine *exquisita*
- 3. Cells of discoidal and subcostal areas subopaque, rounded, abruptly much smaller than cells on apical half of hemelytron. Paranotum narrow, its cells elongate, no wider than outer limiting vein *sigillata*
- Cells of discoidal areas hyaline, similar to or only slightly smaller than cells in apical half of hemelytron. Paranotum wide, its cells rectangular to transverse, larger ones about 3× as wide as outer limiting vein *spinicosta*
- 4. Midline of head with a very long (almost as long as antennal segment I), tapering, subvertical spine between eyes. Paranotum at level of calli vertically reflexed, bringing marginal spines to a vertical or inflexed position *dira*
- Midline of head without a long spine, sometimes with a short, conical tubercle. Paranotum and marginal spines not reflexed, directed obliquely outward 5
- 5. Basal seventh of costal margin with 1–3 short, oblique spines *thaumana*
- Costal margin with no spines 6
- 6. Discoidal area open apically, not closed by a slightly elevated vein connecting the parallel inner and outer limiting vein. All antennal segments, occipital spines, legs (except sometimes tarsi), veins of paranotum and basal two-thirds or more of costal vein wholly dull black *abducta*

- Discoidal area closed apically by a noticeably elevated cross vein connecting inner and outer limiting veins and forming acute angle with latter in a more-or-less prominent pale spot. Antennal segment III, occipital spines, legs, and veins of paranotum and costa in noticeable part yellow to hyaline *armigera*

Genus *Carvalhotingis*, NEW GENUS

(Figs. 2, 4)

Diagnosis. — As defined and keyed above.

Characters. — Length 2.8–3.8 mm. Dorsal surface and appendages with many long, pale, erect or recumbent hairs. Hemelytral axes virtually parallel, apices slightly separated.

Head. — Short, without cephalic spines (often with matted groups of decurved hairs resembling spines). Eye one-third to one-half as wide as interocular width. Bucculae parallel, not attaining apex of clypeus. Labium almost reaching or surpassing meso-metasternal suture. Antenna slender, segment I two-thirds to fully as long as interocular width, about twice as long as II. Subantennal plate with anterior margin vertical, not approaching margin of clypeus (Fig. 4).

Pronotum. — Anteromedian cyst, when present, confined to area anterior to calli. Median carina simple or slightly elevated with a single row of small, obscure cells. Lateral carinae absent or only vaguely indicated on posterior projection. Paranotum no wider than an eye, narrowing posteriorly, uniseriate, lateral margin with a single row of 7–10 long, stout, tapering spines. Posterior projection of pronotum reaching basal third or midlength of discoidal area, acutely triangular, apex sharp or roundly truncated.

Hemelytron. — With or without a discal elevation. Discoidal area reaching nearly or quite to midlength of hemelytron, 2–4 cells wide, inner limiting vein scarcely or not at all elevated. Subcostal area distinctly oblique, 3–4 cells wide, outermost row of cells punctiform and set off by thickened vein. Costal margins concavely constricted along basal twelfth, thence gently convex; marginal row of long, tapering spines and

interspersed hairs extending well beyond apex of discoidal area. Costal area (beyond basal constriction) with 1–2 rows of cells along discoidal area, 2 rows beyond. Hypocosta uniseriate near base, becoming evanescent near midlength of abdomen.

Peritreme weakly to distinctly elevated. Metapleural flange very narrowly expanded, with or without a row of cells. Sternal laminae present on all 3 sterna, low; on mesosternum close together near base, thence well separated and parallel or converging; on metasternum broadly to narrowly cordate, apices variously separated. Abdomen convex basoventrally.

Type species. — *Acanthocheila tumida* Drake, here designated.

Known geographic range. — Central and South America from Mexico to Argentina.

Comments. — This genus is named in honor of Dr. José C. M. Carvalho, of Rio de Janeiro, Brazil.

Examination of the five cataloged taxa that run to the first half of couplet 4 in the key below [*comitis* Drake, *denier* Monte, *hollandi* Drake, *rustica rustica* Monte, and *rustica plana* Drake] failed to find constant fundamental characters for their separation, and this coupled with the variation exhibited in a series of 28 specimens labeled “Vicososa, Brazil, Minas Geraes, 23-5-34, E. H. Hambleton” associated with a code number “111” leaves no alternative to synonymizing all of them. In that series of 28 specimens, the basal fourth of the expanded costal area may be wholly uniseriate, may have one to several extra interspersed individual cells on one side (as in holotype of *Acanthocheila rustica plana*) or on both sides or a second partial row; occasionally an extra cell may be found in the costal area near the apical fourth of the discoidal area.

LIST OF *CARVALHOTINGIS* Species

Carvalhotingis comitis (Drake). NEW COMBINATION.

Acanthocheila comitis Drake, 1948: 23.
Known distribution: Mexico, Guatemala.

Carvalhotingis hollandi (Drake). NEW COMBINATION.

Acanthocheila hollandi Drake, 1935: 16.

Acanthocheila denieri Monte, 1940: 287.

NEW SYNONYMY.

Acanthocheila rustica Monte, 1942: 91.

NEW SYNONYMY.

Acanthocheila comentis Drake, 1953: 13.

NEW SYNONYMY.

Acanthocheila rustica plana Drake, 1953: 13. NEW SYNONYMY.

Known distribution: Argentina, Brazil, Paraguay.

Carvalhotingis nexa (Drake). NEW COMBINATION.

Acanthocheila nexa Drake, 1936: 701.

Known distribution: Argentina, Brazil.

Carvalhotingis tumida (Drake). NEW COMBINATION.

Acanthocheila tumida Drake, 1924: 94.

Known distribution: Bolivia, Brazil.

Carvalhotingis visenda (Drake and Hambleton). NEW COMBINATION.

Acanthocheila visenda Drake and Hambleton, 1934: 442.

Known distribution: Argentina, Brazil, Peru.

KEY TO *CARVALHOTINGIS* SPECIES

(ignore outer row of punctiform cells in subcosta)

- 1. Discal elevation of hemelytron strongly inflated, inflation laterally rising almost or quite vertically from inner limiting vein of costal area. Collar medially with distinctly elevated, inflated cyst usually as high as or higher than interhumeral convexity 2
- Discal elevation of hemelytron not or scarcely inflated, laterally rising obliquely from inner limiting vein of costal area. Collar sometimes visibly tectate but not inflated, distinctly lower than interhumeral convexity 3
- 2. Costal area in basal third or more with a single row of large, rectangular cells *nexa*
- Costal area with 2 irregular rows of cells to base *visenda*
- 3. Subcostal area along basal half or more of discoidal area coriaceous with punctiform cells, thence (ignore outer row of punctiform cells) abruptly with large hyaline cells *tumida*

- Subcostal area along basal third or fourth of discoidal area with punctiform cells, thence (ignore outer row of punctiform cells), on apical two-thirds, cells gradually enlarging 4
- 4. Dorsal outline of discal elevation, in lateral view, a low, convexity *hollandi*
- Dorsal outline of discal elevation, in lateral view, a blackened, abrupt, erect, tabular projection *comitis*

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***PROBOSCIDOTYLUS CARVALHOI*, A NEW GENUS AND
SPECIES OF SEXUALLY DIMORPHIC PLANT BUG FROM MEXICO
(HETEROPTERA: MIRIDAE: ORTHOTYLINAE)**

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Abstract.—The new orthotyline genus and species *Proboscidotylus carvalhoi* are described from specimens collected in Veracruz, Mexico. This new mirid, with the male possessing an elongate tubercle at the apex of the tylus, represents one of the most unusual cases of sexual dimorphism in the subfamily Orthotylinae. An adult habitus drawing, illustrations of male genitalia, and scanning electron micrographs of selected structures are furnished to aid in recognition, and relationships are discussed.

Key Words: Insecta, Heteroptera, Orthotylinae, new genus, new species, sexual dimorphism, Mexico, Veracruz

The subfamily Orthotylinae is one of the largest and most poorly studied groups in the Miridae, especially in the Neotropics. Five tribes are recognized (Austromirini, Halticini, Ceratocapsini, Nichomachini, and Orthotylini), but this level of the classification is unstable (Schuh 1974, Henry 1994) and a worldwide analysis is needed to establish the monophyly of these orthotyline tribes. Discovery of a bizarre new genus and species fitting into Schuh's (1974) *Zanchius* group (Orthotylini) adds new and corroborative character information that should be useful to future phylogenetic investigations of the subfamily.

Herein, I describe the new genus and new species *Proboscidotylus carvalhoi*, provide an adult habitus drawing, illustrations of male genitalia, and SEM micrographs of pertinent structures, and discuss the relationship of this peculiar new genus to other orthotyline genera.

This paper and the new species described within it are dedicated to the memory of

Dr. José Candido de Melo Carvalho, who published on the Miridae for more than 50 years. Landmarks in an outstanding career were his 1113-page world catalog of the Miridae (1957-1960), keys to the mirid genera of the world (1955), and many papers in which he described more than 385 genera and 2080 species (Carvalho and Froeschner 1987, 1990, in press). It is hard to imagine that José's voluminous contributions to our knowledge of this large and diverse family will ever be surpassed.

***Proboscidotylus* Henry, NEW GENUS**

Type species.—*Proboscidotylus carvalhoi* Henry, new species.

Diagnosis.—This genus can be recognized by the strongly swollen frons (Figs. 2, 4), prominent tylus, and the scattered black scalelike setae on the hemelytra (Fig. 6). Most distinctive, however, are the peculiar autapomorphic structures found only in males. The elongate, apically setose, tubercle arising from the apex of the tylus (Fig.

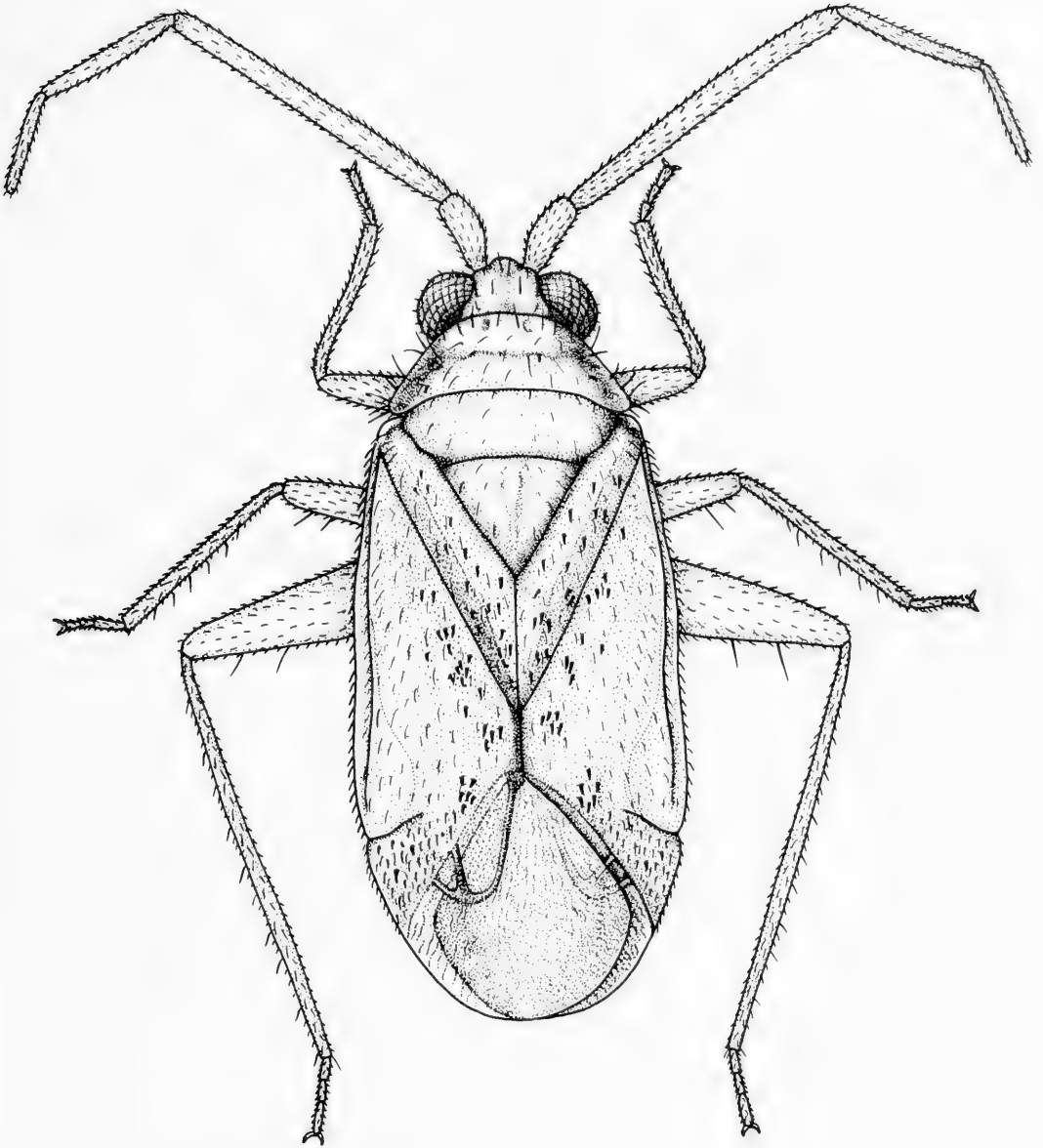
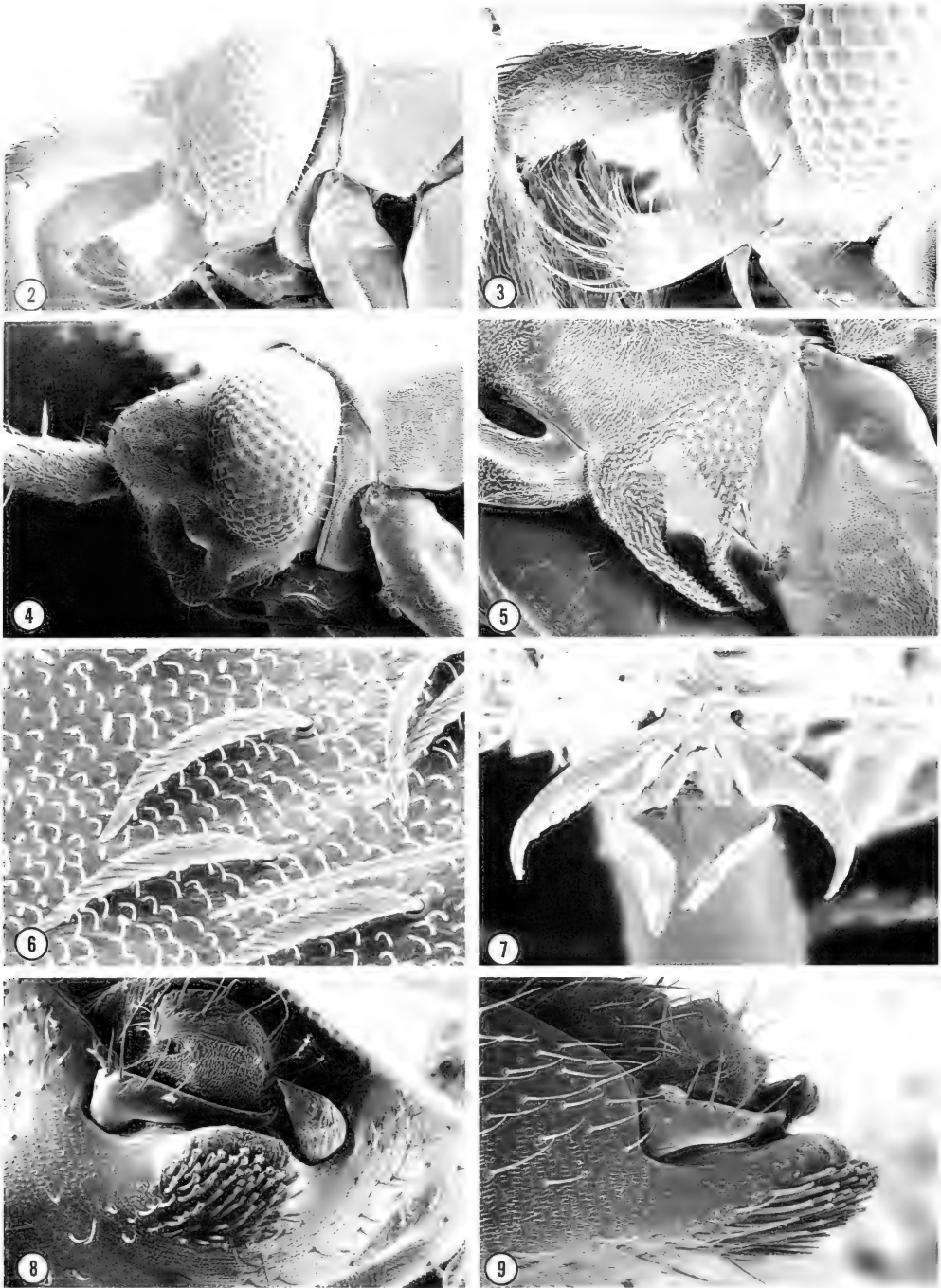


Fig. 1. Dorsal habitus of *Proboscidotylus carvalhoi*, male.

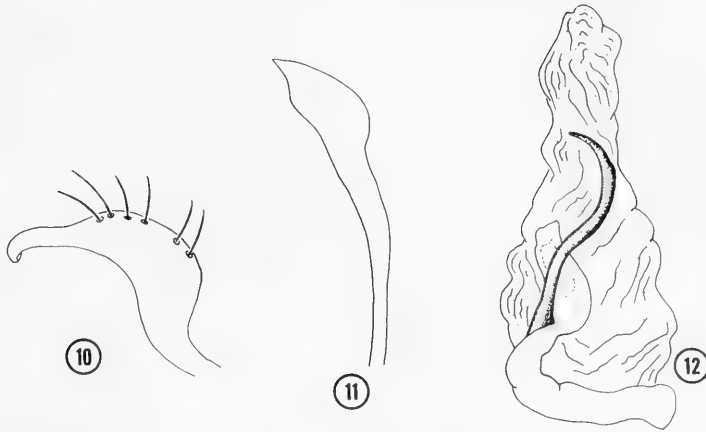
2, 3) and the tuberclelike process bearing a field of stout bristlelike setae on the genital capsule (Figs. 8, 9) are unique in the subfamily Orthotylinae and support the monophyly of *Proboscidotylus*.

Description.—Orthotylinae: Orthotylini. Small, delicate (Fig. 1), length 2.64–3.04 mm. Head (Figs. 2–4) broader than long;

interocular area in female flattened, in male weakly depressed; frons abruptly and strongly swollen in both sexes but more so in females (Fig. 4), then flattened to meet base of pronounced, broadly rounded tylus; male with apex of tylus extended into an elongate, apically rounded tubercle, having long dorsally directed setae distally (Figs. 2,



Figs. 2-9. *Proboscidotylus carvalhoi*. 2, head, lateral aspect of male (150 \times). 3, lateral aspect of male tylus (260 \times). 4, head, lateral aspect of female (151 \times). 5, ostiolar area (359 \times). 6, scalelike setae of hemelytra (1610 \times). 7, claw (1040 \times). 8, male genital capsule, caudal aspect (426 \times). 9, male genital capsule, lateral aspect (447 \times).



Figs. 10–12. Male genitalia. 10, left paramere. 11, right paramere. 12, vesica.

3), tubercle absent in female; eye prominent, oblong oval, strongly faceted, occupying all but lowermost edge of head in lateral aspect, posterior margin nearly touching anterior margin of pronotum, set with scattered short setae, posterior lateral margin with a row of stout, erect setae. Rostrum extending nearly to bases of metacoxae. Antenna slender; segment I shortest, stoutest; segment II slender, more than 2 times length of segment III in males, less than 2 times length of segment III in females; segment III longer than segment IV. Pronotum trapeziform, collar absent, much broader than long, with a transverse impression through middle separating calli from disc; posterior width much greater than anterior width; anterior angles rounded; lateral margins straight and angled outward posteriorly, margins weakly carinate; pleural area flattened, subquadrate; posterior margin deeply sinuate; calli weakly swollen. Scutellum flattened, equilateral; mesoscutum wide, about two thirds as long as scutellum, broadly exposed. Hemelytron hyaline, weakly sinuate laterally through middle in males, more nearly straight or weakly rounded in females; set with relatively long, semierect simple setae, sparsely intermixed with flattened, apically acute, scalelike, black setae (Fig. 6) on clavus, corium, and cuneus;

cuneus about as long as wide; membrane hyaline, broadly rounded apically, with two closed cells. Ventral surface weakly shining, with scattered simple setae. Ostiolar area (Fig. 5) small, auricle roughly triangular, margins bordered with modified evaporative or mycoid surface. Legs slender; tibial spines short, indistinct; tarsi three segmented; claws (Fig. 7) slender, apically recurved, parempodia broad and convergent. Male genital capsule (Figs. 8, 9) small, apically pointed, with a broad process or tubercle arising below basal margin of aperture bearing a field of stout, apically blunt, bristlelike (and likely glandular) setae. Left paramere (Fig. 10) elongate, extended transversely into an apically acute, slender arm; right paramere (Fig. 11) oval, apically acute; vesica (Fig. 12) membranous, bearing a single, slender, apically acute and curved spiculum, secondary gonopore absent or indistinct.

Remarks.—Relationships of the New World Orthotylinae are insufficiently known to fully place *Proboscidotylus* in a phylogenetic context. This genus belongs in the tribe Orthotylini as it is now defined and can be assigned to Schuh's (1974) *Zanchius* group, members of which have a general delicate body structure, flattened appearance, hyaline hemelytra, and a vesica lack-

ing spiculi (although some taxa appear to have at least one spiculum, including *Proboscidotylus carvalhoi*). I add to these diagnostic characters a broadly exposed mesoscutum (resulting in part from a deeply sinuate posterior pronotal margin) and a blunt, apically extended process on the male genital capsule below the caudal edge of the aperture. This combination of characters is unique in the Orthotylinae and suggests that members of this group warrant placement in a separate tribe. Such an action, however, needs to await a comprehensive study of the subfamily.

Neotropical genera that Schuh (1974) placed in the *Zanchius* group are *Brasiliomiris* Carvalho, *Hyalochloria* Reuter, *Itacoris* Carvalho, *Jobertus* Distant, and *Parapropa* Distant. To this list, in addition to *Proboscidotylus*, I add *Saileria* Hsiao and *Diaphnocois* Kelton.

In Knight's (1968) key to western U.S. genera, *Proboscidotylus* will run to either *Squamocoris* Knight or *Melanotrichus* Reuter based on head and eye characteristics and the presence of scalelike setae on the hemelytra. In Carvalho (1955), it will key to *Parthenicus* Reuter, if the head is said to lack a well-defined posterior margin, or, if the posterior margin is considered well defined, to *Ilnacora* Reuter having black, scalelike, dorsal setae and antennal segment I subequal to the width of the vertex.

Only a few New World orthotyline genera bear black, scalelike hemelytral setae (e.g. *Brooksetta* Kelton, *Ilnacora*, *Ilnacorella* Knight, *Macrotlyoides* Van Duzee, and *Parthenicus*). *Proboscidotylus*, however, appears to have little to do with these taxa based on overall morphology and male genitalia.

Strong sexual dimorphism is uncommon in the Orthotylinae. Although hemelytral brachyptery or microptery is common in females of some taxa (e.g. *Ceratocapsus* Reuter, *sensu lato*), other structural differences between the sexes are rare. The primary exception occurs in the Neotropical

genus *Hyalochloria* Reuter, in which males always have one or two stout, often decurved spines on the basal $\frac{1}{3}$ of the second antennal segment (Henry 1978). *Proboscidotylus* provides another striking example of sexual dimorphism, with the male bearing an elongate tylar process and a blunt genital tubercle covered by a field of stout apically blunt and, perhaps, glandular setae.

***Proboscidotylus carvalhoi* Henry,**
NEW SPECIES
Figs. 1-12

Diagnosis.—This species is recognized by the overall pale brownish-yellow coloration, strongly swollen frons (Figs. 2, 4), and hyaline hemelytra possessing scattered black, scalelike setae (Fig. 6), as well as by the generic characters discussed above.

Description.—Male (n = 4): Length 2.68–2.84 mm, width 1.20–1.26 mm; overall coloration pale brownish yellow. *Head*: Weakly shining, with scattered erect setae; width 0.64–0.66 mm, vertex (interocular width) 0.24–0.28 mm, length of setigerous tubercle on tylus about 0.10 mm, apex with a cluster of long, erect, simple setae. *Rostrum*: Length 0.74–0.78 mm, extending nearly to bases of metacoxae. *Antenna*: Segment I, length 0.28–0.30 mm; II, 1.20–1.24 mm; III, 0.56–0.64 mm; IV, 0.34–0.40 mm. *Pronotum*: Length 0.28–0.30 mm, basal width 0.84–0.86 mm. Scutellum and mesoscutum with scattered erect and semierect simple setae. *Hemelytron*: Translucent pale brownish yellow, clothed with numerous semierect simple setae, intermixed with flattened, apically acute, scalelike, black setae on clavus, corium, and inner angle of cuneus. *Ventral surface*: Shiny pale brownish yellow, with scattered simple setae, especially on abdomen. *Male genitalia*: Genital capsule small, tapered apically, ending in a broad setigerous process or tubercle; left paramere (Fig. 10), right paramere (Fig. 11), and vesica (Fig. 12) as described under genus.

Female (n = 8): Length 2.64–3.04 mm,

width 1.24–1.28 mm. *Head*: Width 0.60–0.62 mm, vertex 0.28–0.30 mm. *Rostrum*: Length 0.80–0.86 mm. *Antenna*: Segment I, length 0.30–0.32 mm; II, 1.12–1.20 mm; III, 0.74–0.78 mm; IV, 0.40–0.46 mm. *Pro-notum*: Length 0.28–0.32 mm, basal width 0.84–0.88 mm.

Very similar to male in overall shape and coloration, differing in lacking the elongate, setigerous tubercle at the apex of the frons and having a more strongly swollen frons (Fig. 4).

Host.—Unknown.

Etymology.—The specific epithet of this unusual species is named in memory of my good friend and colleague Dr. José C. M. Carvalho.

Type data.—Holotype ♂, Mexico: Veracruz, Los Tuxlas Estac. Biol., N of Cate-maco, 16–19 Sept. 1989, E. Barrera, T. J. Henry, and I. M. Kerzhner colls., taken at incandescent porch light (USNM [U.S. National Museum of Natural History, Washington, D.C.]). Paratypes: 4 ♂♂, 8 ♀♀, same data as for holotype (UNAM [Universidad Nacional Autónoma de México, México, D.F.], USNM).

Other specimens examined.—1 ♂, 1 ♀, same data as for holotype, prepared for scanning electron microscope investigations; 1 ♂, with abdomen missing (USNM).

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***REUTEROSCOPIUS CARVALHOI* N. SP., A NEW FOSSIL PLANT BUG
(HETEROPTERA: MIRIDAE: PHYLINAE)**

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Abstract.—The fossil mirid *Reuteroscopus carvalhoi* n. sp. is described from Dominican amber and compared to extant species of the genus.

Key Words: Miridae, *Reuteroscopus carvalhoi* n. sp., fossil, Dominican Amber

The mirid genus *Reuteroscopus* Kirkaldy, 1905, occurs in the Greater and Lesser Antilles, northern coast of South America (specimens from the last two places in JMC's collection), Central America, and in North America as far north as Canada. It includes about 40 species that live on weeds and a few species of trees.

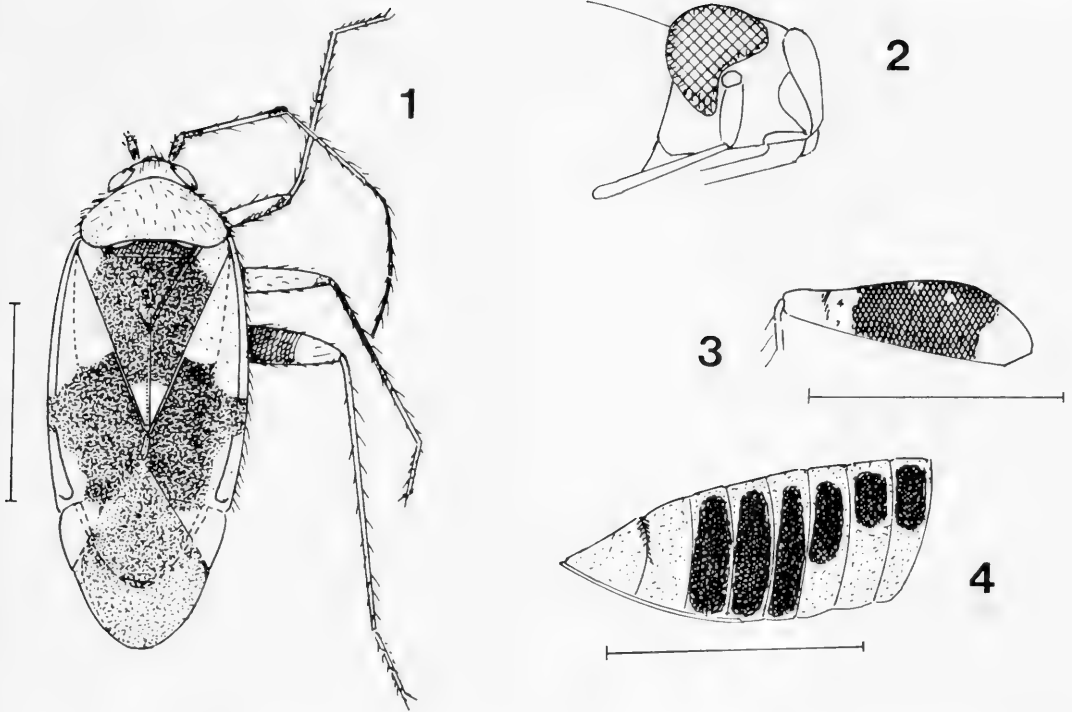
The fossil species described in this paper is very similar to many extant species, especially in the typical color pattern of the hemelytra. In the description we use the same colors used by Knight (1965) to facilitate comparison.

The only morphological difference we noticed between this fossil and modern species of *Reuteroscopus* is the shape of the eyes. In the dorsal view, instead of being hemispherical they are somewhat elliptical. As in modern species, the eyes extend backward for a short distance along the lateral margins of the pronotum, but in this species they extend a little more forward, thus, occupying a slightly larger area of the vertex. In lateral view (Fig. 2), the anterior margin is concave to receive the insertion of the antenna. Extant species have vertical, oval eyes, some of the them with the posterior margin shall-

lowly indented, and the antennae are inserted close to or are slightly separated from the anterior margin. The eyes of specimens from the Antilles, northern South America, Central America and southern United States were examined.

There are few mirid fossil records. As cited by Carvalho (1959), Scudder (1890) described 14 species as mirids from the Florissant (Cenozoic, Oligocene). Carvalho (1959) indicated that Scudder's taxa look more like anthocorids or at least cannot be assigned to annectant genera. Scudder placed his species in *Aporema* Scudder, *Closterocoris* Uhler, *Fuscus* Distant, *Poecilocaspus* Reuter, *Capsus* Fabricius, and *Hadronema* Uhler. Despite such assignments the characters he used are insufficient to place them in subfamilies and tribes. Also cited by Carvalho, Germar and Berent (1856) described 13 species, mostly from Prussian amber, placing all of them in what they loosely called *Phytocoris*.

Our new species is in a piece of amber originating from mines in Cordillera Septentrional between Puerto Plata and Santiago in northern Dominican Republic. These mines are in the Altamira facies of the El



Figs. 1–4. *Reuteroscopus carvalhoi* Maldonado and Poinar, n. sp., holotype, female. 1, habitus, dorsal view. 2, head, lateral view. 3, hind femur, lateral external view. 4, abdomen, lateral view. Scale lines represent 1.0 mm.

Mamey Formation and the estimated age ranges between 25 and 40 million years (upper Oligocene-upper Eocene) (Lambert et al. 1985).

Reuteroscopus carvalhoi
Maldonado and Poinar, NEW SPECIES
Figs. 1–4

Female. Overall coloration of body probably pale green in life, hemelytra, hind femur and abdomen conspicuously ornamented with black. Head, pronotum, lateral angles of mesoscutum, base and apex of clavus, most of corium including its apex (mesad to cuneus), embolium, and cuneus pale green. Excluding membrane, remaining parts of fore wings black (Fig. 1); membrane—basal half apparently black, most of inner cell blackish, outer cell grayish, caudad of cells to apex of membrane grayish. Antennal segments: I black basally, apical

half pale because of its silvery pilosity; II fuscous, basally and apically black; III and IV uniformly dark fuscous, slightly darker than II. Rostrum probably fuscous, at least not pale. Pronotum laterally, most of mesopleura except for pale area around base of mesocoxa, and metapleura black. Osteolar peritreme pale greenish. Abdominal sterna pale green along upper margin; first three segments black above the pale green below, next three with a small pale green basal area, the black areas almost contiguous with the pale green ovipositor (Fig. 3). Legs: anterior—coxa mostly pale green, inner and outer surfaces with a small black central area; trochanter pale green; femur pale green, ventral edge thinly lined with black; tibia with basal $\frac{2}{3}$ blackish, apically pale fuscous; tarsi pale fuscous; middle—coxa and trochanter green, fuscous apically, tibia fuscous, slightly lighter than last two

antennal segments; hind—coxa and trochanter pale green; femur black, basal and apical fourths pale green, the latter with an incomplete, irregular ring and two or three small black spots (Fig. 4).

Pilosity.—Head, pronotum, light areas of corium, embolium, cuneus, and costal margin with decumbent fine pilosity; dark areas of fore wing with yellow or greenish fine, decumbent pilosity; the dark areas seem to have some pale green, scalelike, adpressed setae. Extant species have only one kind of setae on the dark areas of the hemelytra, so, these “scalelike” setae are either an illusion due to refraction, or at least a second type of setae, not necessarily scalelike. Spinelike setae of hind tibia not arising from black spots.

Measurements (in mm).—Head length 0.13, width across eyes 0.50, eyes moderately large, ellipsoidal, lower margin far from ventral margin of head, length 0.31; pronotum length 0.31, humeral width 0.81; mesoscutum exposed; scutellum width 0.50, length 0.37. Antennal segments: I, 0.13; II, 0.56; III, 0.31; IV, 0.50; all short decumbent setose. Rostrum 1.56, reaching IV sternum, i.e., surpassing base of ovipositor. Legs—fore: femur 0.53, tibia 0.53; middle: femur 0.62, tibia 0.68; hind: femur 0.76, tibia 1.15. Tarsi as in Phylinae, linear, about $\frac{1}{2}$ length of corresponding tibia, parempodia apparently small, not visible, claws elongate, slender. Hemelytra well surpassing abdominal apex, length 1.87, greatest width 1.00. Abdomen length 1.1. Total length of body 2.31.

Holotype female, from Dominican Amber, DOMINICAN REPUBLIC; the amber piece containing the specimen is designated HE-4-47 and is deposited in the Poinar collection of Dominican amber maintained at the University of California, Berkeley. We take pleasure in naming the species after J. C. M. Carvalho, the father of modern miridology.

Discussion.—The morphological differences between the eyes of this fossil and modern species do not seem to warrant es-

tablishing a new genus. Considering that *R. carvalhoi* is described from a female 2.31 mm long and that males are usually shorter than females evidently this is the smallest species in the genus. The best way to define species in *Reuteroscopus* is by means of the shape of the vesica of the male genitalia. Knight (1965: 102) points out that differences in coloration, whether the black of the hemelytra is sharply (the “ornata” group as in *R. carvalhoi*) or diffusely separated from the pale areas, the relative lengths of antennal segment II and humeral width of pronotum, and the relative thickness of antennal segment II and thickness of protibia can be used to separate females.

Reuteroscopus carvalhoi n. sp. runs in both Knight's (1965) and Kelton's (1964) key to *R. aztecus* Kelton after skipping characters related to male genitalia in the latter key. The females of *R. aztecus* are 3.78–4.06 long, with green abdominal sterna and infuscated cuneus. The females of *R. femoralis* Kelton, from Mexico and *R. hamatus* Kelton are slightly under 3.00 long, but in both the rostrum extends to the tip of hind coxae. Other species in the genus are 3.00 or longer and differ in coloration. In *R. carvalhoi* the humeral width is 1.4 times greater than the length of antennal segment II, whereas in the two species mentioned above, the humeral width is 1.0–1.1 greater than antennal segment II, and their abdominal sterna are yellow.

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A PHYLOGENETIC REVIEW OF THE *POTAMOBATES* FAUNA OF
COLOMBIA (HETEROPTERA: GERRIDAE), WITH
DESCRIPTIONS OF THREE NEW SPECIES

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Abstract.—Three new species of *Potamobates* are described from Colombia and surrounding regions: *P. manzanoae* n. sp. from the Rio Anchicaya drainage in Valle de Cauca Province; *P. anchicaya* n. sp. from the Rio Anchicaya area and Panama; and *P. carvalhoi* n. sp. from the Rio Claro in Antioquia Province, and Venezuela. These new species are compared with other previously described taxa in the genus, and a set of phylogenetically inferred intrageneric species groupings is proposed, accompanied by a key and checklist for all known species, and a species level phylogeny. Distribution maps are provided for species occurring in Colombia, and country-level distributional data are given for all other known species.

Key Words: *Potamobates*, Gerridae, Colombia, taxonomy, phylogeny distribution, key

Due to its equatorial position and mountainous character, Colombia supports one of the richest and yet most poorly investigated aquatic Heteroptera biotas in South America. In the current report we review the region's fauna of *Potamobates* water striders, describe three new species, provide a key and checklist to all known species, and present a preliminary phylogenetic analysis of the genus at the species level. The three new taxa described herein bring the total number of documented species in the genus to 15, which we assign to four intrageneric species groups, based primarily on apomorphic characters of the male and female abdominal terminalia. Country-level distributions and complete nomenclatural citations for all described species are also provided, plus detailed distribution maps for all species occurring in Colombia.

The genus *Potamobates* was described by Champion (1898), and redescribed by Drake

and Harris (1934), Kuitert (1942) and Matsuda (1960). Members of this genus are moderately large, muscular water striders that are generally found actively skating on the midstream waters of swift, rocky streams at low to intermediate elevations. The genus is wholly Neotropical, ranging from southern Mexico to Peru, and appears to represent the Western Hemisphere ecological equivalent of the Oriental genus *Ptilomera*. Distribution data and keys to species were previously published by Drake and Harris (1934) and Kuitert (1942), but these authors did not have access to all of the known species, and their omissions plus the three new species described below have necessitated the development of the revised key presented herein.

All measurements in the descriptions below are given in millimeters. CL numbers following localities in the material examined sections refer to a data coding system

used by the authors to cross reference specimens, ecological field notes, and habitat photographs.

***Potamobates carvalhoi*, NEW SPECIES**

Figs. 1–6, 19

Diagnosis.—*Potamobates carvalhoi* occupies a phylogenetic position immediately basal to the insular South American *P. williamsi* group (see Figs. 30, 31), but is set aside in its own monotypic intrageneric grouping because of the unusual and diagnostic character of the abdominal terminalia in both males and females (see subsequent group analysis). The completely hidden female tergite VIII is unique within the genus.

Description (all measurements in millimeters).—*Apterous male*: Ground color blackish, faintly shining, covered with very short dark pubescence; head except vertex along eyes and longitudinal oval black spot ahead of eyes, median longitudinal wedge on pronotum, figures on mesonotum if present (Fig. 2), propleura, mesopleura, metacubulae, coxae, fore trochanters, dorsum of fore femur except distally, pygophore and venter brownish yellow to leucine. Anterolateral angles of pronotum, longitudinal stripe on lateral margins and posterolateral angles of mesonotum, lateral margins of abdominal tergites, and coxal cavities dorsally covered with short bright golden pubescence. Legs black to brown, middle and hind femora lighter beneath, antennae black. Legs set with short inconspicuous black spines.

Length of head (1.22) more than four times narrowest interocular space (0.28); width of eye 0.72; eyes extending posteriorly about $\frac{1}{2}$ length of propleura. Rostrum short, barely reaching onto mesosternum. Pronotum short (1.05), width (1.89) about equal to head across eyes. Mesonotum long (2.33), widest across mesocoxae (2.89). Metanotum short (0.83), widest across metacoxae (2.39). Abdomen excluding genital segments relatively short (2.33), genital segments long (2.05). Tergites III–V about

of equal length (0.17–0.22), tergites II and VI longer (0.28), tergite VII longest (0.67); VIII long (1.44), large, slightly modified, ventrally asymmetrical (Figs. 2, 5, 6); proctotiger modified, with long projection on left side, terminating in a “bird-head” shape; male terminalia as shown in Figs. 5, 6. Connexiva angulate caudally, not produced; raised along entire length.

Antennae long, slender, segments I and IV slightly stouter than II and III; length of segments I–IV: 1.83; 0.61; 0.67; 1.00. Anterior femur stout, tapering distally; anterior tibia slightly flattened, not dilated. Measurements of legs as follows: Femur, tibia, tarsal 1, tarsal 2 of fore leg, 2.55: 2.61: 0.14: 0.50; of middle leg, 9.43: 6.94: 3.33: 0.94; of hind leg, 9.82: 6.60: 0.44: 0.28.

Length, mean 9.68 (N = 6, min. 9.50, max. 9.86).

Width, mean 2.93 (N = 6, min. 2.84, max. 3.04).

Apterous female: Body more robust than male (Fig. 1), otherwise similar in general size, coloration, and other features except abdominal terminalia very differently formed. Connexiva produced posteriorly into long slender digitate lobes, usually convergent (Fig. 3). Abdominal ventrite VIII produced symmetrically, lateral lobes large, folded over tergite VIII which is hidden (Figs. 3, 4).

Length, mean 8.84 (N = 10, min. 8.61, max. 9.14).

Width, mean 3.13 (N = 10, min. 3.02, max. 3.29).

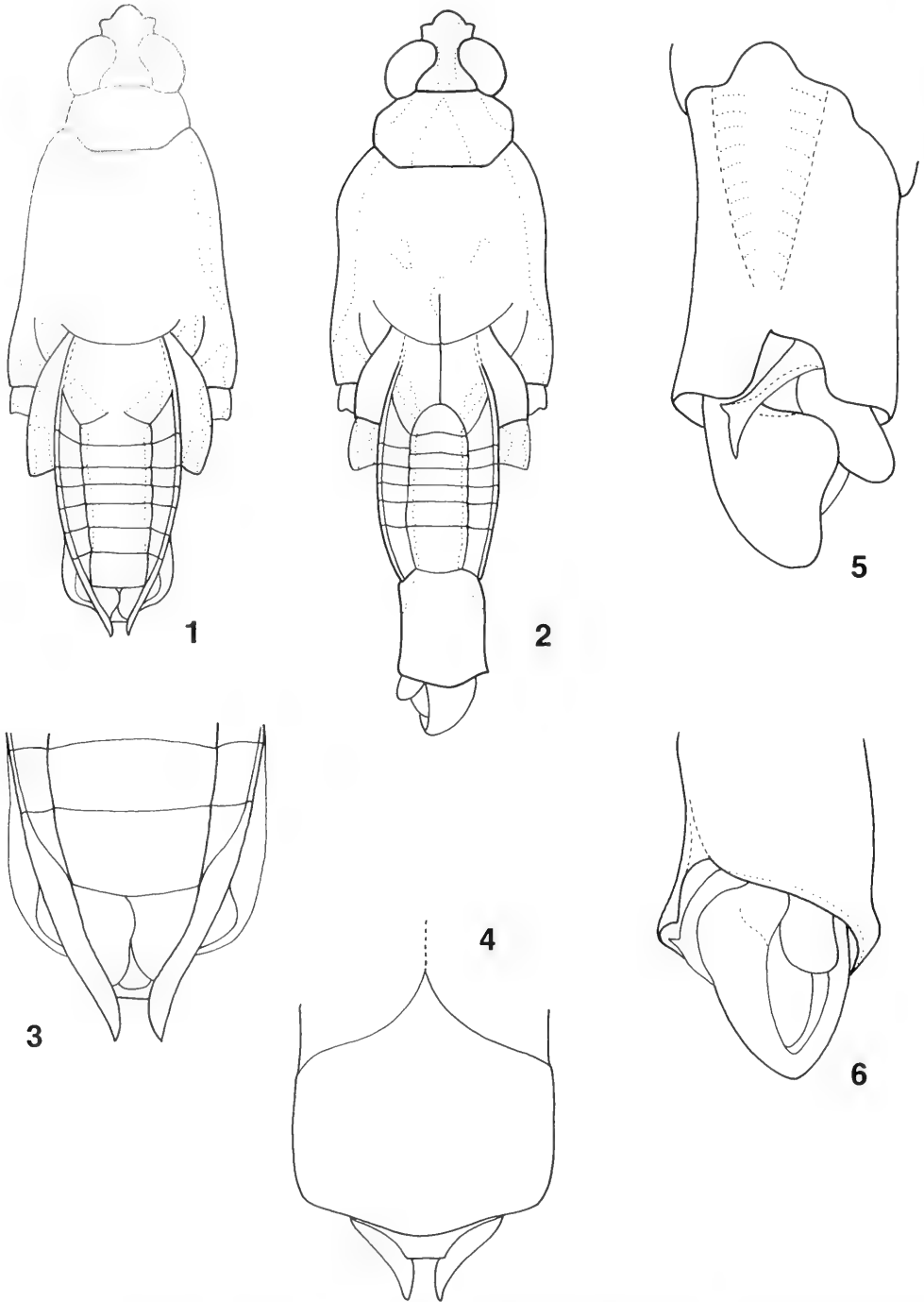
Macropterous male: Similar to apterous form in most respects, except pronotum long, with posterior lobe raised and broadly margined with brownish yellow, humeri prominent. Wings light brown, reaching beyond tip of abdomen, veins blackish brown, without pubescence, with five closed cells.

Length, 11.28 (N = 1).

Width, 3.02 (N = 1).

Macropterous female: Unknown.

Etymology.—The name *carvalhoi* honors José Candido de Melo Carvalho for his many



Figs. 1-6. *Potamobates carvalhoi* n. sp. 1, Female, dorsal habitus (legs omitted). 2, Male, dorsal habitus (legs omitted). 3, 4, Female terminal abdomen. 3, Dorsal view. 4, Ventral view. 5, 6, Male terminal abdomen, showing distal part of segment VII, all of VIII, IX & X partially hidden within VIII. 5, Lateral view. 6, Oblique ventral view.

splendid contributions to our knowledge of Heteroptera.

Ecological notes.—*P. carvalhoi* was taken in midstream, skating in areas of slow, smoothly flowing current.

Material examined.—*Holotype*, apterous male and allotype, apterous female (USNM), COLOMBIA: Antioquia Prov., Rio Claro, 13 km W. of Dorodal, water temp. 25 °C, 250 m, CL 2405, 21.vii.1989, J. T. & D. A. Polhemus. *Paratypes* as follows (all apterous unless noted): COLOMBIA: Antioquia Prov.: 4 males, 5 females, 1 macropterous female, same data as holotype (JTPC, USNM); 2 males, 5 females, Quebrada La Negra, small tributary to Rio Claro, 13 km W. of Dorodal, 250 m, CL 2406, 21.vii.1989, J. T. & D. A. Polhemus (JTPC). VENEZUELA: Barinas Prov.: 2 males, 4 females, Barinitas, Dec. '42, P. Anduzee (det. C. J. Drake as *P. unidentatus*) (JTPC, USNM).

***Potamobates anchicaya*, NEW SPECIES**

Figs. 7–13, 21

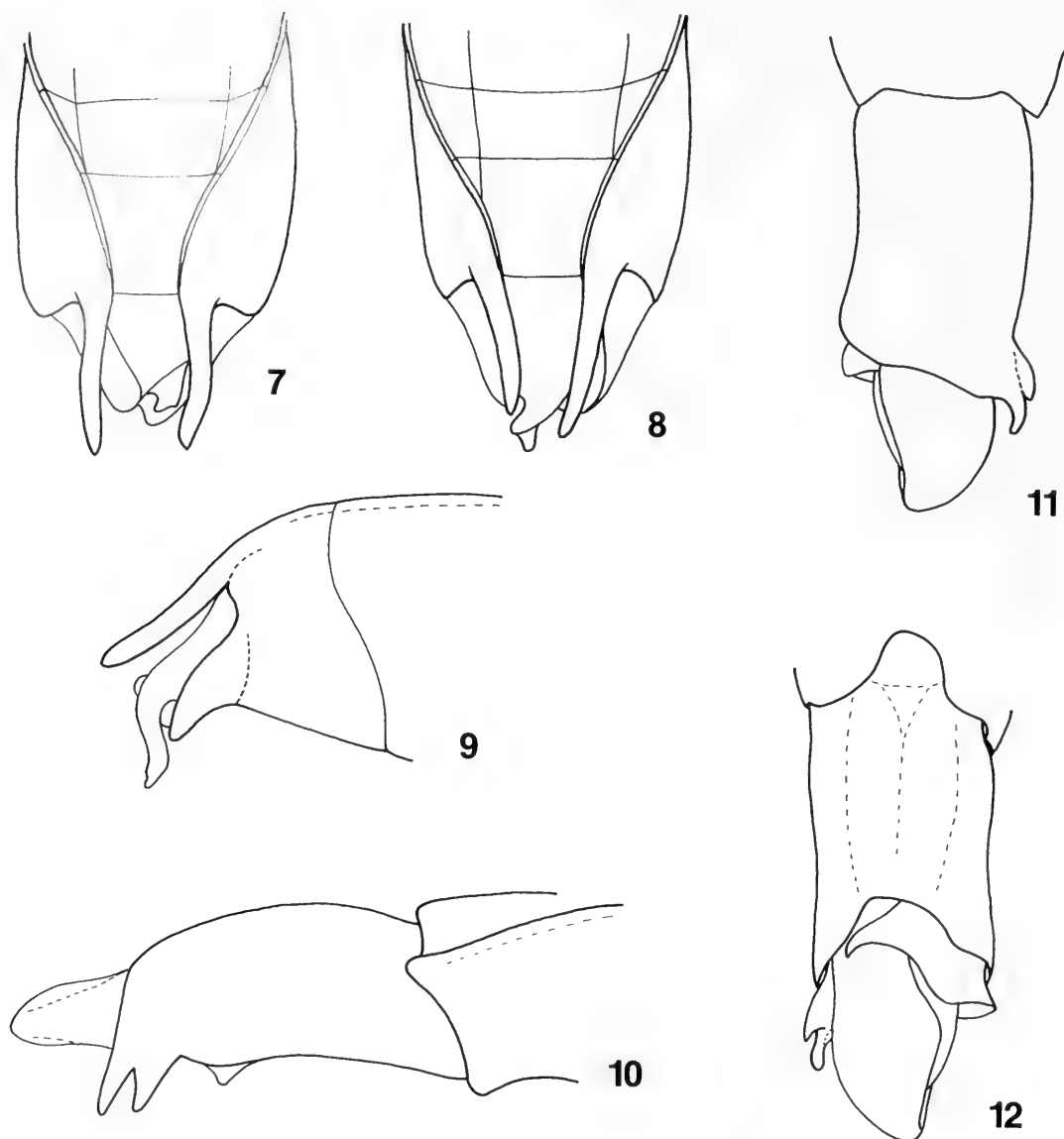
Diagnosis.—*Potamobates anchicaya* is most closely related to *P. tridentatus* Esaki, but compared to the latter *anchicaya* may be separated by the narrower silvery pubescent stripe laterally on the mesonotum; the less pronounced incision between the “teeth” on the lobe of male abdominal segment VIII, and in having this lobe of different shape (Fig. 10; compare with Esaki 1926, Fig. 1e); by the emarginate ventral incision of male abdominal segment VIII being narrower and shallower, and the laterally directed process of the proctiger larger, longer and of different shape (Fig. 12; compare with Esaki 1926, Fig. 1d); and by female ventrite VIII extending posteriorly about the length of ventrite VI (vs. about ½ the length of ventrite VI in *tridentatus*), unless strongly bent ventrad (vs. never strongly bent ventrad), and with the lateral lobes less asymmetrical, having both right and left lobes developed (vs. left lobe developed), with one or both sometimes wrapped over

tergite VIII basally (vs. left lobe wrapped over or at least alongside).

Description (all measurements in millimeters).—*Apterous male*: Ground color blackish, faintly shining, covered with very short dark pubescence; head except vertex along eyes and often longitudinal oval black spot ahead of eyes, median longitudinal wedge on pronotum, figures on mesonotum (Fig. 13), propleura, mesopleura, metacephalae, coxae, fore trochanters, dorsum of fore femur except distally, pygophore and venter brownish yellow to leucine. Antero-lateral angles of pronotum, longitudinal stripe on lateral margins and posterolateral angles of mesonotum, lateral margins of abdominal tergites, and coxal cavities dorsally covered with short bright golden pubescence. Legs black to brown, middle and hind femora lighter beneath basally, antennae black. Legs set with short inconspicuous black spines.

Length of head (1.05) about four times narrowest interocular space (0.28); width of eye 0.58; eyes extending posteriorly about ½ length of propleura. Rostrum short, barely reaching onto mesosternum. Pronotum short (0.83), width (1.39) about equal to head across eyes. Mesonotum long (2.44), widest across mesocoxae (2.55). Metanotum short (0.78), widest across metacoxae (2.05). Abdomen excluding genital segments relatively short (2.22), genital segments long (2.00). Tergites II–VI about of equal length (0.22–0.28), tergite VII about twice as long (0.55); VIII long (1.39), large, highly modified, with a lobe on left side bearing two large “teeth” (Fig. 10); proctiger highly modified, with long projection on left side (Fig. 12); male terminalia as shown in Figs. 10–12. Connexiva angulate caudally, not produced; raised along entire length.

Antennae long, slender, segments I and IV slightly stouter than II and III; length of segments I–IV: 1.55; 0.57; 0.50; 0.89. Anterior femur stout, tapering distally; anterior tibia slightly flattened, not dilated. Measurements of legs as follows: Femur, tibia,



Figs. 7-12. *Potamobates anchicaya* n. sp. 7-9, Female terminal abdomen. 7, Dorsal view, without caudal projection. 8, Dorsal view. 9, Lateral view. 10-12, Male terminal abdomen. 10, Lateral view. 11, Dorsal view. 12, Oblique ventral view.

tarsal 1, tarsal 2 of fore leg, 2.33: 2.11: 0.14: 0.44; of middle leg, 8.55: 5.77: 2.39: 0.61; of hind leg, 9.26: 4.83: 0.36: 0.22.

Length, mean 9.36 (N = 10, min. 9.24, max. 9.59).

Width, mean 2.50 (N = 10, min. 2.31, max. 2.75).

Apterous female: Body more robust than male, otherwise similar in general size, coloration, and other features except dark markings on head usually more extensive, and abdominal terminalia very differently formed. Connexiva produced posteriorly into long slender digitate lobes, usually al-

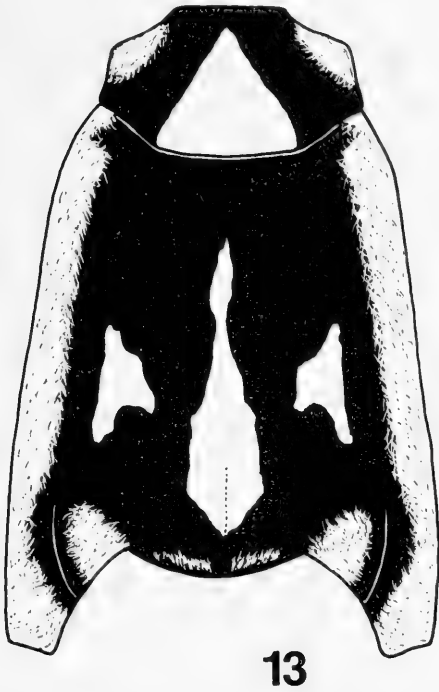


Fig. 13. *Potamobates anchicaya* n. sp. Thorax, dorsal view.

most parallel distally, sometimes divergent (Figs. 7, 8). Abdominal ventrite VIII produced asymmetrically, embracing or paralleling tergite VIII which may be either truncate (Fig. 7) or produced into a sinuate spine (Figs. 8, 9).

Length, mean 8.59 ($N = 10$, min. 8.08, max. 9.24).

Width, mean 2.70 ($N = 10$, min. 2.58, max. 2.84).

Macropterous male: Similar to apterous form in most respects, except pronotum long, with posterior lobe raised and broadly margined with brownish yellow, humeri prominent. Wings light brown, reaching beyond tip of abdomen, veins blackish brown, without pubescence, with five closed cells; wings often mutilated, presumably to facilitate mating, sometimes without even basal stub remaining.

Length, mean 10.42 ($N = 6$, min. 10.12, max. 10.57; de-alated specimens not measured).

Width, mean 2.56 ($N = 6$, min. 2.49, max. 2.66).

Macropterous female: Similar to macropterous male in most respects, except slightly broader, and wings reaching far beyond tip of abdomen.

Length, mean 10.46 ($N = 5$, min. 10.39, max. 10.66; de-alated specimens not measured).

Width, mean 2.79 ($N = 5$, min. 2.66, max. 2.84).

Etymology.—The name *anchicaya*, a noun in apposition, refers to the type locality, the valley of the Rio Anchicaya.

Ecological notes.—*Potamobates anchicaya* was taken in midstream on swift, smoothly flowing reaches above riffles, in company with *Metrobates fugientis* Drake and Harris. *Potamobates horvathi* was also present at the type locality, but was found on the slower waters of pools both above and below riffles, and not in the midstream areas favored by *P. anchicaya*.

Remarks.—*Potamobates* species are highly variable in the development and shape of the bizarre modifications of the abdominal terminalia in both males and females, which led previous workers to overlook or misidentify specimens of *P. anchicaya* in their collections. *Potamobates anchicaya* specimens from Panama, for example, were identified as *P. tridentatus* Esaki by both Drake (in Drake Collection, USNM) and Hungerford (1937b). For many years specimens of *anchicaya* from the Canal Zone of Panama in the Polhemus collection have been marked as “not *tridentatus*,” but a satisfactory delineation was possible only with good series of both species available from a number of localities.

Material examined.—*Holotype*, apterous male and allotype, apterous female (USNM), COLOMBIA: Valle de Cauca Prov., Rio Tatabro, 7 km E. of Sabaletas, water temp. 24 °C, CL 2436, 30.vii.1989, J. T. & D. A. Polhemus. *Paratypes* as follows (all in JTPC, all apterous unless noted): COLOMBIA: Valle de Cauca Prov.: 4 males, 3 macrop-

terous males, 8 females, 3 macropterous females, 3 nymphs, same data as holotype; 14 males, 1 female, swift rocky tributary to Rio Anchicaya, east of CL 2436, 100 m, water temp. 24 °C, CL 2435, 30.vii.1989, J. T. & D. A. Polhemus; 11 males, 11 females, 2 nymphs, small forest stream near Bajo Calima research station, NE of Buenaventura, 40 m, water temp. 25 °C, CL 2437, 30.vii.1989, J. T. & D. A. Polhemus; 1 male, 2 females, Bajo Calima, 3.iii.1987, M. R. Manzano (NNC); 4 males, 2 females, Rio Tatabro, 7 km E. of Sabaletas, 1.ii.1987, #87004, Gonzáles (NNC; JTPC); 3 males, 3 females, Gorgona, Quebrada Acueducto, 30.xii.1989, M. Baena (NNC); 1 male, 1 macropterous female, Rio San Cipriano, 40 m, 7.viii.1989, M. R. Manzano (UVCC). PANAMA: Panamá Prov. (all collected by JTP unless noted): 1 male, 1 macropterous male, La Cascada, small stream and waterfall on Madden Highway, about 4 km S. of Maria Eugenia, trib. of Rio Pedro Miguel, ~100 m, water temp. 24 °C, CL 2771, 31.xiii.1992, J. T. Polhemus & A. R. Gillogly; 5 males, 1 macropterous male, 3 females, 2 macropterous females, 1 nymph, Rio Juan Grande, off Pipeline Road, nr. Gamboa, km 2, ~30 m, CL 2784, 5.i.1993; 4 males, 1 female, 1 nymph, Rio Agua Salud, off Pipeline Road, km 17, ~5 m, CL 2785, 5.i.1993; 3 males, 3 females, 2 nymphs, unnamed stream off Pipeline Road, km 13.8, ~5 m, CL 2786, 5.i.1993; 1 female, unnamed stream off Pipeline Road, km 15, ~5 m, CL 2789, 6.i.1993; 7 males, 6 females, small unnamed stream off Pipeline Road, km 10.6, ~5 m, CL 2790, 6.i.1993; 1 female, small unnamed stream off Radar Site road S. of Gamboa, ~50 m, CL 2795, 7.i.1993; 1 male, 2 macropterous males, 2 macropterous females, stream crossing road between Gamboa Rd. and Cascada on Madden Hwy., ~50 m, CL 2796, 7.i.1993; 1 male, Rio Indio, Altos del Cerro Azul, E. of Panama City, 560 m, CL 2799, 8.i.1993; 2 females, stream on main road past Altos del Cerro Azul, 26.5 km from Pan Am Hwy. nr. Villa Linda, E. of

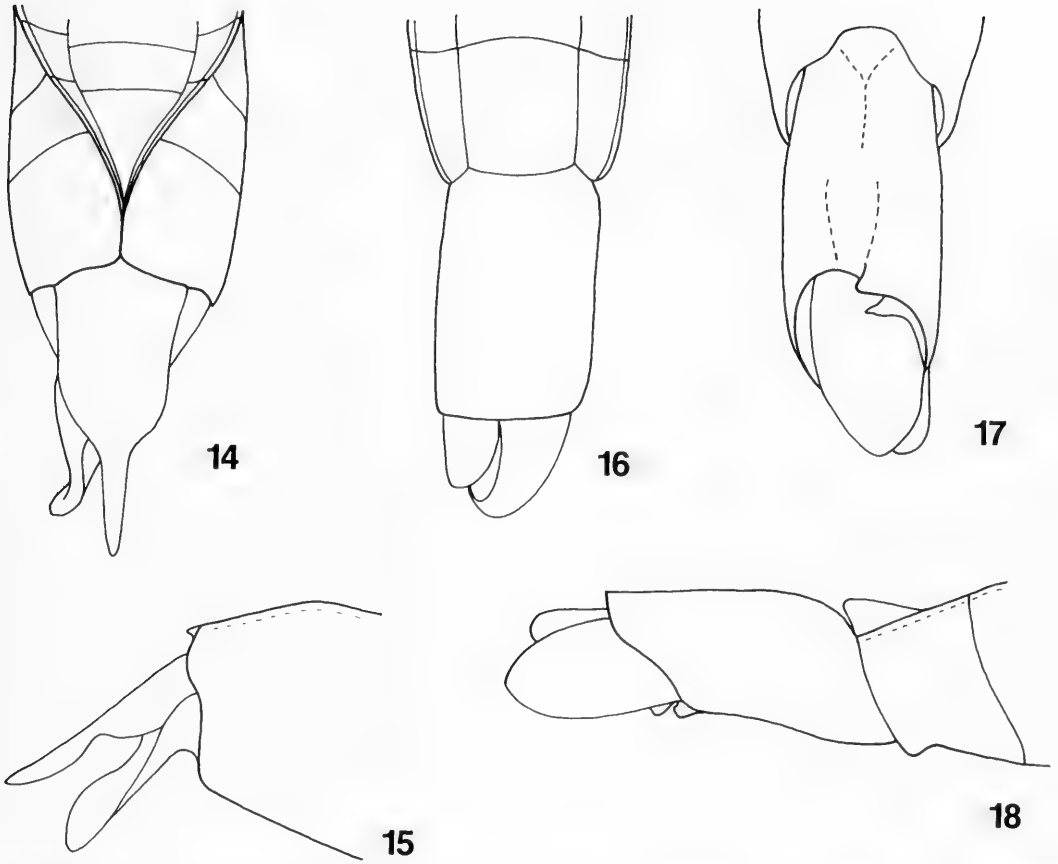
Panama City, ~900 m, CL 2800, 8.i.1993; 1 apterous male, N. of Portobello, CL 1296, 2.i.1970; 1 apterous female, Canal Zone, 10.ii.1939, C. J. Drake; 1 apterous male, 1 apterous female, Pearl Islands, San Jose, 30.vii.1944, J. P. E. Morrison. San Blas Prov.: 7 males, 1 macropterous male, 2 females, 3 macropterous females, Rio Nusagandi, west of Nusagandi, ~200 m, water temp. 24.5 °C, CL 2772, 1.i.1993, J. T. Polhemus & A. R. Gillogly.

Potamobates manzanoae, NEW SPECIES

Figs. 14–18, 20

Diagnosis.—*Potamobates manzanoae* is a sister species to *P. unidentatus* Champion (see Figs. 30, 31), but compared to the latter *manzanoae* may be separated by the shorter yellowish stripe medially on the mesonotum, which does not extend anteriorly much beyond the middle (vs. reaching to pronotum in *unidentatus*); the laterally directed process of proctiger, which is larger, longer and of different shape (process in *unidentatus* small, usually hidden); and the unique, bizarre female abdominal terminalia, not resembling those of any other species (Figs. 14, 15).

Description (all measurements in millimeters).—*Apterous male*: Ground color blackish, faintly shining, covered with very short dark pubescence; head except vertex along eyes and longitudinal oval black spot ahead of eyes, median longitudinal wedge on pronotum, figures on mesonotum (similar to *P. anchicaya* but somewhat smaller; see Fig. 13), propleura, mesopleura, metacephalae, coxae, fore trochanters, dorsum of fore femur except distally, and venter brownish yellow to leucine. Anterolateral angles of pronotum, longitudinal stripe on lateral margins and posterolateral angles of mesonotum, lateral margins of abdominal tergites, and coxal cavities dorsally covered with short bright golden pubescence. Legs black to brown, middle and hind femora lighter beneath basally, antennae black. Legs set with short inconspicuous black spines.



Figs. 14–18. *Potamobates manzanoae* n. sp. 14, 15, Female terminal abdomen. 14, Dorsal view. 15, Lateral view. 16–18, Male terminal abdomen. 16, Dorsal view. 17, Ventral view. 18, Lateral view.

Length of head (1.17) about four times narrowest interocular space (0.28); width of eye 0.61; eyes extending posteriorly about $\frac{1}{2}$ length of propleura. Rostrum short, barely reaching onto mesosternum. Pronotum short (0.83), width (1.44) about equal to head across eyes. Mesonotum long (2.72), widest across mesocoxae (2.66). Metanotum short (0.88), widest across metacoxae (2.33). Abdomen excluding genital segments relatively short (2.55), genital segments long (2.00). Tergites II–V about of equal length (0.17–0.22), tergite VI longer (0.33), tergite VII longest (0.67); VIII long (1.33), large, modified, asymmetrical beneath (Fig. 17); proctiger highly modified, with long projection on left side (Fig. 17); male terminalia as shown in Figs. 16–18. Connexiva angulate

caudally, not produced; slightly raised along entire length.

Antennae long, slender, segments I and IV slightly stouter than II and III; length of segments I–IV: 1.83; 0.67; 0.67; 1.00. Anterior femur stout, tapering distally; anterior tibia slightly flattened, not dilated. Measurements of legs as follows: Femur, tibia, tarsal 1, tarsal 2 of fore leg, 2.77: 2.60: 0.11: 0.44; of middle leg, 9.05: 6.22: 2.77: 0.72; of hind leg, 9.54: 5.38: 0.50: 0.28.

Length, mean 9.72 (N = 2, min. 9.41, max. 10.04).

Width, mean 2.58 (N = 2, min. 2.49, max. 2.66).

Apterous female: Body more robust than male, otherwise similar in general size, coloration, and other features except dark

markings on head usually less extensive, and abdominal terminalia very differently formed. Connexiva truncate, not produced (Fig. 14). Abdominal ventrite VIII strongly produced posteriorly, long, asymmetrical, twisted, spatulate; tergite VIII long, produced, acuminate distally (Figs. 14, 15).

Length, 9.24 (N = 1).

Width, mean 2.84 (N = 1).

Macropterous male: Similar to apterous form in most respects, except pronotum long, with posterior lobe raised and broadly margined with yellowish, humeri prominent. Wings light brown, reaching beyond tip of abdomen, veins blackish brown, without pubescence, with four closed cells, distal cell open.

Length, mean 10.39 (N = 2, min. 10.30, max. 10.48).

Width, mean 2.53 (N = 2, min. 2.49, max. 2.58).

Macropterous female: Similar to macropterous male in most respects, except slightly broader, and wings reaching far beyond tip of abdomen.

Length, 10.39 (N = 1).

Width, 2.75 (N = 1).

Etymology.—The name *manzanoae* honors Maria Rosario Manzano for her contributions to our knowledge of the aquatic Heteroptera of Colombia.

Ecological notes.—*P. manzanoae* was taken in midstream in areas of swift, smooth current.

Material examined.—*Holotype*, apterous male and allotype, apterous female (USNM), COLOMBIA: Valle de Cauca Prov., swift rocky tributary to Rio Anchicaya, water temp. 24 °C, CL 2435, 30.vii.1989, J. T. & D. A. Polhemus. *Paratypes* as follows (all in JTPC, all apterous unless noted): COLOMBIA: Valle de Cauca Prov.: 1 male, 1 macropterous male, 1 female, 1 macropterous female, same data as holotype; 1 male, 1 female, Rio Danubio, 35 km W. of Quereamal, CL 2432, 30.vii.1989, J. T. & D. A. Polhemus.

Potamobates tridentatus Esaki

Fig. 19

The range of *P. tridentatus* extends from northern Costa Rica southward to Chiriqui Province in northern Panama. Repeated collections southward have not revealed any intervening populations between Chiriqui Province and the region of the Panama Canal Zone, where *P. anchicaya* is common. Esaki (1926) provided splendid figures of the abdominal terminalia of both males and females that illustrate the differences between these two species (see discussion under *P. anchicaya*).

Wheelwright and Wilkinson (1985) studied the ecology of *P. tridentatus* in the Osa Peninsula of Costa Rica.

Material examined.—(all in JTPC, all apterous unless noted). COSTA RICA: Guanacaste Prov.: 1 male, 12.vii.1957, D. R. Leach. Puntarenas Prov.: 1 male, 2 females, Cañas, Rio Lagarto, 9.xi.1981, E. Berrera & H. Brailovsky; 2 males, 1 macropterous male, 2 females, 1 macropterous female, river 24 km N of Esparta, CL 1264, 24.xii.1969, J. T. Polhemus. PANAMA: Chiriquí Prov.: 5 males, 1 female, Balneario, river 3.8 km N of David, CL 2819, 13.i.1993, J. T. Polhemus & A. R. Gillogly; 1 female, small stream ~110 km S of David, CL 1289, 31.xii.1969, J. T. Polhemus.

Potamobates horvathi Esaki

Fig. 20

This is the commonest and most widespread species in the genus, with a range from southern Mexico to Colombia. It occurs in both the Atlantic and Pacific drainages, usually at low elevations.

Matsuda (1961) studied the relative growth of all nymphal instars and adults of this species in a Panamanian population.

Material examined.—(all in JTPC, all apterous unless noted). BELIZE: 1 male, Rio Grande, Nov. 1931; 2 females, Punta Gorda, 1932. COLOMBIA: Valle de Cauca Prov.: 4 males, 4 females, Rio Tatabro, 7 km E. of Sabaletas, water temp. 24 °C, CL



Fig. 19. Distributions of *Potamobates* species. Solid triangles: *P. tridentatus* Esaki. Open triangle: *P. carvalhoi* n. sp.

2436, 30.vii.1989, J. T. & D. A. Polhemus; 3 males, 1 macropterous male, 1 female, 2 macropterous females, Rio San Cipriano, 40 m, 7.viii.1989, M. T. Manzano (UVCC). COSTA RICA: Guanacaste Prov.: 4 males, 2 macropterous males, 4 females, 3 macropterous females, 1 nymph, Rio Sanzapote, 6 km N of La Cruz, nr. Nicaragua border, CL 1307, 8.i.1970, J. T. Polhemus. Puntarenas Prov.: 6 males, 2 macropterous males, 4 females, 1 macropterous female, 1 nymph, river 24 km N of Esparta, CL 1264, 24.xii.1969, J. T. Polhemus. GUATEMALA: 1 male, Esquintla; 2 males, 1 female, Los Amates; 2 males, 7 females, 1 macropterous female, small river, Azucho, 24 km S of Esquintla, CL 1252, 20.xii.1969, J. T. Polhemus; 5 males, 2 macropterous males,

1 female, Stain Creek, 11 km N of Zacapa, CL 1316, 11.i.1970, J. T. Polhemus; 5 males, 1 nymph, stream, E of Quirigua, CL 1317, 11.i.1970, J. T. Polhemus. HONDURAS: 1 male, Lancetilla, 22.iii.1936, John Deal. NICARAGUA: 15 males, 4 females, small stream, 13 km N of Esteli, CL 1262, 23.xii.1969, J. T. Polhemus. PANAMA: Bocas del Toro Prov.: 2 males, 5 females, deep stream on road to oil tanks, S. of Chiriquí Grande, sea level, CL 2829, 14.i.1993, J. T. Polhemus & A. R. Gillogly; 1 male, 1 female, vegetated stream, 5.1 km S. Punta Peña, ~50 m, CL 2830, 14.i.1993, J. T. Polhemus & A. R. Gillogly. Chiriquí Prov.: 1 macropterous female, Balneario, river 3.8 km N of David, CL 2819, 13.i.1993, J. T. Polhemus & A. R. Gillogly; Colon Prov.: 2



Fig. 20. Distributions of *Potamobates* species. Solid triangles: *P. horvathi* Esaki. Open triangle: *P. manzanoae* n. sp.

males, 2 females, 2 km N of Maria Chiquita, 27.ii.1993, A. R. Gillogly; 2 males, 4 females, 3 nymphs, N of Portobello, sea level, CL 1296, 2.i.1970, J. T. Polhemus. Herrera Prov.: 1 male, 1 macropterous male, 3 females, Rio Paritas, 2.8 km S of Ocu, CL 2802, 9.i.1993, J. T. Polhemus & A. R. Gillogly; Panamá Prov.: 3 males, 1 macropterous male, 3 females, 2 macropterous females, Rio Cabra, ~3 km N of jct. to Altos Cerro Azul, ~20 m, CL 2797, 7.i.1993, J. T. Polhemus; 7 males, 16 females, 5 km N of San Carlos, CL 1300, 4.i.1970, J. T. Polhemus; 2 males, Panama City, ii.1939, C. J. Drake; 1 macropterous male, Canal Zone, 10.ii.1939, C. J. Drake; 9 males, 7 females, 3 nymphs, E of Panama City, CL 1295, 2.i.1970, J. T. Polhemus.

Potamobates unidentatus Champion

Fig. 22

This species is common and widespread throughout Costa Rica and Panama, occurring in both the Pacific and Atlantic watersheds, in contrast to *P. tridentatus* which has so far been found only in Pacific drainages. We did not collect this species during our surveys in Colombia, and to our knowledge it has been reported from the country only once, at Mamatoco, Magdalena Province (Esaki 1926).

Matsuda (1961) studied the relative growth of all nymphal instars and adults of this species in a Costa Rican population.

Material examined.—(all in JTTC, all apterous unless noted). COSTA RICA: Car-



Fig. 21. Distributions of *Potamobates* species. Solid triangles: *P. vivatus* Drake & Roze. Open triangle: *P. anchicaya* n. sp.

tago Prov.: 1 male, 1 female, km 20, Turrialba—Siquirres Rd., 22.ii.1982, E. Berrera. Heredia Prov.: 19 males, 1 macropterous male, 18 females, 1 macropterous female, Ojo de Agua, nr. San Antonio, CL 1269, 25.xii.1969, J. T. Polhemus. Limon Prov.: 1 male, 2 females, Rio Santa Clara, Guapiles, 26.iv.1984, E. Berrera. Puntarenas Prov.: 1 male, 2 macropterous males, 3 females, 3 macropterous females, 1 nymph, Rio Java, nr. San Vito de Java, CL 1283, 29.xii.1969, J. T. Polhemus. PANAMA: Bocas del Toro Prov.: 2 males, 4 females, stream 6.6 km N. of Continental Divide on rd. to Chiriqui Grande, ~600 m, CL 2824, 13.i.1993, J. T. Polhemus & A. R. Gillogly; 6 males, 4 females, tributaries to Rio Hornitos, Reserva la Fortuna, 1400 m, CL 2825,

14.i.1993, J. T. Polhemus & A. R. Gillogly. Coclé Prov.: 1 male, 2 females, stream in forest below El Valle, CL 1299, 3.i.1970, J. T. Polhemus. Panamá Prov.: 2 males, 1 female, 1 macropterous female, Rio Indio, Altos Cerro Azul, 558 m, CL 2799, 8.i.1993, J. T. Polhemus; 1 male, small stream nr. Villa Linda, W. of Altos Cerro Azul, 26 km from Pan Am Hwy, ~900 m, CL 2800, 8.i.1993, J. T. Polhemus. San Blas Prov.: 1 male, 1 female, Rio Nusagandi, W. of Nusagandi, ~200 m, CL 2772, 1.i.1993, J. T. Polhemus & A. R. Gillogly; 4 males, 9 females, small stream nr. Nusagandi, ~500 m, CL 2774, 2.i.1993, J. T. Polhemus; 2 males, 4 females, waterfall ~5 km E. of Nusagandi, ~450 m, CL 2775, 2.i.1993, J. T. Polhemus & A. R. Gillogly.



Fig. 22. Distribution of *Potamobates unidentatus* Champion.

Potamobates vivatus Drake and Roze

Fig. 21

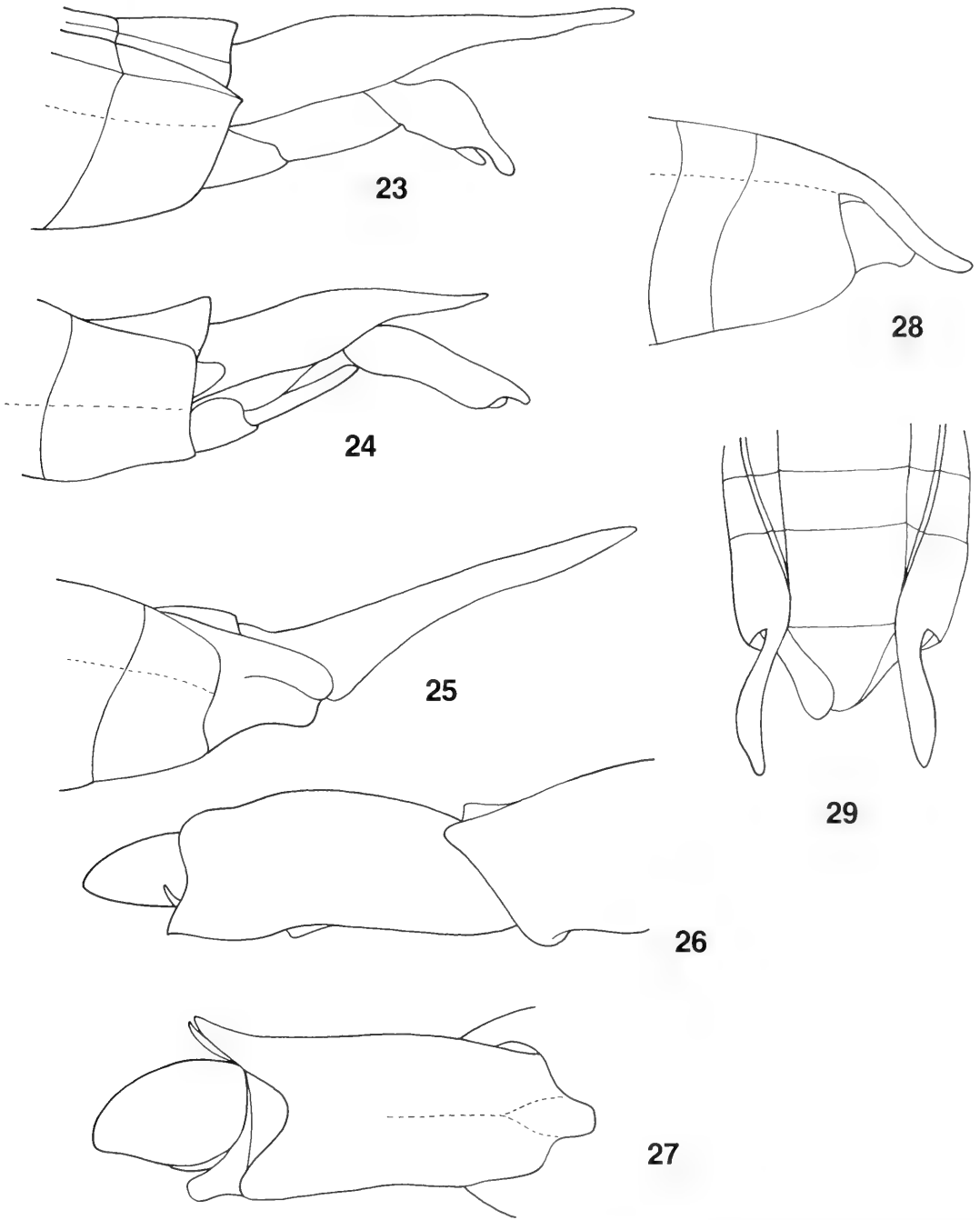
This species was originally described from two localities in the coastal ranges of northern Venezuela. We did not collect this species in Colombia, and to our knowledge it has been taken in this country at only a single locality, the Serrania de la Macarena in Meta Province, an isolated sandstone massifying to the east of the main Andean uplift (Fig. 21).

Material examined.—(all in JTPC, all apterous unless noted). COLOMBIA: Meta Prov.: 7 males, 1 macropterous male, 5 females, 4 nymphs, Rio Santo Domingo, Serrania de la Macarena, 24.i.1989, C. Murillo (JTPC, UVCC). VENEZUELA: Distrito Federal: 1 male paratype, Cerro el Avila, 16.viii.1952, J. A. Roze; Carabobo Prov.:

1 female paratype, Belén, 27.vi.1953, J. A. Roze.

KEY TO THE SPECIES OF *POTAMOBATES*

Species keys were last published for the genus *Potamobates* by Drake and Harris (1934) and Kuitert (1942). The former included only six, and the latter only ten, of the fifteen presently known species, therefore a new key is provided below, including all described taxa. A fully illustrated key, though desirable, was beyond the scope of this paper, whose primary focus is the fauna of Colombia; the present key thus makes reference to previously published figures, with new illustrations being provided only for those species in which one or both sexes have never before been figured.



Figs. 23–29. *Potamobates* spp., abdominal terminalia. 23, *P. osborni* Drake & Harris, female, lateral view. 24, *P. bidentatus* Champion, female, lateral view. 25–27, *P. vivatus* Drake & Roze; 25, female, lateral view; 26, male, lateral view; 27, male, ventral view. 28, 29, *P. williamsi* Hungerford, female; 28, lateral view; 29, postero-dorsal view.

- 1. Pronotum medially with a roughly parallel sided linear longitudinal yellow stripe. Male abdominal segment VIII modified, segments IX, X rotated a maximum of 45° 2
- Pronotum medially with a roughly triangular or wedge shaped yellow mark. Male abdominal segment VIII modified (except *thomasi*), segments IX, X rotated variably in each species, from about 10° to about 90° 5
- 2(1). Male abdominal segment VIII not modified; segments IX, X not rotated. Female with short sharp connexival spines, and a pair of ventral prolongations; anal cone not tubular (see Hungerford 1937, pl. II; habitus, Andersen 1982, fig. 438) *thomasi* Hungerford
- Male abdominal segment VIII modified, with an asymmetrical tumescence or tooth (Fig. 17); segments IX, X rotated at most 30° to 45°. Female without connexival spines or ventral prolongations; anal cone tubular (Figs. 23, 24) 3
- 3(2). Mesonotum of apterous forms without light markings, except golden or silvery setae forming stripes or spots. Male abdominal segment VIII broad, almost parallel sided, distally modified asymmetrically. Female abdominal segment VIII dorsally produced into long spine; ventrally anal cone long, curved, tubular (Figs. 23, 24) 4
- Mesonotum of apterous forms with median yellow longitudinal stripe (rarely completely dark). Male abdominal segment VIII narrow, tapering posteriorly, not expanded distally, with only a small tooth (see Drake and Harris 1934, pl. XXVI f, g). Female abdominal segment VIII dorsally triangular, ventrally with a short finger-like protuberance (anal cone) (see Matsuda 1960, fig. 471) .. *horvathi* Esaki
- 4(3). Vertex of head largely yellow, with a large elongate black region anteriorly, mostly anterad of eyes. Male abdominal segment VIII modified, with an asymmetrical tumescence (see Drake and Harris 1934, pl. XXV h). Female abdominal segment VIII dorsally with moderately long process (Fig. 23) *osborni* Drake and Harris
- Vertex of head largely black, with a small elongate yellow spot between eyes. Male abdominal segment VIII modified, with an asymmetrical lobe bearing two blunt teeth (see Drake and Harris 1934, pl. XXVI a). Female abdominal segment VIII dorsally with moderately long process (Fig. 24) *bidentatus* Champion
- 5(1). Male abdominal segment VIII modified, segments IX, X rotated a maximum of 45°. Female without connexival prolongations 6
- Male abdominal segment VIII modified, segments IX, X rotated about 90°. Female with large connexival prolongations 7
- 6(5). Male abdominal segment IX distally light; process of proctiger spatulate, usually hidden; segments IX, X rotated 5° to 10° (see Matsuda 1960, fig. 479). Female abdominal segment VIII dorsally triangular; ventrally with a triangular structure (see Matsuda 1960, fig. 472) .. *unidensatus* Champion
- Male abdominal segment IX distally dark; process of proctiger acuminate, exposed (Fig. 17); segments IX, X usually rotated 30° to 45°. Female abdominal segment VIII dorsally produced into long spine-like structure; ventrally with an asymmetrical spoon-shaped structure (Figs. 14, 15) .. *manzanaoae* n. sp.
- 7(5). Male abdominal segment VIII broad, short, slightly modified (Figs. 2, 5, 6). Female abdominal terminalia truncate (Figs. 1, 3, 4). *carvalhoi* n. sp.
- Male abdominal segment VIII longer, modified, with spinose or dentate lobes on right side (Figs. 10-12). Female abdominal segment VIII dorsally with short to long median digitate or spine-like prolongation (polymorphic, sometimes short), but never truncate (Figs. 7-9) 8
- 8(7). Distal lobe on right side of male abdominal segment VIII forming a single acute angle posteroventrally (Figs. 26, 27). Female abdominal segment VIII dorsally produced into a long posterodorsally directed spine (Fig. 25) *vivatus* Drake
- Distal lobe on right side of male abdominal segment VIII variably formed, but not forming a single acute angle posteroventrally. Female abdominal segment VIII dorsally with short or long process, but not posterodorsally directed 9
- 9(8). Distal lobe on right side of male abdominal segment VIII forming a posteriorly directed acute angle, plus a posteroventrally directed twisted spatulate lobe (see Polhemus and Polhemus 1983, fig. 1). Female abdominal segment VIII dorsally short, triangular; ventrally with a long process extending posteriorly far beyond

iting the largest number of plesiomorphic character states discussed first in the annotated checklist that follows. The geographic progression of phylogenetically increasing complexity from north to south suggested an ancestral stock in Mexico, and a secondary radiation southward through Mesoamerica into South America. The genus is currently known on this latter continent only in the Andean mountain chain from Colombia to Peru, and in the coastal sierras of northern Venezuela, inhabiting swift clear streams associated with mountainous terrain.

The checklist below, arranged by groups, contains all known species and includes the references for the original descriptions of all previously described species. Kirkaldy (1899) tentatively identified material from Ecuador as *P. bidentatus* and *P. unidentatus*; this material, in the Turin Museum, has not been restudied, but the identifications are almost certainly incorrect, and the records are not included here, because many new species have since been described from South America. New distributional records for described species are indicated with an asterisk (*).

P. thomasi group

Diagnosis.—Male genitalia simple, only slightly modified; segment IX not rotated; abdominal segment VIII not modified; proctiger with modest modification. Female with small connexival spines; abdominal segment VII ventrally modified, with two (1 + 1) lateral prolongations; VIII, IX not modified.

thomasi Hungerford 1937: 63. Mexico (western)

P. unidentatus group

Diagnosis.—Male genitalia relatively simple; segment IX slightly rotated, or rotated a maximum of 30° to 45°; abdominal segment VIII at most slightly modified ventrally. Female without significant connexival prolongations; abdominal segment VIII dorsally without or with modest median prolongation, ventrally without or with only

a modest prolongation; anal cone tubular, longest in Mexican species, shortest in *unidentatus*.

bidentatus Champion 1898: 155. Eastern Mexico (Catemaco area). [Note: *P. bidentatus*, collected by "Sallé, in Mexico" (1831–1834), remained an enigma ever since its original description, with the exact collection locality unknown, until Brailovsky and coworkers rediscovered it in the Sierra de Tuxtla, on a peninsula near Catemaco, where it is apparently endemic. The female, previously unknown, is figured herein (Fig. 24). *P. osborni* also occurs in the same general area, but further inland.]

horvathi Esaki 1926: 254. Belize, Colombia*, Costa Rica, Guatemala, Honduras, Mexico (Chiapas), Nicaragua*, Panama

manzanaoae J. & D. Polhemus, n. sp. Colombia

osborni Drake & Harris 1928: 25. Eastern Mexico

unidentatus Champion 1898: 155. Colombia, Costa Rica, Panama

P. carvalhoi group

Diagnosis.—Male genitalia relatively simple, only slightly modified, very broad, short; segment IX rotated almost 90°; abdominal segment VIII slightly modified ventrally; proctiger modified, prolongation long, complex. Female tergite VII depressed, connexival prolongations long; ventrite VII prolonged, upturned distally; abdominal segments VIII, IX small, unmodified, symmetrical, withdrawn.

carvalhoi J. & D. Polhemus, n. sp. Colombia, Venezuela

P. tridentatus group

Diagnosis.—Male genitalia highly modified, segment IX strongly rotated; abdominal segment VIII modified, with spines or modest to large lobe-like extension on right side (sometimes divided); proctiger with a plate-like or long curved spine-like extension, distally always spine-like. Female with long connexival prolongations; abdominal

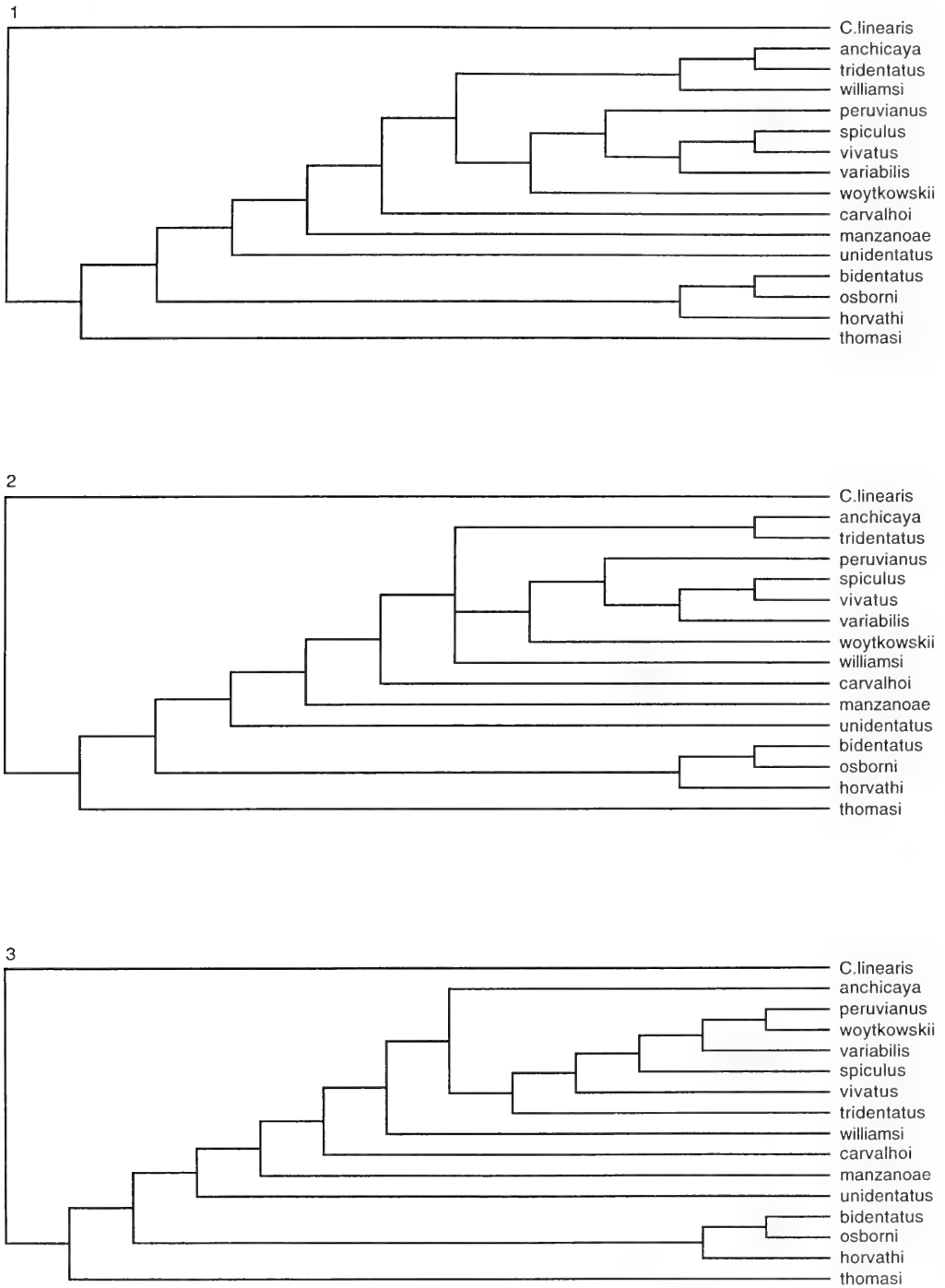


Fig. 30. Three most parsimonious trees generated from preliminary phylogenetic analysis of *Potamobates* species (see Appendices 1 and 2 for explanation).

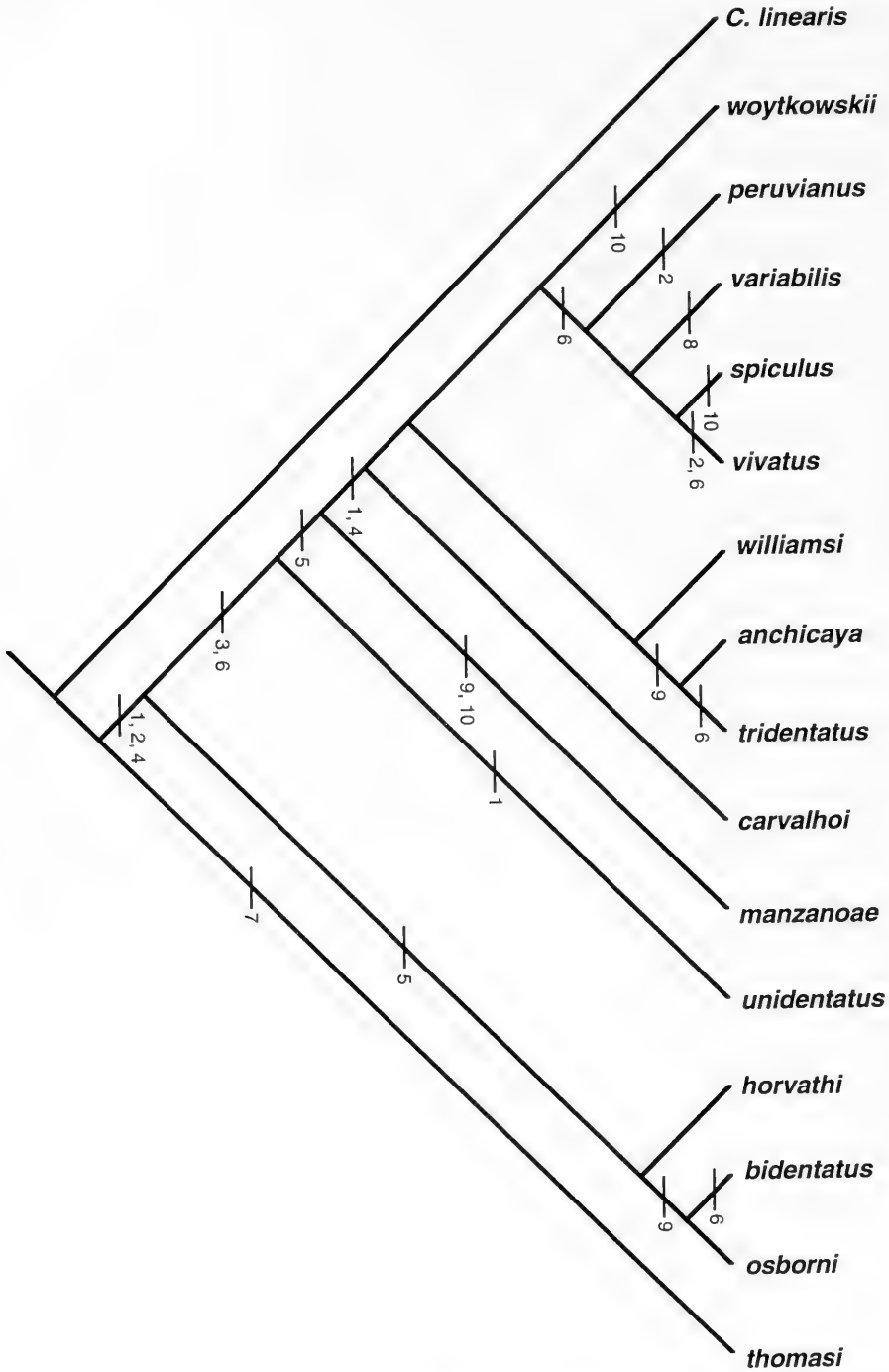


Fig. 31. Preferred cladogram for *Potamobates* species, with characters used in its construction (character numbering refers to that employed in Appendix 1). Numbers indicate characters changing from plesiomorphic to apomorphic state along a given branch.

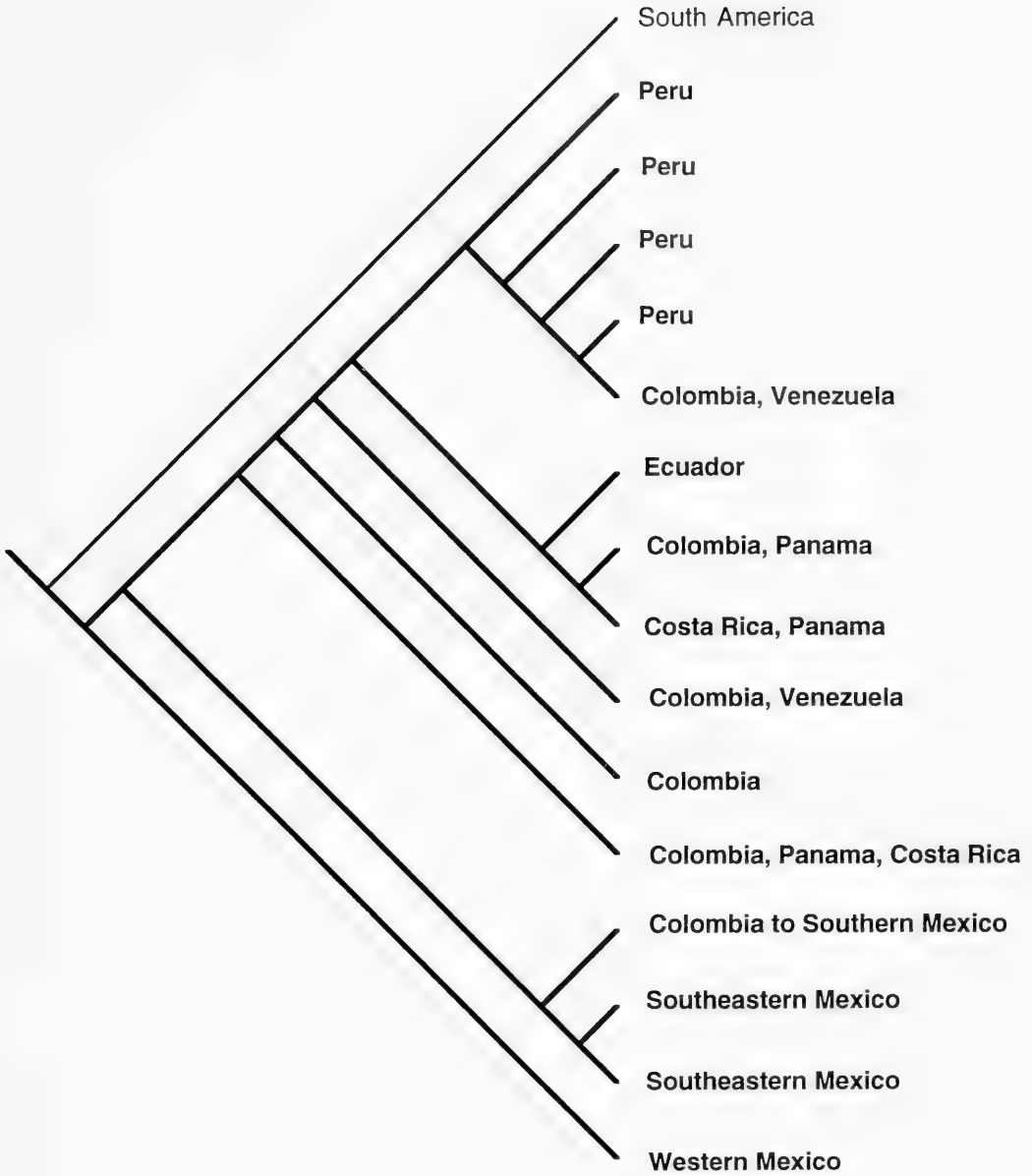


Fig. 32. Taxon-area cladogram based on preferred phylogeny for *Potamobates* species (see Fig. 31).

segment VIII modified, dorsally short, triangular or with a long median spine-like prolongation, ventrally with one or two short to long flap-like lobes, or with complex spoon-like prolongation.

anchicaya J. & D. Polhemus, n. sp. Colombia (western), Panama
peruvianus Hungerford 1936: 178. Peru

spiculus J. & D. Polhemus 1983: 286. Peru
tridentatus Esaki 1926: 251. Costa Rica, Panama
variabilis Hungerford 1938: 85. Peru
vivatus Drake & Roze 1954: 228. Colombia* (eastern), Venezuela
williamsi Hungerford 1932: 228. Ecuador
woytkowskii Hungerford 1937: 144. Peru

We have subsequently tested our hypothesis of species groupings via a preliminary cladistic analysis with a more comprehensive character set (see Appendices 1 and 2), which reveals that our groupings based on genitalic characters alone represent three monophyletic clades plus one basal paraphyletic grade (the *unidentatus* group). Our initial attempts to further discriminate two separate groupings among the South American species forming a clade at the far end of the tree (the *tridentatus* group) are not supported phylogenetically, since the entire suite of characters used contains systems that vary independently to such a degree that all groupings based on genitalic structures alone end up being polyphyletic in at least one of the most parsimonious trees.

The north to south biogeographic progression in genitalic character development alluded to previously was supported based on both our initial intuitive group hypothesis, and on the results of the phylogenetic analysis. In addition, the taxon-area cladogram derived from the phylogenetic analysis (Fig. 32) strikingly illustrates Colombia's pivotal role as a crossroads or Neotropical biogeography, which has acted as both a conduit between South America and Mesoamerica, and as an insular center of regional diversification. In marked contrast to the Peruvian *Potamobates* species, which all arise from a single clade, the Colombian *Potamobates* fauna contains members of all but one of the currently recognized intra-generic clades, including all the constituents of the paraphyletic *unidentatus* group as defined herein.

ACKNOWLEDGMENTS

We are indebted to the following colleagues for the loan or gift of material: M. R. Manzano, University de Valle de Cauca, Cali, Colombia (UVCC), and Nico Nieser, Tiel, The Netherlands (NNC). Holotypes of all new species described herein are deposited in the National Museum of Natural History, Smithsonian Institution, Washing-

ton, D.C. (USNM). All remaining material examined in the course of this study is held either in the foregoing institution, or in the J. T. Polhemus Collection, Englewood, Colorado (JTPC). The field surveys that catalyzed this investigation were funded by National Geographic Society Grant 4092-89, and we gratefully acknowledge their continued support for research into the systematics and zoogeography of aquatic Heteroptera.

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APPENDIX 1

Phylogenetic analysis of *Potamobates* species

Characters and polarity.—The set of characters listed below were employed in a preliminary analysis of *Potamobates* phylogeny. For each character, two or more discrete states were defined and symbolized by numbers. The most primitive (plesiomorphic) state was assigned a zero (0) value, and each successive derived (apomorphic) state a value of 1 or greater using successive integers. Multistate characters (those with more than two states) were ordered in linear transformation series, with 0 the most plesiomorphic state and each subsequent state assumed to be more apomorphic. Character polarities were generally determined *a priori* by complexity, with a 0 state being the least complex and therefore presumably the most plesiomorphic. In a few cases characters were also ordered by comparison with the outgroup (*Cylindrostethus linearis*).

1. Male distal genital segments (abdominal segments IX, X): 0 = not rotated; 1 = rotated 5° to 10° max.; 2 = rotated

30° to 45° max.; 3 = rotated approx. 90°.

2. Modifications to male first genital segment (abdominal segment VIII): 0 = not modified; 1 = distal ventral or lateral angle or angles; 2 = distal tumescence on left side; 3 = distal angulate lobe on left side; 4 = distal dentate lobe on left side.
3. Median pronotal markings, male, female: 0 = roughly linear stripe; 1 = triangular or wedge shaped mark; 2 = absent.
4. Female connexival spines: 0 = short spines, acuminate; 1 = absent; 2 = long, thickened.
5. Female anal cone: 0 = not tubular; 1 = tubular, short; 2 = tubular, long.
6. Mesonotum, medial markings: 0 = dark, no light marks; 1 = longitudinal light stripe; 2 = complex figures.
7. Female ventrite VII: 0 = unmodified; 1 = modified, with prolongations.
8. Modification of male proctiger: 0 = simple angle; 1 = long process, distally simple; 2 = long process, distally "dog head" shaped; 3 = long process, distally bifurcate; 4 = long process, distally strongly twisted (corkscrew fashion), at least 90°.
9. Female first dorsal genital segment (tergite VIII): 0 = triangular; 1 = posterior extension digitate, short; 2 = posterior extension spinose, long.
10. Female first ventral genital segment (ventrite VIII): 0 = triangular; 1 = truncate, hidden; 2 = short flaps, often asymmetrical; 3 = posterior extension spatulate, elongate, not twisted; 4 = posterior extension complex, twisted, narrow, spoon-shaped, long.

Computer analysis.—A cladistic analysis of *Potamobates* species was performed using the program PAUP 3.0.m (D. L. Swofford, Illinois Natural History Survey). This program generates phylogenies using the principle of maximum parsimony, and eliminates trees that are identical due to

zero length branches. The ingroup taxa for the analysis were the 15 species in the genus *Potamobates*, while the outgroup for the analysis was *Cylindrostethus linearis*, another Neotropical member of the subfamily Cylindrostethinae. Using the rooting option on PAUP, the outgroup was constrained to be a monophyletic sister group to the ingroup.

The PAUP analysis was carried out using the *branch and bound* option, using the furthest addition sequence and collapsing zero length branches to yield polytomies. This analysis produced three most parsimonious trees, depicted in Fig. 30. These trees had lengths of 47, consistency indices of 0.53, and retention indices of 0.52. Two of the three trees were fully resolved, while one of the trees (tree 2 of Fig. 30) had an internal polytomy at the base of the clade containing the insular South American species. Based on evolutionary considerations involving genitalic characters and biogeographic parsimony, one of the two fully resolved trees (tree 1 of Fig. 30) was chosen as a preferred phylogeny, and is shown (with some branches swapped) in Fig. 31. A taxon-area cladogram based on this tree is given in Fig.

32, and depicts a clear biogeographic progression from plesiomorphic clades occupying Mesoamerica to apomorphic clades in South America.

APPENDIX 2. Coding of characters for phylogenetic analysis. Character matrix for *Potamobates* species (character states are ordered sequentially for characters 1–10 as given in Appendix 1).

Taxon	Character States
<i>Cylindrostethus linearis</i> ¹	0000100001
<i>Potamobates anchicaya</i>	3412020122
<i>Potamobates bidentatus</i>	2101200221
<i>Potamobates carvalhoi</i>	3212020201
<i>Potamobates horvathi</i>	2101210000
<i>Potamobates manzanoae</i>	2111020024
<i>Potamobates osborni</i>	2101210121
<i>Potamobates peruvianus</i>	3312000402
<i>Potamobates spiculus</i>	3412000423
<i>Potamobates thomasi</i>	0000111000
<i>Potamobates tridentatus</i>	3412010122
<i>Potamobates unidentatus</i>	1111120002
<i>Potamobates variabilis</i>	3412000312
<i>Potamobates vivatus</i>	3312010422
<i>Potamobates williamsi</i>	3412020102
<i>Potamobates woytkowskii</i>	3412020403

¹ Outgroup.

**CARVALHOISCA, A NEW GENUS OF ORTHOTYLINI FROM
MEXICO (MIRIDAE, HETEROPTERA)**

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Abstract.—The orthotyline genus *Carvalhoisca* and the species *C. jacquiniae* from the state of Oaxaca and *C. michoacanus* from the state of Michoacan are described as new. A scanning electron micrograph of the stridulatory device of *C. jacquiniae* is presented. Illustrations of the male genitalia are provided. It is not obvious to what other genera *Carvalhoisca* may be related.

Key Words: Heteroptera, Miridae, Orthotylini, *Carvalhoisca*, new genus, new species

The genus described herein represents another new genus of the rich and diverse orthotyline fauna found in the arid regions of southern Mexico. The two species of this rather unusual genus are found on plants of the genus *Jacquinia* Linnaeus, which is widely distributed through the New World tropics. Measurements are given in mm.

***Carvalhoisca* n. gen.**

Characterized by the small size, minutely granulate surface, wide and sharply declivent head, rather quadrate pronotum, deeply incised cuneal fracture, and the presence of a stridulatory device involving the hemelytron and hind femur.

Body appearing minutely granulate, not shining, vestiture consisting primarily of scattered decumbent hairs. Head sharply declivous, almost as wide as width of pronotum; vertex with posterior margin sharply angulate, frons slightly rounded; clypeus weakly delimited from frons, recurved; jugum, clypeus, lorum, buccula, and gena small relative to size of head; eyes large, touching pronotum; antennal socket contig-

uous with anteroventral margin of eye, length of antennal segments in ascending order I-IV-III-II, vestiture semidecumbent; rostrum extending beyond hind coxae.

Pronotum flat; calli weakly delimited; collar extremely narrow, clearly delimited; anterior and posterior corners of pronotum angulate; lateral margins angulate, straight; posterior margin convex; mesoscutum covered; scutellum convex; corium curved downward along costal margin; embolium only delimited basally, costal margin with well-developed stridulitrum (Fig. 2); cuneal fracture deeply incised, moderately deflected; femora only slightly incrassate, with three setae or trichobothria longer than diameter of femur, hind femur with plectrum (Fig. 2); tibiae lacking erect spines or setae. Apex of abdomen of male somewhat pointed; parameres small.

Type species: *Carvalhoisca jacquiniae* n. sp.

We take great pleasure in naming this genus in honor of Dr. J. C. M. Carvalho, Museo Nacional, Rio de Janeiro, Brazil, whose contributions to our knowledge of the mirid fauna of the neotropics are unexcelled.

This distinctive genus exists at couplet 82 with the genera *Amixia* Reuter and *Aserymus* Distant in Carvalho's key to the mirid genera of the world (1955) but bears no particular resemblance to either. Its relationship to other New World genera is not readily apparent, but it is superficially similar to *Adfalconia* Distant.

Due to the small size of the insect, the stridulatory device is difficult to see with an ordinary light dissecting microscope. This type of stridulatory apparatus has been reported as occurring in other mirid subfamilies.

The host plant for these two mirid species are members of the genus *Jacquinia* (Theophrastaceae). These plants have stiff narrow leaves, the tips of which are acuminate, imparting some protection for the bugs that feed rather openly among the leaves. Both nymphs and adults of the two species were taken. The chlorotic spots on the thick leaves caused by the feeding were readily apparent and were somewhat like the damage seen on orchids caused by members of the bryocorine genus *Tenthecoris* Scott or that caused by *Caulotops* Bergroth or *Halticotoma* Townsend on *Yucca* Linnaeus.

Approximately 50 species of *Jacquinia* are known from tropical America, including the West Indies. Nine species have been reported from Mexico. Inasmuch as the *Carvalhoisca* species described are from the northern areas of the plant distribution, it is likely that additional species of this mirid genus will be found. The crushed fruit of this plant has been reported (Standley 1923) to be widely used by Indians to stupefy fish and also as a medicinal plant.

***Carvalhoisca jacquiniae* n. sp.**

(Figs. 1, 2)

Male (measurements of holotype given first followed in parentheses by means and ranges, $n = 20$): Length, 1.88 (1.93, 1.74–2.04); width, 0.96 (0.98, 0.90–1.04). Head length, 0.16 (0.14, 0.12–0.16); width through eyes, 0.68 (0.70, 0.68–0.74); vertex width,

0.30 (0.30, 0.28–0.30). Length of antennal segment I, 0.24 (0.23, 0.20–0.24); II, 0.72 (0.75, 0.70–0.82); III, 0.36 (0.39, 0.36–0.42); IV, 0.28 (0.30, 0.28–0.34). Pronotal length, 0.32 (0.33, 0.32–0.34); width, 0.76 (0.78, 0.74–0.84). Cuneal length, 0.36 (0.34, 0.32–0.36); width, 0.22 (0.24, 0.22–0.24).

General coloration black with appendages pale yellowish white. Head black downward to level of antennal insertions, juga and area of clypeus between juga reddish brown, lora and area of clypeus between lora pale; antenna pale, faint reddish brown coloration on base of antennal segment I; rostrum pale, dark fuscous at apex. Thorax, including scutellum and hemelytron, dark fuscous to black, membrane of hemelytron paler along outer margin; bases of mid and hind coxae dark fuscous, remainder of legs pale. Abdomen dark fuscous.

Morphological characters are given for genus. Genitalia similar to those of *C. michoacanus* (Figs. 3–5).

Female (means followed in parentheses by ranges, $n = 20$): Length, 1.96 (1.84–2.08); width, 1.03 (0.92–1.12). Head length, 0.17 (0.12–0.22); width through eyes, 0.74 (0.68–0.78); vertex width, 0.35 (0.34–0.36). Length of antennal segment I, 0.22 (0.20–0.24); II, 0.61 (0.54–0.66); III, 0.34 (0.30–0.36); IV, 0.30 (0.26–0.34). Pronotal length, 0.34 (0.30–0.36); width, 0.83 (0.74–0.88). Cuneal length, 0.32 (0.28–0.36); width, 0.26 (0.24–0.28).

Similar to male in form and color.

Holotype: ♂, MEXICO: Oaxaca, 2.1 mi. nw. Totolapan, July 11–17, 1981, [D. S.] Bogar, [J. C.] Schaffner, [T. P.] Friedlander. Deposited in the collection of the Instituto de Biología, Universidad Nacional Autónoma de México, México, D.F.

Paratypes: 24 ♂, 76 ♀, same data as holotype: ♂, 4 ♀, same locality as holotype, August 7, 1980, [J. C.] Schaffner and [T. P.] Friedlander; 8 ♂, 43 ♀, Oaxaca, 10 mi. e. Totolapan, elev. 4000 ft., July 20, 1987, [P. W.] Kovarik, [J. C.] Schaffner. Deposited in

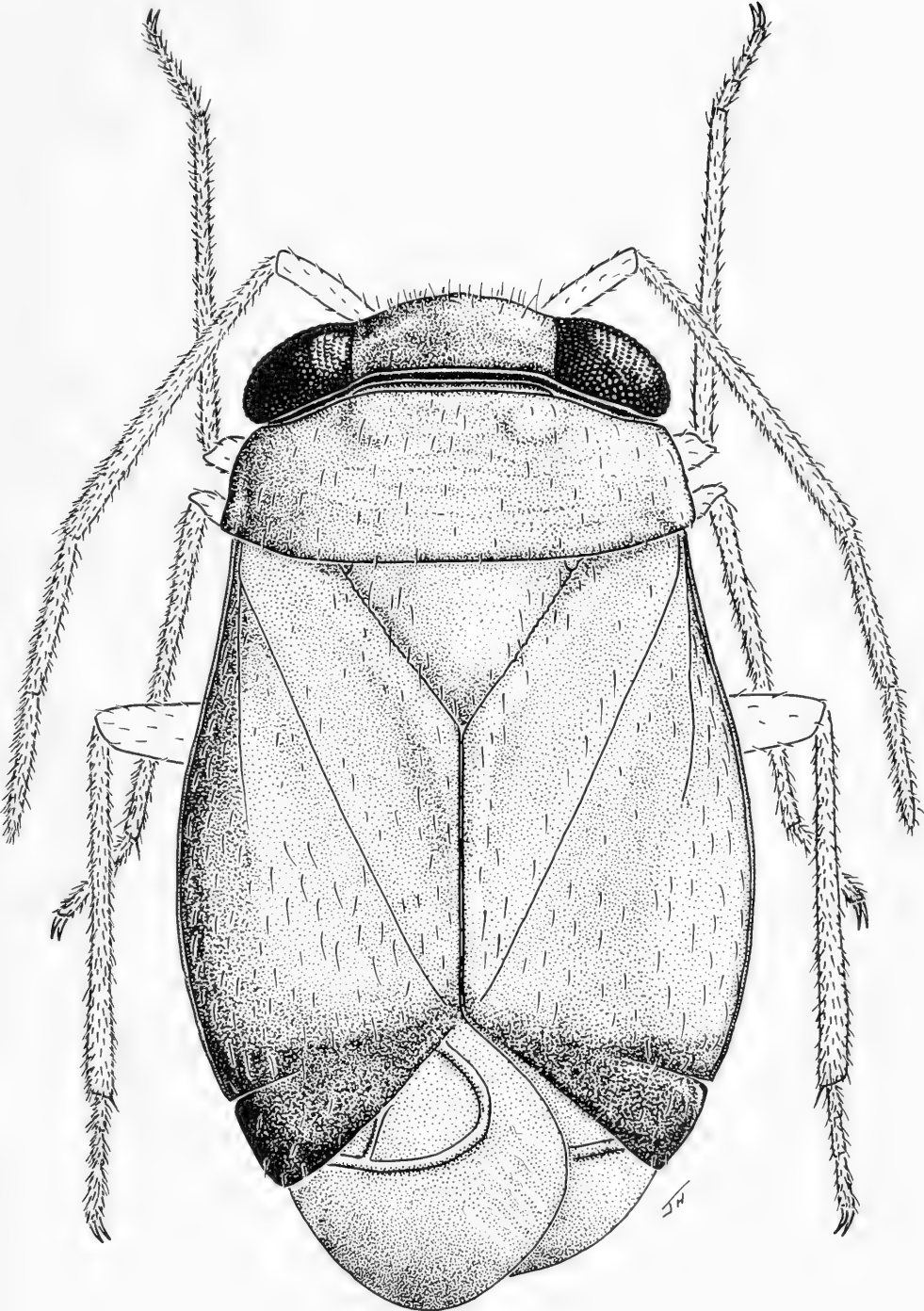


Fig. 1. *Carvalhoisca jacquiniae*, dorsal habitus.

the National Museum of Natural History, Washington, D.C.; in the collection of the Department of Entomology, Texas A&M University, College Station, Texas; in the J. C. M. Carvalho collection, Rio de Janeiro, R.J.; and in the collection of the Instituto de biologia, U.N.A.M., Mexico, D.F.

The host plant for both nymphs and adults of this species is *Jacquinia seleriana* Urb. & Loes.

***Carvalhoisca michoacanus* n. sp.**

(Figs. 3–5)

Male (measurements of holotype given first followed in parentheses by means and ranges, $n = 20$): Length, 1.60 (1.60, 1.44–1.66); width, 0.96 (0.94, 0.90–0.98). Head length, 0.14 (0.12, 0.10–0.14); width through eyes, 0.76 (0.75, 0.74–0.78); vertex width, 0.34 (0.33, 0.32–0.34). Length of antennal segment I, 0.22 (0.21, 0.20–0.22); II, 0.68 (0.65, 0.60–0.68); III, 0.38 (0.35, 0.34–0.40); IV, 0.26 (0.24, 0.24–0.28). Pronotal length, 0.34 (0.34, 0.34–0.36); width, 0.82 (0.81, 0.80–0.84). Cuneal length, 0.32 (0.32, 0.30–0.34); width, 0.20 (0.21, 0.20–0.22).

General coloration black with appendages pale yellowish brown. Head black, juga and base of tylus reddish black, lora and apical half of tylus pale yellowish brown; antenna pale yellowish brown, apex dark fuscous; rostrum pale yellowish brown. Thorax including scutellum and hemelytron black, membrane of hemelytron black becoming abruptly pale near margin; thoracic sterna reddish brown to reddish black; bases of mid and hind coxae dark fuscous, remainder of legs light yellowish brown. Abdomen reddish brown to reddish black.

Morphological characters as given for genus. Genitalia as in Figs. 3–5.

Female (means followed in parentheses by ranges, $n = 20$): Length, 1.72 (1.62–1.84); width, 1.03 (1.00–1.06). Head length, 0.16 (0.14–0.20), width through eyes, 0.80 (0.78–0.82); vertex width, 0.40 (0.38–0.42). Length of antennal segment I, 0.19 (0.18–



Fig. 2. *Carvalhoisca jacquiniae*, costal margin of hemelytron showing stridulitrum and hind femur showing plectrum.

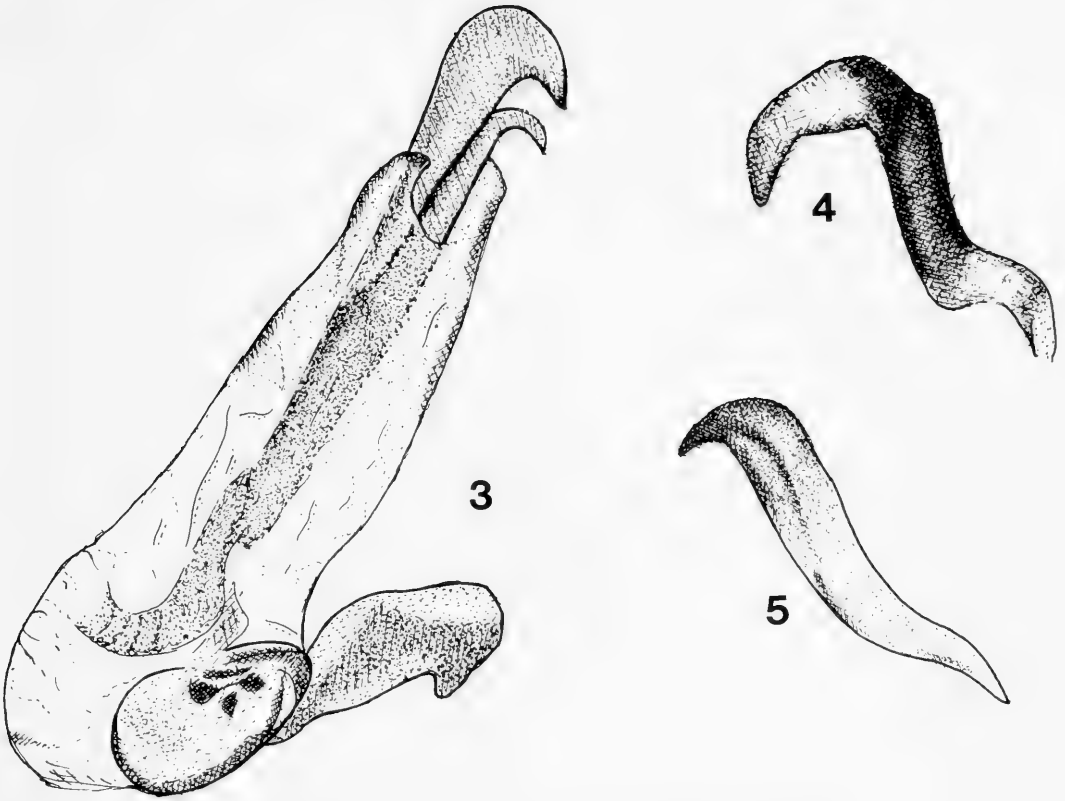
0.22); II, 0.52 (0.48–0.56); III, 0.34 (0.32–0.38); IV, 0.25 (0.24–0.30). Pronotal length, 0.36 (0.34–0.38); width, 0.87 (0.86–0.90). Cuneal length, 0.33 (0.32–0.34); width, 0.24 (0.22–0.26).

Similar to male in form and color.

Holotype: ♂, MEXICO: Michoacan, 28.5 miles south of Nueva Italia, July 9, 1985, [R. W.] Jones, [J. C.] Schaffner. Deposited in the collection of the Instituto de Biologia, Universidad Nacional Autonoma de Mexico, D.F.

Paratypes: 25 ♂, 54 ♀, same data as holotype. Deposited in the National Museum of Natural History, Washington, D.C.; in the collection of the Department of Entomology, Texas A&M University, College Station, Texas; in the J. C. M. Carvalho collection, Rio de Janeiro, Brasil; and in the collection of the Instituto de Biologia, U.N.A.M., Mexico, D.F.

Specimens of this species are nearly al-



Figs. 3-5. *Carvalhoisca michoacanus*. 3. Vesica. 4. Left paramere. 5. Right paramere.

ways shorter than those of *C. jacquiniae*. The males range in length from 1.44–1.66 mm and the females 1.62–1.84 mm. The males of *C. jacquiniae* are 1.74–2.04 mm in length and females 1.84–2.08 mm. The head width of *C. michoacanus* is greater than that of *C. jacquiniae*. The male head width is 0.74–0.78 mm, that of the female, 0.78–0.82 mm. In the case of *C. jacquiniae*, the male head width is 0.68–0.74 mm and the female, 0.68–0.78 mm. The antennal segment lengths are shorter on individuals of *C. michoacanus*. By using the head width divided by the length of antennal segment II, a ratio for easy separation of the 2 species can be derived. The males of *C. jacquiniae* have antennal segment II longer than the head width (1.12–1.23), whereas in the case of *C. michoacanus* the second antennal seg-

ment is shorter than the head width (0.90–0.97). Antennal segment II is 1.39–1.67 times as long as the head width in females of *C. jacquiniae* individuals but only 1.13–1.28 as long for specimens of *C. michoacanus*. We are unable to separate the species on the basis of the genitalia.

The host plant for both nymphs and adults of this species is *Jacquinia pungens* A. Gray.

ACKNOWLEDGMENTS

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sincere thanks are also extended to Dr. P. A. Fryxell, University of Texas, Austin, for identifying the host plants.

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**EUROPIELLA REUTER (HETEROPTERA: MIRIDAE):
RECOGNITION AS A HOLARCTIC GROUP, NOTES ON SYNONYMY, AND
DESCRIPTION OF A NEW SPECIES, *EUROPIELLA CARVALHOI*,
FROM NORTH AMERICA**

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Abstract.—The subgenus *Poliopterus* Wagner of *Plagiognathus* Fieber is placed in synonymy with *Europiella* Reuter. The identity of Holarctic species is clarified. New combinations are created because of generic synonymy, species are transferred from other genera, and many names are placed in synonymy. Most species for which hosts are known feed on *Artemisia*, a few feeding on other Asteraceae such as *Chrysothamnus*, *Helichrysum*, and *Tanacetum*, with two species being recorded from the Lamiaceae.

Key Words: Heteroptera, Miridae, *Europiella*, new species, new synonymy, Holarctic

Reuter (1909) used the name *Europiella* for two species of phylinae Miridae from North America. Since that time many additional American species have been placed in the genus. Wagner (1949) described the subgenus *Plagiognathus* (*Poliopterus*) to contain several species of Palearctic Phylinae related to *P. albipennis* (Fallén). Our individual research efforts have shown that many species placed in *Europiella* and *Plagiognathus* are in fact congeneric, or in a few cases conspecific, that many species from North America that have previously been placed in *Europiella* do not belong there, and some Palearctic species placed in *Plagiognathus* sensu stricto and *Chlorillus* actually belong to *Europiella*. There is much confusion regarding the correct application of species-group names, including substantial synonymy. In the following pages we provide solutions to these problems and describe a new species. Additional details on

the history of synonymy for the Nearctic fauna, as well as more detailed distributions of the species, can be found in Henry and Wheeler (1988).

This paper is presented in honor of our long-time colleague and friend José Candido de Melo Carvalho. His influence on the study of the Miridae has been profound, because of his monumental world catalog and his unparalleled descriptive efforts, particularly on the Neotropical fauna.

We thank Thomas J. Henry and Michael D. Schwartz for reviewing the manuscript.

Europiella Reuter

Type species.—*Agalliastes stigmosus* Uhler 1893.

Europiella Reuter 1909: 83 (n. gen., desc.);

Knight 1968: 37 (key to spp.).

Poliopterus Wagner 1949: 53 (n. subgen. of *Plagiognathus*, desc.). **NEW SYNONYMY.**

Diagnosis.—Relatively small, length 2–5 mm; some spp. sexually dimorphic, body form varying from elongate and nearly parallel-sided to broadly ovoid, especially in females. Coloration varying from almost completely black to almost completely green or white, usually with a few dark markings at the bases of spines on the legs. Vestiture of dorsum with reclining simple setae and recumbent, woolly, sericeous setae; head weakly produced and not overlapping anterior margin of pronotum. Male genitalia varying greatly in size, but pygophore always large relative to total size of abdomen; right paramere truncate apically, with a more or less well-developed protrusion on either side, never lanceolate in form; vesica always with two apical spines, these sometimes elongate and broadened basally (Figs. 12, 13), or much shorter and variously acuminate and/or strongly curving (Figs. 6, 7, 9, 10, 15–17); secondary gonopore placed to the side of the chitinous bands of the vesica rather than between them and distinctly proximad of attachment of spines. Often breeds exclusively on *Artemisia*, occasionally on other Asteraceae, and rarely on other plant families.

Discussion.—Wagner (1949) described the subgenus *Poliopterus*, with *albipennis* (Fallén) as the type. He consistently placed it in the genus *Plagiognathus* Fieber by virtue of its members having two elongate chitinous spines apically on the vesica and with the secondary gonopore rather distant from them. Within *Plagiognathus*, Wagner recognized *Poliopterus* by the presence of only light colored setae on the dorsum. Wagner (1975) placed 13 species from the Mediterranean Region in *Poliopterus*; the majority of those for which hosts are known feed on species of *Artemisia*.

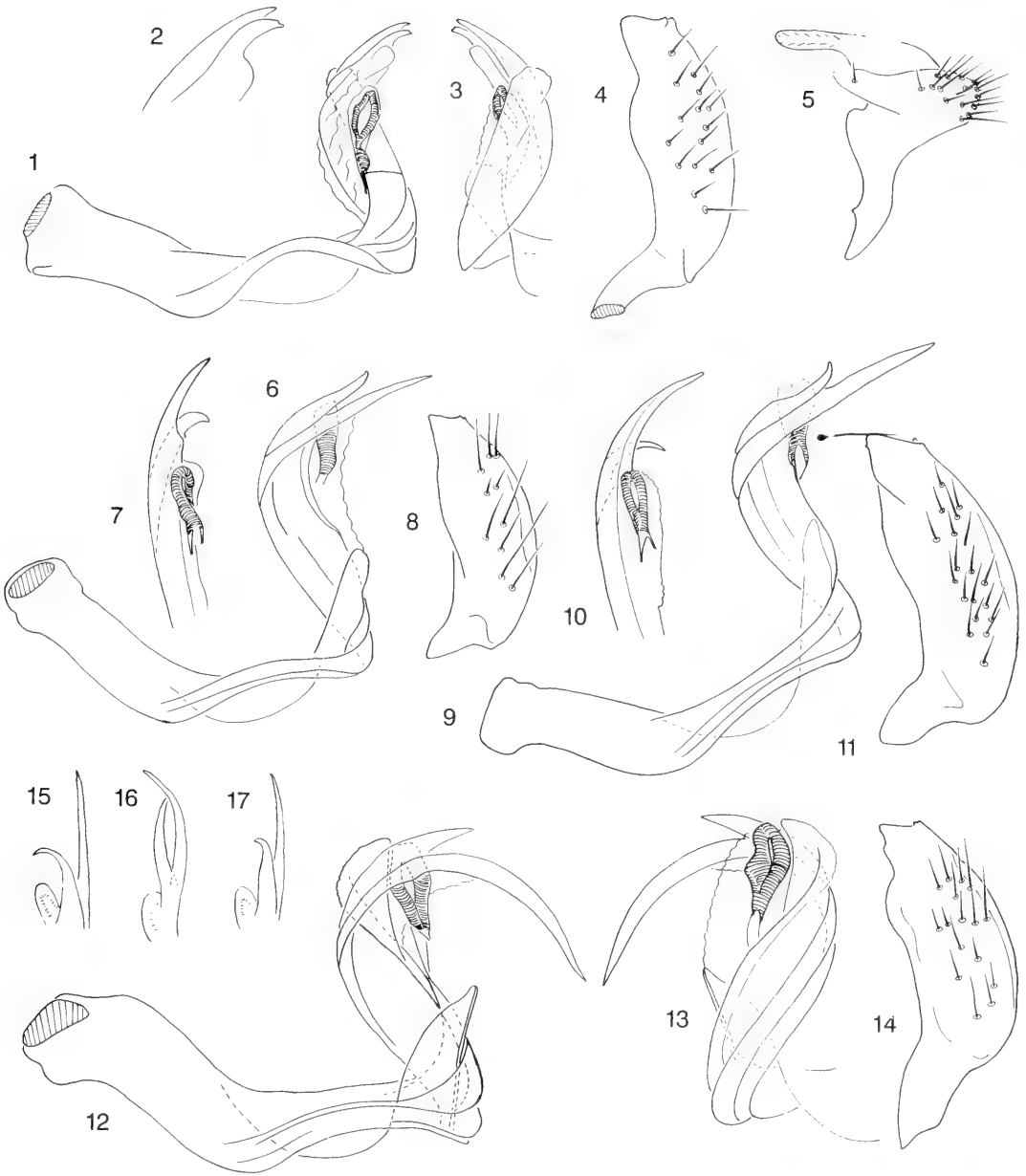
Members of another assemblage of Palearctic species, richly represented in the Far East (Kerzhner 1988a) and including one European species, are green and dissimilar to *albipennis* in appearance. They were traditionally placed in *Plagiognathus* sensu

stricto, but some species such as *Plagiognathus alpinus*, have been placed in *Chlorillus* or *Psallus* by some authors. The structure of the genitalia indicates that they should be placed in *Europiella*, as does comparison with some North American species, which are similar in coloration. All but two of them feed on *Artemisia*.

In the New World there are several species that are very closely related to *albipennis*, and a number of others that we treat as congeneric. Among these is *stigmosa* (Uhler), the type species of *Europiella* Reuter 1909. We are therefore treating *Poliopterus* Wagner as the junior synonym of *Europiella*. The male genitalia of *stigmosa* are shown in Figs. 12–14 and those of *albipennis* in Fig. 16.

The generic limits of *Plagiognathus* are a subject that can be properly addressed only with a much more wide-ranging analysis of the Holarctic Phylini, something that we do not attempt in this paper. Because subgenera have been used primarily in the Palearctic, a consistent treatment of the world fauna including the use of Palearctic subgeneric concepts would leave many species unplaced as to subgenus. It is for these reasons that we treat *Europiella* as a distinct genus.

Knight (1968, 1969, 1970) diagnosed *Europiella* without examining the structure of the male genitalia. He included some species which are clearly congeneric with *stigmosa*, the type. He also included many other species (as enumerated by Henry and Wheeler 1988) which bear a superficial resemblance to *stigmosa* and its congeners. These species are found in desert areas of western North America feeding primarily on *Atriplex*, *Sarcobatus* (Chenopodiaceae), and *Lycium* (Solanaceae), but nearly all of them belong to a separate lineage. Comparison of preparations of the male genitalia of paratypes of most of these species and the genitalia of *Megalopsallus atriplicis* Knight, the type species of *Megalopsallus* Knight, indicates that most, if not all, of



Figs. 1-17. Male genitalia of *Europiella* spp. 1-5. *E. carvalhoi*. 1. Vesica. 2. Detail of apex of vesica. 3. Obverse view of distal portion of vesica. 4. Right paramere. 5. Left paramere. 6-8. *E. decolor* (western North America). 6. Vesica. 7. Apex of vesica, rotated 90 degrees. 8. Right paramere. 9-11. *E. artemisiae* (western North America). 9. Vesica. 10. Apex of vesica, rotated 90 degrees. 11. Right paramere. 12-14. *E. stigmosa*. 12. Vesica. 13. Obverse view of distal portion of vesica. 14. Right paramere. 15-17. Comparative views of apex of vesica of Holarctic species. 15. *E. artemisiae* (Europe). 16. *E. albipennis* (Europe). 17. *E. decolor* (Europe).

them are congeneric. We provide below a list of all names for which new combinations are formed in *Megalopsallus*.

Some species which are clearly congeneric with *stigmosa* have often been placed in other genera. We have transferred all of those of which we are aware.

In the Holarctic there are *Artemisia*-feeding species placed in other genera of Phylinae (e.g. species placed in *Phyllopiidea* Knight) as well as in other subfamilies of Miridae. Critical examination of these species indicates that although the host preference of *Europiella* spp. is helpful in beginning to establish a basis for their generic identity, it is often only with examination of the male genitalia that generic placement and specific identity can be determined with certainty.

We have organized most of our treatment on geographical grounds, because the pertinent literature is organized on that basis.

IDENTITY AND SYNONYMY OF
EUROPIELLA ALBIPENNIS AND TWO
RELATED SPECIES

Three closely related species of *Europiella* are widely distributed in the Palearctic, two of these also occurring in the Nearctic. No other species of the genus are Holarctic. All three of these species have been identified by various authors as *Plagiognathus albipennis*. We found that these taxa are reliably distinguished from one another by the form of the vesical appendages as seen in dorsal view (e.g. Figs. 15–17). The size and color are highly variable, but in some regions the species can be recognized by external appearance.

Europiella albipennis (Fallén),
NEW COMBINATION
Fig. 16

Phytocoris albipennis Fallén 1829: 107 (n. sp., desc.).

Agalliastes albipennis: Fieber 1861: 311 (key); Puton 1873: 25 (syn.).

Agalliastes tibialis Fieber 1864: 228 (n. sp., desc.).

Agalliastes lanuginosus Jakovlev 1875: 172 (n. sp., desc.).

Plagiognathus albipennis var. *tibialis*: Jakovlev 1877: 279 (syn.).

Plagiognathus albipennis: Reuter 1878: 175 (part; descr., variability, syn.).

Plagiognathus collinus Wagner 1941: 249 (n. sp., desc., figs.). NEW SYNONYMY.

Plagiognathus arenicola Wagner 1941: 252 (n. sp., desc., figs.). NEW SYNONYMY.

Plagiognathus (Poliopterus) collinus: Wagner 1952a: 197 (key, desc., figs.).

Plagiognathus (Poliopterus) arenicola: Wagner 1952a: 197 (key, desc., figs.);

Wagner and Weber 1964: 413 (key, desc., figs.); Wagner 1975: 35 (key, desc., figs.).

Plagiognathus (Poliopterus) lanuginosus: Josifov 1974: 14, 20 (restored from synonymy, list, host); Wagner 1975: 34 (key, desc., figs.).

Distribution.—From southernmost Sweden, southeastern Finland, and Leningrad Province, Russia, at least to Bulgaria and from France east at least as far as East Kazakhstan.

Hosts.—Living exclusively on *Artemisia campestris* in Northern Europe; records of *Plagiognathus lanuginosus* from *A. maritima* in southern Europe probably refer to *E. decolor*.

Notes.—In this species the dark spots on the hind tibia are usually larger than in related species and the venter is black in both sexes, even though the dorsum may be pale. The apex of the vesica is shown in Fig. 16.

Fallén (1829) described *Phytocoris albipennis* from four specimens, including male(s) and female(s), all collected by Zetterstedt in July. Type locality: Sweden, Skåne Prov. (Scania), Esperöd. Extant material qualifying as syntypes is present only in the collection of Fallén, not in the collection of Zetterstedt, both collections deposited in the Zoological Museum, Lund University. It consists of one male labelled "*P. albipennis*

[male symbol]" and a small blue square, and one female labelled "*P. albipennis* [female symbol]" plus a few illegible characters, and "Mellby 12 jun." on the underside of the label. The labels are in Zetterstedt's handwriting, and the small blue square is known to signify that Zetterstedt collected the specimen at Esperöd, Mellby Parish. Among these specimens is pin without any specimen with Fallén's label "*P. albipennis* [male symbol] [female symbol] Esperöd."

According to Wagner (1941: 256), F. Ossiannilsson informed him that the type was no longer present in the collection of Fallén, but rather that only an empty pin remained. Ossiannilsson in a letter to Lindskog (Jan. 15, 1982) explained that his reply to Wagner was based on the opinion of museum authorities that in general only specimens carrying Fallén's labels could be considered as his types. It is known that after the death of Fallén in 1830 his collection passed to the possession of Zetterstedt, who notoriously filled in any missing species with specimens from his own collection. Ossiannilsson wrote (in litt.) "In the present case this was apparently fully justified, as I should have realized if time had been taken to look more closely on Zetterstedt's label and Fallén's text. Fallén described *albipennis* based on four specimens. He probably retained two specimens for his own collection which later were lost somehow, and returned two to the collector Zetterstedt, who in turn placed these in Fallén's collection after he acquired it. These two specimens should accordingly be considered as syntypes."

As Fallén indicated that the types were collected in July, and because Zetterstedt in his handwritten notes in his copy of Fallén's (1829) work (now in the library of the Zoological Institute, St. Petersburg), indicated that he collected the species at "I[ocis] aridis Esp[eroed] 18 jul. freq[uens]," it seems doubtful that the female labelled 12 June belongs to the syntype series although no such doubt exists for the male.

We accept these arguments and designate

the male as lectotype of *P. albipennis* and have labelled it accordingly.

Wagner (1941) stated that the type specimens were presumably lost and designated from his collection "Neotypen," saying nothing about their number, sex, and locality. Wagner's "neotypes" are not conspecific with the true types (see below) and Wagner's nomenclatural act is invalid because more than one specimen was designated as the neotype.

From the examination of Fallén's specimens we have determined that the name *albipennis* should be ascribed to a species which is not the most common in the Palearctic and which does not occur in North America, in spite of many indications in the literature to the contrary.

Agalliastes tibialis was described from Sarepta (now Krasnoarmeysk, part of Volgograd) from Frey-Gessner's collection. The type specimens were apparently examined by Puto and Reuter, and Reuter (1878, pl. 4, fig. 8) published Fieber's figures of a female. We cannot locate the type(s). Judging from the large, black, tibial spots noted in the original description and the figure, and the pale dorsal surface and black abdomen, this species is in almost certainly identical with *albipennis*.

Agalliastes lanuginosus was described from specimens collected at Sarepta by Christoph and at Akhtubinskaya steppe by Becker. The only known syntype is a badly damaged specimen (probably female) from Sarepta in the Zoological Institute, St. Petersburg. Its remnants include the head with antennae, prothorax, and all legs. Judging from these parts and from the original description, the species is identical with *albipennis*.

Plagiognathus arenicola was described from Germany and Poland and *P. collinus* from Poland. We examined the types and paratypes of both species in the Zoological Museum Hamburg and paratypes in other collections. Some paratypes were dissected

for comparison of the male genitalia, and these are conspecific with *albipennis*.

Reuter (1878: 81, 82) described several varieties of *P. albipennis*, assigning them Greek letters. Reuter did not indicate specimens for his varieties and did not label varieties in his collections. Stichel (1934: 282) named these varieties *assmanni*, *albella*, *beckeri*, and *antennaria*. The identity of these names cannot be clarified at present, and it is clear that Stichel did not base his names on specimens which he himself examined.

Europiella decolor (Uhler)

Figs. 6–8, 17

? *Phytocoris pallidulus* Dahlbom 1851: 211 (n. sp., descr.). Questionable **NEW SYNONYMY.**

Agalliastes decolor Uhler 1893: 380 (n. sp., desc.).

Agalliastes apiatus Uhler 1895: 53 (n. sp., desc.). **NEW SYNONYMY.**

Agalliastes signatus Uhler 1895: 55 (n. sp., desc.). **NEW SYNONYMY.**

Chlamydatus bakeri Bergroth 1898: 35 (n. n. for *Agalliastes signatus* Uhler).

Plagiognathus albipennis var. *extrema* Reuter 1901: 187 (n. var., descr.). **NEW SYNONYMY.**

Chlamydatus uhlerianus Kirkaldy 1909: 390 (unnecessary n. n. for *Agalliastes signatus* Uhler).

Plagiognathus decolor: Reuter 1909: 81 (disc.).

Europiella decolor: Van Duzee 1916: 47 (list).

Chlamydatus apiatus: Van Duzee 1917: 417 (n. comb.).

Psallus waldeni Knight 1923: 468 (n. sp.). **NEW SYNONYMY.**

Psallus bakeri: Knight 1941: 43 (key, desc.).

Plagiognathus (Poliopterus) litoralis Wagner 1949: 53 (n. sp., desc., figs.); Wagner 1952a: 199 (key, desc., figs.). **NEW SYNONYMY.**

Plagiognathus extremus: Wagner 1954: 77 (n. status, descr.).

Plagiognathus (Poliopterus) litoralis f. *abrotani* Wagner 1949: 53 (n. form, desc.). **NEW SYNONYMY.**

Europiella bakeri: Carvalho 1955: 227 (n. comb.); Knight 1969: 86 (disc., redesc., host).

Plagiognathus (Poliopterus) abrotani: Wagner and Weber 1964: 413 (new status, key, desc., figs.).

Psallus artemisicola Knight 1964: 149 (n. sp., desc., host). **NEW SYNONYMY.**

Europiella nigricornis Knight 1968: 40 (n. sp., desc., host). **NEW SYNONYMY.**

Plagiognathus (Poliopterus) laeae Kerzhner 1978: 46 (n. sp., desc., figs.). **NEW SYNONYMY.**

Psallus albipennis (not Fallén 1829): Wheeler and Hoebeke 1982: 696 (n. comb., syn., figs.).

Distribution.—Broadly distributed throughout the Holarctic.

Hosts.—Nearctic hosts include *Artemisia californica*, *A. campestris*, *A. dracuncululus*, *A. filifolia*, *A. ludoviciana*, *A. nova*, *A. tridentata*, and *Chrysothamnus* sp. In the western Palearctic known from *Artemisia absinthium*, *A. maritima*, and *A. abrotani* (in botanical gardens). Kurile Islands specimens are from *A. schmidtiana*, belonging to the "Maritimae" series.

Notes.—The name *decolor* (Uhler) has previously been applied only to the North American fauna. Our studies indicate, however, that the taxon to which this name applies also occurs in the Palearctic.

Uhler (1893) indicated in his discussion of *decolor* that he examined four specimens from American Fork, Utah, as well as larger specimens collected near Los Angeles, California. We located in the National Museum of Natural History, Washington, D.C., a single female specimen from American Fork that seems to pertain to material originally examined by Uhler. In addition to the data noted above it bears the labels "COTYPE

(by Uhler) *Agalliaestes decolor* Uh1." [apparently affixed by H. H. Knight], and "Cotype No. 52835 U.S.N.M."

Uhler (1895) described *Agalliaestes apiatatus* from specimens collected at Fort Collins, Manitou, and Steamboat Springs, Colorado. He indicated that it also occurred in Kansas. The collections of the USNM contain 10 specimens associated with the *apiatus* identification. One of these was labelled as a cotype by H. G. Barber. It is clearly congeneric with *decolor*.

Uhler (1895) described *Agalliaestes signatus* from a single male specimen from Manitou, Colorado. We were not able to find any specimens labelled as *signatus* after careful checking of the USNM collections. Bergroth (1898) proposed the replacement name *bakeri* for the preoccupied *signatus*. Our use of the name *bakeri* is based on specimens identified by H. H. Knight, which are clearly conspecific with *decolor*. We therefore treat *bakeri* as a junior synonym.

Wheeler and Hoebeke (1982) correctly synonymized *Psallus waldeni* Knight with what they called *albipennis* (Fallén), but our examination of specimens and literature indicates that the senior synonym is in fact *decolor* (Uhler), not *albipennis* (Fallén).

We examined type specimens of *Plagiognathus litoralis* (described from Germany and the Netherlands), *P. abrotani* (from the Hamburg Botanical Gardens), and *P. larvae* (from Kurile Islands), as well as many additional specimens, and found these nominal taxa to be conspecific with *decolor* from North America.

Plagiognathus albipennis var. *extrema* Reuter 1901 (p. 187) was described from several specimens (length 1.75–2.00 mm) collected by J. Sahlberg at "Constantinovskaya" (Konstantinovskaya on River Chu, about 20 km N of Beshkek, Kirgizia). Wagner (1954) examined a female from the University Zoological Museum, Helsinki labelled "Tokmak" (about 60 km E of Beshkek). He designated it as lectotype and considered *Plagiognathus extremus* as a valid

species. Additional single male and female specimens identified as this species were found in the collections in Helsinki together with the lectotype. All of them are labelled "Tokmak," but the male has Sahlberg's code label indicating that it was collected at Constantinovskaya. Other cases of confusion in labelling specimens from these two localities were also encountered. All specimens belong to *E. decolor*.

The identity of *Phytocoris pallidulus* Dahlbom, 1851 is unclear. Reuter (1878) placed this name in synonymy with *P. albipennis*. Wagner (1941) treated *pallidulus* as a valid species, but later (Wagner 1952a) considered it as a pale variety of *P. albipennis* sensu Wagner. *Phytocoris pallidulus* was described from two specimens (apparently a male and a female) collected by Dahlbom at Stensuga, Gotland Island, Sweden, from Umbelliferae. The type specimens are apparently lost; according to R. Danielsson (in litt.), Zoological Museum, Lund University, they cannot be located in the collections of Dahlbom, Thomson, or other pertinent collections. Dahlbom's original description is inadequate for identification and was apparently based on teneral specimens. At least the description can hardly be referred to *E. albipennis* or *E. artemisiae* (*albipennis* sensu Wagner). Lindskog was unable to find either of these species from Gotland Island either in Swedish collections or through intensive personal collecting. The only species of *Europiella* found on Gotland Island is *E. decolor* which is abundant there on *Artemisia absinthium*. But, as Dahlbom's description may refer to some other small Miridae, especially to teneral specimens, we prefer to consider *Phytocoris pallidulus* as a possible synonym of *E. decolor* rather than treat it as a valid species.

***Europiella artemisiae* (Becker),**

NEW COMBINATION

Figs. 9–11, 15

Capsus artemisiae Becker 1864: 487 (n. sp., desc.).

Plagiognathus solani Matsumura 1917: 432 (n. sp., desc.). **NEW SYNONYMY.**

Plagiognathus albipennis var. *obscura* Sahlberg 1920: 167 (n. var., desc.). **NEW SYNONYMY.**

Plagiognathus albipennis (not Fallén 1829): Wagner 1941: 248 (desc., figs.).

Plagiognathus (Poliopterus) albipennis (not Fallén 1829): Wagner 1952a: 198 (key, desc., figs.); Kerzhner 1964: 761 (key, figs.); Kerzhner 1988a: 853 (key, figs.); Li and Zheng 1991: 90 (key, dist., figs.).

Plagiognathus (Poliopterus) gracilis Wagner 1956b: 74 (n. sp., desc., figs.). **NEW SYNONYMY.**

Distribution.—This species is widely distributed in the Palearctic, in the north to Scandinavia and Chukotka. Our examination of collections from Canada and the Western United States indicates that although this species has not previously been recorded from North America, it ranges from Alaska south to montane areas of the northwestern United States (detailed locality records to be published separately).

Host.—Palearctic hosts include *Artemisia vulgaris*, the related *A. montana*, and *A. rubripes*, as well as other species. The only known Nearctic host is *Artemisia ludoviciana*.

Notes.—This is the most common species of *Europiella* in the Palearctic. Wagner (1941) designated a neotype for what he considered to be *Plagiognathus albipennis*. But because Wagner misidentified the species under discussion as *Phytocoris albipennis* Fallén, his neotype(s) belongs to another species, the oldest available name for which appears to *Capsus artemisiae* Becker.

Capsus artemisiae was described from specimens collected by Becker in 1862 at Sarepta in southern Russia, from a plant he identified as *Artemisia fragrans*. This plant species does not grow in the Lower Volga region, so probably Becker collected from another species of *Artemisia*. In the Zoological Institute, St. Petersburg, there are six specimens which were received from Beck-

er: three females (received in 1866), two males (1872), and one female (1874); one additional male collected by Becker was received with the Jakovlev collection. All males belong to *artemisiae* (Becker) (*albipennis* sensu Wagner). The male bearing the number 13737 is designated here as lectotype. In the Naturhistorisches Museum Wien, there are two males received from Becker in 1870 and one female received in 1869. They were examined by Reuter. One male belongs to *artemisiae*, the other to *albipennis*.

Plagiognathus solani Matsumura was described from Sakhalin and Hokkaido. The name was synonymized with *albipennis* sensu Wagner by Miyamoto (1977) and should put in synonymy with *artemisiae* (Becker). Also the varietal name *obscura* (Sahlberg) given to dark specimens from Finland should be placed here in synonymy.

Plagiognathus gracilis was described from Austria and Croatia. The type series was examined by us and paratypes dissected for study of the male genitalia, indicating that *gracilis* is a junior synonym.

NEARCTIC SPECIES

Europiella angulata (Uhler)

Maurodactylus angulatus Uhler 1895: 53 (n. sp., desc.).

Europiella angulata: Knight 1968: 41 (n. comb., disc., dist., host).

Europiella yampae Knight 1968: 43 (n. sp., desc., host). **NEW SYNONYMY.**

Distribution.—Montane western United States.

Hosts.—*Artemisia arbustorum*, *A. dracuncululus*, *A. ludoviciana*, *A. tridentata* (Asteraceae).

Notes.—Uhler (1895) mentioned having examined "Only one specimen . . . a male . . ." [of *angulatus*]. The specimen here recognized as the holotype of *angulata*, in the USNM, fits Uhler's original description, and bears the additional label "*Maurodactylus angulatus* Uhl."

Examination of the male genitalia of the

holotype of *angulatus* and paratype males of *E. yampae* Knight from the type locality indicates that the two are synonymous.

Europiella artemisiae (Becker), see above.

***Europiella carvalhoi* Schuh,**

NEW SPECIES

Figs. 1–5

Diagnosis.—Recognized by the light coloration of the dorsum with pale simple setae and weakly-flattened, recumbent, sericeous setae, the elongate oval body shape, antennal segment one black, segment two black basally and progressively lighter distally, and the form of the male genitalia, the vesica with two relatively short apical spines of nearly equal length, the more ventral spine with a small notch at the apex. *Europiella carvalhoi* is most similar among described species in body form and coloration to *E. unipuncta* Knight which has more differently formed vesical spines and *E. signicornis* Knight which has totally pale antennae.

Description.—*Male*: Dorsum, including membrane pale, white to tan, tinged with green; neck (when visible) castaneous; thoracic pleuron and venter and pregenital abdominal segments weakly infuscate, pygophore somewhat darker; antennal segment one black, segment two black proximally, progressively lighter distally, segments three and four weakly infuscate; legs weakly infuscate, tibiae narrowly black at femoral articulation, tibial spines black with black bases; femora with a few diffuse scattered infuscate areas.

Dorsum densely clothed with reclining pale simple setae and weakly flattened, recumbent, sericeous setae.

Body elongate ovoid; frons bulging; eyes globular, touching anterior margin of pronotum; posterior margin of vertex sinuous.

Pygophore very large, occupying well more than half of abdomen; vesica with two relatively short apical spines of nearly equal length, the more ventral with a small notch at the apex (Figs. 1–3); left paramere as in Fig. 5; right paramere as in Fig. 4.

Measurements:

	Apex tylus —cuneal fracture	Width head	Inter- ocular space	Width pro- notum	Length antennal segment 2
M 8	1.87–2.11	0.67–0.73	0.41–0.47	0.86–0.96	0.60–0.70
F 8	1.65–2.07	0.66–0.74	0.43–0.49	0.82–1.00	0.50–0.68

Holotype.—male, USA: Wyoming: *Big Horn Co.*: 27 mi. W Burgess Jct. on Rt. 14, 7700 ft., Aug. 12, 1986, Schuh, Schwartz, and Stonedahl; *Artemisia tridentata* Nutt. (Asteraceae); deposited in the AMNH.

Paratypes.—3 males, 9 females, same data as holotype (AMNH, OSU, USNM). USA: Nevada: *Washoe Co.*: 7 mi. W of Vya toward Decarville, 1800 m, July 2, 1979, R. T. Schuh and B. M. Massie, ex *Artemisia* sp. (not *tridentata*) (Asteraceae) (AMNH), 5 males, 9 females. Oregon: *Jackson Co.*: Ashland, 6500 ft., September 24, 1968, Oman (OSU), 4 males, 13 females; 1 mi. below summit of Mt. Ashland, 6500 ft., September 24, 1968, J. D. Lattin (OSU), 7 males, 7 females. *Umatilla Co.*: 2 mi. W Tollgate, 4600 ft., August 4, 1986, Schuh, Schwartz, and Stonedahl, *Artemisia tridentata* Nutt. (Asteraceae) (AMNH, USNM), 32 males, 59 females. *Wheeler Co.*: 2 mi. W Mitchell on Rt. 26, June 22, 1979, M. D. Schwartz, G. M. Stonedahl, ex *Artemisia tridentata* (AMNH), 7 males, 20 females; Mitchell, June 22, 1979, R. T. Schuh, ex *Artemisia tridentata wyomingensis* (AMNH), 2 males, 8 females.

Hosts.—*Artemisia tridentata*, *Artemisia tridentata wyomingensis* (Asteraceae).

***Europiella consors* (Uhler),**

NEW COMBINATION

Maurodactylus consors Uhler 1895: 53 (n. sp., desc.).

Europiella fuscicornis Knight 1969: 82 (n. sp., desc., host). **NEW SYNONYMY.**

Europiella basicornis Knight 1970: 230 (n. sp., desc.). **NEW SYNONYMY.**

Distribution.—Western North America.

Hosts.—*Artemisia dracunculus*, *A. filifolia*, *A. ludoviciana ludoviciana*, *A. tridentata*,

Chrysothamnus nauseosus, *C. parryi*, *C. viscidiflorus*, *C. sp.* (Asteraceae).

Notes.—Uhler (1895) described *consors* on the basis of “one specimen, a male . . . from Colorado.” We have examined a specimen in the USNM which fits Uhler’s original description, and bears the label “*Mauroidactylus consors* col. Uhler.” We therefore have assumed that it is the specimen originally examined by Uhler. Dissections of specimens which are almost certainly conspecific indicate that this is actually a species of *Europiella* rather than belonging to the European *Mauroidactylus* Reuter, and it is therefore transferred.

Examination of the holotypes of *Europiella basicornis* Knight and *E. fuscicornis* Knight, a large amount of additional material, and many dissections of the male genitalia, indicate that these two nominal species represent the same species and are both junior synonyms of *consors*.

Europiella decolor (Uhler), see above.

Europiella pilosula (Uhler)

Atomoscelis pilosulus Uhler 1893: 377 (n. sp., desc.).

Tuponia subnitida Uhler 1895: 45 (n. sp., desc.). **NEW SYNONYMY.**

Psallus pilosulus: Van Duzee 1915: 118 (list, n. comb.).

Microphylidea pallens Knight 1968: 29 (n. sp., desc.). **NEW SYNONYMY.**

Europiella pilosula: Knight 1968: 44 (n. comb., note).

Europiella flavicornis Knight 1969: 82 (n. sp., desc., host). **NEW SYNONYMY.**

Europiella pallida Knight 1969: 83 (n. sp., desc., host). (Syn. by Stonedahl 1990:79).

Europiella albata Knight 1969: 85 (n. sp., desc.). **NEW SYNONYMY.**

Distribution.—Interior western United States.

Hosts.—*Artemisia filifolia*, *A. tridentata* (Asteraceae).

Notes.—Uhler (1893) described *Atomoscelis pilosulus* on the basis of “Several spec-

imens . . . collected on *Bigelovia* near American Fork, June 22.” We have located in the USNM 2 specimens, a male and a female, that bear the correct data. A third specimen, a female, was actually a misidentified example of *unipuncta* Knight.

Comparison of the male genitalia of *pilosula* with those of the holotype of *Microphylidea pallens* Knight indicates that the two are synonymous. Comparison of the male genitalia of *pilosula* with those of topotypic males collected on the same date as the holotype of *Europiella albata* Knight indicates that the two are synonymous. Comparison of *pilosula* with *E. flavicornis* Knight indicates that the two are synonymous.

Uhler (1895) described *Tuponia subnitida* from Steamboat Springs, Colorado, on the basis of two specimens. We searched the collections of the USNM, but were unable to find any specimens which appeared to have been examined by Uhler. We did find, however, specimens from Ft. Garland, Colorado, collected by H. H. Knight and labelled by him as “*Tuponia subnitida* Uhler, compared with type.” These specimens agree closely with the Uhler’s description of *subnitida* with the exception of the fact that antennal segment one is not “blackish” as indicated by Uhler, but rather only weakly brown. All other attributes, including size, shape, and distribution agree, however, and we are therefore treating *subnitida* as a synonym of *pilosula*.

Europiella signicornis Knight

Europiella signicornis Knight 1969: 84 (n. sp., desc., host).

Distribution.—Northern Arizona.
Host.—*Artemisia sp.* (Asteraceae).

Europiella stigmosa (Uhler)
Figs. 12–14

Agalliastes stigmosus Uhler 1893: 379 (n. sp., desc.).

Europiella stigmosa: Reuter 1909: 84 (disc.); Knight 1968: 43 (in part, dist., host).

Distribution.—Western United States.

Hosts.—*Artemisia californica*; *Artemisia tridentata* (Asteraceae).

Notes.—In his original description, Uhler said that “Specimens [of *stigmosa*] were collected at American Fork, June 22.” We located three specimens in the USNM which bear these data. One of these, a female, bears an identification label which appears to have been written by Uhler as well as a “lectotype” label affixed by H. G. Barber, although we can find no evidence that Barber ever published this designation. The other two, both males, were in the collection of H. H. Knight and bear his identification labels, but there is no direct evidence that they are part of the material examined by Uhler. We have not designated a lectotype, but neither do we consider the identity of *stigmosa* to be in question.

Europiella umbrina Reuter

Europiella umbrina Reuter 1909: 85 (n. sp., desc.).

Europiella similis Knight 1969: 81 (n. sp., desc., host). **NEW SYNONYMY.**

Europiella stigmosa: Knight 1968: 43 (mis-identification).

Distribution.—Western United States.

Hosts.—*Artemisia californica*, *A. nova*, *A. tridentata* (Asteraceae).

Notes.—Henry and Wheeler (1988) listed *umbrina* Reuter as a synonym of *stigmosa*. Comparison of the types of *stigmosa*, *umbrina*, and *similis* Knight, and the male genitalia of these nominal species, indicates that *umbrina* is distinct from *stigmosa*, but that *similis* is synonymous with *umbrina*.

Europiella unipuncta Knight

Europiella unipuncta Knight 1968: 44 (n. sp., desc., host).

Distribution.—Interior western United States.

Host.—*Artemisia tridentata* (Asteraceae).

Species transferred from *Europiella* to *Megalopsallus* Knight 1927

- albipubescens* Knight 1968 (*Europiella*), **NEW COMBINATION**
arizonae Knight 1968 (*Europiella*), **NEW COMBINATION**
balli Knight 1968 (*Europiella*), **NEW COMBINATION**
brevicornis Knight 1968 (*Europiella*), **NEW COMBINATION**
franseriae Knight 1969 (*Europiella*), **NEW COMBINATION**
grayiae Knight 1968 (*Europiella*), **NEW COMBINATION**
humeralis Van Duzee 1923 (*Sthenarus*), **NEW COMBINATION**
knowltoni Knight 1970 (*Europiella*), **NEW COMBINATION**
lycii Knight 1968 (*Europiella*), **NEW COMBINATION**
montanae Knight 1968 (*Europiella*), **NEW COMBINATION**
monticola Knight 1968 (*Europiella*), **NEW COMBINATION**
multipunctipes Knight 1970 (*Europiella*), **NEW COMBINATION**
nicholi Knight 1968 (*Europiella*), **NEW COMBINATION**
nigrofemoratus Knight 1968 (*Europiella*), **NEW COMBINATION**
punctipes Knight 1968 (*Europiella*), **NEW COMBINATION**
rubicornis Knight 1968 (*Europiella*), **NEW COMBINATION**
rufiventris Knight 1968 (*Europiella*), **NEW COMBINATION**
sarcobati Knight 1969 (*Europiella*), **NEW COMBINATION**
sparsus Knight 1969 (*Europiella*), **NEW COMBINATION**
stitti Knight 1968 (*Europiella*), **NEW COMBINATION**
viridiventris Knight 1968 (*Europiella*), **NEW COMBINATION**

PALEARCTIC SPECIES

Europiella albipennis (Fallén), see above.

***Europiella alpina* (Reuter 1875),**

NEW COMBINATION

Plagiognathus alpinus Reuter 1875: 56 (n. sp., descr.); Kerzhner 1964: 761 (key, figs.).

Psallus pallidus Reuter 1880: 24 (n. sp., descr.) (syn. by Wagner 1958).

Plagiognathus alpinus f. *nigrescens* Stichel 1934: 279 (n. form, key).

Plagionathus alpinus f. *simplex* Stichel 1956: 332 (n. form, key).

Psallus (*Psallus*) *alpinus*: Wagner 1956a: 298 (disc., figs.); Wagner 1958: 325 (syn.).

Plagiognathus (*Chlorillus*) *alpinus*: Kerzhner 1962: 384 (disc., figs.).

Chlorillus alpinus: Wagner 1963b: 155 (disc.); Wagner 1975: 13 (desc., key, figs.).

Distribution.—Europe, western Palearctic Asia. Contrary to Wagner (1975), this species is not recorded from North America.

Host.—*Mentha aquatica* (Lamiaceae).

Europiella artemisiae (Becker), see above.

***Europiella canoflavida* (Qi and Nonnaizab),**

NEW COMBINATION

Plagiognathus (*Poliopterus*) *canoflavidus* Qi and Nonnaizab 1993: 31 (n. sp., desc., figs.).

Distribution.—China: Inner Mongolia.

Note.—We have not examined specimens of this species. It is probably synonymous with either *E. decolor* or *E. artemisiae*, based on the published figures of the male genitalia.

Europiella decolor (Uhler), see above.

***Europiella herbaalbae* (Wagner),**

NEW COMBINATION

Plagiognathus (*Poliopterus*) *herbaalbae* Wagner 1969a: 13 (n. sp., desc., figs.); Wagner 1975: 29 (desc., key, figs.).

Distribution.—Algeria, Libya, Tunisia.

Host.—*Artemisia herba-alba* (Asteraceae).

***Europiella gilva* (Kulik),**

NEW COMBINATION

Plagiognathus gilvus Kulik 1965: 155 (n. sp., desc., figs.); Kerzhner 1979: 54 (key, syn., figs.); Kerzhner 1988a: 855 (key, figs.).

Chlorillus pilosus Wagner 1969b: 34 (n. sp., desc., figs.).

Distribution.—Russia (Primorsk Territory). Records from Korea (Josifov and Kerzhner 1972) refer to *E. livida*.

Host.—*Rabdosia excisa* (Lamiaceae).

***Europiella kiritschenkoi* (Kulik),**

NEW COMBINATION

Plagiognathus kiritschenkoi Kulik 1975: 587 (n. sp., desc., figs.); Kerzhner 1979: 55 (key, figs.); Kerzhner 1988a: 855 (key, figs.); Li and Zheng 1991: 90 (key, distr., figs.).

Distribution.—Russia (Primorsk Territory); China (Heilongjiang).

Host.—*Artemisia* sp. (Asteraceae).

***Europiella leucopus* (Kerzhner),**

NEW COMBINATION

Plagiognathus leucopus Kerzhner 1979: 50 (n. sp., desc., figs.); Kerzhner 1988a: 854 (key, figs.); Li and Zheng 1991: 90 (key, distr., figs.).

Distribution.—Russia (Primorsk Territory); China (Heilongjiang).

***Europiella livida* (Reuter),**

NEW COMBINATION

Plagiognathus lividus Reuter 1906: 73 (n. sp., desc.); Kerzhner 1979: 51 (part; distr., figs.); Kerzhner 1988a: 855 (key, figs.); Li and Zheng 1991: 91 (key, distr., figs.).

Distribution.—Russia (Amur Province; Primorsk Territory); Korea; eastern China (to Sichuan).

Host.—*Artemisia gmelinii* (Asteraceae).

***Europiella lividella* (Kerzhner),
NEW COMBINATION**

Plagiognathus lividellus Kerzhner 1979: 51 (n. sp., desc., figs.); Kerzhner 1988a: 855 (key, figs.); Li and Zheng 1991: 90 (key, distr., figs.).

Distribution.—Russia (Far East); China (Heilongjiang; Fujian, Ningxia).

Hosts.—*Artemisia montana*, *A. rubripes*, and *A. vulgaris* (Asteraceae).

***Europiella miyamotoi* (Kerzhner),
NEW COMBINATION**

Plagiognathus lividus (not Reuter 1906): Miyamoto 1969: 90 (desc., figs.); Kerzhner 1979: 54 (part).

Plagiognathus miyamotoi Kerzhner 1988a: 955 (n. sp., key, figs.); Kerzhner 1988b: 64 (desc.).

Distribution.—Russia (Sakhalin and Kurile Islands); Japan.

Host.—*Artemisia montana* (= *gigantea*) (Asteraceae).

***Europiella moesta* (Reuter),
NEW COMBINATION**

Plagiognathus albipennis var. *moesta* Reuter 1906: 75 (n. var., desc.).

Plagiognathus (Poliopterus) moestus: Wagner 1954: 75 (n. stat., desc., figs.); Li and Zheng 1991: 90 (key, distr., figs.).

Distribution.—China: Sichuan. Collected at high altitudes.

Host.—Unknown.

Note.—This species is very close to *E. artemisiae* and does not differ from it in the structure of the male genitalia, except in size. It is, however, markedly larger, very dark, and strongly shining.

***Europiella nigrocunealis* (Putshkov),
NEW COMBINATION**

Plagiognathus (Poliopterus) nigrocunealis Putshkov 1975: 283 (n. sp., desc.).

Distribution.—Armenia; Azerbaijan.

Host.—*Tanacetum vulgare* (Asteraceae).

***Europiella ovatula* (Wagner),
NEW COMBINATION**

Plagiognathus (Poliopterus) ovatulus Wagner 1952b: 41 (n. sp., desc., figs.); Putshkov 1971: 35 (dist., host); Wagner 1975: 31 (key, desc., figs.).

Distribution.—Croatia; Ukraine.

Hosts.—*Helichrysum angustifolium*, *H. arenarium* (Asteraceae).

Note.—This species does not differ from *E. artemisiae* in the structure of the aedeagus, but shows marked differences in size and color, and because the host plants are also different, we regard it as a separate species. It is closely related to the less well-known *E. tomentosa* and possibly synonymous with it.

***Europiella strawinskii*
(Sienkiewicz),
NEW COMBINATION**

Plagiognathus (Poliopterus) strawinskii Sienkiewicz 1986: 373 (n. sp., desc., figs.).

Distribution.—Romania.

Note.—Probably a synonym of *E. decolor*.

***Europiella strigifemur*
(Wagner),
NEW COMBINATION**

Europiella (Poliopterus) strigifemur Wagner 1964: 70 (n. sp., desc., figs.); Wagner 1975: 28 (desc., key, figs.).

Distribution.—Libya.

Host.—Unknown.

Note.—We examined only female specimens of this species. They clearly belong to the group of species closely related to *Europiella albipennis*.

***Europiella tomentosa* (Reuter),
NEW COMBINATION**

Plagiognathus tomentosus Reuter 1888: 236 (n. sp., desc.).

Plagiognathus (Poliopterus) ovatulus (not

Wagner 1952b); Wagner and Weber 1964: 415 (desc.).

Plagiognathus (Poliopterus) tomentosus: Wagner 1975: 31 (key, desc.).

Distribution.—Southern France; Sicily.
Host.—*Helichrysum* spp. (Asteraceae).

COMMENTS ON ADDITIONAL PALEARCTIC SPECIES

Psallus argyrotrichus Fieber 1861.

This taxon was described from Germany and Spain. Wagner (1963a) examined four specimens from Spain belonging to the collections of Meyer-Dür (now in the AMNH) identified as *P. argyrotrichus*, designating one of them as the lectotype. He transferred *argyrotrichus* to *Plagiognathus (Poliopterus)* and placed *P. decolor* Lindberg in synonymy with it. We re-examined the material studied by Wagner and have determined that the specimens are actually *Compsidolon crotchi* (Scott). Contrary to what Wagner (1963a) indicated, the identification label attached to the specimens is written by Meyer-Dür, not by Fieber. Although all of the specimens are badly rubbed, they have remnants of black setae on the hemelytra, which contradicts Fieber's original description. It is clear that the specimens examined by Wagner do not belong to the type series of Fieber and were misidentified. The identity of *P. argyrotrichus* needs clarification.

Plagiognathus bicolor (Jakovlev 1880).

This species, the only representative of *Plagiognathus (Zophocnemis)* Kerzhner 1962, resembles some species of *Europiella* in coloration and size, but male genitalia are typical of *Plagiognathus* sensu stricto, and we therefore place it in that genus.

Plagiognathus decolor Lindberg 1934.

This species was described on the basis of four females from Spain (Lindberg 1934). Wagner (1963a) placed the taxon in synonymy with *Psallus argyrotrichus* Fieber and transferred *argyrotrichus* to *Plagiognathus (Poliopterus)*. The synonymy, taxonomic

position, and consequent possible secondary homonymy of *P. decolor* Lindberg with *Europiella decolor* (Uhler) need re-examination. See also notes under *Psallus argyrotrichus*.

Plagiognathus flavipes Reuter 1875.

This species is known from southwestern Europe, living on *Lonicera*. Wagner (1952a) placed it in *Plagiognathus (Poliopterus)*. We examined about 10 specimens, including some from Corsica, the type locality, identified by Puton. The structure of the male genitalia is typical of *Plagiognathus* sensu stricto.

Plagiognathus servadeii Wagner 1972.

Wagner (1972) described this species from northern Italy and placed it in *Plagiognathus (Poliopterus)*. Judging from the figure of the right paramere accompanying the original description, it does not belong to *Europiella*; the structure of the aedeagus will not clearly place the species in either *Europiella* or *Plagiognathus*, and we therefore provisionally leave the species in *Plagiognathus* sensu stricto.

Plagiognathus pallescens Zheng and Li 1991.

This species was described (Zheng and Li 1991) from China (Sichuan). The type series (of which we examined three specimens labelled as paratypes), is mixed, as could be presumed from the great variability in the length, males 3.30–4.28, females 3.02–3.22. One male specimen labelled as a paratype from "Szechwan, 2000–2300 m, 10.IX.1963," measures 4.5 mm in length and contradicts the original description regarding length and collecting data; it bears a handwritten paratype label where the other two specimens available for our examination have printed labels. The genitalia of this specimen are of the species figured with the original description. A male from "Hsiao-chin" is 4.2 mm long, has genitalia very different in structure from the first discussed specimen, and is possibly not even congeneric with it. Neither of these specimens belong to *Europiella* and could only be placed in *Plagiognathus*

sensu stricto with difficulty. The third specimen is a female measuring 3.2 mm in length, from "Pao-shing, 950–1350 m, 1.VII.1963," these data matching the original description except for the date; it possibly belongs to the group of species closely related to *alpina*.

Salicarus bimaculatus Zheng and Li 1991.

This species was described from Sichuan, China. Judging from the size variability indicated in the original description (2.09–3.5 mm), it may be based on a mixed series. Clearly, this is not a species of *Salicarus*, but judging from the description closely resembles species closely related to *albipennis*, especially *E. artemisiae*.

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THE FIRST RECORD FOR *BOTHYNOTUS PILOSUS* (BOHEMAN)
(HEMIPTERA; MIRIDAE) IN THE NEARCTIC REGION

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Abstract.—The mirid species *Bothynotus pilosus* (Boheman) is reported from the Nearctic Region for the first time. This species, formerly known only from the Palearctic Region is recorded from Yukon and British Columbia. It is considered a natural Beringian element.

Key Words: Heteroptera, Miridae, *Bothynotus pilosus*, Nearctic Region

During a study of the Heteroptera of the Yukon, the deraeocorine mirid *Bothynotus pilosus* (Boheman) was collected in three localities. It has also been found in one locality in northern British Columbia. The distribution suggests that this species is a natural Beringian element in the Nearctic fauna, and not an introduced species.

Male and female of the species are redescribed and illustrated, and notes given to distinguish it from other members of the genus in the New World.

Bothynotus pilosus (Boheman)

Phytocoris pilosus Boheman 1852: 68.

Capsus fairmairii Signoret 1852: 542. Syn. by Reuter 1873: 8.

Capsus horridus Mulsant and Rey 1852: 132. Syn. by Reuter 1875: 91.

Bothynotus minki Fieber 1864: 77. Syn. by Puton 1873: 24.

Bothynotus kiritschenkoii Lindberg 1934: 20. Syn. by Josifov and Kerzhner 1972: 152.

Redescription (measurements for mean and range in mm; range in parentheses).—*Macropterous male* (Fig. 1): Oblong, thickly clothed with more or less erect, long, brown setae. Head, pronotum (including

collar and calli), scutellum and thoracic venter black and shiny; head posteriorly and ventrally sometimes reddish. Antennae brown; rostrum pale brown with tip almost black. Hemelytra with corium uniform brown; cuneus dark brown; membrane dusky brown. Legs pale brown, with femora often yellowish; apex of tibiae and whole of tarsi dark brown. Abdominal venter pale to dark brown.

Head smooth and shiny; head width 0.89 (0.83–0.95), vertex width 0.53 (0.50–0.55); first antennal segment about $\frac{3}{4}$ width of vertex; second antennal segment cylindrical and not incrassate, distinctly longer than head width; third and fourth antennal segments much thinner than second, combined length of third and fourth segments subequal to or slightly longer than second; all antennal segments with both short and long setae, shorter setae dense, oblique and about as long as width of second antennal segment, longer setae more scattered, more erect and over twice as long as width of second antennal segment; antennal measurements I 0.43 (0.40–0.45); II 1.17 (1.00–1.27); III 0.63 (0.53–0.70); IV 0.48 (0.43–0.57); rostrum reaching to middle coxae, length 1.16 (1.13–1.20).

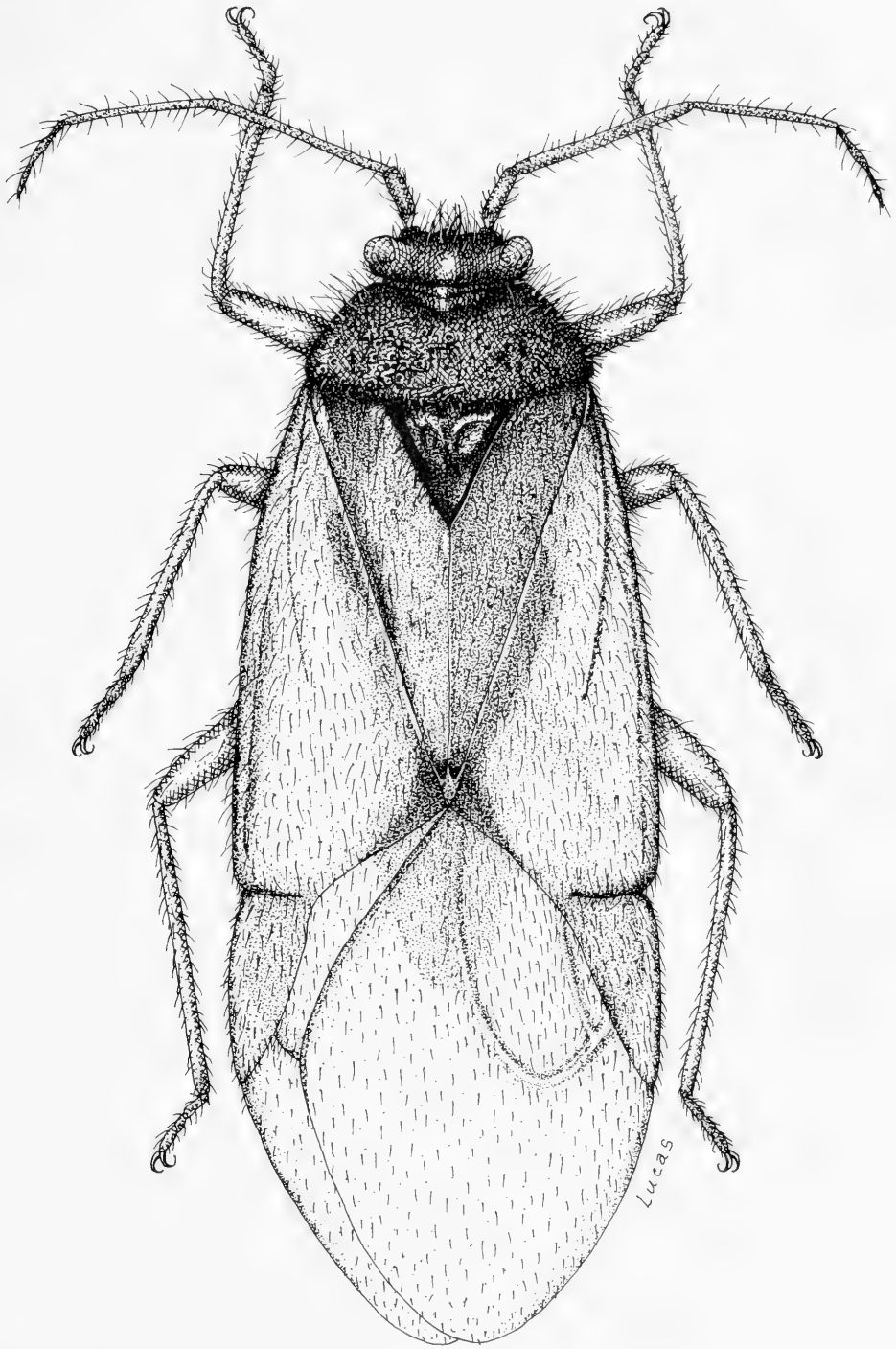


Fig. 1. *Bothynotus pilosus*, male.

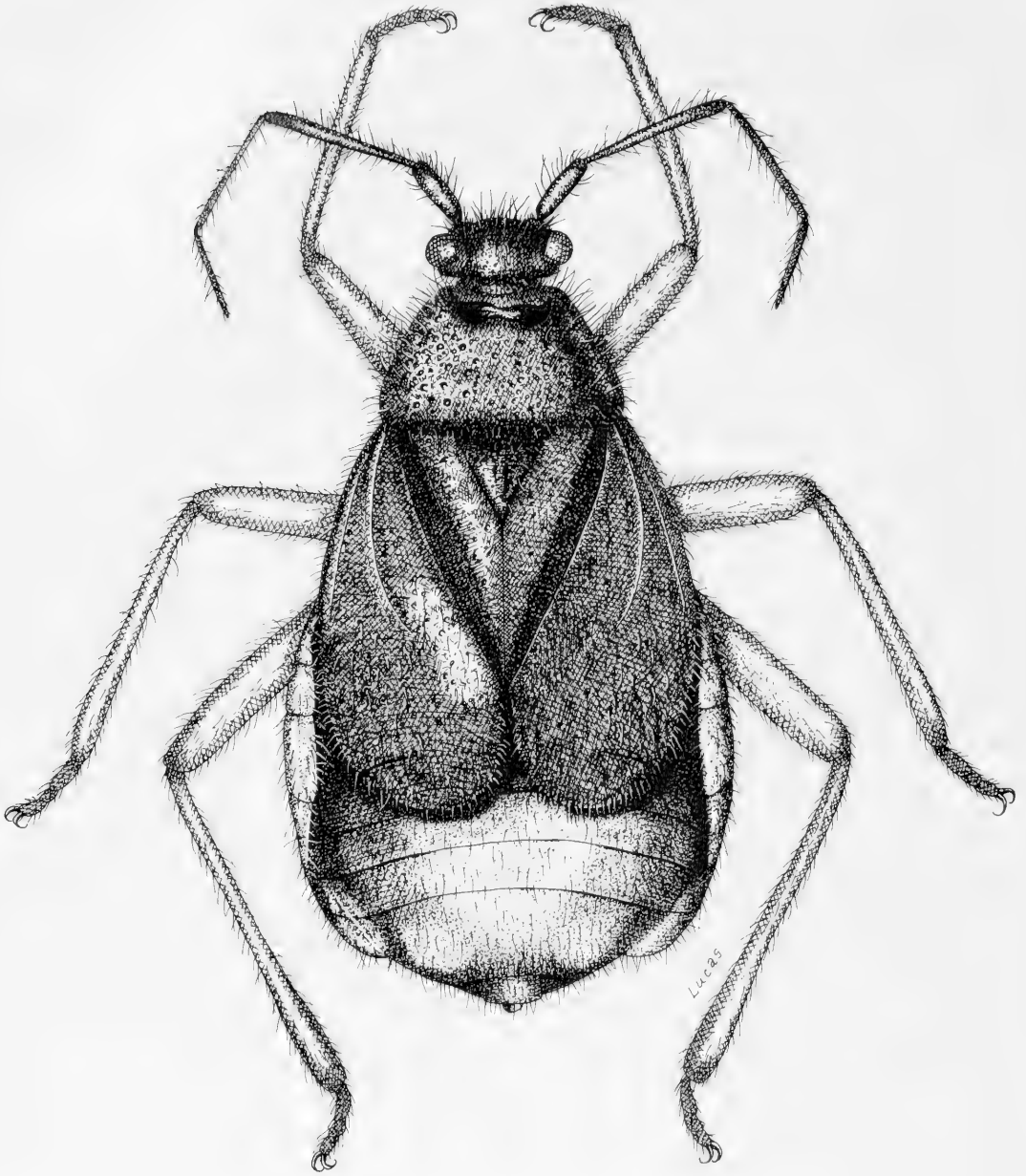


Fig. 2. *Bothynotus pilosus*, female.

Pronotum distinctly punctate; calli smooth and sunken; pronotal length 0.98 (0.87–1.03), pronotal width 1.61 (1.37–1.77), 1.2–1.6 \times greater than length of second antennal segment. Scutellum shiny, transversely wrinkled and appearing some-

what swollen. Meso- and metapleura smooth and shiny. Corium and clavus shiny and appearing roughened, but not distinctly punctate; membrane shiny and reticulately wrinkled; hemelytra extending well beyond end of body, apex of cuneus reaching be-

yond end of abdomen. Tibiae with shorter oblique setae equal to width of tibia, and longer, more erect setae much longer than width of tibia. Total length 5.70 (5.30–6.10).

Brachypterosus female (Fig. 2): Oval, thickly clothed with long, erect, brown setae. Body both above and below, including hemelytra, collar and calli, shiny black; head posteriorly and ventrally distinctly red; antennae brown, with first segment except extreme base and apex pale yellow. Legs brown with femora and tibiae pale yellow.

Structured as for male, except as follows: head width 0.99 (0.97–1.00), vertex width 0.59 (0.57–0.63); antennal measurements I 0.44 (0.43–0.45); II 1.05 (1.00–1.13); III 0.67 (0.63–0.70); IV 0.51 (0.50–0.53); rostral length 1.32 (1.30–1.33).

Pronotum closely and coarsely punctate; pronotal length 0.86 (0.77–0.92), pronotal width 1.57 (1.50–1.67). Scutellum transversely wrinkled, with raised central longitudinal line; meso- and metapleura transversely wrinkled. Hemelytra lacking membrane, and attaining tergum IV; costal margin of corium strongly convex throughout; surface of corium, clavus and cuneus coarsely roughened, but not distinctly punctate. Total length 4.40 (3.80–4.80).

North American material examined: 1 ♂, BRITISH COLUMBIA, Summit Lk., 16.viii.1982 (L. A. Kelton); 1 ♂, YUKON, mi 51, Dempster Hwy., 18–27.vii.1973 (G. and D. M. Wood); 1 ♂, YUKON, Klondike R., Dempster Corner, 1 km W, 63°59'N 138°48'W, 20.vii.1982 (G. G. E. Scudder); 7 ♂ 5 ♀, YUKON, Old Crow, in root mats of *Polemonium pulcherrimum* Hook., 14.vii.1983 (S. G. Cannings); 1 ♀, YUKON, Old Crow, fall trap, S-facing *Artemisia* slope, 4–19.vii.1983 (S. G. Cannings); 1 ♂, YUKON, Old Crow, pitfall trap, boreal forest clearing, 21–26.vii.1984 (S. G. Cannings). In the Canadian National Collection (CNC), Ottawa, ON; Spencer Entomological Museum, University of British Columbia, Vancouver, BC; and Department of Entomology, Oregon State University, Corvallis, OR.

Discussion: The above specimens were compared with material determined as this species by H. Lindberg in 1958 with data: AL. Eckero Torp, 14.vii.1943 (H. Lindberg) [CNC]. Dissection of the male genitalia by M. D. Schwarz showed no noticeable differences.

Bothynotus pilosus will key to complete 9 in the key to the New World species of *Bothynotus* Fieber by Henry (1979). Like *B. barberi* Knight, the calli in *B. pilosus* appear sunken into the pronotum. However, the pronotal collar and calli are fuscous in *B. pilosus* and not pale orange as in *B. barberi*. The male in *B. pilosus* with an average total length of 5.70 mm is also much larger than *B. barberi* with length 3.44 mm. *Bothynotus pilosus* with black collar and calli, with black procoxal cleft, and head anteriorly black, is clearly distinct from both *B. floridanus* Henry and *B. mexicanus* Henry.

Bothynotus pilosus was reported by Carvalho (1957) from Austria, Belgium, Corfu, Finland, France, Great Britain, Germany, Greece, Hungary, Italy, Netherlands, Russia, Scandinavia, and Switzerland. Stichel (1956) also listed Czechoslovakia and Jugoslavia, and Josifov and Kerzhner (1972) added Korea.

Stichel (1956) reported the species from *Pinus sylvestris* L. and *Picea excelsior* Lk., but Woodroffe (1970) considered that moss is the primary habitat of this species, at least in Scotland, where he collected both adults and larvae in the moss *Hypnum cupressiforme* Hedw. The fact that *B. pilosus* in the Yukon was collected in root mats of *Polemonium pulcherimum* (Polemoniaceae), and also in pitfall traps, confirms that the members of the genus *Bothynotus* are largely ground-dwelling as suggested by Henry (1979). However, *B. pilosus* was also taken by sweeping in the Yukon. Southwood and Leston (1959) also report that this species can often be collected by sweeping in the evenings in the British Isles.

Southwood and Leston (1959) observed that the species overwinters in the egg stage,

and that adults occur from the last weeks in June until early October in Britain. All Nearctic specimens were collected in July and August, so the life cycle may be the same in the New World.

ACKNOWLEDGMENTS

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**METASEQUOIAMIRIS CARVALHOI, A NEW GENUS AND SPECIES OF
CONIFER-INHABITING MIRINI FROM CHINA
(HEMiptera: MIRIDAE: MIRINAE)**

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Abstract.—*Metasequoiamiris carvalhoi*, a new genus and species of mirine Miridae from West Hubei Province, China, is described and illustrated. This bug apparently inhabits the conifers *Cephalotaxus fortunei* Hook., *Metasequoia glyptostroboides* Hu and Cheng, and *Torreya* sp. The relationships of the new genus to other Mirini is discussed.

Key Words: Insecta, Hemiptera, Miridae, Mirini, *Metasequoiamiris*, new genus

While sorting unidentified Miridae from the California Academy of Sciences, San Francisco (CAS), I uncovered the first plant bug species known to inhabit *Metasequoia*. This new species of Mirini is reminiscent of *Orthops* Fieber and *Pinalitus* Kelton but has several features that require its placement in a new genus. *Metasequoiamiris carvalhoi*, new genus, new species, is described and documented, and its affinities to related Mirini genera are discussed.

It is appropriate that the recognition of a new genus, apparently the associate of an ancient and rare host plant, be included in this issue honoring our venerable and productive colleague, José C. M. Carvalho.

***Metasequoiamiris* Schwartz,
NEW GENUS
(Figs. 1–19)**

Type species.—*Metasequoiamiris carvalhoi*, new species.

Diagnosis.—Distinguished from other Mirini by the following combination of attributes: wide, pale collar, contrasting in color with dark calli (Fig. 1); campanulate pronotum (Figs. 1, 3); rounded, swollen frons and adjoining jugum, imperceptible dorsal

margin of tylus (Fig. 2); strongly punctate dorsum; nondeflected cuneus; long, sub-erect setae; convergent parempodial apices (Fig. 7); and long, trough-shaped sclerite of vesica (Fig. 14).

Description.—Male. Macropterous; general coloration castanaceous, with pale collar and abdominal sternites; dorsal surface strongly punctate, shining; head and scutellum smooth; dorsal vestiture consisting of uniformly distributed, long, fine, sub-erect, yellow setae; calli without setae, frons with sparse setae; pronotal and hemelytral setae set in punctures (Fig. 3). Head: triangular with tylus obscured by frons and posterior margin straight in dorsal view; frons and temporal area rounded, swollen anterior and dorsal to eyes; dorsal carina obsolete; tylus short with ventral margin not projecting anterior to dorsal junction in lateral view; antecular portion of head shorter than eye height; eye small, gena subequal to half eye height; labium reaching to apex of mesocoxa. Antenna: cylindrical, segments I and II of similar diameter, III and IV slightly narrower; inserted slightly ventral to middle of eye, fossa adjacent to anterior margin of eye; segment I longer than

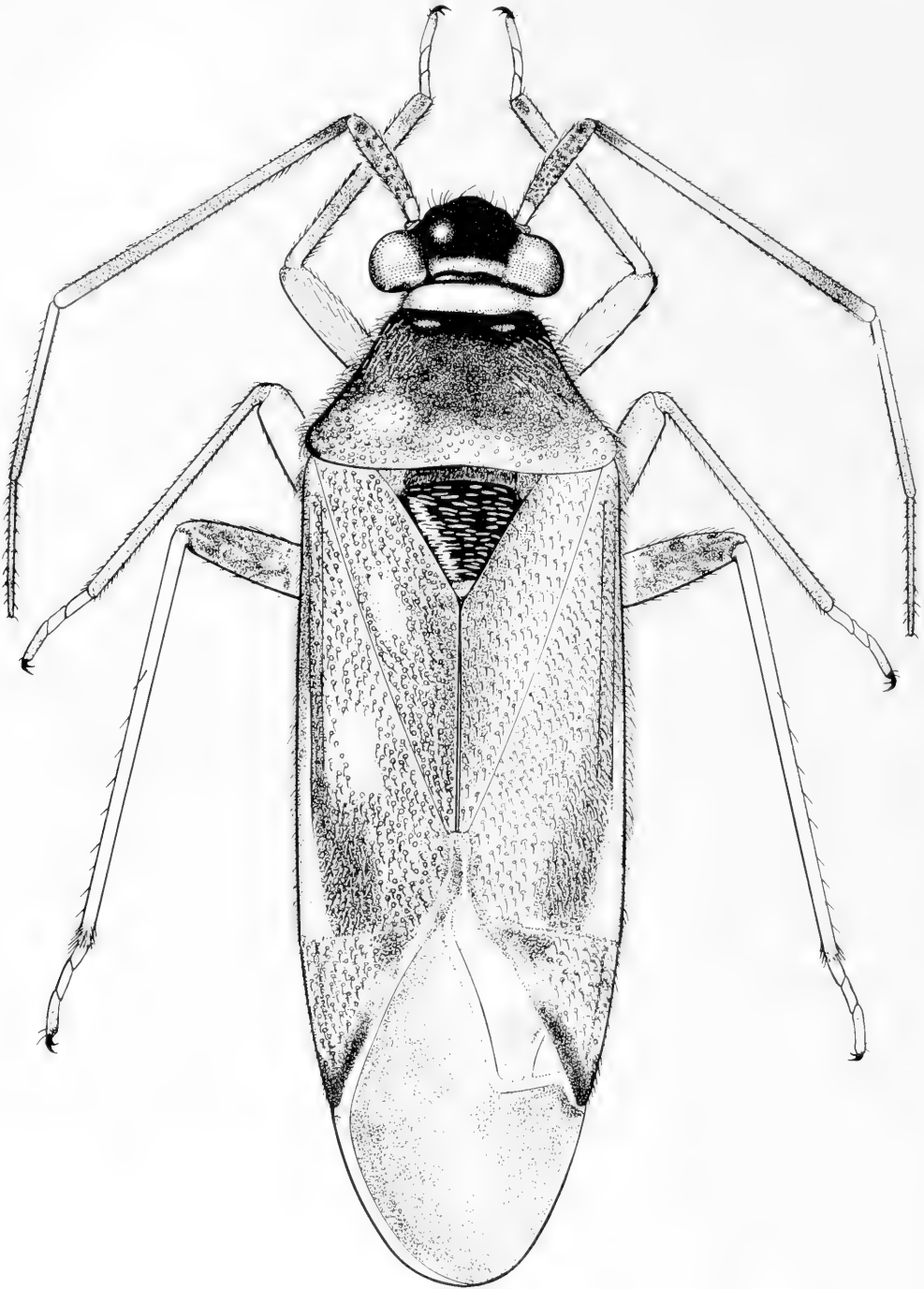
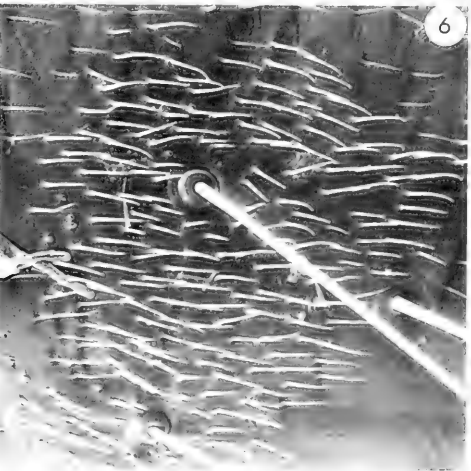
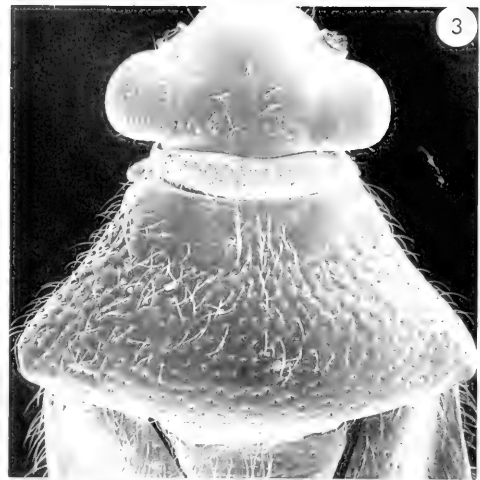
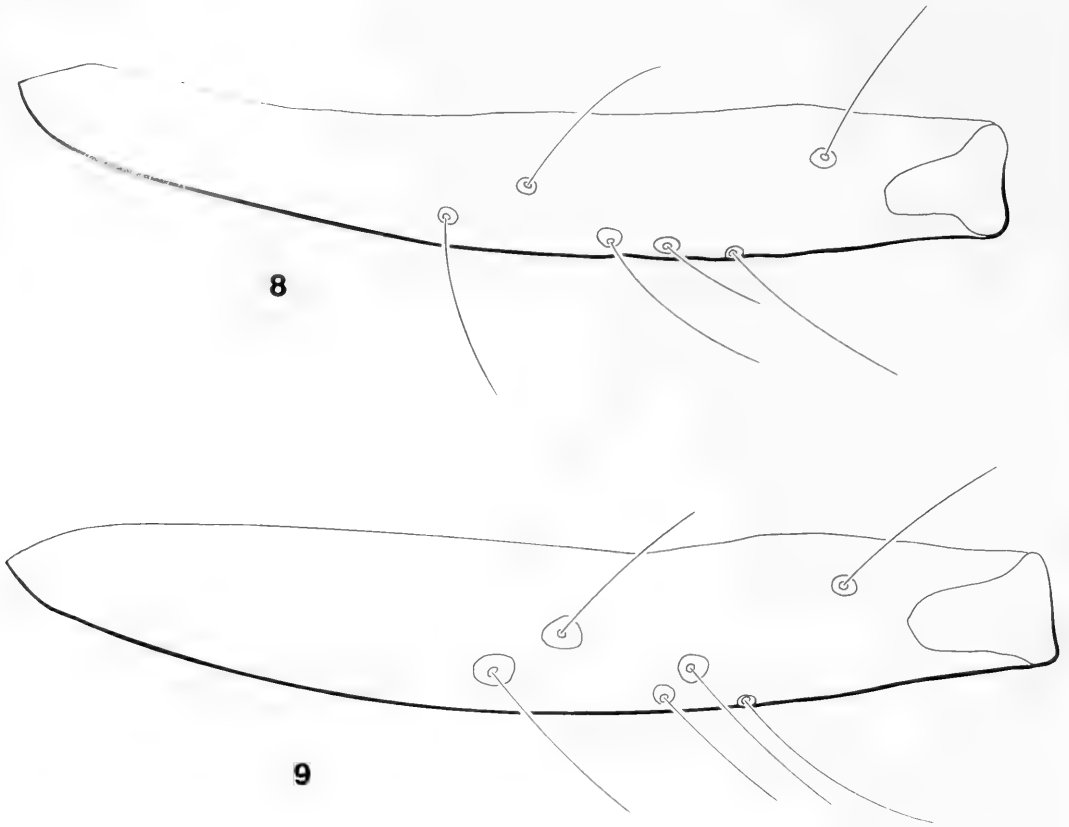


Fig. 1. *Metasequoiamiris carvalhoi*, n. sp., dorsal habitus of male.



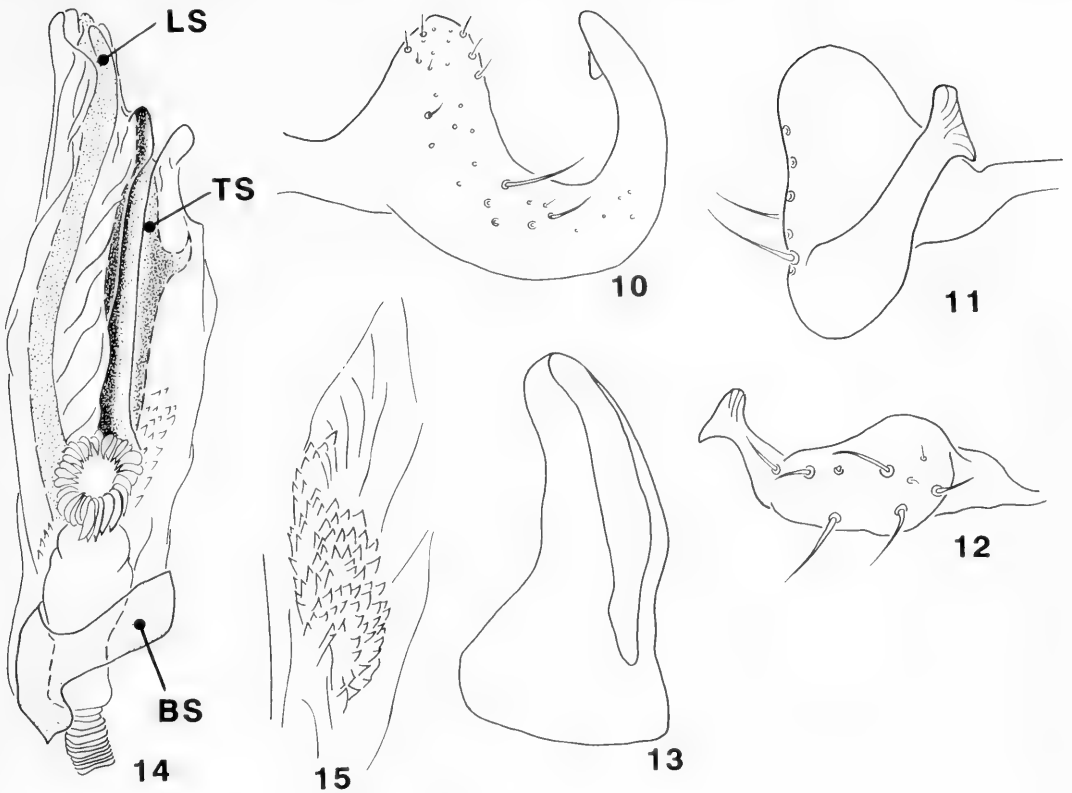
Figs. 2–7. Scanning electron micrographs of *Metasequoiamiris carvalhoi*. 2, head, lateral view; 3, pronotum and head, dorsal view; 4, metathoracic scent efferent system, lateral view; 5, apex of protibia, ventral view; 6, mesofemoral trichobothrium; 7, pretarsus, posterior view (pulvillus, arrow).



Figs. 8, 9. Metafemoral trichobothria of *Metasequoiamiris carvalhoi*, ventral view. 8, male; 9, female.

width of vertex, segment II just longer than posterior width of pronotum, segment III longer than IV; all segments with reclining dark setae, segments III and IV also with a few longer, suberect setae. Pronotum: campanulate; collar wider than width of antennal segment I, with dense trichomae (Fig. 2), anterior margin slightly concave medially; calli flat, separated medially, reaching lateral margins of pronotum. Scutellum: weakly elevated. Metathoracic scent efferent system: triangular evaporative area; peritremal disc small, slightly raised; disc and adjacent metapleuron densely pubescent (Fig. 4). Hemelytra: elongate, parallel-sided, surpassing genital segment in lateral view, declivous at cubitus; embolium obsolete; cuneus about two times as long as broad, not bent ventral to corium; cuneal fracture

small; primary cell much longer than broad, secondary cell narrow. Legs: with moderately distributed, suberect, shining, pale setae; femora slightly fusiform with oval cross-section; metafemora with 6 trichobothria (Fig. 8), trichomae strongly developed (Fig. 6); tibiae cylindrical, protibia with concave apex and comb (Fig. 5); tarsi three-segmented, segment 3 subequal to combined length of 1 and 2; pretarsus with small, curved claws; lamellate parempodia with convergent apices; pulvilli apparently absent (Fig. 7 cf. arrow). Genitalia: *Genital capsule*: without tubercles dorsal to paramere insertions; aperture oval. *Left paramere*: C-shaped (Fig. 10). *Right paramere*: narrow distally (Fig. 12). *Phallosome*: horn-shaped, without apical spines or tubercles, aperture almost reaching base (Fig. 13). *Ve-*



Figs. 10–15. Male genitalia of *Metasequoiamiris carvalhoi*. 10, 11, left paramere. 10, lateral view; 11, distal view; 12, right paramere, lateral view; 13, phallosome, lateral view; 14, 15, vesica. 14, posterior view (BS, basal sclerite; LS, lobal sclerite; TS, trough-shaped distal portion of basal sclerite); 15, anterior view.

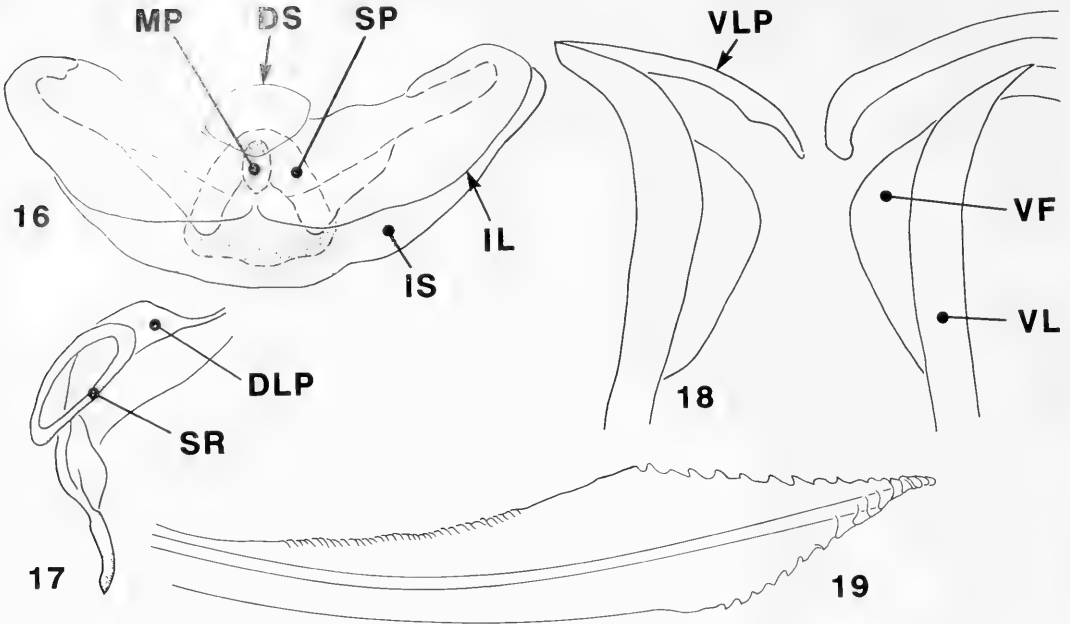
sica: ductus seminis slightly thickened medially; aperture of secondary gonopore oval and complete; basal sclerite trough-shaped and lobal sclerite narrow (Fig. 14).

Female.—Macropterous; similar to male in color and structure, except apex of protibia with deeper concavity. Legs: metafemora with 6 trichobothria (Fig. 9). Genitalia: *Posterior wall*: narrow, with lateral apices strongly recurved (Fig. 16, IS). *Lateral lobe*: absent. *Median process*: present (Fig. 16, MP). *Dorsal structure*: oval (Fig. 16). *Sclerotized rings*: small, flattened oval (Fig. 17, SR). *Dorsal labiate plate*: continuous, narrow and indistinct medially (Fig. 17, DLP). *Ventral labiate plate*: discontinuous (Fig. 18, VLP). *First valvulae*: distal serrations coarse (Fig. 19).

Distribution.—All known specimens are from Lichuan district, West Hubei province, China.

Etymology.—Named for one of the host plants, *Metasequoia glyptostroboides*.

Discussion.—The campanulate pronotum, parallel-sided, elongate hemelytra, nondeflected cuneus, and convergent parmpodia of *Metasequoiamiris* are similar in appearance to the Neotropical orthotyline genus *Falconia* Distant. However the new genus is clearly placed in the Mirini and possesses characters which show a relationship to some of the genera examined by Schwartz (1994). The addition of the new genus to the data set and analysis in Schwartz (1994, Table 1; coded for characters 0 to 36 as follows: 00001 20000 00010 10033 13301



Figs. 16–19. Female genitalia of *Metasequoiamiris carvalhoi*. 16, posterior wall, anterior view (DS, dorsal structure; IL, inter-ramal lobe; IS, inter-ramal sclerite; MP, median process; SP, shovel-shaped anterior surface of median process); 17, left sclerotized ring, dorsoposterior view (DLP, dorsal labiate plate; SR, sclerotized ring); 18, ventral labiate plate, anterior view (VF, first valvifer; VL, first valvulae; VLP, ventral labiate plate); 19, distal end of first valvulae, lateral view.

35141 21401 00) produces one most parsimonious cladogram (length = 114, ci = 72, ri = 72, after removal of uninformative characters and successive approximations weighting of two resultant equally parsimonious cladograms) with a structure which places *Metasequoiamiris* as the sister genus to the monophyletic taxa forming node 5 (Schwartz 1994, Fig. 29). *Metasequoiamiris*, *Orthops*, *Pinalitus*, *Salignus* Kelton, and *Oreolygus* Linnavuori form a group based on the possession of the following characters: white pronotal collar (Fig. 1); left paramere with tapered shaft (Fig. 11); narrow inter-ramal sclerite with recurved lateral apices (Fig. 16); and small, oval sclerotized rings (Fig. 17) (the left paramere and sclerotized rings are homoplasious in *Orthops* and the collar and inter-ramal sclerite are homoplasious in *Salignus*). The vesica of the new genus is most similar to *Orthops* in the structure of the posterior lobe of the

basal sclerite. The strongly developed metafemoral trichomae and apparent absence of pretarsal pulvilli, in addition to the suite of characters listed in the Diagnosis of *Metasequoiamiris*, are unusual for the Mirini. The utility of the hypothesized relationships of the “*Lygus* complex” genera presented here and in Schwartz (1994) can be properly addressed only with a comprehensive analysis of the tribe.

The presence of lamelliform parempodia with either divergent or convergent apices has been used as a diagnostic feature of the Mirinae and Orthotylinae respectively (Knight 1968). That there is variation in the two subfamilial forms of lamelliform parempodia is well known (see Figs. 54–67 in Knight 1968). *Closterocoris* Uhler and *Cyphopelta* Van Duzee in the Herdoniini have narrow, straplike lamelliform parempodia which resemble the setiform parempodia of Phylini. Mirini with convergent parempo-

dia, like those in *Metasequoiamiris*, have not been documented previously.

Metasequoiamiris carvalhoi,
Schwartz, NEW SPECIES
(Figs. 1–19)

Description.—Castanaceous with variable brown to black areas on head, antennal segments II–IV (except base of II), anterior portion of pronotum (calli always) including disk laterally, proepisternum, propleuron, mesoscutellum, scutellum, near claval commissure, distal one-third of cubitus, meso and metasternite, anterior portion of evaporative area of metathoracic scent efferent system, abdominal segment 2, rest of abdominal sternite laterally, and genital segment; pale yellow on legs, labium, posterior portion of evaporative area of metathoracic scent efferent system, and abdominal sternites 3–8 medially; orange to red on interior and distal lateral margins of cuneus, distal half of metatibia, and most of antennal segment I; hemelytral membrane dusky brown. **Genitalia:** *Left paramere:* sensory lobe prominent, without apical spines, with short setae (Fig. 10); arm and angle C-shaped, with short to moderate length setae; shaft short and tapered; apex with rounded dorsal point and sharp ventral point (Fig. 11). *Right paramere:* with broadly rounded sensory area, with moderate length setae; distal one-third a narrow shaft; apex with rounded dorsal point and sharp ventral point (Fig. 12). *Vesica:* Basal sclerite: narrowly enveloping base of vesica (Fig. 14, BS); anterior lobe continuing posterior to ductus seminis and secondary gonopore as a narrow, trough-shaped sclerite terminating at edge of membrane (Fig. 14, TS); posterior lobe forming a strongly spinulose patch posterior to secondary gonopore (Fig. 15). Membrane: reduced dorsal to secondary gonopore, associated with basal portion of the lobal sclerite. Lobal sclerite: long, curved, attached at base of vesica projecting dorsally beyond membrane and apex of basal sclerite, without spines (Fig. 14, LS).

Measurements (in mm; $n = 20$).—Length from apex of tylus to apices of membrane 3.49–4.10; length from apex of tylus to cuneal fracture 2.66–2.91; width across hemelytra at apex of clavus 1.09–1.26; posterior width of pronotum 1.13–1.23; width of head across eyes 0.73–0.76; width of vertex 0.34–0.38; length of antennal segment I 0.41–0.46; II 1.18–1.28; III 0.59–0.73; IV 0.53–0.58; length of labium 1.08–1.16.

Female.—Color similar to male. **Genitalia:** *Posterior wall:* Inter-ramal sclerite: narrow, ventral margin broadly rounded, sclerite deeply incised on both sides of median process (but with membrane); lateral apices strongly recurved (Fig. 16, IS). Inter-ramal lobe: broadly contiguous medially, broadly rounded ventrally (Fig. 16, IL). Median process: well-sclerotized, with broad shovel-shaped anterior surface (Fig. 16, MP, SP). Dorsal structure: edge not extending beyond width of shovel-like median process (Fig. 16, DS). *Dorsal labiate plate:* width equal to width of rings (Fig. 17, DLP).

Measurements ($n = 20$).—Length from apex of tylus to apices of membrane 4.10–4.43; length from tylus to cuneal fracture 2.85–3.10; width across hemelytra at apex of clavus 1.28–1.40; posterior width of pronotum 1.18–1.30; width of head across eyes 0.73–0.76; width of vertex 0.38–0.41; length of antennal segment I 0.38–0.43; II 0.95–1.07; III 0.60–0.66; IV 0.54–0.60; length of labium 1.28–1.40.

Distribution.—All known specimens are from Lichuan District, West Hubei Province, China, a region with a distinctive floral association (Chu and Cooper 1950, Wang 1961).

Etymology.—Named to honor the late José C. M. Carvalho in appreciation of his long and productive career devoted to the systematics of the Miridae.

Holotype male.—China. *West Hupeh:* [West Hubei, Lichuan District:] Suisapa [Shui-hua-pa], [1000 m], 25 July 1948, J. L. Gressitt Collector, ex. *Torreyia* sp. (deposited in the CAS).

Paratypes.—All with the same label data as the holotype except as follows—24 July: 1 ♂, 2 ♀ [1 ♀ dissected]; ex. *Castanea* sp., 1 ♂ [metafemora dissected, Fig. 8]; ex. *Cephalotaxus fortunei* (possibly a *Torreya*—sterile), 2 ♂, 4 ♀ [♂ used in Fig. 1]. 25 July: 2 ♀; ex. *Metasequoia glyptostroboides* Hu and Cheng, 3 ♂, 1 ♀; ex. *Torreya* sp., 1 ♂, 3 ♀; ex. *C. fortunei* (possibly a *Torreya*—sterile), 14 ♂, 7 ♀ [2 ♂ used in Fig. 1]. 26 July, 1 ♂. 1 Aug., #2401, ex. *M. glyptostroboides*, Bishop Museum, 1 ♂, 7 ♀, 30 Aug.: ex. *C. fortunei* (possibly a *Torreya*—sterile), 1 ♂, 29 ♀ [♂ dissected, Figs. 10–15; 1 ♀ SEM #189a, Fig. 7]; ex. *M. glyptostroboides*, 3 ♀ [metafemora dissected, Fig. 9]. 12 Sept.: ex. *C. fortunei* (possibly a *Torreya*—sterile), 20 ♀; ex. *Liquidambar formosana* Hance, 1 ♀. 17 Sept., 1 ♀ [dissected, Figs. 16–19]. China. *West Hubei*: Lichuan District: Leong-Ho-Kow, 9 Sept. 1948, ex. *C. fortunei* (possibly a *Torreya*—sterile), 1 ♀. Voucher specimens are deposited in the American Museum of Natural History, New York, NY; Bishop Museum, Honolulu, HI; CAS; Canadian National Collection, Ottawa (CNC); Nankai University, Tianjin; Natural History Museum, London; and U.S. National Museum, Washington, D.C.

Other specimens.—All with the same label data as the *Suisapa* paratypes from the following dates. The specimens are not included in the type series because they are either damaged or teneral—24 July 1 ♀; 25 July 3 ♂ [1 ♂ SEM #288b; Fig. 6], 3 ♀; 26 July 5 ♂, 1 ♀; 1 Aug. 3 ♀; 30 Aug. 3 ♂ [1 ♂ SEM #288a, Figs. 2–5], 4 ♀; 12 Sept. 15 ♀ (CAS, CNC).

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NEW GENERA AND SPECIES OF RHYPAROCHROMINAE FROM
WEST AFRICA (HEMIPTERA; LYGAEIDAE) DESCRIBED IN
HONOR OF J. C. M. CARVALHO

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Abstract.—*Carvalhodrymus* n.g.; *Carvalhodrymus elegans*, *Mizaldus lestoni*, *M. linnavoorii*, *M. carvalhoi*, *M. tenuis*, *Fontathanus rostratus*, *F. ghanaensis*, *Paromius carvalhoi* and *Esinerus humidus* n. spp. are described as new from West Africa. A key is given for the African species of *Mizaldus*. Modifications of a key to African Drymini genera and a discussion of zoogeographic relationships of West African Lygaeidae is included.

Key Words: Lygaeidae, West Africa, Drymini, Myodochini, zoogeography

It is a special pleasure and honor to dedicate this paper to Dr. José C. M. Carvalho, my good friend and colleague for half a century, in recognition of his many contributions to our knowledge of the world fauna of Heteroptera and especially that of the tropics.

The present paper has been made possible by the field work and careful study of several of Dr. Carvalho's friends and colleagues. Without the material that they have brought together, the great West African fauna would still be very poorly understood. In the present paper I have acknowledged my debt to some of these people by the establishment of patronymics for them.

The West African rhyparochromine fauna is an especially important one for several reasons. Not only is it very rich in species (a great many still undescribed), but it shows a number of close relationships to the Oriental fauna, particularly of the forest-living forms. This strongly suggests (as it does in other animal groups) a former closer connection faunistically and floristically between West Africa and East Asia.

The richness of the West African fauna is

not only due to isolation within the region but also, presumably, for two additional reasons. First, the occurrence of a savanna corridor of long duration separating the West African forest fauna from that of Central Africa. Second, the distinction between the fauna of the wet tropical forest, both coastal and montane, from the increasingly arid savanna and desert areas to the north. The savanna fauna is for the most part composed of species with wide ranges, many occurring in a broad arc around the rain forest, often all the way from Senegal to South Africa (see *Mizaldus nidulus* discussion below).

There is also a southern Palearctic element that reaches the savanna in West Africa. When one, in addition, considers the frequent disjunction of the montane and lowland forests, the reasons for the richness and frequent endemism of parts of the fauna becomes evident.

Students of West Africa have become increasingly interested in possible West African-South American relationships since the acceptance of continental drift. Such relationships are not evident in the rhyparo-

chromine fauna, at least, at the present state of our knowledge. For example, the tribes Drymini and Rhyparochromini, which are dominant elements in West Africa, are completely absent in South America and in the Lethaeini and Antillocorini, where such sister groups may exist, our knowledge is totally inadequate to demonstrate any close African-South American relationships.

All measurements are in millimeters.

Carvalhodrymus, NEW GENUS

Body elongate, slender, parallel sided. Eyes set near middle of head, remote from anterior pronotal margin. Ocelli placed far behind posterior margins of eyes. Tylus acuminate, extending only over basal one-fifth of first antennal segment. Vertex convex. Pronotum with a well-defined anterior collar; lateral pronotal margins very narrowly explanate, deeply incised at level of complete and deep transverse impression; humeral angles evenly rounded; posterior margin shallowly concave. Anterior pronotal lobe convex, slightly higher than posterior lobe. Scutellum not elevated throughout but with a raised Y-shaped carina. Clavus with three rows of punctures, but punctures of inner row smaller and less closely spaced than those of outer two rows. Lateral corial margins straight, not expanded posteriorly. Apical corial margin straight. Metathoracic scent gland auricle short, bent caudad. Evaporative area small, occupying only area immediately around auricle with dorsal margin rounded. Fore femora slender, armed below with a single small, inconspicuous spine near distal end. Body non-pruinose, glabrous or nearly so. Pronotal punctures on anterior and posterior pronotal lobes equal in size and distribution. Antennae extremely elongate, very slender, filiform, fourth segment not at all fusiform.

Type species.—*Carvalhodrymus elegans* new species. By monotypy.

Carvalhodrymus will run to couplet 14 in Slater's (1993) key to African genera of Drymini, but it is not closely related to either

genus at that couplet. It is much more similar to the Palearctic genus *Thaumastopus* Fieber. Both of these genera are relatively elongate slender taxa with acuminate heads, elongated first antennal segments, coarsely punctate pronota, very narrowly explanate pronotal margins, eyes set well away from the anterior margin of the pronotum, a Y-shaped scutellar carina, and elongate filiform antennae.

Carvalhodrymus differs from *Thaumastopus* in lacking incrassate, multispinose fore femora, possessing straight rather than convex lateral corial margins, having compound eyes that are elliptical rather than round in dorsal view, by having greatly elongated antennae with both segments two and three much longer than the pronotal length (subequal in *Thaumastopus*). In the type species of *Thaumastopus* (*marginicollis* Lucas), the tylus nearly attains the middle of the relatively short first antennal segment that is shorter than or subequal to the pronotal length (see Kiritshenko's (1951) excellent figure No. 340), whereas in *Carvalhodrymus* the tylus attains only the proximal $\frac{1}{5}$ of the first antennal segment that is appreciably longer than the length of the pronotum.

It is a great pleasure to name this striking new genus in honor of Dr. J. C. M. Carvalho.

Carvalhodrymus elegans, NEW SPECIES

(Fig. 1)

Coloration uniformly yellowish-brown with strongly contrasting dark brown punctures on pronotum, scutellum and hemelytra. Membrane of forewing dark fumose, lacking a pale apical macula. Corium with a narrow, elongate, smooth, pale patch adjacent to radial vein at level of apex of scutellum. Hemelytra anterior to this macula slightly paler than corium distally (coloration difference marked by a straight transverse line). Legs and antennae uniformly pale yellow.

Length head 1.06 (distance anterior to eye

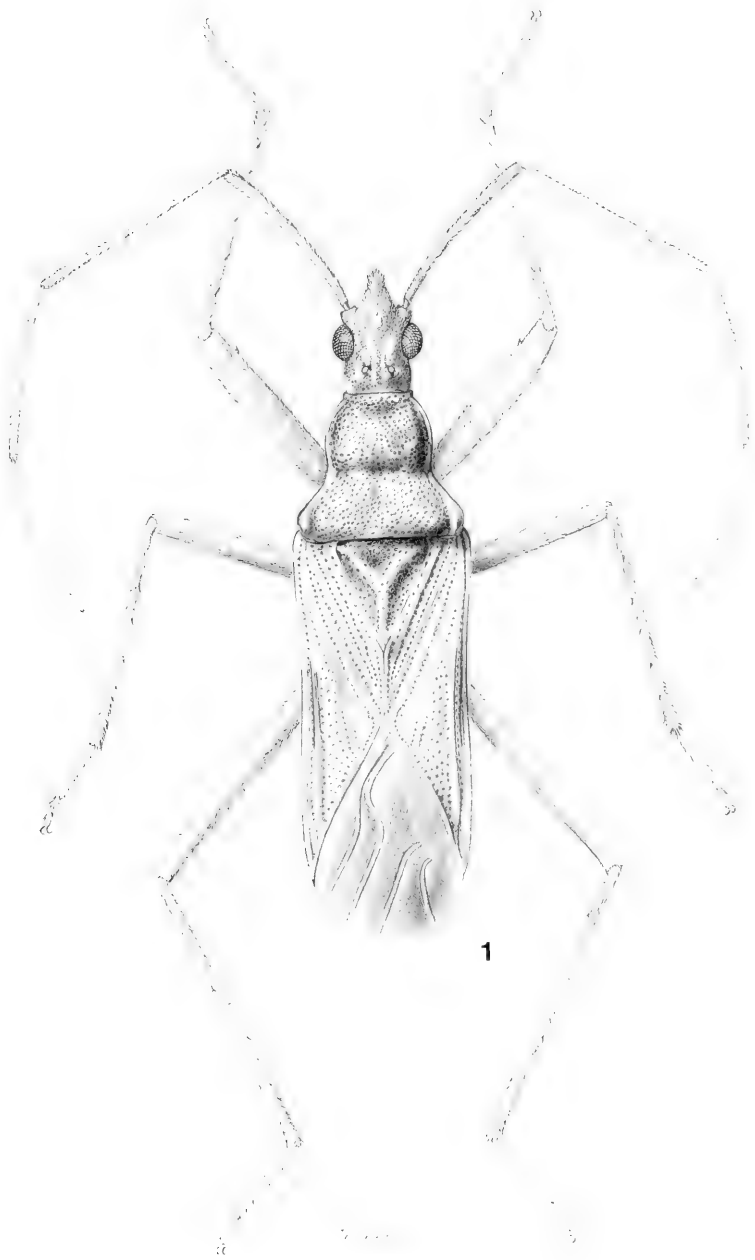


Fig. 1. *Carvalhodrymus elegans* n. sp. Dorsal view.

0.46, distance posterior to eye 0.28), width head 0.76, interocular space 0.40. Length pronotum 1.20 (length anterior lobe 0.66, posterior lobe 0.54), width pronotum 1.46. Length scutellum 1.00, width 0.80. Length

claval commissure 0.54. Midline distance apex clavus-apex corium 1.30. Midline distance apex corium-apex abdomen 0.60. Length labial segments I 0.66, II 0.80, III 0.46, IV 0.28 (approx.). Length antennal

segments I. 1.60, II 1.76, III 1.44, IV 1.36 (approx). Total body length 5.60.

Holotype.—♂: *Ghana*: Sunjami. 12.XII.1965 (Leston) (UV trap). In American Museum of Natural History.

Paratype.—1 ♂: *Cameroon*: Southwest Prov. 25 km. W. Limbe Bakingili. 16.VII.1984 (James Digiulio) (Malaise trap). In Carnegie Museum of Natural History.

The paratype, while apparently not differing structurally from the holotype, is very differently colored. The ground color is dark chocolate brown. The pale macula on the hemelytra near the lateral margin at the level of the apex of the scutellum (which is only faintly differentiated in the holotype) is a sharply contrasting white in the paratype and the entire corium anterior to this macula is much paler than the posterior area. The paratype has a small white area on the membrane adjacent to the apex of the corium. The third antennal segment is dark chocolate brown and contrasts strikingly from the pale yellow first and second segments and the almost white fourth segment. The fore femora are dark red-brown. Despite these striking color differences the holotype does not appear to be teneral and there seem to be no significant structural differences.

This apparently is a rare species, or at least comes very rarely to lights, as in the many thousands of West African Rhyparochrominae that I have examined these are the only two specimens known.

Mizaldus Distant

Distant 1901: 483.

Mizaldus is a genus of small drymine lygaeids characterized by the deeply concave apical corial margins, elevated scutellum, lack of fore femoral spines, two rows of claval punctures, short head with large eyes and filiform antennae.

Only two species previously have been known to occur in Africa, *Mizaldus nidulus* Slater and Carayon from Guinea in West

Africa and *Mizaldus sinuaticollis* Linnavuori from the southern Sudan in East Africa.

Specimens are rare in collections. Apparently, species of this genus live in specialized habitats and come only rarely to lights.

In the present paper four new species are described and additional distributional data are given for previously described species.

Characters that appear to be most useful in separating the various species are the shape of the scutellum, the nature of the scutellar punctures, the relative thickness of the antennae and, in some cases, the coloration of these segments, the size and shape of the eyes, and the pronotal proportions. While there appear to be differences in the pruinosity patterns on the pronotum, a more adequate series will be necessary before the utility of this suite of characters can be determined.

Scudder (1968) established the genus *Neomizaldus* with *Mizaldus lewisi* Distant as the type species. His lengthy generic description consists almost entirely of features that are true of both taxa. Scudder notes that the abdominal sterna of species of *Neomizaldus* are longitudinally striate. This condition is found in all of the African species of *Mizaldus* (although obscured by long hairs in *Mizaldus tenuis*). Scudder's chief differentiating character was said to be the presence of a distinct collar in *Neomizaldus*. He notes that this collar is not "really evident" mid-dorsally, but is distinct laterally. I am very dubious of the desirability of recognizing *Neomizaldus* as a distinct genus. The collar is very poorly developed in the type species of Scudder's genus, only slightly more so than in some of the African species of *Mizaldus*. On the other hand, *Neomizaldus lewisi* has a very distinctive scutellum with a broad subbasal transverse smooth raised area that is not found in any *Mizaldus* known to me. However, given the striking differences in the conformation of the scutellum in some of the African species of *Mizaldus*, this seems questionable as a generic feature. Clearly an investigation of

the Oriental elements of these two taxa is in order.

The only published information on the biology, of which I am aware, is that of Slater and Carayon (1963) who reported *M. nidulus* from the nests of ploceid finches in Guinea, where they occurred with anthorcorids and were apparently feeding on small arthropods. This species was reared on Coleoptera larvae in the laboratory. Such a feeding habit may not be true of other species of the genus. *Mizaldus nidulus* is relatively weakly sclerotized as compared with the new species described below and the hemelytral punctures, especially those on the clavus, are pale and little differentiated in color from the surrounding surface. By contrast, the other West African species have hemelytral punctures that are distinctly differentiated. This suggests that possibly *M. nidulus*, being associated with cryptic habitats (bird nests), has lost some of its sclerotization, whereas the other species may be living in less protected environments.

Distribution.—While previously known on the continent only from West and East Africa the genus will probably be found to be widespread throughout much of tropical and subtropical Africa. As noted below *M. nidulus* is now known to occur in Nigeria and both on the high veld and in the tropical corridor in South Africa. The unpublished field notes from Ghana of the late Dennis Leston indicate that specimens upon which several of the new species are based were taken in dense forest by pyrethrum knock-down technique, whereas *M. nidulus* is probably a savanna species. This belief is consistent with the discovery of the latter in South Africa. Such a distribution, as noted previously, suggests a range through a wide savanna arc from West to South Africa around the central African rain forest.

Mizaldus lestoni, NEW SPECIES
(Figs. 4, 5)

Body relatively elongate, tapering anteriorly. Head, pronotum, scutellum, large

apical corial macula, basal $\frac{3}{4}$ of first antennal segment and femora black. Hemelytra white, central area hyaline. A small, narrow, elongate, dark-brown vitta present on distal $\frac{1}{2}$ to $\frac{1}{3}$ of radial vein. Membrane pale translucent basally, contrastingly fumose from level of dark corial macula to apex. Hemelytral punctures dark brown, strongly contrasting with pale ground color. Base and distal end of first antennal segment and all of segments two and three pale yellow (segment four missing). Pleural and sternal surfaces nearly uniformly dark chocolate brown, with posterior lobe of metapleuron white. Tibiae and tarsi yellowish brown, tibiae somewhat darker proximally. Head shining. Pronotum and scutellum nearly completely dull pruinose, obscurely and finely punctate. Head and anterior pronotal lobe clothed with numerous decumbent silvery hairs.

Head sharply acuminate, not declivent. Tylus extending to middle of first antennal segment; vertex strongly convex; eyes sessile, occupying most of lateral head surface but not strongly globose. Ocelli placed much nearer eyes than meson. Length head 0.60, width 0.65, interocular space 0.40. Pronotum with lateral margins narrowly but distinctly carinate, strongly sinuate; transverse impression complete; posterior margin straight before base of scutellum, laterally lobately produced. Length pronotum 0.78, width 1.08. Scutellum evenly elevated, lacking a median carina, punctures distinctly separated from one another. Length scutellum 0.58, width 0.53. Length claval commissure 0.13. Lateral corial margins strongly sinuate. Midline distance apex clavus-apex corium 0.70. Midline distance apex corium-apex abdomen 0.88. Length labial segments I 0.38, II 0.40, III 0.43, IV 0.33. Antennae relatively robust, chiefly terete but with second and third segments slightly enlarged from proximal to distal ends. Length antennal segments I 0.30, II 0.62, III 0.50 (IV missing). Total body length 3.60.

Holotype.—♀: *Ghana*: Eastern Region, Atewa Range Forest Reserve. 25.VII.1969

(D. Leston) (pyrethrum knockdown). In American Museum of Natural History.

This is a relatively large species, generally similar to *Mizaldus linnavuorii* but with a completely differently shaped scutellum that in this species has small inconspicuous punctures. The antennal segments are much thicker, the eyes less protrudent and more elongate and the femora are completely dark on all legs.

The Atewa Range Forest Reserve is mature primary forest, the upper story with a largely complete canopy.

This species is dedicated to the memory of the late Mr. Dennis Leston for his invaluable West African collections and for his important contributions to our knowledge of the world Hemiptera.

Mizaldus linnavuorii, NEW SPECIES

(Fig. 2)

Body robust. Head, pronotum, scutellum, narrow apex of corium and third and fourth antennal segments black. First antennal segment infuscated with red-brown on basal half. Corium and clavus white, or very pale yellow, lacking a transparent central area. Fore femora and distal 1/2 of middle and hind femora red-brown; remainder of legs and antennae pale yellow. Upper 1/2 of posterior metapleural lobe white. Head shining. Pronotum and scutellum completely pruinose. Head and pronotum finely and evenly punctate. Scutellar punctures large, coarse and anastomosing. Membrane hyaline, unicolorous. Body almost completely glabrous above.

Head acuminate, tylus reaching to distal 1/3 of first antennal segment. Eyes large, globose, protruding. Length head 0.56, width 0.64, interocular space 0.36. Pronotum relatively broad, posterior lobe elevated above anterior; lateral margins very narrowly carinate, sinuate; transverse impression complete. Length pronotum 0.84 (length anterior lobe 0.36, length posterior lobe 0.48), width 1.12. Scutellum with a sharp ovate marginal carina, the margins meeting posteriorly in an arc on meson. Scutellar disc

convex basally and mesally, somewhat depressed distally, with a very weak carina near distal end. Length scutellum 0.56, width 0.60. Lateral corial margins relatively shallowly concave. Length claval commissure 0.14. Midline distance apex clavus-apex corium 0.72. Midline distance apex corium-apex abdomen 0.62. Labium extending posteriorly well between mesocoxae. Length labial segments I 0.36, II 0.36, III 0.36, IV 0.30. Antennae elongate, very slender, fourth segment at most narrowly fusiform. Length antennal segments I 0.28, II 0.62, III 0.60, IV 0.54. Total body length 3.12.

Holotype.—♂: *Ivory Coast*: Mt. Tonkoui. 15–22.X.1973 (Linnavuori). In American Museum of Natural History.

Paratype.—1 ♀: *Ivory Coast*: Adiopodoume. 29.IX–7.X.1973 (Linnavuori). In J. A. Slater collection.

This species is readily recognizable by its large size, robust body form, elongate slender antennae with the third and fourth segments black, and especially by the coarsely punctate, elevated and uniquely carinately margined scutellum.

The paratype differs from the holotype in having the posterior pronotal lobe and the scutellum somewhat subshining rather than being completely dull pruinose.

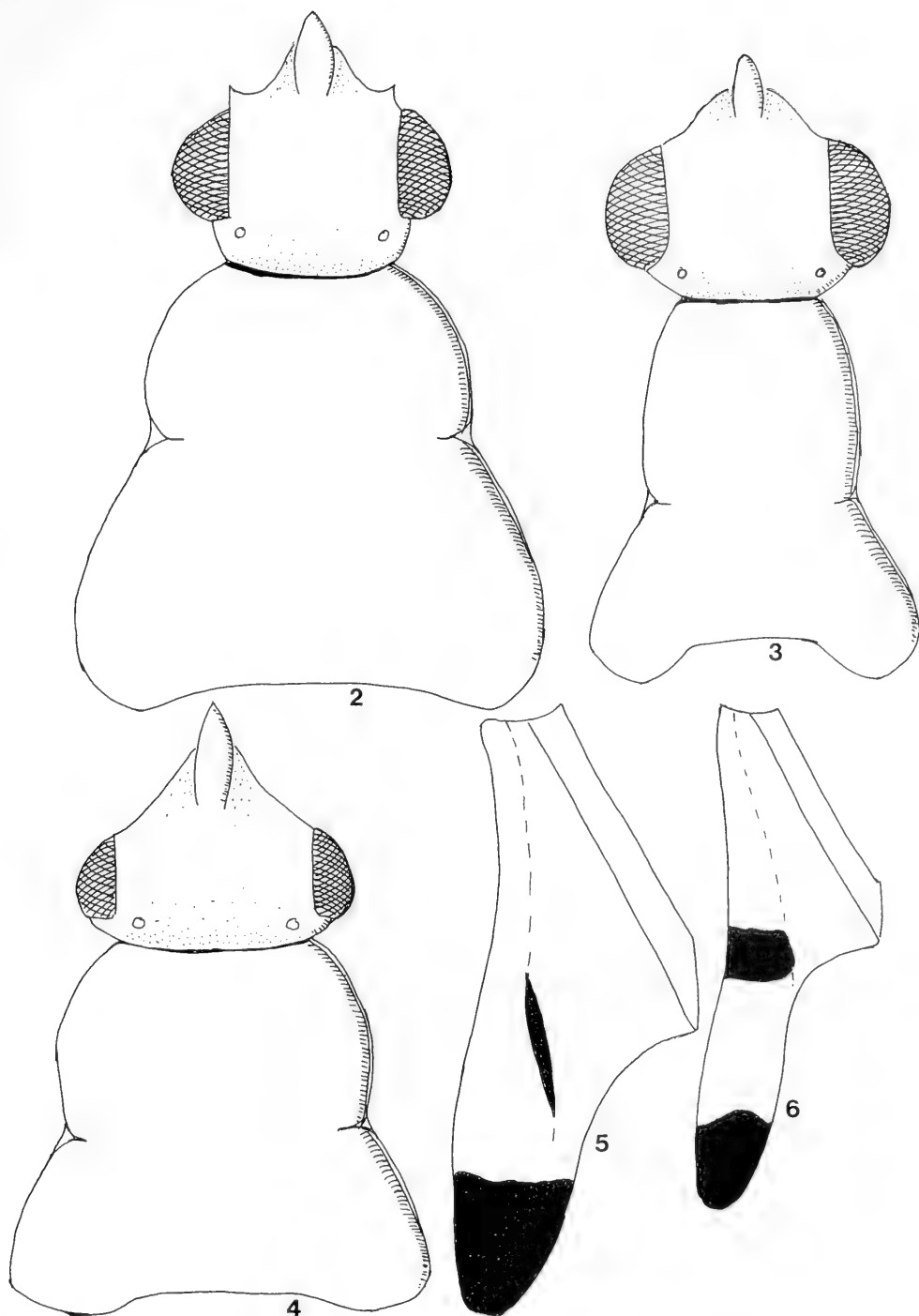
Mizaldus linnavuorii appears to be most closely related to *Mizaldus carvalhoi* as discussed under the latter.

It is a pleasure to dedicate this species to Dr. Rauno Linnavuori in recognition of his unparalleled West African collections and his many contributions to our knowledge of African Hemiptera.

Mizaldus carvalhoi, NEW SPECIES

(Fig. 7)

Body robust. Head, anterior pronotal lobe, apical corial macula and fourth antennal segment black. Posterior pronotal lobe red-brown. Clavus and corium white, latter with central area subhyaline. Membrane uniformly translucent hyaline. Fore femora and distal half of middle and hind femora red-brown. Basal half of antennal segment one



Figs. 2-6. 2. *Mizaldus linnavuori* n. sp. Dorsal view of head and pronotum. 3. *Mizaldus tenuis* n. sp. Dorsal view of head and pronotum. 4. *Mizaldus lestoni* n. sp. Dorsal view of head and pronotum. 5. *Mizaldus lestoni* n. sp. Dorsal view clavus and corium. 6. *Mizaldus tenuis* n. sp. Dorsal view clavus and corium.

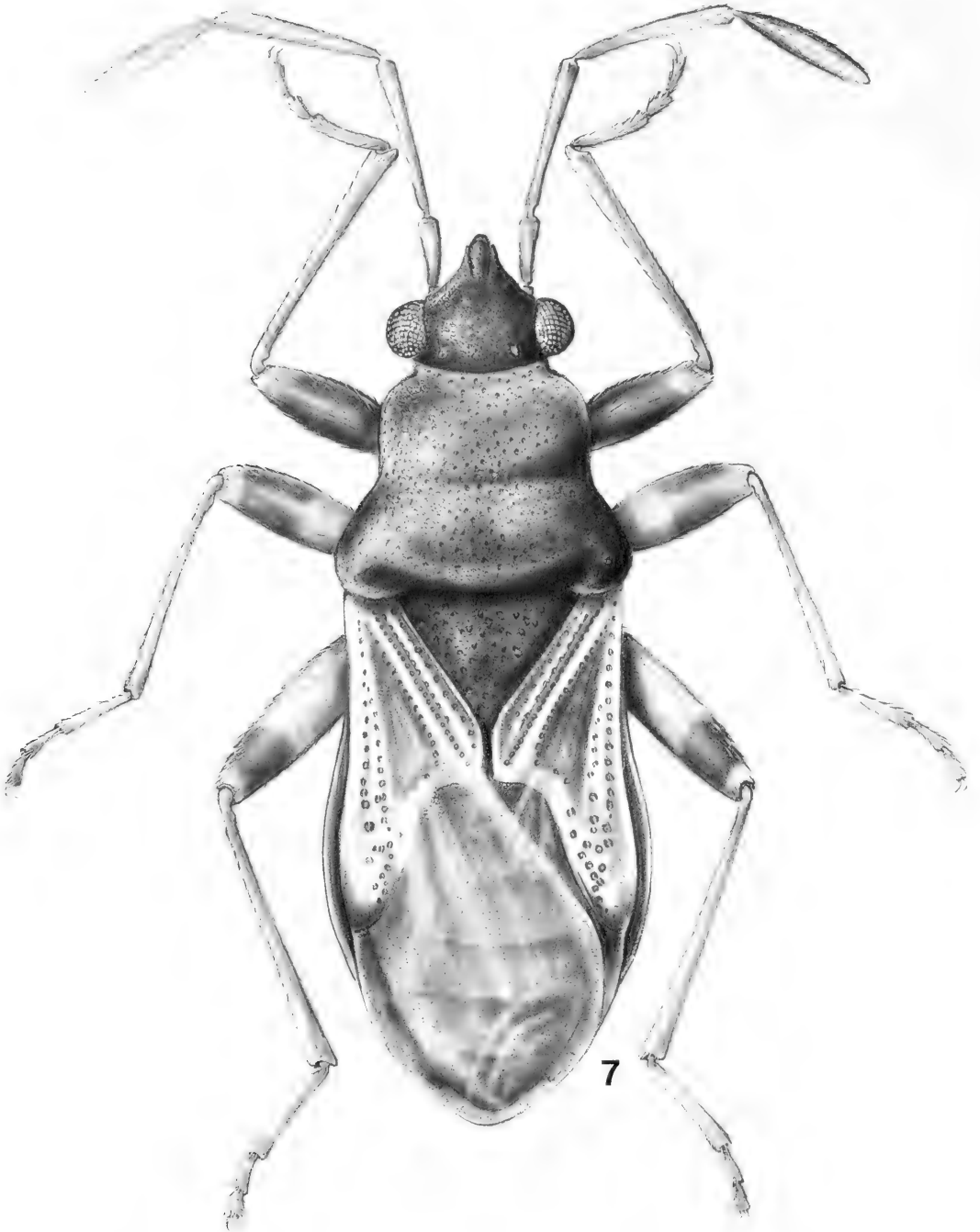


Fig. 7. *Mizaldus carvalhoi* n. sp. Dorsal view.

and suffused proximal half of antennal segment 3 pale yellowish brown. Remainder of legs and antennae pale yellow. Upper portion of posterior metapleural lobe white. Head shining. Pronotal calli, posterior pronotal lobe (with exception of a large quadrate pruinose area on either side of midline immediately behind transverse impression) and scutellum dull to subshining, but contrasting with pruinosity of anterior pronotal lobe. Head, pronotum, and scutellum with distinct well-separated punctures, those on scutellum not anastomosing. Dorsal surface almost glabrous, no elongate hairs present.

Head broad, sub-acuminate; eyes globose, protruding; vertex only slightly convex. Length head 0.50, width 0.60, interocular space 0.34. Pronotum broad, posterior lobe slightly elevated above anterior; lateral margins narrowly carinate, sinuate; transverse impression complete, but relatively shallow. Length pronotum 0.74 (length anterior lobe 0.36, length posterior lobe 0.38), width 0.98. Scutellum with lateral margins carinate, tapering posteriorly to a V-shaped apex; an obtuse median carina present; basal half of surface somewhat elevated. Length scutellum 0.43, width 0.46. Lateral corial margins shallowly concave. Length claval commissure 0.14. Midline distance apex clavus-apex corium 0.68. Midline distance apex corium-apex abdomen 0.62. Labium reaching between mesocoxae. (Approximate labial lengths from paratype I 0.35, II 0.38, III 0.35, IV 0.22.) Antennae slender, filiform, third segment very slightly clavate, fourth segment narrowly fusiform. Length antennal segments I 0.30, II 0.54, III 0.50, IV 0.46. Total body length 2.52.

Holotype.—♂: *Ghana*: Nsemre Forest Reserve, Brog Ahafo 13.XII.1965 (D. Leston). In American Museum of Natural History.

Paratypes.—*Ghana*: 2 ♀♀ same data as holotype. 1 ♂ Tafo, Eastern Region 23.V.1966 (D. Leston) (pyrethrum knock-

down block, R1 cocoa). In J. A. Slater collection.

This species is closely related to *Mizaldus linnavuorii*. The type series is considerably smaller with a differently shaped scutellum in which the punctures are small and discrete, rather than coarse and anastomosing, and the marginal scutellar carina does not meet in a semi-circular curve near the posterior end of the scutellum. The fourth antennal segment is also relatively longer (subequal in length to segment three rather than being appreciably shorter). The pruinosity patterns of the two species and the pale third antennal segment of the present species all appear to be distinctive features.

I have examined an additional female from *Nigeria*: (SE. St. Obudu Cattle Ranch 16–18.VIII.1973 (Linnavuori), which I believe to be conspecific although it is considerably larger. Because this species and *M. linnavuorii* are more closely related to one another than most of the other species of *Mizaldus* described here, the measurements of this Nigerian specimen are given to facilitate relationships when more extensive material becomes available. Length head 0.58, width 0.72, interocular space 0.38. Length pronotum 0.90 (length anterior lobe 0.44, posterior lobe 0.46), width 1.18. Length scutellum 0.52, width 0.64. Length claval commissure 0.16. Midline distance apex clavus-apex corium 0.70. Midline distance apex corium-apex abdomen 0.80. Length antennal segments I 0.34, II 0.64, III 0.58, IV 0.60. Total body length 3.40.

Mizaldus tenuis, NEW SPECIES

(Figs. 3, 6)

Body relatively elongate, nearly parallel sided. Head, pronotum, scutellum, a large apical corial macula and pleural and ventral surfaces uniformly black. A brown quadrate macula present on corium at level of posterior end of claval commissure extending inward from lateral margin to raised radial

vein (Fig. 6). Antennal segments one, two, and three pale yellow, base of segment one weakly infuscated, segment 4 a strongly contrasting dark brown. Fore femora and distal half of middle and hind femora reddish, remainder of legs pale yellow. Posterior metapleural lobe white. Head, pronotum, and scutellum with numerous shallow, evenly separated punctures. Head and anterior pronotal lobe subshining. Posterior pronotal lobe and scutellum dull pruinose. Head dorsally with a few elongate hairs. Remainder of dorsal surface almost glabrous (minute decumbent hairs arising from punctures).

Head strongly declivent. Eyes very large, occupying almost entire lateral surface of head. Tylus extending over basal $\frac{1}{2}$ of first antennal segment. Ocelli placed much closer to eyes than to meson. Length head 0.60, width 0.70, interocular space 0.36. Pronotum relatively long and narrow, length and width subequal. Anterior pronotal lobe longer (0.50) than posterior lobe (0.40). Lateral pronotal margins very narrowly carinate and strongly sinuate; transverse impression complete and very deep; anterior lobe evenly convex. Length pronotum 0.90, width 0.90. Scutellum evenly elevated; without a strong marginal carina. Length scutellum 0.46, width 0.44. Lateral corial margins deeply and evenly concave, maximum width near apex of corium. Length claval commissure 0.16. Midline distance apex clavus-apex corium 0.60. Midline distance apex corium-apex abdomen 0.54. Labium obscured, at most reaching onto mesosternum. Antennae moderately slender, third segment somewhat clavate, fourth segment fusiform. Length antennal segments I 0.22, II 0.44, III 0.38, IV 0.44. Total body length 2.96.

Holotype.—♂: *Ivory Coast*: Adiopodoume. 29.IX–7.X.1975 (Linnavuori). In American Museum of Natural History.

This species is readily recognizable by the relatively elongate, narrow pronotum and other characters as noted in the following key.

Mizaldus sinuaticollis Linnavuori

Linnavuori 1978: 86.

This species was originally described from a female from "Equatoria: Yei-Iwatoka." I have examined a male from *Kenya*: "Limuru 3.IV.1955 (D.C. Thomas) (dead leaves)" in the C. J. Drake collection at the National Museum of Natural History (USNM) that I believe to be conspecific.

I have keyed this species out to two places in the following key because of uncertainty as to the condition of the scutellum. Linnavuori (1978) states that in *M. sinuaticollis* the scutellum is "densely punctate." I take it that this means that the scutellar punctures are large and anastomosing as they are in *M. linnavuorii*. In the Kenya specimen before me, the scutellar punctures are large and dense, but they are not anastomosing and the scutellum thus differs in this regard from *M. linnavuorii*. I have separated the species twice in the following key once on the basis of antennal length in case the scutellar punctures of the type specimen are not anastomosing and once where they would be.

The Kenya specimen also has the third and fourth antennal segments somewhat darker than the two proximal segments. It is certainly related in general habitus to *M. linnavuorii* and a series from intervening localities is very desirable.

Mizaldus nidulus Slater and Carayon

Slater and Carayon 1963: 1–4.

This species is readily recognizable by the dark third antennal segment and relatively weak sclerotization in which the hemelytral punctures are nearly concolorous with the surface of the clavus and corium.

Mizaldus nidulus was originally described from Guinea but is apparently widespread in Africa, although rare in collections. I have examined the following additional material: *Nigeria*: 1 ♂ Zugurma NW state XII.1974 (J. T. Medler). *South Africa*: Transvaal: 1 ♂ Lyttelton 29.II.1968 (J. A. & S. Slater) (UV

light). Natal; 1 ♀ Umtentweni VII.1953 (A. L. Capener). 1 ♀ Umtentweni VII.1954 (A. L. Capener). In J. A. Slater collection.

KEY TO AFRICAN SPECIES OF *MIZALDUS*

- 1. Third antennal segment dark red-brown to black, strongly contrasting with pale coloration of second antennal segment 2
- Third antennal segment pale yellowish, concolorous or nearly so, with coloration of second antennal segment 3
- 2. Fourth antennal segment pale yellow, strongly contrasting with dark third segment and concolorous with antennal segment two; claval punctures obscure, concolorous with pale ground color of hemelytra *nidulus* Slater and Carayon
- Fourth antennal segment black, concolorous with dark third antennal segment and strongly contrasting with pale second antennal segment; claval punctures dark brown, strongly contrasting with pale hemelytral ground color *linnavuorii* n. sp.
- 3. Scutellar punctures large, irregular and anastomosing *sinuaticollis* Linnavuori
- Scutellar punctures small, distinctly separated from one another and not anastomosing 4
- 4. Head less than 1¼ times as broad as long ... 5
- Head 1½ or more times as broad as long ... 6
- 5. Antennal segment two much less than 1.2 times length of segment three (15:13) *sinuaticollis* Linnavuori
- Antennal segment two more than 1.2 times length of segment three *lestoni* n. sp.
- 6. Pronotal length subequal to width of pronotum across humeral angles; a large quadrate brown macula present at level of distal end of claval commissure laterad of radial vein ... *tenuis* n. sp.
- Pronotum wider than long; hemelytra lacking a dark macula laterad of radial vein *carvalhoi* n. sp.

Fontathanus Scudder

Scudder 1963: 1233-1234.

Scudder (1963) erected the genus *Fontathanus* to include four African species. Three of these were known only from Zaire and the fourth from Zaire, Guinea, and Sierra Leone.

Scudder related *Fontathanus* to *Fontejus* Stål. However, Sweet (1967) placed the latter genus in the Udeocorini, whereas *Fontathanus* is a member of the Myodochini

and the relationship presumably was on the basis of myrmecomorphy. Scudder separated the two genera by *Fontethanus* having unarmed fore tibiae, a deeper and more anteriorly placed transverse pronotal constriction and said that "the coloration is different."

Harrington (1980) added to this diagnosis of *Fontathanus* the following: having "phallic type I," the posterior edge of the pygophore "subsharp," four or more rows of claval punctures, a V-shaped buccular juncture, double-ranked fore femoral spines, and an enclosed mesepimeron.

Only one of Scudder's species has a punctate anterior pronotal lobe and, even in this species, the punctures are said to be present only mesally and laterally. Both new species described below have completely punctate pronota. They are both strikingly myrmecomorphic with broad ant-shaped heads, as evidenced by the carinate lateral margins of the head before the eyes that seems to simulate the edges of mandibles. The color pattern viewed laterally enhances the antlike resemblance by the white of the posterior metapleural lobe being continued onto the proximal portions of the hind femora to "break up" the outline and form a pseudopedicel appearance.

Fontathanus rostratus, NEW SPECIES
(Fig. 8)

Shining jetblack above on head and pronotum. A narrow gray pruinose stripe through transverse pronotal impression. Prothorax laterally and ventrally, acetabula, and posterior metapleural lobe gray pruinose. Silvery pruinosity present as follows: scutellum (with exception of raised apex), a large basal corial patch within radial vein that extends onto adjacent area of clavus, a second patch on corium also within radial vein at level of anterior half of claval commissure. Corium variegated, a small pale yellow macula basally at lateral margins and a large yellow patch laterad of radial vein in center of corium, mesal portion of which

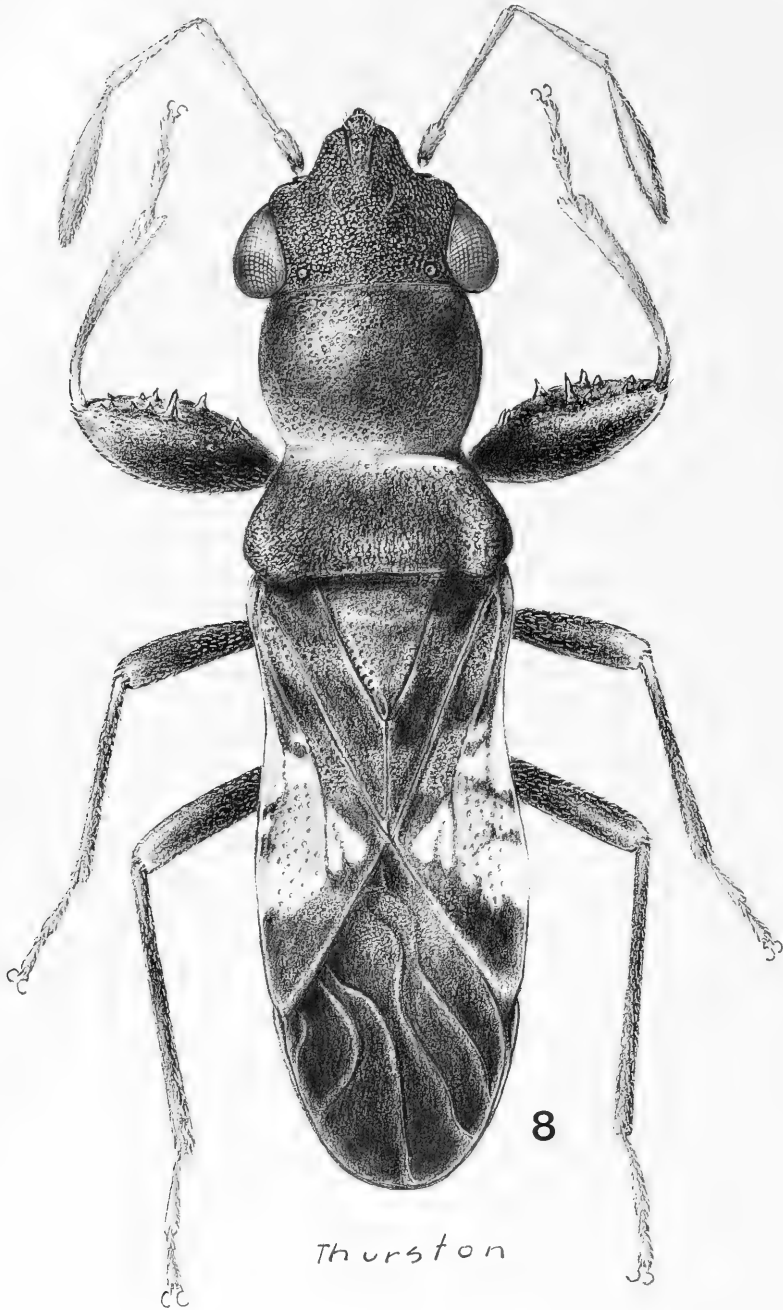


Fig. 8. *Fontathanus rostratus* n. sp. Dorsal view.

becomes bright yellowish orange and is bordered both anteriorly and posteriorly at lateral ends with a dark brown stripe or vitta. Adjacent to bright yellow area mesad of ra-

dus an additional irregular bright yellow marking, this of irregular outline, almost forming three elongate spots. Remainder of clavus and corium velvety in texture and of

an (almost black) dark red color. Membrane uniformly dark fumose, pruinose proximally within apical corial margins. Extreme postero-dorsal corner of metapleuron and subproximal band on middle and hind femora pale yellow to almost white. Extreme distal end of fore femora and entire foretibiae pale orange-yellow. Middle tibiae black at proximal ends, becoming orange-yellow distally. Hind tibiae chocolate brown. All tarsal segments and first three antennal segments pale yellow. First antennal segment infuscated with dark brown basally, fourth segment dark chocolate brown. Head and pronotum finely but conspicuously punctate over entire surface. Body surface finely shagreened, nearly glabrous but with very short fine decumbent hairs arising from punctures.

Head moderately declivent, tapered anteriorly. Head anterior to eyes produced and carinate. Eyes sessile. First antennal segment almost attaining apex of tylus. Ocelli placed far laterad, near inner corner of compound eyes. Length head 0.98, width 1.32, interocular space 0.86. Pronotum with deeply incised transverse impression. Anterior pronotal lobe rounded, ovate, longer than posterior lobe (length anterior lobe 0.86, length posterior lobe 0.58). Posterior pronotal margin nearly straight; lateral margins extremely deeply sinuate. Length pronotum 1.48, width 1.68. Scutellum with a very slight median elevation, posterior end sharply carinate. Length scutellum 0.80, width 0.64. Length claval commissure 0.50. Corium with lateral margins strongly sinuate, narrowest at level of distal portion of scutellum, slightly explanate posterior to this area and very slightly recurved. Midline distance apex clavus-apex corium 0.96. Midline distance apex corium-apex membrane 0.98. Abdomen strongly constricted basally. Metathoracic scent gland auricle elliptical, short. Evaporative area rugulose, covering almost entire anterior metapleural lobe. Fore femora strongly incrassate, armed below with 2 rows of conspicuous sharp

spines, outer row consisting of 2 or 3 major spines with 3 small spines distad of outer large spine; inner row near middle with one extremely large spine and 4 distal small spines. Foretibiae somewhat curved. Labium elongate, reaching third abdominal sternum. First labial segment exceeding base of head. Length labial segments I 0.90, II 0.90, III 0.78, IV 0.62. Antennae slender, segments two and three slightly enlarged near distal ends, fourth segment strongly fusiform. Length antennal segments I 0.28, II 0.68, III 0.62, IV 0.94. Total body length 5.0.

Holotype.—♀: *Nigeria*: Lagos, Olatunde Ayoola Av. 6.III.1975 (Abdul Hamid) (light trap). In American Museum of Natural History.

Paratypes.—*Nigeria*: 1 ♂: same data as holotype. 1 ♂ R. St. nr. Mbiama 4-5.VII.1973 (Linnavuori). 1 ♀ R. St. Ebubu nr. Bori 2.VII.1973 (Linnavuori). 4 ♂♂, 2 ♀♀ Lagos, Glatunda Ayoola Ave. V.1975 (A. Hamid). *Ivory Coast*: 1 ♂ Dunco (sp. ?) Forest 7.X.1973 (Linnavuori). In National Museum of Natural History (USNM), A. Hamid and J. A. Slater collections.

I have examined an additional large female from the Cameroon (Abong Mbang-Ayos 13.VI.1973 [Linnavuori]), which is either conspecific or represents a closely related species. In addition to its larger size this specimen has the pale yellow and orange-yellow markings on the hemelytra much more extensively developed so that the corium is predominately pale rather than dark. The membrane by contrast is uniformly dark and all tibiae, tarsal segments two and three, and antennal segments two, three and four are uniformly dark red-brown.

Fontethanus rostratus runs in Scudder's (1963) key to *Fontethanus punctatus* Scudder because of the distinct punctures present on the anterior pronotal lobe. It is apparently not closely related to *F. punctatus*, the latter having slightly ochraceous humeral pronotal angles, only a pale triangular sub-

apical corial spot, and has a pale area laterally on abdominal sternum five. In *F. punctatus* the labium reaches only to the hind coxae and the anterior pronotal lobe is distinctly punctate only mesally and laterally, rather than over the entire surface.

Fontathanus ghanaensis,
NEW SPECIES

General form and color similar to *F. rostratus*. Pale areas on lateral portion of corium reduced to 3 irregular spots mesad of radial vein and 2 elongate white lateral streaks. Middle and hind femora lacking pale proximal annulations, completely black. First antennal segment black above, with red-brown coloration laterally. Body coloration, punctures and pubescence as in *F. rostratus*. Corium lacking shining silvery pruinose bars adjacent to claval suture.

Head strongly declivent, very broad, margins of head anterior to eyes strongly produced laterad and very sharply carinate. Length head 1.02, width 1.55, interocular space 1.0. Anterior pronotal lobe broadly obovate, maximum width equaling width across humeri; transverse impression extremely deep. Length pronotum 1.55 (length anterior lobe 0.78, length posterior lobe 0.75), width 1.42. Length scutellum 0.88, width 0.72. Length claval commissure 0.40. Clavus with a pruinose area occurring diagonally entirely across clavus near middle. Midline distance apex clavus-apex corium 1.02. Midline distance apex corium-apex membrane 1.12. Metathoracic scent gland auricle relatively slender, elongately elliptical, slightly bent posteriorly. Fore femora similar to *rostratus*. Labium relatively short, extending only slightly beyond mesocoxae, first segment not attaining base of head. Length labial segments I 0.68, II 0.62, III 0.60, IV 0.50. Length antennal segments I 0.25, II 0.70, III 0.58, IV 1.0. Total body length 5.50.

Holotype.—♀: *Ghana*: Tafo 9.X.1965 (D. Leston). In American Museum of Natural History.

This species is very similar to *F. rostratus* in both form and color. It is most readily recognizable by the relatively short labium that does not reach the metacoxae, in contrast to *F. rostratus* where the labium extends well back onto the anterior portion of the abdomen. Also in *F. ghanaensis* the head is much broader and the produced lateral margins anterior to the eye are much more produced and prominent.

Both of these species are strikingly myrmecomorphic. The corial color pattern, striking constriction between the pronotal lobes, constricted base of the abdomen, and the pruinose patches are all presumably ant mimetic adaptations.

Paromius carvalhoi, NEW SPECIES

Elongate, slender, parallel sided. Head black. Anterior pronotal lobe dark gray to nearly black; posterior lobe red-brown, becoming pale testaceous yellow on humeral angles and near posterior margin on either side of midline. Scutellum nearly uniformly red-brown, apex white. Hemelytra nearly uniformly pale testaceous yellow, with punctures strongly contrastingly dark brown; explanate margins dull white. Membrane pale fumose with veins strongly contrasting white. Abdomen red-brown. Femora varying from dark to bright red-brown. Tibiae and first two tarsal segments yellow, third tarsal segment black. Punctuation typical for genus, very fine and obscure on anterior pronotal lobe, except collar where more prominent.

Head moderately acuminate, eyes set far from posterior margin, prominently swollen, tylus extending midway to distal end of first antennal segment, very slightly declivent. Length head 0.92, width 1.05, interocular space 0.58. Pronotum elongate, tapering, anterior lobe not strongly convex dorsally, not appearing globose; lateral margins sinuate; transverse impression complete; posterior lobe with a raised median elevation on anterior half. Length pronotum 1.58, width 1.50. Scutellum elevated

mesally, strongly sloping laterad. Length scutellum 1.15, width 0.72. Midline distance clavus-apex corium 1.80. Midline distance apex corium-apex membrane 1.45. Fore femora moderately incrassate, armed below with two rows of white, dark tipped spines with four to five spines and spinules present in each row. Labium elongate extending between mesocoxae. First segment not quite attaining base of head. Length labial segments I 1.05, II 1.05, III 0.80, IV 0.38. Antennae conventionally terete, slender. Length antennal segments I 0.52, II 1.42, III 1.18, IV 1.48. Total body length 8.00.

Holotype.—♂: *Ghana*: Tafo 1.IV.1967 (D. Leston). In American Museum of Natural History.

Paratypes.—*Ghana*: 1 ♂ Tafo 12.XII.1965 (Leston) (UV trap). 1 ♂ same except 23.I.1966. 1 ♀ same except 15.XII.1965. 1 ♀ same except 16.XI.1965. 1 ♂ Accra 1.XII.1969 (C. W. Campbell) (blacklight trap). In National Museum of Natural History (USNM) and J. A. Slater collections.

Many of the species of *Paromius* are very similar in habitus to one another. The genus is certainly in need of a revisional study. However, only three species of *Paromius* have the labium elongate i.e. extending to, or nearly to, the mesocoxae. In all other species the labium is appreciably shorter, barely extending onto the anterior portion of the mesosternum. Of the three species in which the labium is elongate, the Ethiopian species *Paromius apicatus* Stål differs from *P. carvalhoi* by being much larger, having a more elongate head, a strongly tapered pronotum, and a very much longer labium that in *P. apicatus* extends well onto the abdomen. *Paromius carvalhoi* is much more similar in general habitus to the Oriental species *Paromius piratoides* (Costa), which it closely resembles. However, the two are certainly distinct in that *P. piratoides* has a relatively shorter more strongly declivent head, a more prominently, convexly rounded, anterior

pronotal lobe, lacks the median elevation of the posterior pronotal lobe, and has many less claval punctures mesad of the cubital vein. Also in most specimens of *P. piratoides*, only the apex of the third tarsal segment is black, whereas in *P. carvalhoi* the entire third tarsal segment of all legs is black.

Actually *P. carvalhoi* may prove to be more closely related to *P. apicatus*, despite the more readily apparent morphological differences. Both of these species have an elevated mesal posterior line on the pronotum and elongate attenuated pronota and heads.

Both *Paromius paraclypeatus* Scudder (1969a) and *P. carvalhoi* have been confused in the literature with *Paromius gracilis* (Rambur). I have not seen authentic specimens of *P. gracilis* from Ghana, although it is probable that it occurs in the northern savanna. *Paromius gracilis* is an abundant species in eastern and southern Africa.

Esinerus Scudder

Scudder 1969b: 88–90.

Scudder (1969b) separated *Esinerus* from *Sinierus* Distant by the former lacking a pronotal collar, having a relatively short first antennal segment, a dull tylus, a more flattened scutellum, and with less prominently erect body hairs.

The new species described below necessitates some modifications of the generic diagnosis, because it has considerably longer hairs than does the type species of *Esinerus* (*refractarius* Scudder) and has a pronotal collar that is nearly as well developed as it is in species of *Sinierus*. The relatively flattened scutellum, short first antennal segment, and dull tylus will still separate the two genera but are questionable features for generic status. However, I believe that *Esinerus* and *Sinierus* should be retained as distinct genera, as there are three morphological characters not mentioned by Scudder that seem to be important. In species of *Esinerus* the bucculae are well developed

along the entire ventral surface of the head with a groove present between them so that the first labial segment lies immersed between the bucculae and scarcely extends out of the buccular groove. In *Sinierus* the bucculae are low, obsolete posteriorly and the first labial segment is not enclosed by the bucculae for most of its length. In *Esinerus* the compound eyes do not have a series of large conspicuous hairs protruding from them as do the species of *Sinierus*. The metathoracic scent gland auricle of species of *Sinierus* is produced well above the surrounding evaporative area and has an oval buttonlike shape, whereas in *Esinerus* the auricle is not raised above the evaporative surface and curves evenly posteriorly as a narrow lunate arc. *Esinerus* species have a longitudinal row of silvery hairs running through the center of the clavus. They are not present in species of *Sinierus*. These silvery hairs are rather obscure in *E. refractarius*, but are very conspicuous in *E. humidus*.

My recent (Slater 1993) key to the African genera of Drymini is inaccurate. Couplet 1 of that key separates the genera on the basis of elongate hairs on the dorsal surface. Both *Esinerus* and *Sinierus* have numerous upstanding hairs present but are keyed to the half of the couplet where such hairs are lacking. It is true that the vestiture of these genera is much less elongate and upstanding than in the genera keyed that way, but anyone using the key would surely be misled by this couplet. Also couplet 3 states that the apical corial margin of *Esinerus* must be deeply concave. It is true that *Esinerus* species do have a weakly concave area near the base of the apical corial margin, but this is easily overlooked and certainly is not "deeply concave" in the sense that it is used in *Mizaldus*. The Slater (1993) key will work much better if *Sinierus* Distant (1901) and *Esinerus* are carried to couplet 2 where they may readily be separated from *Parastilboris* Carayon (1964) and *Psilomydrus* Scudder (1969b), the other two genera with

elongate dorsal hairs, by having the dorsal body surface pruinose rather than shining or subshining.

Esinerus humidus, NEW SPECIES

Head uniformly gray, shading to dark gray-brown on anterior pronotal lobe and basal third of scutellum. Posterior pronotal lobe, posterior two-thirds of scutellum and distal half of corium bright red-brown. Clavus, anterior half of corium, a large macula on membrane adjacent to apex of corium and an elongate macula distally in middle of membrane yellow. Remainder of membrane black. Legs pale testaceous. Antennae uniformly dark brown. Head and anterior pronotal lobe clothed with conspicuous velvety pruinosity, remainder of body surface also pruinose but less conspicuously so. Dorsal surface thickly clothed with upright, or semidecumbent, yellowish hairs. Anterior and posterior pronotal lobes, scutellum and hemelytra densely and finely punctate.

Head slightly declivent, tylus greatly exceeding juga, reaching midway to distal end of first antennal segment. Eyes set slightly away from antero-lateral pronotal angles. Length head 0.32, width 0.60, interocular space 0.40. Pronotum with a distinct anterior collar, lateral margins deeply sinuate and obtusely carinate; posterior margin straight or very slightly concave before scutellum; transverse pronotal impression obsolete mesally; calli low and faintly differentiated from remainder of pronotal disc. Length pronotum 0.52, width 0.98. Scutellum somewhat impressed basally, flat over most of surface, lacking a median elevation. Length scutellum 0.52, width 0.55. Length claval commissure 0.20. Corium with lateral margins somewhat sinuate, narrowest at level of distal third of scutellum; apical corial margin slightly concave near inner end. Midline distance apex clavus-apex corium 0.58. Midline distance apex corium-apex membrane 0.52. Metathoracic scent gland auricle appearing to be bilobed (a conventional posteriorly curving lobe present,

but with also an ovoid raised anterior buttonlike lobe nearly reaching anterior margin of metapleuron). Evaporative area small, not extending dorsally to middle of metapleuron, its dorsal margin truncate but rounded posteriorly. Metapleuron completely dull, covered with short pruinose hairs in addition to the elongate upright hairs. Labium extending to mesocoxae. Length labial segments I 0.30, II 0.28, III 0.25, IV obscured. Antennae relatively slender, second segment terete, segments three and four fusiform. Length antennal segments I 0.25, II 0.50, III 0.38, IV 0.35. Total body length 2.56.

Holotype.—♂: *Ghana*: Eastern region forest reserve, Nkwanda 28.X.1967 (D. Leston). In American Museum of Natural History.

Paratype.—[no abdomen]. *Ghana*: Tafo 17.X.1965 (D. Leston). In J. A. Slater collection.

Esinerus humidus is readily separable from *E. refractorius* in being considerably more elongate and slender and having a distinct anterior pronotal collar, with much more elongate upstanding hairs, lacking a white fourth antennal segment, with obtuse lateral pronotal margins (in contrast to *E. refractorius* where the margins are narrowly but sharply carinate), and in having a much longer, and relatively more slender, second antennal segment.

The presence of three large pale spots on the membrane of the forewing in this species also occurs on many species of forest rhyparochromines from West Africa. Whether this is a defective color marking for species living on the forest floor should certainly be investigated.

The biology of *E. humidus* is unknown. Our collecting party (Schuh, J. & S. Slater, Sweet) took many specimens of *E. refractorius* in South Africa feeding on the fallen seeds of *Ficus sycamorus* L.

I have examined specimens from the Cameroon, which probably represent an undescribed species. These specimens have a

pale fourth antennal segment, lack the large pale spots on the membrane of the forewing, have the metapleuron subshining with elongate hairs present, and the middle of the abdominal sternum shining.

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**CARVALHOFULVIUS GIGANTOCHLOAE, A NEW GENUS AND SPECIES OF
BAMBOO-INHABITING FULVIINI FROM WEST MALAYSIA
(HETEROPTERA: MIRIDAE: CYLAPINAE)**

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Abstract.—*Carvalhofulvius gigantochloae*, a new genus and species of fulviine Miridae from West Malaysia is described and illustrated. This bug lives inside the shoot internodes of *Gigantochloa scortechinii* (Poaceae: Bambusoideae), where it apparently feeds on developing fungal hyphae. The tribal placement of *Carvalhofulvius* and its relationship to other fulviine mirids are discussed. Biological information is provided, including a summary of a field study of colonization densities on different internode types (e.g. shoots, older culms).

Key Words: Heteroptera, Miridae, Fulviini, *Carvalhofulvius*, new genus, West Malaysia, bamboo-inhabiting, phytotelmata, biology

An ongoing study of the arthropod species inhabiting internodes of the giant bamboo, *Gigantochloa scortechinii* Gamble, in West Malaysia (coordinated by DK) has revealed an interesting species of fulviine Miridae that cannot be placed in any known genus of the tribe. *Carvalhofulvius gigantochloae*, new genus and new species, is here described and illustrated; its biology, placement in the Fulviini, and relationship to other fulviine genera are discussed.

Institute abbreviations used to record the depositories of types and other specimens are as follows: American Museum of Natural History, New York (AMNH); Forschungsinstitut Senckenberg, Frankfurt (FS); National Museum of Natural History, Washington, D.C. (USNM); Natural History Museum, London (NHM).

All measurements are given in millimeters.

***Carvalhofulvius* Stonedahl and Kovac,
NEW GENUS
(Figs. 1-14)**

Type species.—*Carvalhofulvius gigantochloae*, new species, here designated.

Diagnosis.—Distinguished from other genera of Fulviini by the long head, with eyes well removed from anterior margin of pronotum (Figs. 1, 2, 9); enlarged profemora, with two irregular rows of socketed spines ventrally (Figs. 6, 8); and by the structure of the male genitalia, especially the various sclerotized appendages of the vesica (Fig. 14).

Description.—Male. Macropterous; dark brown to nearly black with pale markings at base of hemelytra and apex of corium; dorsal surface finely granular, slightly shining; posterolateral regions of pronotum finely wrinkled; dorsal vestiture of short, stout,

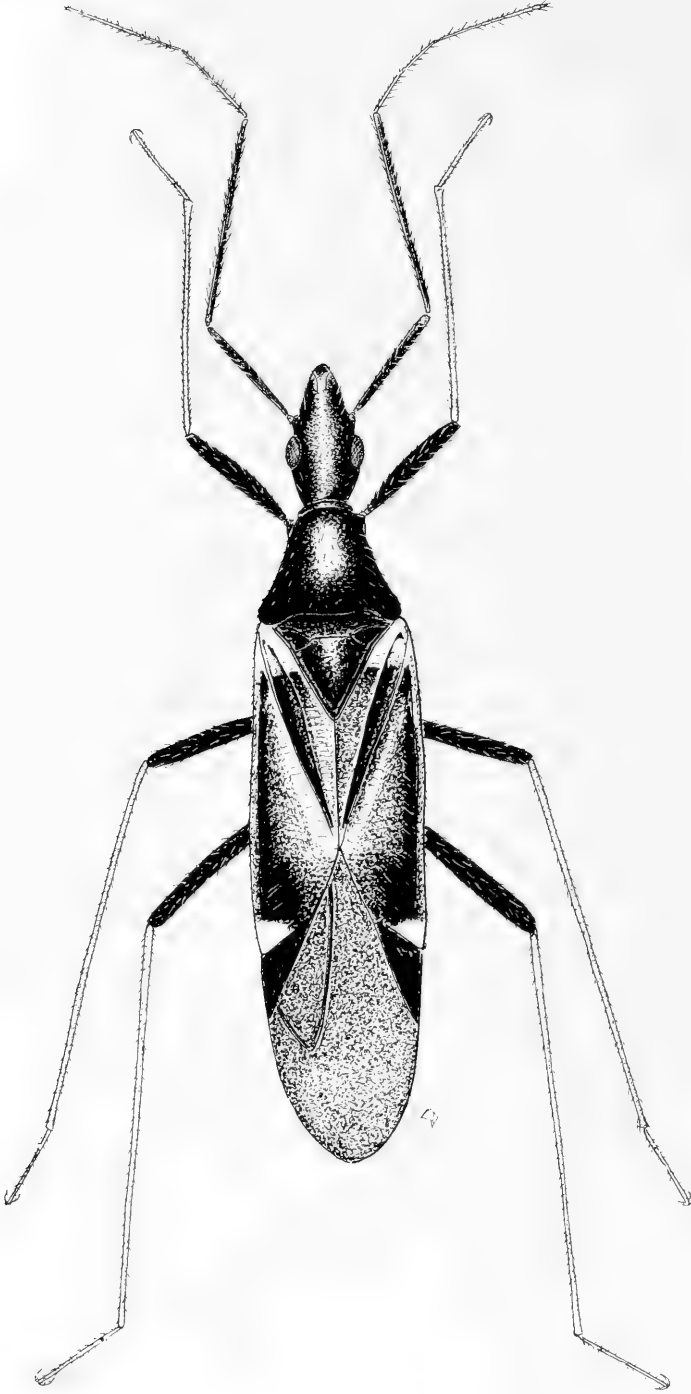
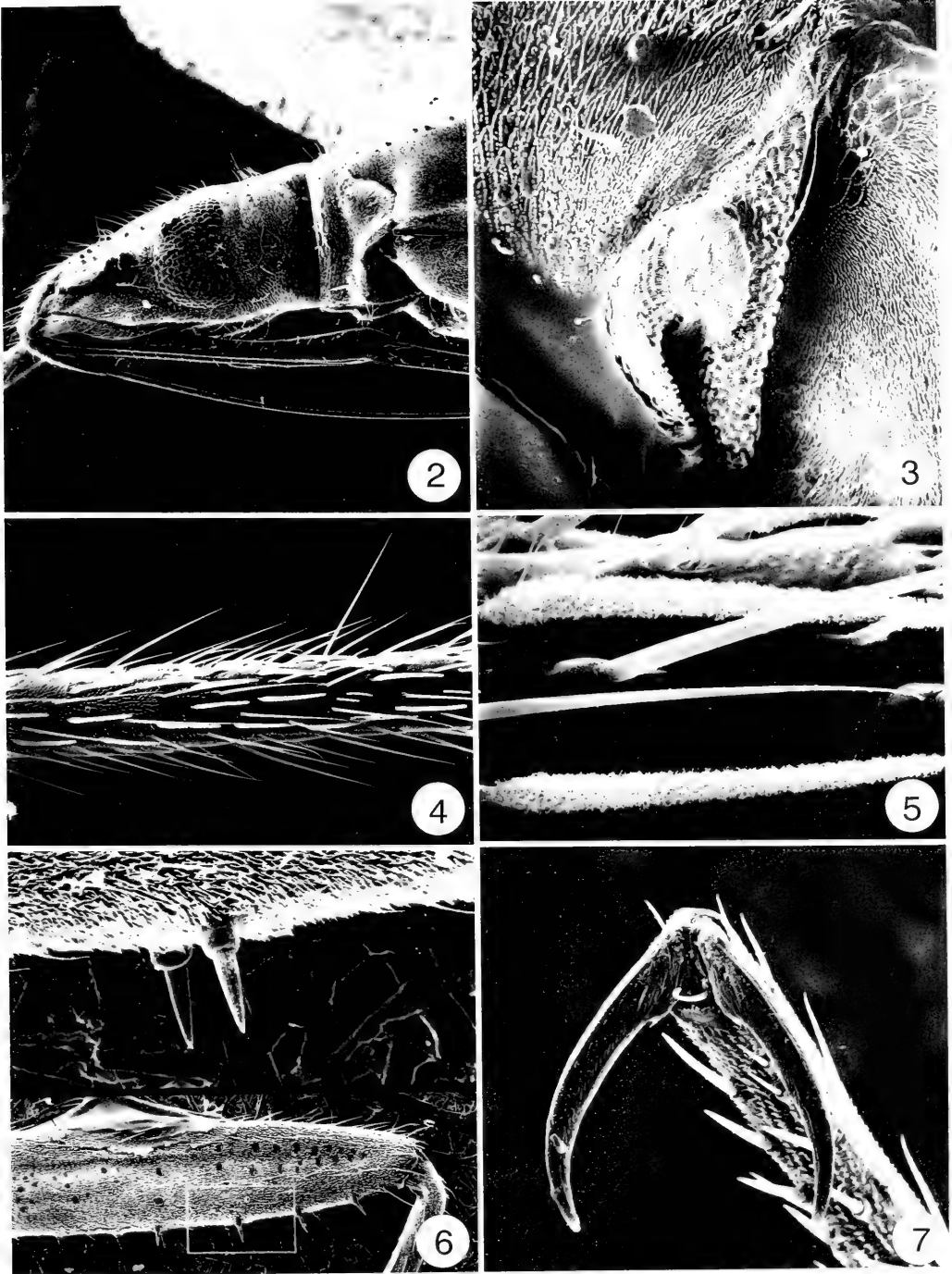


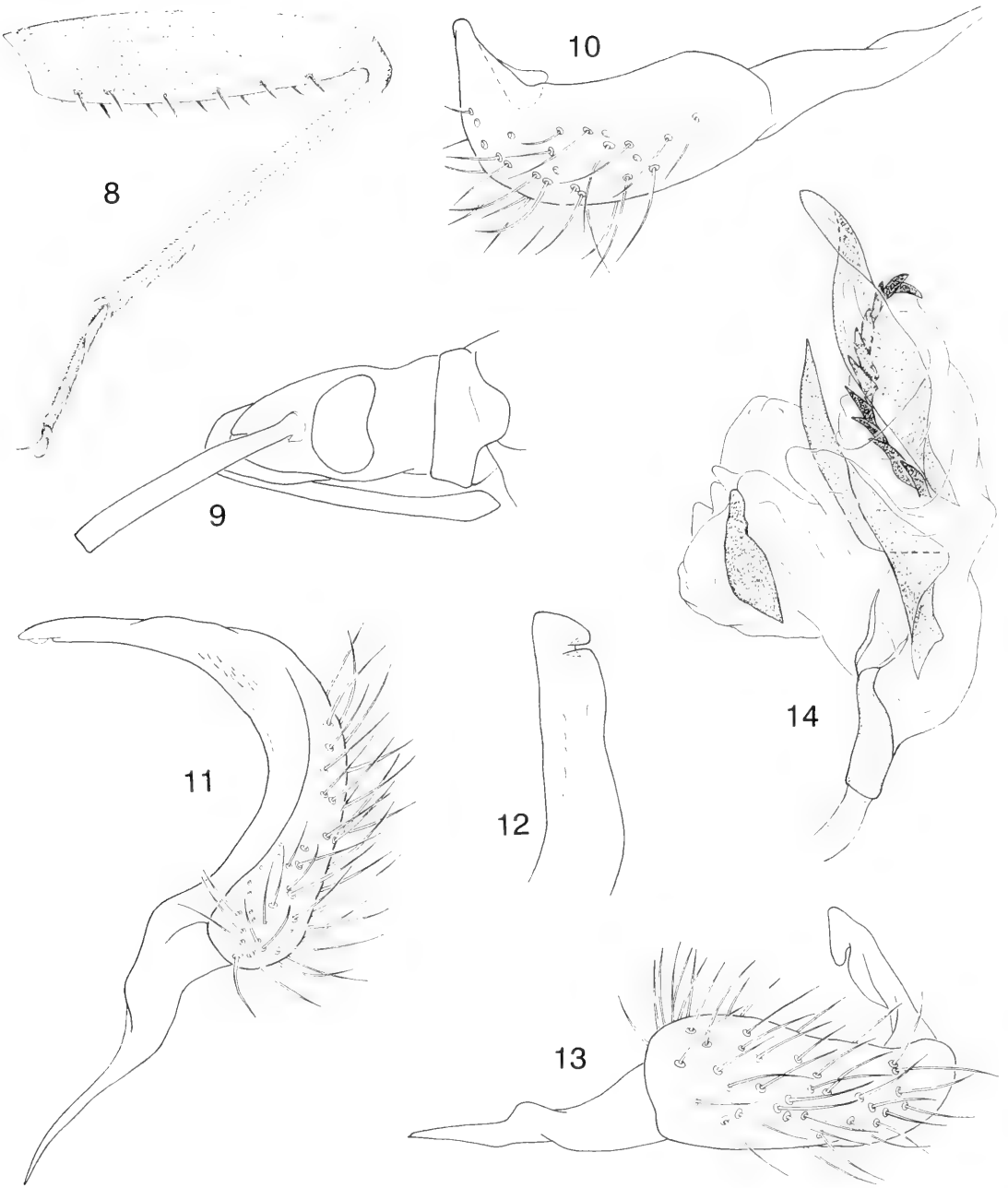
Fig. 1. *Carvalhofulvius gigantochloae*, n. sp., dorsal habitus of male.



Figs. 2-7. Scanning electron micrographs of *Carvalhofulvius gigantochloae*. 2, lateral view of head. 3, metathoracic scent efferent system. 4, distal third of antennal segment II. 5, detail of woolly setae on antennal segment II. 6, lateral view of profemora showing socketed spines on ventral surface. 7, pretarsus, posterior view.

suberect, dark setae, usually slightly longer and more densely distributed along lateral margins of pronotum, sparsely distributed on hemelytra, except more common along veins. *Head*: Length about equal to median length of pronotum; strongly produced anterior to eyes (Figs. 1, 2, 9); eyes small, pubescent, weakly protruding from head, removed from anterior margin of pronotum by distance equal to their width in lateral view, reaching ventrally to gular ridge; head posterior to eyes slightly depressed dorsally, weakly inflated laterally; frons nearly flat, gradually declining from vertex to tylus; tylus moderately prominent, distal half strongly declivous; maxillary and mandibular plates prominent; bucculae well developed, reaching posteriorly to level of anterior margin of eyes; buccal cavity ovate; genae very narrow, nearly obsolete, bordered ventrally by distinct gular ridge; gula broadly developed, depressed; labium reaching to base of genital capsule or slightly beyond, segment I reaching onto xyphus, segments II and III slightly longer than I, segment IV about half as long as III. *Antennae*: Cylindrical, segments I and II similar in diameter, III and IV narrower; inserted at median level of eye, fossae removed from anterior margin of eye by distance equal to diameter of antennal segment II; segment I about as long as head, reaching well beyond apex of tylus in lateral view; segment II slightly more than twice as long as I; length of segment III slightly less than I; length of segment IV about equal to segment I; all segments with suberect, dark setae, segment II also with some narrow, reclining, woolly setae ventrally and distally (Figs. 4, 5), segments III and IV with scattered, longer, pale setae. *Thorax*: Pronotum trapeziform, without distinct anterior and posterior lobes; anterior margin in the form of a flattened collar, about as broad as diameter of antennal segment I; lateral margins sinuate, weakly carinate posteriorly; posterior margin with deep, subquadrate excavation medially; calli strongly promi-

nent, occupying most of anterior two-thirds of pronotum, confluent medially, reaching lateral margins of pronotum anteriorly. Mesoscutum broadly exposed. Scutellum weakly elevated. Metathoracic scent efferent system with evaporative area narrowly developed; peritremal disc small, moderately raised, tongue-shaped, densely pubescent (Fig. 3). *Hemelytra*: Elongate, parallel-sided; embolium broadening slightly distally; cuneus about three times as long as broad; cuneal incisure shallow, fracture well developed; membrane reaching well beyond apex of abdomen, primary cell much longer than broad, secondary cell narrowly triangular. *Legs*: Profemora noticeably enlarged, with two irregular rows of large, socketed spines ventrally (Figs. 6, 8); meso- and metafemora narrower, nearly linear, without spines; tibiae cylindrical, set with four rows of dark spinules and some longer, pale setae; tarsi cylindrical, two-segmented, segment II twice as long as segment I (Fig. 8); pretarsus with long weakly curved claws, short setiform parempodia and no pulvilli (Fig. 7). *Genitalia*: Genital capsule subquadrate, with strongly developed posterodorsal margin; aperture bridged medially by flattened sclerite originating from dorsal margins of paramere sockets. Left paramere with sensory lobe moderately produced, gradually tapering to broad U-shaped angle, outer surface with long, pale setae; shaft slightly shorter than arm, with distinctly notched apex (Figs. 11-13). Right paramere lance-shaped, with strongly narrowed, curved apical region; outer surface with long pale setae; inner-dorsal surface with flattened, toothlike process (Fig. 10). Phallosome strongly asymmetrical, broadly opened distally. Vesica with ductus seminis terminating in weakly sclerotized tube with expanded posterodistal margin; secondary gonopore indistinct, unmodified, positioned at base of distal expansion of ductus seminis; primary membranous sac of vesica multilobed, with three sclerotized appendages: smallest, flattened sclerite originating near left distal margin of



Figs. 8–14. *Carvalhofulvius gigantochloae*. 8, lateral view of proleg. 9, lateral view of head. 10–14, male genitalia. 10, right paramere, lateral view. 11, left paramere, dorsal view. 12, apex of left paramere, lateral view. 13, left paramere, lateral view. 14, vesica.

sclerotized tube; larger, coiled, cone-shaped sclerite originating near right basal margin of sclerotized tube; strongly twisted, lance-shaped sclerite lying right and distal to cone-

shaped sclerite (position of all sclerites described in uninflated vesica with secondary gonopore in dorsal orientation—Fig. 14); vesica also with 8–12 strong spines rimming

distal margin of membranous sac, these wrapping around posterobasal region of lance-shaped sclerite in uninflated vesica.

Female.—Macropterous; similar to male in color and general structure, except first antennal segment relatively shorter and hemelytra not reaching as far beyond apex of abdomen; genitalia not examined.

Distribution.—West Malaysia.

Etymology.—Named in honor of José C. M. Carvalho for his extensive and lasting contributions to the systematics of the Miridae on a worldwide scale.

Discussion.—Based on the tribal characterizations presented by Poppius (1909), Carvalho (1955, 1978) and Schmitz and Stys (1973), *Carvalhofulvius* belongs to the Cylapinae tribe Fulviini. The primary characters supporting this placement are the elongate head with horizontal frons and strongly developed gula; enlarged, medially confluent calli, occupying most of anterior two-thirds of pronotum; conical coxae, with front pair much larger than middle and hind pairs; and pretarsus with long, weakly curved claws, setiform parempodia and no pulvilli.

Schmitz and Stys (1973) elevated the fulviines to subfamily rank, offering among other supporting evidence, the unique female reproductive system and egg-laying habit. Schuh (1976) considered the proposed change of status unwarranted, and neither Carvalho (1978) nor Schmitz (1978) supported a subfamily ranking in subsequent treatments of the group.

The relationship of *Carvalhofulvius* to other genera of Fulviini is uncertain, as are the generic relationships of most of the predominantly tropical Cylapinae. In Carvalho (1955: 19), *Carvalhofulvius* keys with difficulty to the genus *Fulvius* in couplet 11, and is superficially very similar to some of the larger species of this genus. However, *Carvalhofulvius* is easily distinguished from *Fulvius* by the characters of the head and profemora given in the generic diagnosis. We are not familiar enough with fulviine male genitalia to make more than general

comments about these structures, but it appears from our examination of other published accounts (e.g. Carvalho 1978), that the vesica of *Carvalhofulvius* is much more heavily adorned with sclerotized appendages than is commonly found in the genus *Fulvius*. Obviously, a much broader survey of external and genitalic characters is required to accurately address the question of generic relationships.

***Carvalhofulvius gigantochloae*,
Stonedahl and Kovac, NEW SPECIES**

(Figs. 1–14)

Diagnosis.—Recognized by the characters given in the generic diagnosis.

Description.—Male (n = 3). Length from apex of tylus to apices of hemelytra 5.62–6.30; width across hemelytra 1.20–1.42; surface texture and dorsal vestiture as in generic description. *Head*: Length 0.91–0.98, width across eyes 0.55–0.64, width of vertex 0.29–0.32; blackish brown with maxillary and mandibular plates and tylus somewhat paler; antennal segments I and II dark brown, II usually somewhat paler distally; antennal segment III brown, segment IV yellowish brown; length of antennal segment I 0.73–0.91, segment II 1.67–2.13; length of labium 3.42–4.27, segments I and IV brown or dark brown, segments II and III yellowish brown. *Thorax*: Pronotum uniformly blackish brown, except posterolateral margins sometimes slightly paler; posterior width of pronotum 0.98–1.20, median length 0.73–0.88; propleuron, mesoscutum and scutellum uniformly fuscous. *Hemelytra*: Dark grayish brown to nearly black; basal quarter of clavus, extreme base of corium, and posterolateral angle of corium white (Fig. 1); cuneus fuscous, sometimes tinged with red along inner margin; membrane uniformly infuscated, veins darkened. *Legs*: Femora dark brown, extreme base and apex usually paler yellowish brown; tibiae and tarsi pale yellow; pretarsal claws yellowish brown. *Genitalia*: Fig. 10–14.

Female (n = 5).—Length 5.47–6.00; width across hemelytra 1.13–1.28; length of head 0.91–0.97; width of head across eyes 0.55–0.60; width of vertex 0.32–0.36; length of antennal segment I 0.70–0.78, segment II 1.35–1.79; length of labium 3.15–4.34; median length of pronotum 0.69–0.81; posterior width of pronotum 1.03–1.17.

Distribution.—West Malaysia.

Etymology.—Named for its host plant, *Gigantochloa scortechinii*.

Holotype male.—West Malaysia. *Selangor Prov.*: Ulu Gombak Field Studies Centre, University of Malaya, 250 m, Sample 2, 8.XII.1993, ex shoot internode (no. 10) of *Gigantochloa scortechinii*, D. Kovac (AMNH).

Paratypes.—West Malaysia. *Selangor Prov.*: 1 female, same data as holotype (AMNH); 1 female, same data as holotype, except Sample 1, 13.XI.1993, internode of decaying shoot of *G. scortechinii* on ground (FS); 1 male, 1 female, same data as holotype, except Sample 3, 2.XII.1993, internode (no. 6) of *G. scortechinii* (FS); 1 female, same data as holotype, except Sample 4, 30.XI.1993, internode (no. 9) of *G. scortechinii* (FS); 1 male, 1 female, same data as holotype, except Sample 5, 23.XI.1993, internode (no. 5) of *G. scortechinii* (NHM).

Additional specimens.—West Malaysia. *Selangor Prov.*: Ulu Gombak Field Studies Centre, University of Malaya, 250 m: 3 males (1 damaged, 1 teneral), 15.VI.1989; 2 females, 18.III.1989; 1 male (teneral), 9.V.1989; 1 female, 16.VI.1989; all from internodes of *G. scortechinii*, D. Kovac (FS).

The specimens collected in March–June, 1989 are smaller on the average (males 3.8–5.5; females 4.7–4.9) than those collected in November and December, 1993. However, the external characters and male genitalia of the smaller specimens are consistent with those of the holotype and paratypes, confirming that the two groups of specimens are conspecific. The 1989 specimens were not measured or included here as paratypes primarily because of their poor condition.

Biology.—Although several Miridae are known to be strictly associated with bamboo in Asia (Zheng, 1994 recorded four species from China), *Carvalhoholmius gigantochloae* is the only species that lives inside the internodes of bamboo shoots. It has been collected in Peninsular Malaysia from *Gigantochloa scortechinii*, *G. latifolia* Ridl. and *Dendrocalamus pendulus* Ridl. The following biological account was compiled from observations made by DK on *G. scortechinii*, a bamboo species endemic to the Malay Peninsula, whose culms grow 25 m tall (internode length 20–60 cm, diameter 8–10 cm). The bug gains access to the internodes through holes made by other insects or through cracks in the internode wall. Holes as small as 1.9 × 0.9 mm, such as those made by larvae of the leaf beetle *Lasiochiloga goryi* (Guér.), allow *C. gigantochloae* easy access to bamboo internodes. All internodes investigated were partially filled with water that had entered through holes or cracks after rainstorms. These small water reservoirs within bamboo shoots, sometimes referred to as phytotelmata, create a unique environment supporting a rich fauna of aquatic and terrestrial insects (for details see Kovac 1994 and Kovac and Streit 1994).

Different internode types (e.g. young, old, living, decaying) exhibit differential colonization densities of *C. gigantochloae*. Young shoots are much preferred to older culms—20.6% of the internodes examined in standing shoots were inhabited, while only 1–2% of the internodes of older culms were colonized. Bugs were found only in the lower section of the shoots from just above the ground to a height of four meters. Older felled culms in a state of decomposition showed higher levels of colonization. In a six-month investigation of 100 internodes taken from 10 felled culms, bugs were observed in a total of 28 internodes, with up to 11 internodes inhabited simultaneously. The majority (19) of inhabited internodes belonged to just two of the 10 culms studied.

Internodes of felled shoots were colonized

by both adults and nymphs of *C. giganteochloae*. Some bugs stayed in the same internodes for up to 2.5 months, but stays of shorter duration were much more common. Development from egg to adult was estimated to take somewhere in the range of 45–60 days. In one case, a new generation of bugs reached the adult stage 59 days after the appearance of the initial colonizing adult. The first copulation was seen seven days after the last molt. No observations were made on oviposition sites.

Carvalhofulvius giganteochloae was seen to touch the moist substrate of the inner wall with its labium while walking, often in close vicinity to the water surface. In two cases, the stylets were seen to be inserted into moist debris which contained fungal hyphae. Fungi may well be the staple food of this mirid species, a feeding habit consistent with that reported for other fulviine Miridae (Schuh 1976, Wheeler and Wheeler 1994). The bug prefers damp places in which an intense decomposition of wall substance of the bamboo occurs. This is true for both the inner walls of living shoots after a connection to the outside environment has been created and the wall of dead culms that decompose completely. In older living culms, only the inner nutrient-rich layer decomposes, while the remaining wall substance remains intact. Dead stumps of bamboo culms are another particularly favorable habitat for *C. giganteochloae*.

In the course of the six-month investigation of felled older culms there were eight observations of predation on *C. giganteochloae* by internode-inhabiting predators. Two adult bugs and one nymph were found in the webs of theridiid spiders, one nymph was captured by a jumping spider of the subfamily Spartaeinae and three nymphs were attacked by the assassin bug *Emesopsis* sp. Another nymph had apparently fallen onto the water surface and then been caught by the waterstrider *Baptista* sp.

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**PLANT BUGS (HETEROPTERA: MIRIDAE) OF *PHLOX SUBULATA* AND
OTHER NARROW-LEAVED PHLOXES IN EASTERN UNITED STATES**

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Abstract. — *Phlox subulata* L. (Polemoniaceae) is a prostrate, suffruticose perennial characteristic of shale and serpentine barrens of the eastern United States. It serves as a host of various little-known insect species. The mirid fauna of this plant was inventoried during 1989–1994, mainly in shale barrens of Maryland, Pennsylvania, Virginia, and West Virginia, but also in outcrops of shale and other types of bedrock, and in eastern serpentine barrens. Four plant bug species were consistently collected in shale barrens: the bivoltine generalists *Lopidea heidemanni* Knight and *L. minor* Knight and the univoltine specialists *Polymerus tinctipes* Knight and *P. wheeleri* Henry; previously, the two monophagous species of *Polymerus* had been known only from their type localities in Maryland and West Virginia, respectively. Information on distribution, seasonal history, and habits is presented for all four species, as well as their use of the only other eastern narrow-leaved phloxes of prostrate growth habit, *P. bifida* and *P. nivalis*. *Lopidea minor*, *P. tinctipes*, and *P. wheeleri* are as characteristic of shale barrens as are the endemic plant species; these specialized communities and their associated biota are deserving of protection from habitat degradation.

Key Words: Insecta, Miridae, shale barrens, serpentine barrens, insect distribution, life history, host-plant specificity

Scientific interest in shale barrens is generally restricted to botanists and geologists.

—R. B. Platt 1951

Geologists and botanists are agreed that outcrops of Devonian shales may be traced by the presence on them of creeping phlox (*Phlox subulata*) . . .

—M. Brooks 1965

Shale barrens of the mid-Appalachian region—extending from south-central Pennsylvania (40°N) through western Maryland to eastern West Virginia and southwestern Virginia (37°N)—have long fascinated field botanists (Wherry 1930, Platt 1951). The barrens occur on discontinuous shale outcrops and talus of steep southern exposure (>20°) that are characterized by high insolation temperatures and low moisture availability at the surface; they are often

undercut by a stream. Shale barrens, in the lee of mountains and within rain shadows, receive an average rainfall of 70 to 100 cm per year (Platt 1951, Brooks 1965, Keener 1983, DeSelm and Murdock 1993). Despite the hot, dry microclimate and sparse vegetation—treeless openings are common—these shale slopes retain sufficient soil moisture to sustain the growth of herbaceous endemic plants (Platt 1951, Keener 1983).

Occurring mainly on Upper Devonian

shales of the Brallier formation, shale barrens may also be associated with Ordovician Martinsburg shales or even Silurian strata (Artz 1937, Platt 1951, Keener 1983, Morse 1983). Like other unusual soil types, these edaphic islands in the eastern deciduous forest of the Valley and Ridge phytogeographic province (Appalachian Valley) support a distinctive flora (e.g., Wherry 1930, Core 1940, 1952, Allard and Leonard 1946, Platt 1951, Henry 1954, Keener 1970, 1983, Morse 1993). The presence of several endemic plants, disjuncts, and various rare or endangered plant taxa that are absent or seldom present in the surrounding woodlands suggests the occurrence of a diverse fauna of phytophagous insects. Such is indeed the case (A.G.W. unpublished data), although entomologists have paid relatively little attention to insect-plant relationships in these communities. The butterflies and skippers characteristic of shale barrens, however, are well known (Clench and Opler 1983, Opler and Krizek 1984, Pague and Schweitzer 1991), and Pennsylvania shale barrens contain some of that state's rarest butterfly and moth species (Smith 1989). Species in a few other insect groups have also been studied, e.g. the grasshopper *Melanoplus impudicus* Scudder (Gurney 1941) and the psyllid *Craspedolepta eas* (McAtee) (Wheeler 1994).

Moss phlox, or moss or mountain pink (*Phlox subulata* L.), is a prostrate or matlike suffruticose (i.e. becoming somewhat woody) perennial that characterizes shale barrens. It harbors an unusually rich insect fauna, including the recently described whitefly *Trialeurodes phlogis* Russell (Russell 1993), and several other poorly known species (Henry 1979, Wheeler et al. 1983, Wheeler 1994, unpublished data). In the present paper, I provide biological information on the mirids or plant bugs that develop on *P. subulata* growing on various types of bedrock; mirid-moss phlox relationships in mid-Appalachian shale barrens are emphasized. Data from an inventory of the mirids as-

sociated with other eastern subulate or narrow-leaved phloxes are also presented. This paper commemorates the remarkably productive scientific career of José C. M. Carvalho and his devotion to the Miridae. His research and numerous publications, including a world catalog of the group, stimulated interest in mirid systematics and biology.

HOST PLANTS

The genus *Phlox* belongs to the Polemoniaceae, a mostly New World family. It contains numerous endemic eastern species but is most diverse in western North America (Grant 1959). Mirids were collected principally from *P. subulata*, although collections were also made from *P. bifida* Beck and *P. nivalis* Lodd. ex Sweet. These three apparently closely related species (particularly *P. bifida* and *P. subulata* [Gleason and Cronquist 1964]) are the only narrow-leaved members of the genus (Section or Subsection Subulatae) occurring in eastern North America (Wherry 1935b, 1951, Flory 1970). *Phlox nivalis* is sometimes relegated to the Section Protophlox (Wherry 1955) but is actually similar in both morphology and cytology to *P. bifida* and *P. subulata* (Smith and Levin 1967).

Phlox subulata.—Moss phlox (Figs. 1, 2) is a suffruticose perennial that has many-branched trailing or creeping stems, is woody at the base, and has persistent awl-shaped or needlelike leaves. The main blooming period is April to May, or in cooler localities, into June; colonies vary in flower color from rose-purple to pink or white. Forming dense, low, evergreen mats on sandy or gravelly soil and rocky ledges (Fig. 1), moss phlox occurs not only in shale barrens but also in serpentine barrens, on limestone cliffs, and on other types of bedrock (Stout 1917, Wherry 1929a, 1930, 1936, 1955, 1964, Core 1966, Everett 1981, Keener 1983, Bartgis 1985). *Phlox subulata* typically grows in well-drained, slightly alkaline to strongly acidic soils. This pioneer, xero-



Figs. 1-2. *Phlox subulata*. 1, Colony on shale outcrop in West Virginia. 2, Close-up of inflorescence. (Photographs courtesy of T. J. Allen.)

phytic plant is seldom found in nearby woods or meadows, where it is outcompeted by faster-growing plants (Wherry 1929b, 1935b, Allard and Leonard 1946, Morse 1988).

Moss phlox is native from southern Ontario and New York to southern Michigan and south to the mountains of North Carolina and Tennessee (Wherry 1929b, 1935b, 1955, Flory 1970, Everett 1981, Gleason and Cronquist 1991). Its dispersal center may be the Appalachians of eastern West Virginia (Wherry 1935b). *Phlox subulata* is used extensively in rock gardens and borders, and as a ground cover on slopes; it often escapes from cultivation, establishing colonies in cemeteries and on artificial barrens such as road and railroad cuts (Wherry 1929b, c, Everett 1981, Cooperrider 1986, Hudak 1993).

Phlox bifida.—Cleft or sand phlox is a tuft-forming species superficially similar to *P. subulata*. It differs, however, in its looser, often more erect, growth habit; longer leaves, which are fewer in number; and deeply cleft (bifid) petal blades. Flowers vary from pale blue or violet to white, but are mostly lavender. This spring-blooming perennial shows a disjunct distribution from southern Michigan to Tennessee, northern Arkansas, and eastern Kansas. A plant mainly of the Interior Highland and Low Plateaus with its range centering in southern Illinois, this pioneer species colonizes sandy banks and dunes, rocky slopes, and bare cliffs (Wherry 1929b, 1935b, 1955, Winterringer and Vestal 1956, Everett 1981, Gleason and Cronquist 1991).

Phlox nivalis.—Piney-woods or trailing phlox has foliage similar to that of *P. subulata*, but some of its leaves are usually broader. Although these species have been confused botanically, they differ markedly in floral structure: *P. nivalis* has much shorter stamens and style and somewhat larger flowers. The specific epithet, *nivalis*, refers to the often snowy white flowers, but the corolla may be pink or light purple. More southern in distribution than the other east-

ern narrow-leaved phloxes, *P. nivalis* ranges from southern Virginia to Florida and Alabama. Its dispersal center lies in the Piedmont of South Carolina. Piney-woods phlox grows mainly in acid soils on dry sandy slopes of open pine and oak woods. It blooms from March to April in the southern part of its range, April and May toward the northern end (Wherry 1929b, 1935b,d, 1955, Everett 1981, Gleason and Cronquist 1991).

STUDY SITES AND METHODS

Mirids were observed and collected from 1989 to 1994, chiefly on *P. subulata* in mid-Appalachian shale barrens of Upper Devonian strata and Ordovician Martinsburg outcrops (Fig. 3). Included were such well-known botanical sites as Green Ridge in Maryland; Eagle Rock, Head Waters, Millboro, and Short Mountain in Virginia; and Kates Mountain in West Virginia (Wherry 1935a, Butts 1940, Core 1940, 1952, Allard and Leonard 1946, Platt 1951, Keener 1983, Morse 1983). Numerous shale outcrops that cannot be characterized as true barrens were also sampled in the Valley and Ridge Province, as were a few ornamental plantings. In addition, collection sites included eastern serpentine barrens such as Nottingham, Pink Hill, and Unionville in Pennsylvania, and Soldiers Delight in Maryland (Wheeler 1988 and references therein), and sites in the Appalachian Highlands where *P. subulata* grows on dolomite, greenstone, limestone, and other substrates. Limited sampling was conducted to determine the mirid fauna of *P. subulata* outside this plant's center of distribution: in Kentucky, New Jersey, New York, North Carolina, and Ohio. Information on seasonality and habits of mirids associated with *P. subulata* was obtained largely from the following sites; the number of visits to each site is given in parentheses (see also Table 1).

MARYLAND: *Allegany Co.*, Country Club shale barren above Evitts Cr., NE. of Cumberland (3) and shale barrens, Green Ridge State Forest, Fifteen Mile Creek Rd.

Table 1. Miridae observed on *Phlox subulata* during 1989-1994; asterisks denote ornamental plantings.

State	County	Locality	<i>Lopidea heidemanni</i>	<i>L. minor</i>	<i>Polymerus tinctipes</i>	<i>P. wheeleri</i>	
Maryland	Allegany	Country Club shale barren, NE. of Cumberland	●			●	
		Fort Hill, south tip ridgetop			●		
		Green Ridge State Forest, Fifteen Mile Creek Rd. at Piclic Rd.	●				
		Romney-Oldtown shale barren, E. of Oldtown	●				
	Baltimore	Soldiers Delight serpentine barren, SW. of Reisterstown	●	●			
	Montgomery	Great Falls			●		
	Washington	Boy Scout shale barren, Sideling Hill Wildlife Management Area	●		●		
North Carolina	Union	*N. of Fairview, Rt. 601	●				
Ohio	Athens	Buffalo Beats prairie, SE. of Buchtel			●		
		York Twp., Twp. Rd. 73, 0.3 mi. W. of Co. Rd. 1	●		●		
		York Twp., Twp. Rd. 293 nr. junc. Twp. Rd. 295	●		●		
	Guernsey	N. of Winterset, Twp. Rd. 871	●	●			
Pennsylvania	Allegheny	SW. of Tarentum, Bull Creek Rd.	●				
		Bedford	E. of Fishertown, Rt. 56	●		●	
			NE. of Ryot, Rt. 96	●		●	●
	Chester	Silver Mills shale barren, E. of Inglesmith	●		●		
		Fern Hill serpentine barren, West Goshen Twp.	●				
		Nottingham Park serpentine barren	●	●			
		Sugartown serpentine barren, Willistown Twp.	●	●			
	Delaware	Unionville serpentine barren, NE. of Unionville	●	●			
		Pink Hill serpentine barren, Tyler Arboretum, nr. Lima	●		●		
		Monroe	NE. of Shawnee, Mosier Knob Rd.	●	●		
Northumberland	*2 mi. E. of Milton, Rt. 642			●			
Virginia	Alleghany	7.6 mi. S. of Covington, Rt. 18	●				
		10.6 mi. S. of Covington, Rt. 18	●	●	●		
		N. of Sweet Chalybeate, Rt. 311	●				
	Bath	Fort Lewis shale barren, Rt. 678 at Cowpasture River	●	●	●		
		3 mi. SW. of Millboro Springs, Rt. 42	●	●			
		*Millboro			●		
	Bland	3.5 mi. SW. of Bland, Rt. 42	●				
		1.2 mi. E. of Crandon, Rt. 42	●				
	Botetourt	Eagle Rock shale barren, 2.5 mi. NW. of Eagle Rock			●		
	Carroll	SE. of Dugspur, Rt. 638	●	●			
	Floyd	*SE. of Willis, Rt. 799	●	●			
	Highland	Head Waters shale barren	●	●		●	
		E. of Frost, W. Va., Rt. 600 S. of Rt. 64	●				
	Madison	Shenandoah Nat. Park, Skyline Drive, Franklin Cliffs	●	●	●		
	Montgomery	Coffee Valley, S. of Ironto	●	●			
		N. of Ironto, Rt. 713	●		●		
	Page	Shenandoah Nat. Park, Skyline Drive, Little Stony Man Cliffs			●		
	Roanoke	Dixie Cliff, SW. of Glenvar	●	●	●		
		S. of Catawba, Rt. 311			●		
	Rockbridge	Goshen, Rts. 39-42	●		●		
Rockingham	George Washington Nat. Forest, For. Rd. 87, W. of Fulks Run			●			
Shenandoah	2.5 mi. N. of Edinburg, Rt. 675	●		●			
	Short Mountain shale barren, 3 mi. SE. of Mount Jackson	●	●	●	●		

at Piclic Rd. (5); *Baltimore Co.*, serpentine barrens, Soldiers Delight Natural Environmental Area, W. of Owings Mills (3); *Washington Co.*, Boy Scout shale barren above

Sideling Hill Cr., E. of Little Orleans (4).

OHIO: *Athens Co.*, Buffalo Beats prairie, SE. of Buchtel (2); *Guernsey Co.*, shale banks along county road, NW. of Winterset (3).

Table 1. Continued.

State	County	Locality	Lopidea heidemanni			Polymerus tinctipes		
			L. minor	P. wheeleri				
West Virginia	Greenbrier	Kates Mountain shale barren, S. of White Sulphur Springs	●	●	●			
		White Sulphur Springs	●	●	●			
		E. of Alvon, Whites Draft Rd.	●	●	●			
	Grant	Cave Mountain, 1 mi. N. of Landes	●	●	●			
		N. of Arthur, Patterson Creek Rd.						●
		4 mi. N. of Landes, Rt. 220		●				
		2.3 mi. S. of Landes, Rt. 220	●					
		3 mi. S. of Landes, Rt. 220						●
		3.5 mi. S. of Petersburg, Rt. 220	●					
	Hampshire	S. of Romney, River Rd.	●	●				
		nr. Forks of Cacapon, Rt. 29, 0.3 mi. S. of Rt. 127	●					
		3 mi. E. of Augusta, Rt. 50	●					
		Shanks, Rt. 50	●					●
		3 mi. E. of Romney, Rt. 50	●					
		8 mi. W. of Romney, Rt. 50	●					
		3.5 mi. N. of Slanesville, Rt. 29	●					●
		Mathias, Lost River Rd.	●					
		NW. of Lost River State Park, Lost River Rd.	●					
		Mooresfield, South Fork Rd.		●				
		N. of Mooresfield, Rt. 220	●	●	●			
	Mineral	7.5 mi. NE. of Mooresfield, Trough Rd.	●					●
		2 mi. E. of Wardensville, Rt. 55		●	●			
		Burlington, Rt. 50	●					●
	Morgan	Largent, Rt. 9	●					
		10 mi. S. of Great Cacapon, Rt. 9						●
	Pendleton	nr. Fort Seybert, Conrad Rd.	●					
		North Fork Mountain, nr. Smoke Hole		●				
		2.3 mi. SE. of Upper Tract, Schmucker Rd.	●	●	●			
		E. of Brandywine, Rt. 33		●				
		N. of Brandywine, Rt. 33	●	●	●			
	Pocahontas	6 mi. S. of Franklin, Rt. 220	●					
		NW. of Huntersville, Rt. 28						●
		3.5 mi. SE. of Minnehaha Springs, Rts. 39-92	●					

PENNSYLVANIA: *Bedford Co.*, roadside slope, NE. of Ryot (4); *Chester Co.*, Nottingham(3), Sugartown(4), and Unionville (2) serpentine barrens; *Delaware Co.*, Pink Hill serpentine barren, Tyler Arboretum, NE. of Lima (4); *Monroe Co.*, roadside bank along Mosier Knob Rd., NE. of Shawnee (2).

VIRGINIA: *Alleghany Co.*, shale barren above Potts Creek, Rt. 18, 10.6 mi. SW. of Covington (8); *Bath Co.*, shale barren above Cowpasture River, Rt. 678, Ft. Lewis (5); *Highland Co.*, Head Waters shale barren

above Shaws Fork, nr. junc. Rts. 250 and 616 (19); *Montgomery Co.*, shaly slope, Rt. 622 nr. junc. Rt. 603 N. of Ironto (5); *Ronoke Co.*, Dixie Cliff, SW. of Glenvar (2); *Rockbridge Co.*, shale slopes along Rts. 39-42, Goshen (9); *Rockingham Co.*, shaly banks along For. Rd. 87, George Washington National Forest, W. of Fulks Run (4); *Shenandoah Co.*, shale barren, south end of South Mountain, SE. of Mount Jackson (8).

WEST VIRGINIA: *Greenbrier Co.*, shale barren, Kates Mountain, S. of White Sulphur Springs (9) and shale banks along



Fig. 3. Occurrence of mid-Appalachian shale barrens based on Keener (1983); larger stippled area = Upper Devonian shale strata, smaller area = Ordovician Martinsburg outcrops in the Massanutten Mountains.

Whites Draft Rd., E. of Alvon (3); *Hampshire Co.*, roadside slopes, Rt. 29, 3.5 mi. N. of Slanesville (6) and Rt. 50, Shanks (6); *Hardy Co.*, shale banks along Lost River Rd., W. of Mathias (2); *Mineral Co.*, shale banks, Rt. 50 nr. Burlington (2), *Pendleton Co.*, shale banks along Schmucker Rd., SE. of Upper Tract (3).

Mirids were sampled on *P. bifida* in Illinois along bluff top woods, LaRue-Pine Hills Ecological Area, Shawnee National Forest, Union Co.; on limestone bluffs near Prairie du Rocher, Randolph Co.; and in Mason Co. in loess hill prairie, Revis Nature Preserve SW. of Mason City, and in sand prairie, Sand Ridge State Forest NE. of Havana. Collections were made in Indiana on limestone bluffs above the Ohio River at Porters Point, SW. of Laconia, Harrison Co.; in Kentucky on limestone ledges of "Boones Knoll," Camp Nelson, Jessamine Co.; and in Tennessee in cedar glades near Cedars of

Lebanon State Park and at Long Hunter State Recreation Area, Wilson Co.

Limited sampling of mirids associated with *P. nivalis* was conducted. In North Carolina a collection was made from a roadside bank along Rt. 601 W. of Stanfield, Cabarrus Co.; no mirids were found on this plant at Bluff Mountain, N.C., or at several sites in South Carolina (Lexington, Pickens, and York counties).

The main collecting sites were visited at irregular intervals from early or mid-April through June; in some years, sampling of *P. subulata* began in late March and extended into early October. At each site, mirids were sampled by shaking mats of phlox over a shallow white tray and recording any mirid species present and their relative abundance. Sampling times varied from 10–15 minutes for small host patches to 45–60 minutes or more for sites having extensive phlox colonies. In the first season of study

(1989), different-appearing nymphs were reared on sprigs of the host plant to associate them with adults of the various mirids. Nymphal stages of each species present were recorded in the field or, when necessary, collected and sorted to instar in the laboratory. Information on feeding habits was obtained in the field and supplemented by laboratory observations. Voucher specimens of the four phlox-associated mirids have been deposited in the collections of Cornell University, Ithaca, N.Y.; the National Museum of Natural History, Washington, D.C.; and the Pennsylvania Department of Agriculture, Harrisburg.

RESULTS

Information is presented on four mirid species that occur consistently on *P. subulata*: the generalists *Lopidea heidemanni* Knight and *L. minor* Knight (Orthotylinae: Orthotylini) and specialists *Polymerus tinctipes* Knight and *P. wheeleri* Henry (Mirinae: Mirini). For each species, the known distribution is summarized and any new state records obtained are noted; literature on host plants, including those used for reproduction as well as adult feeding, is reviewed; and the seasonal history and habits on *P. subulata* are summarized. Associations with other plants found in shale barrens and shale outcrops, and on other narrow-leaved eastern phloxes, are included. Nymphs of the phlyne *Plagiognathus politus* Uhler occasionally developed on *P. subulata* in shale barrens, but this polyphagous species will not be mentioned further.

Lopidea heidemanni Knight

This polyphagous plant bug, common on weedy vegetation along roads and in other disturbed habitats, is more likely to be encountered by the general collector than the other phlox-associated mirids that were studied. Despite its wide range and frequency of collection, the habits of *L. heidemanni* are not well known.

Distribution. — Described by Knight

(1917) from New York, *L. heidemanni* has since been recorded from 30 additional states and the District of Columbia, ranging from Vermont, south to Georgia, and west to Minnesota, Wyoming, and Texas (Henry and Wheeler 1988, Asquith 1991). Although *L. heidemanni* was present on *P. subulata* at 62 of 79 sites that yielded plant bugs (Table 1), no new state records were obtained during this study. Asquith (1991) mapped the known distribution of this species.

Host plants. — Nymphs have been recorded from yarrow (*Achillea millefolium* L.), ninebark (*Physocarpus opulifolius* (L.) Maxim.), and terminal growth of young elm (*Ulmus* sp.) (Knight 1923, 1941, Wheeler and Hoebeke 1985). This species has also been collected on numerous other herbs, shrubs, and trees (e.g. Messina 1978, Snodgrass et al. 1984, Blinn and Yonke 1985, Asquith 1991). Because adults readily disperse to various plants (see "Seasonal history and habits"), some of the recorded "hosts" may be used only for adult feeding or shelter. Although this species is said to develop mainly on deciduous trees (Asquith 1993), herbs would appear to be used more frequently as host plants than shrubs or trees.

In the present study, nymphs developed on *Phlox bifida* and *P. nivalis*, and on *P. subulata* in native colonies and landscape plantings. In shale barrens and outcrops, nymphs were also observed on *Ceanothus americanus* L., *Centaurea biebersteinii* DC. (= *C. maculosa* of authors), *Clematis albicoma* Wherry, *Crataegus* sp., *Draba ramosissima* Desv., *Eriogonum allenii* S. Wats., *Oxalis stricta* L., *Penstemon canescens* (Britt.) Britt., *Rhus aromatica* Ait., *Senecio antennariifolius* (Britt.) Britt., *Silene caroliniana* ssp. *pensylvanica* (Michx.) Clausen, *Thlaspi perfoliatum* L., and *Vicia villosa* Roth. Adults were found on *Hypericum prolificum* L., *Quercus ilicifolia* Wangerh., *Rhus copallinum* L., and *Senecio anonymus* Wood in shale barrens. A common breeding host in serpentine barrens was

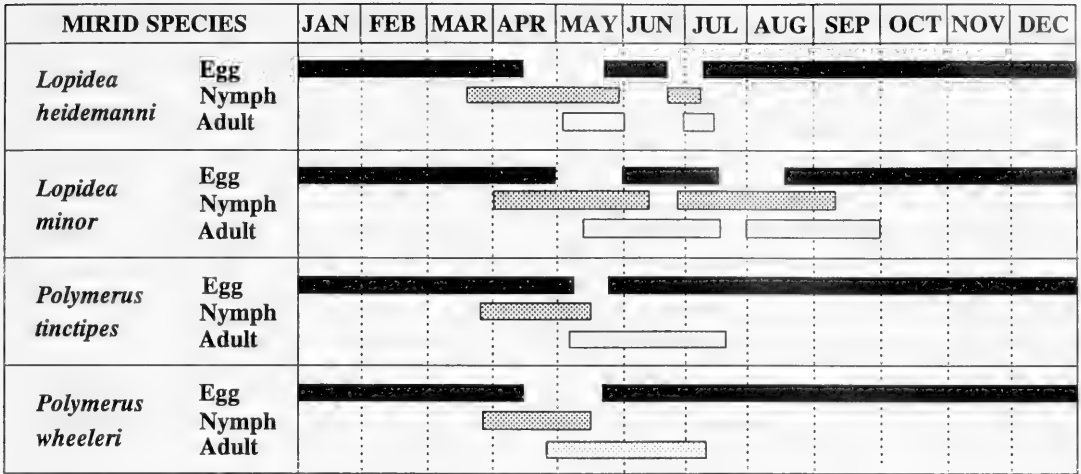


Fig. 4. Generalized mirid seasonal histories based on sampling of *Phlox subulata* in eastern West Virginia–southwestern Virginia, 1989–1994; see text for seasonality of populations occurring at higher altitudes and latitudes.

Cerastium arvense L.; adults were observed on *Quercus stellata* Wangeh.

Seasonal history and habits.—Overwintered eggs usually began to hatch from mid- or late March to early April in shale barrens of Virginia (Fig. 4) and mid- to late April in Pennsylvania serpentine barrens. In early season, the bright red nymphs were often shaken only from plants that were in bloom. Early instars fed on parts of the corolla, both in the field and laboratory, but probably also feed on the foliage. Although the needlelike leaves of *P. subulata* did not show feeding injury, chlorotic blotches were observed on the foliage of *V. villosa* fed on by *L. heidemanni* nymphs. In Virginia, fourth and fifth instars were present on *P. subulata* as early as mid- or late April (rarely in early April), with adults appearing during the first week of May (Fig. 4). Late-instar nymphs, however, were typically present in shale barrens until mid- or late May, often feeding on the fruits. Development of populations at the Kates Mountain shale barren (elevation about 760 m) lagged behind that in other barrens of Virginia and West Virginia (elev. generally 300–700 m). During 5–6 May 1990, for example, late instars and teneral adults were observed in several shale

barrens of southwestern Virginia, but only third instars were seen on Kates Mountain.

First-generation adults of *L. heidemanni* often dispersed to nearby shrubs and trees soon after developing on *P. subulata*; adults were never as common on moss phlox as the nymphs. A short-distance dispersal from breeding hosts is known in several other *Lopidea* species (Asquith 1991). At several sites, a small second generation developed on *P. subulata*. The first through third instars observed in late June 1990 and fourth and fifth instars in late June 1994 apparently represented another generation rather than a late hatching of overwintered eggs. The collection of adults over a three-month period (19 May–18 August) in North Carolina (McPherson et al. 1983), and the appearance of adults in that state during April (A.G.W. unpublished data) is further evidence for bivoltinism in *L. heidemanni*. The latest records of adults on *P. subulata* were 10 July at the Head Waters shale barren in Virginia and 11 July at the West Virginia site near Slanesville. Adults, however, have been collected in West Virginia on other plants as late as 19 August (Wheeler et al. 1983).

On *P. nivalis* in North Carolina (Cabarrus

Co.), fourth instars were observed in mid-April 1990. During 19–23 April 1991, second and third instars were found on *P. bifida* in sand prairies of Illinois and on Boones Bluff at Camp Nelson, Kentucky, and fourth and fifth instars were present on *P. bifida* in Tennessee cedar glades.

Lopidea minor Knight

This widespread generalist feeder is found east of the Rocky Mountains to New York and south to Florida. A characteristic plant bug of the semiarid plains (Knight 1965), it occurs mainly in relict prairies, serpentine barrens, and shale barrens in the mid-Atlantic states. This plant bug was usually found on moss phlox growing in the most open, sunlit portions of shale barrens. Some of the records of *L. minor* have been published under names recently proposed as synonyms: *L. petalostemi* Knight, *L. johnstoni* Knight, and *L. phlogis* Knight (Asquith 1991).

Distribution.—This orthotyline was described from Colorado and North Dakota (Knight 1918) and has since been recorded from Alberta, British Columbia, Florida, Illinois, Iowa, Kansas, Louisiana, Manitoba, Minnesota, Mississippi, Missouri, New York, North Carolina, Oklahoma, Pennsylvania, Saskatchewan, South Dakota, Texas, Virginia, West Virginia, and Wyoming (Henry and Wheeler 1988, Asquith 1991). Maryland is a new state record. *Lopidea minor* was present in 32 of 79 sites (Table 1).

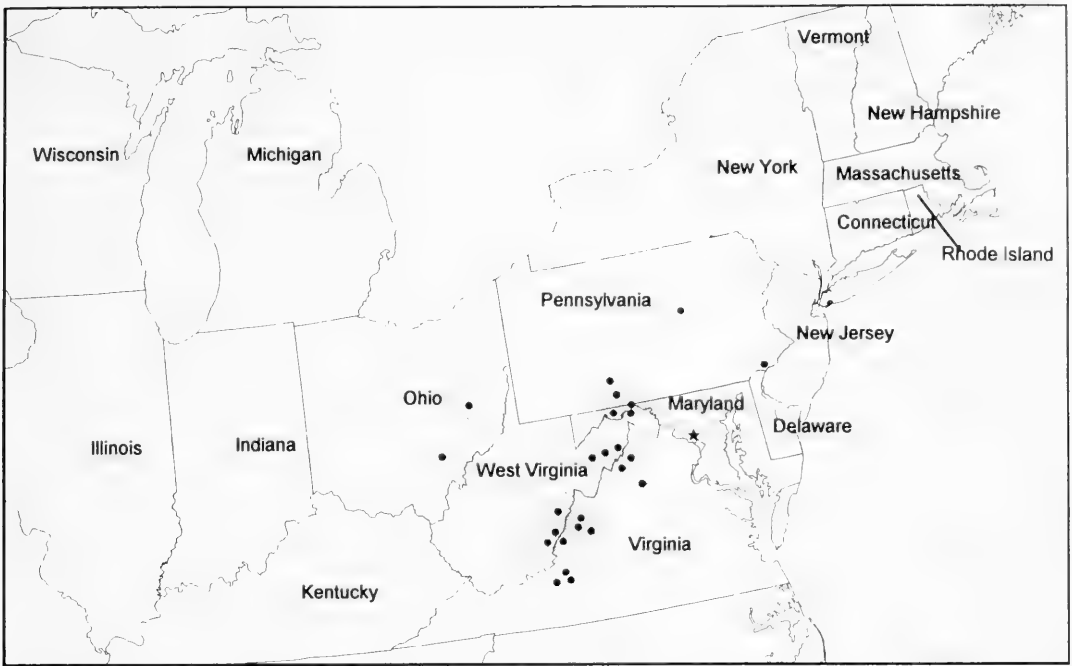
Host plants.—In western North America, prairie clover (*Dalea purpurea* Vent var. *purpurea* (= *Pelalostemon purpureus*) serves as a common host (Knight 1927, 1941, 1965, Blinn and Yonke 1985); *L. minor* has also been recorded from the legume *Hedysarum* sp. in the Canadian Prairie Provinces (Kelton 1980). *Phlox subulata* is used as a host in the eastern United States (Knight 1965, Wheeler et al. 1983); records from this plant in a Pennsylvania serpentine barren and shale barrens in Virginia and West Virginia

(Asquith 1991) were based on material collected during the present study.

In this study, *L. minor* was found only on *P. subulata* among the eastern narrow-leaved phloxes, occurring occasionally in ornamental plantings. Nymphs were also collected on *Eriogonum allenii*, *Paronychia montana* (Small) Pax & K. Hoffmann, and *Senecio anonymus* in shale barrens, and they were found once on and under a fern (*Cheilanthes lanosa* (Michx.) D.C. Eat.) in the Virginia shale barren near Eagle Rock in Botetourt Co. Adult males sometimes dispersed to flowers of *Chrysanthemum leucanthemum* L., *Sedum* spp., and grasses, and to fruits of *Staphylea trifolia* L.

Seasonal history and habits.—Hatching of overwintered eggs began in early or mid-April in shale barrens of southwestern Virginia and in late April in Pennsylvania serpentine barrens (Fig. 4). Egg hatch typically was spread over several weeks so that four or even all five nymphal stages overlapped in populations sampled during May. Nymphs are gray rather than bright red as in *L. heidemanni*. Adults first appeared in mid-May in more southern shale barrens, although late instars were often observed until early June; females persisted until mid-July. Each season, a clear-cut second generation was produced (Fig. 4), which confirms the bivoltine life history that had been suggested for *L. minor* (Asquith 1991). Egg hatch began in late June in southern shale barrens, and second-generation adults began to appear in late July. Late instars, however, were usually common through August and were sometimes present into September. The latest records of adults were 1–2 October in three Virginia shale barrens.

Nymphs of *L. minor*, while occasionally seen on flower buds of *Eriogonum allenii* in shale barrens, were not observed on flower buds or inflorescences of *P. subulata*. They live within or under mats of moss phlox and apparently feed on leaves or stems. Second-generation nymphs develop in midsummer when moss phlox is essentially dormant,



Map 1. Known distribution of *Polymerus tinctipes*. Star = type locality; filled circles = new records (see also Table 1); shading = counties in which specimens were collected.

having finished blooming and produced seeds, and are restricted to feeding on foliage that often appears brownish rather than lush green as in April and May.

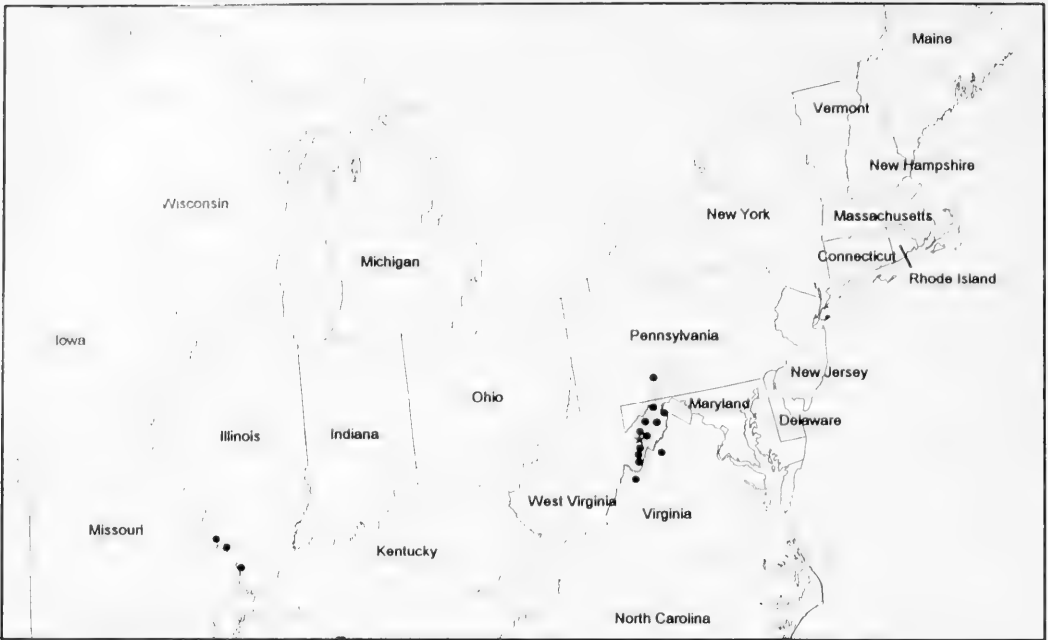
Polymerus tinctipes Knight

This phlox specialist has not been mentioned in the literature since its original description (Knight 1923), except in catalogs (Carvalho 1959, Henry and Wheeler 1988). It is, however, a characteristic species of moss phlox, the dearth of biological information merely reflecting entomologists' lack of attention to the insect fauna associated with this prostrate plant.

Distribution.—This mirine is known historically only from the type locality, Great Falls, Md., where four specimens were collected on 3 May 1915 (Knight 1923). In the present study, *P. tinctipes* was found on *P. subulata* at 32 of 79 sites sampled. New state records are Ohio, Pennsylvania, Virginia, and West Virginia (Map 1, Table 1).

Host plants.—No host has been previously recorded for *P. tinctipes*, the type specimens having been taken at Great Falls, Md., on a "lichen covered rock" (Knight 1923). This plant bug was found in the present study only on *P. subulata*, mainly in mid-Appalachian shale barrens and other shale outcrops, and in Pennsylvania serpentine barrens; it was also collected on moss phlox in a relict prairie in Ohio, a greenstone glade in the Blue Ridge of Virginia, and rarely in ornamental plantings. During visits to the type locality, where *P. subulata* grows on rocks above the Potomac River (Hitchcock and Standley 1919), this bug was found to be common. Adults mate on *P. subulata* and tend to remain on their host rather than disperse to nearby vegetation, unlike the two *Lopidea* species.

Seasonal history and habits.—Eggs of this univoltine mirid may hatch in late March, as evidenced by the presence of third instars during 8–12 April 1990. In most years,



Map 2. Known distribution of *Polymerus wheeleri*. Star = type locality; filled circles = new records (see also Table 1); shading = counties in which specimens were collected.

hatching probably does not begin in southwestern Virginia shale barrens until early or mid-April (Fig. 4). Eggs did not hatch until late April or early May in higher-elevation shale barrens (e.g. Kates Mountain) or sites at even higher latitudes, in serpentine barrens in Pennsylvania, and at sites in Ohio. Fourth and fifth instars were usually common in more southern shale barrens by early May. The green nymphs were observed to feed on flowers and fruits of *P. subulata*. The earliest record of adults was 7 May, but typically they did not appear until mid- to late May and were present only until late June or early July. The latest records for adults were 17–18 July at Millboro, Va., and Kates Mountain, W. Va.

Polymerus wheeleri Henry

The collection of this plant bug, at the time undescribed, from a West Virginia shale barren in 1978 was responsible for stimulating my interest in mirids and other insects associated with *P. subulata*. No ad-

ditional collections of this phlox specialist have been reported since the original description (Henry 1979, Henry and Wheeler 1988).

Distribution.—This mirine has been known only from the type locality, a shale barren west of Petersburg, W. Va. (Henry 1979), which has nearly been destroyed by construction. New state records obtained during the present study are Illinois, Maryland, Pennsylvania, and Virginia (Table 1). *Polymerus wheeleri* was found at fewer sites (12 on *P. subulata*) than any of the other plant bugs associated with eastern narrow-leaved phloxes (Map 2, Table 1).

Host plants.—Described from specimens collected on *P. subulata*, this species is characteristic of the fauna of mid-Appalachian shale barrens and outcrops, as well as mats of *P. bifida* ssp. *bifida* that festoon limestone ledges and bluffs in the Ozark Division (Mohlenbrock 1986) of southern Illinois. It was not found on *P. subulata* in eastern serpentine barrens. *Polymerus wheeleri* adults

show little tendency to disperse to nearby plants, although at the Short Mountain shale barren in Virginia an adult was observed on flowers of the crucifer *Draba ramosissima*.

Seasonal history and habits.—Eggs of this univoltine, early-season species began to hatch at about the same time as those of *L. heidemanni*: generally late March to early April (Fig. 4). In 1991 the presence of a third-instar nymph (with firsts and seconds) at the Head Waters shale barren on 27 March suggests that hatching had begun by mid-March. Nymphs are dark red rather than green as in *P. tinctipes*; they fed on petals, sepals, fruits, and pedicels of *P. subulata*, but they may also feed on the foliage. Fourth instars were observed as early as 8 April but were not usually present until mid- to late April. Adults began to appear from late April to early or mid-May at most sites in Virginia and West Virginia, although in 1991 a fifth instar collected on 14 April at the Short Mountain shale barren molted just two days later when held at room temperature. Adults remained on mats of moss phlox and generally disappeared by late June, males usually dying 7–10 days before females. The latest records were 10–11 July at Head Waters, Va., and near Slanesville, W. Va.

DISCUSSION

Phlox subulata supports an unexpectedly rich mirid fauna: two generalist and two specialist species. Many shrubs and trees of eastern North America do not serve as hosts for as many as four mirids (personal observation). Absent from the fauna of *P. subulata* and other eastern narrow-leaved phloxes of prostrate growth habit are mirids that develop on native and cultivated phloxes of erect growth; *Lopidea davisi* Knight (Cory and McConnell 1927) and *L. confluenta* (Say) (Asquith 1991, personal observation) were not encountered during this study.

Lopidea heidemanni, *L. minor*, *Polymerus tinctipes*, and *P. wheeleri* develop on the glandular *P. subulata* ssp. *brittonii* in the

region sometimes referred to as the Southern Appalachian Highlands (Blauch 1975); they appear to be most common in the southern part of this region. These bugs were often present on *P. subulata* that colonized the most xeric sites. The importance of slope was evident when colonies subject to different exposures were sampled along a winding mountain road; mirids typically were found on moss phlox in the drier sites rather than in more mesic sites less than a kilometer away. Except for occasional individuals observed feeding on reproductive structures, the bugs generally were not seen on exposed portions of *P. subulata*. They perhaps remain mostly within or under mats of the host plant (at least by day) to reduce the risk of desiccation in shale barrens and other slopes of high insolation temperatures. Even when bugs were not apparent on host plants, several individuals (sometimes 5–10) could be found when a plant was shaken over a pan or tray.

Plant bugs that develop on *P. subulata* are characteristic members of a shale barren fauna, occurring in the Valley and Ridge Province on Upper Devonian shales of the Brallier formation (elev. 300–700 m) and on Ordovician Martinsburg outcrops in Virginia's Massanutten Mountains (elev. about 700 m at sample site). Only at the southern end of Short Mountain in the Massanutten complex, however, were all four mirid species observed at one site. *Polymerus tinctipes* was found at altitudes ranging from near sea level along the Potomac River at Great Falls, Md., to about 1040 m in Madison Co., Va., in the Blue Ridge. This species and the other mirids of *P. subulata* were generally scarce in the Blue Ridge (*Polymerus wheeleri* was absent).

Lopidea heidemanni, which shows the greatest diet breadth among the four species, occurred on *P. subulata* at more sites (62) than any of the other plant bugs and was the sole mirid recorded from 19 sites. It was also found in several ornamental plantings of *P. subulata* and developed on

P. bifida and *P. nivalis*, the other eastern narrow-leaved phloxes. It was the only one of the four mirid species that developed on *P. divaricata* among the phloxes of upright growth habit that were sampled in the Appalachians during this study.

The generalist *L. minor* and phlox specialist *P. tinctipes* were both found at 32 sites and showed spotty distributions in shale and in serpentine barrens; they coexisted at 12 sites. Both were found occasionally in landscape colonies of *P. subulata*. Their presence perhaps was the result of being moved with native plants collected for ornamental use, or possibly should be attributed to dispersal to ornamental plants from nearby native colonies of *P. subulata*. The surprising record of *P. tinctipes* from an ornamental planting in Northumberland Co., Pa. (E. of Milton), might be explained by this site's proximity to the historical occurrence of the host 1.5 mi. ESE of Milton (1961 record in herbarium of Academy of Natural Sciences, Philadelphia).

The specialist *P. wheeleri* occurred at 12 sites in shale barrens and outcrops, coexisting with *P. tinctipes* at only 2 sites; it was absent from serpentine barrens. It also developed on *P. bifida* in the Ozark region of southern Illinois. Another phlox specialist, the psyllid *Craspedolepta eas*, shows a similar disjunct distribution (Wheeler 1994). Appalachian-Ozarkian distributions are also known in other insect groups (e.g. Ross 1944, Stannard 1968, Pratt et al. 1994), and the two regions have long been considered "faunally related" (e.g. Holt 1969).

Mirids were nearly always present and, often, were abundant in colonies of *P. subulata* in eastern West Virginia and western Virginia, an area that likely is the host plant's dispersal center (Wherry 1935b). Plant bugs typically were scarce or absent from *P. subulata* colonies in northern New Jersey and Pennsylvania and in New York, but more sampling is needed to determine if the *Polymerus* spp. might be present in these formerly glaciated areas. Additional sampling

is also necessary to determine if mirids are associated with *P. subulata* on Bluff Mountain (Tucker 1972), which is near the fringe of this plant's range in northwestern North Carolina.

The Southern Appalachian Highlands is a center of distribution for *P. tinctipes* and *P. wheeleri*, species that can be considered monophagous (i.e. restricted to developing on *Phlox* spp.). How these specialists on mat-forming phloxes came to occupy this region and their history during the Pleistocene remain unknown. *Polymerus tinctipes* may prove to be a southern Appalachian endemic.

The two *Polymerus* species represent the most significant discoveries among the mirids that occur on eastern narrow-leaved phloxes. *Polymerus tinctipes* had been known previously only from the type locality and its host had remained unrecorded; *P. wheeleri* was an undescribed species whose collection prompted a closer look at mirid-phlox associations in shale barrens. The distribution of both specialist herbivores is now better known, and information on their host plant range and seasonality is available. Much, however, remains to be learned about their distribution and habits; a phylogenetic study of the genus would elucidate the relationship of these apparently closely related species and, perhaps, suggest modes of speciation.

Lopidea minor and *Polymerus tinctipes* can be considered characteristic insects of serpentine barrens. In addition, these species, plus *P. wheeleri*, are as characteristic of shale barrens as the much better known endemic plants occurring in these communities. The plant bugs are subject to the same types of anthropogenic disturbances (road construction, quarrying, etc.) that threaten the shale (and serpentine) barren flora. Protection of Appalachian shale barrens will not only preserve the endemic plants of these communities but also the phytophagous insects that depend on them. This specialized biota can be used in studies

of island biogeography (see Tepedino and Stanton 1976) and eventually may be useful in helping to interpret the complex history of the Appalachians.

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A NEW GENUS OF MIRINE PLANT BUG, *CARVALHOPANTILIUS*, WITH
TWO NEW SPECIES FROM TAIWAN (HETEROPTERA, MIRIDAE)

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Abstract.—A new genus of the Miridae, *Carvalhopantilius*, and two new species, *C. purus* and *C. rufescens*, are described from Taiwan. The genus is characterized by the elongate body, long antenna and rather delicate hemelytra. The vertical head and laterally carinate pronotum are similar to those found in *Pantilius* Curtis, to which the new genus seems to have the closest relationship.

Key Words: Heteroptera, Miridae, new genus, new species, Taiwan

The mirid fauna of Taiwan is poorly known. Only a few authors have described new taxa and/or presented faunal lists (e.g. Poppius 1914, Esaki 1926, Miyamoto and Yasunaga 1989, 1992, Yasunaga 1994). Needless to say, the Taiwanese fauna is very rich and in great need of investigation.

Recently, through the courtesy of Mr. M. Tomokuni, of the National Science Museum, Tokyo, Japan, I had an opportunity to examine three specimens of two peculiar mirine plant bugs collected in Taiwan. These specimens were found to be two undescribed species that represent a new genus in the tribe Mirini of the subfamily Mirinae. Externally, they are similar to certain species of the genus *Pantilius* Curtis in having the vertical head and laterally carinate pronotum, or to those of *Megacoelum* Fieber in the elongate, subparallel-sided dorsal habitus. But the male genital structures and several external characters sufficiently differ from those of the latter two genera, and, therefore, I describe them as two new species in a new genus.

All measurements in the text are given in millimeters. Type specimens are all depos-

ited in the collection of Department of Zoology, National Science Museum, Tokyo, Japan.

Carvalhopantilius Yasunaga,
NEW GENUS

Body elongate, subparallel-sided, more than 8 mm in length; dorsal surface sparsely clothed with uniform pale setae. Head vertical; eyes in dorsal view rather small, removed from pronotal collar; vertex with a shallow, short, longitudinal, mesal sulcation, not carinate basally; frons projected anteriorly. Antenna long; segment I broad, provided with dark setae inwardly; segment II almost linear; segment III slightly shorter than II, longer than basal width of pronotum. Rostrum relatively long, extending beyond middle coxa.

Pronotum weakly shining, minutely, shallowly, and sparsely punctate, weakly carinate laterally, sparsely set with pale erect or suberect setae; calli undeveloped; collar shagreened, narrow, with several pale, erect setae. Scutellum rather flat, sparsely set with pale, erect setae. Hemelytra semitransparent, delicate, sparsely and minutely punc-

tate, sparsely clothed with pale, suberect setae. Legs long; tibiae with brownish spines and erect pale setae; tarsomere III longer than I or II.

Male genitalia (Fig. 2): Parameres lacking setae; left paramere semicircularly curved, triangularly projected basally (A); right paramere short and straight, terminated in small apical claw (B). Vesica bilobed, with a remarkable elongate, apical spiculum terminating in apical hook and a thin ventral sclerite; gonopore opening rather large, with U-shaped sclerite above gonoporal rim (C & D).

Type species.—*Carvalhopantilius purus* Yasunaga, new species.

Etymology.—Named after the late Dr. J. C. M. Carvalho, in combination with generic name *Pantilius* Curtis, to which this new genus seems to be related; gender masculine.

Distribution.—Central Taiwan.

Discussion.—This new genus is similar in some external characters to the Palearctic genus *Pantilius* Curtis, especially in having the vertical head and projected frons. However, the following characters differ from those of the latter: the dorsal surface uniformly clothed only with suberect setae and lacking silvery pubescence; antennal segment II almost linear and not strongly incrassate; antennal segments III and IV much longer; lateral carina of pronotum weak; hemelytra composed of rather delicate integument; vesica with a remarkable elongate spiculum but lacking a pair of rounded apical spinose sclerites, which are always found in species of *Pantilius* (see Yasunaga 1992). *Carvalhopantilius* also resembles certain species of the genus *Megacoelum* Fieber in having the elongate, subparallel-sided dorsal habitus, but the structures of head (especially, the anteriorly projected frons), pronotum (presence of lateral carination), and genitalia are different.

The new genus *Carvalhopantilius* is known by two conspicuous species endemic to the central mountain area of Taiwan.

Carvalhopantilius purus Yasunaga,

NEW SPECIES

(Figs. 1 & 2)

Description.—*Male*: Body generally whitish, large; dorsal surface sparsely clothed with suberect pale setae. Head pale brown, shining; vertex 0.41 times as wide as head, glabrous, with a short, longitudinal, mesal sulcation; margin of antennal tubercle darkened; tylus, jugum, lorum, gena, and buccula bearing silky erect hairs. Antennal segment I pale brown, with a dark brown stripe dorsally and several dark spots, bearing blackish setae; segment II pale brown, with dark narrow bands on basal $\frac{2}{5}$ and apex; segment III pale brown, somewhat tinged with red at apical half, with narrow, dark reddish brown bands on basal $\frac{2}{5}$ and apex; segment IV pale reddish brown, with pale brown base; length of segments I–IV: 1.60, 3.93, 3.70, 1.58. Rostrum pale brown, except dark apical part of segment IV, reaching hind coxae; length of segments I–IV: 0.93, 0.90, 0.73, 1.15.

Pronotum yellowish white, sparsely closed with pale, suberect, short setae, lateral carina darkened; propleuron with a dark median stripe. Mesoscutum and scutellum with a dark mesal stripe. Hemelytra yellowish white, semitransparent, with a dark mesal stripe along each inner margin of clavus; each corium with a small dark submarginal spots before midlength and one at cuneal fracture; lateral margin of embolium narrowly darkened; membrane pale brown, with 3 somber spots along posterior margin of vein. Legs pale brown; femora with small dark spots, bearing pale erect setae and some dark trichobothria; tibiae with pale erect setae and brownish spines; hind tibia with a dark spot at base and a narrow stripe from base to middle; apical parts of tarsomeres III somewhat darkened; length of hind femur, tibia and tarsus: 4.10, 6.60, 0.90; that of hind tarsomeres I–III: 0.31, 0.38, 0.44.

Abdomen pale brown; male genital seg-

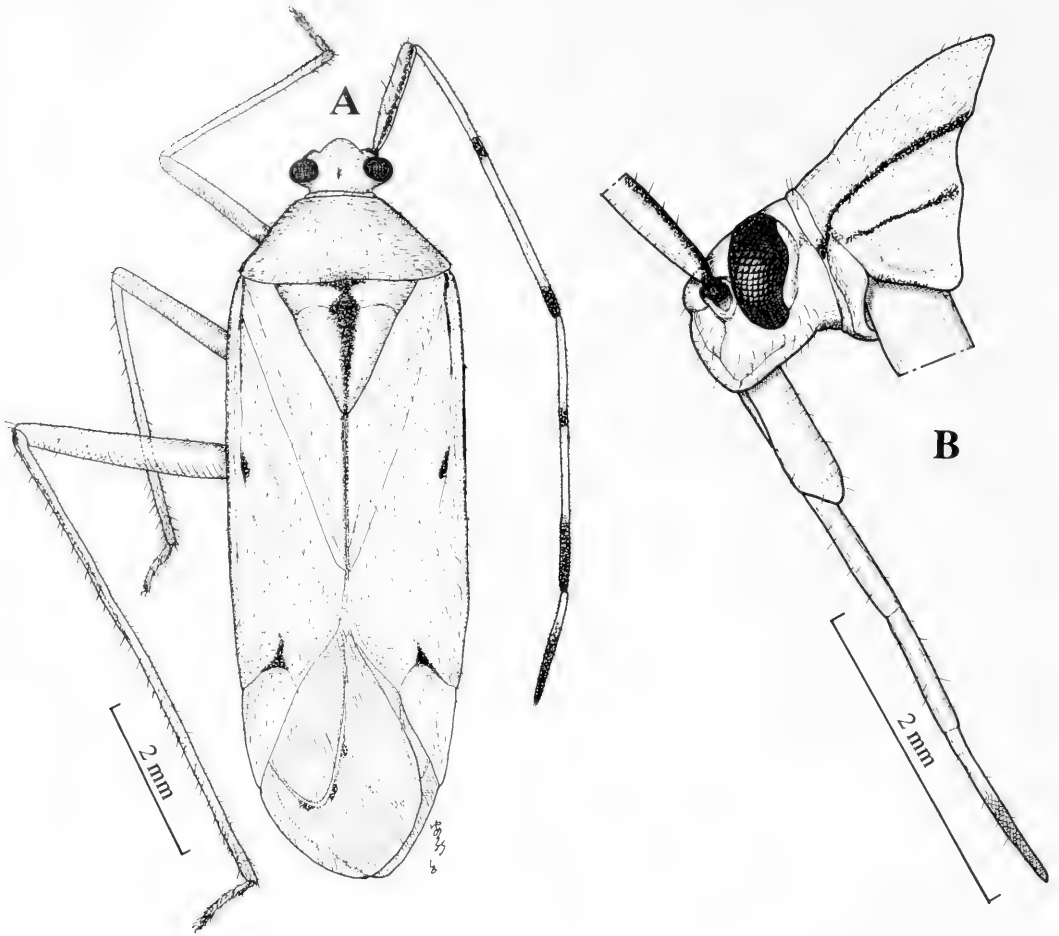


Fig. 1. *Carvalhopantilius purus*, holotype male. A, dorsal habitus. B, left lateral view of head and pronotum.

ment with a mesal keel-like process posteriorly.

Male genitalia as mentioned in generic description (Fig. 2).

Dimensions: Body length 11.10, head width 1.38, total rostral length 3.55, mesal pronotal length 1.38, basal pronotal width 2.73 and width across hemelytra 3.20.

Female: Unknown.

HOLOTYPE: ♂, Wuling-Chika Shan-chuang, 1900–2400 m alt., Mt. Hsuehshan, Hoping, Taichung Hsien, 13. Aug, 1990, M. Tomokuni.

Etymology.—From the Latin, *purus* (pure

or untainted), referring to the pure whitish general coloration.

Distribution.—Central mountain area of Taiwan.

Remarks.—This new species is easily recognized by the large, elongate, whitish body, and such whitish coloration that at first appears teneral is unusual within the Miridae. Yasunaga and Takai (1994) recently described *Eocalocoris albicerus* from Japan, which also exhibits yellowish-white general coloration. The latter species is associated with the white flowers of *Clethra barbinervis* (Clethraceae). Its cryptic whitish coloration

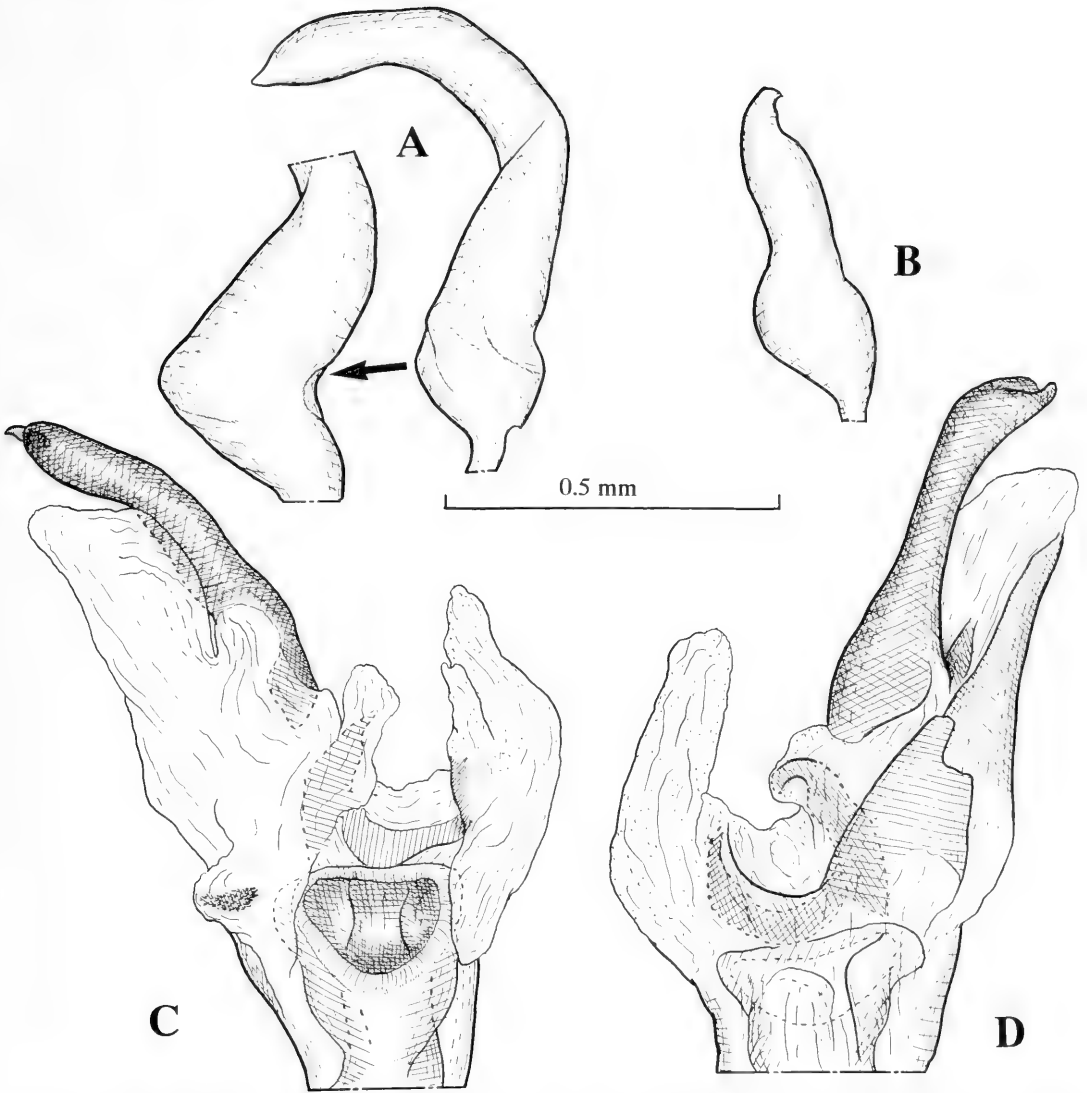


Fig. 2. Male genitalia of *Carvalhopantilius purus*, holotype. A, left paramere. B, right paramere. C, vesica in dorsal view. D, vesica in ventral view.

undoubtedly affords considerable protection against natural enemies. No other information is available on its ecology.

***Carvalhopantilius rufescens* Yasunaga,
NEW SPECIES
(Fig. 3)**

Description.—*Female*: Body generally pale reddish brown, somewhat sanguineous; setae on dorsum indistinct. Head red-

dish brown, subshining, somewhat shagreened, sparsely set with short erect hairs; vertex 0.38–0.39 times as wide as head, with a weak mesal longitudinal sulcation. Antennae almost unicolorously reddish brown; apical part of segment II and median and apical parts of III slightly darker; extreme base of segment IV yellowish; length of segments I–IV: 1.23, 3.05–3.13, 2.90–2.98, 1.33–1.45. Rostrum pale reddish brown,

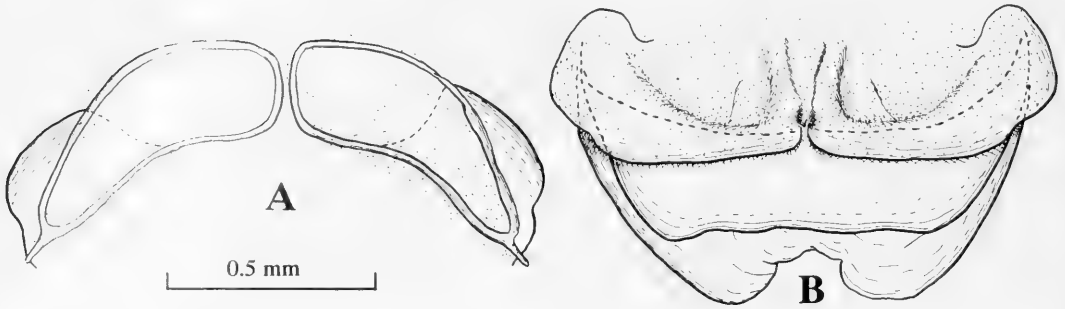


Fig. 3. Female genitalia of *Carvalhopantilius rufescens*, paratype. A, sclerotized ring in ventral view. B, posterior wall of bursa copulatrix in anterior view.

reaching middle coxa; apical half of segment IV darkened; length of segments I–IV: 0.73–0.75, 0.73–0.75, 0.50–0.55, 0.80–0.88.

Pronotum reddish brown, somewhat darkened medially and laterally, sparsely with shallow minute punctures, lateral margin weakly carinate; setae on pronotum very short and sparse; ventral margin of propleuron darkened. Mesoscutum and anterior margin of scutellum somewhat darkened medially. Hemelytra reddish brown, sparsely set with pale suberect short setae; lateral margin of corium narrowly darkened medially; apex of embolium darkened; cuneus deep red or sanguineous; membrane somber pale brown, with partly reddish veins. Legs pale reddish brown; bases of femora paler; tibiae lacking erect setae; tarsi pale brown, except apical halves of tarsomeres III dark brown; length of hind femur, tibia and tarsus: 3.18–3.33, 5.08–5.30, 0.70–0.73; that of hind tarsomeres I–III: 0.25, 0.31–0.36, 0.34–0.39.

Abdomen reddish brown, widely darkened dorsally.

Female genitalia (Fig. 3): Sclerotized ring thin-rimmed, with a lateral pointed projection, each ring contiguous to one another medially (A); posterior wall of bursa copulatrix with rather wide interramal lobes and a distinct interramal sclerite (B).

Dimensions: Body length 8.15–8.40, head width 1.28–1.30, total rostral length 2.75–2.78, mesal pronotal length 1.20–1.23, basal

pronotal width 2.33–2.48 and width across hemelytra 2.93.

Male: Unknown.

HOLOTYPE: ♀, Wuling, 1900 m alt., Hoping, Taichung Hsien, 11. Aug. 1990, M. Tomokuni. **PARATYPE**: 1 ♀, same data as for holotype.

Etymology.—From the Latin, *rufescens* (becoming red), referring to the reddish general coloration.

Distribution.—Central mountain area of Taiwan.

Remarks.—This new species resembles *C. purus*, from which it is easily distinguished by the reddish coloration of the body, the shorter and more sparse setae on dorsum, the long antennal segment IV that is longer than segment I, the shorter rostrum that is not reaching the hind coxa, and the hind tibiae lacking the erect setae, in addition to being significantly smaller in size. There is no information on its ecology.

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A LIST OF THE MIRIDAE (HETEROPTERA) RECORDED FROM CHINA
SINCE J. C. M. CARVALHO'S "WORLD CATALOGUE"

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Abstract.—This paper provides a list of the Miridae recorded from China since the publication of the J. C. M. Carvalho (1952–1960) "World Catalogue of Miridae." A total of 423 species are listed, bringing the total number of Miridae known from China to 554 species. Bibliographical sources and provincial (or territorial) distribution data are given for each species.

Key Words: Miridae, list, China

This paper is dedicated to Dr. J. C. M. Carvalho in honor of his contribution to the systematics of Miridae, especially for his monumental "World Catalogue of Miridae," which tremendously facilitated the studies of this large family all over the world and in China as well.

Records of Chinese mirids since the publication of the "World Catalogue" are documented herein, including a few unpublished records by the author. A total of 423 species are listed, bringing the total number of Miridae known from China to 554 species. Chinese records already found in Dr. Carvalho's World Catalogue are marked with an asterisk. Original references are included for genera having the type species from China and type localities are given for species described from China. Distribution data (not including those given in the literature), listed by province or region are given in brackets at the end of each species. Only literature since the Carvalho Catalog is cited in the bibliography. The subfamilial system used in this paper follows that of Henry and Wheeler (1988).

I am greatly indebted to Thomas J. Henry of (Systematic Entomology Lab., USDA, Washington, D.C.) for his encouragement,

comments, English corrections, and kind assistance in publishing this paper.

Abbreviations used in this paper are as follows: A = Anhui, C = China, CEN = Central China, F = Fujian, GD = Guangdong, GS = Gansu, GX = Guangxi, GZ = Guizhou, H = Hongkong, HA = Hainan, HEB = Hebei, HLJ = Heilongjian, NH = Henan, HUB = Hubei, HUN = Hunan, IM = Inner Mongolia, JL = Jilin, JS = Jiangsu, JX = Jiangxi, LN = Liaoning, N = Ningxia, NC = North China, NE = Northeast China, O.D. = original description, PT(S) = paratype(s), Q = Qinghai, SAX = Shaanxi, SC = Sichuan, SD = Shandong, SX = Shanxi, T = Taiwan, unpub. = unpublished data, XJ = Xinjiang, XZ = Xizang (= Tibet), Y = Yunnan, Z = Zhejiang, (!) = written in Chinese with English summary.

Subfamily Bryocorinae

Abibalus regulus Distant 1909. Zheng [unpub.] [F]

**Bryocoris convexicollis* Hsiao 1941. Zheng [unpub.] [GS]

Bryocoris flaviceps Zheng and Liu 1992 [O.D.: HUN]

Bryocoris gracilis Linnavuori 1962. Miyamoto and Yasunaga 1989b [T]

- Bryocoris hsiaoi* Zheng and Liu 1992 [O.D.: HUN]
- Bryocoris pallidipes* Zheng and Liu 1992 [O.D.: HUN]
- **Cyrtopeltis tenuis* Reuter 1895. Hsiao and Meng 1963 [C]
- **Ernestinus pallidiscutum* (Poppius) 1915. Miyamoto 1965 [T]
- **Harpedona fulvigenis* (Poppius) 1915. Stonedahl 1988 [T]
- Harpedona marginata* (Distant) 1904. Stonedahl 1988 [F]
- Helopeltis bradyi* Waterhouse 1886. Zheng [unpub.] [HA (det. by Stonedahl)]
- **Helopeltis cinchonae* Mann 1907 (= *H. brevicornis* Poppius 1915). Stonedahl 1991b [T]
- **Helopeltis fasciaticollis* Poppius 1915. Stonedahl 1991b; Zheng [unpub. (det. by G. M. Stonedahl)] [GX, T, Y]
- Helopeltis theivora* Waterhouse 1886. Stonedahl 1991b [C]; Zheng [unpub. (det. by G. M. Stonedahl)] [HA]
- Pachypeltis cinnamomi* Zheng and Liu 1992 [O.D.: HUN]
- Pachypeltis politus* (Walker) 1873. Zheng and Liu 1992 [HUN]
- Pachypeltis sassafri* Zheng and Liu 1992 [O.D.: HUN]
- Pachypeltis wangi* Zheng and X.-Z. Li 1992 [O.D.: HUN]
- Prodromus clypeatus* Distant 1904. Stonedahl 1988 [F, T, GD]
- Pseudodoniella chinensis* Zheng 1992b [O.D.: GX]
- Subfamily Deraeocorinae
- **Alloeotomus chinensis* Reuter 1903. Linnavuori 1963; Kerzhner 1988; Zheng and X.-Z. Li 1992 [GX, JS, HEB]
- Alloeotomus simplus* (Uhler) 1896. Miyamoto and Yasunaga 1989b; Zheng [unpub.] [GS, HEB]
- Angerianus maurus* Distant 1904. Stonedahl 1991a [T]
- Genus *Apilophorus* Hsiao and Ren 1983 [O.D., type sp.: *Apilophorus fasciatus* Hsiao and Ren 1983]
- Apilophorus fasciatus* Hsiao and Ren 1983 [O.D.: Y]
- Bothynotus pilosus* (Boheman) 1852. Zheng [unpub.] [LN]
- Genus *Cimidaeorus* Hsiao and Ren 1983 [O.D., type sp.: *Cimidaeorus nigrorufus* Hsiao and Ren 1983]
- Cimidaeorus nigrorufus* Hsiao and Ren 1983 [O.D.: F]
- **Deraeocoris annulipes* (Herrich-Schaeffer) 1842. Qi and Nonnaizab 1993a [IM]
- **Deraeocoris annulus* Hsiao and Ren 1983 [O.D.: SC, Y]
- **Deraeocoris aphidicidus* Ballard 1927. Zheng and Liu 1992 [HUN, SC]
- **Deraeocoris ater* Jakovlev 1889. Qi and Nonnaizab 1993a; Kerzhner 1988; Zheng and Gao 1990 [GS, IM]
- Deraeocoris kerzhneri* Josifov 1983. Kerzhner 1988; Qi and Nonnaizab 1993a [IM, NE]
- Deraeocoris koreanus* Linnavuori 1963. Zheng and Liang 1991 [HEB]
- Deraeocoris lutescens* (Schilling) 1837. Qi and Nonnaizab 1993a [IM]
- **Deraeocoris montanus* Hsiao 1941. Zheng and Liu 1992 [HUN, HEB, SC]
- Deraeocoris morio* (Boheman) 1852. Qi and Nonnaizab 1993a [IM]
- Deraeocoris olivaceus* (Fabricius) 1777. Kerzhner 1988; Zheng and Gao 1990; Qi and Nonnaizab 1993a [IM, N, NE]
- Deraeocoris omeiensis* Hsiao and Ren 1983 [O.D.: SC]
- Deraeocoris pallidicornis* Josifov 1983. Qi and Nonnaizab 1993a [IM]
- **Deraeocoris punctulatus* Fallen 1807. Hsiao and Meng 1962; Zheng and Gao 1990; Qi and Nonnaizab 1993a [IM, N, NC]
- Deraeocoris salicis* Josifov 1983. Zheng and Gao 1990 [N]
- Deraeocoris scutellaris* (Fabricius) 1794. Zheng and Gao 1990 [N]
- Deraeocoris serenus* Douglas and Scott 1868. Zheng and Gao 1990; Qi and Nonnaizab 1993a [IM, N]
- Deraeocoris ventralis* (Reuter) 1904. Qi and Nonnaizab 1993a [IM]

- Fingulus brevisrostris* Ren 1983 [O.D.: Y]
Fingulus inflatus Stonedahl and Cassis 1991 [T]
Fingulus longicornis Miyamoto 1965. Stonedahl and Cassis 1991 [T]
Fingulus porrectus (Bergroth) 1916. Stonedahl and Cassis 1991 [H]
Fingulus ruficeps Hsiao and Ren 1983 [O.D.: SC]
Nicostratus sinicus Hsiao and Ren 1983 [O.D.: HA]
 Genus *Paranix* Hsiao and Ren 1983 [O.D., type sp.: *Paranix bicolor* Hsiao and Ren 1983]
Paranix bicolor Hsiao and Ren 1983 [O.D.: Y]
Stethoconus japonicus Schumacher 1910. Kerzhner 1988: [C]
Termatophylum montanum Ren 1983 [O.D.: Y]
Termatophylum yunnanum Ren 1983 [O.D.: Y]
- Subfamily Isometopinae
- Isometopus beijingensis* Ren and Yang 1988 [O.D.: HEB]
Isometopus citri Ren 1987 [O.D.: SAX]
Isometopus marginatus Ren and Yang 1988 [O.D.: Y]
Isometopus nigrisignatus Ren 1987 [O.D.: Y]
Isometopus puberulus Ren 1991 [O.D.: Y]
Isometopus shaowuensis Ren 1987 [O.D.: F]
Letaba xizangana Ren 1988 [O.D.: XZ]
Myiomma altica Ren 1987 [O.D. SC]; Ren 1992 [SC]
 Genus *Paraletaba* Ren and Yang 1988: [O.D., type sp.: *Paraletaba montana* Ren and Yang 1988]
Paraletaba annulata Ren and Huang 1987 [O.D.: F]
Paraletaba montana Ren and Yang 1988 [O.D.: GX]
Sophianus lamellatus Ren and Yang 1988 [O.D.: GX]
- Subfamily Mirinae
- **Adelphocoris albonotatus* (Jakovlev) 1881.
 Hsiao and Meng 1963 (*Trichophoronchus*); Kerzhner 1988; Zheng and X.-Z. Li 1989 [A, GS, HEB, HLJ, JL, JS, JX, SAX, SC]
 **Adelphocoris annulicornis* (Sahlberg) 1848. Hsiao 1962 (as *A. quadripunctatus* (Fabr.)); Zheng and X.-Z. Li 1989; Qi et al. 1992 [GS, HEB, HLJ, IM, LN, N, SC, SJ, SX]
 **Adelphocoris apicalis* Reuter 1906. Zheng and X.-Z. Li 1989; Qi et al. 1992 [GS, GZ, HEB HLJ, HUB, IM, JS, JX, SC, Z]
 **Adelphocoris divergens* Reuter 1906. Zheng and X.-Z. Li 1989 [SC]
 **Adelphocoris fasciaticollis* Reuter 1903. Hsiao 1962; Hsiao and Meng 1963; Zheng and X.-Z. Li 1989; Qi et al. 1992 [A, HA, HEB, HLJ, HN, HUB, IM, JL, JS, JX, LN, SAX, SC, SD, SX]
 **Adelphocoris fasciiger* Reuter 1906. Zheng and X.-Z. Li 1989 [SC]
Adelphocoris ferrugineus Hsiao 1962 [O.D.: HEB, SX]; Zheng and X.-Z. Li 1989; Qi et al. 1992 [HEB, IM, SX]
 **Adelphocoris funestus* Reuter 1903. Zheng and X.-Z. Li 1989; Zheng and Liu 1992; Zheng and X. Z. Li 1992; Zheng [unpub.] [GS, HEB, HUB, SAX, SC]
Adelphocoris fuscicornis Hsiao 1962 [O.D.: HEB, HN]; Zheng and X. Z. Li 1989 [HEB, HN, SX]
Adelphocoris laeviusculus Vinokurov 1975. Zheng and X. Z. Li 1989; Qi et al. 1992 [HLJ, IM, SC]
 **Adelphocoris lineolatus* (Goeze) 1778. Hsiao 1962; Hsiao and Meng 1963; Zheng and X.Z. Li 1989; Zheng and Gao 1990; Qi et al. 1992 [GS, GX, HEB, HLJ, HN, HUB, IM, JL, JS, JX, LN, N, Q, SAX, SC, SD, SX, XJ, Y, Z]
 **Adelphocoris luridus* Reuter 1906. Hsiao 1962; Zheng and X. Z. Li 1989; Qi et al. 1992 [GS, IM, SC]
 **Adelphocoris melanocephalus* Reuter 1903 (= *A. transversus* Lindberg 1934) Hsiao 1962; Zheng and X. Z. Li 1989 (synonymy with *A. transversus* Lindb.); Zheng

- and Gao 1990; Qi et al. 1992 [HEB, IM, LN, N, SX]
- Adelphocoris nigritylus* Hsiao 1962 [O.D.: HEB, HN, SD]; Hsiao and Meng 1963; Zheng and X.-Z. Li 1989; Zheng and Gao 1990; Zheng and X. Z. Li 1992; Qi et al. 1992 [A, GS, GZ, HA, HEB, HLJ, HN, IM, JL, JS, JX, LN, N, SAX, SC, SD, SX, Z]
- Adelphocoris obliquefasciatus* Lindberg 1934. Kerzhner 1988; Zheng and X. Z. Li 1989; Qi et al. 1992; Zheng [unpub.] [HEB, HLJ, HUB, IM, LN]
- Adelphocoris piceosetosus* Kulik 1965. Qi et al. 1992 [IM]
- Adelphocoris ponghvariensis* Josifov 1977. Kerzhner 1988; Zheng and X. Z. Li 1989; Qi et al. 1992 [HEB, HLJ, IM, JL, JX, SAX, SD]
- Adelphocoris reicheli* (Fieber) 1837 (= *A. flavicornis* Hsiao 1962). Hsiao 1962 [O.D. of *A. flavicornis*]; Zheng and X.-Z. Li 1989 (synonymy with *A. flavicornis* Hsiao); Zheng and Gao 1990; Qi et al. 1992 [HEB, HLJ, IM, N, SD]
- Adelphocoris rufescens* Hsiao 1962 [O.D.: HEB, HN, SD]; Kerzhner 1988; Zheng and X.-Z. Li 1989; Qi et al. 1992 [F, GZ, HEB, HLJ, HN, HUB, IM, SD, SX, Z]
- **Adelphocoris seticornis* (Fabricius) 1775. Hsiao 1962; Zheng and X.-Z. Li 1989 [A, GS, HEB, HLJ, SC, XJ]
- **Adelphocoris suturalis* Jakovlev 1882. Hsiao 1962; Hsiao and Meng 1963; Kerzhner 1988; Zheng and X.-Z. Li 1989; Zheng and Liu 1992; Zheng and X.-Z. Li 1992; Qi et al. 1992 [A, GS, GX, GZ, HEB, HLJ, HN, HUB, HUN, IM, JL, JS, JX, LN, SC, SD, Z]
- **Adelphocoris taeniophorus* Reuter 1906. Zheng and X.-Z. Li 1989 [SC]
- Adelphocoris tenebrosus* Reuter 1875. Hsiao 1962; Zheng and X.-Z. Li 1986; Kerzhner 1988; Qi et al. 1992; Zheng [unpub.] [HEB, HLJ, IM, JL, LN, SX]
- Adelphocoris tibetanus* Zheng and X.-Z. Li 1990 [O.D.: XZ]
- **Adelphocoris torquatus* Reuter 1906. Zheng and X.-Z. Li 1989 [SC]
- **Adelphocoris triannulatus* (Stal) 1858. Hsiao 1962; Kerzhner 1988; Zheng and X.-Z. Li 1989; Qi et al. 1992 [GS, HLJ, IM, JL]
- Adelphocoris yunnanensis* Zheng and X.-Z. Li 1990 [O.D.: Y]
- Adelphocoris zoui* Zheng and X.-Z. Li 1990 [O.D.: SC]
- Allorhinocoris chinensis* Lu 1994 (in Lu and Zhang 1994) [O.D.: GS, HEB, SX]
- Allorhinocoris flavus* J. Sahlberg 1878. Lu and Zhang 1994 [XJ]
- Calocoris striatellus* (Fabricius) (= *C. ochromelas* (Gmelin) 1788). Zheng and Gao 1990 [N]
- Capsus cinctus* (Kolenati) 1845. Vinokurov 1977 [XJ]
- Capsus pilifer* (Remane) 1950. Vinokurov 1977 [IM, HLJ]
- Capsus wagneri* (Remane) 1950. Vinokurov 1977 [IM, HLJ]
- Charagochilus angusticollis* Linnavuori 1961. Zheng 1990; Zheng and Liu 1992; Zheng and X.-Z. Li 1992; Zheng and Liu 1993 [A, F, GD, GX, GZ, HA, HEB, HN, HUB, HUN, JX, SAX, SC, SX, Y, Z]
- **Charagochilus longicornis* (Reuter) 1884. Zheng 1990; Zheng and X.-Z. Li 1992; Zheng and Liu 1993 [A, F, GD, GX, GZ, HUB, SC, T, XZ, Y]
- Charagochilus pallidicollis* Zheng 1990 [O.D.: F, GD, GX, GZ, HUB, JX, SC, Y]; Zheng and X.-Z. Li 1992 [same as O.D.]
- Charagochilus spiralifer* Kerzhner 1987 (= *Charagochilus similis* Zheng 1990, syn. nov.). Zheng 1990 [O.D. of *C. similis*: HLJ]
- **Charagochilus taivanus* (Poppus) 1915. Zheng 1990 (transfer from *Proboscocoris*) [T]
- Charagochilus yulongensis* Zheng 1990 [O.D.: Y]
- Chrysorrhani lineatus* Carvalho 1979 [O.D.: HA (PTS)]

- Creontiades bipunctatus* Poppius 1915, Miyamoto and Yasunaga 1989b [T]
Creontiades coloripes Hsiao 1963. Hsiao and Meng 1963 [O.D.: HN]
Creontiades gossypii Hsiao 1963. Hsiao and Meng 1963 [O.D.: JX, Y]
 **Creontiades pallidifer* (Walker) 1873. Miyamoto and Lee 1966 [T]
Cyphodema inexpectata Zheng and Liu 1992 [O.D.: HUN]
Dagbertus kirkaldyi (Poppius) 1915. Miyamoto and Yasunaga 1989b: [T]
Dolichomiris antennatis (Distant) 1904. Zheng 1986, 1987; Zheng and Liu 1992; Zheng and X.-Z. Li 1992 [F, GD, HUB, HUN, JX, N, SAX, SC, Y, XZ]
Dolichomiris hirticornis Zheng 1986 [O.D.: Y]; Zheng 1988 [Y, XZ]
Dolichomiris planiceps Zheng 1986 [O.D.: Y]; Zheng 1988 [Y, XZ]
 Genus *Elthemidea* Zheng 1992a [O.D., type sp.: *Elthemidea picea* Zheng 1992]
Elthemidea picea Zheng 1992a [O.D.: SC]
Elthemidea sichuaense Zheng 1992a [O.D.: SC]
Eurystylopsis chinensis Zheng and Chen 1991 [O.D.: SC, Y]; Zheng and Gao 1990 [N, SC, Y]
 **Eurystylopsis clavicornis* (Jakovlev) 1890. Zheng and Chen 1991 (transfer from *Calocoris*); Zheng and X.-Z. Li 1992 [F, GS, GX, GZ, HUB, SC, Y, Z]
Eurystylus burmanicus (Distant) 1904. Zheng and Chen 1991 [Y]
 **Eurystylus coelestialium* (Kirkaldy) 1902. Kerzhner 1988; Zheng and Chen 1991; Zheng and Liu 1992; Zheng and X.-Z. Li 1992 [F, GD, GX, HEB, HLJ, HUB, HUN, JS, JX, SC, SC, Z]
 **Eurystylus costalis* Stål 1870. Zheng and Chen 1991; Zheng and Liu 1993 [A, F, Heb, HN, JS, SC, SD, Y]
 **Eurystylus luteus* Hsiao 1941. Zheng and Chen 1991. [A, F, GD, HA, JX, SC, Y]
 **Eurystylus sauteri* Poppius 1915. Miyamoto and Yasunaga 1989b; Zheng and Chen 1991 [T]
 Genus *Heterolygus* Zheng and Yu 1990 [O.D., type sp.: *Lygus trivittulatus* Reuter 1906]
 **Heterolygus clavicornis* (Reuter) 1906. Zheng and Yu 1990 (transfer from *Lygus*) [SC, SAX]
 **Heterolygus duplicatus* (Reuter) 1903. Zheng and Yu 1990 (transfer from *Charagochilus*); Zheng [unpub.] [GS, HUB, SC, Y]
Heterolygus flavoventris Zheng and Yu 1990 [O.D.: SC]
Heterolygus fusconiger Zheng and Yu 1990 [O.D.: SC]
Heterolygus longus Zheng and Yu 1990 [O.D.: Y]
Heterolygus tenuicornis Zheng and Yu 1990 [O.D.: SC]
 **Heterolygus trivittulatus* (Reuter) 1906. Zheng and Yu 1990 (transfer from *Lygus*) [SC, XZ]
Heterolygus univittatus Zheng and Yu 1990 [O.D.: XZ]
 **Heterolygus validicornis* (Reuter) 1906. Zheng and Yu 1990 (transfer from *Lygus*); Zheng [unpub.] [GS, SC]
Heterolygus yadongensis Zheng and Yu 1990 [O.D.: XZ]
 Genus *Heteropantilius* Zheng and Liu 1992 [O.D., type sp.: *Heteropantilius rhopalimorphus* Zheng and Liu 1992]
Heteropantilius rhopalimorphus Zheng and Liu 1992 [O.D.: HUN]
Hyalopeplus spinosus Distant 1904. Zheng [unpub.] [GD, GX]
Hyalopeplus vitripennis (Stål) 1855. Zheng [unpub.] [GX, HA]
 **Isabel ravana* (Kirby) 1891. Zheng and Liu 1992; Zheng [unpub.] [F, GD, GZ, JX, SC]
Lasiomiris picturatus Zheng 1986 [O.D.: F, SC, T]
Lasiaomiris purpurascens Zheng 1986 [O.D.: Y]
Leptopterna albescens (Reuter) 1891. Vinokurov 1981 [IM]

- **Leptopterna ferrugata* (Fallén) 1807. Nonnaizab and Jorigtoo 1993 [IM]
- Leptopterna griesheimae* Wagner 1952. Nonnaizab and Jorigtoo 1993 [IM]
- Leptopterna kerzhneri* Vinokurov 1981. Zheng 1986; Nonnaizab and Jorigtoo 1993 [HLJ, IM]
- Leptopterna magnospicula* Lu and Tang 1987 [O.D.: N]
- Leptopterna xilingolana* Nonnaizab and Jorigtoo 1993 [O.D.: IM]
- **Liocoridae mutabilis* Reuter 1904. Zheng and Liu 1992 [HUB, HUN, GS, GZ, SC]
- Loristes decoratus* (Reuter) 1908. Kerzhner 1988; Zheng [unpub.] [LN]
- Lygidea illota* Stål 1858. Kerzhner 1988 [NE]
- Lygocoris (Apolygus) angustus* Zheng and Wang 1983 (*Lygus*) [O.D.: SC]; Lu and Zheng (in press) (transfer from *Lygus*) [SC]
- Lygocoris (Apolygus) badius* Lu and Zheng (in press) (= *Lygocoris (Apolygus) pubescens* (Zheng and Wang) 1982, nom. preoccup.). Zheng and Wang 1982 (*Lygus*) [O.D. of *Lygus pubescens*: GD, SC]; Lu and Zheng (in press) [new name for *Lygus pubescens* Zheng and Wang] [GD, SC]
- Lygocoris (Apolygus) castaneus* Zheng and Wang 1983 (*Lygus*) [O.D.: SC]; Lu and Zheng (in press) (transfer from *Lygus*) [SC]
- Lygocoris (Apolygus) concinnus* Wang and Zheng 1982 (*Lygus*) [O.D.: F]; Lu and Zheng (in press) (transfer from *Lygus*) [F]
- Lygocoris (Apolygus) curvipes* Zheng and Wang 1982 (*Lygus*) [O.D.: HUB]; Lu and Zheng (in press) (transfer from *Lygus*) [HUB]
- Lygocoris (Apolygus) elegans* Zheng and Wang 1982 (*Lygus*) [O.D.: HA]; Lu and Zheng (in press) (transfer from *Lygus*) [HA]
- Lygocoris (Apolygus) emeia* Zheng and Wang, 1982 (*Lygus*) [O.D.: SC]; Lu and Zheng (in press) (transfer from *Lygus*) [SC]
- Lygocoris (Apolygus) evonymi* Zheng and Wang 1983 (*Lygus*) [O.D.: SAX]; Lu and Zheng (in press) (transfer from *Lygus*) [SAX]
- Lygocoris (Apolygus) fujianensis* Wang and Zheng 1982 (*Lygus*) [O.D.: F]; Lu and Zheng (in press) (transfer from *Lygus*) [F]
- Lygocoris (Apolygus) hainanensis* Zheng and Wang 1983 (*Lygus*) [O.D.: HA]; Lu and Zheng (in press) (transfer from *Lygus*) [HA]
- Lygocoris (Apolygus) hilaris* (Horvath) 1905. Zheng and Wang 1983 (*Lygus*) [Z]
- **Lygocoris (Apolygus) lucorum* (Meyer-Dür) 1845. Hsiao and Meng 1963 (*Lygus*) [NC—possibly a mixture of allied species]; Zheng and Liu 1992; Zheng [unpub.] [GS, HUN, LN, LN]
- Lygocoris (Apolygus) major* Zheng and Wang 1983 (*Lygus*) [O.D.: SC]; Lu and Zheng 1992 (in press) (transfer from *Lygus*) [SC]
- Lygocoris (Apolygus) marginatus* Zheng and Wang 1982 (*Lygus*) [O.D.: SC]; Lu and Zheng (in press) (transfer from *Lygus*) [SC]
- Lygocoris (Apolygus) mosaicus* Zheng and Wang 1982 (*Lygus*) [O.D.: GD]; Lu and Zheng (in press) (transfer from *Lygus*) [GD]
- Lygocoris (Apolygus) nigricans* Wang and Zheng 1982 (*Lygus*) [O.D.: F]; Lu and Zheng (in press) (transfer from *Lygus*) [F]
- Lygocoris (Apolygus) nigrifulus* (Linnavuori) 1961. Zheng and Wang 1983 (*Lygus*); Zheng and X.-Z. Li 1992 [F, GD, GX, HUN, SC]
- **Lygocoris (Apolygus) nigrocinctus* (Reuter) 1906. Kerzhner 1972 (sp. distinct. = *L. pulchellus* var. *nigrocinctus* Reuter) [SC]
- Lygocoris (Apolygus) nigrovirens* Kerzhner 1987. Kerzhner 1988 [CEN]
- Lygocoris (Apolygus) ornatus* Zheng and Wang 1983 (*Lygus*) [O.D.: HUB]; Lu and Zheng (in press) (transfer from *Lygus*) [HUB]
- Lygocoris (Apolygus) picturatus* Zheng and Wang 1982 (*Lygus*) [O.D.: GX]; Lu and Zheng (in press) (transfer from *Lygus*) [GX]
- **Lygocoris (Apolygus) pulchellus* Reuter 1906. Linnavuori 1961 (*Lygus*) (sp. dis-

- tinct., in Hsiao 1942 as synonym of *L. adustus*); Linnavuori 1963 (*Lygus*); Kerzhner 1972 (transfer from *Lygus*) [SC]
- Lygocoris (Apolygus) signatus* Zheng and Wang 1982 (*Lygus*) [O.D.: SC]; Lu and Zheng (in press) (transfer from *Lygus*) [SC]
- Lygocoris (Apolygus) triangulus* Zheng and Wang 1983 (*Lygus*) [O.D.: HUB]; Lu and Zheng (in press) (transfer from *Lygus*) [HUB]
- Lygocoris (Apolygus) ulmicolus* Lu and Zheng (in press) (= *Lygocoris (Apolygus) ulmi* (Zheng and Wang) 1983, nom. preoccup.). Zheng and Wang 1983 (*Lygus*) [O.D.: HEB, HN, HUB]; Lu and Zheng (in press) (new name for *lygus ulmi* Zheng and Wang) [HEB, HN, HUB]
- Lygocoris (Apolygus) yunnananus* Zheng and Wang 1982 (*Lygus*) [O.D.: Y]; Lu and Zheng (in press) (transfer from *Lygus*) [Y]
- **Lygocoris (Arbolygus) dasypterus* (Reuter) 1906. Kerzhner 1979 (transfer from *Lygus*); Zheng [unpub.] [HUN, SC]
- **Lygocoris (Arbolygus) potanini* (Reuter) 1906. Kerzhner 1979 (transfer from *Lygus*); Kerzhner 1988; Zheng and Gao 1990; Zheng [unpub.] [GS, LN, N, SC]
- Lygocoris (Arbolygus) pronotalis* Zheng and Liu 1992 [O.D.: HUN]
- Lygocoris (Arbolygus) rubripes* (Jakovlev) 1876. Zheng and Gao 1990 [N]
- Lygocoris (Arbolygus) ulmi* Kerzhner 1979 [O.D.: HLJ (PT)]; Kerzhner 1988 [HLJ]
- **Lygocoris (Lygocoris) longipennis* (Reuter) 1906. Kerzhner 1972 (transfer from *Lygus*) [SC]
- **Lygocoris (Lygocoris) rugosicollis* (Reuter) 1906. Kerzhner 1972 (transfer from *Lygus*) [SC]
- **Lygocoris (Lygocoris) stricornis* (Reuter) 1906. Kerzhner 1972 (transfer from *Lygus*) [SC]
- Lygus adpersus* (Schilling) 1836. Qi 1993 [IM]
- **Lygus discrepans* Reuter 1906. Zheng 1990: 16; Zheng and Yu 1992; Qi 1993; Zheng [unpub.] [GS, HEB, IM, N, SC, Y]
- **Lygus gemellatus* (Herrich-Schaeffer) 1835. Zheng and Gao 1990; Zheng and Yu 1992; Qi 1993 [GS, IM, N, SAX, SX, XJ]
- Lygus hsiaoi* Zheng and Yu 1992 [O.D.: XZ]
- Lygus paradiscrepans* Zheng and Yu 1992 [O.D.: GS, SC, Y, XZ]
- Lygus poluensis* (Wagner) 1967. Zheng and Yu 1992 (transfer from *Exolygus*) [IM, SAX, XJ, XZ]
- **Lygus pratensis* (Linnaeus) 1758. Hsiao and Meng 1963 [NC—possibly a mixture of allied species]; Zheng and Yu 1992 [SC, XJ—The HN & IM records in Hsiao 1942 and GS record in Lindberg 1934 need verification]
- **Lygus punctatus* (Zetterstedt) 1840. Zheng and Gao 1990; Zheng and Yu 1992; Qi 1993 [GS, HEB, HLJ, IM, JL, N, SC, XZ]
- **Lygus rugulipennis* (Poppus) 1807. Josifov and Kerzhner 1972 (as *L. disponis* Linnavuori); Zheng and Gao 1990; Zheng and Yu 1992; Qi 1993 [HEB, HLJ, HN, IM, LN, N, SJ]
- Lygus saundersi* Reuter 1906. Kerzhner 1988; Zheng and Gao 1990; Zheng [unpub.] [GS, N]
- Lygus sibiricus* (Aglyamzyanov) 1989; Qi 1993; Zheng [unpub.] [IM, HLJ, GS, SC, XJ]
- Lygus tibetanus* Zheng and Yu 1992 [O.D.: XZ]
- Lygus wagneri* (Remane) 1955. Zheng and Yu 1992; Qi 1993 [HLJ, IM, SC, XJ]
- **Macrolonius schenklingi* (Poppus) 1915. Carvalho 1979 [T]
- **Mecistoscelis scirtetoides* Reuter 1891. Zheng [unpub.] [Y]
- Megacoelum chinensis* X.-Z. Li and Zheng 1991 [O.D.: F, GD, Z]; Zheng and X.-Z. Li 1992 [F, GD, HUB, HUN, Z]
- **Megacoelum clypeale* Poppus 1915. X.-Z. Li and Zheng 1991 [T]
- Megacoelum fuscescens* Hsiao 1963, Hsiao and Meng 1963 [O.D.: Y], X.-Z. Li & Zheng 1991 [GD, GX, HA, Y]
- **Megacoelum minutum* Poppus 1915. X.-Z. Li and Zheng 1991 [T]

- **Megacoelum picea* (Reuter) 1906. Zheng and X.-Z. Li 1992; Zheng [unpub.] [GS, HUB, SC]
Megacoelum pronotalis X.-Z. Li and Zheng 1991 [O.D.: JX, SAX, Z]
Megacoelum pseudopronotalis X.-Z. Li and Zheng 1991 [O.D.: F]
Megacoelum rubripedum X.-Z. Li and Zheng 1991 [O.D.: F]
Megacoelum tenuicorne X.-Z. Li and Zheng 1991 [O.D.: GD, GX, SC]; Zheng and Liu 1992 [GD, GX, HUN, SC]
Megacoelum yunnanum X.-Z. Li and Zheng 1991 [O.D.: Y]
Megacoelum zoui X.-Z. Li and Zheng 1991 [O.D.: Y]
**Mermitelocerus annulipes* Reuter 1908. Kerzhner 1972, 1988; Zheng [unpub.] [GS, HLJ]
Mystilus priamus Distant 1904. Zheng [unpub.: Y]
**Notostira poppiusi* Reuter 1911. Zheng 1987 [XZ]
Notostira sibirica Golub 1978. Kerzhner 1988 [NE]
Onomaus coloratus Zheng and Liu 1992 [O.D.: HUN]
Onomaus lautus (Uhler) 1896. Zheng and Liu 1992 [HUN, HUB]
**Orthops kalmi* (Linnaeus) 1758. Hsiao and Meng 1963 (*Lygus*) [HN—identification doubtful]
**Orthops lindbergi* (Hsiao) 1941. Kerzhner 1987 (transfer from *Lygus*) [SC]
**Orthops minutus* (Hsiao) 1941. Kerzhner 1987 (transfer from *Lygus*) [SC]
**Orthops mutans* (Stål) 1858. Zheng and Gao 1990 [N]
Orthops sachalinus (Carvalho) 1959. Kerzhner 1988; Zheng and Gao 1990 [N, NE]
Genus *Paramiridius* Miyamoto and Yasunaga 1992 [O.D., type sp.: *Paramiridius tigrinus* Miyamoto and Yasunaga 1992]
Paramiridius trigrinus Miyamoto and Yasunaga 1992 [O.D.: T]
Parapantilius flavomarginatus Miyamoto and Yasunaga 1989a [O.D.: T]
**Parapantilius flavomarginatus* Miyamoto and Yasunaga 1989a [O.D.: T]
**Parapantilius thibetanus* Reuter 1903. Zheng and Gao 1990 [N]; Zheng and Liu 1992, 1993 [GS, HUB, HUN, N, S, SC]
Phytocoris (Ktenocoris) alashanensis Nonnaizab and Jorigtoo 1992 [O.D.: IM]
Phytocoris (Ktenocoris) caraganae Nonnaizab and Jorigtoo 1992 [O.D.: IM]
Phytocoris (Ktenocoris) desertorum Nonnaizab and Jorigtoo 1992 [O.D.: IM]
Phytocoris (Ktenocoris) insignis Reuter 1876. Nonnaizab and Jorigtoo 1992 [IM]
Phytocoris (Ktenocoris) issykensis Poppius 1912. Nonnaizab and Jorigtoo 1992 [O.D.: IM]
Phytocoris (Ktenocoris) mongolicus Nonnaizab and Jorigtoo 1992 [O.D.: IM]
Phytocoris (Ktenocoris) nigritus Nonnaizab and Jorigtoo 1992 [IM]
Phytocoris (Ktenocoris) rubiginosus Nonnaizab and Jorigtoo 1992 [O.D.: IM]
**Phytocoris (Phytocoris) intricatus* Flor 1860. Nonnaizab and Jorigtoo 1992 [IM, SC]
Phytocoris (Phytocoris) longipennis Flor 1860. Nonnaizab and Jorigtoo 1992 [IM]
Phytocoris (Phytocoris) populi (Linnaeus) 1758. Nonnaizab and Jorigtoo 1992 [IM]
Phytocoris (Phytocoris) procerus Nonnaizab and Jorigtoo 1992 [O.D.: IM]
Phytocoris (Phytocoris) zhengi Nonnaizab and Jorigtoo 1992 [O.D.: IM]
**Phytocoris knighti* Hsiao 1941. Zheng [unpub.: GS]
Polymerus brevicornis (Reuter) 1879. Zheng and X.-Z. Li 1986; Zheng [unpub.] [IM, HLJ, LN]
Polymerus carpathicus Horvath 1861. Zheng and X.-Z. Li 1986 [HLJ, IM]
**Polymerus cognatus* (Fieber) 1858. Hsiao and Meng 1963; Zheng and X.-Z. Li 1986; Kerzhner 1988 [GS, HEB, HLJ, HN, IM, SAX, SC, SD, SX, XJ]
**Polymerus funestus* (Reuter) 1906. Zheng and X.-Z. Li 1986 [SC, XZ]
Polymerus nigritus (Fallen) 1807. Zheng and X.-Z. Li 1986 [XJ]

- Polymerus palustris* (Reuter) 1905. Zheng and X.-Z. Li 1986 [HLJ, JL]
- **Polymerus pekinensis* Horvath 1900. Zheng and X.-Z. Li 1986; Kerzhner 1988; Zheng and Gao 1990 [A, F, HEB, HLJ, IM, JX, N, SAX, SC, SD, SX, Z]
- **Polymerus unifasciatus* (Fabricius) 1794. Zheng and X.-Z. Li 1986 [GS, HEB, IM, SC, XJ]
- Polymerus vulneratus* (Wolff) 1801. Zheng and X.-Z. Li 1986 [XJ]
- **Proboscidocoris malayus* Reuter 1907. Miyamoto and Lee 1966 [T]; Zheng 1990; Zheng and Liu 1992; Zheng and Liu 1993 [A, F, GD, GX, HA, HUB, HUN, JX, SC, Y]
- **Salignus distinguendus* Reuter 1875. Kerzhner 1979, 1988; Zheng [unpub.] [GS, SC]
- **Salignus duplicatus* (Reuter) 1906. Kerzhner 1979 (sp. distinct., = *Lygus distinguendus* var. *duplicatus* Rt.); Kerzhner 1988 [GS, SC]
- **Stenodema alpestre* Reuter 1904. Zheng 1981b; Zheng and Gao 1990; Zheng 1992a [F, HUB, JX, N, SAX, SC, Y]
- Stenodema alticola* Zheng 1981a [O.D.: SC]; Zheng 1992a [SC, Y]
- Stenodema angustatum* Zheng 1981a [O.D.: XZ]; Zheng 1981b, 1987, 1988 [XZ]
- Stenodema antennatum* Zheng 1981a [O.D.: XZ]; Zheng 1981b [XZ]
- Stenodema calcaratum* (Fallén) 1807. Zheng 1981a, b; Nonnaizab & Jorigtoo 1994 [HLJ, IM, JL, XJ]
- **Stenodema chinense* Reuter 1904. Zheng 1981b, 1992a [SC]
- Stenodema crassipes* Kiritschenko 1931. Nonnaizab and Jorigtoo 1994 [IM]
- Stenodema daliensis* Zheng 1992a [O.D.: Y]
- Stenodema deserta* Nonnaizab and Jorigtoo 1994 [O.D.: IM]
- **Stenodema elegans* Reuter 1904. Zheng 1981b, 1992a; Zheng and Gao 1990; Zheng and X.-Z. Li 1992; Zheng and Liu 1993; Zheng [unpub.] [F, GS, GZ, HUB, HUN, JX, N, SAX, SC, T, Y, Z]
- Stenodema holsatum* (Fabricius) 1787. Zheng 1981a, b; Muminov 1989; Nonnaizab and Jorigtoo 1994 [IM, SC, XJ]
- Stenodema hsiaoi* Zheng 1981b [O.D.: SC]
- **Stenodema laevigatum* (Linnaeus) 1758. Zheng 1981b; Nonnaizab and Jorigtoo 1994 [GS, IM]
- **Stenodema longicolle* Poppius 1915. Zheng 1981b; Zheng [unpub.] [GD, T]
- Stenodema longulum* Zheng 1981a [O.D.: JX, SC]; Zheng 1988; Zheng and X.-Z. Li 1992 [GZ, JX, SC, XZ]
- Stenodema mongolica* Nonnaizab and Jorigtoo 1994 [O.D.: IM]
- Stenodema nigricalum* Zheng 1981a [O.D.: SC]; Zheng 1981b, 1992a; Zheng and Gao 1990; Zheng [unpub.] [GS, N, Y]
- Stenodema parvulum* Zheng 1981a [O.D.: SC, XZ]; Zheng 1981b, 1987, 1992a [SC, XZ]
- Stenodema pilosa* (Jakovlev) 1889. Muminov 1989; Nonnaizab and Jorigtoo 1994 [IM, NE, XJ]
- Stenodema qinlingensis* Tang 1994 [O.D.: SAX]
- **Stenodema plebejum* Reuter 1904. Zheng 1981b; Zheng [unpub.] [GS, SC]
- Stenodema sericans* Fieber 1861. Nonnaizab and Jorigtoo 1994 [IM]
- Stenodema sibiricum* Bergroth 1878. Zheng 1981a, 1981b; Kerzhner 1988; Muminov 1989; Nonnaizab and Jorigtoo 1994, [IM, JL]
- Stenodema tibetum* Zheng 1981a [O.D.: XZ]; Zheng 1981b, 1987 [XZ]
- Stenodema trispinosum* Reuter 1904. Zheng 1981a, b; Nonnaizab and Jorigtoo 1994 [IM, N, SC, XJ]
- Stenodema turanicum* Reuter 1904. Zheng 1981b [as *S. virens* (L.), misidentified]; Muminov 1989; Zheng and Gao 1990; Nonnaizab and Jorigtoo 1994 [IM, N, Q, XJ]
- Stenodema virens* (Linnaeus) 1767. Nonnaizab and Jorigtoo 1994 [IM]
- Stenotus rubrovittatus* (Matsumura) 1913. Hsiao and Meng 1963 [HN, HUB]

- **Taylorilygus apicalis* (Leston) 1952. Miyamoto and Lee 1966; Zheng [unpub.] [GX, T]
- Teratocoris saundersi* Douglas and Scott 1869. Jorigtoo and Nonnaizab 1991 [IM]
- **Trigonotylus caelestialium* (Kirkaldy) 1902. Carvalho and Wagner 1957; Zheng 1985; Zheng and Gao 1990 [HEB, HLJ, HN, HUB, IM, JL, JS, JX, LN, N, SC, SD, SX, XJ, Y]
- Trigonotylus cremeus* Golub 1989 [O.D.: IM (PTS)]
- Trigonotylus fuscitarsis* Lammes 1987. Jorigtoo and Nonnaizab 1993 [IM]
- Trigonotylus longitarsis* Golub 1989 [O.D.: IM, HLJ]
- Trigonotylus major* Zheng 1985 [O.D.: XJ]; Golub 1989 [Q, XJ]
- Trigonotylus pallescens* Golub 1989. Jorigtoo and Nonnaizab 1993 [IM]
- Trigonotylus pilipes* Golub 1989. Jorigtoo and Nonnaizab 1993 [IM]
- Trigonotylus procerus* Jorigtoo and Nonnaizab 1993 [O.D.: IM]
- Trigonotylus pulchellus* (Hahn) 1834. Jorigtoo and Nonnaizab 1993 [IM]
- **Trigonotylus ruficornis* (Geoffroy) 1785. Hsiao and Meng 1963 [NC—misidentification of *T. caelestialium*]; Zheng 1985 [IM]
- Trigonotylus tenuis* Reuter 1893. Zheng 1985 (as *T. doddi* (Distant)) [F, GD, GX, HUB, JX, SC, T, Y, Z]
- Trigonotylus viridis* (Provencher) 1827. Zheng 1985 (as *T. bianchi* Kiritschenko 1926); Zheng 1992a (as *T. bianchi*) [SC]
- Trigonotylus yangi* Tang 1994 [O.D.: GX]
- Genus *Zhengiella* Yasunaga and Lu 1994 [O.D., type sp.: *Zhengiella scutellata* Yasunaga and Lu 1994]
- Zhengiella scutellata* Yasunaga and Lu 1994 [O.D.: GX]
- Subfamily Orthotylinae
- Campylotropis jakovlevi* Reuter 1904. Kerzhner 1988 [IM, NE]
- Cylloceria equestris* Stål 1858. Kerzhner 1988; Zheng and Gao 1990 [N]
- **Cyrtorrhinus lividipennis* Reuter 1884. Hsiao and Meng 1963; Zheng and Liu 1992 [A, F, GD, HA, HN, HUN, JX, Z]
- Dryophilocoris alni* Zou 1986 [O.D.: SC]
- Dryophilocoris limbatus* Zou 1986 [O.D.: SC]
- Dryophilocoris longus* Zou 1986 [O.D.: SC]
- **Ectmetopterus micantulus* (Horvath) 1905 (= *E. angusticeps* Reuter). Josifov and Kerzhner 1972; Zheng and Liu 1992; Zheng and Liu 1993 [F, HEB, HUN, JS, SC, Z]
- Halticus apterus* (Linnaeus) 1758. Zheng and Gao 1990 [N]
- Halticus comitans* Josifov and Kerzhner 1972 [O.D.: HEB]; Kerzhner 1988 [HEB]
- Halticus fuscous* Zou 1985 [O.D.: JX]
- Halticus maculipes* Zou 1985 [O.D.: HUB, SC]
- **Halticus minutus* Reuter 1884. Hsiao and Meng 1963; Zheng [unpub.] [A, HUN, JS, SAX, SC, Z]
- Halticus niger* Zou 1985 [O.D.: GZ]
- Mecomma ambulans* (Fallén) 1807. Liu and Zheng 1993 [Y, SC]
- **Mecomma chinensis* Reuter 1906. Liu and Zheng 1993 [SC]
- Mecomma capitata* Liu and Zheng 1993 [O.D.: SC]
- Mecomma gansuana* Liu and Zheng 1993 [O.D.: GS]
- Mecomma opaca* Liu and Zheng 1993 [O.D.: SC]
- **Orthocephalus funestus* Jakovlev 1881. Kerzhner 1988; Zheng and Gao 1990; Zheng [unpub.] [GS, N]
- **Orthotylus (Melanotrichus) flavosparsus* Sahlberg 1842. Hsiao and Meng 1963 [HEB, HN, SD]
- Orthotylus interpositus* Schmidt 1938. Zheng and Gao 1990 [N]
- Pseudoloxops guttatus* Zou 1987b [O.D.: HN, SD]; Zheng and Liang 1991 [HN, SD]
- Pseudoloxops marginatus* Zou 1987b [O.D.: GD]

- Genus *Reuteriolo* Hsiao 1963 [O.D., type sp.: *Reuteriolo annulicornis* Hsiao 1963]
Reuteriolo annulicornis Hsiao 1963. Hsiao and Meng, 1963 [O.D.: Y]
 **Strongylocoris leucocephalus* (Linnaeus) 1758. Zheng and Gao 1990 [N]
Strongylocoris niger (Herrich-Schaeffer) 1835. Zheng [unpub.] [XJ]
Ulmica baicalica (Kulik) 1965. (= *Mala-cocoris baicalica*). Kerzhner 1987; Kerzhner 1988 [HLJ]
 Genus *Ulmocyllus* Seidenstucker 1964 [O.D., type sp.: *Ulmocyllus virens* Seidenstucker 1964]
Ulmocyllus virens Seidenstucker 1964. Seidenstucker 1964 [O.D.: HLJ]; Kerzhner 1987 [C]
Zanchius marmoratus Zou 1987a [O.D.: Y]
Zanchius mosaicus Zheng and Liang 1991 [O.D.: HEB]
Zanchius quinque maculatus Zou 1987a [O.D.: Y]
Zanchius tarasovi Kerzhner 1987. Zheng and Liang 1991 [HEB]
Zanchius zoui Zheng and Liu 1993 [O.D.: Y]
- Subfamily Phylinae
- Acrorrhinium hongkong* Schuh 1984 [O.D.: H]
Acrotelus pilosicornis (Reuter) 1901. Kerzhner 1962 [HLJ, IM]
Atomophora flavidus Nonnaizab and Yang 1994 [O.D.: IM]
Atomophora punctulatus Nonnaizab and Yang 1994 [O.D.: IM]
Atomoscelis asiaticus Josifov 1979. Zheng and Gao 1990 [N]; Nonnaizab 1992 [IM]
Atomoscelis onustus (Fieber) 1961. Nonnaizab 1992 [IM]
Atomoscelis pubescens Nonnaizab 1992 [O.D.: IM]
Camptotylus reuteri Jakovlev 1881. Hsiao and Meng 1963 [HEB, SD]
Campylomma chinensis Schuh 1984 [O.D.: F, H]
 **Campylomma diversicornis* Reuter 1878. Hsiao and Meng 1963; Zheng and Gao 1990 [HEB, HN, N, SAX, SC, XJ]
 **Campylomma livida* Reuter 1884. Miyamoto and Yasunaga 1989b [T, C]
Campylomma nicolasi Puton and Reuter 1883. Hsiao and Meng 1963 [HN, HUB, JX, SC, Y]
 **Chlamydatus pullus* Reuter 1870. Hsiao and Meng 1963; Zheng and Gao 1990 [GS, HEB, HN, JL, N, SAX]
Cleotomiris chinensis Schuh 1984 [O.D.: F]
Compsidolon gobicus Nonnaizab and Yang 1994 [O.D.: IM]
Compsidolon pumilus (Jakovlev) 1876. Nonnaizab and Yang 1994 [IM]
 **Decomia cephalotes* Poppius 1915. Schuh 1984 [T]
Decomioides schneirlai Schuh 1984 [O.D.: T, H]
 **Druthmarus coxalis* (Reuter) 1891. Schuh 1984 (transfer from *Atractotomus*) [T]
 **Ellenia obscuricornis* (Poppius) 1914. Schuh 1984 [T]
Eumecotarsus breviceps (Reuter) 1878. Kerzhner 1962; Zheng [unpub.] [XJ]
Eumecotarsus chinensis Kerzhner 1962 [O.D.: SC]
Excentricoris pictipes Reuter 1897. Kerzhner 1988 [HLJ]
Glaucopterum gobicum Kerzhner 1984 [O.D.: IM]; Zheng [unpub.] [GS, IM]
Hallodapus albofasciatus (Motschulsky) 1863. Schuh 1984 [H]
 **Hallodapus brunneus* Poppius 1915. Schuh 1984 [T]
Hallodapus centrimaculatus (Poppius) 1914. Schuh 1984 [H]
Hallodapus fasciatus (Poppius) 1909. Schuh 1984 [H]
Hallodapus fenestratus Linnavuori 1961. Miyamoto and Lee 1966; Schuh 1984 [T]
 **Hallodapus persimilis* (Poppius) 1915. Schuh 1984 [T]
Hallodapus ravenar (Poppius) 1914. Schuh 1984 [H]
Opuna annulatus (Knight) 1935. Schuh 1984 [F, H, T]
Pherolepis aenescens (Reuter) 1901. Kerzhner 1970, 1988 [LN]

- Phylus coryloides* Josifov and Kerzhner 1972 [O.D.: HLJ]; Kerzhner 1988 [HLJ]
- Pilophorus alstoni* Schuh 1984. Zou 1989 [GD, SC, Y]
- Pilophorus aureus* Zou 1983 [O.D.: HEB]
- Pilophorus bistriatus* Zou 1987c [O.D.: Y]
- Pilophorus castaneus* (Zou) 1983 (*Strictotergum*) [O.D.: Y]; Schuh 1989 (Synonymy) [Y]
- Pilophorus dailahn* Schuh 1984. Zou 1989 [Y]
- Pilophorus decimaculatus* Zou 1983 [O.D.: Y]
- **Pilophorus formosanus* Poppius 1914. Schuh 1984 [T]
- Pilophorus gallicus* Remane 1954. Zou 1989 [SC]
- Pilophorus koreanus* Josifov 1977. Zou 1989 [HN]
- Pilophorus latus* Zou 1989 [O.D.: Y]
- Pilophorus lucidus* Linnavuori 1962. Zou 1989 [HN, HUB]
- Pilophorus niger* Poppius 1914. Schuh 1984 [HU]
- Pilophorus setulosus* Horvath 1905. Zou 1989; Zheng and Gao 1990 [IM, N]
- Pilophorus typicus* (Distant) 1909. Schuh 1984 [F, H, T]
- Pilophorus yunganensis* Schuh 1984 [O.D.: F, H]
- Pilophorus vitellinus* Zou 1989 [O.D.: Y]
- Plagiognathus (Plagiognathus) alashanensis* Qi and Nonnaizab 1993b [O.D.: IM]
- Plagiognathus (Plagiognathus) amurensis* Reuter 1883. Hsiao and Meng 1963 [O.D. of *P. nigricornis*]; Kerzhner 1988; H.-Y. Li and Zheng 1991b (Synonymy, = *P. nigricornis* Hsiao and Meng 1963) [GZ, HA, HEB, HLJ, HN, JX, SD, SX]
- **Plagiognathus (Plagiognathus) arbustorum* (Fabricius) 1794. H.-Y. Li and Zheng 1991b [SC]
- **Plagiognathus (Plagiognathus) chrysanthemii* (Wolff) 1804. Zheng and Gao 1990; H.-Y. Li and Zheng 1991b [HJL, IM, N, SC, XJ]
- Plagiognathus (Plagiognathus) collaris* (Matsumura) 1912. Kerzhner 1988; Zheng and Gao 1990; H.-Y. Li & Zheng 1991b; Zheng [unpub.] [GS, HEB, HLJ, IM, N, XJ]
- Plagiognathus (Plagiognathus) kiritschenkoi* Kulik 1975. H.-Y. Li and Zheng 1991b [HLJ]
- Plagiognathus (Plagiognathus) leucopus* Kerzhner 1979. H.-Y. Li and Zheng 1991b [HLJ]
- Plagiognathus (Plagiognathus) lividellus* Kerzhner 1979. Zheng and Gao 1990; H.-Y. Li and Zheng 1991b [F, HLJ, N]
- **Plagiognathus (Plagiognathus) lividus* Reuter 1906. Kerzhner 1979; Kerzhner 1988; H.-Y. Li and Zheng 1991b [HEB, HLJ, SC]
- Plagiognathus (Plagiognathus) obscuriceps* (Stål) 1858. Qi and Nonnaizab 1993b [IM]
- Plagiognathus (Plagiognathus) pallescens* Zheng and H.-Y. Li 1991 [O.D.: SC]; H.-Y. Li and Zheng 1991b [SC]
- Plagiognathus (Plagiognathus) yomogi* (Miyamoto) 1969. H.-Y. Li and Zheng 1991b [GZ, HEB, HLJ, SC, Y]
- **Plagiognathus (Poliopterus) albipennis* (Fallén) 1929. Zheng and Gao 1990; H.-Y. Li and Zheng 1991b [F, HA, HEB, HLJ, N, SC, SD, SX, Y]
- Plagiognathus (Poliopterus) canoflavidus* Qi and Nonnaizab 1993b [O.D.: IM]
- **Plagiognathus (Poliopterus) moestus* Reuter 1906. H.-Y. Li and Zheng 1991b [SC]
- Psallopsis halostachydis* Putshkov 1975. Nonnaizab and Yang 1994 [IM]
- Psallopsis kirgisisicus* (Becker) 1864. Nonnaizab and Yang 1994 [IM]
- **Psallus alpestris* Reuter 1906. H.-Y. Li and Zheng 1991a [SC]
- Psallus ater* Josifov 1983. H.-Y. Li and Zheng 1991a [SC]
- Psallus betuleti* (Fallén) 1776. H.-Y. Li and Zheng 1991a [IM]
- Psallus castanae* Josifov 1983. H.-Y. Li and Zheng 1991a [SC]
- Psallus clarus* Kerzhner 1988. H.-Y. Li and Zheng 1991a [SC]
- Psallus falleni* Reuter 1883. Qi and Nonnaizab 1994 [IM]
- Psallus flavescens* Kerzhner 1987. Qi and Nonnaizab 1994 [IM]

- Psallus fukienanus* Zheng and H.-Y. Li 1990 [O.D.: F]; H.-Y. Li and Zheng 1991a [F]
- Psallus guttatus* Zheng and H.-Y. Li 1990 [O.D.: SC]; H.-Y. Li and Zheng 1991a [SC]
- Psallus hani* Zheng and H.-Y. Li 1990 [O.D.: HN]; H.-Y. Li and Zheng 1991a [HN]
- **Psallus holomelas* Reuter 1906. H.-Y. Li and Zheng 1991a [SC, Y]
- Psallus kerzhneri* Qi and Nonnaizab 1994 [O.D.: IM]
- Psallus luridus* (Reuter) 1878. H.-Y. Li and Zheng 1991a [HLJ]
- Psallus mali* Zheng and H.-Y. Li 1990 [O.D.: GS, SAX]; H.-Y. Li and Zheng 1991a [GS, SAX]
- Psallus tonnaichanus* Muramoto 1973. H.-Y. Li and Zheng 1991a [HUB]
- Psallus ulmi* Kerzhner and Josifov 1966 [O.D.: HLJ (PTS)]; H.-Y. Li and Zheng 1991a [HEB, HLJ, IM, N, SAX]
- Psallus vittatus* (Fieber) 1861. H.-Y. Li and Zheng 1991a [HEB]
- Salicarus bimaculatus* Zheng and H.-Y. Li 1991 [O.D.: SC]
- Sejanus hongkong* Schuh 1984 [O.D.: H]
- Sejanus neofunereus* Schuh 1984 [O.D.: H]
- Sejanus potanini* (Reuter) 1906. Kerzhner 1987 (transfer from *Sthenarus*); Kerzhner 1988 [SC]
- **Sthenaridea rufescens* (Poppus) 1915. Schuh 1984 [T]
- Sthenaridea piceoniger* (Motschulsky) 1863. Schuh 1984 [F, H, T]
- Sthenaropsis gobicus* Putshkov 1977. Zheng [unpub.] [GS, IM, N]
- Genus *Strictotergum* Zou 1983: 283, 287 [O.D., type sp.: *Strictotergum castaneus* Zou 1983] (junior synonym of *Pilophorus* Hahn; synonymized by Schuh 1989)
- Tuponia (Chlorotuponia) albescens* Zheng and H.-Y. Li 1992 [O.D.: XJ]
- Tuponia (Chlorotuponia) chinensis* Zheng and H.-Y. Li 1992 [O.D.: HEB, SD]
- Tuponia (Tuponia) elegans* (Jakovlev) 1867. Zheng and H.-Y. Li 1992 [N]
- Tuponia (Tuponia) elegantulus* Zheng and H.-Y. Li 1992 [O.D.: XJ]
- Tuponia (Tuponia) hsiao* Zheng and H.-Y. Li 1992 (= *Tuponia tamaricicola* Hsiao 1963 (preocc.)). Hsiao and Meng 1963 [O.D. of *T. tamaricicola*: HEB, SD]; Drapolyuk 1980 (doubtful synonymy with *T. arcuifera* Reuter 1879); Zheng and H.-Y. Li 1992 (new name for *Tuponia tamaricicola* Hsiao; sp. distinct.) [SD, HEB]
- Tuponia (Tuponia) roseipennis* Reuter 1879. Zheng and H.-Y. Li 1992 [XJ]
- Tuponia unicolor* (Scott) 1872. Hsiao and Meng 1963 [SD]
- Wygomiris mingorum* Schuh 1984 [O.D.: H]
- Wygomiris taipokau* Schuh 1984 [O.D.: H]

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REPORTS OF OFFICERS

MEMBERSHIP REPORT

LIST OF NEW MEMBERS FOR 1994

George J. Balogh
Alessandra Rung de Paula Baptista
Nell Benton
Michael J. Firko
R. Wills Flowers
J. H. Frank
Phillip A. Furr
David G. Furth
Rodney S. Hanley
Lynn S. Kimsey
Jeff B. Knight
Peter W. Kovarik
Jon A. Lewis
Andrea Lucci
Charles D. Michener

Matthew D. Moran
John K. Moulton
Dawn Southard
David L. Wagner

Letters were sent to each of the applicants after his/her name was read at a regular meeting. Several letters were sent in response to requests for membership applications. All members are urged to invite their colleagues and students to become members of the Society.

Ralph P. Eckerlin,
Membership Chairman

SUMMARY FINANCIAL STATEMENT FOR 1994

	General Fund	Special Publications Fund	Total Assets
Assets: November 1, 1993	\$10,239.78	\$114,999.53	\$125,239.31
Total Receipts for 1994	62,382.32	4,574.04	66,956.36
Total Disbursements for 1994	59,926.59-	840.00-	60,766.59-
Assets: October 31, 1994	12,695.51	118,733.57	131,429.08
Net Changes in Funds	\$ 2,455.73	\$ 3,734.04	\$ 6,189.77

Audited by the Auditing Committee, November 23, 1994, consisting of Natalia J. Vandenberg, Warren E. Steiner, Jr., and Michael E. Schauff, Chairman. Presented to the membership at the meeting of December 1, 1994.

Respectfully submitted,
Norman E. Woodley, *Treasurer*

EDITOR'S REPORT

Seventy-eight articles, eight notes, six book reviews, and two obituaries were published in 1994 for a total of 779 pages. This is an increase of nine articles and 119 pages over 1993. Page charges for book reviews, obituaries, and approximately three articles (up to 15 pages each) per issue were defrayed by the Society.

I thank Gary L. Miller for his efforts in obtaining book reviews and A. G. Wheeler, Jr. for the excellent copy editing of two memoirs now in production. F. Christian Thompson continued his laborious efforts

to format and code these two nearly completed memoirs scheduled to go to the printer in early 1995. I also give special thanks to Marie Blair for her continued assistance in routing manuscripts and aiding with correspondence.

As usual, the Society is indebted to the many specialists who served as reviewers for the more than 86 manuscripts received in 1994. Their services are critical to maintaining the high quality of papers published in the Proceedings.

Thomas J. Henry, *Editor*

SOCIETY MEETINGS

994th Regular Meeting—May 5, 1994

The 994th Regular Meeting of the Entomological Society of Washington was called to order by President Paul J. Spangler at the Log Lodge, Beltsville, Maryland, at 8:10 pm on May 5, 1994. Thirteen members and six visitors were present. Minutes of the April meeting were read by the Recording Secretary M. Alma Solis and approved as read.

President Spangler called for reports from officers. Ralph Eckerlin, Membership Chairman, reported four new members: R. Wills Flowers, Agricultural Research Programs, Florida A. & M. University, Tallahassee, Florida; Jon A. Lewis, Systematic Entomology Laboratory, Washington, D.C.; Charles D. Michener, Snow Entomological Museum, University of Kansas, Lawrence, Kansas; Matthew D. Moran, Department of Biology, University of Delaware, Newark, Delaware.

President Spangler called for announcements, notes, or exhibits. John H. Fales reported finding for the first time in Calvert County, Maryland, the following butterflies: *Erynnis brizo* (May 15, 25 at Lusby), *Hesperia metae* (June 16 at Plum Point), and *Satyrium liparops strigosum* (June 22 at St. Leonard). Also, in 1993 the Monarch butterfly recovered from the poor populations in 1992. Monarch butterflies migrating northward in 1994 were seen on April 18, 21, 26. He also distributed copies of a list of "Butterflies known from the Western Shore of Southern Maryland northward to the Largo area in Prince Georges County and the South River in Anne Arundel County."

Nathan Schiff, Program Chairman, introduced the speaker for the evening, Dr. Suzanne Batra, Bee Research Laboratory, ARS, USDA, whose talk was entitled "A Buzz About Fuzz." Many bees are utilized as pollinators, for example, bumblebees, horn-

facéd bees, *Anthophora* sp., *Osmia* sp., and *Colletes* sp. Honeybees remain the most important pollinators of crops. They are fast, show a high degree of fidelity, fly long range, and carry much pollen, mainly through the use of their hairy bodies. There are many different kinds of hairs: branched or plumose, stiff, sturdy, straight setae, twisted hairs (spirals), barbed, flat-tipped, rough and straight, and flattened, leaflike or spatulate. Bees use these hairs for a wide variety of important functions. They collect pollen, as a lump of nectar-moistened pollen on the corbicula, held in place by setae, a mass of loose pollen on the hind legs, held in place by plumose hair, or loose pollen held beneath the abdomen by spiralled, flat-tipped, or rough hairs. In courtship and mating the males of Anthophoridae and Megachilidae may have modified legs with elaborate brushes of specialized hairs, which they brush over the female's face, antennae, and eyes; they hold onto her with stiff setae inside their other legs. They collect and distribute pheromones with velvety patches of flattened hair, usually on the feet or legs. Other specialized setae on various parts of the body collect nectar or floral oils, specialized flattened hairs lay down waterproof Dufour's gland secretions for nest construction, and one genus uses "foot-pats" for communication.

Our visitors were introduced and the meeting was adjourned at 10:45 pm. After the meeting refreshments were provided by John Neal and an anonymous individual.

M. Alma Solis, *Recording Secretary*

995th Regular Meeting—June 2, 1994

The 995th Regular Meeting was held at a banquet with the Maryland Entomological Society at the Associates Court at the National Museum of Natural History, 10th &

Constitution, Washington, D.C. Jeffrey R. Aldrich was Master of Ceremonies. The speaker for the evening was Professor Lincoln P. Brower whose presentation was entitled "The Magnificent Migration of the Monarch Butterfly." Over 150 people attended and the banquet was adjourned at 9:45 pm.

M. Alma Solis, *Recording Secretary*

996th Regular Meeting—October 6, 1994

The 996th Regular Meeting of the Entomological Society of Washington was called to order by President Paul J. Spangler in the Waldo Schmitt Room, National Museum of Natural History at 8:10 pm on October 6, 1994. Thirteen members and three visitors were present. Minutes of the May meeting were read by Don Anderson and approved as read.

President Spangler called for reports from officers. Membership Chairman, Ralph P. Eckerlin, read the names of the following applicants for membership: Alessandra Rung de Paula Baptista, Departamento de Zoologia, Laboratorio de Entomologia, Universidad Federal do Rio de Janeiro, Brazil; George J. Balogh, Portage, Michigan; Nell Benton, Alexandria, Virginia; J. H. Frank, Entomology and Nematology Department, University of Florida, Gainesville, Florida; Phillip A. Furr, Albemarle, North Carolina; Michael J. Firko, Columbia, Maryland; David G. Furth, Department of Entomology, Smithsonian Institution, Washington, D.C.; Lynn S. Kimsey, Department of Entomology, University of California, Davis, California; Jeff B. Knight, Nevada Division of Agriculture, Reno, Nevada. Two new members, David Furth and Michael Firko, were present.

President Spangler called for notes or exhibits. Nathan Schiff brought a hepialid caterpillar, *Korscheltellus gracilis* (Grote), he found underneath moss mats from Spruce Knob, West Virginia, and a sawfly, *Atmocera decepta* Rohwer, he found on *Hi-*

biscus moscheutos and asked if anyone knew of any more specimens for study. John Neal brought up the 1000th Regular Meeting, Dave Furth suggested an archival meeting, and Russell Stewart suggested a buffet. Walter Sheppard and John Heraty volunteered to be on an ad hoc committee for the 1000th Regular Meeting. President Spangler asked for volunteers for refreshments: J. Neal (November), R. Eckerlin (December), M. Firko (May).

Nathan Schiff, Program Chairman, introduced the speaker for the evening, Dr. Walter S. Sheppard, whose talk was entitled "Genetic Diversity in the Honey Bee." Dr. Sheppard described the biogeography and biology of *Apis* species around the world with beautiful photos of honey bees. He illustrated unusual nesting habits worldwide, such as giant honey bees out in the open in trees and water towers and dwarf honey bee honey combs for sale in a Bangkok market. Although the original distribution of *Apis mellifera* L. was from Scandinavia to Africa with 25 subspecies, the species has been introduced worldwide and in some areas displacing *Apis cerana*. This species, also known as the eastern cavity nesting bee, was the most important bee for honey production in India and Asia until *A. mellifera* was introduced. *A. mellifera lamarckii* in modern Egypt are kept in mud tubes just as in ancient Egypt. The tubes were kept on barges and the honey sold on the Nile. Bee parts found in a 3000 year old piece of wax found alongside mummified Egyptians in the Egyptian Museum Torino were collected for DNA sequencing to compare with the modern *lamarckii* group. Dr. Sheppard also discussed the relationships between the species and subspecies using DNA sequencing results.

Our visitors were introduced and the meeting was adjourned by President Spangler at 9:30 pm. After the meeting refreshments were provided by contributors who wish to remain anonymous.

M. Alma Solis, *Recording Secretary*

997th Regular Meeting—November 3, 1994

The 997th meeting of the Entomological Society of Washington was called to order by Dr. Paul J. Spangler, President, in the Waldo Schmitt Room of the Natural History Building at 8:10 pm on November 3, 1994. Twelve members and six guests were present. Minutes of the October meeting were read by Ms. Hollis Williams and approved as read.

President Spangler called for reports from officers. Dr. Ralph P. Eckerlin, Membership Chairman, reported no new members. The Nominating Committee consisting of Dr. E. Eric Grissell (Chairman), Dr. Donald M. Anderson, and Dr. Donald R. Davis provided a slate of officers for the following year: Dr. Ralph P. Eckerlin, President-Elect; Ms. Darlene D. Judd, Recording Secretary; Ms. Hollis B. Williams, Corresponding Secretary; Mr. James Pakaluk, Custodian; Dr. Norman E. Woodley, Treasurer; Dr. Nathan M. Schiff, Program Chairman; Dr. M. Alma Solis, Membership Chairman; Mr. Thomas J. Henry, Editor; Dr. David Smith, Associate Editor. The slate was read by Dr. Anderson. Additional nominations will be accepted and the entire slate voted on at the Annual Meeting on December 1. Dr. John Heraty, who is a member of the Ad Hoc Committee for the 1000th Regular Meeting with Dr. Steve Sheppard, made two suggestions. The committee suggested either a restaurant or a wine and cheese reception in the museum or elsewhere. Funds for a speaker are available and the society needs suggestions.

President Spangler called for notes and specimens. Dr. Raymond J. Gagné showed some slides of mass larval migration of black fungus gnat larvae (Diptera: Sciaridae). This phenomenon may be more common than indicated by the few references in the scientific literature. The migrations are ephemeral and seeing one depends mainly on luck. During his 30 years' experience in Washington, Dr. Gagné has had several calls about long snakelike streams of worms

crawling through a backyard, but always long after the fact, and the observers had taken no specimens or photographs. On September 29, 1994, in Silver Spring, Maryland, Ms. Louise Rickard, an amateur naturalist, observed two rings of migrating sciarids on the front walk of her residence, watched their progress, took photographs, and saved specimens in alcohol. The larger ring was about 60 cm in circumference, about 1.2 cm wide, and 0.6 cm high. When she disturbed a ring, the larvae reformed it, but near nightfall the larvae in one ring that was left undisturbed finally crawled off into the adjacent lawn and disappeared. Steffan (1966, Univ. Calif. Pubs. Entomol. 44: 1-77) reviewed sciarid mass migration reports. Two reports are particularly good, one by Beebe (1949, High Jungle: 261-269) and one by Becker (1914, Psyche 21: 94-95). Both reported that movement of the mass was jerky and effected mainly by the larvae at the top crawling forward over those on the bottom. Beebe noticed that his larvae were of several sizes, evidently belonging to several instars, indicating that their dispersal is related to the larvae having depleted a food source. The present case is especially noteworthy because Ms. Rickard noticed and saved a larger, differently shaped larva crawling along with the sciarids. It was *Muscina stabulans* (Fallèn) (Diptera: Muscidae), a carnivorous maggot that preys heavily on many kinds of gregarious larvae in such media as dung and mushrooms. This is the first record of another species associated with mass migration of sciarids.

Dr. Schiff, Program Chairman, introduced the speaker for the evening, Dr. Bruce McPheron of Pennsylvania State University, whose talk was entitled "Ode to St. Bush or Why Are There So Many Kinds of Tephritid Flies." Dr. McPheron studies the evolution of fruit fly diversity and is interested in how it reflects insect diversity in general. While most fruit flies are associated with fruits, as their name indicates, species in this family exhibit a variety of habits: several hundred species are leaf miners, for

example, on parsnip; a whole subfamily is associated with flower heads and seeds of Compositae; *Blepharoneura* is associated with Cucurbitaceae where partitioning of resources has been shown. Specifically Dr. McPherson is studying the relationship between host plant use and the number of fruit fly species. A single species studied extensively, such as the Mediterranean fruit fly, has a diversity of hosts such as coffee, hot peppers, and tropical almond, but shows no evidence for substructuring of host plant choice. But where *Anastrepha* is introduced, its distribution is tied in space and host plant use to the presence of native fruit fly species. In northern Brazil it infests only one plant species, but in southern Brazil where other *Anastrepha* species occur it is not found on the same host plant as in northern Brazil. Although this is ecologically interesting, there is no evidence that host plants are a driving factor in the population differentiation between the fruit fly species. In 1865, Benjamin Walsh speculated that in *Rhagoletis pomonella* (Walsh), there was a linkage between use of hosts and population divergence. One hundred years later, in 1965, Guy Bush published his revision of the North American genus *Rhagoletis*. He compared morphological evolution with host plant use and identified a correlation between morphological species groups and host plant use, suggesting a host plant shift within the natural distribution of a species, the occurrence of reproductive isolation, and sympatric evolution. Bush listed characteristics of organisms having undergone sympatric evolution: close association with the host plant; mating on the host plant; larva spending its entire life cycle within one fruit and tied into the production of fruit. Dr. McPherson studied *R. pomonella* on two major hosts with overlapping distributions, hawthorns and apples. He collected fruits, reared the larvae to adults, conducted genetic analyses with allozyme electrophoresis. He found that *R. pomonella* populations feeding on the different host plants were genetically different.

Our visitors were introduced and the meeting was adjourned at 9:35 pm. After the meeting refreshments were provided by Dr. John W. Neal, Jr., President-Elect.

M. Alma Solis, *Recording Secretary*

998th Annual Meeting—December 1, 1994

The 998th Annual Meeting of the Entomological Society of Washington was called to order by President Paul J. Spangler in the Naturalists' Center of the Natural History Building at 8:00 pm on December 1, 1994. Fifteen members and four guests were present. Minutes of the November meeting were read by Recording Secretary Alma Solis and approved as read.

President Spangler called for officers' reports. Membership Chairman, Ralph D. Eckerlin, reported no new members. He reported a total of 19 new members for 1994 and encouraged more new members. The report by the Editor, Thomas Henry, was read by M. Alma Solis. Seventy-eight articles were published for a total of 779 pages. T. Henry also thanked Gary L. Miller, Book Review Editor, A. G. Wheeler, Jr., Special Publications Editor, and F. C. Thompson for their service to the society. He thanked the reviewers of the journal articles and Marie Blair for assistance. The report by the Custodian, Jim Pakaluk, was read by Paul Spangler. He thanked Sarah Donahue and Tami Carlow who helped with mailings and record keeping. The report by the Corresponding Secretary, Hollis Williams, was read by Paul Spangler. She reported writing fourteen letters to new members, speakers, and contributors on behalf of the society. M. Alma Solis read the financial report by Treasurer Norman Woodley that showed the society to be solvent. The report was examined and approved by the Audit Committee, Michael E. Schauff, Chairman, Warren E. Steiner, Jr., and Natalia J. Vandenberg, Members. Outgoing President Spangler thanked Don Anderson for his help, John Neal for organizing the banquet, Tom Henry as Editor of the journal, the officers,

and the members of the Auditing, Nominating, and Ad Hoc 1000th Meeting Committees.

The slate of officers for 1995 by the Nominating Committee was presented by Dave Smith

President—John W. Neal, Jr.
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 Program Chairman—Nathan M. Schiff
 Membership Chairman—M. Alma Solis
 Custodian—James Pakaluk
 Editor—Thomas J. Henry

The motion to accept the slate was made by Ted Spilman, seconded by John Heraty, and was voted upon and unanimously accepted by the members present.

President Spangler called for notes and specimens. Nathan Schiff reported that the meetings will be held at the Naturalists' Center until April, possibly May. Ted Spilman brought a book entitled *The Beetles of Northeastern North America*, Volume I: Introduction; Suborders Archostemata and Adephaga, by N. M. Downie and Ross H. Arnett, Jr. (1994, The Sandhill Crane Press, Gainesville, Florida, \$160.00 for 3 volumes). Nathan Schiff brought specimens of male and female acrocerid flies, or small-headed flies. The female lays thousands of eggs, and the larvae crawl up the legs of spiders and live as ectoparasites on the book lungs. Ralph Eckerlin brought in an article in the Metro section of the Washington Post describing the removal of a cockroach from the ear of a student from George Washington University. William Bickley brought to the attention of the society that Manya Stoezel, a member of this society, has been elected President-Elect of the Entomological Society of America. Curtis Sabrosky reported the death in Brazil of José Carvalho, a specialist in Miridae (Heteroptera).

Program Chairman, Nathan Schiff, intro-

duced the speaker for the evening, Dr. L. P. S. (Bas) Kuenen, USDA, ARS Bee Research Laboratory, whose talk was entitled "Flights of Fancy? Factors Mediating Male Moths' Flight Toward a Pheromone Source." Dr. Kuenen described his work on factors affecting the movement of male moths toward a pheromone source. A video produced at Cardé's laboratory showed the structure and function of a wind tunnel, a sustained flight tunnel that allows the controlled study of flight by insects. The male moths regulate their velocity by visually looking at the moving floor pattern, and can be slowed down if necessary by regulating the speed of the floor pattern. The male moths fly upwind toward a pheromone source. If the pheromone plume is ended abruptly in the wind tunnel, the male continues flying toward the pheromone source, but exhibits casting behavior. As the male moth flies upwind it doesn't move up or down and just moves in the same plane with a characteristic side to side movement. This work was done with the gypsy moth in the wind tunnel, but studies in a forest environment were also done. In nature casting behavior is also apparent when the male leaves the pheromone plume, but it is more complex due to the lateral shifts in the wind. He has also investigated pupal size as a factor affecting flight and found that smaller males fly faster or appear to fly faster. He has also tested the hypothesis that velocity equals distance over time. In locusts, studies had shown that they fly faster at higher altitudes. In moths, he found that they fly slower at higher altitudes which is believed to be because of other visual cues.

Our visitors were introduced, new members present were introduced, and President Paul Spangler transferred the gavel to President-Elect John W. Neal, Jr. John Neal adjourned the meeting at 9:25 pm and refreshments were provided by Ralph Eckerlin.

M. Alma Solis, *Recording Secretary*

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Both papers on cynipid galls	6.00
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Taxonomic Studies on Fruit Flies of the Genus <i>Urophora</i> (Diptera: Tephritidae), by George C. Steyskal. 61 pp. 1979.....	2.00
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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: Chalcidoidea), 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

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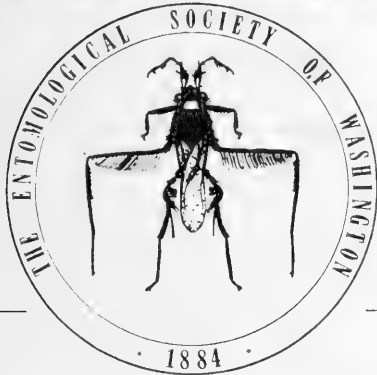
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THE
ENTOMOLOGICAL SOCIETY
OF WASHINGTON

ORGANIZED MARCH 12, 1884

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**PLEASE SEE P. 218 OF THE JANUARY, 1991 ISSUE FOR INFORMATION REGARDING
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THE SYSTEMATIC STATUS OF *AMBLYCYPHRUS ASPERATUS*,
THRENUS NIGER, *PYCNOMORPHA CALIFORNICA*,
EMMENASTUS RUGOSUS, AND
BIOMORPHUS TUBERCULATUS MOTSCHULSKY
(COLEOPTERA: TENEBRIONIDAE)

ROLF L. AALBU, THEODORE J. SPILMAN, AND KIRBY W. BROWN

(RLA) Essig Museum of Entomology, 211 Wellman Hall, University of California, Berkeley, California 94720; (TJS) 4903 Jamestown Road, Bethesda, Maryland 20816; and (KWB) 4570 E. 3rd. N., Joseph City, Arizona 86030.

Abstract.—The systematic status of *Amblycyphrus asperatus*, *Threnus niger*, *Pycnomorpha californica*, *Emmenastus rugosus*, and *Biomorphus tuberculatus* Motschulsky (Coleoptera: Tenebrionidae) is resolved.

The following changes are proposed: *Amblycyphrus* is placed as a junior synonym of *Cryptoglossa* Solier (Cryptoglossini); *Amblycyphrus asperatus* Motschulsky is placed as a junior synonym of *Cryptoglossa spiculifera pectoralis* (Blaisdell) [new combination and status]; *Threnus* Motschulsky is placed as a synonym of *Argoporis* Horn (Cerenopini), *Threnus niger* Motschulsky becomes *Argoporis niger niger* (Motschulsky) [new combination], *Argoporis constanzae constanzae* Berry is placed as a junior synonym of *Argoporis niger niger* (Motschulsky), *Argoporis constanzae inflata* Berry becomes *Argoporis niger inflata* Berry [new combination]; *Emmenastus* Motschulsky is placed as a synonym of *Oxycara* Solier [Tentyriini]; *Emmenastus rugosus* Motschulsky becomes *Oxycara rugosa* (Motschulsky) [new combination]; *Biomorphus* Motschulsky is placed as a synonym of *Helops* Fabricius; *Biomorphus tuberculatus* Motschulsky is placed as a junior synonym of *Helops attenuatus* LeConte (Helopini); *Pycnomorpha* Motschulsky is retained as a valid genus with *Pycnomorpha californica* Motschulsky as type and two species added, *Pycnomorpha gibbicollis* (Horn) [new combination, transferred from *Trichiasida*], and *Pycnomorpha tumidicollis* (Blaisdell) [new combination, transferred from *Stenomorpha*] (Asidini). Keys are provided to *Pycnomorpha* and its species.

Key Words: Coleoptera, Tenebrionidae, Motschulsky, *Amblycyphrus*, *Threnus*, *Pycnomorpha*, *Emmenastus*, *Biomorphus*, classification

A number of genera have historically been included in catalogs as belonging to the North American fauna but have remained a mystery to later workers. Five of these are genera described by Motschulsky in the late 19th century. All five species, described by Motschulsky in 1845, 1870, and 1872 were known only from the type specimen. The types were deposited in the Moscow State

Museum, then the Imperial University Museum, in Moscow, Russia. These five specimens remained unknown for more than a hundred years since their original description. Recently, through the kind help of Dr. N. B. Nikitsky of the Moscow State Museum, Russia, these five holotypes were borrowed by one of us (RLA) and examined by us, finally solving the mystery of these gen-

era. Two occur in California, two occur in Baja California and one is not North American. The taxonomic position of these genera is discussed below.

Amblycyphrus and *Threnus*

While working on a Ph.D. dissertation (Aalbu 1985) concerning the systematics of the tribe Cryptoglossini, it became necessary to determine the status of genera and species previously included in catalogs as belonging to this tribe. These included the Motschulsky genera *Amblycyphrus* and *Threnus*.

Amblycyphrus Motschulsky 1870: 401.

Amblycyphrus asperatus Motschulsky 1870: 404. Champion 1895: 46 (catalog); Gebien 1910: 121, 1937: 701 (catalog).

Threnus Motschulsky 1870: 404. Bradley 1930: 184 (classification)

Threnus niger Motschulsky 1870: 406. Gebien 1911b: 611, 1937: 701 (catalog); Leng 1920: 224 (catalog); Arnett 1960: 652, 672 (classification, distribution); Papp 1961: 106 (catalog); Blackwelder and Arnett 1975: 73.20 (catalog); Arnett 1985: 347 (list).

Motschulsky (1870: 401–404) assigned *Amblycyphrus*, as a “Melasoma of the tribe of the Akisites,” mentioning that this genus was most closely related to *Centrioptera* Mannerheim. He distinguished *Amblycyphrus* from *Centrioptera* by the following characters: (1) “retractile labrum, which is often entirely hidden under the clypeus”; (2) “mandibles, which are more distinctly denticulate”; (3) “less thickened, non-moniliform antennae with a non-transverse sub-apical segment”; (4) “finely punctate elytral striae with the asperities being more obtuse but more pronounced”; (5) “more parallel prosternum, terminating arrow-shaped and not emarginate”; (6) “non-bilobed mesosternum”; and (7) “more slender legs with longer apical tarsal segment,” all unreliable, non-diagnostic characters. Motschulsky also distinguished this genus from *Asbolus* LeConte mentioning “the genus *Asbolus* of

M. LeConte has a generally shorter form, with the asperities of the elytra tuberculate and much more developed, the truncate, very transverse, apical segment, the visible labrum etc.”

Unlike *Amblycyphrus*, Motschulsky assigned *Threnus*, as a “Melasoma of the tribe of the Centriopterides” but compared this genus not to *Centrioptera* but to *Cerenopus* LeConte [Tenebrioninae: Cerenopini] (Lacordaire, in 1859 had included *Cerenopus* in the Centriopterides). Motschulsky distinguished *Threnus* from *Cerenopus* by: (1), antennae distinctly enlarged toward extremity; (2), elytra not enlarged posteriorly; (3), epistoma less produced posteriorly; and (4), dissimilar dentition on inflated parts of femorae and tibiae.

Upon examination of these types, several bibliographical problems became apparent. The following observations were made:

(1) The specimen labeled “*Threnus niger* Mots., Calif.” (green label with black handwritten ink) is an *Argoporis* (Cerenopini), specifically *Argoporis constanzae constanzae* Berry 1980, a species which occurs in Baja California Sur. The problem in this case is that the genus *Argoporis* Horn, was also described in 1870 in Horn’s Revision (p. 325).

(2) The other specimen is labeled “*Centrioptera asperata* Mots., Calif.,” not *Amblycyphrus asperatus* (also green label with black handwritten ink). This specimen is not *Centrioptera asperata* Horn, as one might suspect, but what Blaisdell (1921: 199) described as *Centrioptera dulzurae*. The problem in this case is that *Centrioptera asperata* Horn was also described in 1870 (p. 279) which makes these homonyms.

As the exact date of both publications cannot be positively determined, following the Rules of Zoological Nomenclature, both articles are dated December 31, 1870. Because less disruption of current literature and classification will result, Horn 1870 is selected as having priority over Motschulsky 1870.

As part of the systematic treatment of the

tribe Cryptoglossini, a number of changes in combination and/or status of various genera and species resulted. These changes are discussed in detail in Aalbu (in press). Some of these changes, pertinent to a discussion of *Amblycyphrus*, are listed here. *Amblycyphrus asperatus* Motschulsky is a synonym [of *Cryptoglossa spiculifera pectoralis* (Blaisdell)] and a secondary homonym [of *Cryptoglossa asperata asperata* (Horn) 1870] and is retained in the Cryptoglossini.

The following changes are proposed:

Cryptoglossa Solier 1836: 680

Amblycyphrus Motschulsky 1870: 401 NEW SYNONYMY

Cryptoglossa spiculifera pectoralis (Blaisdell) 1921: 198 NEW COMBINATION and NEW STATUS

Amblycyphrus asperatus Motschulsky 1870: 404 NEW SYNONYMY

Centrioptera dulzurae Blaisdell 1921: 199 NEW SYNONYMY

Argoporis Horn 1870: 325

Threnus Motschulsky 1870: 404 NEW SYNONYMY

Argoporis niger niger (Motschulsky 1870: 406) NEW COMBINATION

Argoporis constanzae constanzae Berry 1980: 35 NEW SYNONYMY

Argoporis niger inflata Berry 1980: 36 NEW COMBINATION

Emmenastus

Emmenastus Motschulsky 1845: 75.

Emmenastus rugosus Motschulsky 1845: 76. Lacordaire 1859: 59 (classification); Gemminger and Harold 1870: 1934 (catalog); Gebien 1910: 18, 1937: 588 (catalog); Leng 1920: 221 (catalog); Blackwelder 1945: 512 (*Emmenastus*) (catalog); Arnett 1960: 665 (distribution); Papp 1961: 100 (catalog); Blackwelder and Arnett 1975: 73.10 (catalog).

Emmenastus rugosus Motschulsky has been doubtfully recorded from Alaska. *Emmenastus* was described as a new genus by

Motschulsky (1845: 75) with two new species: *compactus* (1845: 76) from Kamchatka in eastern Siberia and *rugosus* (1845: 76) from Sitka in Russian America, now Alaska. Because it had not been collected since its original description *E. compactus* was doubtfully included in the Kamchatka faunal list. That problem was solved by Bogachev (1968: 889) when he examined three type specimens of *E. compactus* in the Zoological Museum of University of Moscow and determined that *compactus* is actually a species of *Oxycara* Solier previously known as *O. cribrata* Wollaston 1867; it occurs not on Kamchatka but on the Cape Verde Islands off western Africa. Even though Motschulsky's published type locality was Kamchatka, the type specimens bore labels indicating Tenerife. (Bogachev did not find the type of *E. rugosus* in Moscow University or the Zoological Institute.)

Soon after Motschulsky described *Emmenastus rugosus*, Mannerheim (1852: 287, 288, 291, 387) discussed the lack of Melasomes (Tenebrionidae) in the area of Sitka and their abundance in California, said he did not receive specimens of *E. rugosus* from Motschulsky, doubted that the species occurs at Sitka, and indicated the doubt with question marks in his list of species. Then Mannerheim (1853: 110–112) said he examined Motschulsky's specimens but doubted that the type specimen of *E. rugosus* came from Sitka; he placed *E. rugosus* in *Blapstinus* near *B. pulverulentus* Mannerheim, saying that he had specimens from northern California. LeConte (1866: 106) and Horn (1870: 268, 402) considered *Emmenastus rugosus* to be unrecognizable. Nevertheless, they along with Champion (1884: 8) applied the generic name *Emmenastus* to previously described species (by LeConte) and to new species that are at present in the tribe Eurymetopini. These species were subsequently placed as types of or as species in other new genera by Casey (1907: 287) with only *E. rugosus* remaining in the genus but rejected as part of the American fauna. Blackwelder (1945: 512) placed *Em-*

menastus (attributed in error to Champion) as a synonym of *Hylocrinus* Casey. This synonymy is not explained, but the first species listed by Champion (1884: 9) is *Emmenastus longulus* (LeC.) which was later designated the type of *Hylocrinus* by Casey (1907: 289).

We have studied a specimen of *E. rugosus* from the Zoological Museum of the University of Moscow. The specimen has 3 small handwritten labels: "type"; "Tenerife?"; "*Emmenastus rugosus* Mots Tenerife?" The first label is on uncoated card, the other two on light blue coated card. The handwriting on these labels is different from that on the two examples of Motschulsky's labels published by Korchevsky (1937: pl. 16, fig. 23; pl. 21, fig. 33). We consider the specimen to be the type, even though Motschulsky's published locality, Sitka, does not appear on its labels. (As mentioned above, Bogachev had similar difficulties with labels on the original specimens of *E. compactus*.)

The type of *Emmenastus rugosus* differs from *E. compactus* as described by Bogachev (1968: 889), in the following ways: Pronotum having lateral margin with a thin, unraised flange; surface moderately convex. Elytra in dorsal view gradually widened from base to half-length, laterally curved gradually and then bluntly triangular to apex; dorsal surface moderately convex and widely embracing body; epipleura relatively broad, gradually narrowed posteriorly; surface with 4 or 5 irregular longitudinal furrows from which emanate short irregular lateral furrows. Prosternum without depression and erect hairs of male. Protibia with spurs long, the longer spur extending to apex of second tarsal article.

Motschulsky did not designate a type species for *Emmenastus*. The fate of the generic name depends on the designation of a type species and the fate of that species. LeConte (1866: 106) stated that *E. rugosus* is the type species, and Horn (1870: 268) agreed. Casey (1907: 287) says that *E. compactus* is the

type species because "it was so intended by Motschulsky." Casey was wrong; perhaps he thought that Motschulsky's placement of *compactus* before *rugosus* was an intention to designate. Gebien (1937: 588) in his catalogue stated that *compactus* is the type species. Surely LeConte's designation of 1866 was the first and therefore valid designation.

It appears that *E. rugosus*, like *E. compactus*, should be placed in *Oxycara* (Tentyriini). However, we have not been able to synonymize it with other described species of *Oxycara*. We make this placement especially because of two distinctive characters on the pro- and mesosternal processes: (1) Prosternal process broad, apex acute, in lateral view horizontal and projecting posterior to coxae so as to appear shelf-like; (2) mesosternum between coxae flat, broad, and distinctly lowered from remainder of mesosternum, anterior half becoming strongly grooved, and finally with distinct notch on anterior border for reception of apex of prosternal process.

The following changes are proposed:

Oxycara Solier 1835: 254

Emmenastus Motschulsky 1845: 75 NEW SYNONYMY

Oxycara rugosa (Motschulsky 1845: 76) NEW COMBINATION

Biomorphus

Biomorphus Motschoulsky 1872: 38. Bradley 1930: 323 (classification)

Biomorphus tuberculatus Motschulsky 1872: 40. Gebien 1911a: 463, 1941: 811(666) (catalog); Leng 1920: 236 (catalog); Arnett 1960: 688 (distribution); Papp 1961: 130 (catalog); Blackwelder and Arnett 1975: 73.71 (catalog); Arnett 1985: 348 (list).

Biomorphus tuberculatus is definitely North American. It has been placed in the Tenebrionini in most catalogs. Of the five under consideration here, its taxonomic position is perhaps the easiest to solve. It clear-

ly falls within the range of variation found in *Helops attenuatus* LeConte (Helopini). The following changes must be made:

- Helops* Fabricius 1775: 257
- Biomorphus* Motschulsky 1872: 38 NEW SYNONYMY
- Helops attenuatus* LeConte 1851: 137
- Biomorphus tuberculatus* Motschulsky 1872: 40 NEW SYNONYMY

Pycnomorpha

- Pycnomorpha* Motschulsky 1870: 398. Gebien 1910: 126 (synonymy)
- Pycnomorpha californica* Motschulsky 1870: 399. Champion 1895: 251 (catalog); Gebien 1910: 127 (catalog); Arnett 1960: 674 (distribution); Papp 1961: 110 (catalog); Blackwelder and Arnett 1975: 73.29 (catalog); Arnett 1985: 348 (list).

The type specimen of *Pycnomorpha californica* is in relatively poor condition. It was apparently found dead. It is encrusted with dirt, dust and old glue and missing its left mesothoracic and metathoracic legs and its right prothoracic and mesothoracic legs. Additionally, the left prothoracic leg has been reglued on to the specimen but not quite at the right position. The specimen is labeled "*Pycnomorpha californica* Mots., California" and "California," two green labels with black handwritten ink.

Motschulsky, in his description of *Pycnomorpha*, compared the genus to *Stenomorpha* Solier. Based on Solier's illustration, he distinguished the genus by the transverse labium, obtuse mandibles with pronounced middle tooth, more protruding ligula, prominent pronotum, legs not hairy, and elytra carinate on lateral margin. None of these characters are diagnostic. Fortunately, a number of specimens obviously conspecific with the type have been recently collected. This has made possible a more thorough comparison with other genera.

From the description alone coupled with the cited locality (Nova-Helvetia, an early

name for modern Sacramento) one of us (KWB) assumed that this species was the same as *Stenomorpha capitosa* (Horn), the only similar species known from the Sacramento area. However, examination of the Motschulsky specimen and the recently collected conspecific specimens clearly show that the locality cited must be in error and the actual location is central Baja California. Under the present classification of genera in the tribe Asidini, *Pycnomorpha* must be retained as a valid genus. Couplets in the Brown (1971: 28) key to genera of Asidini should be modified as follows:

- 10(9). Postgenal process projecting well beyond middle of mentum, often greatly thickened or swollen (Fig. 19); mentum in tight, broad contact with postgenal process; pronotum dilated laterally; elytral disc costate (1 sp., central Mexico) *Zaleucus* Champion
- 10'. Postgenal process rarely projecting beyond middle of mentum; if process projects beyond middle of mentum, then elytra disc not costate (see couplet 24) 11
- 23(22). Humeri of elytra prominent and reflexed, body length under 16 mm. (see couplet 21) *Asidopsis* Casey (part)
- 23'. Humeri of elytra inconspicuous, not reflexed 24
- 24(23). Mentum large, often in parallel contact with postgenal process; postgenal process thickened, rarely projecting beyond midpoint of mentum, base opposite gular pedestal abruptly bent, forming a quadrate open space; pronotum often inflated and gibbose; body glabrous; maxillary palpi weakly sexually dimorphic (3 spp., Baja California) *Pycnomorpha* Motschulsky
- 24'. Mentum smaller, not in contact with postgenal process which is usually thin; base of postgenal process opposite gular pedestal gradually bent, not forming a distinct quadrate open space 34
- 34(24'). Apical segment of maxillary palpus greatly enlarged and sexually dimorphic, rectitriangular in the female (Fig. 3), larger and scalene with proximal angle prolonged in the male (Fig. 2); ligula large and tumid (Fig. 25); body rarely hirsute (85 spp., & sub spps.; SW Canada, W. & Central U.S., Mexico) **Stenomorpha* Solier

34'. Apical segment of maxillary palpus smaller, only moderately enlarged and often not notably sexually dimorphic, at most recti-triangular in the male (Fig. 24); disc of pronotum and elytra with setae present, body often hirsute; ligula small, not tumid (Fig. 6) (20 spp.; SW. U.S., Mexico) *Trichiasida* Casey (part)

Pycnomorpha shares characteristics with the genera *Stenomorpha* and *Trichiasida*. It may be distinguished by the following:

It differs from *Stenomorpha* and *Trichiasida* by the thicker postgenal process, larger and thicker mentum, its lateral edge parallel to the postgenal process; proximal edge of postgenal process abruptly bent opposite gular pedestal forming a notable quadrate pocket, and by a more horizontal antennal shelf with a deeper and longer groove near the eye.

It further differs from *Stenomorpha* by a more slender antenna, smaller tomentose areas of the tenth antennal segment, and weaker sexual dimorphism of maxillary palpi.

It further differs from *Trichiasida* by the smaller tenth antennal segment, and glabrous body.

Two additional described species from Baja California are clearly congeneric with *Pycnomorpha californica*. They are *Trichiasida gibbicollis* (Horn) (originally described in *Asida*) and *Stenomorpha tumidicollis* Blaisdell. One might note that Horn (1880: 152) proposed *Asida gabbi* as a replacement name for *Asida gibbicollis* which was preoccupied in *Asida*; Casey (1912: 178) in placing *A. gabbi* into his new genus *Trichiasida*, restored the name as *T. gibbicollis*. The following changes are proposed:

Pycnomorpha gibbicollis (Horn 1870: 288)

NEW COMBINATION

Pycnomorpha tumidicollis (Blaisdell 1943: 226) NEW COMBINATION

The following key will separate the three species:

1. Lateral edge of pronotum thin, barely re-

flexed; posterior pronotal gibbae smoothly rounded; posterior pronotal angles obtuse, lateral margin of elytra rounded or carinate at basal ¼ only; body surface sculpture dull or shiny 2

- 1'. Lateral edge of pronotum thick, strongly reflexed; posterior pronotal gibbae sharply carinate; posterior pronotal angles acute, lateral margin of elytra entirely carinate; body surface sculpture shiny *gibbicollis* (Horn)
- 2. Lateral margin of elytra rounded; body surface sculpture shiny *tumidicollis* (Blaisdell)
- 2a. Lateral margin of elytra rugosely carinate at basal ¼; body surface sculpture dull *californica* Motschulsky

A satisfactory number of specimens each species has been examined to verify that the characters are sufficiently constant to justify maintaining the above three distinct species. *Pycnomorpha tumidicollis* is from northern to central Baja California, *californica* from central, and *gibbicollis* southern. Several undescribed species from Baja California are on hand. Some species of *Stenomorpha* from southern California (Riverside and San Diego Counties) may also belong in *Pycnomorpha*. Further work on these genera is in progress.

ACKNOWLEDGMENT

Special appreciation is extended to Dr. N. B. Nikitsky of the Moscow State Museum, USSR, who kindly sent the types of *Amblycyphrus*, *Threnus*, *Pycnomorpha*, *Emmenastus* and *Biomorphus* Motschulsky.

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REVIEW OF THE BLASTOBASIDAE OF THE REPUBLIC OF THE
SEYCHELLES (LEPIDOPTERA: GELECHIOIDEA)

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Abstract.—*Blastobasis legrandi* is described from misidentified specimens collected from The Republic of The Seychelles by Legrand in 1959. *Blastobasis acarta* Meyrick and *B. intrepida* Meyrick are redescribed, and a lectotype is designated for the former species. A key, illustrations of adults and of male and female genitalia are provided.

Key Words: Lepidoptera, Gelechioidea, Blastobasidae, Blastobasinae, *Blastobasis*, Seychelles

About sixty islands and islets make up the present Republic of The Seychelles. They are divided into three island types: the granitic islands or Seychelles proper, which form a compact group of mountainous islands emerging from a submarine plateau between 4–5 degrees south of the equator and 56 degrees east of Greenwich; the sand cays which are located south-west of the Seychelles proper, but also include isolated islands along the northern and southern edge of the Seychelles plateau; the elevated reefs of the Aldabra group.

The granitic islands are situated about 930 km from Madagascar, 1600 km from East Africa and Mauritius, and over 1700 km from India. Aldabra lies 800 km from Mahé of the granitic islands, and is much closer to Madagascar and East Africa.

Several expeditions to the Seychelles that included collecting Lepidoptera have occurred since the French coleopterist, Charles Alluaud, visited the islands in 1892. The earliest of these expeditions yielded several undescribed Lepidoptera (Lionnet 1984).

The first major collections of Lepidoptera from the Seychelles were amassed by The Percy Sladen Trust Expeditions of 1905 and 1908. These British collections represented

111 species, of which 90 species were considered endemic to the Seychelles (Meyrick 1911). All the microlepidoptera collected from The Percy Sladen Trust Expeditions were studied by E. Meyrick (Lionnet 1984).

Another major collection of Lepidoptera of the Seychelles was made by Henry Legrand of The Muséum National D'Histoire Naturelle, Paris. He visited the Seychelles in 1956 and 1958–60 and collected, more than 3500 specimens, and recognized 363 species, of which 117 were new to science (Legrand 1965).

Two subsequent collections of Lepidoptera of The Seychelles were made by American Lepidopterists. In 1968, Jay Shaffer participated in an international collecting expedition to Aldabra Atoll. This expedition was one of several sponsored by The Royal Society of London from 1966 to 1980. In 1986, I participated in a Smithsonian sponsored expedition to the granitic Seychelles and to Aldabra. Both expeditions yielded many Lepidoptera, most of which had been recorded previously from the Seychelles and from the region. The specimens collected on the latter two expeditions are deposited in the United States National Museum. The purpose of this paper is to

review the Blastobasidae of The Republic of the Seychelles Islands.

The Methuen Handbook of Colour (Kornerup and Wanscher 1978) was used as a color standard for the description of the adult vestiture. Genitalia were dissected as described by Clarke (1941), except mercurochrome and chlorazol black were used as stains. Pinned specimens and genital preparations were examined with dissecting and compound microscopes. Wing measurements were made using a calibrated ocular micrometer.

RESULTS

Key to the Blastobasidae of the Republic of the Seychelles

1. Males 2
- Females 3
2. Two apical articles of labial palpus normal (Fig. 4); proximal flange of valva with long hairlike setae, elongate valval spine absent, apical process of lower part of valva normal, aedeagus angled apically (Fig. 7) *Blastobasis acarta*
- Two apical articles of labial palpus widened dorsoventrally (Fig. 5); proximal flange of valva without long hairlike setae, elongate valval spine present, apical process of lower part of valva small, aedeagus straight (Fig. 8) *Blastobasis intrepida*
3. Membrane surrounding ostial area with dense microtrichia (Fig. 9) *Blastobasis acarta*
- Membrane surrounding ostial area without dense microtrichia (Figs. 10-11) 4
4. Membrane posterior to seventh tergum with two small crescent-shaped sclerites (Fig. 11) *Blastobasis legrandi*
- Membrane posterior to seventh tergum without such sclerotizations; with a round and wrinkled, small invagination within lateral membrane between sixth and seventh segments (Fig. 10) *Blastobasis intrepida*

Blastobasis legrandi Adamski,

NEW SPECIES

(Figs. 1, 11)

Diagnosis.—Female with membrane posterior to seventh tergum bearing two small crescent-shaped sclerites.

Head: Vertex and frontoclypeus uniform grayish orange; outer surface of labial palpus

grayish orange intermixed with brown scales tipped with white, inner surface grayish orange intermixed with white scales; antennal scape and pedicel grayish orange, flagellomeres brown; proboscis grayish brown.

Thorax: Tegula and mesoscutum grayish orange intermixed with brown scales tipped with white; outer surface of legs grayish orange intermixed with brown scales tipped with white; tibia and tarsomeres grayish orange apically; inner surface of legs grayish orange intermixed with white; forewing (Fig. 1), length 6.4–7.5 mm (n = 3), grayish orange intermixed with brownish-orange; scales tipped with white; two brownish-orange spots near apical area of discal cell, one spot near middle; undersurface uniform grayish brown; both surfaces of hindwing pale grayish orange; venation similar to *B. acarta* and *B. intrepida* (Fig. 6).

Abdomen: Grayish orange above, white beneath.

Male genitalia: Unknown.

Female genitalia (Fig. 11): Ovipositor telescopic, in four membranous divisions; ostium within membranous area posterior to seventh sternum, seventh tergum with stout setae; membrane posterior to seventh tergum with two small crescent-shaped sclerotizations; antrum membranous, short, and linear, forming a common inception for ductus seminalis and ductus bursae; ductus bursae long, with two rows of platelike sclerotizations within anterior end; corpus bursae membranous, signum hornlike.

Holotype.—♀, "Seychelles, Mahé, B[eau] Vallon, 20-VI-1959, H. Legrand," "♀ genitalia slide by DA 3273 [green label]." Holotype in Muséum National D'Histoire Naturelle, Paris (MNHP).

Paratypes.—♀, "Seychelles, Mahé, B[eau] Vallon, 19-IV-1959, H. Legrand," "♀ genitalia slide by DA 3170 [green label]," "Seychelles, Mahé, B. Vallon, 24-III-1959, H. Legrand," "♀ genitalia slide by DA 3272 [green label]." Paratypes in MNHP.

Remarks.—The three specimens of *B. legrandi* were intermixed in Legrand's series of *B. acarta* and *B. intrepida* and can be



1

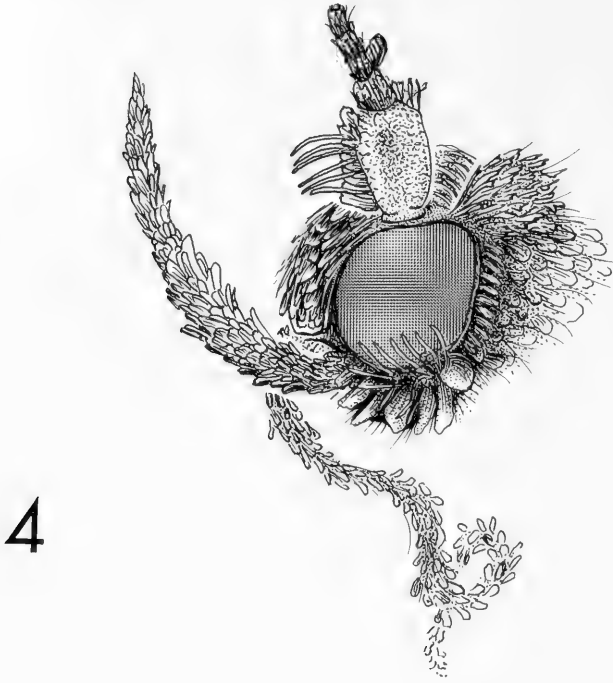


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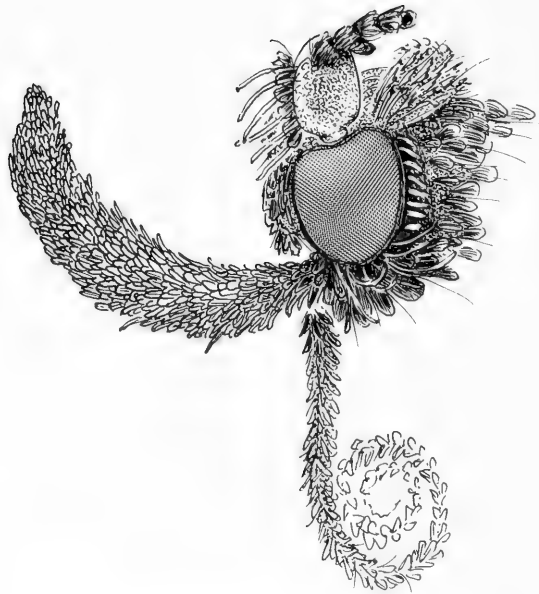


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Fig. 1. Holotype of *Blastobasis legrandi* Adamski. Fig. 2. Adult of *Blastobasis acarta* Meyrick.
Fig. 3. Adult of *Blastobasis intrepida* Meyrick.



4



5

Fig. 4. Lateral view of head of male *Blastobasis acarta* Meyrick.

Fig. 5. Lateral view of head of male *Blastobasis intrepida* Meyrick.

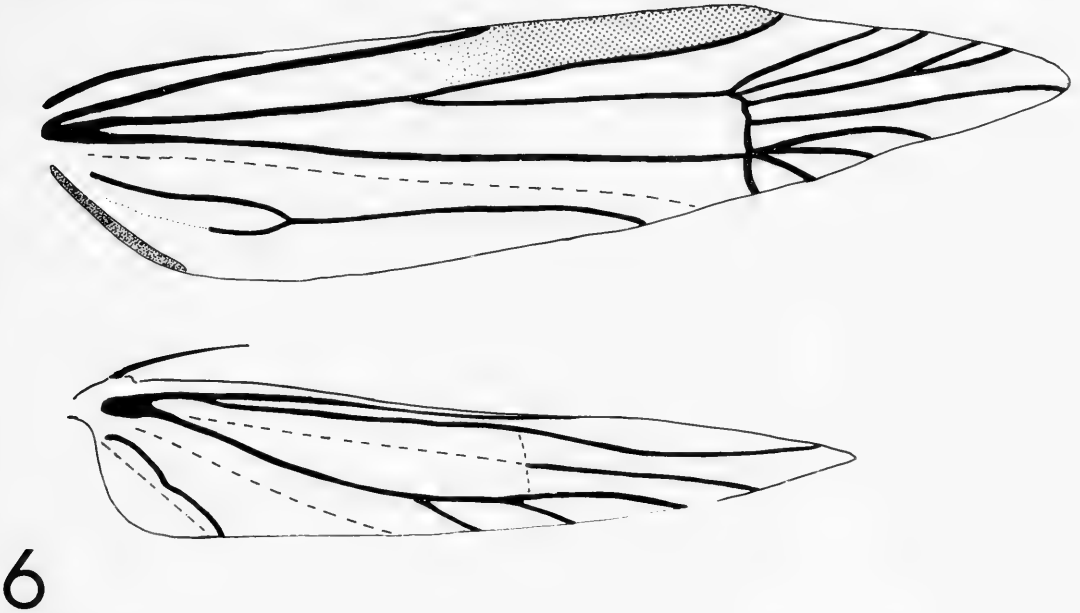


Fig. 6. Wing venation of *Blastobasis intrepida* Meyrick.

distinguished from female specimens of the latter two species only by examination of genitalia.

Etymology.—This species is named in honor of H. Legrand who was devoted to collecting the Lepidoptera of The Seychelles.

Blastobasis acarta Meyrick, 1911
(Figs. 2, 4, 7, 9)

Blastobasis acarta Meyrick, 1911. Trans. Linn. Soc. Lond. 14(2): 286–87. Legrand, H. 1965. Mém. Mus. natn. Hist. nat. Ser. A, 37: 54.

Diagnosis.—Proximal flange of valva with long setae, apical process of lower part of valva normal in size, aedeagus angled apically, membrane surrounding ostial area of female with dense microtrichia.

Head (Fig. 4): Vertex and frontoclypeus with brownish-gray scales tipped with white; outer surface of labial palpus mostly brown intermixed with brownish-gray scales, basal

and apical areas pale brownish gray or white; inner surface of labial palpus mostly white intermixed with grayish-brown and brown scales; antennal scape and pedicel with grayish-brown scales tipped with white; flagellomeres brown; male flagellum ciliate; first flagellomere of male with a subconical basal process, forming notch; proboscis grayish brown intermixed with pale-gray scales.

Thorax: Tegula and mesoscutum with brownish-gray scales tipped with white; outer surface of legs mostly brown intermixed with pale brownish-gray and white scales, tibia and tarsomeres white apically; inner surface of legs mostly white intermixed with brownish-gray scales and pale-gray scales; forewing (Fig. 2), length 4.6–8.0 mm ($n = 21$), brownish gray intermixed with pale-gray scales, some specimens with scales tipped with white; two brown spots near apical area of discal cell, one near middle; undersurface uniform grayish brown; hindwing with both surfaces pale brownish gray; venation similar to *B. legrandi* and *B. intrepida* (Fig. 6).

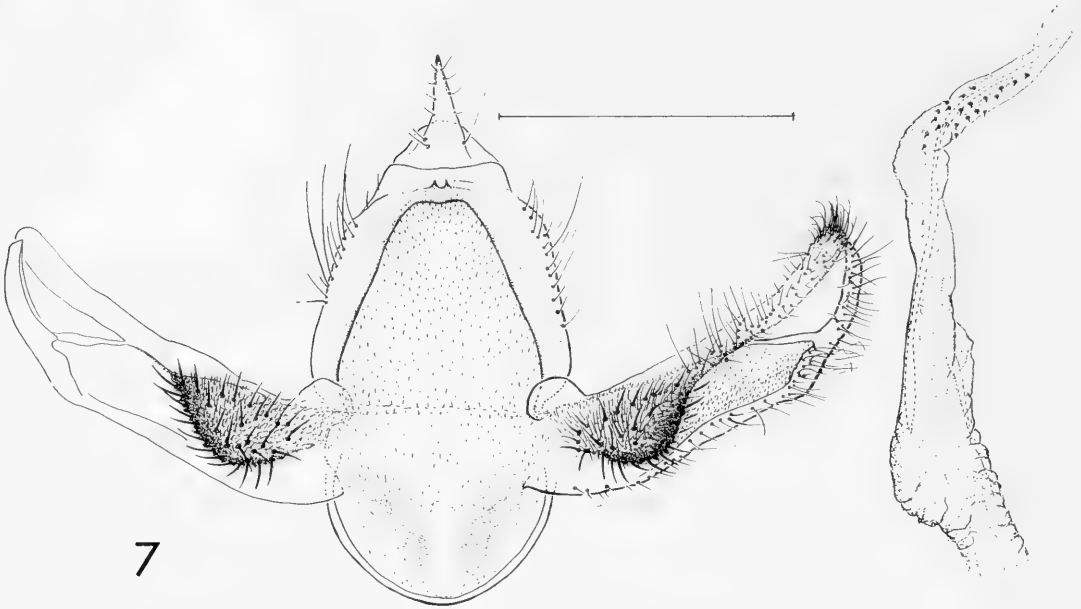


Fig. 7. Male genitalia of *Blastobasis acarta* Meyrick (lectotype). Scale line = 0.5 mm.

Abdomen: Brownish gray above, white beneath.

Male genitalia (Fig. 7): Uncus with somewhat widened base, narrowed to apex, angled posteriorly; gnathos with two pointed teeth; tegumen setose dorsolaterally, dorsal strut of tegumen absent; diaphragma with microtrichia throughout; proximal flange of valva with dense microtrichia interspersed with several long, hairlike setae; aedeagus angled near base of anellus, anellus setose.

Female genitalia (Fig. 9): As in *B. la-grandi*, except membrane surrounding ostium with dense microtrichia.

Types.—Lectotype here designated: ♂, "Lectotype" [round purple-bordered label], "Type" [round red-bordered label], "Seychelles, Morne Blanc, Mahé, 800 f[ee]t, IX-1908, H. Scott," "Brit[ish] Mus[eum], 1913-170," "*Blastobasis acarta* Meyr[ick], Type ♂," "BM ♂ genitalia slide no. 26553." Right labial palpus is missing. Lectotype in British Museum (Natural History) (BMNH). Paralectotypes: ♂, "Paralectotype" [round blue-bordered label], "Silhouette, Seychelles

[island] [19]08," "♂," "*Blastobasis acarta* Meyr[ick] 1/1, E. Meyrick det., in Meyrick Coll[ection]," "*acarta* Meyr[ick]," [not dissected]. ♀, "Seychelles: Cascade Estate, Mahé, 800 f[ee]t, IX-1908, H. Scott," "Brit[ish] Mus[eum], 1913-170." The specimen is missing the abdomen, and the wings are not spread. Paratypes in BMNH.

Other specimens examined: ♂, "Seychelles, Mahé, B[eau] Vallon, 28-II-1959, H. Legrand," "♂ genitalia slide by DA 3168 [green label]," "♂ wing slide by DA 3176 [green label]," ♂, same data as above except: "18-VII-1950, M. Gerber," "♂, genitalia slide by DA 3171," ♀, "Seychelles, Mahé, B[eau] Vallon 2-I-1959, H. Legrand," "♀ genitalia slide by DA 3169," 7♀, same data as above except, "6-V-1960," "♀ genitalia slide by DA 3172," "20-IV-1956," "*Blastobasis intrepida* Meyr." [handwritten label], "♀ genitalia slide by DA 3263," "10-IV-1956," "♀ genitalia slide by DA 3264," "12-I-1959," "♀, genitalia slide by DA 3265," "11-III-1959," "♀ genitalia slide by DA 3266," "11-III-1959," "♀ genitalia slide

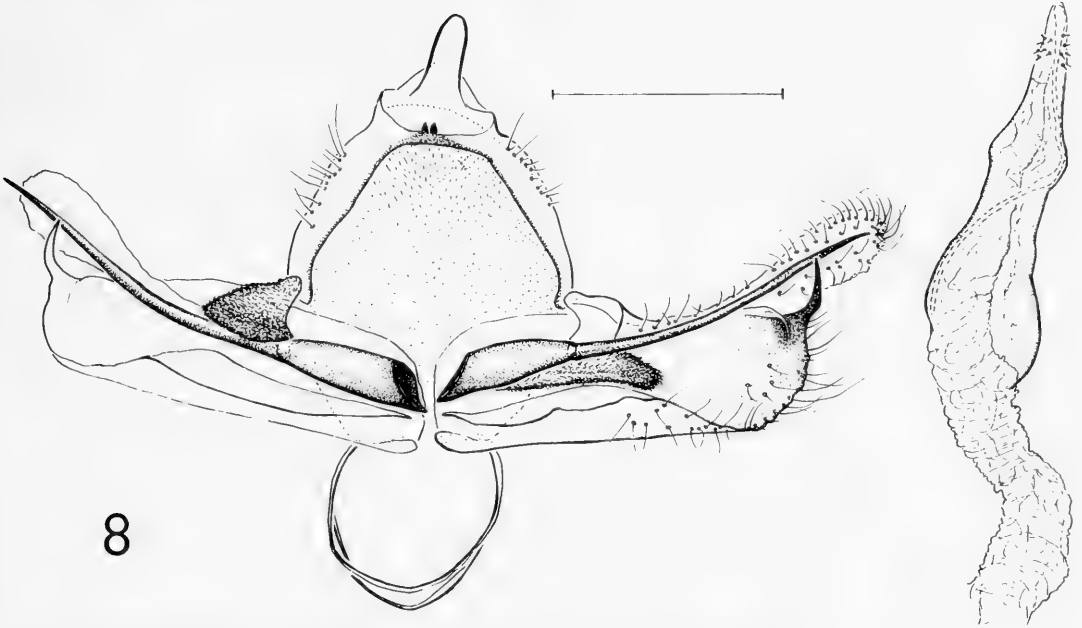


Fig. 8. Male genitalia of *Blastobasis intrepida* Meyrick (holotype). Scale line = 0.5 mm.

by DA 3269," "20-IV-1959," "♀ genitalia slide by DA 3270," ♀, "Seychelles, Mahé, B[eau] Vallon, 12-VII-1959, M. Gerber," "♀ genitalia slide by DA 3282," 4♀♀, same data as above except, "8-I-1960," "♀ genitalia slide by DA 3277," "25-I-1959," "♀ genitalia slide by DA 3268," "1-V-1959," "♀ genitalia slide by DA 3271," "28-IV-1960," "♀ genitalia slide by DA 3276," ♂, "Aldabra Atoll, 9°24'S, 46°20'E, Takamaka Grove, 12 Feb[ruary] 1968, Jay C. Shaffer," ♂ "USNM genitalia slide 81564, DA 3145 [green label]," 2 ♂, same data as above except, "13 Feb[ruary] 1968," ♂, same data as above except, "14 Feb[ruary] 1968," 2 ♀, same data as above except, "11 Feb[ruary] 1968," "♀ USNM genitalia slide 81565, DA 3146," 5 ♀, same data as above except, "12 Feb[ruary] 1968," ♀, same data as above except, "13 Feb[ruary] 1968," ♀ same data as above except, "14 Feb[ruary] 1968," 3 ♀, same data as above except, "15 Feb[ruary] 1968," "Pond No. 42, near Takamaka Grove," ♂, "Seychelles: Aldabra Atoll, Ile Picard, Set-

lement, 12-22 Mar[ch] 1986, David Adamski," "♀ USNM genitalia slide 81559, DA 3140 [green label]," ♂, same data as above except, "♀ genitalia slide label 81561, DA 3142," 3 ♀, same data as above except, "♀ USNM genitalia slide 81560, DA 3141," "♀, USNM genitalia slide 81562, DA 3143," "♀, USNM genitalia slide 81563, DA 3144," ♂, "Seychelles, Mahé, Victoria, Botanical Gardens, 3-8 Apr[il] 1986, David Adamski," ♂ USNM genitalia slide 81558, DA 3139 [green label]."

Remarks.—The lectotype had previously been labelled, but no designation had been made. Because older specimens are faded, the color description is based upon the most recent specimens collected. Meyrick (1911) states that two males were collected at 1000 feet on Mahé (♂ lectotype collected on Morne Blanc, and ♂ paralectotype collected at Cascade Estate). Label data show that both specimens were collected at 800 feet. Meyrick (1911) also states that another paralectotype male was collected on Silhouette at

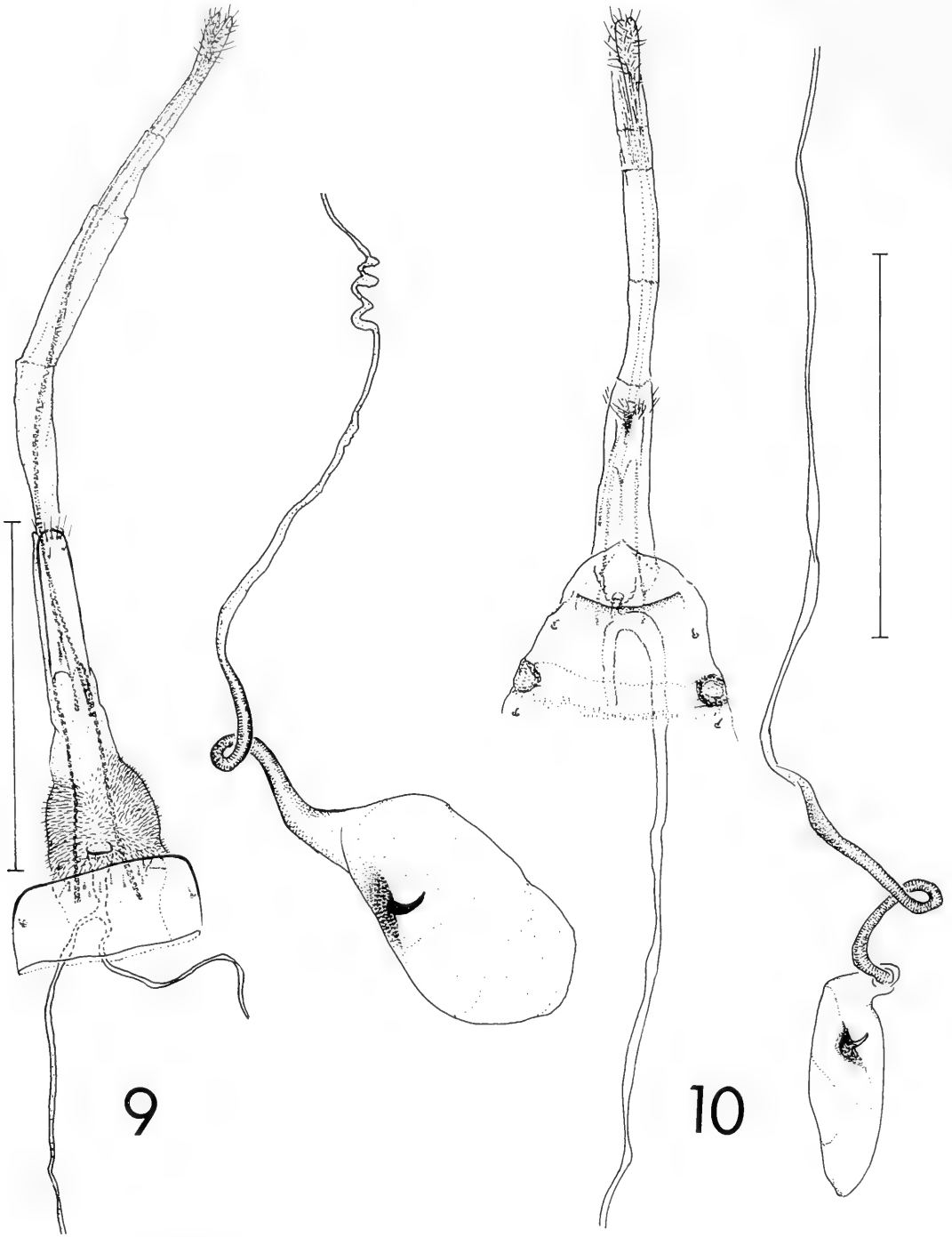


Fig. 9. Female genitalia of *Blastobasis acarta* Meyrick. Scale line = 1.0 mm.

Fig. 10. Female genitalia of *Blastobasis intrepida* Meyrick. Scale line = 1.0 mm.

Mare aux Cochons plateau at 1000 feet, but these data are not on the label of the pinned specimen.

Blastobasis intrepida Meyrick, 1911
(Figs. 3, 5–6, 8, 10)

Blastobasis intrepida Meyrick, 1911. Trans. Linn. Soc. Lond. 14(2): 287. Legrand, H. 1965. Mém. Mus. natn. Hist. nat. Ser. A, 37: 54.

Diagnosis. — Male with two apical articles of labial palpus widened dorsoventrally, an elongate valval spine present, apical process of lower part of valva small, aedeagus straight, apical part of aedeagal sclerite angled, lateral membrane with a round and wrinkled, small invagination between sixth and seventh segments.

Head (Fig. 5): Similar to *B. acarta*, except male with two apical articles of labial palpus widened dorsoventrally (Fig. 5).

Thorax: Tegula and mesonotum with brown scales tipped with white, intermixed with pale-brown scales; legs similar to *B. acarta*; forewing (Fig. 3), length 4.1–6.2 mm ($n = 11$), grayish brown intermixed with grayish-brown scales tipped with white or grayish-brown scales intermixed with brown scales; basal fascia distinct in specimens with basal area dominated by white scales; two brown spots near apical area of discal cell, one brown spot near middle; undersurface uniform grayish brown; hindwing with both surfaces pale brownish gray; venation similar to previous species (Fig. 6).

Abdomen: Grayish brown above, white beneath.

Male genitalia (Fig. 8): Uncus slightly angled posteriorly, apically rounded; gnathos with two pointed teeth; tegumen with several dorsolateral setae; diaphragma with microtrichia dorsally; upper part of valva fingerlike, narrowed basally; apical process of lower part of valva small; elongate spine projecting about entire length of valva, fused to a subtriangular area (distorted on left valva in Fig. 8); subtriangular plate with dense

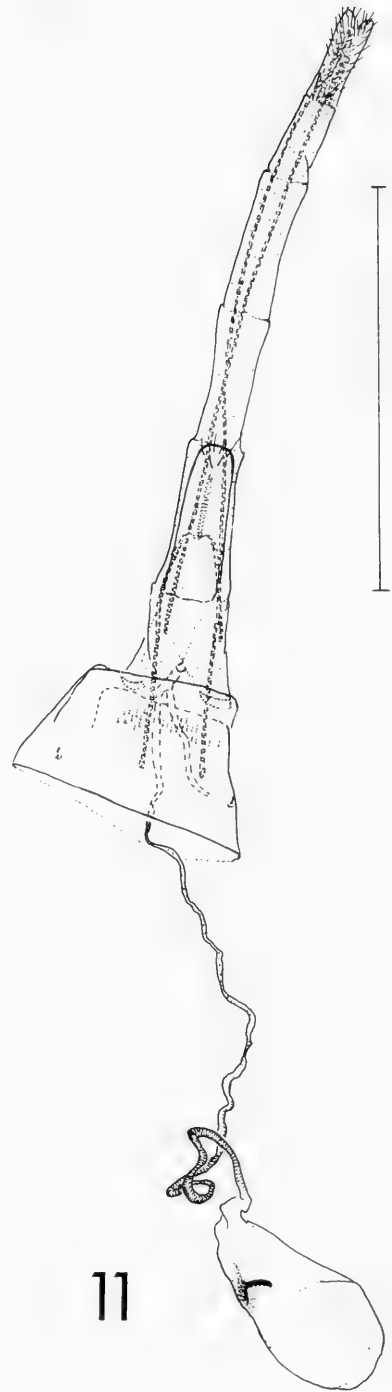


Fig. 11. Female genitalia of *Blastobasis legrandi* Adamski. Scale line = 1.0 mm.

microtrichia; aedeagus straight, apical portion of aedeagal sclerite angled, anellus setose.

Female genitalia (Fig. 10): As in previous species except: ostial area membranous throughout; seventh sternum transversely shortened; lateral membrane between sixth and seventh segments with a round, wrinkled, small invagination.

Types.—Holotype, ♂, "Holotype" [round red-bordered label], "Type" [label is upside down], "Seychelles: Cascade Estate; Mahé, 800 [feet]; XII-1908, H. Scott," "Brit[ish] Mus[eum], 1913-170," "*Blastobasis intrepida* Meyr[ick], Type ♂," "BM genitalia slide 26552." Holotype in BMNH.

Other specimens examined.—♂, "Seychelles, Mahé, B[ea]u Vallon, 13-VI-1959, H. Legrand," "♂ genitalia slide by DA 3167 [green label]," ♂, same data as above except, "11-V-1959, M. Gerber," ♀, "Seychelles, Mahé, B[ea]u Vallon, 11-V-1959, M. Gerber," "♀, genitalia slide by DA 3267," 7♀ same data as above except, "20-V-1959," "♀ genitalia slide by DA 3274," "7-VI-1960," "♀ genitalia slide by DA 3275," "15-VII-1959," "♀ genitalia slide by DA 3278," "11-VI-1959," "♀ genitalia slide by DA 3279," "21-IV-1959," "♀ genitalia slide by DA 3280," "7-VII-1959," "♀, genitalia slide by DA 3281," "21-III-1960," "♀ genitalia slide by DA 3283," ♀, same data as above except, "6-VI-1960, H. Legrand [specimen missing abdomen]."

Remarks.—Female *intrepida* can be distinguished from female *legrandi* and *acarta* only by examination of genitalia.

Discussion.—Adamski and Brown (1989) provided a phylogenetic classification for the North American Blastobasidae that included evidence for the monophyly of *Blastobasis* Zeller. *B. acarta* shares many synapomorphies of the genus, except for the dorsal strut of the tegumen and the posterior lobe of the corpus bursae. The cubital area of the hindwing is typical of several Palearctic species, e.g. *Blastobasis phycidella* Zeller, however, it is unlike most New World

blastobasids, in which the cubitus is stalked in series (veins M_2 , M_3 , CuA_1 and CuA_2 are stalked about the same distance from posterior wing margin). Similarly, *B. intrepida* shares several synapomorphies for *Blastobasis*. Unlike *acarta*, *B. intrepida* does possess the dorsal strut. However, *B. intrepida* has two characters, an elongate valval spine and the diminutive apical spine of the lower valva, that are found in *Neoblastobasis* Kuznetsov and Sinev (1985) and related species recently described from the eastern Palearctic Region. The placement of *B. legrandi* is uncertain because males are not known. A reasonable assessment for the placement of species of *Blastobasis* awaits a phylogenetic analysis of the world species.

ACKNOWLEDGMENTS

I thank K. Sattler of The British Museum (Natural History) for the loan of the types of *Blastobasis acarta* Meyrick and *B. intrepida* Meyrick; G. Luquet of The Muséum National D'Histore Naturelle, Paris, for the loan of specimens of Blastobasidae collected by H. Legrand and M. Gerber; and Ronald W. Hodges for providing names for specimens that were misidentified in Legrand's collection of Blastobasidae. I also acknowledge funding from the Smithsonian Institution and leadership from Brian Kensley, who headed our expedition in 1986. Finally, I express thanks to the Seychelles Islands Foundation for facilitating my field work on Mahé and Aldabra.

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A REVIEW OF NEW WORLD *ENTOMOGNATHUS* WITH DESCRIPTIONS OF
SEVEN NEW SPECIES (HYMENOPTERA, SPHECIDAE, CRABRONINI)

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Abstract.—A key is given to the 14 New World species of the genus *Entomognathus* Dahlbom (1894). Of the seven new species six are assigned to the subgenus *Toncahua* Pate: *alaris* (western U.S., Durango, Mexico), *apache* (Arizona), *arizonae* (Arizona, Mexico), *coloratus* (Arizona, New Mexico), *guerreroi* (Guerrero, Mexico), and *occidentalis* (California, Nevada). One new species is assigned to *Entomognathus* s.s.: *dinocer* (Morelos, Mexico).

Key Words: *Entomognathus*, Hymenoptera, Sphecidae, Crabronini, New World, *Toncahua*

The genus *Entomognathus* Dahlbom had 42¹ species assigned to it in 1976 (Bohart and Menke). All of these have hairy eyes and occur primarily in the Holarctic and Ethiopian Regions. A revised key to the four subgenera was given by Bohart and Menke (1976: 381). All seven of the previously known American species are in the subgenus *Toncahua* Pate (1944) in which the males have only 12 antennal articles and some of the terga of both sexes have their posterior margins concave. In the present paper seven additional species are described, six in *Toncahua*, and one in the subgenus *Entomognathus* Dahlbom.

Comments by reviewers, especially those by Karl Krombein, were most helpful. Thanks are also extended to curators of institutions which have lent material (type deposition is indicated by the city involved in capitals):

American Museum of Natural History
(NEW YORK).

California Academy of Sciences (SAN FRANCISCO).

Oregon State University Entomology Museum (CORVALLIS).

University of Arizona (TUCSON).

University of California Bohart Museum (DAVIS).

University of Kansas Snow Museum (LAWRENCE).

U.S. National Museum of Natural History (WASHINGTON).

Terms used in the key and descriptions which may be unfamiliar are: foveolate: divided into small cell-like units; flagellomeres: antennal articles beyond pedicel; MOD: median ocellus diameter; omaulus: carina at widest point of mesothorax; S-I to S-VII: abdominal sterna beyond propodeum; T-I to T-VII: abdominal terga beyond propodeum; prepectus: anterior section of mesopleuron below pronotal lobe.

KEY TO NORTH AMERICAN
ENTOMOGNATHUS

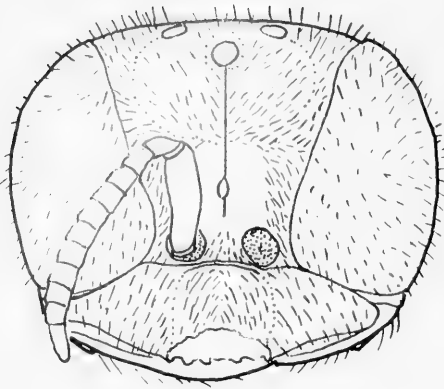
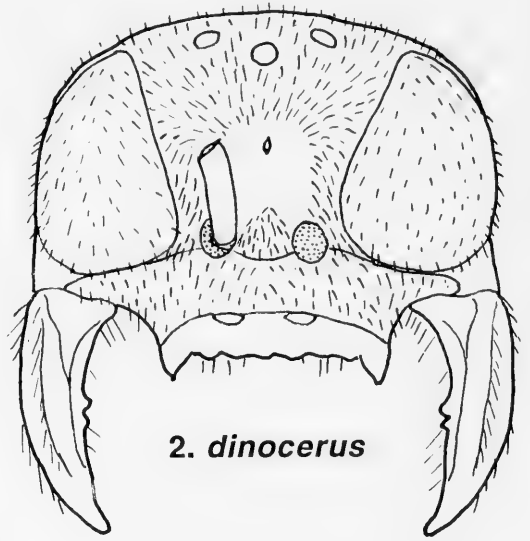
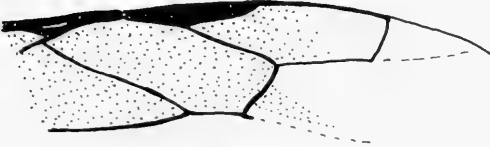
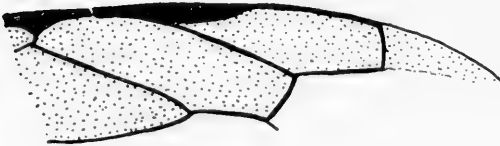
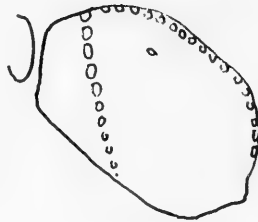
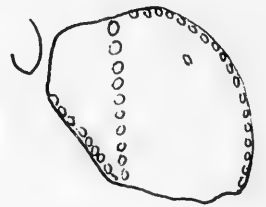
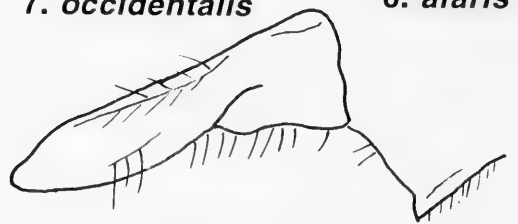
1. Body length less than 4.0 mm (males) or 5.0 mm (females); prescutellar groove foveolate; wings clear or weakly, evenly stained 2

¹ There are now 45 species known. Marshakov (1976) described two from Asia and *nasutus* (Gribodo) (1884) was transferred from *Lindenius* by Leclercq (1989).

- Body length more than 4.0 mm (males) and at least 5.0 mm (females), prescutellar groove various, wings considerably stained (in most species) 7
- 2. Mesopleuron and scutum rather densely punctate, dull; flagellomeres white beneath in male, more dully in female; wings clear, propodeum granulate posteriorly and laterally; pronotal collar thin; Arizona *arizonae* R. Bohart, new species
- Mesopleuron, at least above, polished; scutum with scattered, fine punctures, but polished overall; other characters various 3
- 3. Mesopleural groove behind and adjacent to omaulus finely foveolate (as in Fig. 8), partly obscured by silvery pubescence; pronotal collar rounded over; mesopleuron with numerous small punctures, especially below, not highly polished; terga with whitish or yellow spots 4
- Mesopleural groove behind and adjacent to omaulus coarsely foveolate; pronotal collar narrow, not rounded; mesopleuron highly polished; terga unspotted 5
- 4. Terga partly or entirely rust red except for lateral whitish spots, female scutellum and metanotum all whitish, female clypeal bevel broadly lenticular, New Mexico *coloratus* R. Bohart, new species
- Terga black except for small lateral whitish yellow spots in female, absent or weak in male; female scutellum with two whitish yellow spots, small and more lateral in male, metanotum with posterior linear spots; female clypeal bevel subtriangular, reddish; Arizona, w. Texas, Baja California, Sonora, Durango (Mexico) *apache* R. Bohart, new species
- 5. Propodeum posteriorly with flat, polished areas flanking median furrow, also basolaterally polished, scape yellow in front, Central America *geometricus* Leclerq
- Propodeum granulate posteriorly on either side of median furrow, basolaterally granulate, scape various 6
- 6. Wings slightly and evenly dusky, scape whitish yellow, Florida, North Carolina *arenivagus* Krombein
- Wings hyaline, scape black, Mexico *mexicanus* Cameron
- 7. Wings hyaline, prescutellar groove foveolate, notauli somewhat impressed anteriorly to give scutum a tripartite appearance, Mexico *evolutionis* (Leclerq)
- Wings slightly or heavily stained, other characters various. 8
- 8. Mesopleuron at its widest point with or without sharp ridge, but without foveolate vertical groove just behind widest point (Fig. 7) ... 9
- Mesopleuron at its widest point with omaulus or sharp ridge, adjacent to vertical foveolate groove (Fig. 8) 11
- 9. Mesopleuron at widest point rounded over, no omaulus or sharp edge (Fig. 7); punctuation fine and separated, but extensive, surface not polished; prescutellar groove simple, not foveolate; scutellum whitish yellow, not 2-spotted, California, Nevada *occidentalis* R. Bohart, new species
- Mesopleuron at widest point with sharp edge; punctuation indistinct, surface polished; prescutellar groove with at least a median longitudinal ridge; scutellum black or with two yellow spots 10
- 10. Prescutellar groove with four or more foveae separated by longitudinal ridges, markings pale yellow, female mandible weakly incised beneath, U.S. east of Sierra Nevada, n. Mexico *texanus* (Cresson)
- Prescutellar groove in two sections separated by a median ridge; markings deep yellow; female mandible sharply excised beneath; Guerrero, Mexico *guerreroi* R. Bohart, new species
- 11. Large species, about 15 mm long (female); occipital carina ending laterally in sharp tooth; top of clypeal bevel with pair of prominent, forwardly directed processes; wings dark brown; Morelos, Mexico *dinocerus* R. Bohart, new species
- Medium-sized species, less than 7.0 mm long; occipital carina not toothed laterally; top of clypeal bevel unarmed, wings various but not all dark brown 12
- 12. Wings brown toward base, clear beyond cellular area; prepectal yellow spot present; scutellum often all yellow, sometimes two-spotted; w. U.S.: 100th meridian west to Arizona; Durango, Mexico *alaris* R. Bohart, new species
- Wings weakly stained, no prepectal spot, scutellum black or with two yellow spots 13
- 13. Terga black, U.S. east of 100th meridian ... *lenapeorum* Viereck
- Terga with one or more whitish-yellow, lateral spots, U.S. east of 100th meridian *memorialis* Banks

SUBGENUS *TONCAHUA* PATE

Toncahua Pate 1944: 341. Generotype *Craebro texanus* Cresson 1887, original designation.

1. *occidentalis*2. *dinoceris*3. *occidentalis*4. *alaris*5. *dinoceris*6. *dinoceris*7. *occidentalis*8. *alaris*9. *occidentalis*10. *dinoceris*

Figs. 1-10. Species of *Entomognathus*. 1 ($\times 37$), 2 ($\times 18$), front view of head. 3 ($\times 25$), 4 ($\times 25$), 5 ($\times 12$), cellular area of forewing. 6 ($\times 18$), clypeus from above. 7 ($\times 37$), 8 ($\times 25$), mesopleuron. 9 ($\times 50$), mandible, side view. 10 ($\times 25$), mandible and end of occipital carina, side view.

Florkinis Leclercq 1956: 2. Generotype *Encopognathus evolutionis* Leclercq 1956, original designation.

The 13 species agree in the following characters: ocelli in a low triangle, male flagellum with 10 articles (male of *coloratus* unknown), clypeus with apical bevel ending in four to six teeth but no projections from upper margin of bevel, forewing recurrent reaching at or slightly before middle of marginal cell (Fig. 3), T-III-IV posterior margins broadly incurved, males customarily with flagellar articles whitish beneath, body length less than 10 mm.

Entomognathus (Toncahua) alaris

R. Bohart, NEW SPECIES

Figs. 4, 8

Female holotype. Length 6.0 mm. Black, marked with pale yellow as follows: scape in front, mandible basally, pronotum all across including lobes, tegula in front, scutellum, metanotum, prepectal spot, forefemur and midfemur distally, all tibiae and basitarsi outwardly, large lateral spots (ivory yellow) on T-I to T-V; flagellum yellowish beneath, S-VI reddish brown, basal 0.75 of forewing (Fig. 4) and all of hindwing brown. Pubescence of head (including eyes) pale. Most body surfaces polished, punctation sparse, a little thicker on T-V. Mandible sharply incised basoventrally (as in Fig. 9); polished clypeal bevel elliptical (as in Fig. 1), 0.4× as long as clypeus whose medial apex has six small teeth; antennal sockets separated by a socket diameter, a little closer to eye; supraorbital fovea indistinct; prescutellar groove foveolate; omaulus raised sharply, adjacent to narrow foveolate groove (Fig. 8); acetabular carina present; pygidial plate angled at 45°, moderately silvery setose.

Male. Length 5.0–6.0 mm. Sculpture and markings about as in female. Prepectal spot may be small, band on collar ridge may be broken medially, metanotum may be mostly black, T-VII and S-VII reddish brown;

T-VI closely punctate; clypeal apex with four apical teeth, bevel small.

Holotype female (DAVIS), Willcox, Cochise Co., Arizona, VIII-24-74 (R. M. Bohart). Paratypes, Arizona: ♂ (DAVIS) same data as holotype; 2 ♂ (CORVALLIS), 8 mi n. Douglas, Cochise Co., VII-31-46 (H. A. Scullen); ♀ (DAVIS), 28 mi n. Douglas, Cochise Co., VIII-2-78 (R. W. Brooks); ♀ (NEW YORK), 25 mi se. Saunders, Apache Co., VIII-14-72 (J. G. Rozen, R. McGinley); ♂ (NEW YORK); 11 mi s. Apache, Cochise Co., VIII-10-73 (M. Favreau); ♀ (SAN FRANCISCO), 4 mi sw. Forestdale, Navajo Co., VIII-24-52 (H. B. Leech). Other paratypes: New Mexico: ♀ (DAVIS), VIII-23-64 (M. A. Cazier, *et al.*); ♂ (DAVIS), 18 mi n. Rodeo, IX-7-76 (R. M. Bohart). Colorado: ♂ (WASHINGTON), (C. F. Baker); ♀ (DAVIS), Great Sand Dunes Monument, Alamosa Co., VII-3-76 (H. E. Evans); Texas: ♂ (DAVIS), Kingsville, Kleberg Co. III-20-72 (J. E. Gillaspay); 4 ♀ (SAN FRANCISCO, DAVIS), 20 mi. se. Kingsville, Kleberg Co., V-4-85 (W. J. Pulawski); ♀ (SAN FRANCISCO, DAVIS), Junction, Kimble Co., IV-24-86 (W. J. Pulawski); ♂♀ "Tex." (WASHINGTON); Kansas: ♀ (WASHINGTON) Reno Co., VII-12-60; Wyoming: 2 ♂ (WASHINGTON, DAVIS), Glendo, VII-13-60 (R. J. Lavigne); Mexico: Jalisco: ♀ (DAVIS), (Crawford); Durango: 3 ♂, ♀ (DAVIS), 20 mi w. Durango, VI-17-64 (D. Bolinger); ♂ (CORVALLIS), 76 mi s. Durango, VI-16-56 (H. A. Scullen).

The moderate size, distinct omaulus, with adjacent foveolate groove, bicolored wings, yellow prepectal spot and extensively yellow pronotal collar and often scutellum, characterize the species. The bicolored wings and prepectal spot distinguish it from *memorialis*.

Entomognathus (Toncahua) apache

R. Bohart, NEW SPECIES

Female holotype. Length 4.5 mm. Black, marked with whitish yellow as follows: scape

in front, mandible mostly, pronotal collar except medially, pronotal lobe, tegula partly, lateral scutellar spot extending to hindwing base, postlateral metanotal edge, femora distally, fore- and midtibiae mostly, hindtibia basally, basitarsi, small lateral spots on T-I to IV; wings clear; clypeal bevel and mandible tip dark red, pygidial plate rust red. Pubescence pale. Punctuation fine, scattered over upper frons, mesonotum, and mesopleuron, which are, however, polished overall; terga lightly punctate, polished; S-II rather closely punctate but shiny; propodeum posteriorly granulate but enclosure areolate, laterally granulate but a little shiny. Mandible sharply incised basoventrally; polished clypeal bevel subtriangular, 0.6 as long as clypeus which has six weakly defined apical teeth; antennal sockets 1.0 diameter apart, 0.5 diameter from eye; supraorbital fovea present, narrowly oval; pronotal collar rounded over; omaulus present but adjacent foveolate groove indistinct; prescutellar groove finely foveolate; pygidial plate angled at 45°, densely silvery setose.

Male. Length 2.5 mm. Sculpture, punctuation, and pale markings about as in female except: terga all black, pronotum black except lobes, scutellum black (lateral pale lines present).

Holotype female (NEW YORK), 13 mi sw. Apache, Cochise Co., Arizona, VIII-21-71 (J. Rozen, M. Favreau). Paratypes: ♀ (SAN FRANCISCO), Baja California Sur, 9 km se. Santa Rita, VIII-25-77 (E. Fisher, R. Westcott); ♀ (DAVIS), Dateland, Arizona, VII-5-56 (G. Butler); ♂ (NEW YORK), near Rodeo, New Mexico, VIII-25-71 (J. Rozen and M. Favreau); ♂♂, ♀ (DAVIS, TUCSON), Roll, Arizona, VIII-21-54 and X-6-56 (D. Tuttle, G. Butler); ♂ (DAVIS), Ceballos, Durango, Mexico, X-19-68 (G.E. Bohart); ♂ (DAVIS), 20 mi. s. Estacion Llano, Sonora, Mexico, VIII-17-64 (M.E. Irwin).

This species is similar to *arizonae* but the mesonotum and mesopleuron of *apache* are

more polished, and the clypeal bevel is subtriangular rather than broadly oval.

Entomognathus (Toncahua) arizonae

R. Bohart, NEW SPECIES

Female holotype. Length 4.0 mm. Black, marked with whitish yellow as follows: scape in front, mandible basally, pronotal collar laterally, pronotal lobe, tegula partly, lateral scutellar spot, femora distally, tibiae outwardly, tarsi mostly, small lateral spots on T-I-II; wings clear, abdominal segment VI reddish brown. Pubescence pale. Punctuation fine and extensive; vertex, scutum, propodeum laterally, dull; terga and S-II with many punctures, somewhat shiny. Mandible sharply incised basoventrally; polished clypeal bevel semicircular, 0.5 as long as clypeus whose medial apex has six small teeth, most lateral one sharp; antennal sockets 1.0 diameter apart, 0.5 diameter from eye; supraorbital fovea indistinct; prescutellar groove finely foveolate; no distinct omaulus or adjacent foveolate groove at front of pubescent prepectus; acetabular carina present; pygidial plate angled at 45°, moderately silvery setose.

Male. Length 3.0 mm. Sculpture, punctuation, and pale markings about as in female. Mandible often mostly whitish, flagellum mostly whitish yellow beneath, tegula and post-tegula partly yellow, terga without yellow spots, T-VI closely punctate.

Holotype female (DAVIS), 28 mi n. Douglas, Cochise Co., Arizona, VIII-II-78 (R. W. Brooks). Paratypes (all from Cochise Co., Arizona): 3 ♂ (DAVIS, SAN FRANCISCO, WASHINGTON), same data as holotype; ♂ (NEW YORK) 13 mi sw. Apache, VIII-14-74 (J., B., and K. Rozen); 2 ♂ (DAVIS, NEW YORK), 13 mi sw. Apache, VIII-20-71 (J. & D. Ehrenfeld). Other paratypes: ♂ ♀ (DAVIS, WASHINGTON), Phoenix, Maricopa Co., Arizona; ♂ (TUCSON), Avra valley, Arizona, VII-6-55 (G. Butler, F. Werner); ♂ (SAN FRANCISCO), 7 mi. s. Quartzite, Yuma Co., X-1-82

(W. J. Pulawski); ♂ (SAN FRANCISCO), 3 mi. w. Superior, Pinal Co., VII-12-85 (W. J. Pulawski). Some of the paratypes were collected on *Helianthus annuus*, others on *Euphorbia albomarginata*.

This small species (3.0–4.0 mm long) has the upper frons, vertex, mesonotum, mesopleuron, and terga extensively punctate; the propodeal base not polished laterally; and the wings not stained. A somewhat similar species is *arenivagus* Krombein but it has the mesopleuron polished and its wings are dusky.

Entomognathus (Toncahua) coloratus

R. Bohart, NEW SPECIES

Female holotype. Length 3.0 mm. Black, pale yellow, and rust red; whitish yellow are: scape, mandible on basal half, pronotal collar to lobe (all across), tegula partly, post-tegula mostly, scutellum and metanotum (nearly all white), femora distally, tibiae outwardly, lateral spots on T-I to IV, T-V mostly; rust red are: femora mostly, sterna, terga except for pale spots; wings lightly, evenly stained. Pubescence pale. Punctuation fine and scattered on head, scutum, mesopleuron, and abdomen, but these areas polished overall; propodeum shiny laterally. Mandible sharply incised basoventrally; polished clypeal bevel crescentic, $0.3 \times$ as long as clypeus whose medial apex has six small teeth, most lateral one largest; antennal sockets about 0.7 diameter apart, 0.7 diameter from eye; supraorbital fovea distinct; prescutellar groove foveolate; omaulus weakly developed, adjacent to a foveolate groove; acetabular carina present; pygidial plate angled at 45° , moderately silvery setose.

Holotype female (DAVIS), 1 mi. e. Douglas, Cochise Co., Arizona, VIII-12-62 (M. A. Cazier). Paratypes: 2 ♀ same data as holotype; ♀ (NEW YORK), 4 mi. e. Animas, Hidalgo Co., New Mexico, VIII-24-74 (J. Rozen, M. Favreau).

The presence of an omaulus and adjacent

groove on this small species together with the extensive rust-red abdominal coloration differentiate *coloratus* from other known members of the genus in North America. Also remarkable are the entirely whitish scutellum and metanotum, along with an all-dark clypeus.

Entomognathus (Toncahua) guerreroi

R. Bohart, NEW SPECIES

Female holotype. Length 7.0 mm. Black, marked with deep yellow as follows: scape in front, mandible basally, inner streak on foretibia and midtibia, inner distal spot on hindtibia, large lateral spots which are attenuate medially on T-I to III, T-IV-V mostly; reddish brown are: scape partly, pronotal lobe, tegula, post-tegula; wings moderately brown stained, lighter basad. Pubescence silvery on face, off-silvery on terga, microsetae dark and plentiful on wing cells. Punctuation faint, most body areas polished, including propodeum anterolaterally. Mandible incised basoventrally; clypeal bevel not polished, irregular above, $0.5 \times$ as long as clypeus whose medial apex has six small teeth; antennal sockets 1.0 diameter apart, 0.5 diameter from eye; prescutellar groove with a single median divider, not foveolate; omaulus represented by a sharp edge at front of prepectus, no adjacent foveolate groove; acetabular carina present; pygidial plate angled at 45° , densely pale-golden setose.

Male. Length 5.0–6.0 mm. Sculpture about as in holotype, yellow markings often more extensive: clypeal midlobe, four pronotal spots, two spots on scutellum, tibiae and tarsi mostly, band across T-I, T-VI entirely. Some paratype males nearly as dark as type female; clypeal bevel less pronounced; and wings a little lighter.

Holotype female (DAVIS), 9 mi s. Tierra Colorado, Guerrero, Mexico, VII-21-63 (F. D. Parker and L. A. Stange). Paratypes (all from Guerrero, Mexico): 6 ♂ (DAVIS, SAN FRANCISCO, WASHINGTON), same

data as holotype; ♀ topotype (LAWRENCE), VIII-5-51; 3 ♂ (DAVIS), Acapulco, VII-19-63 (F. D. Parker and L. A. Stange).

M. guerreroi is similar to *texanus* in size, but averaging a little smaller. Also, the form of the prepectus, polished vertex, scutum, and mesopleuron are much the same. A striking difference is the deep-yellow of the markings in *guerreroi* rather than the ivory-yellow of *texanus*. In female mandibles the basoventral emargination is much more pronounced in *guerreroi*. Furthermore, the clypeal bevel of female *guerreroi* is less polished and topped by a series of small bumps. In *texanus* the bevel is more polished and topped by a simple angle. The type series of *guerreroi* all have the prescutellar groove divided into two chambers, whereas in *texanus* it has five or six foveolae.

Entomognathus (Toncahua) occidentalis

R. Bohart, NEW SPECIES

Figs. 1, 3, 7, 9

Female holotype. Length 8.0 mm. Black, marked with whitish yellow as follows: scape, basal half of mandible, median clypeal lobe, pronotal collar all across, pronotal lobe, tegula mostly, post-tegula laterally, scutellum, femora distally, tibia and basal three tarsomeres outwardly, T-I with subapical band, broken medially, large lateral spots on T-II-III, band on T-IV, median spot on T-V; wings lightly stained, becoming clear basad. Pubescence of head (including eyes) pale. Punctuation fine but extensive on head, thorax, S-II, S-V, these areas shiny but hardly polished; T-I to IV, S-III-IV polished with little punctuation. Mandible sharply incised basoventrally (Fig. 9); polished clypeal bevel elliptical, $0.33 \times$ as long as clypeus whose medial apex has six small teeth; antennal sockets about 1.0 diameter from eye and each other; supra-orbital fovea present but weak; prescutellar groove not foveolate; omaulus absent, widest point of thorax sharply rounded but not carinate and no adjacent foveolate groove

(Fig. 7); no acetabular carina; pygidial plate angled at 50° , moderately coppery setose.

Male. Length 5.0–7.0 mm. Sculpture and markings about as in female. Hindtibia with large brown outer spot, apex of median clypeal lobe with four teeth, T-I with complete yellow band.

Holotype female (DAVIS), Ash Mountain, Tulare Co., California, VI-26-83 (J. A. Halstead). Paratypes (all from California): 2 ♂ (DAVIS, WASHINGTON), topotypical but taken VI-12-83 and VI-19-83 (D. J. Burdick); 2 ♂ (DAVIS), Borrego Valley, San Diego Co., IV-19-57 (J. C. Hall); 2 ♂ (DAVIS), near Darwin Falls, Inyo Co., V-8-58 (E. G. Linsley) and V-12-69 (J. Powell); ♂ (DAVIS), Warthan Canyon Road, Fresno Co., I-19-81 (N. J. Smith); ♂ (DAVIS), 8 mi ne. Auberry, Fresno Co., VI-11-81 (N. J. Smith); ♂ (DAVIS) near Santa Margarita, San Luis Obispo Co., V-22-58 (E. G. Linsley) and VI-8-62 (P. D. Hurd); ♂ (DAVIS), Carrizo Creek, Riverside Co., V-31-63 (E. I. Schlinger); ♂ (SAN FRANCISCO), Potwisha, Sequoia National Park, Tulare Co., VII-1-41 (E. C. Van Dyke). Other paratypes, 4 ♂ (SAN FRANCISCO, DAVIS), Candelaria, Mineral Co., Nevada, VI-23-52 (J. P. Figg-Hoblyn).

The sharply rounded front margin of the prepectus, without an omaulus or adjacent groove (Fig. 7), and the extensive but moderate punctuation on the head and thorax, characterize the species. The absence of an anterior prepectal groove occurs also in *texanus* and *guerreroi*, but these species have the prepectus sharp anteriorly, and the mesopleuron polished. Also remarkable is the simple, rather than foveolate, prescutellar groove in *occidentalis*. The male paratypes from Nevada have slightly denser punctuation on the mesopleuron and scutum than California specimens.

Subgenus *Entomognathus* Dahlbom
(1844: 295)

Entomognathus dinocerus, described below, is the first record in the New World of

a species in the typical subgenus. The posterior margins of T-III and T-IV are straight. A possibly important difference from *E. brevis* Vander Linden, the generotype, is that the recurrent vein of the forewing reaches the marginal cell slightly but definitely beyond its middle (Fig. 5).

Entomognathus (Entomognathus) dinocerus

R. Bohart, NEW SPECIES

Figs. 2, 5, 6, 10

Female holotype. Length 13 mm. Black, marked with deep yellow as follows: scape in front, two elongate spots on pronotal collar, pronotal lobe, scutellum mostly, metanotum laterally, femora mostly, tibiae and tarsi, lateral spots on T-I to V, those on I separated by 4.0 MOD, irregular band on S-II; reddish brown are: mandible medially, tegula, post-tegula; wings dark brown (Fig. 5). Pubescence off-silvery on lower face, mesopleuron; fulvous on upper face, vertex, scutum, T-IV-V; microsetae of wing cells black. Punctuation fine, sparse, body extensively polished. Mandible weakly indented basoventrally (Fig. 10), occipital carina toothed apically; clypeal bevel lenticular, surface irregular, shiny, 0.5× as long as clypeus, upper edge with a pair of stout, porrect lobes, lower edge with six irregular teeth, lateral ones large; antennal sockets separated by 1.3 socket diameter, 0.5 diameter from eye; scutum with long, well-marked median groove, notauli, and shorter parapsidal lines; prescutellar groove with four foveolae; omaulus sharply raised, adjacent to a foveolate groove; acetabular carina absent; recurrent vein of forewing reaching marginal cell beyond its middle

(Fig. 5); T-II-III-IV posterior margins straight; pygidial plate angled at 50°, densely golden setose.

Holotype female (DAVIS), Alpuyecá, Morelos, Mexico, VII-3-51 (P. D. Hurd).

In this unusually large species, the tooth at the end of the occipital carina, and the projections on the dorsal rim of the clypeal bevel are reminiscent of some dinosaur fossil heads, hence the specific name. Also unusual are the dark brown wings, grooved scutum, and slightly distal position of the recurrent vein (Fig. 5). The weak indentation of the mandible basoventrally (Fig. 10) is found also in *texanus*, where it is less pronounced.

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NEW SPECIES OF NEARCTIC SNOW CRANE FLIES OF THE
GENUS *CHIONEA* (DIPTERA: TIPULIDAE)

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Abstract.—*Chionea jenniferae*, n. sp., from southern California, and *C. reclusa*, n. sp., from southern Illinois, are described and illustrated. A note on variation in *C. scita* Walker is appended, and new occurrences of *C. scita* and *C. valga* are recorded.

Key Words: *Chionea*, Tipulidae, Limoniinae, distribution, variation, winter insects

When the North American species of *Chionea* were dealt with in some detail more than a decade ago (Byers 1983), I would not have predicted the discovery of any additional nearctic species, except perhaps in remote boreal forests of Canada. But late in 1993 two remarkable new species were collected, one far south of the previously known range of the genus in California and the other near the southernmost range in Illinois. I am indebted to Saul I. Frommer of the University of California, Riverside, and Michael A. Goodrich of Eastern Illinois University, Charleston, for forwarding these interesting insects to me.

Discovery of these two species brings to 18 the number of species of *Chionea* known from North America.

Chionea jenniferae, NEW SPECIES

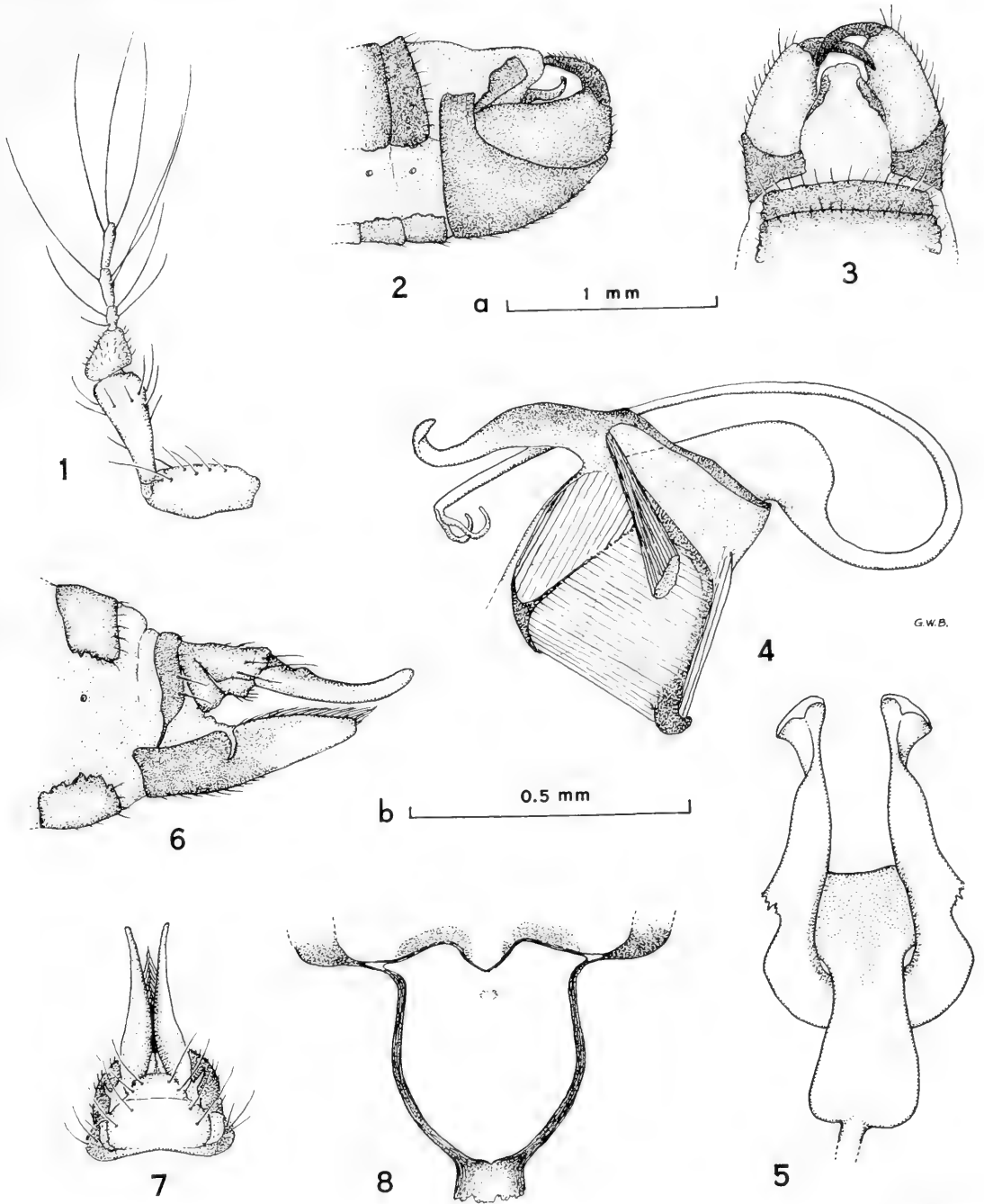
Description based on 7 males and 15 females, preserved in alcohol.

Diagnosis: A dark brown, southwestern species with 2 or 3 flagellomeres beyond fusion segment; sclerotized parts of ninth abdominal tergum of male widely separated medially by membrane, gonapophyses with pale, upturned apices; eighth abdominal tergum of female abruptly narrowed at sides, ninth sternum not divided medially.

Head: Dark brown. Antennae (Fig. 1) comprising subcylindrical scape, long-turbinate or subconical pedicel about as long as scape, fusion segment and three, less often two, additional flagellomeres, if three the basal one shorter than others. Major setae on vertex about as long as diameter of eye, black, about six in number, directed forward. Compound eyes of 80-90 ommatidia, nearly same number and size in both male and female.

Thorax: Sclerotized surfaces brown to dark brown, almost black in some males; membranous areas paler. Halteres light brownish gray. Sparse (6-8) dark setae on mesonotum, shorter setae on pronotum. Coxae and trochanters brown to dark brown, darker than yellowish brown to brown femora and tibiae. Tarsi approximately same color as tibiae except fifth tarsomere darker. Femoral setae nearly as long as diameter of femur at level of attachment, in four dorsal rows and three often indistinct ventral rows; ventral setae on femora of robust males not in rows. Tibial setae longer than diameter of tibia.

Abdomen of male: Terga 1-8 unevenly brown to dark grayish brown; posterior margin of each bearing 16-18 dark setae, 3-4 additional setae at each side and a few



Figs. 1-8. *Chionea jenniferae*, n. sp. 1, left antenna, holotype, left lateral aspect. 2, terminal abdominal segments, male holotype, left lateral aspect (most setae omitted). 3, same, dorsal aspect. 4, gonapophysis, penis or aedeagus, associated apodemes and muscles, male paratype, right lateral aspect. 5, gonapophyses and basal enlargement of penis, dorsal aspect. 6, terminal abdominal segments, female allotype, left lateral aspect. 7, same, dorsal aspect. 8, ninth sternum and genital furca, female paratype, posteroventral aspect. Scale a, Figs. 1, 4-5, 8; scale b, Figs. 2-3, 6-7.

scattered, short ones. Corresponding sterna slightly paler. Pleura unevenly light grayish brown. Ninth tergum and sternum (Figs. 2, 3) dark brown, tergum broadly divided dorsomedially, membranous surfaces pale gray-brown, those of ninth and tenth terga continuous. Lateral sclerites of tenth segment (tergal derivatives?) dark brown. Basistyles lighter brown than ninth sternum; dististyles dark brown, mostly glabrous, widened at base but without distinct basal teeth. Gonapophyses (Figs. 4, 5) dark yellowish brown to brown except apical one-third yellowish, each slightly twisted subapically, apex widened and curved upward. Penis (Fig. 4) unusually elongate, conspicuously expanded and only moderately sclerotized at base; basal expansion projecting upward between bases of gonapophyses, then abruptly curved cephalad; slender portion recurved, with two curled apical filaments directed laterad.

Abdomen of female: Tergum 1 uniformly dark yellowish brown. Terga 2–7 mostly yellowish brown, darker along anterior edge and very narrowly along posterior edge, at sides and diffusely along mid-line; posterior margin with about 10 black setae, scattered shorter setae elsewhere. Sterna more evenly yellowish brown, with about 20 dark brown to black setae along posterior margin, a few others scattered over surface. Pleural areas unevenly light brown. Tergum 8 abruptly narrowed at each side (Fig. 6); terga 9–10 short, wide (Fig. 7); cerci mostly light yellowish brown, darker along dorsal edge, slightly upcurved, with bluntly rounded apex (Fig. 6). Hypovalves light yellowish brown clouded with brown; eighth sternum brown. Genital furca (Fig. 8) lyre-shaped, with slender arms bowed outward. Ninth sternum formed of convergent slender prolongations from lower corners of tergum 9, with area of light sclerotization adjoining each; median portion deflected somewhat ventrad.

Body length (excluding antennae): Male, 3.51–4.34 mm. (holotype 3.59 mm.); fe-

male, 3.90–6.48 mm. (allotype 6.34 mm.). Hind femur of holotype 2.39 mm. long, that of allotype also 2.39 mm. Specimens are variously contracted or extended in fluid preservative.

Types: Male holotype, female allotype, 6 male and 14 female paratypes, collected from surface of snow in San Gorgonio Wilderness, near Fish Creek Camp (4.3 km. northeast of Mt. Gorgonio, at elevation approximately 2620 m.), in the San Bernardino National Forest, about 46 km. (29 mi.) east of San Bernardino, San Bernardino Co., California, on 13 November 1993, by Gregory P. Walker. Holotype, allotype, 2 male and 2 female paratypes in Snow Entomological Museum, University of Kansas, Lawrence; 4 male and 12 female paratypes in collection of University of California at Riverside.

In a letter, Dr. Walker describes the type locality as “. . . in a coniferous forest dominated by Jeffrey pine (*Pinus jeffreyi*) and white fir (*Abies concolor*). There is not much of an understory; it is pretty open with scattered shrubs and lots of bare soil. The terrain . . . was fairly steep and the ground was completely covered in snow.”

At the request of the collector, Dr. G. P. Walker, this species is named for his six-year-old daughter, Jennifer, who first noticed the *Chioneas*, called them to her father's attention and helped collect them.

Chionea jenniferae most closely resembles *C. carolus* Byers of the northern and central Sierra Nevada (Byers 1983: 169–172, figs. 163–170) and is somewhat less similar to *C. lyrata* Byers (1983) of the northern Sierras. Characteristics shared by *jenniferae* and *carolus* include small size, dark color, short antennal flagellum and, in males, the twisted, upturned apices of the gonapophyses and the shape of the dististyles. Females of these species are similar in the shapes of abdominal terga 8–10 and of the genital furca. Differences include, most significantly, the complete dorsomedial inter-

ruption or separation of the ninth abdominal tergum in the male of *jenniferae*, a character unique among all known species of *Chionea*. In *carolus*, the ninth tergum is deeply emarginate medially, more so than in any other species, yet is clearly continuous. While unlike that of any other nearctic species, the penis or aedeagus of the male in *jenniferae* has a form decidedly like that in *C. lutescens* Lundstrom and some other western palearctic species that have been differentiated from *Chionea* and assigned to a genus *Niphadobata* (cf. Burghele-Bălăcescu, 1969: plates 2, 5). This may have a causal relationship to the membranous division of the ninth tergum, for (in preserved specimens) the penis arches dorsad and is deeply impressed against the underside of both the ninth and tenth terga. The structure of the genital fork and ninth sternum in the female shows no apparent adaptation to either the aedeagal curvature and length or the apical filaments* (i.e. no conspicuous differences from corresponding parts in females of other species). The male keys to *C. jellisoni* at couplet 10 in my earlier key (Byers 1983: 123); the female goes to couplet 16 but not to either species identified there (p. 126).

Chionea reclusa, NEW SPECIES

Description based on one male specimen preserved in alcohol.

Diagnosis: A light yellowish brown species with 13-segmented antennae; male dististyles enlarged apically but without blackened points near base, ninth abdominal tergum shallowly emarginate medially, apex of each gonapophysis pointed in dorsal aspect but truncated in lateral aspect.

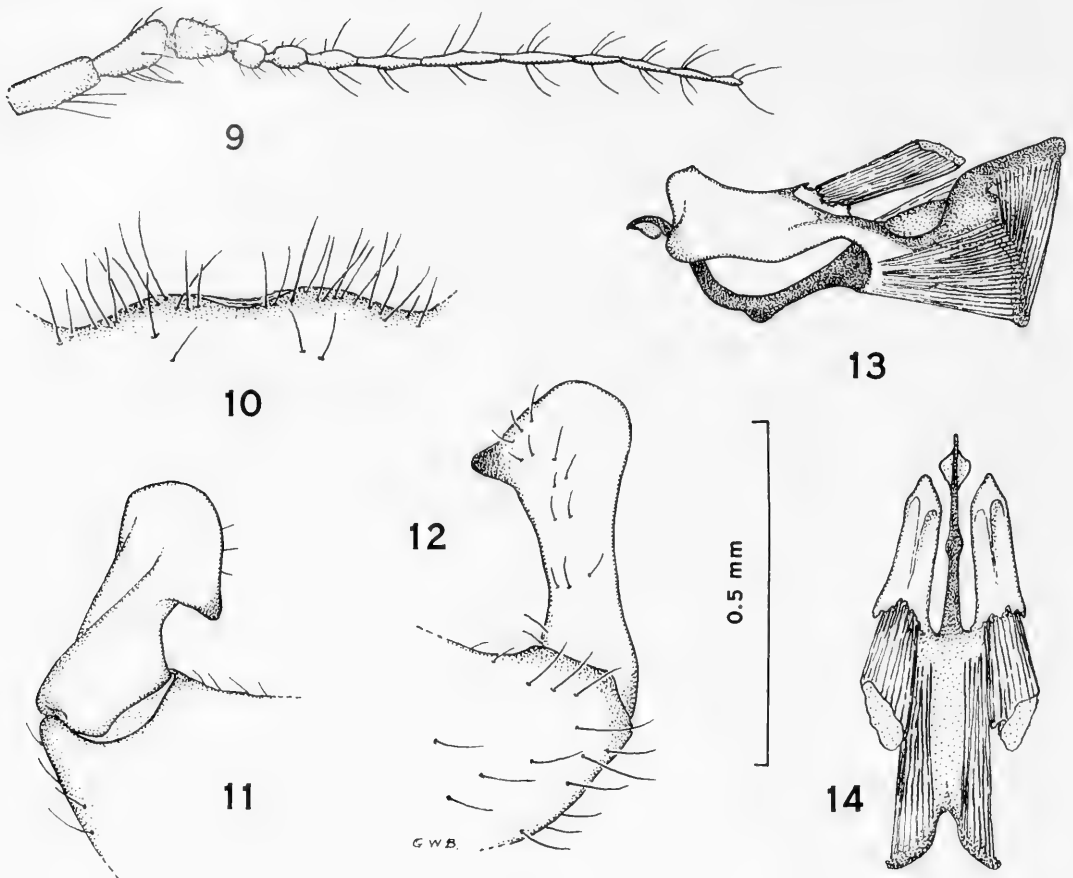
Head: Dark yellowish brown. Antennae (Fig. 9) with subcylindrical scape, pedicel about as long as scape, fusion segment and

ten additional flagellomeres. About 16 dark setae scattered over vertex, directed generally forward. Compound eyes of approximately 110 ommatidia each. Antennae and maxillary palps pale grayish brown; cervical sclerites grayish brown.

Thorax: Most sclerotized surfaces yellowish brown; sternum, coxae and trochanters slightly paler yellowish brown; membranous areas and halteres pale buff-gray. About 12 prominent setae on mesonotum; shorter setae on pronotum. Wings minute, smaller than in other species of similar body size. Femora, tibiae and most of basitarsi yellowish brown; apical one-fourth of each basitarsus and all of other tarsomeres grayish brown. Most setae on hind coxa in outer vertical row; others on ventro-mesal surface. Hind femora only slightly thickened (as other femora), each with four dorsal rows of setae and three ventral rows. (Right middle leg missing from holotype.)

Abdomen of male: Terga 1–8 mostly yellowish brown, 2–7 grayish brown at each side and narrowly along anterior margin; tergum 1 darker at sides only; about 14 dark setae along posterior edge of each tergum, other setae at sides; no conspicuous setae on tergum 8. Sterna 2–7 light yellowish brown bordered on sides by light brown; 14–18 dark setae long posterior edge, a few others at each side and elsewhere on posterior half of each sternum. Pleural areas pale buff. Genital bulb pale yellowish brown with dark brown setae. Ninth tergum (Fig. 10) broadly rounded, only slightly emarginate medially, with 12–14 marginal setae at each side. Dististyles (Figs. 11, 12) without basal teeth, expanded and rounded apically, with blunt, darkly sclerotized, subapical point directed inward and somewhat forward. Gonapophyses (Figs. 13, 14) pale yellowish brown with brown lateral markings, with truncate dorsal apex and rounded, more ventrolateral apex. Penis slightly expanded near mid-length, bearing thin, rounded, yellowish flange at each side shortly before apex.

* In an earlier paper on *Chionea* (Byers 1983: 78), I stated incorrectly that apical filaments occur in *C. valga* and *C. obtusa*; these are present in *C. valga* and in *C. hybrida*.



Figs. 9–14. *Chionea reclusa*, n. sp., male holotype. 9, left antenna, left ventrolateral aspect. 10, ninth abdominal tergum (medial portion), dorsal aspect. 11, left dististyle and apex of basistyle, mesal aspect. 12, same, left lateral aspect. 13, gonapophysis and penis or aedeagus, associated apodemes and muscles, right lateral aspect. 14, same, dorsal aspect. Scale, all figures.

Body length (excluding antennae): Male holotype, 4.90 mm.; length of hind femur, 3.01 mm.

Type: Male holotype, collected in Malaise trap operated from 15 November to 30 December 1993, 11.2 km. (7 miles) west of Carbondale, Jackson Co., Illinois, by M. A. Goodrich and D. L. Wood. The holotype is in the Snow Entomological Museum, University of Kansas, Lawrence.

This site is in the edge of the Shawnee National Forest. Dr. Goodrich has described the habitat as “a mature second-

growth deciduous forest . . . (with) numerous standing dead trees and downed logs in the vicinity.” The location is T9S, R2W, Sec. 20, NW $\frac{1}{4}$.

Chionea reclusa is so named because of its isolation from what appears to be its only close relative, *C. wilsoni* Byers of northeastern Alabama (Latin *reclusa* = separated, removed). Although the true extent of the ranges of both these species is as yet unknown, the collections that provide our only hints are separated by nearly 560 km. (350 miles).

Chionea reclusa, as understood from the male only, belongs to the *scita* group of species (Byers 1983: 126) on the basis of its coloration, its elongate antennae, and its vertically oriented gonapophyses without upturned apical hook. It shares with *C. wilsoni* 13-segmented antennae and the unusually shaped dististyles, which instead of tapering to an acute apex as in all other species are apically expanded, rounded and mesally concave. *C. reclusa* differs from *wilsoni* in the shapes of the gonapophyses, penis, ninth abdominal tergum, and in several details of the dististyles (cf. Byers 1983: 193, figs. 219–226). The male keys to *C. wilsoni* at couplet 3 in the existing key (Byers 1983: 122).

Chionea scita Walker

Dr. Richard L. Hoffman, of the Virginia Museum of Natural History, Martinsville, sent for my examination a collection of six males and seven females of this species, which he caught in a pitfall trap set in a forest of mixed hardwoods, 25 October to 23 November 1991. The site is at an elevation of 1190 m. on a peak of the Blue Ridge called "The Priest," in the George Washington National Forest, 7.2 km. southeast of Montebello, in Nelson Co., Virginia.

This collection, while not large, shows considerable variation in dimensions of individuals, such as has been noted in other species (e.g. Byers, 1983: 73, 148). The largest male, for example, is nearly twice the size of the smallest in overall length (ratio of 1.98 to 1). Earlier, I have used the hind femur as an indicator of the disproportionate development of "robust" males of *Chionea* as compared to small, slender-legged males. In this case, while the ratio of length of hind femur is only 1.78 to 1, greatest femoral width shows a ratio of 2.75 to 1. The females also show great size difference, largest to smallest being in a ratio of 1.74 to 1 for overall length, but there is less variation in dimensions of the ovipositor (ratios

of length of ovipositor, hypovalves, etc., being 1.38–1.40 to 1).

Measurement of those parts of the male external genitalia likely to be in direct contact with the female ovipositor reveals much less variation than in body length, etc. Length of dististyle, for example, varies in this sample (largest male: smallest male) in a ratio of 1.25 to 1, and length of anterior edge of basistyle (taken as a measure of inner curvature, which is difficult to obtain without dissection) shows a ratio of only 1.05 to 1. The point of all this is that in their apparently haphazard search for mates on the snow surface (or in leaf litter, etc.), males need not go from one female to another until they reach one of corresponding overall size.

This is only the second reported occurrence of *Chionea scita* in Virginia, the other being far to the southwest in Smythe County. The species, however, ranges fairly widely, from Vermont westward to Michigan and southward to northern Georgia (but probably only in the Appalachian Mountains, south of Pennsylvania).

Two female specimens of this species were recently received from Dr. Peter Adler of Clemson University. These were collected in a Malaise trap set by a spring brook at Tanglewood Spring, near Pendleton, elevation 226 m, Anderson Co., South Carolina, 1 December 1987–3 January 1988, by John Morse. They constitute the first record of the occurrence of the genus *Chionea* in South Carolina.

Chionea valga Harris

A male of *C. valga* was recently received for examination from Dr. Charles Parker, research biologist in the Great Smoky Mountains National Park. It was found in a drift net (24-hour sample) set in Noland Creek, Swain Co., North Carolina, elevation 1727 m, 17 February 1993, by G. Salsansky. This discovery extends the species' range about 240 km (140 miles) south west-

ward from its previously known range (Virginia and northward) and is the first recorded occurrence of *C. valga* in North Carolina.

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NICHOLAS A. KORMILEV: A LIST OF HIS ENTOMOLOGICAL PUBLICATIONS AND PROPOSED TAXA

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Abstract.—A list of the 231 entomological publication titles and the taxonomic names proposed, alone or in coauthorship, by Nicholas A. Kormilev from 1936 to 1992 is given. Names proposed in two orders of insects—for Heteroptera: 1 family; 2 subfamilies; 6 tribes; 105 genera and subgenera; and 1182 species and subspecies; for Neuroptera: 1 generic name; 1 subspecies name.

Key Words: Kormilev, lists, publications, taxa, Heteroptera, Neuroptera

Nicholas Alexander Kormilev, born January 29, 1901, in Yalta in the Crimea, published the first of his 231 entomological articles in 1936. Nearly all of these 231 entomological articles were on members of the insect group the Hemiptera-Heteroptera, including proposals of one family, two subfamilies, six tribes, 105 genera and subgenera, and 1182 species and subspecies. In the insect order Neuroptera he proposed one new genus and one new subspecies.

His early life was made difficult by the Balkan Wars, the Russo-Japanese War, ethnic battles, revolutions, frequent family moves because of his father's changes of military assignments, World War I, military service, and World War II; but his perseverance, his expanding knowledge, and his familiarity with several languages enabled him to obtain employment in a variety of jobs—academic and otherwise.

In 1926 he graduated from the School of Agriculture at the University of Zagreb, in Yugoslavia. Then came employment with the Ministry of Education and the Ministry of Agriculture. While working at Skoplje he frequently visited the Natural History Museum, and at the urging of its director he

published his first paper in 1936. In 1947 he emigrated to Argentina where he became an entomologist with the Museo Argentino de Ciencias Naturales "Bernardino Rivadavia," Buenos Aires. He was also employed at the Institute de Investigacion Museum, Anex de Colegio Maximo de San Jose, en San Miguel. In 1957 he came to the United States and in New York worked at an electric corporation in quality control and production of silver-zinc batteries. In New York he began studies in the collections at the American Museum of Natural History. After retirement in 1968 he concentrated his research on two families of Heteroptera, the flat bugs (Aradidae) and the ambush bugs (Phymatidae). Then, with help from Dr. J. L. Gressitt, he went to Hawaii and there wrote his large monograph of the flat bug subfamily Mezirinae of the Oriental Region and the South Pacific (Kormilev 1971a). In 1970 he spent some time in Australia before returning to the United States.

His early, European collection was deposited in the Serbian Museum. His later Heteroptera collection and a sizable tiger beetle (Cicindelidae) collection were deposited in the Smithsonian Institution's Na-



Nicholas Kormilev, 1984.

LIST OF PUBLICATIONS

tional Museum of Natural History in Washington, D.C.

Nicholas, or "Nick" as he is affectionately called by entomological colleagues, has always been an avid scholar who willingly served his science by identifying large numbers of Heteroptera for others as well as through his numerous publications. But his interests are broader than that, and he often made special efforts to see collections of art and historically important landmarks.

Now, because "Nick," who will be 94 in 1995, told me he has published his last paper, it seems appropriate to furnish the scientific community with a complete listing of his many entomological publications and proposed names.

This paper is arranged in two parts: The first contains a chronological list of Kormilev's publications, with coauthors listed in parentheses at the end of each title. The abbreviated journal titles are given in full at the end of the literature section. The second list contains all taxa he proposed, arranged by family-group, genus-group, and species-group, followed by a date-page reference to the above-mentioned list of publications.

- 1936a I. Beitrag zur Kenntnis der Verbreitung jugoslavischer Hemiptera-Heteroptera (Serbien und Südserbien). *Bull. Soc. Sci. Skoplje* 17(5): 29-54, 5 figs.
- 1938a II. Beitrag zur Kenntnis der Verbreitung jugoslavischer Hemiptera-Heteroptera (Serbien und Südserbien). *Bull. Soc. Sci. Skoplje* 18(6): 167-172, 1 fig.
- 1939a III. Beitrag zur Kenntnis der Verbreitung jugoslavischer Hemiptera-Heteroptera (Serbien und Südserbien). *Ann. Mus. Serbiae Merid., Skoplje* 1(2): 21-29, 2 figs.
- 1939b IV. Beitrag zur Kenntnis der Verbreitung jugoslavischer Hemiptera-Heteroptera. *Bull. Soc. Sci. Skoplje* 20(7): 193-199, 6 figs.
- 1943a V. Beitrag zur Kenntnis der Verbreitung balkanischer Hemiptera-Heteroptera (Serbien und Mazedonien). *Roy. Serbien Acad. Sci. Separate issue* 136, *Natur. Sci. and Math., 35, Ohridski Sbornik*, 6: 123-132, 1 map.
- 1948a Una especie nueva de la familia Elasmodeimidae L. & S. de la Republica Argentina. *Rev. Soc. Ent. Argent.* 14: 141-147, 2 figs.
- 1949a Notas sobre los Colobathristidae de Bolivia. *Notas Mus. La Plata*, 14, *Zool.* 124: 167-176, 3 figs.
- 1949b A new species of the genus *Macrocephalus* Swederus from Brasil (Hemiptera-Phymatidae). *Rev. Ent. Rio de Jan.* 20 (1-3): 583-588, 1 fig.
- 1949c Una especie nueva del genero *Placocoris* Mayr en la Argentina (Hemiptera-Pentatomidae). *Com. Inst. Nac. Inv. Cien. Nat. Bs. As., Zool.* 1(9): 3-12, 3 figs.
- 1949d *Riggiella vianai* n. g., n. sp. de la Argentina (Hemiptera-Lygaeidae). *Com. Inst. Nac. Inv. Cien. Nat. Bs. As., Zool.* 1(11): 3-13, 4 figs.
- 1949e La familia Colobathristidae Stal en la Argentina, con la descripcion de tres especies nuevas neotropicales (Hemiptera). *Acta Zool. Lilloana* 7: 359-383, 6 figs., 1 map.
- 1949f Dos especies nuevas del genero *Adoxoplatus* Breddin, 1903, de Bolivia (Hemiptera-Pentatomidae). *Notas Mus. La Plata* 14, *Zool.*, 128: 313-324, 2 figs.
- 1950a La subfamilia Oxycareninae Stal en la Argentina, con la descripción de una especie nueva (Hemiptera-Lygaeidae). *An. Soc. Cien. Argent.* 149: 22-32, 7 figs.
- 1950b Notes on Neotropical Pentatomidae, with description of one new genus and two new species (Hemiptera). *Rev. Brasil. Biol.* 10: 339-346, 5 figs.
- 1950c Notes on Neotropical Phymatidae; diagnosis of new species (Hemiptera). *Rev. Ent. Rio de Jan.* 21(3): 581-591.
- 1950d Notas Hemipterologicas. *Acta Zool. Lilloana* 9: 495-503, 4 figs., 1 pl.
- 1951a Notas sobre Colobathristidae Neotropicales

- (Hemiptera), con la descripción de tres géneros y siete especies nuevos. *Rev. Brasil. Biol.* 11(1): 63–84, 17 figs. 1 map.
- 1951b Notas sobre Phymatidae Neotropicales III, con la descripción de dos especies nuevas (Hemiptera). *Mis. Est. Patol. Reg. Argent.* 22(79): 53–58, 4 figs.
- 1951c Sobre los géneros *Vulsirea* Spinola (1837), *Ramosiana* Kormilev (1950) y *Adoxoplatys* Breddin (1903), con la descripción de tres especies nuevas (Hemiptera-Pentatomidae). *Rev. Soc. Ent. Argent.* 15: 83–95, 13 figs.
- 1951d Aradidae Argentinos I. (Hemiptera). *Com. Inst. Nac. Inv. Cien. Nat. Bs. As., Zool.* 2(6): 83–95, 1 map.
- 1951e Notas sobre Phymatidae Neotropicales II, con la descripción de cuatro especies nuevas (Hemiptera). *An. Soc. Cien. Argent.* 152: 167–178, 4 figs.
- 1951f Notas sobre Colobathristidae Neotropicales II, con la descripción de dos especies nuevas (Hemiptera). *Rev. Brasil. Biol.* 11(3): 333–339, 3 figs.
- 1951g Phymatidae Argentinas (Hemiptera), con observaciones sobre Phymatidae en general. *Rev. Inst. Nac. Inv. Cien. Nat. Bs. As., Zool.* 2(2): 45–110, 8 figs., pls. 1–14, 3 maps.
- 1951h Notas sobre Hemipteros Bolivianos, con la descripción de un género y tres especies nuevas. *Publ. Univ. Cochabamba, Bolivia, Folia Univ.* 5: 35–45, 3 figs.
- 1952a Notas Hemipterológicas II. *Dusenía* 3(1): 51–56, pl. 3.
- 1952b La subfamilia Graphosomatinae Jakovlev en la Argentina (Hemiptera-Pentatomidae), con la descripción de un género y una especie nuevos. *An. Soc. Cien. Argent.* 153: 212–218, 3 figs. (senior author with A. A. Piran).
- 1952c Notes on Neotropical Aradidae, with description of one new species. *Pan-Pac. Ent.* 23(2): 119–122, 2 figs.
- 1952d Notas sobre Coreidae Neotropicales con la descripción de dos especies nuevas (Hemiptera). *EOS* 28(1): 91–99, 7 figs.
- 1952e Notas sobre Phymatidae Neotropicales IV (Hemiptera-Reduvidae). *Mis. Est. Patol. Reg. Argent.* 23(81–82): 123–130, 4 figs.
- 1952f Los Insectos de las Islas Juan Fernandez, I. Lygaeidae (Hemiptera). *Rev. Chilena Ent.* 2: 7–14, 4 figs.
- 1952g Una especie nueva del género *Ochterus* Latreille, 1807, del Paraguay (Hemiptera-Ochteridae). *An. Soc. Cien. Argent.* 154: 155–159 (senior author with J. A. De Carlo).
- 1952h Una especie nueva del género *Glypheapomis* Berg, 1891, de la Argentina (Hemiptera-Pentatomidae). *Rev. Soc. Ent. Argent.* 15: 302–306, 4 figs. (as senior author with A. A. Piran).
- 1953a The first apterous aradid from Argentina (Hemiptera). *Dusenía* 4(2): 125–126, 1 fig.
- 1953b Revisión de Microlytrinae Stal de la Argentina. Con descripción de un género y siete especies nuevos de Argentina, Brasil y Bolivia (Hemiptera, Coriscidae). *Rev. Soc. Ent. Argent.* 16(2): 49–66, 6 figs., 1 map.
- 1953c Notes on Aradidae from the Eastern Hemisphere (Hemiptera). *Verh. Naturf. Ges. Basel* 64(2): 333–346, 8 figs.
- 1953d Notes on Colobathristidae from Borneo and Java in the Collections of the Museum of Natural History in Basle (Hemiptera). *Bull. Soc. Ent. Suisse* 26(4): 287–292.
- 1953e Notes on Neotropical Aradidae III (Hemiptera). On some apterous Mezirinae from Brasil. *Dusenía* 4(4–5): 229–242, pl. 18.
- 1953f Notas sobre Phymatidae Neotropicales V (Hemiptera). *Mis. Est. Pat. Reg. Argent.* 24(83–84): 57–61, 1 fig.
- 1953g Notas sobre Phymatidae Nearcticas I (Hemiptera). *Mis. Est. Patol. Reg. Argent.* 24(83–84): 63–67, 7 figs.
- 1954a Notas sobre Coreidae Neotropicales II (Hemiptera), Merocorinae de la Argentina y países limítrofes. *Rev. Ecuat. Ent. Parasit.* 2(1–2): 153–186, 7 figs.
- 1954b Notas sobre Aradidae del hemisferio Oriental V.—Aradidae de España e Islas Canarias (Hemiptera-Aradidae). *Rev. Ecuat. Ent. Parasit.* 2(1–2): 203–208, 3 figs.
- 1954c Notes on Nearctic Phymatidae II (Hemiptera); a new subspecies of *Macrocephalus prehensilis* (F.) from Florida. *Jour. Kans. Ent. Soc.* 27(4): 158–159.
- 1954d Una familia nueva para la fauna Argentina (Hemiptera-Megaridae). *An. Soc. Cien. Argent.* 157: 47–54, 8 figs., 1 map.
- 1954e Notes on Neotropical Aradidae IV (Hemiptera). On some apterous Mezirinae from Brasil II. *Dusenía* 5(3–4): 125–130, 2 figs.
- 1954f Notes on Aradidae from the Eastern Hemisphere (Hemiptera). II. Aradidae from the Oriental and Australian Regions in the Hungarian National Museum, Budapest, Hungary. *Philipp. Jour. Sci.* 83(2): 123–136, 5 figs.
- 1955a Aradidae (Hemiptera) Argentinae II. *Acta Zool. Lilloana* 13: 207–256, 52 figs., pls. I–III, 2 maps (1953).
- 1955b Notas sobre Tingidae Neotropicales (Hemiptera). *Rev. Brasil. Biol.* 15(1): 63–68, 1 fig.
- 1955c Notes on Aradidae from Eastern Hemisphere III (Hemiptera). On some Aradidae from Japan, Russian Far East and Formosa (Taiwan). *Mushi* 28(4): 31–41, pl. 6.
- 1955d Notes on Aradidae from the Eastern Hemisphere IV (Hemiptera-Heteroptera). Aradidae from the Oriental and Australian Regions.—2. *Ann. Mag. Nat. Hist. ser. 12*, 8: 194–203, 12 figs.
- 1955e Notas sobre Pentatomoidea Neotropicales II

- (Hemiptera). Acta Sci. Inst. Inv. de San Miguel, Prov. de Bs. As. 1: 1-15, 7 figs.
- 1955f Notas sobre Lygaeidae Neotropicales I (Hemiptera); la subfamilia Cyminae (Stål) en la Argentina. Acta Sci. Inst. Inv. San Miguel, Prov. de Bs. As. 2: 1-8, 7 figs.
- 1955g Una curiosa familia de Hemípteros nueva para la fauna Argentina, Thaumastotheiidae (Kirkaldy), 1907. Rev. Soc. Ent. Argent. 18: 5-10, 9 figs.
- 1955h Notes on Aradidae from the Eastern Hemisphere VIII (Hemiptera). Aradidae from the Oriental Region VI. Verh. Naturf. Ges. Basel 66(2): 141-146, 3 figs.
- 1955i La subfamilia Cyrtocorinae Distant en la Argentina (Hemiptera: Pentatomoidea). Rev. Ecuat. Ent. Parasit. 2(3-4): 321-334, 2 pl.
- 1955j A new myrmecophil family of Hemiptera from the delta of Rio Parana, Argentina. Rev. Ecuat. Ent. Parasit. 2(3-4): 465-477, 1 pl.
- 1955k Notes on Aradidae from the Eastern Hemisphere VI (Hemiptera). Aradidae from the Oriental and Australian Regions-IV. Rev. Ecuat. Ent. Parasit. 2(3-4): 485-508, 2 pl.
- 1955l Notes on Aradidae from the Eastern Hemisphere (Hemiptera). VII. Aradidae from Fukien, South China. Quart. Jour. Taiwan Mus. 8(3): 177-191, pls. 1-2.
- 1956a Notas sobre Pentatomoidea Neotropicales IV (Hemiptera). Acta Scient. Inst. Inv. de San Miguel, Prov. Bs. As. 3: 1-12, 12 figs.
- 1956b Notas sobre Pentatomoidea Neotropicales V (Hemiptera). Acta Scient. Inst. Inv. de San Miguel, Prov. Bs. As. 4: 3-7.
- 1956c Notes on Aradidae from the Eastern Hemisphere, IX (Hemiptera). Aradidae from the Ethiopian Region. Ann. Mag. Nat. Hist. ser. 12, 9: 250-256, 5 figs.
- 1956d Notes on Aradidae from the Eastern Hemisphere, X (Hemiptera). On some apterous Mezirinae from India and Indonesia. Philipp. Jour. Sci. 85(2): 283-294, 9 figs.
- 1956e Notes on Aradidae from the Eastern Hemisphere XII (Hemiptera). Mitt. Münchner Ent. Ges. 46: 42-46, 8 figs.
- 1957a Notes on Aradidae from the Eastern Hemisphere, XI (Hemiptera). On some apterous Mezirinae from New Guinea. Philipp. Jour. Sci. 85(3): 389-403, 20 figs. (1956)
- 1957b Notes on American "Phymatidae" (Hemiptera). Rev. Brasil. Biol. 17(1): 123-138, 14 figs.
- 1957c Notas sobre Aradidae Neotropicales VI (Hemiptera). An. Soc. Cien. Argent. 162: 148-159, 1 pl. (1956).
- 1957d Notas sobre Pentatomoidea Neotropicales VI (Hemiptera). An. Soc. Cien. Argent. 163: 47-57, 10 figs.
- 1957e Notes on Aradidae from the Eastern Hemisphere (Hemiptera) XIII. On some Aradidae in the Drake Collection. Quart. Jour. Taiwan Mus. 10(1): 37-46, 1 pl.
- 1957f Notes on Aradidae from the Eastern Hemisphere XIV (Hemiptera). Aradidae from the Oriental and Australian Regions IX. Ann. Mag. Nat. Hist. ser. 12, 10: 265-273, 11 figs.
- 1957g Notes on Neotropical Aradidae (Hemiptera), VII. Two new apterous Aradidae. Amer. Mus. Novit. 1860: 1-7, 4 figs.
- 1957h Los Insectos de las Islas Juan Fernandez. 30. Lygaeidae (Suplemento) (Hemiptera). Rev. Chilena Ent., 5: 385-389, 4 figs.
- 1957i On some Phymatidae in the American Museum of Natural History (Hemiptera-Heteroptera). Jour. N. Y. Ent. Soc. 65: 33-40, 2 figs.
- 1957j Notes on oriental Phymatidae (Hemiptera). The oriental Phymatidae in the Drake Collection. Quart. Jour. Taiwan Mus. 10: 63-69, 2 figs.
- 1958a Concerning the apterous Aradidae of the Americas (Hemiptera). Ann. Ent. Soc. Amer. 51(3): 241-247, 2 figs. [junior author with C. J. Drake].
- 1958b Notes on Aradidae from the Eastern Hemisphere XV (Hemiptera). Jour. N. Y. Ent. Soc. 66: 87-97, pl. 5.
- 1958c Notas Hemipterologicas III. Acta Zool. Lilloana 16: 55-59.
- 1959a Notes on Aradidae in the U.S. National Museum (Hemiptera). I. Subfamily Calisiinae. Proc. U.S. Nat. Mus. 109(3413): 209-222, 18 figs. (1958).
- 1959b Notes on Neotropical Aradidae II (Hemiptera). Proc. Ent. Soc. Wash. 61(2): 61-71, 6 figs.
- 1959c Notas sobre Aradidae Neotropicales V (Hemiptera). Sobre el género *Pictinus* Stål, 1873. Rev. Soc. Uruguay Ent. 3: 21-33, pl. 1.
- 1959d Notas sobre Mantispidae neotropicales I (Neuroptera). Rev. Soc. Ent. Argent. 21: 1-18, 24 figs. [junior author with G. W. Williner].
- 1959e Notes on Neotropical Aradidae. IX (Hemiptera). Studia Ent. 2(1-4): 309-320, 6 figs.
- 1960a Notes on Aradidae in the U.S. National Museum (Hemiptera) II. Jour. N. Y. Ent. Soc. 68: 36-47, 1 pl.
- 1960b Notes on Aradidae from the Eastern Hemisphere XVI (Hemiptera). Proc. Ent. Soc. Wash. 62(2): 106-107.
- 1960c Notas sobre Aradidae Neotropicales VIII (Hemiptera). An. Soc. Cient. Argent. 169(5-6): 83-94, 5 figs.
- 1960d Notas sobre Aradidae Neotropicales X (Hemiptera). Rev. Soc. Uruguay Ent. 4: 3-17, pl. I.
- 1960e Notes on Neotropical Aradidae XI (Hemiptera). Jour. N. Y. Ent. Soc. 68: 208-220, 9 figs.
- 1960f Notes on Aradidae from the Eastern Hemisphere XVII (Hemiptera). Quart. Jour. Taiwan Mus. 13(3-4): 163-174, 2 figs.
- 1961a Notes on Aradidae from the Eastern Hemisphere XVIII (Hemiptera). Jour. Ent. Soc. S. Africa 24: 248-252, 2 figs.

- 1961b Concerning *Phylus breviceps* Reuter, 1900, and *P. balcanicus* Kormilev, 1939 (Hemiptera: Miridae). Ent. Month. Mag. ser. 4, 256: 77-78, 3 figs.
- 1962a Notes on American Phymatidae II (Hemiptera, Reduvoidea). Jour. N. Y. Ent. Soc. 70: 47-58, 15 figs.
- 1962b Notes on Aradidae in the Naturhistoriska Riksmuseum, Stockholm (Hemiptera-Heteroptera). Arkiv för Zool., Ser. 2, 15(14): 255-273, 15 figs.
- 1962c Notes on African and Asiatic Macrocephalinae (Hemiptera: Phymatidae). Amer. Mus. Novit. 2107: 1-15, 20 figs.
- 1962d Revision of Phymatinae (Hemiptera: Phymatidae). Philipp. Jour. Sci. 89(3-4): 287-486, pls. 1-19 (1960).
- 1962e Notes on Phymatidae in the British Museum (Nat. Hist.) (Hemiptera-Heteroptera). Ann. Mag. Nat. Hist., ser. 13, 5: 349-367, 20 figs.
- 1963a Notes on Aradidae in the Naturhistoriska Riksmuseum, Stockholm, Hemiptera-Heteroptera. Arkiv för Zool. Ser. 2, 15(31): 443-455, 4 figs.
- 1963b On some Calisiinae in the British Museum (Nat. Hist.) (Hemiptera-Heteroptera, Aradidae). Ann. Mag. Nat. Hist. ser. 13, 5: 601-607, 9 figs.
- 1963c Notes on American Phymatidae III (Hemiptera-Heteroptera). Proc. Ent. Soc. Wash. 65(3): 215-226, 21 figs.
- 1964a Notes on Aradidae in the U.S. National Museum III. Subfamily Mezirinae (Hemiptera). Proc. U.S. Nat. Mus. 115(3483): 245-258, 7 figs.
- 1964b Neotropical Aradidae XII (Heteroptera: Aradidae). Jour. N. Y. Ent. Soc. 72: 34-39, 6 figs.
- 1964c New Genera and Species of Queensland Aradidae (Hemiptera: Heteroptera). Jour. Ent. Soc. Queensland 3: 42-47, 7 figs.
- 1964d Neotropical Aradidae XIII (Hemiptera: Aradidae). Jour. N. Y. Ent. Soc. 72: 112-119, 17 figs.
- 1964e The Third Species of *Neoanthylla* Kormilev, 1951, from Peru (Hemiptera: Phymatidae). Proc. Ent. Soc. Wash. 66(3): 137-140, 4 figs.
- 1964f Notes on Aradidae in the Naturhistoriska Riksmuseum, Stockholm (Hemiptera-Heteroptera). Arkiv för Zool. Ser. 2, 16(23): 463-479, 21 figs.
- 1964g Notes on Neotropical Aradidae XIV (Hemiptera: Heteroptera). Studia Ent. 7(1-4): 153-160, 8 figs.
- 1964h Concerning [!] the genera *Reeceicus* Drake and *Signocoris* Hoberlandt, Hemiptera-Heteroptera, Aradidae. Quart. Jour. Taiwan Mus. 17(3-4): 187-191, 2 figs.
- 1965a Notes on Aradidae in the Naturhistoriska Riksmuseum, Stockholm (Hemiptera Heteroptera). Arkiv för Zool. Ser. 2, 18(1): 1-8, 5 figs.
- 1965b Notes on Australian Aradidae (Hemiptera: Heteroptera), with descriptions of new genera and species. Proc. R. Soc. Queensland 77(3): 11-35, 11 figs.
- 1965c Two new species of the genus *Phymata* Latreille from Brasil (Hemiptera-Heteroptera, Phymatidae). Studia Ent. 8(1-4): 205-208, 4 figs.
- 1965d Notes on Neotropical Aradidae XV (Hemiptera-Heteroptera). Opusc. Zool. 84: 1-7, 10 figs.
- 1966a On some Aradidae from Africa and Polynesia (Hem.-Heteroptera). EOS 41(2-3): 387-394, 6 figs.
- 1966b Two new American Aradidae (Hemiptera-Heteroptera). Psyche 73(1): 26-29, 8 figs.
- 1966c A new species of the genus *Pictinellus* Usinger & Matsuda, 1959 (Hemiptera: Aradidae). Proc. Ent. Soc. Wash. 68(4): 306-308, 1 fig.
- 1966d Notes on Aradidae in the U.S. National Museum, IV (Hemiptera: Heteroptera). Proc. U.S. Nat. Mus. 119(3548): 1-25, 23 figs.
- 1966e Aradidae in the South Australian Museum, Adelaide (Hemiptera-Heteroptera). Rec. S. Austral. Mus. 15(2): 275-307, 31 figs.
- 1966f Notes on Neotropical Aradidae XVI (Hemiptera-Heteroptera). Studia Ent. 9(1-4): 515-521, 1 fig.
- 1966g On some Phymatidae from the Old and New Worlds (Hem. Heteroptera). EOS 42(1-2): 275-286, 2 figs.
- 1967a A new apterous genus and species of Aradinae from Mexico (Hemiptera-Heteroptera, Aradidae). L. A. Co. Mus. Contr. Sci. 122: 2-4, 3 figs.
- 1967b Notes on Australian Aradidae (Hemiptera-Heteroptera) with descriptions of new species of *Calisius* Stål and *Glochocoris* Usinger & Matsuda. Proc. R. Soc. Queensland 79(6): 71-78, 6 figs.
- 1967c Notes on Aradidae from the Eastern Hemisphere XX (Hem.-Heteroptera). EOS 42(1-4): 467-491, 20 figs.
- 1967d A new species of *Neuroctenus* Fieber from Tanganyika (Hemiptera, Aradidae). Opusc. Zool. 92: 1-3, 3 figs.
- 1967e Aradidae in the Bishop Museum, Honolulu (Hemiptera-Heteroptera). Pac. Ins. 9(3): 447-479, 25 figs.
- 1967f Some Aradidae (Hemiptera-Heteroptera) from the Philippine, Bismarck and Solomon Islands. Ent. Medd. 35: 291-300, 8 figs.
- 1967g Aradidae in the South Australian Museum, Adelaide II (Hemiptera-Heteroptera). Rec. S. Austral. Mus. 15(3): 513-550, 27 figs.
- 1967h On some Aradidae from Brasil, Argentina and Laos (Hemiptera, Heteroptera). Opusc. Zool. 100: 1-10, 13 figs.
- 1968a Notes on Aradidae in the U.S. National Museum V, (Hemiptera: Heteroptera). Proc. U.S. Nat. Mus. 125(3651): 1-16, 8 figs.
- 1968b North and Central American species of *Aneuris* Curtis (Hemiptera: Aradidae). Proc. U.S. Nat. Mus. 125(3657): 1-12, 19 figs.
- 1968c Notes on Neotropical Aradidae XVII. Aradidae in the Field Museum of Natural History, Chicago, Illinois (Hem.-Heteroptera). Ann. Soc. Ent. France, n. s. 4(2): 279-289, 12 figs.

- 1968d Aradidae in the Bishop Museum, Honolulu, II (Hemiptera-Heteroptera). Pac. Ins. 10(2): 249-260, 19 figs.
- 1968e Notes on Neotropical Aradidae XVIII (Hemiptera-Heteroptera). Papéis Avul. Zool., Sao Paulo 22(6): 47-56, 7 figs.
- 1968f A new species of the genus *Macrocephalus* Swederus from Mexico (Hemiptera: Phymatidae). Proc. Ent. Soc. Wash. 70(3): 242-245, 1 fig.
- 1968g Aradidae in the Bishop Museum, Honolulu III (Hemiptera: Heteroptera). Pac. Ins. 10(3-4): 575-597, 31 figs. 1 map.
- 1968h Notes on Aradidae from the Eastern Hemisphere XIX (Hemiptera). Khumbu Himal 3(1): 27-28.
- 1968i 51. Two new species of Aradidae (Hemiptera-Heteroptera) from Rennell Island. Nat. Hist. Rennell Isl. 5: 99-102, pl. 2.
- 1968j Notes on Aradidae from the Eastern Hemisphere XXI. Aradidae in the Field Museum of Natural History, Chicago, Illinois (Hemiptera: Heteroptera). Quart. Jour. Taiwan Mus. 21(3-4): 225-233, 7 figs.
- 1968k Notes on Neotropical Aradidae XIX (Hemiptera-Heteroptera). Rev. Facultad Agron. Univ. Centr. Venezuela 1: 43-56, 8 figs.
- 1969a Aradidae in the Bishop Museum, Honolulu IV, (Hemiptera-Heteroptera). Pac. Ins. 11(1): 49-70, 35 figs., 1 map.
- 1969b Thaicorinae, n. subf. from Thailand (Hemiptera: Heteroptera: Piesmatidae), Pac. Ins. 11(3-4): 645-648, 4 figs.
- 1970a Two new species of the genus *Aradus* F., 1803, from Palaearctic Region (Hemiptera: Aradidae). Ann. Naturh. Mus. Wien 74: 201-204, 4 figs.
- 1971a Mezirinae of the Oriental Region and South Pacific (Hemiptera-Heteroptera: Aradidae). Pac. Ins. Monogr. 26: 1-165, 233 figs., 3 maps.
- 1971b Aradidae in the Bishop Museum, Honolulu V. (Supplement) (Hemiptera-Heteroptera). Pac. Ins. 12(4): 701-722, 15 figs. (1970). [issue number 4 was marked "25 December 1970." but the table of "Contents of Volume 12" gives the date of issue as "30 January 1971"].
- 1971c New Records of some Oriental Phymatidae, with a new species of *Chelocoris* Bianchi (Hemiptera: Heteroptera). Pac. Ins. 12(4): 883-886, 1 fig. (1970). [see note under 1971b].
- 1971d Ochteridae from the Oriental and Australian Regions (Hemiptera-Heteroptera). Pac. Ins. 13(3-4): 429-444, 23 figs., 2 maps.
- 1971e Aradidae de la Hacienda El Limon, D. F. (Hemiptera-Heteroptera). Mem. Soc. Cient. Nat. La Salle 31(89): 165-174, 3 figs.
- 1971f Key to American species of the genus *Mezira* (Hemiptera: Aradidae). Proc. Ent. Soc. Wash. 73(3): 282-292.
- 1972a Two new species of North American Flat Bugs (Hemiptera: Aradidae). Bull. S. Calif. Acad. Sci. 71(2): 91-93, 5 figs.
- 1972b A new species of ambush bugs from Arizona (Hemiptera: Phymatidae). Bull. S. Calif. Acad. Sci. 71(2): 93-95, 1 fig.
- 1972c Aradidae in the Bishop Museum, Honolulu, VI (Hemiptera: Heteroptera). Pac. Ins. 14(3): 553-570, 9 figs.
- 1972d Mezirinae of the Oriental Region and South Pacific, Supplement (Hemiptera-Heteroptera: Aradidae). Pac. Ins. 14(3): 571-583, 17 figs.
- 1972e A new species of the genus *Ochterus* Latreille, 1807, from New Guinea (Hem.-Het.: Ochteridae). Pac. Ins. 14: 585-587, 3 figs.
- 1973a Ochteridae from western and southern Africa (Hemiptera: Heteroptera). Occ. Pap. Calif. Acad. Sci. 106: 1-9, 11 figs., 1 map.
- 1973b Aradidae from the Oriental Region and South Pacific (Hemiptera-Heteroptera). Pac. Ins. 15(1): 67-83, 19 figs.
- 1973c Aradidae from the Oriental and Australian Regions in the Museum National d'Histoire Naturelle, Paris (Hem.-Heteroptera.). Ann. Soc. Ent. France, n. s. 9(1): 193-209, 15 figs.
- 1973d Notes on Neotropical Aradidae XXI (Hem. Heteroptera). Ann. Soc. Ent. France, n. s. 9(2): 433-439, 5 figs., pl. 10.
- 1973e A new species of the genus *Aneuris* Curtis, 1825, from Nepal (Hemiptera: Aradidae). Ent. Rec. 85: 141-146, pl. 10. [senior author with E. Heiss].
- 1973f Neotropical Aradidae in the Museum National d'Histoire Naturelle, Paris. Ann. Soc. Ent. France, n. s. 9(3): 735-746, 7 figs.
- 1973g On some Aradidae (Hemiptera: Heteroptera) from Nepal and Thailand. Ber. nat.-med. Ver. Innsbruck 60: 61-77, 25 figs, 6 photos. [senior author with E. Heiss].
- 1974a Aradidae from the tropical Africa and Madagascar in the Museum National d'Histoire Naturelle, Paris. (Hem. Heteroptera). Ann. Soc. Ent. France, n. s. 10(1): 59-77, 5 figs.
- 1974b A new genus of Calisiinae from Kameroun (Hem., Aradidae). EOS 48: 295-299, 2 figs.
- 1974c Aradidae in the Rijksmuseum van Natuurlijke Historie, Leiden (Hemiptera-Heteroptera). Zool. Meded. 48(21): 233-247, 11 figs.
- 1975a Neotropical Aradidae in the collections of the California Academy of Sciences, San Francisco (Hemiptera-Heteroptera). Occ. Papers Cal. Acad. Sci. 122: 1-28, 14 figs.
- 1975b Notes on the Neotropical Aradidae, XX (Hem. Heteroptera). EOS 49: 219-224, 5 figs. (1973).
- 1975c Ergebnisse der Bhutan-Expedition 1972 des Naturhistorischen Museums in Basil. Hemiptera: Fam. Aradidae. Ent. Basil. 1: 93-112, 25 figs., 8 photos. [senior author with E. Heiss].
- 1976a On some Aradidae from the Old and New World

- (Hemiptera-Heteroptera). Zool. Scripta 5: 67–78, 23 figs.
- 1976b Three new species of Aradidae from Japan and Taiwan (Hemiptera-Heteroptera). Dtsch. Ent. Zeitschr. n. f., 23 (1–3): 221–228, 16 figs. [senior author with E. Heiss].
- 1976c On new and little known species of Aradidae, I (Hemiptera, Heteroptera). Zeitschr. Arbgem. Österr. Ent. 28(1–3): 39–44, 10 figs., 3 photos. [senior author with E. Heiss].
- 1976d Notes on Aradidae from China and India (Hemiptera-Heteroptera). Pac. Ins. 17(1): 87–90, 4 figs.
- 1976e A new genus and seven new species of Neotropical Aradidae (Hemiptera-Heteroptera). Rev. Brasil. Biol. 36: 735–743, 12 figs.
- 1977a A new species of the genus *Overlaetiella* Schouteden from Sumatra (Hemiptera: Aradidae). Proc. Ent. Soc. Wash. 79(3): 354–357, 3 figs.
- 1977b A new genus and a new species of the Carventinae from Surinam (Hemiptera, Aradidae). Zool. Meded. 52(1): 1–6, 4 figs., 1 pl. [senior author with P. H. van Doesburg].
- 1977c New species of Aradidae from the Philippines and Borneo (Hemiptera: Heteroptera). Pac. Ins. 17(2–3): 261–163, 5 figs.
- 1977d Aradidae from the Oriental and Australian Regions in the collections of the California Academy of Sciences, San Francisco (Hemiptera: Heteroptera). Trans. Amer. Ent. Soc. 103: 603–622, 33 figs.
- 1977e Five new Aradidae from the Oriental Region (Insecta: Heteroptera). Ber. nat.-med. Ver. Innsbruck 64: 97–106, 13 figs. [senior author with E. Heiss].
- 1978a Two new species of American Aradidae (Hemiptera). Proc. Ent. Soc. Wash. 80(2): 228–233, 7 figs.
- 1978b *Aradus frigidus* Kiritshenko, 1913, and *Aradus italicus* Kormilev, 1970 (Hemiptera: Aradidae). Ann. Naturh. Mus. Wien 81: 505–506, 6 figs.
- 1978c Aradidae in the Bishop Museum, Honolulu VII (Hemiptera: Heteroptera). Pac. Ins. 18(1–2): 53–60, 13 figs.
- 1978d Two new species of Aradidae from Brasil (Hemiptera, Heteroptera). Zeitschr. Arbgem. Österr. Ent. 30(1–2): 29–32, 4 figs. [senior author with E. Heiss].
- 1978e On some Aradidae from the Oriental and Australian Regions (Hemiptera). Philipp. Jour. Sci. 105(4): 235–254, 12 figs. (1976).
- 1978f A new species of the genus *Neasterocoris* Usinger and Matsuda from Ecuador (Hemiptera: Aradidae). Rev. Brasil. Ent. 22(3–4): 199–201, 2 figs.
- 1979a A new apterous species of Aradidae from Kenya (Hemiptera). Pan-Pac. Ent. 55(1): 57–60, 2 figs.
- 1979b A new species of the genus *Aradus* F., 1803, from Alaska (Insecta: Heteroptera). Ber. nat.-med. Ver. Innsbruck 66: 47–52, 4 figs., 8 photos. [senior author with E. Heiss].
- 1979c New Aradidae from Ceylon and Malaya in the British Museum (N.H.) (Heteroptera). Orient. Ins. 13(1–2): 155–162, 20 figs. [senior author with E. Heiss].
- 1979d Four new species and lectotype designation of some neotropical Aradidae (Insecta, Heteroptera). Ent. Arb. Mus. Frey 28: 93–118, 35 figs. [senior author with E. Heiss].
- 1979e Dos nuevas especies y algunas especies poco conocidas de Aradidae de Brasil (Hemiptera). An. Inst. Biol. Univ. Nac. Autón Mexico, 50, Ser. Zool. (1): 341–345, 8 figs.
- 1980a Homonymy in the Aradidae (Hemiptera). Pac. Ins. 22(3–4): 328.
- 1980b Notes on American Aradinae (Hemiptera: Aradidae). Proc. Ent. Soc. Wash. 82(1): 99–107, 9 figs.
- 1980c Sobre especies Argentinas del genero *Aneurus* Curtis, 1825 (Hemiptera: Aradidae). Acta Zool. Lilloana 36(1): 53–56, 10 figs.
- 1980d Three new species of Aradidae from Mexico (Hemiptera). Proc. Ent. Soc. Wash. 82(4): 695–699, 7 figs.
- 1980e A new species of the genus *Daulocoris* Usinger and Matsuda, 1959, from Sumatra (Hemiptera: Aradidae). Sociobiology 5(1): 21–24, 3 figs.
- 1981a Aradidae (Hemiptera) from Ceylon. Ceylon Jour. Sci. (Biol. Sci.) 14(1–2): 122–131, 9 figs.
- 1981b A new micropterous species of *Carventus* Stål from Chile (Hemiptera: Aradidae). Proc. Ent. Soc. Wash. 83(2): 296–299, 3 figs.
- 1981c On some Neotropical species of the genus *Macrocephalus* (Hemiptera: Phymatidae). Sociobiology 6(2): 214–220, 2 figs.
- 1982a Six new species of Neotropical Aradidae (Hemiptera). Proc. Ent. Soc. Wash., 84(3): 480–488, 14 figs.
- 1982b Records and Descriptions of North American and Oriental Aradidae (Hemiptera). Wasmann Jour. Biol. 40(1–2): 1–17, 24 figs.
- 1982c On *Mezira granulata* (Say) group (Hemiptera: Aradidae). Jour. Nat. Hist. 16: 775–779, 6 figs.
- 1982d Five new species of the Neotropical Aradidae (Hemiptera). Rev. Brasil. Ent. 26(3–4): 269–275, 9 figs.
- 1982e On some Aradidae in the collections of the University of Georgia, Athens, Georgia, U.S.A. (Hemiptera). Jour. Ga. Ent. Soc. 17(3): 333–337, 5 figs.
- 1982f Records and descriptions of Central American Aradidae (Hemiptera). Wasmann Jour. Biol. 40(1–2): 26–44, 21 figs.
- 1982g A new species of *Neuroctenus* from nests of termites (Hemiptera: Aradidae). Sociobiology 7: 25–28, 4 figs.
- 1983a New oriental aradid bugs in the collection of the British Museum (Natural History) (Insecta: Hemiptera). Jour. Nat. Hist. 17: 437–469, 34 figs.
- 1983b A new species of the genus *Phymata* Latreille from Mexico. Jour. Ga. Ent. Soc. 18(1): 138–141, 5 figs.

- 1983c On the homonymy of *Hybocoris* Kormilev, 1982 (Hemiptera: Aradidae). Proc. Ent. Soc. Wash. 85(4): 690.
- 1983d Two new species of Neotropical Aradidae and notes on the genus *Glyptocoris* Harris and Drake (Hemiptera). Proc. Ent. Soc. Wash. 85(4): 818–821, 5 figs.
- 1984a A new species of the genus *Chinessa* Usinger and Matsuda, 1959, from Papua New Guinea (Hemiptera: Aradidae), Pan-Pac. Ent. 60(2): 76–78, 2 figs.
- 1984b Keys to the genera and descriptions of new taxa of macrocephaline ambush bugs (Heteroptera: Phymatidae). Jour. Nat. Hist. 18: 623–637, 11 figs.
- 1985a On some aradid bugs described by Francis Walker (Insecta: Hemiptera). Jour. Nat. Hist. 19: 1045–1047, 2 figs.
- 1985b Replacement name for *Carventus parvus* Kormilev (Hem. Aradidae). Ent. Month. Mag. 121: 98.
- 1985c A new species of the genus *Notapictinus* Usinger and Matsuda from Venezuela (Hemiptera: Aradidae). Rev. Brasil. Ent. 29(1): 153–154, 2 figs.
- 1986a The first find of a Mesozoic aradid bug fossil in Northeast Siberia (Hemiptera: Aradidae). Jour. Nat. Hist. 20: 279–282, 3 figs., 1 table. [senior author with Y. A. Popov].
- 1986b Notes on Phymatidae (Heteroptera). Zool. Meded. 60(2): 113–127, 11 figs. [senior author with P. H. van Doesburg].
- 1986c Notes on Asiatic and African Macrocephalinae (Heteroptera: Phymatidae) with description of a new genus. Zool. Meded. 60(18): 273–276, 3 figs. [senior author with P. H. van Doesburg].
- 1986d Notes on American Macrocephalinae with descriptions of two new species (Hemiptera: Phymatidae). Pan-Pac. Ent. 62(4): 303–310, 4 figs.
- 1986e Two new genera and seven new species of Aradidae (Heteroptera). Jour. N. Y. Ent. Soc. 94(2): 249–261, 10 figs.
- 1986f Two new species of Macrocephalinae from Mexico (Hemiptera, Phymatidae). Rev. Brasil. Ent. 30(2): 299–302, 6 figs.
- 1987a Notes on North and Central American *Lophoscutus* spp. (Hemiptera: Phymatidae, Macrocephalinae). Proc. Ent. Soc. Wash. 89(4): 701–705, 2 figs.
- 1987b On African Macrocephalinae (Hemiptera, Phymatidae). Rev. France Ent. n. s. 9(4): 159–161, 1 fig.
- 1987c Flat bugs of the world: A synonymic list (Heteroptera: Aradidae). Entomography 5: 1–246, 3 figs. [senior author with R. C. Froeschner].
- 1988a Notes on *Agreuocoris* Handlirsch (Hemiptera: Phymatidae) Ann. Soc. Ent. France, n. s. 24(4): 115–116.
- 1988b On some Phymatidae of the Natural History Museum Basel (Hemiptera). Ent. Basil. 12: 63–76, 8 figs.
- 1988c Four new species of the genus *Lophoscutus* Kormilev, 1951, from Latin America (Hemiptera: Phymatidae, Macrocephalinae). EOS 64: 141–146, 5 figs.
- 1989a A new species of the genus *Lophoscutus* Kormilev from Mexico (Hemiptera: Phymatidae: Macrocephalinae). Pan-Pac. Ent. 65(4): 451–453, 1 fig.
- 1989b Corrections for two ambush bugs described from Pakistan (Hemiptera: Phymatidae). Bishop Mus. Occ. Papers 29: 149–150.
- 1989c The preliminary study of the Phymatidae in Inner Mongolia, China (Hemiptera: Phymatidae). Zool. Res. 10(4): 341–347, 15 figs. [second author with Nonnaizab and B. Qi].
- 1989d A new species of the genus *Lophoscutus* Kormilev from the Dominican Republic (Hemiptera, Phymatidae). Mitt. Münch. Ent. Ges. 79(4): 61–63, 4 figs.
- 1990a Phymatidae or ambush bugs of the world: A synonymic list with keys to species, except *Lophoscutus* and *Phymata* (Hemiptera). Entomography. 6: 1–75, 8 figs. [junior author with R. C. Froeschner].
- 1990b Case 2700. *Carchochelis* Fieber, 1861 (Insecta, Heteroptera): proposed designation of *Carchochelis alutaceus* Handlirsch, 1897, as the type species. Bull. Zool. Nomencl. 47(1) March 1990: 30–31. [second author with Richard C. Froeschner].
- 1990c A new species of the genus *Chelocoris* from Vietnam (Hemiptera: Phymatidae: Carcinocorinae). Bishop Mus. Occas. Papers 30: 298–300.
- 1990d Two new species of the genus *Lophoscutus* Kormilev, 1951 (Hemiptera, Phymatidae). Rev. Brasil. Ent. 34: 221–225.
- 1990e A new homonym in the Carventinae (Hemiptera: Aradidae). Pan-Pac. Ent. 66: 325.
- 1990f Notes on American Phymatidae, with description of a new species of *Phymata* Latreille. Anales Inst. Biol. Univ. Nac. Auton. Mexico, Ser. Zool. 61: 99–106.
- 1991a Notes on Caribbean Phymatidae (Hemiptera: Heteroptera). Zool. Meded. 65: 277–285. [senior author with P. H. van Doesburg].
- 1992a A New Homonym in the Mezirinae (Hemiptera: Aradidae). Jour. N. Y. Ent. Soc. 100(1): 184.
- 1992b Notes on Macrocephalinae (Heteroptera: Phymatidae). Zool. Meded. 66: 417–421. [senior author with P. H. van Doesburg].

LIST OF JOURNALS CITED BY ABBREVIATIONS

- Acta Sci. Inst. Inv. San Miguel.—Acta Scientifica de los Institutos de Investigacion de San Miguel, Province de Buenos Aires.
- Acta Zool. Lilloana.—Acta Zoologica Lilloana.

- Amer. Mus. Nov.—American Museum Novitates.
- An. Inst. Biol.—Anales Instituto del Biología, Universidad Nacional Autónoma de México, serie Zoológica.
- An. Soc. Cien. Argent.—Anales de la Sociedad Científica Argentina.
- Ann. Ent. Soc. Amer.—Annals of the Entomological Society of America.
- Ann. Mag. Nat. Hist.—Annals and Magazine of Natural History.
- Ann. Naturh. Hofsmus. Wien.—Annalen des Naturhistorischen Museums in Wien.
- Ann. Soc. Ent. France.—Annales de la Société entomologique de France, Nouvelle série.
- Ann. Mus. Serbiae Merid., Skoplje.—Annales Musei Serbiae Meridionalis, Skoplje (Yugoslavia).
- Ark Zool.—Arkiv för Zoologi.
- Ber. nat.-med. Ver. Innsbruck.—Berichte des naturwissenschaftlich-medizinischen Vereins in Innsbruck.
- Bishop Mus. Occ. Papers.—Bishop Museum Occasional Papers.
- Bull. S. Cal. Acad. Sci.—Bulletin of the Southern California Academy of Sciences.
- Bull. Soc. Ent. Suisse.—Bulletin Société Entomologique Suisse.
- Bull. Soc. Sci. Skoplje.—Bulletin de la Société Scientifique de Skoplje (Yugoslavia).
- Bull. Zool. Nomencl.—Bulletin of Zoological Nomenclature.
- Ceylon Jour. Sci.—Ceylon Journal of Science.
- Com. Inst. Nac. Inv. Cien. Nac.—Comunicaciones del Instituto Nacional de Investigación de las Ciencias Naturales, Ciencias Zoológicas.
- Dscht. Ent. Zeitschr.—Deutsche entomologische Zeitschrift.
- Dusenja.—Dusenja.
- Ent. Arb. Mus. Frey.—Entomologische Arbeiten Museum G. Frey.
- Ent. Basil.—Entomologica Basiliensia.
- Ent. Medd.—Entomologiske Meddelelser.
- Ent. Month. Mag.—Entomologist's Monthly Magazine.
- Ent. Rec.—Entomologist's Record.
- Entomography.—Entomography
- EOS.—Official title for Revista Española de Entomología.
- Jour. Ent. Soc. Queensland.—Journal of the Entomological Society of Queensland.
- Jour. Ent. Soc. S. Africa.—Journal of the Entomological Society of Southern Africa.
- Jour. Ga. Ent. Soc.—Journal of the Georgia Entomological Society.
- Jour. Kans. Ent. Soc.—Journal of the Kansas Entomological Society.
- Jour. N. Y. Ent. Soc.—Journal of the New York Entomological Society.
- Jour. Nat. Hist.—Journal of Natural History.
- Khumbu Himal.—published by Universitätsverlag Wagner, Innsbruck-München.
- L. A. Co. Mus. Contr. Sci.—Los Angeles County Museum Contributions to Science.
- Mem. Soc. Cien. Nat. La Salle.—Memorias de la Sociedad de Ciencias Naturales La Salle.
- Mis. Est. Patol. Reg. Argent.—Misión de Estudios de Patología Regional Argentina.
- Mitt. Münch. Ent. Ges.—Mitteilungen der Münchner Entomologischen Gesellschaft.
- Mushi.—Mushi [official title of publication of the Fukuoka Entomological Society].
- Nat. Hist. Rennell Isl.—The Natural History of Rennell Island, British Solomon Islands.
- Notas Mus. La Plata, Zool.—Notas del Museo de la Plata, Zoológica.
- Occ. Pap. Cal. Acad. Sci.—Occasional Papers of the California Academy of Sciences.
- Opusc. Ent.—Opuscula Entomologica.
- Orient. Ins.—Oriental Insects.
- Pac. Ins.—Pacific Insects.
- Pac. Ins. Monogr.—Pacific Insect Monographs.
- Pan-Pac. Ent.—Pan-Pacific Entomologist.

- Papéis Avul. Zool.—Papéis Avulso de Zoologia, Sao Paulo.
- Philipp. Jour. Sci.—The Philippine Journal of Science.
- Posebna Izdanja.—Posebna Izdanja, Srpska Akademija Nauka, Belgrade [vol. 136] (Monographii Srpska Akademeiji Nauka [vol. 35] or Monographiarum Regia Academia Serbica [vol. 35]).
- Proc. Ent. Soc. Wash.—Proceedings of the Entomological Society of Washington.
- Proc. R. Soc. Queensland.—Proceedings of the Royal Society of Queensland.
- Proc. U.S. Nat. Mus.—Proceedings of the United States National Museum.
- Psyche—Psyche, a Journal of Entomology.
- Publ. Univ. Cochabamba.—Publicaciones de la Universidad de Cochabamba, Folia Universitaria.
- Quart. Jour. Taiwan Mus.—Quarterly Journal of the Taiwan Museum.
- Rec. S. Austral. Mus.—Records of the South Australian Museum.
- Rev. Brasil. Biol.—Revista Brasileira de Biologia.
- Rev. Brasil. Ent.—Revista Brasileira de Entomologia.
- Rev. Chilena Ent.—Revista Chilena de Entomologia.
- Rev. Ecuat. Ent. Parasit.—Revista Ecuatoriana de Entomologia Y Parasitologia.
- Rev. Ent.—Revista de Entomologia, Rio de Janeiro.
- Rev. Facultad Agron. Univ. Centr. Venezuela.—Revista de la Facultad de Agronomía, Universidad Central de Venezuela.
- Rev. France Ent.—Revue Francais d'Entomologie.
- Rev. Inst. Nac. Inv. Cien. Nat.—Revista del Instituto Nacional de Investigación de las Ciencias Naturales.
- Rev. Soc. Ent. Argent.—Revista de la Sociedad Entomologica Argentina.
- Rev. Soc. Uruguay Ent.—Revista de la Sociedad Uruguay de Entomologia.
- Roy. Serbian Acad. Sci.—Royal Serbian Academy of Sciences, Special Issues, Natural History & Mathematical Papers, Ohridski Zbornik.
- Sociobio.—Sociobiology.
- Stud. Ent.—Studia Entomologica.
- Trans. Amer. Ent. Soc.—Transactions of the American Entomological Society.
- Verh. Naturf. Ges. Basel.—Verhandlungen der Naturforschenden Gesellschaft in Basel.
- Wasmann Jour. Biol.—The Wasmann Journal of Biology.
- Zeitschr. Arbgem. Österr. Ent.—Zeitschrift der Arbeitsgemeinschaft Österreichischer Entomologen.
- Zool. Meded.—Zoologische Mededelingen, Rijksmuseum van Natuurlijke Historie te Leiden.
- Zool. Res.—Zoological Research.
- Zool. Scripta.—Zoologica Scripta.

LIST OF NAMES PROPOSED

Order Heteroptera
Family-group Names

Aradidae

- Llaimacorini Kormilev and Froeschner, 1987c: 7 and 197 (misspelled "Llaimocorini" on p. 197)
- Tretocorini Kormilev and Froeschner, 1987c: 6 and 93

Coreidae

- Merocorini Kormilev, 1954a: 156
- Meropachyni [sic] Kormilev, 1954a: 156 and 159
- Spathophorini Kormilev, 1954a: 156 and 174

Lygaeidae

- Robinsonocorini Kormilev, 1952f: 9

Piesmatidae

- Thaicorinae Kormilev, 1969b: 645

Thaumastotheriidae

- Discocorinae Kormilev, 1955g: 7

Vianaididae Kormilev, 1955j: 466

Genus-group Names

Alydidae

- Bactrocoris* Kormilev, 1953b: 55

Aradidae

- Aegisocoris* Kormilev, 1967g: 521
Aellocoris Kormilev, 1964c: 53
Aneuris (*Aneurillus*) Kormilev, 1968d: 259
Apaniocoris Kormilev, 1983a: 443
Aparilocoris Kormilev, 1983c: 690 [new name for preoccupied *Hybocoris* Kormilev, 1982]
Apterocoris Kormilev and Doesburg, 1977b: 1
Aradiolus Kormilev, 1967a: 2
Arbanatus Kormilev, 1951: 180
Argocoris Kormilev, 1967g: 519 [preoccupied, see *Pseudoargocoris* Kormilev, 1992: 184]
Aspisocoris Kormilev, 1967g: 515
Atactocoris Kormilev, 1964d: 114
Axapisocoris Kormilev and Heiss, 1979c: 157
Biroana Kormilev, 1957a: 395
Caecicoris Kormilev, 1957a: 398
Chapadia Kormilev, 1960a: 42
Chelysosoma Kormilev, 1956d: 283
Chrysodaspis Kormilev, 1971a: 99
Clavicornia Kormilev, 1960f: 167
Delnocoris Kormilev, 1982f: 41
Dihybobogaster Kormilev, 1953d: 230 [in generic heading misspelled “*Dyhibogaster*”]
Dimifaia Kormilev, 1971a: 96
Diphyllonotus Kormilev, 1959b: 61 [“*Dyhibogaster*”—see *Dihybobogaster*]
Drakeida Kormilev, 1958b: 89
Erineocoris Kormilev, 1960f: 163
Eunotoplocoris Kormilev, 1957g: 4
Euricoris Kormilev, 1957a: 393
Forficulassa Kormilev, 1960a: 40
Froeschnerissa Kormilev, 1986e: 253
Glyptoaptera Kormilev, 1965b: 18
Glyptomorpha Kormilev, 1977d: 412 [preoccupied, see *Morphocoris* Kormilev, 1980a: 328]
Gnostocoris Kormilev, 1967e: 449
Halaszfyia Kormilev, 1960e: 210
Heissia Kormilev, 1986e: 251
Hybocoris Kormilev, 1982b: 7 [preoccupied, see *Aparilocoris* Kormilev, 1983c: 690]
Kaulocoris Kormilev, 1971b: 718
Kelaino Kormilev, 1963a: 451
Kema Kormilev, 1955h: 141
Kiritshenkiana Kormilev, 1976a: 71
Kiritshenkiessa Kormilev, 1971a: 10
Leiocoris Kormilev, 1971a: 112
Leurocoris Kormilev, 1971b: 720
Libiocoris Kormilev, 1957a: 390
Limonocoris Kormilev, 1971e: 166
Llaimacoris Kormilev, 1964d: 117
Magdalena Kormilev, 1983a: 445
Mapiri Kormilev, 1959b: 69
Micromezira Kormilev, 1967c: 488
Morphocoris Kormilev, 1980a: 328 [new name for the preoccupied *Glyptomorpha* Kormilev, 1977d: 412]
Odontonotus Kormilev, 1955c: 34
Paracalisiopsis Kormilev, 1963b: 602 and 605
Paracalisius Kormilev, 1974b: 296
Paracarventus Kormilev, 1964c: 42
Parahesus Kormilev, 1960a: 46
Paramezira Kormilev, 1974c: 246
Parapictinus Kormilev, 1956d: 291
Pararhombocoris Kormilev, 1990e: 325 [new name for the preoccupied *Rhombocoris* Kormilev, 1965b: 18]
Parartabanus Kormilev, 1972d: 573
Pelecicoris Kormilev, 1971a: 97
Probaticeps Kormilev, 1965b: 21
Pseudoargocoris Kormilev, 1992a: 184 [new name for preoccupied *Argocoris* Kormilev, 1967: 519]
Pseudopictinus Kormilev, 1966f: 517
Rhombocoris Kormilev, 1965b: 17 [preoccupied, see *Pararhombocoris* Kormilev, 1965b: 18]
Rhynchomirus Kormilev, 1976e: 742
Rustem Kormilev, 1957e: 39
Santaremia Kormilev, 1960a: 44
Scirrhocoris Kormilev, 1965b: 26
Scironocoris Kormilev, 1957a: 401
Usingerida Kormilev, 1955h: 142
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- Chrysodaspis ovatus* Kormilev, 1971a: 101
- Cinyphus alatus* Kormilev, 1960d: 4
- Cinyphus amazonicus* Kormilev, 1960c: 83
- Cinyphus andinus* Kormilev, 1960d: 5
- Cinyphus meziroides* Kormilev, 1960d: 8
- Cinyphus ovatus* Kormilev, 1960d: 6
- Cinyphus peruvianus* Kormilev, 1960d: 7
- Cinyphus saileri* Kormilev, 1964a: 246
- Cinyphus terminalis* Kormilev, 1968k: 53
- Cinyphus venezuelanus* Kormilev, 1968k: 52
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- Clavicornia usingeri granulata* Kormilev, 1967b: 75
- “*Coloborrhinus*”—see *Coloborrhinus*
- Coloborrhinus meziroides* Kormilev, 1973f: 742
- Coloborrhinus peruvianus* Kormilev, 1975a: 10
- Crimia inermis* Kormilev, 1953c: 336
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- Ctenoneurus bakeri* Kormilev, 1978e: 242
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- Ctenoneurus camerounensis* Kormilev, 1974a: 69
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- Ctenoneurus halaszfyi* Kormilev, 1958b: 92
- Ctenoneurus hammaensis* Kormilev, 1971a: 58
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- Ctenoneurus lugubris* Kormilev, 1971a: 55
- Ctenoneurus major* Kormilev, 1971a: 54
- Ctenoneurus malayensis* Kormilev, 1973b: 73
- Ctenoneurus mandrakaensis* Kormilev, 1974a: 70
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- Ctenoneurus samoensis* Kormilev, 1971a: 61
- Ctenoneurus simulans* Kormilev, 1971a: 61
- Ctenoneurus solomonensis* Kormilev, 1971a: 52
- Ctenoneurus spiculifer* Kormilev, 1971a: 60
- Ctenoneurus sumatrensis* Kormilev, 1973b: 74
- Ctenoneurus terminalis* Kormilev, 1974a: 68
- Ctenoneurus wolffi* Kormilev, 1968i: 101
- Ctenoneurus zimmermani* Kormilev, 1971a: 52
- Daulocoris australis* Kormilev, 1973c: 200
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- Daulocoris sumatrensis* Kormilev, 1980e: 23

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- Drakiessa minor* Kormilev, 1963a: 446
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- Drakiessa tertia* Kormilev, 1964c: 47
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- Erineocoris lobulatus* Kormilev, 1960f: 164
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- Eunotoplocoris ruckesi* Kormilev, 1957g: 4
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- Glochocoris biroi* Kormilev, 1960f: 170
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- Glochocoris brisbanicus* Kormilev, 1967b: 76
- Glochocoris cristatus* Kormilev, 1960f: 173
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- Glochocoris similis* Kormilev, 1967c: 487
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- Glochocoris tuberculatus* Kormilev, 1960f: 171
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- Glyptocoris minutus* Kormilev, 1959e: 313 and 314
- Glyptocoris plaumanni* Kormilev, 1954e: 126
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- Hybocoris mexicanus* Kormilev, 1982b: 9
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Mezira cubana Kormilev, 1960e: 215
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Mezira dybasi Kormilev, 1968c: 283
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Mezira eurycephala Kormilev, 1960c: 87
Mezira exarmata Kormilev, 1971a: 37
Mezira formosa Kormilev, 1955a: 226 and 243
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- Mezira ghanaensis* Kormilev, 1966a: 393
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Mezira (Zemira) incisa Kormilev, 1971a: 40
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Mezira incrustata Kormilev, 1973d: 741
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Mezira lobuliventris Kormilev, 1953c: 340
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Mezira neonigripennis neonigripennis Kormilev, 1955a: 238
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Mezira occidentalis "variety" *appendiculata* Kormilev, 1968c: 288, invalid name, a post-1960 proposal of a "variety"
Mezira paraangustata Kormilev, 1968c: 282
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Mezira paralata Kormilev, 1964a: 257
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Mezira pauperula Kormilev, 1962b: 270
Mezira peruviana Kormilev, 1960d: 11
Mezira (Zemira) philippinensis Kormilev, 1971a: 43
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- Mezira plaumanni* Kormilev, 1966f: 520
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Mezira (Zemira) quadridentata Kormilev, 1971a: 35
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Mezira romani Kormilev, 1962b: 268
Mezira (Zemira) rossi Kormilev, 1971a: 47
Mezira saltensis Kormilev, 1955a: 230
Mezira sangabrielensis Kormilev, 1962b: 270
Mezira sanmartini Kormilev, 1968a: 9
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Mezira (Zemira) serrata Kormilev, 1971a: 41
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Mezira smithi Kormilev, 1982e: 336
Mezira (Zemira) solomonensis Kormilev, 1971a: 47
Mezira spinipes Kormilev, 1965a: 6
Mezira spissigrada Kormilev, 1960c: 88
Mezira (Zemira) stolidi Kormilev and Heiss, 1977e: 104
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Mezira wilsoni Kormilev, 1967g: 542
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Miorrhynchus longicornis Kormilev, 1960d: 3
Miorrhynchus paraguayensis Kormilev, 1952a: 54
Miorrhynchus peruvianus Kormilev, 1960d: 4
Miorrhynchus plaumanni Kormilev, 1957c: 154
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- Miorrhynchus usingeri* Kormilev, 1952c: 120
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Nannium brasiliense Kormilev, 1959e: 319 [genus name misspelled “*Nanium*”]
Neasterocoris costaricensis Kormilev, 1982d: 273
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Neuroctenus eurycephalus Kormilev, 1971a: 86
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Neuroctenus foratus Kormilev, 1971a: 82
Neuroctenus franzi Kormilev and Heiss, 1973g: 71
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Neuroctenus fulgidus Kormilev, 1971a: 80
Neuroctenus gracilis Kormilev, 1965b: 29
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- Neuroctenus longiusculus* Kormilev, 1957c: 157
- Neuroctenus longiventris* Kormilev, 1960d: 15
- Neuroctenus lucti* Kormilev, 1971a: 87
- Neuroctenus luteomaculatus* Kormilev and Heiss, 1977e: 103
- Neuroctenus luteomarginatus* Kormilev, 1958b: 94
- Neuroctenus meziroides* Kormilev, 1958b: 94
- Neuroctenus millironi* Kormilev, 1971a: 88
- Neuroctenus minor* Kormilev, 1971a: 92
- Neuroctenus minusculus* Kormilev, 1971a: 71
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- Neuroctenus muiri* Kormilev, 1971a: 94
- Neuroctenus necopinatus* Kormilev, 1971a: 73
- Neuroctenus pauperulus* Kormilev, 1971a: 79
- Neuroctenus pavlitzkiae* Kormilev, 1956e: 44
- Neuroctenus perplexus* Kormilev, 1983a: 453
- Neuroctenus persimilis* Kormilev, 1971a: 87
- Neuroctenus perssoni* Kormilev, 1976a: 75
- Neuroctenus placidus* Kormilev, 1974a: 73
- Neuroctenus proseni* Kormilev, 1960c: 92
- Neuroctenus pygmaeus* Kormilev, 1978c: 58
- Neuroctenus reynaudi* Kormilev, 1973c: 204
- Neuroctenus robustus* Kormilev, 1973f: 739
- Neuroctenus rossi* Kormilev, 1975a: 15
- Neuroctenus sauteri* Kormilev, 1978c: 58
- Neuroctenus scabrosus* Kormilev, 1971a: 70
- Neuroctenus schlingeri* Kormilev, 1975a: 14
- Neuroctenus seclusus* Kormilev, 1971a: 81
- Neuroctenus sedlaceki* Kormilev, 1971a: 78
- Neuroctenus sertiventris* Kormilev, 1971a: 73
- Neuroctenus sinensis* Kormilev, 1955l: 186
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- Neuroctenus spiniceps* Kormilev, 1974a: 72
- Neuroctenus subandinus* Kormilev, 1955a: 249
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- Neuroctenus substitutus* Kormilev, 1975a: 17
- Neuroctenus sumbaensis* Kormilev, 1973b: 76
- Neuroctenus sundaicus* Kormilev, 1973b: 75
- Neuroctenus surinamensis* Kormilev, 1974c: 241
- Neuroctenus taiwanicus* Kormilev, 1955c: 39
- Neuroctenus termitophilus* Kormilev, 1982g: 25
- Neuroctenus testaceus* Kormilev and Heiss, 1978d: 29
- Neuroctenus thailandicus* Kormilev, 1982b: 14
- Neuroctenus tritonicus* Kormilev, 1973c: 207
- Neuroctenus vanduzeei* Kormilev, 1975a: 16
- Neuroctenus villersi* Kormilev, 1973f: 740
[preoccupied, see *Neuroctenus andrei* Kormilev, 1975a: 2]
- Notapictinus amazonicus* Kormilev, 1968k: 50
- Notapictinus angulatus* Kormilev, 1964f: 471
- Notapictinus araguaensis* Kormilev, 1985c: 153
- Notapictinus bimaculatus* Kormilev, 1979e: 343
- Notapictinus christae* Kormilev, 1967h: 6
- Notapictinus dihypargus* Kormilev, 1960d: 13
- Notapictinus dissimilis* Kormilev and Heiss, 1979d: 109

- Notapictinus dollingi* Kormilev, 1986e: 260
- Notapictinus dyscritus* Kormilev, 1960d: 14
- Notapictinus equatoriensis* Kormilev, 1973d: 438
- Notapictinus hoguei* Kormilev, 1975b: 219
- Notapictinus incaicus* Kormilev, 1964f: 473
- Notapictinus kjellanderi* Kormilev, 1964f: 472
- Notapictinus micropterus* Kormilev, 1964b: 38
- Notapictinus notatus* Kormilev, 1974c: 239
- Notapictinus ornatus* Kormilev, 1966d: 21
- Notapictinus paramaculatus* Kormilev, 1960e: 214
- Notapictinus parvulus* Kormilev, 1960a: 37
- Notapictinus piliger* Kormilev, 1982a: 483
- Notapictinus platyceps* Kormilev, 1966d: 20
- Notapictinus plaumanni* Kormilev, 1976a: 75
- Notapictinus similis* Kormilev and Heiss, 1979d: 107
- Notapictinus subparallelus* Kormilev, 1968k: 51
- Notapictinus surinamensis* Kormilev, 1974c: 239
- Notapictinus terminalis* Kormilev, 1964g: 159
- Notapictinus testaceus* Kormilev and Heiss, 1978d: 29
- Notapictinus uruguayensis* Kormilev, 1966d: 19
- Notapictinus varelai* Kormilev, 1975b: 221
- Notapictinus venezuelanus* Kormilev, 1971e: 172
- Notoplocaptera breviceps* Kormilev, 1983a: 440
- Notoplocaptera dollingi* Kormilev, 1983a: 439
- Notoplocaptera malaisei* Kormilev, 1963a: 444
- Notoplocaptera mystica* Kormilev, 1968g: 591
- Notoplocoris guanabarensis* Kormilev, 1982d: 274
- Notoplocoris leptocerus* Kormilev, 1963a: 452 and 454
- Notoplocoris ovatus* Kormilev, 1964b: 36
- Notoplocoris robustus* Kormilev, 1963a: 453
- Notoplocoris triangulatus* Kormilev, 1957g: 1
- Notoplocoris usingeri* Kormilev and Heiss, 1979d: 102
- Odontonotus maai* Kormilev, 1955i: 179
- Odontonotus oviventris* Kormilev, 1957f: 265
- Odontonotus sauteri* Kormilev, 1955c: 35
- Overlaetiella elongata* Kormilev, 1983a: 448
- Overlaetiella orientalis* Kormilev, 1977a: 354
- Paracalisiopsis aethiopicus* Kormilev, 1963b: 607
- Paracalisius granulatus* Kormilev, 1974b: 296
- Paracarventus woodwardi* Kormilev, 1964c: 43
- Parahesus truncatus* Kormilev, 1960a: 47
- Parapictinus brachypterus* Kormilev, 1957e: 42
- Parapictinus confusus* Kormilev, 1983a: 444
- Parapictinus ovatus* Kormilev, 1956d: 293
- Parartabanus tuberculatus* Kormilev, 1972d: 573
- Pelecoris angustus* Kormilev, 1971a: 98
- Pictinellus brunneus* Kormilev, 1968j: 228
- Pictinellus elongatus* Kormilev, 1967g: 539
- Pictinellus leai* Kormilev, 1967g: 536
- Pictinellus longiceps* Kormilev, 1967g: 539
- Pictinellus malayensis* Kormilev, 1967g: 540
- Pictinellus moturikiensis* Kormilev, 1967g: 538
- Pictinellus papuasicus* Kormilev, 1967g: 534
- Pictinellus thelmae* Kormilev, 1966c: 306

- Pictinus bechynei* Kormilev, 1968k: 48
Pictinus beckeri Kormilev, 1959c: 22
Pictinus brachypterus Drake and Kormilev, 1958a: 245
Pictinus carioca Kormilev, 1964f: 467
Pictinus derivatus Kormilev, 1959c: 25
Pictinus fictus Kormilev, 1959c: 29
Pictinus granuliferus Kormilev, 1959e: 318
Pictinus intermediarius Kormilev, 1953e: 241
Pictinus luteoincrustatus Kormilev, 1959c: 24
Pictinus maculatus Kormilev, 1959c: 26
Pictinus martinezi Kormilev, 1955a: 220 [genus name misspelled “*Pictius*” in species heading]
Pictinus montrouzieri Kormilev, 1953e: 239
Pictinus nanus Kormilev, 1959c: 23
Pictinus pilosulus Kormilev, 1959c: 27
Pictinus plaumanni Kormilev, 1953e: 238
Pictinus rhombocarيناتus Kormilev, 1964b: 37
Pictinus rutilus Kormilev, 1959c: 30
Pictinus sanmigueli Kormilev, 1959c: 24
Pictinus stali Kormilev, 1959: 27
Pictinus stolidus Kormilev, 1964g: 157
Pictinus venezuelanus Kormilev, 1968k: 49
Pictinus wittmeri Kormilev, 1959c: 28
“*Pictius*”—see *Pictinus*
“*Placogenis*”—see *Placogenys*
Placogenys clarkei Kormilev, 1966d: 17 [genus name misspelled “*Placogenis*”]
Placogenys parva Kormilev, 1976e: 741 [genus name misspelled “*Placogenis*”]
Placogenys constricta Kormilev, 1973d: 437
Probatoceps monteithi Kormilev, 1965b: 22
Proxius (Neoproxius) amazonicus Kormilev, 1976e:
Proxius (Nesoproxius) angulatus Kormilev, 1968g: 587
Proxius (Neoproxius) carioca Kormilev, 1982d: 270
Proxius (Nesoproxius) constrictus Kormilev, 1978c: 54
Proxius (Neoproxius) costaricensis Kormilev, 1982f: 38
Proxius (Nesoproxius) gracilis Kormilev, 1968g: 583
Proxius (Nesoproxius) hexagonalis Kormilev, 1968g: 584
Proxius incaicus Kormilev, 1976e: 736 [new name for preoccupied *Proxius peruvianus* Kormilev, 1975a: 4]
*Proxius (Neoproxius) lindemanna*e Kormilev, 1965d: 3
*Proxius (Neoproxius) magdalena*e Kormilev, 1982f: 34
Proxius (Nesoproxius) malayensis Kormilev, 1983a: 438
Proxius (Neoproxius) nicaraguensis Kormilev, 1982f: 36
Proxius (Neoproxius) panamensis Kormilev, 1982d: 272
Proxius (Neoproxius) peruvianus Kormilev, 1966d: 9
Proxius (Neoproxius) peruvianus Kormilev, 1975a: 4 [preoccupied, see *Proxius (Neoproxius) incaicus* Kormilev, 1976e: 736]
Proxius (Nesoproxius) punctulatus Kormilev, 1968g: 585
Proxius (Nesoproxius) vietnamensis Kormilev, 1968g: 584
Proxius (Nesoproxius) yoshimotoi Kormilev, 1971b: 716
Pseudoartabanus brachypterus Kormilev, 1971a: 133
Pseudopictinus dispar Kormilev, 1966f: 520
Rhombocoris distinctus Kormilev, 1965b: 18
Rhynchomirus brachypterus Kormilev, 1976e: 742
Rhysocoris cubanus Kormilev, 1976e: 740
Rhysocoris jamaicensis Kormilev, 1964d: 112
Rustem bellicosus Kormilev, 1957e: 41
Santaremis armata Kormilev, 1974c: 237
Santaremia robusta Kormilev, 1960a: 45 [“*Schirrhocoris*”—see *Scirrhocoris*]

- Scironocoris armigerus* Kormilev, 1957a: 402
Scironocoris baliensis Kormilev, 1972d: 577
Scironocoris malayensis Kormilev, 1983a: 454
Scironocoris obscurus Kormilev, 1971a: 26
Scironocoris papuasicus Kormilev, 1971a: 27
Scirrhocoris australiensis Kormilev, 1965b: 27
Scirrhocoris mirabilis Kormilev, 1965b: 27 [genus name misspelled "Schirrhocoris"]
Stelgidocoris villiersi Kormilev, 1974a: 67
Strigocoris bishopi Kormilev, 1972d: 574
Trigonaptera pandani Kormilev, 1968j: 226
Trigonaptera scabrosa Kormilev, 1978c: 390
Usingeria moralesi Kormilev, 1966a: 390
Usingerida angulata Kormilev, 1971a: 132
Usingerida longiceps Kormilev, 1977c: 262
Usingerida longirostris Kormilev, 1983a: 455
Usingerida montana Kormilev, 1974c: 236
Usingerida parva Kormilev, 1967f: 297
Usingerida similis Kormilev and Heiss, 1975c: 107
Usingerida walshi Kormilev, 1955h: 143
Usumbaraia ampliata Kormilev, 1956c: 254
Usumbaraia arnaudi Kormilev, 1979a: 57
Usumbaraia elongata Kormilev, 1956c: 255
Wuiessa brachyptera Kormilev, 1978e: 243
Wuiessa longicornis Kormilev and Heiss, 1975c: 103
Wuiessa minor Kormilev, 1971a: 131
Wuiessa wittmeri Kormilev and Heiss, 1975c: 104
Zimmermania angulata Kormilev, 1968g: 581
Zimmermania bicaudata Kormilev, 1968g: 580
Zimmermania breviceps Kormilev, 1971b: 714
Zimmermania excavata Kormilev, 1968g: 578
Zimmermania gressitti Kormilev, 1968g: 582
Zimmermania magdalenae Kormilev, 1954f: 130
Zimmermania solomonensis Kormilev, 1968g: 578
Zimmermania usingeri Kormilev, 1967c: 475
- Colobathristidae
Carvalhoia carioca Kormilev, 1951a: 68
Colobasiastes proseni Kormilev, 1951f: 337
Diascopoea carvalhoi Kormilev, 1951a: 78
Labradoria bridrollii Kormilev, 1951a: 80
Neocolobathristes bituberus Kormilev, 1951a: 71
Neocolobathristes longispinus Kormilev, 1951a: 73
Paraelopura tipuliformis Kormilev, 1953d: 291
Peruda monrosi Kormilev, 1949e: 378
Perudella denieri Kormilev, 1949a: 170
Phaenacantha saileri Kormilev, 1951a: 65
Symphylax handschini Kormilev, 1953d: 288
Symphylax walshi Kormilev, 1953d: 289
Trichocentrus amazonicus Kormilev, 1951f: 335
Trichocentrus guayanensis Kormilev, 1951a: 74
Trichocentrus horvathi Kormilev, 1949e: 372
Trichocentrus vianai Kormilev, 1949e: 368
- Coreidae
Bathysolens nubilus form *grisescens* Kormilev, 1939a: 4
Ceraleptus brevicornis Kormilev, 1939a: 25
Flavius tristriatus Kormilev, 1951h: 42

- Hirilcus burmeisteri* Kormilev, 1954a: 171
Hirilcus stali Kormilev, 1954a: 173
Hirilcus willineri Kormilev, 1954a: 169
Lycambes martinezi Kormilev, 1954a: 178
Marichisme boliviana Kormilev, 1954a: 163
Paralycambes misionensis Kormilev, 1954a: 181
Petalops bridarollii Kormilev, 1952d: 97
Petalops willineri Kormilev, 1952d: 94
- Cyrtocoridae
Cyphothyrea bridarollii Kormilev, 1955i: 325
Cyrtocoris subobtusus Kormilev, 1955i: 330
- Elasmodemidae
Elasmodema bosqi Kormilev, 1948a: 143
- Lygaeidae
Crophius coleopteroides Kormilev, 1950a: 25
Cymoninus argentinensis Kormilev, 1955f: 6
Karamania balcanica Kormilev, 1938a: 168
Micrymenus kuscheli Kormilev, 1952f: 12
Micrymenus rugosus Kormilev, 1957h: 387
Rigiella vianai Kormilev, 1949d: 6
Robinsonocoris tingitoides Kormilev, 1952f: 10
- Megaridae
Megarix vianai Kormilev, 1956a: 3
- Miridae
Phylus balcanicus Kormilev, 1939b: 197
Systellonotus skopljensis Kormilev, 1936a: 49 [manuscript name]; 1939b: 195
- Ochteridae
Ochterus foersteri Kormilev, 1952g: 155
Ochterus gressitti Kormilev, 1971d: 438
Ochterus jaczewskii Kormilev, 1971d: 439
Ochterus minor Kormilev, 1973a: 4
Ochterus piliferus Kormilev, 1973a: 6
Ochterus secundus Kormilev, 1971d: 441
Ochterus papuasicus Kormilev, 1972e: 585
- Ochterus philippinensis* Kormilev, 1971d: 436
- Pentatomidae
Adoxoplatys brasiliensis Kormilev, 1951c: 91
Adoxoplatys bridrolli Kormilev, 1949f: 316
Adoxoplatys gallardoii Kormilev, 1951c: 93
Adoxoplatys gii Kormilev, 1950b: 343
Adoxoplatys panamensis Kormilev, 1951c: 90
Adoxoplatys willineri Kormilev, 1949f: 320
Carpocoris lunulatus nigricornis Kormilev, 1936a: 53
Daimonocoris bolivianus Kormilev, 1951h: 38
Glypheapomis setigera Kormilev, 1952h: 304
Harpagogaster willineri Kormilev, 1957d: 50
Heteroscelis zischkai Kormilev, 1951h: 40
Neoadoxoplatys haywardi Kormilev, 1956b: 5
Neoadoxoplatys saileri Kormilev, 1956b: 5
Neoderoploa willineri Kormilev, 1955e: 10
Neoleprosoma argentinensis Kormilev, 1952b: 214
Ornithosoma rivierei Kormilev, 1957d: 54
Placocoris albovenosus Kormilev, 1949c: 4
Prionotocoris suilari Kormilev, 1955e: 8
Ramosiana militaris Kormilev, 1950b: 340
Serdia bergi Kormilev, 1956b: 4
Serdia stali Kormilev, 1956b: 4
Serdia vianai Kormilev, 1956b: 3
Willinerinia decorata Kormilev, 1950d: 497
- Phymatidae
 ["*Agdistis*"]—see *Agdistocoris*
Agdistocoris pallida Kormilev, 1962e: 359
 [genus name misspelled "*Agdistis*"]

- Agdistocoris testacea* Kormilev, 1962e: 359
- Amblythyreus chapa* Kormilev, 1962e: 353 and 356
- Amblythyreus izzardii* Kormilev, 1962e: 353
- Bakerinia acutangula* Kormilev, 1962c: 12
- Bakerinia granulata* Kormilev, 1962c: 11
- Carcinocoris ochraceus* Kormilev, 1962e: 365
- Chelocoris alatus* Kormilev, 1988b: 69
- Chelocoris bianchii* Kormilev, 1971c: 884
- Chelocoris brancuccii* Kormilev, 1988b: 73
- Chelocoris spinosulus* Kormilev, 1962e: 362
- Chelocoris truncatus* Kormilev, 1962e: 360
- Chelocoris vietnamensis* Kormilev, 1990c: 298
- Chelocoris wittmeri* Kormilev, 1988b: 70
- Cnizocoris abselluiferus* Nonnaizab, Kormilev, and Qi, in 1990a: 21 [manuscript name, changed to *C. acellularis* after manuscript was submitted to press—see that combination]
- Cnizocoris acellularis* Nonnaizab, Kormilev, and Qi, 1989c: 349 [published form of manuscript name *C. abselluiferus*—see that combination]
- Cnizocoris aphyllus* Nonnaizab, Kormilev, and Qi, 1990a: 21 [manuscript name, changed to *C. unicellularis* after manuscript was submitted to press—see that combination]
- Cnizocoris bhutanensis* Kormilev, 1988b: 64
- Cnizocoris drakei* Kormilev, 1957j: 64
- Cnizocoris mongolicus* Nonnaizab, Kormilev and Qi, 1989c: 342 and 347
- Cnizocoris sinensis* Kormilev, 1957j: 67
- Cnizocoris unicellularis* Nonnaizab, Kormilev, and Qi, 1989c: 342 and 347 [published form for manuscript name *C. aphyllus*—see that combination]
- Diurocoris thailandicus* Kormilev, 1984b: 631
- Diurocoris truncatus* Kormilev, 1962c: 13
- Eurymnus insignis* Kormilev, 1984b: 628
- Glossopelta indica* Kormilev, 1966g: 283
- Kelainocoris farri* Kormilev, 1963c: 223
- Lophoscutus armatus* Kormilev, 1986f: 301
- Lophoscutus arnaudi* Kormilev, 1988c: 142
- Lophoscutus brasiliensis* Kormilev and Doesburg, 1986b: 119
- Lophoscutus chemsaki* Kormilev, 1984b: 627
- Lophoscutus confusus* Kormilev, 1989d: 61 [was listed as a manuscript name “In press,” 1990a: 30]
- Lophoscutus dimorphus* Kormilev, 1986f: 299
- Lophoscutus froeschneri* Kormilev, 1987a: 702
- Lophoscutus geijskesi* Kormilev and Doesburg, 1986b: 121
- Lophoscutus haitiensis* Kormilev, 1987a: 703
- Lophoscutus hispaniolensis* Kormilev and Doesburg, 1991a: 280
- Lophoscutus maurus* Kormilev, 1989a: 451 [was listed as a manuscript name “In press,” 1990a: 30]
- Lophoscutus michelbacheri* Kormilev, 1984b: 628
- Lophoscutus paracrassimanus* Kormilev, 1988c: 144
- Lophoscutus pugil* Kormilev and Doesburg, 1992b: 417
- Lophoscutus rideri* Kormilev, 1988c: 144
- Lophoscutus rileyorum* Kormilev, 1990d: 221 [was listed as a manuscript name “In press,” 1990a: 32]
- Lophoscutus sagimani* Kormilev and Doesburg, 1986b: 116
- Lophoscutus schaffneri* Kormilev, 1986b: 304
- Lophoscutus virginensis* Kormilev, 1986d: 306
- Lophoscutus viridis* Kormilev, 1984b: 626
- Lophoscutus woolleyi* Kormilev, 1988c: 141
- Lophoscutus ypsilon* Kormilev, 1990d:

- 223 [was listed as a manuscript name
"In press," 1990a: 33]
- Macrocephalus argentinus* Kormilev,
1950c: 581
- Macrocephalus (Lophoscutus) aterrimus*
Kormilev, 1981c: 216
- Macrocephalus dissolutus* Kormilev,
1984b: 625
- Macrocephalus dollingi* Kormilev, 1984b:
625
- Macrocephalus (Lophoscutus) domini-
canus* Kormilev, 1963c: 224
- Macrocephalus (Lophoscutus) drakei*
Kormilev, 1962a: 56
- Macrocephalus (Lophoscutus) dudichi*
Kormilev, 1949b: 587 [new name for
preoccupied *M. obscurus* Dudich,
1922: 172]
- Macrocephalus incisus maya* Kormilev,
1962a: 52
- Macrocephalus insignis* Kormilev, 1957i:
39
- Macrocephalus (Lophoscutus) margaritis*
Kormilev, 1962a: 52
- Macrocephalus (Lophoscutus) marmora-
tus* Kormilev, 1966g: 279
- Macrocephalus notatus costariguensis*
Kormilev, 1962a: 51
- Macrocephalus (Lophoscutus) paraspicu-
losus* Kormilev, 1953f: 57
- Macrocephalus (Lophoscutus) prehensilis
minor* Kormilev, 1954c: 159
- Macrocephalus (Lophoscutus) pulcher*
Kormilev, 1981c: 218
- Macrocephalus similis* Kormilev, 1972b:
94
- Macrocephalus (Lophoscutus) spiculiger*
Kormilev, 1968f: 243
- Macrocephalus (Lophoscutus) subproduc-
tus* Kormilev, 1960a: 55
- Macrocephalus testaceus* Kormilev,
1963c: 223
- Macrocephalus (Lophoscutus) wygodzin-
skyi* Kormilev, 1950c: 587
- Neoanthylla bucki* Kormilev, 1951g: 56
- Neoanthylla peruviana* Kormilev, 1964e:
138
- Oxythyreus ruckesi* Kormilev, 1962c: 3
- Parabotha singularis* Kormilev, 1984b:
629
- Parabotha whiteheadi* Kormilev, 1984b:
630
- Paraphymata saileri* Kormilev, 1962d:
464
- Phymata albipennis* Kormilev, 1965c: 207
- Phymata americana obscura* Kormilev,
1957b: 136
- Phymata ampliata* Kormilev, 1962d: 311
and 350
- Phymata anchietai* Kormilev, 1951b: 55
- Phymata argentina montana* Kormilev,
1951g: 98
- Phymata barberi* Kormilev, 1962d: 322
and 434
- Phymata beieri* Kormilev, 1962d: 310 and
333
- Phymata bergi* Kormilev, 1950: 586
- Phymata bipunctata* Kormilev, 1951e:
174
- Phymata birabeni* Kormilev, 1950c: 582
- Phymata bosqi* Kormilev, 1950c: 589
- Phymata brailovskyi* Kormilev, 1990f:
100
- Phymata carioca* Kormilev, 1951e: 171
- Phymata carinata cordobensis* Kormilev,
1951g: 70
- Phymata carinata pampeana* Kormilev,
1951g: 71
- Phymata carinata uruguayensis* Kormi-
lev, 1951g: 72
- Phymata carneipes subangulata* Kormi-
lev, 1962d: 439
- Phymata carvalhoi* Kormilev, 1950c: 588
- Phymata centralis* Kormilev, 1962d: 351
- Phymata chilensis brasiliensis* Kormilev,
1962d: 449
- Phymata chinai* Kormilev, 1962e: 350
- Phymata colombiana* Kormilev, 1962d:
429
- Phymata delpontei* Kormilev, 1950c: 583
- Phymata denieri* Kormilev, 1950c: 583
- Phymata drakei* Kormilev, 1957b: 131
- Phymata elongata* Kormilev, 1963c: 218
[preoccupied, see *Phymata prolata*
Froeschner and Kormilev, 1990a: 67]

- Phymata fasciata panamensis* Kormilev, 1962d: 411
- Phymata foersteri* Kormilev, 1951b: 53 [species name misspelled "foersteri"]
- Phymata foerstieri* [sic] Kormilev, 1951b: 53 [correct of species name species name is *foersteri*]
- Phymata fortificata paranensis* Kormilev, 1951g: 88
- Phymata fortificata patagonica* Kormilev, 1951g: 89
- Phymata granulosa evansi* Kormilev, 1962d: 399
- Phymata granulosa texasana* Kormilev, 1957b: 134
- Phymata haywardi* Kormilev, 1950c: 585
- Phymata husseyi* Kormilev, 1951e: 176
- Phymata incisa* Kormilev, 1951e: 172
- Phymata inconspicua* Kormilev, 1962d: 431
- Phymata jamaicensis* Kormilev, 1963c: 216
- Phymata luteomarginata* Kormilev, 1957b: 130
- Phymata maculata* Kormilev, 1957b: 127
- Phymata malaisei* Kormilev, 1962d: 377
- Phymata mansosotoi* Kormilev, 1952e: 125
- Phymata mayri* Kormilev, 1962d: 393
- Phymata minuta* Kormilev, 1962d: 432
- Phymata monrosi* Kormilev, 1950c: 585
- Phymata nasuta* Kormilev, 1965c: 205
- Phymata orfilai* Kormilev, 1950c: 584
- Phymata pacifica hainesi* Kormilev, 1962d: 424
- Phymata pallida* Kormilev, 1957b: 128
- Phymata paradoxa* Kormilev, 1952e: 126
- Phymata pilifera* Kormilev, 1963c: 220
- Phymata prolata* Froeschner and Kormilev, 1990a: 57 [new name for pre-occupied *Phymata elongata* Kormilev, 1963c: 218]
- Phymata rhynocerata* Kormilev, 1957b: 124
- Phymata roqueensis halaszfyi* Kormilev, 1962d: 343
- Phymata saileri* Kormilev, 1957b: 133
- Phymata sanjuanensis* Kormilev, 1950c: 530
- Phymata severini dyeri* Kormilev, 1962d: 389
- Phymata simulans explanata* Kormilev, 1962d: 346
- Phymata simulans recifensis* Kormilev, 1962d: 348
- Phymata simulans surinamensis* Kormilev, 1962d: 347
- Phymata simulans trinidadensis* Kormilev, 1957b: 125
- Phymata subarmata* Kormilev, 1953f: 59
- Phymata superba* Kormilev, 1962d: 452
- Phymata torresi* Kormilev, 1950c: 588
- Phymata turnbowi* Kormilev, 1983b: 139
- Phymata variegata* Kormilev, 1963c: 219
- Phymata venezuelana* Kormilev, 1950c: 589
- Phymata vianai* Kormilev, 1950c: 587
- Phymata vicina parvula* Kormilev, 1957b: 126
- Phymata wygodzinskyi* Kormilev, 1950c: 586
- Phymatocoris iviei* Kormilev and Doesburg, 1991a: 280
- Themonocoris aethiopicus* Kormilev and Doesburg, 1986b: 114
- Piesmatidae
- Thaicoris sedlaceki* Kormilev, 1969b: 646
- Rhopalidae
- Maccevetthus lineola macedonia* Kormilev, 1936a: 54
- Thaumastocoridae
- Discocoris vianai* Kormilev, 1955g: 10
- Thyreocoridae
- Galgupha denieri* Kormilev, 1956a: 10
- Galgupha durionei* Kormilev, 1956a: 8
- Galgupha fritzi* Kormilev, 1956a: 11
- Galgupha haywardi* Kormilev, 1956b: 6
- Galgupha torresi* Kormilev, 1956a: 7
- Galgupha vianai* Kormilev, 1956b: 6
- Pericrepis bergi* Kormilev, 1956b: 7
- Pericrepis bosqui* Kormilev, 1956b: 7
- Thyreocoris balcanicus ohridanus* Kormilev, 1936a: 53
- Tingidae
- Baeotingis vianai* Kormilev, 1955b: 65

Vianaididae

Vianaida coleopterata Kormilev, 1955j:
472

Order Neuroptera
Genus-group Names

Mantispidae

Paramantispa Williner and Kormilev,
1959d: 10

Species-group Names

Mantispidae

Drepanicus gayi schajovskoyi Williner and
Kormilev, 1959d: 17

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LIFE HISTORY AND DESCRIPTION OF IMMATURE STAGES OF
VALENTIBULLA CALIFORNICA (COQUILLET) (DIPTERA: TEPHRITIDAE)
ON *CHRYSOTHAMNUS NAUSEOSUS* (PALLAS) BRITTON
IN SOUTHERN CALIFORNIA

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Abstract.—*Valentibulla californica* (Coquillett) is univoltine and nearly monophagous on *Chrysothamnus nauseosus* (Pallas) Britton (Asteraceae). The larvae develop in short, subsurface mines mostly formed basally in current season's branches, and are not easily detected on infested plants. They cause limited swellings, not readily detectable galls. The egg, second and third instar larva, and puparium are described and figured. The egg, described for the first time for this genus, is unique among nonfrugivorous, California tephritids studied to date because of its ellipsoidal-fusiform shape, acutely tapered posterior, and its prominent, anterior pedicel bearing aeropyles of two distinct diameters. The third instar characteristically is shagreened, i.e. only the integument of the gnathocephalon, the anterior third of the prothorax, and a small area surrounding the posterior spiracular plates are not covered by minute, dome-shaped verrucae. The puparium also maintains the shagreened surface. Premating, mating, and postmating behaviors are described; they are few, and similar to the closely related genus, *Aciurina*. Hymenopterous parasitoids of *V. californica* include three species of chalcidoids reared as primary, solitary, endoparasitoids from isolated puparia: *Eupelmus* sp. (Eupelmidae), *Eurytoma* sp. (Eurytomidae), and *Halticoptera* sp. (Pteromalidae).

Key Words: Insecta, *Valentibulla*, *Chrysothamnus*, biology, taxonomy of immature stages, mating behavior, parasitoids.

This study of *Valentibulla californica* (Coquillett) was undertaken after prolonged searches by RDG for its "galls," as described and pictured by Wangberg (1978), failed repeatedly during the 1980's at various locations in southern California where adults otherwise were swept. Our subsequent findings reported herein address several inconsistencies in the developmental biologies heretofore reported for *V. californica* and its congeners, and add new knowledge on this tephritid otherwise largely known from States outside its type state-locality and namesake.

MATERIALS AND METHODS

Most field studies were conducted with *V. californica* on *Chrysothamnus nauseosus* (Pallas) Britton (Asteraceae) at a Mojave Desert (high-elevation desert) location in the easternmost foothills of the San Bernardino Mountains, 2 km NW of Pioneertown at 1280-m elevation, SW San Bernardino Co., during 1991-93. Samples of branches from plants that from previous dissections had been found to contain larvae and puparia were collected on different dates, months and seasons. Branch samples were trans-

ported in cold-chests in an air-conditioned vehicle to the laboratory and stored under refrigeration for subsequent dissection, photography, description, and measurement. All larvae and 20 puparia dissected from these branches and eggs obtained from other excised branches used in oviposition studies were preserved in 70% EtOH for scanning electron microscopy (SEM). All other puparia were placed in separate glass rearing vials stoppered with absorbant cotton and held in humidity chambers at room temperature for adult and parasitoid emergence. Specimens for SEM later were hydrated to distilled water in a decreasing series of acidulated EtOH. They were osmicated for 24 h, dehydrated through an increasing series of acidulated EtOH, critically point dried, mounted on stubs, sputter-coated with a gold-palladium alloy, and studied with a JEOL JSM C-35 SEM in the Department of Nematology, University of California, Riverside.

Most adults reared from isolated puparia were individually caged in 850-ml, clear-plastic, screened-top cages with a cotton wick and basal water reservoir and provisioned with a strip of paper toweling impregnated with yeast hydrolyzate and sucrose. These cagings were used for longevity studies and oviposition tests in the insectary of the Department of Entomology, University of California, Riverside, at $25 \pm 1^\circ\text{C}$, and 14/10 (L/D) photoperiod. Virgin male and female flies obtained from emergence vials were paired in clear-plastic petri dishes provisioned with a flattened, water-moistened pad of absorbant cotton spotted with honey (Headrick and Goeden 1991) for direct observations, videorecording, and still-photography of their general behavior, courtship, and copulation. Six pairs were held together for at least 14 d and observations were made as opportunity allowed throughout each day. Field observations on adult behavior also were made on *C. nauseosus* at Cajon Junction at 1010-m elevation, San Bernardino Nat. Forest (N section), SW San

Bernardino Co., from 8.iv.1992 to 12.v.1992 for ca. 4 h per day for 2 days per week.

Plant names used in this paper follow Munz (1974); tephritid names follow Foote et al. (1993) except for *Aciurina trixa* Curran (Dodson and George 1986). Nomenclature used to describe the immature stages follows Goeden and Headrick (1990, 1991a, b, 1992), Headrick and Goeden (1990, 1991, 1993), and the telegraphic format of Goeden et al. (1993). Means \pm SE are used throughout this paper. Voucher specimens of reared adults of *V. californica* and its parasitoids reside in the research collections of RDG; preserved specimens of larvae and puparia are stored in separate collections of immature Tephritidae maintained by DHH and JAT.

RESULTS AND DISCUSSION

Taxonomy

Coquillett (1894) first described *V. californica* (as a *Trypeta*). Foote et al. (1993) reviewed the taxonomy and other literature on this species and described and discussed recognition features for the adults. They also provided the key to U.S. and Canadian species used to confirm the identity of our flies. Wangberg (1978) briefly described and provided line drawings of one third-instar larva and one puparium serving to illustrate both *V. californica* and *V. steyskali* Foote and labelled "*Valentibulla* spp.," but without distinguishing these species.

Egg.—Egg body smooth, shiny, white, elongate ellipsoidal-fusiform (Fig. 1A); pedicel peg-like, 0.02 mm long (Fig. 1B); 17 eggs dissected from branches in oviposition cages averaged 0.50 ± 0.006 (range, 0.41–0.52) mm in length, 0.15 ± 0.002 (range, 0.13–0.17) mm in width.

This is the first egg described for any *Valentibulla* species. The egg of *V. californica* differs in shape from previously studied, nonfrugivorous tephritids (Goeden and Headrick 1992; Goeden et al. 1993, 1994a,

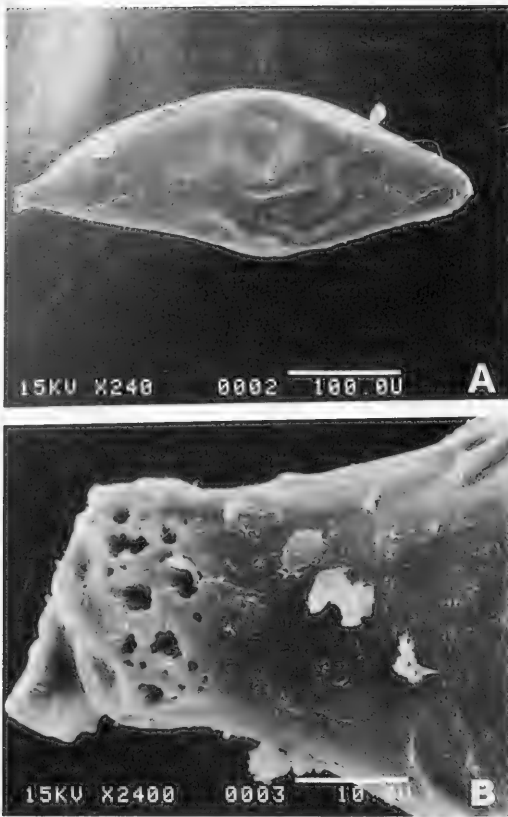


Fig. 1. Egg of *V. californica*: (A) habitus, pedicel at left; (B) detail of pedicel, showing aeropyles.

b; Green et al. 1993; Headrick and Goeden 1990) in that it is more acutely tapered posteriorly opposite the pedicel. *Tephritis arizonaensis* Quisenberry has a similar egg body shape, but does not taper as dramatically at the posterior end and the pedicel is not as prominent (Goeden et al. 1993). The egg of *Trupanea californica* Malloch is similar in length and slightly wider, however the shape is elongate-ellipsoidal and the pedicel is smaller (Headrick and Goeden 1991). The egg of *Acuirina thoracica* Curran, which is in the same subtribe as *V. californica* (Foote et al. 1993), is shaped very differently and bears distinctly raised polygonal reticulation on its surface (Headrick and Goeden 1993). The pedicel of *V. californica* also differs from all previously examined eggs in that the aeropyle openings are of two dis-

tinct diameters (Fig. 1B). *Tephritis baccharis* (Coquillett) has a similar shaped pedicel twice as long as *V. californica* (Goeden and Headrick 1991b).

Third instar.—Third instar creamy white, shagreened, elongate-ellipsoidal, bluntly rounded apically and posteriorly (Fig. 2A); gnathocephalon conical, smooth with very few rugose pads; pad margins laterad of the mouth lumen partly contiguous and not distinctly raised (Fig. 2B-1); paired dorsal sensory organs dorsomedial of anterior sensory lobes each consisting of a single, dome-shaped papilla (Fig. 2B-2, 2C-1); anterior sensory lobes bear the lateral sensory organ (Fig. 2C-2), terminal sensory organ (Fig. 2C-3), and a papillate sensillum dorsad of the lateral sensory organ (Fig. 2C-4); stomal sense organs lie ventrad of anterior sensory lobes, near the mouth lumen (Fig. 2C-5); lateral (Fig. 2B-3) and ventrolateral sensilla present (Fig. 2B-4), each consisting of a smooth, verruciform sensillum with a central pore; mouth hooks bidentate, teeth stout, conical, rounded apically (Fig. 2B-5, 2D-1); median oral lobe laterally compressed, tapers anteriorly between mouth hooks (Fig. 2B-6), attached basally to labial lobe (Fig. 2D-2); labial lobe bears two pore sensilla (Fig. 2D-3); prothorax smooth anteriorly, covered with minute, dome-shaped verrucae posteriorly; anterior thoracic spiracles located dorsolaterally on posterior margin of prothorax, each consisting of four, obovate papillae (Fig. 2E); meso- and metathorax covered entirely by minute, dome-shaped verrucae; lateral spiracular complex on abdominal segments composed of an open spiracle (Fig. 2F-1), and a single verruciform sensillum (Fig. 2F-2); caudal segment bears posterior spiracular plates (Fig. 2G); plates bear three, oval rimae ca. 0.02 mm long (Fig. 2G-1), and four, short, multibranch interspiracular processes, with three to four branches each, the longest measuring 0.006 mm (Fig. 2G-2); stelex sensilla surround margin of caudal segment in four-dorsal, six-ventral arrangement;

caudal segment additionally bears a pair of compound sensilla ventrad of the spiracular plates consisting of a tuberculate chemosensillum (Fig. 2H-1), and a stelex sensillum (Fig. 2H-2).

Valentibulla californica is only the second species examined by us that is shagreened. *Tomoplagia cressoni* Aczél, which belongs to a different tribe, also is shagreened (Goeden and Headrick 1991a). In *V. californica*, only the integument of the gnathocephalon, the anterior third of the prothorax, and a small area surrounding the posterior spiracular plates are not covered by minute, dome-shaped verrucae. *Aciurina thoracica*, a closely related species (Foote et al. 1993), bears irregular patches of acanthae, but the intersegmental areas are smooth (Headrick and Goeden 1993). *Valentibulla californica* also lacks the rows of minute acanthae that circumscribe the intersegmental areas of several other tephritid species (Goeden and Headrick 1991b, 1992, Goeden et al. 1993, 1994b, Headrick and Goeden 1991).

Foote et al. (1993) placed *Valentibulla* in a new subtribe Eurostina along with *Aciurina* and *Eurosta*. *Valentibulla californica* larvae do resemble *A. thoracica* larvae in many morphological characters (Headrick and Goeden 1993). The gnathocephalon is similar to *A. thoracica*, being smooth with few rugose pads. The median oral lobes are similar, laterally compressed and tapered apically. The gnathocephalon sensilla are very similar in structure and placement; however, there is one noteworthy difference. The anterior sensory lobe in *V. californica* lacks a pit sensory organ. This is the second example of a tephritid with its anterior sensory lobe not bearing the pit sensory organ. *Tomoplagia cressoni*, which is also shagreened, lacks the pit sensory organ (Goeden and Headrick 1991a). Pit sensory organs otherwise are typically similar in size, shape, and placement among tephritid species (Carroll and Wharton 1989, Goeden and Headrick 1990, 1991b, 1992, Goeden et al. 1993, 1994a, b, Headrick and Goeden

1990, 1993). The mouth hooks also differ, being bidentate in *V. californica* and tridentate in *A. thoracica* (Headrick and Goeden 1993). Wangberg (1978) reported *Valentibulla* spp. to have tridentate mouth hooks. The abdominal lateral spiracular complex consists of a spiracle and a single, domed-shaped papillae in *V. californica*, similar to those of *A. thoracica* (Headrick and Goeden 1993), *Trupanea californica* (Headrick and Goeden 1991), *T. nigricornis* (Coquillett), *T. bisetosa* (Coquillett) (Knio and Goeden, unpublished), *N. viridescens* Quisenberry (Goeden and Headrick 1992), *Procecidochares flavipes* Aldrich (Goeden et al. 1994a), and *P. stonei* Blanc and Foote (Green et al. 1993).

Second instar.—Second instar creamy white, shagreened, ovoid in shape, rounded anteriorly and posteriorly (Fig. 3A); gnathocephalon conical, laterally flattened, smooth with a few small rugose pads laterad of the anterior sensory lobes and stomal sense organs (Fig. 3B-1), and a few petals dorsad of the mouth lumen (Fig. 3B-2); paired dorsal sensory organs located dorsomedially to the anterior sensory lobes, consisting of a single dome-shaped papilla (Fig. 3C-1); anterior sensory lobes separated by a medial depression (Fig. 3C), flattened, bearing the terminal sensory organ (Fig. 3C-2), lateral sensory organ (Fig. 3C-3), and a papillate sensillum dorsomedial of the lateral sensory organ (Fig. 3C-4); stomal sense organs lie ventrad of anterior sensory lobes, near the mouth lumen (Fig. 3C-5); mouth hooks bidentate, teeth conical, rounded apically (Fig. 3B-3); median oral lobe laterally flattened, tapered anteriorly between mouth hooks (Fig. 3B-4); prothorax smooth anteriorly, covered with minute, dome-shaped verrucae posteriorly; anterior thoracic spiracles located dorsolaterally on posterior margin of prothorax, each consisting of four obovate papillae (Fig. 3D); lateral spiracular complex not observed; caudal segment bears the spiracular plates, plates bear three oval rimae ca. 0.007 mm long, and four, thorn-

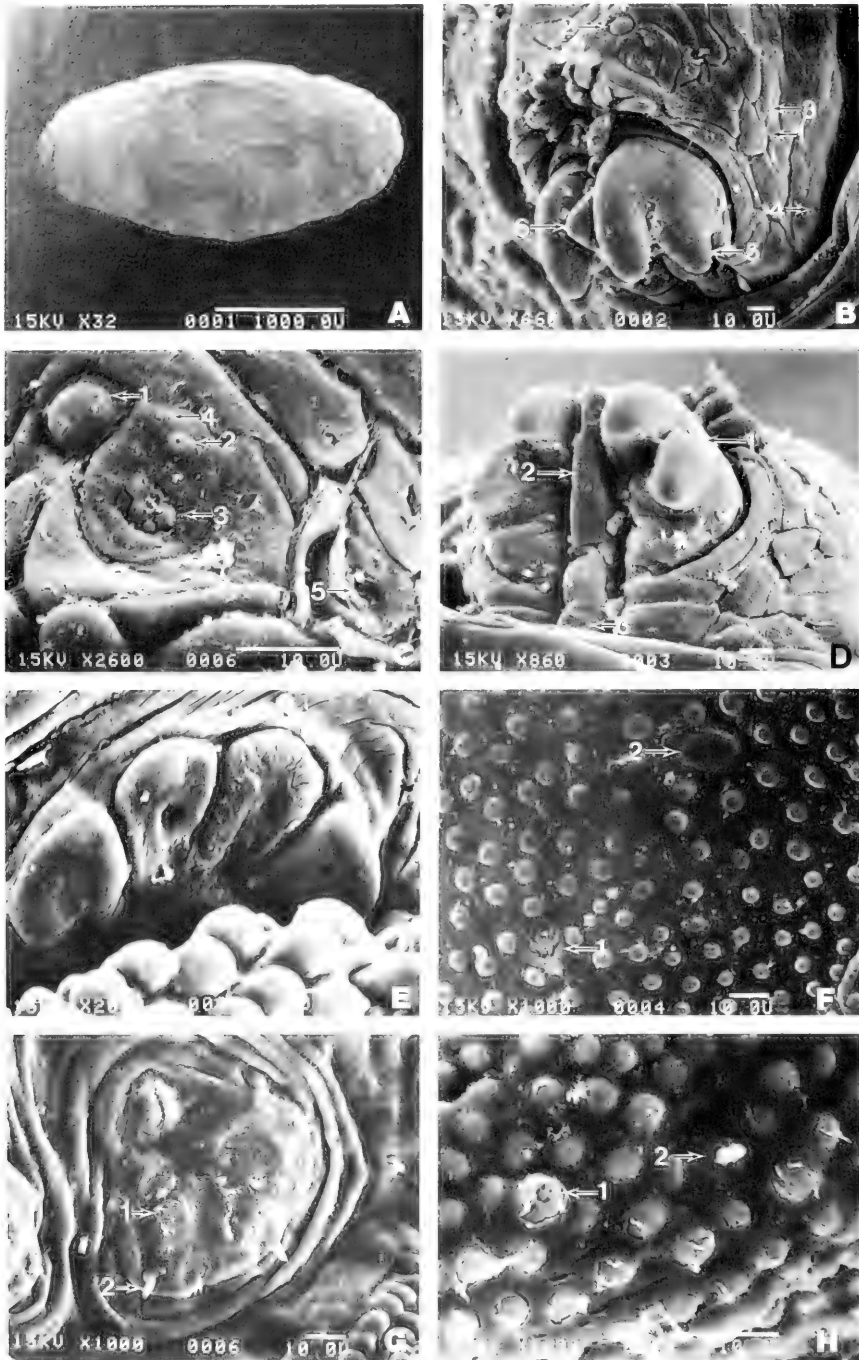


Fig. 2. Third instar larva of *V. californica*: (A) habitus, anterior to left; (B) gnathocephalon, left anterolateral view, 1—rugose pads, 2—dorsal sensory organ, 3—lateral sensillum, 4—ventrolateral sensillum, 5—mouth hooks, 6—median oral lobe; (C) left anterior sensory lobe, 1—dorsal sensory organ, 2—lateral sensory organ, 3—terminal sensory organ, 4—papillate sensillum, 5—stomal sense organ; (D) gnathocephalon, ventral view, 1—mouth hooks, 2—median oral lobe, 3—labial sensilla; (E) anterior thoracic spiracles; (F) lateral spiracular complex,

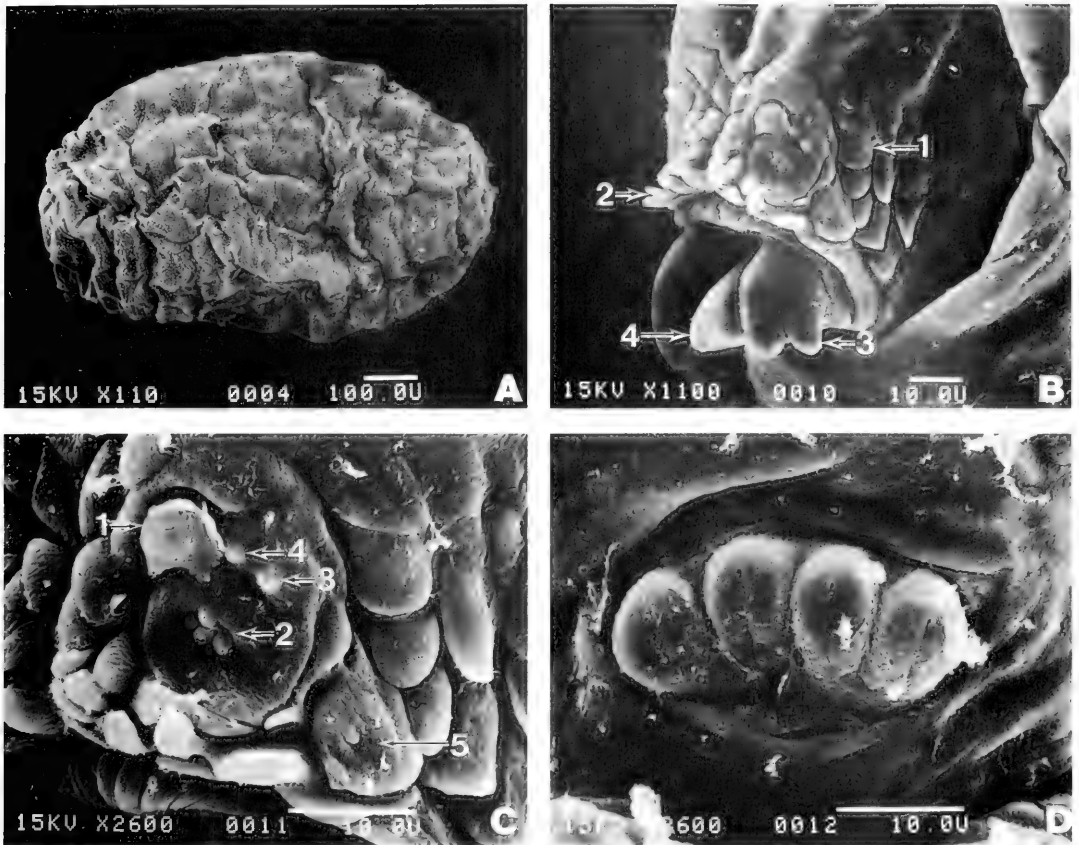


Fig. 3. Second instar larva of *V. californica*: (A) habitus, anterior to left; (B) gnathocephalon, anterolateral view, 1—rugose pads, 2—dorsal petals, 3—mouth hooks, 4—median oral lobe; (C) anterior sensory lobe, 1—dorsal sensory organ, 2—terminal sensory organ, 3—lateral sensory organ, 4—papillate sensillum, 5—stomal sense organ; (D) anterior thoracic spiracles.

like interspiracular processes, longest measuring 0.002 mm; caudal sensilla could not be seen on this specimen.

The features of the second instar of *V. californica* are fairly well-developed morphologically. The gnathocephalon closely resembles that of the third instar. The rugose pads are more widely separated. The petals are present dorsal to the mouth lumen. The mouth hooks are similar in shape to the third instar and bidentate. The me-

dian oral lobe is also similar in shape to that of the third instar. The pit sensory organ was not observed on the anterior sensory lobe of the second instar. The lateral and ventrolateral sensilla were also not observed in the second instar. The lateral spiracular complex could not be seen in the sole specimen examined. The caudal segment, while not pictured, resembled the caudal segment in the third instar.

Puparium.—Puparium creamy white

←
second abdominal segment, 1—spiracle, 2—verruciform sensillum; (G) caudal segment, spiracular plate, 1—rima, 2—interspiracular process; (H) caudal segment, compound sensillum, 1—tuberculate chemosensillum, 2—stelex sensillum.

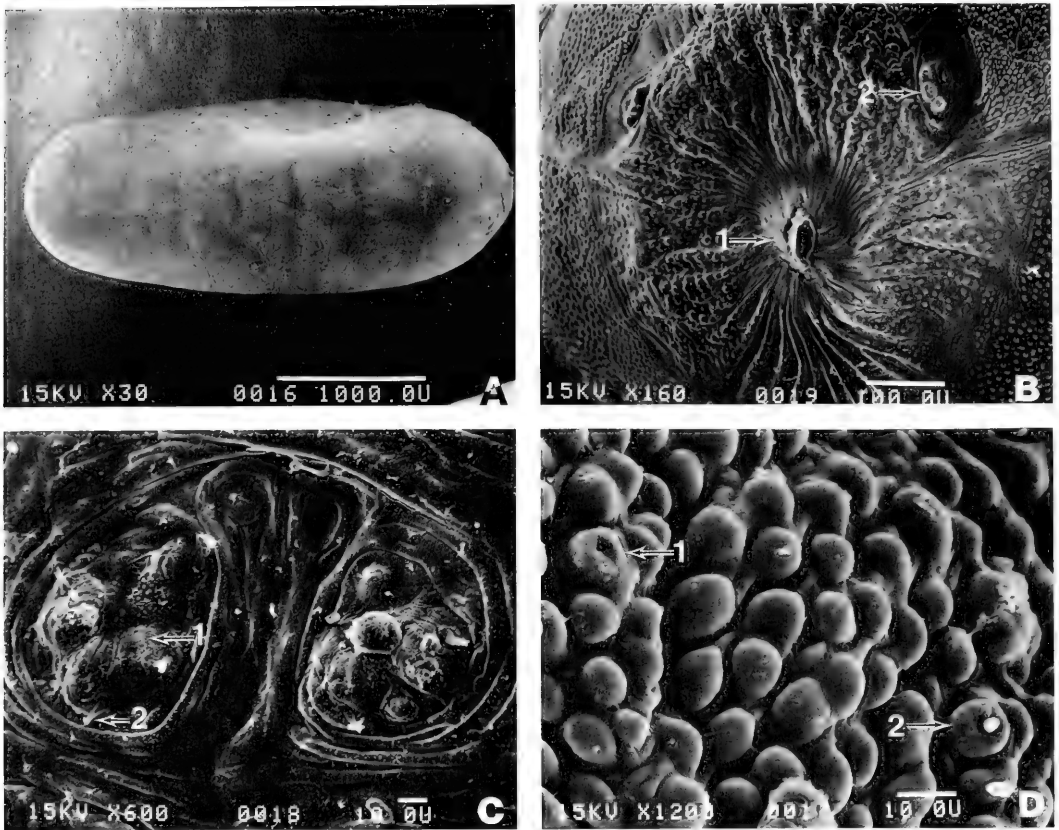


Fig. 4. Puparium of *V. californica*: (A) habitus, anterior to left; (B) anterior end, 1—invagination scar, 2— anterior thoracic spiracles; (C) caudal segment, posterior spiracular plate, 1—rima, 2—interspiracular process; (D) caudal segment, compound sensillum, 1—tuberculate sensillum, 2—stelex sensillum.

when newly formed, darkening to brown, or black with age; elongate-ellipsoidal; minute, dome-shaped verrucae remain distinct (Fig. 4A); 69 puparia averaged 3.14 ± 0.05 (range, 2.3–3.9) mm in length, 1.28 ± 0.02 (range, 0.90–1.59) mm in width; anterior end bears the invagination scar (Fig. 4B-1); anterior thoracic spiracles dorsolaterad of the invagination scar (Fig. 4B-2); posterior spiracular plates bear three oval rimae ca. 0.02 mm in length (Fig. 4C-1), and four, thorn-like interspiracular processes, the longest measuring 0.01 mm (Fig. 4C-2); compound sensilla, i.e. a tuberculate chemosensillum (Fig. 4D-1) and a stelex sensillum (Fig. 4D-2), ventrad of the spiracular plates were retained.

Wangberg (1978) reported that an unstated number of puparia of *Valentibulla* spp. averaged 3.74 (range, 3.2–4.0) mm in length, considerably longer than our mean and lower limit.

Distribution and hosts

The known distribution of *V. californica* includes the western third of the U.S. as mapped by Foote et al. (1993), who also noted that it had been collected in Baja California Norte. Its known hosts are *Chrysothamnus nauseosus* (Novak et al. 1967, Wasbauer 1972, Wangberg 1978, Foote et al. 1993) and *C. parryi* (Gray) Greene (Wangberg 1978), a high-altitude species in southern California (Munz 1974) which we

have not examined for the presence of *V. californica*.

Biology

Egg.—The egg is inserted pedicel-last for up to two-thirds its length into a current or preceding year's branch and within or near a prominent axillary bud. The axillary bud was used as a point of purchase on the smooth stems by the ovipositing female in insectary cages, where as many as eight eggs were inserted into one axil. However, based upon dissections of field samples, an average of only 1.4 ± 0.1 (range, 1–4) eggs ($n = 80$) were inserted singly into or near individual buds by one or more females.

Larva.—Upon eclosion, the first instar tunnels apically (17%) or basally (83%) ($n = 72$) into the branch above or below the axillary bud, which subsequently may or may not be killed by larval feeding. The tunnel increases in diameter as the larva grows and deeply scores the woody pith (Fig. 5A), sometimes reaching the opposite epidermis (Fig. 5C), and thus killing the distal part of a thin branch. In most cases, however, the branch above the larva continues its growth apparently unharmed; accordingly, 45 larval tunnels were found upon dissection to begin an average of 10.1 ± 0.9 (range, 1.7–24.5) cm below the apical meristems in live branches. The initial, narrowest part of the larval mine became packed with frass for a distance of 2.3 ± 0.1 (range, 0.8–8.0) mm ($n = 78$) (Fig. 5C). The remainder of the tunnel was open and formed the cell within which the larva fed, presumably on sap conducted to and expressed from the surrounding woody tissues; these excavations are not much larger than the fully grown larvae and puparia (Fig. 5C, D). This type of larval development closely resembles that of *Tephritis arizonaensis* in its branch-tip mines on the woody shrub, *Baccharis sarothroides* Gray (Goeden et al. 1993). It also resembles *Aciurina thoracica*, the larvae of which feed within small branch-tip galls on *B. sarothroides* (Headrick and

Goeden 1993), because of the small excavations formed by both species. However, unlike *A. thoracica* and contrary to Wangberg (1978), we could not bring ourselves to call the feeding sites of *V. californica* "galls." Instead, like Foote et al. (1993), we prefer the description, slight "swelling," or better yet, as Dodson (1987b) described the "gall" of *V. dodsoni* Foote "a rather inconspicuous swelling" of a branch, because this is the only external sign of the larva or puparium within (Fig. 5A, B, C, D, E). Neither do our observations agree with the description for *V. californica* by Wangberg (1978, p. 481) that its "Galls are usually polythalamous and contain 2–6 . . . larvae. Each larva is housed in a cavity that is separated from the others by a tissue wall." Further discussion of this matter follows in the next subsection.

Before pupariation, the fully grown larva of *V. californica* excavates a circular, epidermal window above one end of its cell (Fig. 5G). The larva then pupariates facing the window either basally (36%) or apically (63%, $n = 78$) along the branch.

Pupa.—Eighty-seven full-size cells containing puparia (Fig. 5D, E) measured 4.6 ± 0.1 (range, 2.6–7.1) mm in length and 1.3 ± 0.02 (range, 0.4–1.7) mm in width. Thirty of these cells were found within branches that averaged 2.2 ± 0.2 (range, 0.8–4.4) mm in diameter. The branch diameters just above ($n = 23$) and just below ($n = 30$) these cells differed from the aforementioned stem diameters at the middle of these cells by only 0.4 ± 0.06 (range, 0.0–1.0) mm and 0.3 ± 0.05 (range, 0.0–1.1) mm, respectively. Masked by normal variations in thickness of uninfested branches and stems of *C. nauseosus* at our study site, and by the conspicuous galls caused by other insects, e.g. *Aciurina trixa* Curran (Wangberg 1981, Dodson and George 1986, Dodson 1987b) and several species of Cecidomyiidae (Gagné 1989), the slight swellings symptomatic of *V. californica* are, indeed, "inconspicuous." We further suggest that the gall of *Valenti-*

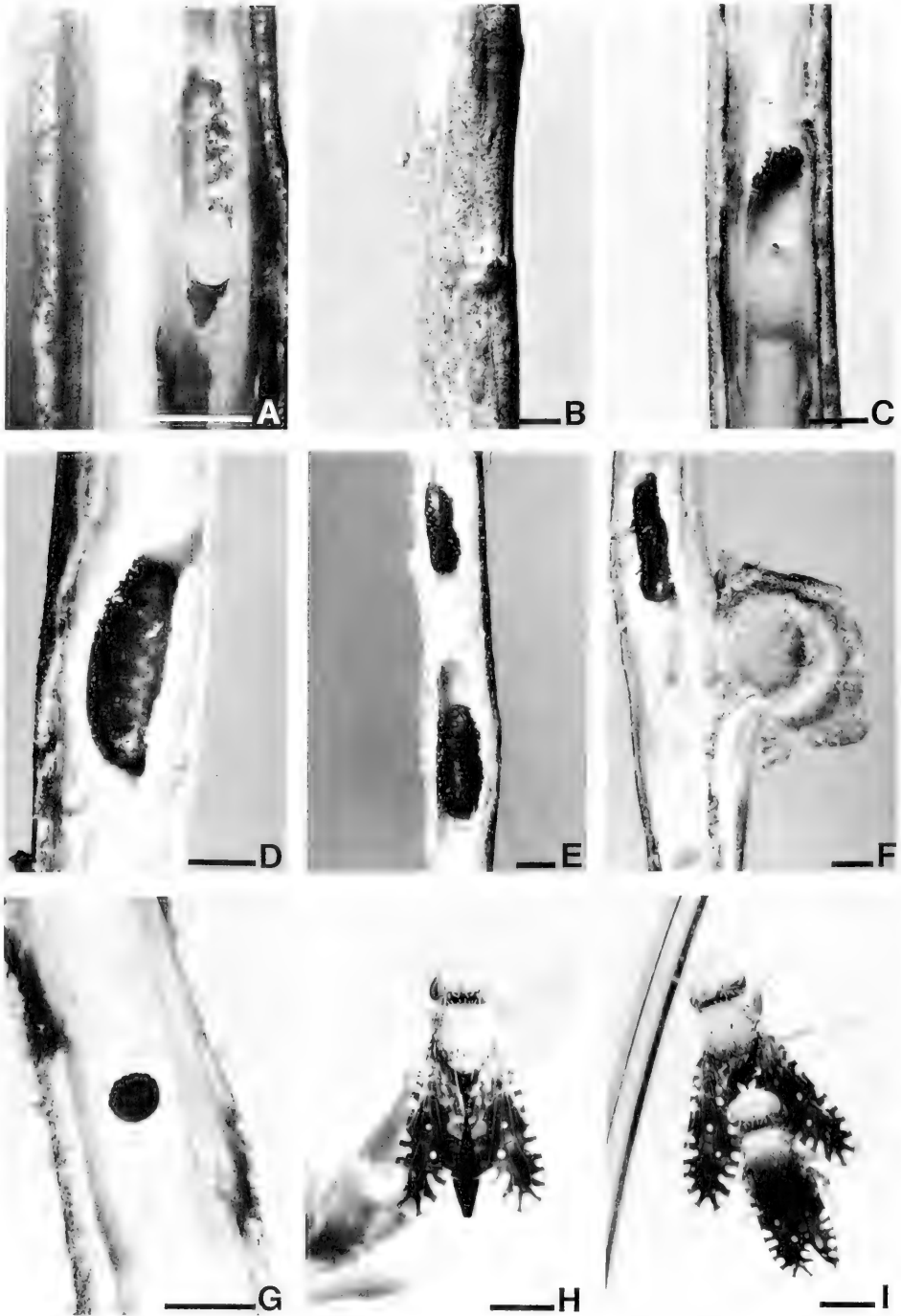


Fig. 5. Life stages of *V. californica*: (A) young larva in branch of *Chrysothamnus nauseosus*; (B) branch where fully grown larva in (C) was found; (D) saggital section of branch with intact puparium in cell facing exit hole still covered by epidermal window; (E) two puparia in cells within same branch; (F) puparium of *V. californica* formed beneath gall of *Aciurina trixa*; (G) exit hole in branch; (H) female adult; (I) mating pair. Line = 1 mm.

bulla spp. pictured by Wangberg (1978) and his description of it quoted above, instead probably refer to a misidentified cecidomyiid gall. This interpretation also may explain differences in the galls described for *V. dodsoni* by Dodson (1987a, b) and for *Valentibulla* spp. by Wangberg (1978). Moreover, *V. californica* larvae and puparia readily were found in juxtaposition to galls of Cecidomyiidae in branches during the present study, and during our laboratory dissections occasionally were located beneath or near galls of *A. trixa* (Fig. 5F, unpublished data). Another ambiguity is the report by Novak et al. (1967) that *V. steyskali* Foote [as *munda* (Coquillett)] larvae form "large, polythalous galls" on stems of *C. nauseosus* in Idaho. These same authors reported *V. californica* from flower heads of *C. nauseosus* in Idaho, where Wangberg (1978) conducted his study. Nevertheless, after 3 years of study, we remain unable to approach individual plants of *C. nauseosus* known from past dissections to harbor *V. californica* at our main study site and with any measure of assurance select branches infested with this tephritid. This alone attests to the inconspicuousness of immature *V. californica* *in situ* in southern California.

Adult.—Egress of the adult (Fig. 5H) entails breaking through the epidermal window covering each exit hole (Fig. 5G). Newly emerged females (Fig. 5H) have immature ovaries ($n = 3$), but within 2 weeks, the numerous, small, irregularly rounded, fat globules found in the haemocoel disappear and are converted into full-size ova. In insectary cages, isolated, unmated, non-ovipositing females (Fig. 5H) lived 45 ± 2.8 (range, 37–56) days; isolated, unmated males lived 49 ± 1.6 (range, 42–55) days.

Wing displays.—Adults of *V. californica* held their wings parted with the posterior wing margins along the abdominal pleura, supinated 45° – 60° relative to the substrate, and with the wing blade bent ventrally at the subcostal break in the costal margin.

Both sexes displayed synchronous and asynchronous supinations with their wing blades in the bent position and with ancillary rotations as described for *Aciurina thoracica* (Headrick and Goeden 1993). Both sexes also displayed abdominal flexures during asynchronous supination, also described for *A. thoracica*, *Paroxynagenalis* (Thomson) (Goeden et al. 1994b), and *Trupanea californica* (Headrick and Goeden 1991).

Mounting, copulatory induction behavior, and copulation.—Males of *V. californica* did not display aggregation behaviors such as abdominal pleural distention, wing displays, territoriality, and male-male combat as described for and commonly observed in other non-frugivorous tephritids (cf. Headrick and Goeden 1990, 1991, 1993, Goeden and Headrick 1991b, 1992b, Goeden et al. 1994b, Headrick et al. 1994). Nor did they initiate courtship displays involving movement of one or more body parts, also commonly observed in non-frugivorous tephritids in either laboratory or field observations (cf. Headrick and Goeden 1990, 1991, 1993, Goeden and Headrick 1991, 1992, Goeden et al. 1993). Males of *V. californica* oriented toward and stalked females from behind, then abruptly jumped onto their dorsa, as described for *V. dodsoni* and *A. trixa* males (Dodson 1987, Headrick and Goeden, unpublished data). As also observed for *A. trixa*, *V. californica* females immediately began rapid walking around the arenas after being mounted, as the males struggled to hold onto them with their front legs. Because mounting by males was so abrupt, they often landed on females in awkward positions that required re-positioning themselves to successfully gain intromission. This readjustment also was observed with *A. thoracica* males (Headrick and Goeden 1993). After mounting and successfully holding onto the female, the male then curled the apex of his abdomen ventrally and placed his epandrium at the apex of her oviscape. His front legs grasped the

widest portion of her abdomen and his middle and hind legs rested on the substrate. The mounted female used her hind legs to push vigorously at the male. The male initiated copulatory induction behavior (CIB) immediately after positioning himself on the female. CIB involved the mounted male drumming vigorously on the venter of the abdomen of the female with his hind legs, unlike *A. thoracica* males who used their middle legs for CIB (Headrick and Goeden 1993). The receptive female exerted her aculeus which pushed the male backward to accommodate its length, because the male kept his abdomen curled ventrally. Insertion of the aedeagus through the ventral flap into the cloacal opening followed aculeus exertion and the female began to slowly retract her aculeus as the male moved forward on the female to assume the copulatory posture (Fig. 5I). During copulation the female intermittently exerted pressure on her aculeus which in turn stimulated the male to begin agitation wing displays. The agitated male lofted his wings, as described for *P. genalis* (Goeden et al. 1994b), 45° above the long axis of his body, while slightly parted and the wing blades were supinated to 90°. Then, the wings were synchronously lowered ca. 10° and raised again without vibration once every half second. The male returned his wings to the typical resting position along his pleura when the agitation stimulus ceased.

After ca. 1 h in copula, the female began to push at the male with her hind legs. This activity signaled the termination of copulation. Disengagement lasted ca. 1 min. The male lifted his abdomen and moved backward on the female; his hind legs were on the substrate and his middle legs were around her ovipositor. He continued to raise his abdomen, disengaged his surstyli from the aculeus, and pulled his aedeagus from the ventral flap while he remained mounted on the female. This disengagement was similar to that described for *P. genalis* males (Goeden et al. 1994b). After disengagement,

the male moved forward on the female and with the aid of his hind legs recoiled the aedeagus. Males initiated CIB behavior in laboratory cagings after ca. 1 min by grasping the ovipositor and drumming it vigorously with the middle legs. Copulations were commonly repeated by the same individuals in less than 1 h; however, no more than two copulations were observed in a single day. After disengagement, females began turning rapidly in circles and resumed buffeting the mounted males with their legs and wings. This latter behavior continued until the male either lost his grip and fell off the female or she again exerted her aculeus. After a second copulation, males fully dismounted from females, which typically displayed aggression by synchronously extending their wings and lunging at males. The only copulation timed from start to finish lasted 1 h.

Field observations.—Adults of *V. californica* were observed on *C. nauseosus* plants along with adults of *Aciurina trixa* and *Proceidochares minuta* Snow at the Cajon Junction study site. Adults of *A. trixa* were prevalent at the start of field observations on 8.iv.1992, but diminished in numbers as densities of *P. minuta* increased to 12.v.1992. A total of only eight adults of *V. californica* was observed during all 4 weeks. Males were observed singly on host plants usually in the interior of the crowns and at rest on stems; all three females were observed while ovipositing. No encounters between the sexes were observed. Females oviposited into leaf axils apparently utilizing the same ovipositional niche as *A. trixa* and *P. minuta* females (Headrick and Goeden unpublished data); however, their oviposition behavior was different from these two species. *Valentibulla californica* females did not climb to the tops of branches before ovipositing in the leaf axils as observed for both *A. trixa* and *P. blantoni* (Headrick and Goeden, unpublished data), but rather explored for oviposition sites on the lower portions of branches.

Wangberg (1978) reported that adults of *Valentibulla* spp. on *C. nauseosus* in Idaho were active on host plants throughout the day and displayed their wings toward congeneric individuals. He further described females as vying for the attention of males, which then pursued the females by following behind them. The male then continued to approach the female and if she stood still, he moved behind her and tapped her with his front tarsi. This initial tracking and contact lasted from 1–2 s to 1–2 h. Receptive females remained motionless and males then mounted them. Wangberg (1978) noted that males bent their abdomens ventrally in “an effort to penetrate (the female) with his genitalia.” He also reported that copulations lasted 60–90 min, but did not note any disengagement behavior or repeated copulations by males. Finally, Wangberg (1978) reported that females oviposited under the epidermis of stems rather than into leaf axils as observed in the present study.

Seasonal history.—*Valentibulla californica* is univoltine and nondiapausing on *C. nauseosus* in southern California. Adults emerge in late winter and early spring (February–April) and mating and oviposition commence shortly thereafter; both latter behaviors continue for about 1½ months. The eggs hatch in about a week and the larvae feed and grow slowly through late-spring, summer, and fall (April–November) with pupariation occurring in winter (December–March), as the cycle resumes.

Natural enemies.—Three species of chalcidoid Hymenoptera were reared as primary, solitary endoparasitoids from individual puparia of *V. californica* dissected from *C. nauseosus*: *Eupelmus* sp. (Eupelmidae), *Eurytoma* sp. (Eurytomidae), and *Halticoptera* sp. (Pteromalidae). Wangberg (1978) reported an *Eupelmus* sp. and *Halticoptera* sp. as associates of *Valentibulla* spp. galls, but also *Platygaster* sp. (Hymenoptera: Platygasteridae), known parasitoids of Cecidomyiidae (Clausen 1962) and never reared by us from any Tephritidae in

southern California to date (unpublished data).

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A BASAL NEW SPECIES OF *OLBIOGASTER*
(DIPTERA: ANISOPODIDAE) IN DOMINICAN AMBER,
AND ITS SYSTEMATIC PLACEMENT

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Abstract. — A distinctively new species of *Olbiogaster* is described from Oligo-Miocene amber of the Dominican Republic. It is based on a single, virtually complete female and named ***Olbiogaster perezi***. Phylogenetic analysis of external morphological characters indicates it is probably the sister group to all of the living species of the genus, or at least among a group of phylogenetically basal species. The four living species of *Olbiogaster* described from Caribbean islands belong to clades that are more recently derived than is the fossil.

Key Words: Anisopodidae, amber, *Olbiogaster*, cladistics

The family Anisopodidae, in the broad sense, is a small family of relatively primitive flies that is of keen phylogenetic interest. Only about 100 species are described for the family, which is probably no more than half of the actual number of species. The larvae occur under bark of decaying trees, rotting vegetation, and associated with fungi. Major, synthetic papers on the systematics of the family are by Amorim and Tozoni (1994) and Tozoni (1989). The former is a phylogenetic classification of the world genera of Anisopodidae, s.l.; the latter is a phylogenetic study of the species of *Olbiogaster*, from which we drew heavily for characters to study.

This is the second paper on Dominican amber Anisopodidae. The first one, by Grimaldi (1991), described four species: *Valeseguya disjuncta*, *Mycetobia antillea*, *Mycetobia cryptambra*, and *Mesochria neotropica*. The last three species Amorim and Tozoni (1994) are placing in a new genus,

Neomesochria, with all the Neotropical species formerly put into *Mycetobia* as well as two New Caledonian species. *Valeseguya disjuncta* is of great interest because it is a relict: its closest living relative is *Valeseguya rieki* from Australia, the only other member of this aberrant genus. Amorim and Tozoni (1994) placed *Valeseguya* in a narrowly defined family, the Mycetobiidae (including also *Mycetobia*, *Mesochria*, and *Neomesochria*). The placement of *Valeseguya* with mycetobiines is currently being tested using DNA sequences from the amber fossils (DeSalle and Grimaldi, in prep.). *Valeseguya disjuncta* is curiously much more common than the other mycetobiines in Dominican amber (even though the genus is now restricted to Australia). Also, the extinct species is represented by a large series of males and females; the one living in Australia is represented by a few poorly preserved males. The finding of an *Olbiogaster* in Dominican amber now adds a major new

component to this extinct fauna of anisopods.

METHODS AND MATERIALS

We are indebted to J. Manuel Perez for providing the specimen to us for study. Exact provenance within the Dominican Republic is uncertain but derives from the group of central mines in the mountains surrounding Santiago. Despite repeated citations of Dominican amber being Eocene in age (ca. 40 myo), there is very little basis for that dating. Grimaldi (1995) reviewed the stratigraphic evidence. At present it is most prudent to assume a Miocene-Oligocene age (ca. 25 million years old). The specimen was prepared and photographed as given in Grimaldi (1991, 1993).

SYSTEMATICS

Genus *Olbiogaster* Osten-Sacken, 1886

Tozoni (1989) and Amorim and Tozoni (1994) provided diagnostic characters of the genus. These included several aspects of male sternite 10 (bifid apically, with a pair of lateral projections, and slender at the base but apically enlarged) and the gonostyles (slender, with setae on the outer face). The most obvious feature that distinguishes this genus is vein M_3 weaker than the other posterior veins.

The genus *Olbiogaster* is restricted to the New World, with all but two species being Neotropical. Tozoni (1989) indicated that there were 7 undescribed species from Brazil. Only 4 species are described from the Caribbean: *antillarum* Lane & D'Andretta (U.S. Virgin Islands), *fulva* Edwards (Puerto Rico), *danista* Stone and *evansi* Stone (island of Dominica, Lesser Antilles).

Olbiogaster perezii Grimaldi and Amorim, NEW SPECIES

Fig. 1

Diagnosis.—Head and thorax with distinctive pattern of dark brown areas (see

description). Wing with stigma surrounding basal half of vein R_{2+3} . Discal cell fusiform, ends not truncate, with medial veins branching directly off apical point. Vein M_3 lost distad of discal cell. Tergites and sternites mostly blackish-brown.

Description.—*Body coloration*: With extensive dark brown areas, including: clypeus and antennal bases; gena, postgena; labium; antenna (except the scape and pedicel); postpronotal lobe; notum, posterior half of scutellum; anepisternum and katepisternum; anterior and posterior basalares; portion of the anatergite; katatergite; coxae and trochanters (mid coxa less so); hind femora and tibiae; all tergites and sternites.

Head: Antenna with 14 cylindrical segments; pedicel very short. Eye large, completely bare. Palp with 5 segments; basal 2 almost circular, third segment longest and widest; 2 apical segments equal to length of segment 3 but half the thickness. Clypeus protruding, extended to apex of palp segment 3. Labellum large, laterally flattened. Gena, postgena, and labium with numerous, fine, whitish setae. Occiput with 6 stiff, black setae.

Thorax: Notum covered with fine, whitish, decumbent acrostichal setulae. Postpronotal lobe large, with ca. 30 fine, whitish setae. Anepisternum heavily sclerotized, with patch of 20 fine, whitish setae on dorsal lobe; rest of anepisternum bare. Katepisternum completely bare. Anterior and posterior basalare heavily sclerotized. Anepimeron lightly sclerotized, with small patch of ca. 10 fine, whitish setae on postero-dorsal portion. Katatergite sclerotized, bare. Legs: Fore and midlegs yellow, apices of tibiae and tarsi brown. All legs with setulae irregularly arranged (not in longitudinal rows); tibiae and tarsi with 3–4 longitudinal rows of stiff, stout, black setae. Comb on apex of hind tibia not visible: lost with tarsi at surface of amber.

Wings: Membrane with microtrichia only, arranged irregularly, not in rows. Wing veins dark; radial veins darkest. Costal vein



Fig. 1. Habitus of holotype of *Olbiogaster perezii*, n. sp.

extended to slightly past R_{4+5} . Sc and R_1 meeting C very close together. Dark stigmal area surrounding apical half of R_{2+3} . R_{4+5} extended to tip of wing. Crossvein r-m very short, connected to middle of discal cell (d); cell d is fusiform in shape, ends not truncate. Veins M_1 and M_2 arising from apical point of cell d, vein M_3 absent distad of discal cell.

Crossvein cu-m very short, proximal to r-m, branch of CuA_1 and CuA_2 almost perpendicular to longitudinal axes of veins. Vein A_1 incomplete, A_2 obscured. Halter light yellow.

Abdomen: Tergites and sternites dark brown; sternites large, covering pleural area. Apical sternite light, elongate, with deep

V-shaped notch in middle. Cerci long, narrow, dark.

Holotype: Female, AMNH-DR11-657, in a clear, light yellow piece of amber, 10 × 13 mm; exact provenance within the Dominican Republic unknown. The surface of the piece on the fly's right side has been ground and polished flat. The specimen is virtually complete, except for loss of the mid and hind tarsi.

Etymology: Patronym, for J. Manuel Perez, an amber dealer in Orlando, Florida, who made this specimen available for study.

RELATIONSHIPS

Tozoni (1989) presented a phylogenetic analysis of the species of *Olbiogaster*, including 21 described and 7 new species (the new species are actually described in Tozoni [1994], with an additional 6 species). Her phylogeny of the genus included four major subgroups widely distributed in the Neotropical region. The genus is defined here in the sense of Amorim and Tozoni (1994), diagnosed above. Features used in her analysis were derived mostly from male terminalia and body coloration. Sexual dimorphism in sclerite colors exists, and not all species are known by both sexes, so separate cladograms had to be developed for males and females. In both males and females there occurred transformation series where the color of sclerites changed from brown to ochre or yellow.

Olbiogaster has most sclerites brown, except part of the scutellum, epimeron II and capitulum of the halter. It is thus clear that *O. perezi* is not a recently derived species in the genus. The basal levels of Tozoni's (1989) phylogeny for the recent species is completely resolved into five clades. Character incongruence was evaluated using the ACCTRAN and DELTRAN procedures, which allowed for reversals and multiple origins of characters, respectively (Figs. 2, 3). The reversals in the cladogram of Fig. 2 do not imply reacquisition of complex structures, so this shorter cladogram is the preferred explanation.

We present below Tozoni's (1989) list of the features that can be examined in the fossil species (e.g. external female), and which refer to the level of generality of this discussion; the character matrix is presented in Table 1. Note that *Olbiogaster mexicana* is known from Mexico, *O. danista* from Dominica, *O. erythrohydra* and *O. tamioi* are from southeastern Brazil; the remaining species, in the *marinonii* group, occur throughout the Neotropical Region (except Chile and southern Argentina). Plesiomorphic states are given first for each character. Use of a superscript cross (+) denotes a monophyletic group plus its sister group(s). This is a convention established by Amorim and used elsewhere (e.g., Amorim and Tozoni, 1994).

1. Scutum entirely brown/scutum yellow or ochre.

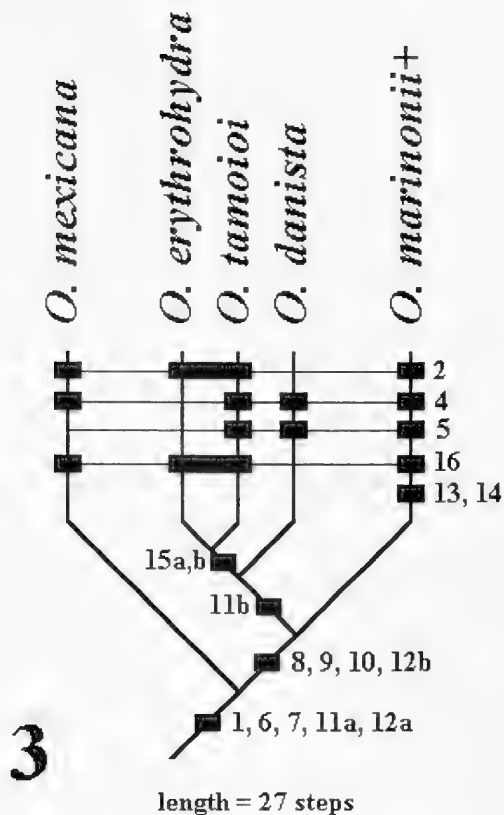
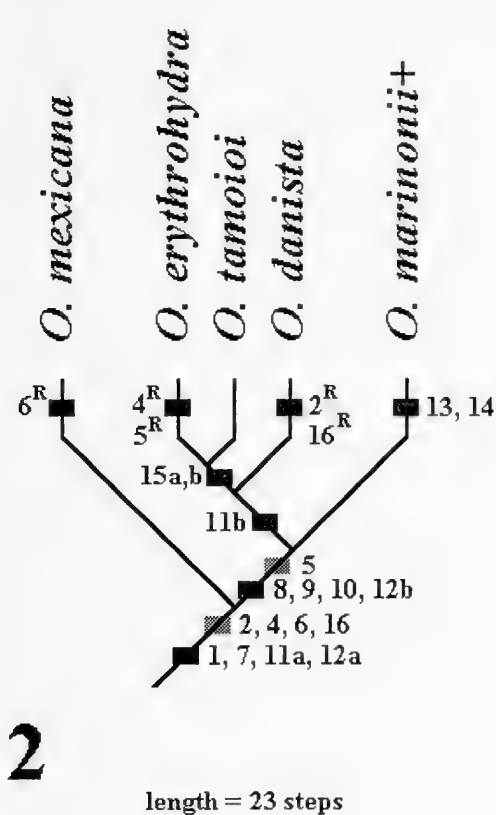
The plesiomorphic condition of this character in *Olbiogaster* is found only in *O. perezi*. This is one of the features that indicates *O. perezi* is the probable sister group of all the remaining species of the genus. Most species of *Eogaster*, *Austrogaster*, and *Olbiogaster* have a brown scutum, leaving no doubt about the polarity of the character.

2. Scutellum entirely brown/scutellum entirely yellow or ochre.
3. Scutellum entirely brown/scutellum yellow below.

The polarization of these characters is also unquestionable. An entirely brown scutellum is known to occur only in *O. danista*, from Dominica. *Olbiogaster perezi* is plesiomorphic for the color in the dorsal part of the scutellum, but has an apomorphic color for the ventral surface of the scutellum. Character two also indicates that *O. perezi* would be the sister group of the remainder of the genus.

4. Anepisternum entirely brown/anespi-sternum entirely yellow or ochre.

The plesiomorphic condition of this character is found in *O. perezi* and *O. erythro-*



Figs. 2, 3. Basal relationships of *Olbiogaster* as proposed by Tozoni (1989), with two interpretations for the transformation series. 2, ACCTRAN procedure for all characters, allowing for character reversals (shaded characters). 3, DELTRAN procedure for all characters, allowing for multiple origins of characters (characters placed above in the cladogram).

hydra. Some species belonging to the monophyletic *marinonii*⁺ group have brown maculae on the anepisternum, but character optimization shows that the ground plan of this group should be apomorphic for these characters (species with maculae being cases of reversals). An ACCTRAN optimization of this character results in two steps, a DELTRAN approach produces four. However, neither approach affects the position of *O. perezii* in the cladogram, since the monophyly of *erythrohydra* + *tamoioi* is well supported and unambiguous.

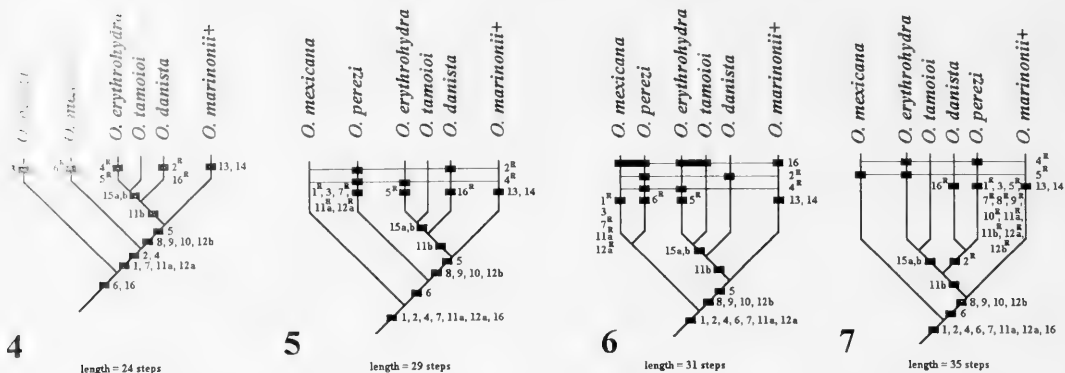
5. Katepisternum brown/katepisternum entirely yellow or ochre.

The plesiomorphic condition of this character is found in *O. perezii*, as well as in *O.*

mexicana and *O. erythrohydra*. As in the preceding character, some species of the *marinonii*⁺ group also have brown maculae on the katepisternum, but the group is apomorphic in its ground plan. On this basis

Table 1. Character matrix for the basal groups of *Olbiogaster*.

Taxon	Character									
	1	2	3	4	5	6	7	8	9	10
Outgroups	0	0	0	0	0	0	0	0	0	0
<i>perezii</i>	0	0	1	0	0	0	0	0	0	1
<i>mexicana</i>	1	1	0	1	0	0	0	0	0	1
<i>erythrohydra</i>	1	1	0	0	0	0	1	1	1	1
<i>tamoioi</i>	1	1	0	1	1	1	1	1	1	1
<i>danista</i> gr.	1	1	0	1	1	1	1	1	1	0
<i>marinonii</i> gr.	1	1	0	1	1	1	1	1	1	1



Figs. 4-7. Four topologies for the relationships of *O. perezi* with remaining species of the genus. 4, Characters 1, 2, 4, 7, 11a, and 12a are taken as true synapomorphies, so *O. perezi* would be the sister group of the rest of the genus. 5, Characters 5, 6, 8, 9, 10, and 12b are considered true synapomorphies, so *O. mexicana* becomes the sister group to the rest of the genus, with *O. perezi* as the next plesiomorphic sister group. 6, Assumption of character 16 having multiple origins and the apomorphic condition shared by *O. perezi* and *mexicana* interpreted as a true synapomorphy. 7, Reversal of character 2 interpreted as a true synapomorphy, which links *danista* and *perezi*, and many plesiomorphic conditions in the latter species thus becoming reversals.

the fossil species is excluded from the *marinonii+* group.

- 6. Epimeron II entirely yellow/epimeron II entirely brown.

Olbiogaster perezi has epimeron II entirely yellow (sometimes referred to in the Anisopodidae as the anepimeron). *Olbiogaster mexicana*, on the other hand, has the sclerite entirely brown (based on the published description) and some species of the *marinonii+* group also have epimeron II maculated brown. The fact that *O. perezi* shares the apomorphic condition with the remaining species of the genus except *O. mexicana* indicates that it could belong to the *danista*⁺⁺ group (Figs. 5-7), a topology different from that suggested by characters 1, 2, 4, 7, and 12a (Figs. 4-6).

- 7. Mediotergite entirely brown/mediotergite entirely yellow or ochre.

Olbiogaster perezi is the only species in the genus to have the mediotergite entirely brown. This would indicate a sister-group relationship between *O. perezi* and the rest of the genus.

- 8. Coxa I entirely brown/coxa I entirely yellow or ochre.
- 9. Coxa II entirely brown/coxa II entirely yellow or ochre.
- 10. Coxa III entirely brown/coxa III entirely yellow or ochre.

Olbiogaster mexicana is the only species of the genus sharing with *O. perezi* the plesiomorphic condition of this character. Although the two species cannot be linked on the basis of this symplesiomorphy, it corroborates that *O. perezi* does not belong to the *danista* group.

- 11. Femur III entirely brown/a. with distal ¼ brown / b. entirely yellow or ochre.

The presence of an entirely brown femur III in *Olbiogaster* is exclusive to *O. perezi*. At this level of the analysis, the most apomorphic condition, of femur III being entirely yellow, is found only in the species of the *danista*⁺ group, and occurring homoplasiously in the *marinonii*⁺ group. The first step corroborates the hypothesis of *O. perezi* being the sister group to the remaining *Olbiogaster*.

12. Tergites I–IV entirely brown/a. with distal $\frac{1}{2}$ yellow / b. with distal $\frac{1}{2}$ yellow.
13. Tergites I–IV entirely brown/with a median yellow line on distal $\frac{2}{3}$.
14. Tergites I–IV entirely brown/a. with a yellow band laterally on distal $\frac{2}{3}$. / b. with a complete yellow band.
15. Tergite V entirely brown/with a median yellow line on distal $\frac{2}{3}$.

A complex transformation series is proposed by Tozoni (1989) for the coloration of the abdominal tergites in *Olbiogaster*, varying from brown to yellow. These modifications include independent changes in different areas of the sclerite (distally, laterally, and mesally), and with homoplasious origins of some of these changes. *Olbiogaster perezii* is the only known species with the tergites entirely brown. *Olbiogaster mexicana* has only the distal fifth of tergites I–IV yellow and other species have a larger portion of the tergites yellow. This, once more, confirms the basal position of *O. perezii* in the genus.

16. Capitulum of halter brown/yellow.

Olbiogaster has the capitulum yellow, as do other basal species of the genus with the exception of the *O. danista* and some species belonging to the *marinonii*⁺ group. If the apomorphic condition of the character is attributed to the ground plan of the genus, the plesiomorphic condition of this character in *O. danista* would be a reversal.

Of the list above, *O. perezii* is apomorphic only for characters 3, 6, and 16. Character 3 is an autapomorphy. Character 6 is shared with all *Olbiogaster* except *O. mexicana* and character 16 is shared with most species of the genus, but is plesiomorphic in *O. danista*. The plesiomorphic conditions of characters 13 and 14 exclude *O. perezii* from the *marinonii* group. The topology of the most parsimonious cladogram has *O. perezii* as the sister group of all remaining known recent *Olbiogaster* (Fig. 4). The apomorphic

features of *O. perezii*, however, allow for some alternative hypotheses. *Olbiogaster perezii* could be the sister group of all recent species of the genus except *O. mexicana*, which in this case would be the most basal species of the genus (Fig. 5). This hypothesis would be obtained if we consider the yellow epimeron II of *O. perezii* (character 6) homologous to the same feature seen in other species of the genus. *Olbiogaster perezii* is theoretically the sister species of *O. mexicana*, if we consider the yellow halter capitulum to be homologous among them (Fig. 6). Finally, *O. perezii* could be the sister group of *O. danista* if we accept character 6 as having a single origin in the group and the brown scutellum (character 2) of *O. perezii* and *O. danista* being homologous (Fig. 7). Still other topologies present even less parsimonious character evolution. The length of the cladogram in which *O. perezii* is the sister group to the remaining species of the genus has 24 steps, five steps shorter than the second most parsimonious cladogram. The other two cladograms have 32 and 35 steps, respectively.

A sister-group relationship of *Olbiogaster perezii* to the other species of the genus adds a basal stem to this monophyletic group. The autapomorphies shown by *O. perezii*—particularly the virtual absence of vein M_3 —indicate that the fossil is itself a derived clade arising mostly closely from the stem group, but not an ancestral member of the genus.

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THE NORTH AMERICAN SPECIES OF *SYSTASIS* WALKER
(HYMENOPTERA: PTEROMALIDAE)

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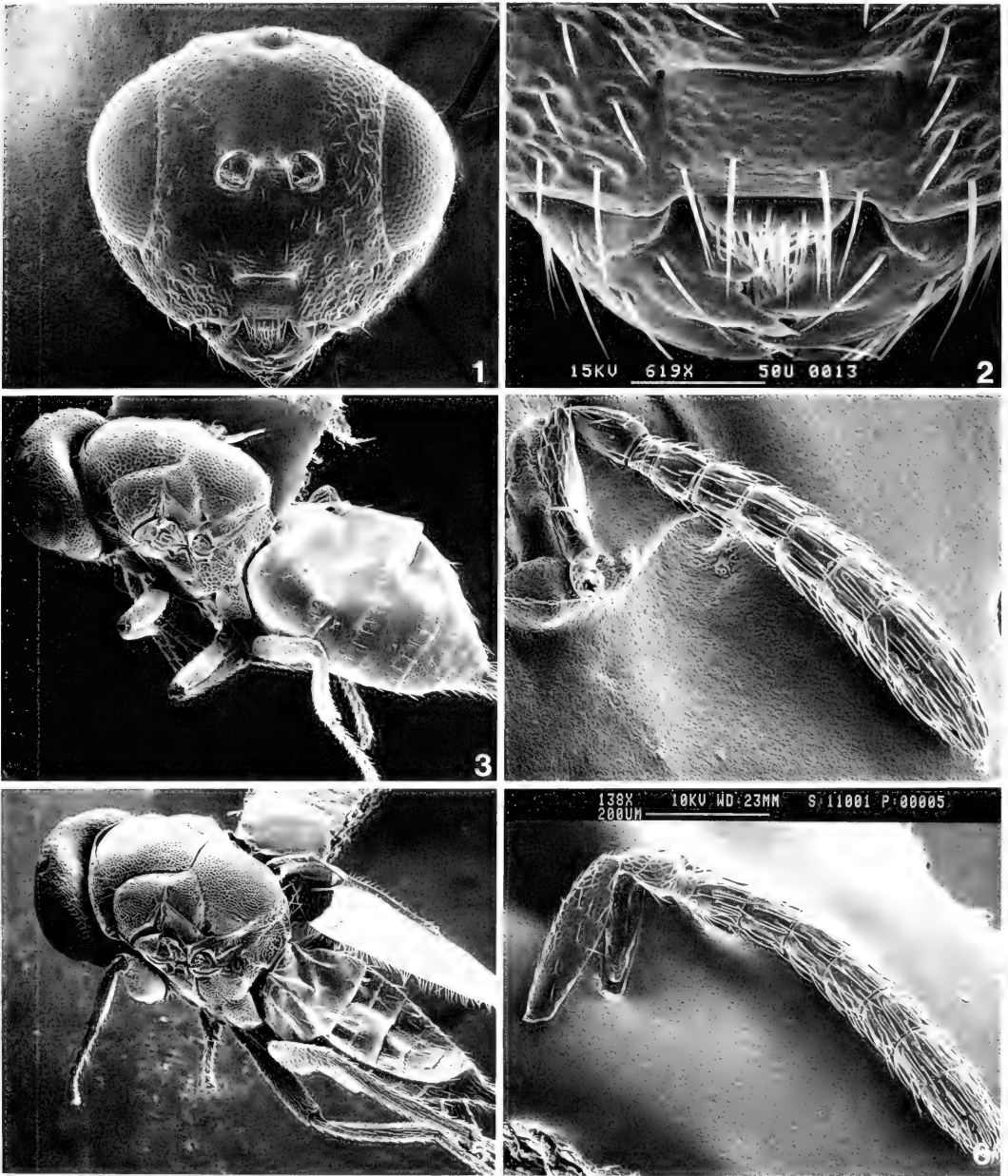
Abstract.—The nearctic species of *Systasis* Walker are reviewed. These include two holarctic species, *S. encyrtoides* Walker and *S. parvula* Walker, and three new nearctic species—*S. aquila*, n. sp., *S. hansonii*, n. sp., and *S. tena*, n. sp. A summary of the biology and distribution for the genus and for each species is presented.

Key Words: *Systasis*, *Semiotellus*, Pteromalidae, Ormocerinae, Cecidomyiidae, gall, blueberry, biology, new species

Systasis Walker, 1834, and *Semiotellus* Westwood, 1839, were placed together in a new tribe, the Systasini (Ormocerinae), by Bouček (1988). Systasini is defined on the basis of reduction in the number of antennal segments to 12 with at least the two basal flagellar segments anelliform (Figs. 4, 6, 8–11), reduction of the number of teeth on each mandible to 3 (Fig. 2), and the uniquely structured clypeus—quadrate, nearly flat, with the anterior margin nearly straight across, and with deep anterior tentorial pits in the dorsolateral corners (Figs 1, 2). Two other unusual characters present in most species of these two genera and which need more study of their distribution are 1) the tendency of the mesepisternum to be non-metallic, varying from almost black to dull yellowish brown depending on the species, and 2) the presence of a narrow membranous fovea basally on the dorsolateral corner of the gaster. *Systasis* and *Semiotellus* are very similar genera, and if the morphological variation found in the Nearctic species described herein is taken into account, *Systasis* species are distinguished from those of *Semiotellus* only in having 1) the speculum of the upper surface of the wing ex-

tending down to the stigmal vein, making the line of strong setae on the ventral side of the wing membrane just posterior to the marginal vein easily visible and 2) the free anterior margin of the clypeus nearly straight across (Fig. 2). *Semiotellus* species have the dorsal surface of the fore wing setose posterior to the marginal vein and the free anterior margin of the clypeus truncate. It is probable that these two genera will someday be regarded as subgenera of *Systasis* once a worldwide survey of the species is completed.

Systasis was originally created for the species *S. encyrtoides* Walker and *S. tenuicornis* Walker. Current authors recognize eight additional palearctic species—*S. acuta* (Fonscolombe), *S. annulipes* (Walker), *S. angustula* Graham, *S. basiflava* Graham, *S. ephedrae* Dzhhanokmen, *S. longula* Bouček, *S. parvula* Thomson, and *S. tenuicornis* Walker; four Oriental species—*S. cenchrivora* Farooqi & Menon, *S. dalbergiae* Mani, *S. dasyneurae* Mani (key to these three species in Farooqi and Menon 1972), and *S. vischnu* (Motschulsky); 21 Australian species—*S. australiensis* (Girault), *S. cecidomyiae* (Ashmead), *S. cecili* Girault, *S. cer-*



Figs. 1-6. 1-4, *Systasis parvula*, female. 1, Head, anterior view. 2, Clypeus. 3, Whole body. 4, Antenna. 5-6, *Systasis aquila*, female. 5, Whole body. 6, Antenna.

nus (Walker), *S. dice* (Walker), *S. doddi* (Girault), *S. euctemon* (Walker), *S. flindersiae* Girault, *S. graminis* (Cameron), *S. grotiusi* Girault, *S. henrici* Girault, *S. horridula* (Girault), *S. insularis* Dodd & Girault, *S. keatsi* Girault, *S. lelex* (Walker), *S. merula* (Walk-

er), *S. persimilis* (Dodd & Girault), *S. punctativertex* Girault, *S. seposita* Girault, *S. varipes* Girault, and *S. viridis* (Girault); and three Ethiopian species—*S. afra* Masi, *S. coerulea* Delucchi, and *S. guierae* (Risbec). There are no described species from the

Neotropical Region, and based on collections I have examined, they do not seem to occur there.

The latest catalog of nearctic Pteromalidae (Burks 1979) lists two species for North America—*S. encyrtoides* and *S. diplosidis* Eckel. The latter species was transferred to *Melancistrus* Graham (Heydon and Bouček 1992). The palearctic species *S. parvula* Thomson is reported from the New World for the first time herein, and three new nearctic species are described—*S. aquila*, n. sp., *S. hansonii*, n. sp., and *S. tena*, n. sp.

Terminology in this paper generally follows that of Graham (1969), except that genal concavity is used instead of genal hollow and club is used instead of clava. In addition, the gastral tergites are numbered T1–T7 beginning with the first tergite after the petiole. The following abbreviations are used: the median ocellar diameter is MOD, the ocellar-ocular distance is OOL, the posterior ocellar distance is POL, the lateral ocellar distance is LOL, the multiporous plate sensilla are MPP sensilla, the lower ocular line is LOCL, and the antennal funicular segments are F1 through F6. The units of measurement given in the descriptions can be converted to millimeters by multiplying by 0.02. The acronyms for the museums from which material was borrowed are listed in the acknowledgments section.

Systasis Walker

Systasis Walker, 1834: 288, 296 (Type species: *Systasis encyrtoides* Walker; Westwood 1840: 70 designation). Thomson, 1876: 193, 203. Ashmead, 1904: 274, 275. Schmiedeknecht, 1909: 275, 276, 280. Girault, 1915: 86. Nikol'skaya, 1952: 240. Bouček, 1955: 324–327. Peck, 1963: 644. Peck *et al.*, 1964: 33. Graham, 1969: 257–263. Bouček 1976: 11. Dzhankmen, 1978: 102, 112. Bouček, 1988: 221, 310–312, 386. Mani, 1989: 539, 540. Bouček and Rasplus, 1991: 106.

Paruriella Girault, 1913a: 308; 1913b: 107 (Type species: *Paruriella australiensis* Gi-

rault; original designation). Bouček, 1988: 310–311 (synonymy).

Guieralia Risbec, 1951: 253 (Type species: *Guieralia guierae* Risbec; monotypic genus). Bouček, 1976: 11 (synonymy).

Bouček (1955) described the subgenus *Systasina* for the palearctic species *S. annulipes* (as *S. clavicornis* Bouček) because this species has a short, clavate antennae and slender body in both sexes, and apparently a four-segmented club in the males. *Systasina* was more completely characterized by Graham (1969), but because *Systasina* contained only one species, it was difficult to differentiate subgeneric from species characters. The discovery of *S. (Systasina) tena*, n. sp., and *S. (Systasina) hansonii*, n. sp., shows that subgeneric characters for *Systasina* are possibly limited to the weakly sculptured body, the elongate gaster and clavate flagellum in females, and the short scape in males. (The female body and antennal proportions for *S. tena* are unknown, however.) Other differences mentioned by Bouček (1955) and Graham (1969) are no longer valid. As in male *S. (Systasis) spp.*, male *S. tena* and *S. hansonii* have the combined length of the flagellum and pedicel as long as or longer than the head width, and at least in *S. tena*, the flagellum parallel-sided with the basal four funicular segments elongate. In male *S. tena*, the club has a small ventral patch of micropilosity and is as long as the distal three funicular segments; in male *S. hansonii*, the club has an enlarged ventral patch of micropilosity surrounded by a well developed sulcus and so appears four-segmented. Male *S. tena* and both sexes of *S. hansonii* have the basal cell open posteriorly.

Biology. The hosts of most *Systasis* species are probably either gall-formers or inquilines, although some *Systasis* species may consume plant material as gall formers in their own right. Several of the Australian *Systasis* species have been reared—*Systasis cecidomyiae* from *Didymomyia tiliacea* (Bremi) (= *Cecidomyia frauenfeldti*) (Ceci-

domyiidae), *S. flindersiae* from galls on *Flindersia* (Rutaceae), *S. graminis* from galls on seeds of *Panicum* sp. (Poaceae), and *S. lelex* from horn galls on iron-bark eucalyptus and galls on spotted gum (all records from Bouček 1988). The palearctic species *Systasis angustula* has been recovered from *Kiefferia pimpinellae* (F. Loew) (Cecidomyiidae) and *Putoniella marsupialis* (F. Loew) (Cecidomyiidae). Rearing records of *S. encyrtoides* from the Old World include Cecidomyiidae in the genera *Contarinia* Rondani, *Dasyneura* Saunders, and *Stenodiplosis* Reuter (Anonymous 1965, Anonymous 1966, Böhm 1954, Graham 1969, Manniger 1940, Rubin 1965, Selivanova 1948); Agromyzidae in seeds (Graham 1969); two Tortricidae (Anonymous 1963 and Anonymous 1965, but see Graham 1969); and *Apion compactum* Desbrochers des Loges (Curculionidae) from broom (Hoffman 1958: 1561). Two of the Oriental species have also been reared from Cecidomyiidae. *Systasis dasyneurae* is recorded from *Dasyneura lini* Barnes (Ahmad 1939) and *S. dalbergiae* from two species on *Dalbergia sissoo* Roxburgh (Fabaceae)—*Contarinia dalbergiae* Mani (Mani 1942, Bouček *et al.* 1978, Mani 1989, and possibly Gangwar and Prasad 1984) and *Erosomyia indica* Grover (Grover 1986 and Grover 1987). Unidentified Indian *Systasis* species are also reported, one from the *Noorda moringae* Tams (Pyrallidae) (Cherian and Basheer 1939), and four others from the Cecidomyiidae species *Asphondylia sesami* Felt (Mathur and Verma 1973), *Contarinia* sp. on *Jasminum sambac* Ait. (Oleaceae) (David, *et al.* 1990), *Dasyneura amaramanjarae* on mango (Anacardiaceae) (Grover 1986), and *Phyllodiplosis* sp. on *Zizyphus jujuba* Tamk. (Rhamnaceae) (Tiwari 1975). The Ethiopian species, *Systasis guierae*, was reared from a gall on *Guiera senegalensis* Lam. (Combretaceae) (Risbec 1951). *Guiera senegalensis* is an African shrub on which walnut-sized galls, caused by *Vuilletia howardi* (Vuillet) (Phlaeothripidae), form on young shoots

(Bradley 1969). These galls are home to a number of inquilines in the orders Thysanoptera and Lepidoptera (Bradley 1969, Pitkin and Mound 1973), so the exact host needs clarification. The type series for the new nearctic species, *S. aquila*, was collected in association with bud galls on *Vaccinium corymbosum* L. (Ericaceae), and *Lyonia ligustrina* (L.) DC. (Ericaceae). *Systasis cenchivora* is phytophagous on the seeds of *Cenchrus ciliaris* Linnaeus and *C. setigerus* Vahl. (Poaceae) (Wadhi and Verma 1970 and Farooqi and Menon 1972). As far as is known, those *Systasis* species on cecidomyiids are always external parasites on the larval stages of their hosts.

KEY TO NEARCTIC *SYSTASIS* WALKER

1. Body sculpturing weak, vertex and metapleuron nearly smooth. Male with scape not quite reaching median ocellus in anterior view 2
 - Body distinctly alveolate, vertex and metapleuron with distinct raised sculpture (Figs. 3, 5). Male with scape reaching at least to median ocellus 3
2. Male with mesepisternum and tibiae metallic blue. Terminal segment of club with large patch of micropilosity (Fig. 10). Fore wing with about 15 or more admarginal setae *hansonii*, n. sp.
 - Male with mesepisternum and tibiae weakly metallic. Terminal segment of club with minute patch of micropilosity (Fig. 11). Fore wing with about 10 admarginal setae. (Female unknown) *tena*, n. sp.
3. Body color olive green to black. Scape pale and nonmetallic. Female with eye height 2.0 or more times malar distance; male eye height 2.2 or more times malar distance *aquila*, n. sp.
 - Body color green or blue. Scape dark brown or black, with distinct metallic reflections or wholly metallic. Female with eye height 2.0 or less times malar distance; male with eye height 2.2 or less times malar distance 4
4. Female body length 1.4–1.7 mm. Antenna with scape reaching the median ocellus; F1 half length of pedicel; club length longer than combined length of F3–5 (Figs. 4, 8). Male antenna with scape reaching vertex; combined length of pedicel and flagellum 1.0–1.1 × head width; funicular setae sparse, setal length equal to that of a funicular segment *parvula* Thomson
 - Female body length 1.8–2.5 mm. Antenna with scape extending to or above vertex; F1 about

as long as pedicel; club length shorter than combined length of F3–5 (Fig. 9). Male antenna with scape extending above vertex; combined length of pedicel and flagellum $1.2\text{--}1.4\times$ head length; funicular setae fairly dense, setal length half that of a funicular segment
*encyrtoides* Walker

***Systasis (Systasis) aquila* Heydon,**

NEW SPECIES

Figs. 5–6

Diagnosis.—*Systasis aquila* may be recognized by the following combination of characters: 1.* Body color greenish black or bluish black. 2.* Scape pale, nonmetallic. 3. Body sculpture coarse. 4. Female body length $1.7\text{--}2.5$ mm; male body length $1.3\text{--}2.0$ mm. 5. Female eye height $2.0\text{--}2.2\times$ malar distance; male eye height $2.2\text{--}3.0\times$ malar distance. 6. Female scape reaching median ocellus, length $\sim\frac{3}{4}$ eye height (range $0.72\text{--}0.82$); male scape reaching just above median ocellus, length $\sim\frac{2}{3}$ eye height (range $0.64\text{--}0.72$). 7. Male with combined length of pedicel and flagellum $1.2\times$ head width. 8. Female antenna with F1 about as long as pedicel, flagellum parallel-sided, width of F5 $1.0\text{--}1.1\times$ width of F1 (Fig. 6). 9. Male funicular setae length $\frac{1}{2}\text{--}\frac{2}{3}$ the length of the funicular segments. 10. Plicae cariniform, extending $\frac{2}{3}$ of way to anterior margin of propodeum. 11. Female gaster length $1.4\text{--}1.8\times$ width, $0.86\text{--}0.95\times$ the combined length of head and mesosoma (Fig. 5).

Description.—Holotype, female. Color: Body greenish black with yellow reflections on face, pleural region, T5–7; dorsellum, propodeum, T1 dark green. Antenna with scape yellow brown; flagellum black. Legs with coxa, trochanter, femur greenish black; fore tibia and tarsi yellow-brown, tibia slightly darker over mesal $\frac{1}{2}$; middle, hind tibiae greenish black (yellow-brown at tips); middle and hind tarsi brownish yellow with

pretarsi brown. Fore wing veins translucent brown.

Sculpture: Head, mesosoma minutely alveolate (Fig. 5); anterior aspect of head (except for strip from anterior margin of clypeus to median ocellus) with distinct piliferous punctures; sculpture of mesopleural region relatively low; middle lobe of mesoscutum and scutellum with scattered piliferous punctures; gaster alveolate, sculpture only slightly raised above body surface.

Structure: Body length 2.5 mm. Head pentagonal in anterior view, width $1.2\times$ height (42:36), $2.1\times$ length (42:20); eye height $1.3\times$ length (20:15), $2.2\times$ malar distance (20:9), length $5.0\times$ temple length (15:3); torulus $1.5\times$ own diameter above LOCL; ratio of MOD, OOL, POL, LOL as 3.5:5.0:13.5:6.0. Antenna (Fig. 6) with length of pedicel plus flagellum $1.0\times$ head width (43:42); scape strongly flattened, length $3.3\times$ greatest width (15.0:4.5); relative lengths of scape, pedicel, anelli, F1–5, club as 15.0:5.5:1.5:5.0:5.0:4.5:5.0:5.0:12.5; widths of F1, F5, club as 4.0:4.0:4.5; 3–5 MPP sensilla in single irregular row visible on each segment. Mesosoma length $1.3\times$ width (54:41); dorsellum just shorter mesally than laterally; propodeum with median carina, posterior $\frac{1}{2}$ of plicae, petiolar foramen strongly carinate; callus with six erect mesal and one reclinate lateral setae; spiracle ovate, partially beneath the metanotum. Fore wing length $2.2\times$ width (110:50); relative lengths of submarginal, marginal, postmarginal, stigmal veins as 38.0:25.0:12.5:10.0; costal cell with single dorsal seta, with complete and partial ventral rows; basal cell bare; basal vein with row of four setae; admarginal setae in more than one row. Gaster chordate, its length $1.4\times$ width (60:42); hind margin of T1 straight; hypopygium extending $0.37\times$ length of gaster (22:60); lateral membranous areas on T1 large, extending posteriorly beyond basal fovea.

Allotype, male: Similar to holotype except generally paler—head, pleural region, gaster dark green; dorsum of mesosoma dark

* Asterisk indicates unique character state among nearctic species.

blue; and flagellum brownish black. Body length 2.0 mm. Antenna with combined length of pedicel and flagellum $1.2 \times$ head width (47.5:38.0); relative lengths of scape, pedicel, anelli, F1–5, club as 13.0:5.0:1.0:7.5:5.5:5.5:5.5:5.0:12.5; widths of F1, F5, club as 4:4:4; scape flattened, length $2.6 \times$ maximum width (13:5); 2–4 MPP sensilla in single irregular row visible per segment; setae dense, semierect, length $\frac{1}{2}$ funicular segment length. Gaster ovate, length $1.2 \times$ width (38:33).

Variation.—Female body length 1.7 to 2.5 mm; male body length 1.3 to 2.0 mm. The color of the dorsum of the male mesosoma is sometimes greenish black. The costal cell may have no dorsal setae and only one ventral setal row. In about half the specimens, there is only a single row of admarginal setae.

Etymology.—The species name, derived from the Latin word *aquilus*, meaning dark colored, refers to the dark body color of this species relative to others in the genus.

Type material.—The holotype, allotype, and 8 female and 3 male paratypes were collected associated with bud galls on *Vaccinium corymbosum* L. from IV–V.1983 at Chatsworth, New Jersey (United States), by H. P. Boyd (USNM). Four other paratypes were collected as follows (CNCI, UCDC, USNM): United States. West Virginia: Cooper's Rock State Forest, 2.5 miles w. Bruceton Mills, 5.VI.1964, 1 ♂, 6.VI.1964, 1 ♂. Unknown locality: 1 ♀; on *Lyonia ligustrina* (L.) DC. bud gall, 1 ♀.

Biology.—The host(s) of *Systasis aquila* are unknown but this species has been reared in association with bud galls on *Vaccinium corymbosum* L. (Ericaceae), and *Lyonia ligustrina* (L.) DC. (Ericaceae).

Systasis (Systasis) encyrtoides Walker
Fig. 9

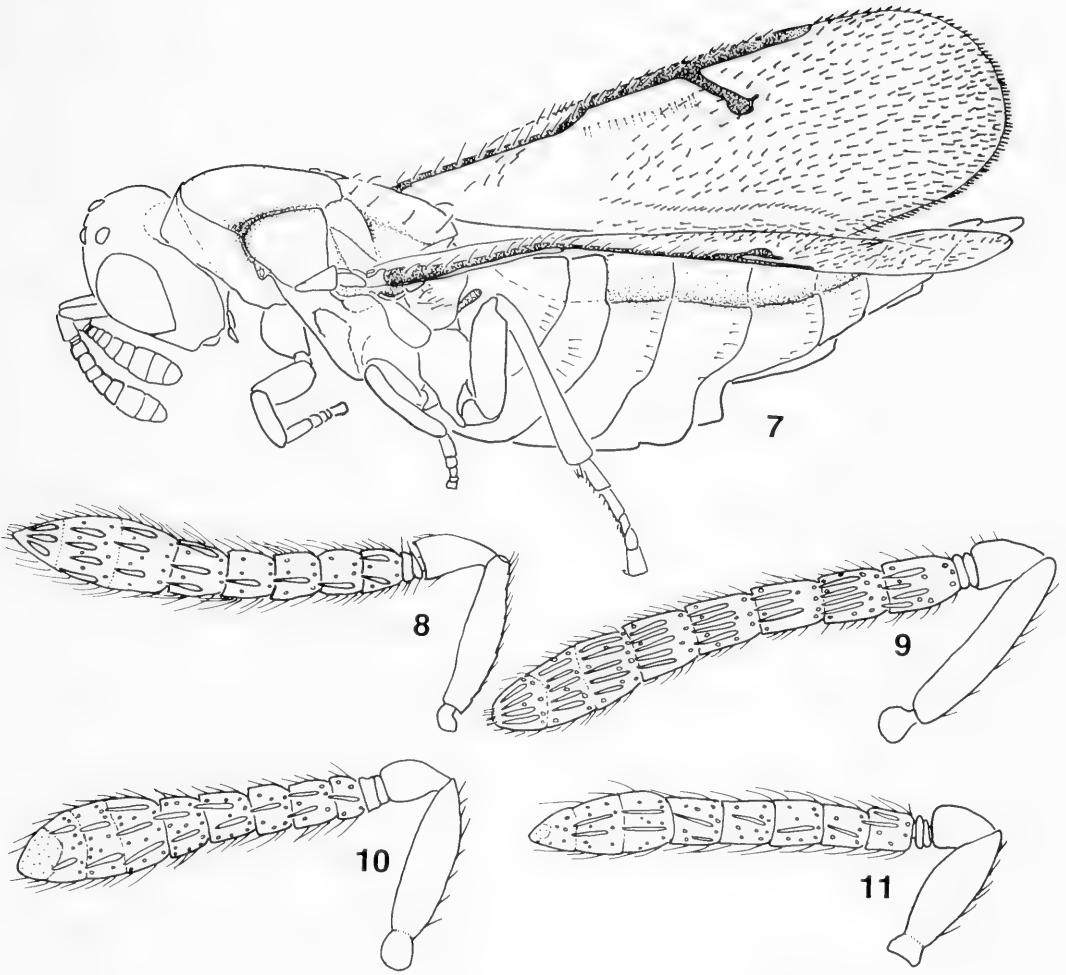
Systasis encyrtoides Walker, 1834: 296.
Haliday, 1841–1842: v, pl. B, fig. 1. Graham, 1969: 259, 261. Bouček, 1977: 56.

Hormocerus impletus Walker, 1872: 96.
Graham, 1969: 261 (synonymy).
Systasis longicornis Thomson, 1876: 204.
Graham, 1969: 261 (synonymy).

The synonymy, proposed by Graham (1969), of *Hormocerus impletus* Walker and *Systasis longicornis* Thomson with *S. encyrtoides* Walker are accepted without confirmation by the author. *Tridymus punctatus* Ratzeburg may also be a synonym of this species (Reinhard 1857 and Graham 1969), but the types are lost.

Diagnosis: *Systasis encyrtoides* can be recognized by the following combination of characters: 1. Body color blue or green. 2. Scape dark, weakly metallic. 3. Body sculpture coarse. 4. Female body length 1.8–2.5 mm; male body length 1.0–1.6 mm. 5. Female eye height $1.6\text{--}2.0 \times$ malar distance; male eye height $2.0\text{--}2.2 \times$ malar distance. 6.* Female scape extending above vertex, length $\sim \frac{3}{4}$ eye height (range 0.73–0.82); male scape extending above vertex, length about $0.7 \times$ eye height. 7.* Males with combined length of pedicel and flagellum $1.2\text{--}1.4 \times$ head width. 8. Female antenna with the length of F1 slightly shorter or equal to that of the pedicel, flagellum parallel sided (Fig. 9). 9. Male funicular setae length $\frac{1}{2}$ length of funicular segments. 10. Plicae ridgelike, with a smooth crest extending $\sim \frac{2}{3}$ of the way to the anterior margin of the propodeum. 11. Female gaster length $1.1\text{--}1.7 \times$ width, $0.80\text{--}0.96 \times$ the combined length of the head and mesosoma.

Material examined.—I examined 14 females and 1 male from the Nearctic Region collected as follows (CNCI, UCDC, USNM): Canada. ALBERTA: Elkwater Lake, 19.VII.1956, 1 ♀. BRITISH COLUMBIA: 15 miles e. Hope, 12.VII.1973, 1 ♀; Robeson, 12.VI.1950, 1 ♀, 21–25.VI.1947, 1 ♀, 22.VI.1947, 1 ♀; Squamish, Diamond Head Trail, 7.VIII.1953, 1 ♀, 28.VIII.1953, 1 ♀. MANITOBA: Churchill, 13.VIII.1952, 1 ♀. NORTHWEST TERRITORIES: Reindeer Depot, Mackenzie Delta, 7.VII.1948, 1 ♀;



Figs. 7–11. 7, *Systasis hansonii*, female, whole body. 8, *Systasis parvula*, female, antenna. 9, *Systasis encyrtoides*, female, antenna. 10, *Systasis hansonii*, male, antenna. 11, *Systasis tena*, male, antenna.

Yellowknife, 5.VI.1953, 1 ♀. United States. ALASKA: McKinley Hotel, 5.VII.1954, 1 ♀. COLORADO: Chicago Cr., Clear Creek Co., 2.VIII.1961, 1 ♀, along Fish Creek, 6 km s. Lake George, 7.VIII.1992, 1 ♀. MARYLAND: Adelphi, 21.V.1988, 1 ♂. OREGON: Saddleback Mountain, Lincoln Co., 3.IX.1960, 1 ♀. *Systasis encyrtoides* is common throughout Europe (Bouček 1977).

Biology.—The host(s) of *Systasis encyrtoides* in the Nearctic Region are unknown, but this species has been reared from galls of cecidomyiids or agromyzids in seeds in Europe. Old World hosts include the agro-

myzid *Phytomyza isais* Hering in seeds of *Odontites verna* (Bell.) Dum. (Scrophulariaceae) (Graham 1969), and the cecidomyiids *Cecidomyia crataegi* Winn. (Ghigi 1901), *Dasyneura affinis* Kieffer (Böhm 1954), *D. epilobii* (F. Loew) on *Chamaenerion angustifolium* L. (Graham, 1969); *Contarinia citri* (Rubin 1965), *C. ilicis* Kieffer (Anonymous 1965), *C. medicaginis* Kieffer (Anonymous 1961, Anonymous 1966, Bonnemaïson 1968, Ferron 1964, Královic 1964, and Stavrakis and Lambrakopoulos 1971), *C. pulchripes* (Kieffer) on *Sarothamnus scoparius* (L.) Wimmer (Parnell 1963);

Stenodiplosis panici (Selivanova 1948); and pods of broom (Walker 1848 Ratzeburg 1852, Reinhard 1857, Graham 1969). There are palearctic records from the tortricids *Conchylidea implicatans* Wek. and *Tortrix viridana* L. (Anonymous 1963 and Anonymous 1965), but Graham (1969) suspects these reports may be in error. Other records include two species of weevils of the genus *Apion* that occur in pods of broom in France (Hoffman 1958), but they do not seem to parasitize this host in England (Parnell 1963). Graham (1969) suspects there may be more than one generation per year in Europe. Further details on the biology of *S. encyrtoides* are found in Ghigi (1901), Parnell (1963), Ferron (1964), and Tudor et al. (1978).

***Systasis (Systasis) hansonii* Heydon,**

NEW SPECIES

Figs. 7, 10

Diagnosis.—*Systasis hansonii* may be recognized by the following combination of characters: 1. Body color metallic blue or blue-green. 2. Scape blue, metallic. 3. Body sculpture weak. 4. Female body length 2.3–2.6 mm, known male body length 1.8 mm. 5. Female eye height 2.8–3.0× malar distance; male eye height 2.9× malar distance. 6. Female scape not extending to median ocellus, length between ½ and ⅔ eye height (range 0.57–64). 7. Male with combined length of pedicel and flagellum 1.0× head width. 8. Female antenna with F1 much shorter than pedicel, flagellum clavate, width of F5 1.8× width of F1. 9. Male funicular setae length about equal to length of the funicular segments. 10. Plicae weakly developed as low broad folds in propodeum, smooth crest lacking. 11. * Female gaster length 2.1–3.6× width, * 1.4–1.6× combined length of the head and mesosoma (Fig. 7).

Description.—Holotype, female. Color: Body blue except dorsum of mesosoma, gaster with yellowish green reflections, pronotum just anterior to spiracle yellowish green. Antenna with scape, pedicel blue; re-

mainder brownish black. Legs blue except fore and middle knees and tibial tips brownish yellow, hind knees and tarsi brown. Wing veins brown.

Sculpture: Clypeus finely granulate; remainder of head weakly alveolate but anterior aspect of head with weak piliferous punctures; mesoscutum, scutellum alveolate; frenum, dorsellum, propodeum weakly alveolate; gastral terga weakly alveolate.

Structure: Body length 2.5 mm. Head nearly circular in anterior view, width 1.2× height (26.0:22.5), 1.9× length (26:14); eye height 1.3× length (14:11), 2.8× malar distance (14:5), length 3.7× temple length (11:3); torulus 1× own diameter above LOcL; ratio of MOD, OOL, POL, LOL as 3.0:3.0:7.0:3.5. Antenna with length of pedicel plus flagellum 0.83× head width (21.5:26.0); scape flattened, length 2.7× its greatest width (8:3); relative lengths of scape, pedicel, anelli, F1–5, club as 8.0:4.0:1.0:1.0:1.5:1.5–2.0:2.0:7.5; widths of F1, F5, club as 2.0:3.5:4.5; 1–2 MPP sensilla in a single row visible per segment. Mesosoma length 1.6× width (41:26); dorsellum shorter mesally than laterally; propodeum with median carina, plicae, petiolar foramen carinate; callus with 1 lateral reclinate seta, 6 mesal erect setae; spiracle round, on the anterior margin of the pronotum. Fore wing length 2.5× width (86:35); relative lengths of submarginal, marginal, postmarginal, stigmal veins as 29.0:19.0:13.0:7.5; costal cell with 5 dorsal setae, ventrally with 1 complete row and partial second row in apical ½; basal cell bare, with 1 or 2 setae on cubital vein; basal vein with narrow band of setae down its length; admarginal setae in single row of 16 setae on left fore wing, 15 setae on right. Gaster lanceolate (Fig. 7); length 2.6× width (75:29), 1.5× combined length of head and mesosoma (75.0:51.5); hind margin of T1 straight; hypopygium extending 0.29× gastral length (22:75); lateral membranous areas on T1 short.

Allotype, male: Similar to holotype except posterior ½ of T1, T2–4 dull dark purple. Body length 1.8 mm. Antenna (Fig. 10)

with combined length of pedicel plus flagellum $1.0 \times$ head width (25:25); relative lengths of scape, pedicel, anelli, F1–5, club as 8.0:3.5:1.0:2.0:2.5:2.5:2.5:2.5:8.5; widths of F1, F5, club as 2:2:4; 1–2 MPP sensilla in single row visible per segment; setae reclinate, length about equal to length of a funicular segment. Gaster ovate, length $3.1 \times$ width (40:13).

Variation.—The body length of females varies from 2.3–2.5 mm. All the specimens in the type series were critical point dried so the body lengths and relative lengths of the gaster reported herein may be somewhat exaggerated. The two females with a gaster length $1.6 \times$ the combined length of the head and mesosoma have the gaster appearing noticeably expanded. The females with a gaster length 1.3 – $1.4 \times$ the combined length of the head and mesosoma have a very natural appearance, and living or air-dried specimens probably have their gaster of about these proportions. The color patterns of the females are generally similar to the holotype except one is noticeably more violet and two are more green. The setae of the dorsal surface of the basal cell are restricted to a single row down the basal vein except in the holotype and allotype where there is a partial second row.

Etymology.—This species is named in honor of Paul Hanson through whose collecting efforts the Oregon chalcidoid fauna is becoming better known.

Type material.—The holotype (OSUO), allotype (OSUO), and 3 female paratypes were collected on 24 June 1983, on the bluff at Pike Creek, Oregon (United States), by Paul Hanson. Three additional paratypes were collected 1 July 1986, 2 miles e. Sisters, Oregon.

Biology.—Nothing is known of the host(s) of *S. hansonii*.

Systasis (Systasis) parvula Thomson
Figs. 1–4, 8

Systasis parvula Thomson 1876: 205. Graham 1969: 259, 260, 263.

Diagnosis: *Systasis parvula* can be recognized by the following combination of characters: 1. The body color blue or green. 2. The scape metallic green or blue. 3. Body sculpture coarse (Fig. 3). 4. Female body length 1.4–1.7 mm; male body length 1.1–1.5 mm. 5. Female eye height 1.8 – $1.9 \times$ malar distance; male eye height $2.0 \times$ malar distance. 6. Female scape reaching median ocellus, length $\sim \frac{2}{3}$ eye height; male scape reaching to vertex, length $\sim \frac{2}{3}$ eye height. 7. Males with combined length of pedicel and flagellum $1.1 \times$ head width. 8. Female antenna with F1 about $\sim \frac{1}{2}$ as long as the pedicel; flagellum gradually broadening, F5 1.2 – $2.0 \times$ the width of F1 (Figs. 4, 8). 9. Male funicular setae about as long as funicular segments. 10. Plicae ridgelike, with smooth crest lacking or extending only $\frac{1}{2}$ way to anterior edge of propodeum. 11. Female gaster length 1.2 – $1.5 \times$ width, 0.85 – $0.92 \times$ combined length of head and mesosoma (Fig. 3).

Material examined.—A total of 29 females and 25 males from the Nearctic Region were collected as follows (CNCI, INHS, UCDC, USNM): United States. ILLINOIS: The South Farms of the University of Illinois, near Champaign, 26.V.1985, 3 ♀, 2 ♂; 7.VI.1983, 5 ♀, 8 ♂; 17.VI.1983, 9 ♀, 4 ♂; 18.VI.1987, 1 ♀; 28.VI.1981, 1 ♀; 6.VII.1983, 1 ♀, 8 ♂; Mississippi Palisades State Park, 2.5 miles n. Savanna, 11.VI.1983, 5 ♀, 2 ♂. INDIANA: 2 miles s. New Lisbon, 14.VII.1981, 1 ♀. VIRGINIA: Monterey, 24.VI.1964, 2 ♀, 1 ♂. WISCONSIN: Door Co., 28.VI.1961, 1 ♀. I examined a female and male from Koszalin, Poland (on loan from BMNH). *Systasis parvula* is known from Ireland, Sweden, and Czechoslovakia (Graham 1969).

Biology.—The host(s) of *S. parvula* are unknown.

Systasis (Systasina) tena Heydon,
NEW SPECIES
Fig. 11

Diagnosis.—*Systasis tena* can be recognized by the following combination of char-

acters: 1. Body color green. 2. Scape dark, weakly metallic. 3. Body sculpture hardly raised above body surface. 4. Body length of known male ~ 1.2 mm. 5. Female unknown; male eye height $3.0\times$ malar distance. 6. Female unknown; * male scape barely reaching to median ocellus, length $0.62\times$ eye height. 7. Males with combined length of pedicel and flagellum $1.2\times$ head width. 8. Female unknown. 9. Male funicular setae about as long as each funicular segment. 10. Plicae low ridge; smooth crest extending $\frac{2}{3}$ of way to anterior margin of propodeum.

Systasis tena differs from male *Systasis annulipes* (Walker), the only other *Systasis* species in the subgenus *Systasina*, in the following ways: 1. *Systasis tena* has the combined length of the head plus flagellum $1.2\times$ the head width, all the flagellar segments elongate (Fig. 11), the club length $1.2\times$ the length of the funiculus, the mesosoma length $1.2\times$ its width, and the fore wing with the basal cell open posteriorly; *S. annulipes* has the combined length of the pedicel plus flagellum less than the head width, the funicular segments transverse, the length of the club equal to that of the funiculus, the mesosoma length $1.7\times$ its width, and the basal cell closed posterior by a row of setae down the cubital vein.

Description.—Holotype, male. Color: Body green except lower epimeron, mesosternum, dorsum of T1–3 brown. Antenna with scape, pedicel dark green; remainder dark reddish brown. Legs with coxae green except hind coxa brown ventrally; femora brown, dorsum of fore femur weakly and hind femur strongly metallic; fore tibia brownish yellow with weak greenish reflections over mesal $\frac{1}{2}$; middle femur brown with weak metallic coloration; hind femur brown on inner face and green on outer face; tarsi brownish yellow except pretarsi brown. Fore wing with submarginal vein brown; parastigma, remainder of venation pale brown.

Sculpture: Clypeus finely alveolate; remainder of head, mesoscutum, scutellum, T1–3 alveolate with reticulation hardly raised above body surface, face and vertex with scattered piliferous punctures; dorsellum, propodeum alveolate; T4–7 coriaceous.

Structure: Body length 1.2 mm. Head transversely ovate in anterior view, width $1.2\times$ height (22:18), $2.0\times$ length (22:11); eye height $1.5\times$ length (12:9), $3.0\times$ malar distance (12:4), length $4.5\times$ temple length (9:2); torulus $2\times$ own diameter above LOcL; ratio of MOD, OOL, POL, LOL as 2.5:3.0:7.0:3.0. Antenna (Fig. 11) with length of pedicel plus flagellum $1.2\times$ head width (27:22); scape flattened, length $2.5\times$ greatest width (7.5:3.0); relative lengths of scape, pedicel, anelli, F1–5, club as 7.5:3.5:1.0:3.0:3.0:3.0:3.0:3.0:8.0; widths of F1, F5, club as 2.0:2.0:3.5; 1–3 MPP sensilla in single row visible per segment, length about equal to that of funicular segments; funicular segments with sparse reclinate setae whose length about equals that of each funicular segment. Mesosoma length $1.3\times$ width (26.5:20.0); dorsellum short, parallel-sided strip; propodeum crested mesally but lacking median carina, plicae extending $\frac{2}{3}$ way to anterior margin, with weak carina along petiolar foramen, callus with 4 erect setae; spiracles circular, on anterior margin of propodeum. Fore wing length $2.0\times$ width (59:29); relative lengths of submarginal, marginal, postmarginal, stigmal veins as 20:16:7:6; costal cell with one dorsal seta, one ventral setal row; basal cell bare; basal vein with three setae; admarginal setae in single row. Gaster ovate, length $1.7\times$ width (25:15); lateral membranous areas of T1 not readily visible.

Female unknown.

Etymology.—The species name is derived from the Latin work *tener*, meaning delicate, refers to the delicate sculpturing of the body of *S. tena*.

Type material.—The holotype (USNM)

is a male, and was collected in stream drift of Hague Creek, 1 mile east of Hayfield, Virginia (United States), on 6 May 1940, by N. D. Richmond.

Biology.—The host(s) of *S. tena* are unknown.

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STRUCTURAL COMPARISON OF THE CHORION SURFACE OF FIVE
PHILONTHUS SPECIES (COLEOPTERA: STAPHYLINIDAE)

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Abstract.—Surface structures of eggs of five species of *Philonthus* are illustrated with the aid of scanning electron micrographs. Eggs studied are of the following cow-dung-inhabiting species in northcentral Florida: *Philonthus longicornis* Stephens, *P. flavolimbatus* Erichson, *P. ventralis* (Gravenhorst), *P. sericans* (Gravenhorst) and *P. hepaticus* Erichson. The eggs of *P. longicornis*, *P. flavolimbatus* and *P. ventralis* have high, longitudinal ridges, which are 4–5 for *P. ventralis*, but 7–8 for the other two species. The ridges of *P. longicornis* eggs are continuous and wider, and the egg surface between the ridges is covered by tubercles, whereas the ridges of *P. flavolimbatus* eggs are discontinuous (with weak connections between the tubercles) and narrower, and the egg surface between the ridges is covered by sharp teeth. Eggs of *P. sericans* have low, parallel and connected ridges, which consist of minute granules and scattered enlarged granules over the entire surface. Eggs of *P. hepaticus* are covered by compact, minute granules and cone-shaped structures resembling volcanoes. Aeropyles occur on the egg ridges in *P. longicornis* and *P. flavolimbatus*, but on the surface between the ridges in *P. ventralis* and *P. sericans*. A key is given to the five species of *Philonthus* eggs.

Key Words: *Philonthus*, eggs, surface structure

Staphylinids are considered to be the most important predators in cow dung, due to the diversity of species and high population levels. Members of the genus *Philonthus* are predacious on eggs and larvae of Diptera (Harris and Blume 1986, Laurence 1956, Sanders and Dobson 1966). They are considered to be efficient predators of the horn fly, *Haematobia irritans* (Fincher and Summerlin 1994, Harris and Oliver 1979, Hunter et al. 1989, Macqueen and Beirne 1975, Roth 1982, Thomas and Morgan 1972), and the face fly, *Musca autumnalis* (Valiela 1969, Wingo et al. 1974).

During a survey of the insect fauna of cow dung in two pastures in Alachua County

(northcentral Florida) in 1993, we collected specimens of six species of *Philonthus*, among which one species (*P. rectangulus* Sharp) is new to Florida (only one specimen was collected). There have been no studies on the ecology of these dung-inhabiting species. Therefore we colonized the previously recorded five species (Frank 1986) for biological studies and predation tests against immature horn flies. The species included *Philonthus longicornis* Stephens, *P. flavolimbatus* Erichson, *P. ventralis* (Gravenhorst), *P. sericans* (Gravenhorst) and *P. hepaticus* Erichson. Egg specimens of each species were prepared for this study.

The surface structure of the egg chorion

of some *Philonthus* species was described by Mank (1923; 1 sp.), Frank (1968; 1 sp.), Tawfik et al. (1976a, b, c; 3 spp.), and Hinton (1981b; 17 spp.) with light microscopy. Scanning electron microscopic (SEM) studies of eggs of *Philonthus* were published by Hinton (1981a) for 3 European species, and by Hunter et al. (1989) for two North American species. Among the *Philonthus* species that we collected, only the eggs of *P. longicornis* and *P. flavolimbatus* were observed under the light microscope and under SEM, respectively (Tawfik et al. 1976c, Hunter et al. 1989). These studies did not provide much detailed description. The objective of this study is to describe and compare the exochorionic surface structures of the five dung-inhabiting *Philonthus* species found in northcentral Florida.

MATERIALS AND METHODS

Insect collection and culture.—Eggs were obtained from females in laboratory colonies. Female *Philonthus* were extracted from the dung using emergence boxes (Hu and Frank 1995), designed by G. T. Fincher (USDA-ARS, College Station, Texas). Fresh cow-dung pads were sampled from two pastures in Alachua County, Florida, placed individually into the emergence boxes and brought into the laboratory. Insects that left the dung in the emergence box were collected daily in a removable plastic vial and cup attached to holes on the end and bottom of the box, respectively. *Philonthus* colonies were maintained by following the method of Hunter et al. (1986). Adult females were confined in Petri dishes (5.1 cm diameter \times 1.3 cm high), lined on the bottom with a moist paper towel. A water-soaked cotton ball was provided for humidity, and horn fly eggs and first-instar larvae were provided for food.

Specimen preparation.—For photography using SEM, eggs were removed from a Petri dish with a fine paintbrush and placed into 70% isopropyl alcohol. These eggs preserved in alcohol for at least 24 h, were

cleaned by an ultrasonic cleaner for 3–5 min to remove pieces of paper towel or remnants of consumed immature horn flies. After cleaning, eggs were dehydrated in a graded alcohol series, then dried in a desiccator over Ca_2SO_4 . Dried eggs were attached to an SEM stub using double-sided tape and sputter-coated with gold in a Denton Vacuum DESK II Gold Sputter Etch Unit. The eggs were examined with an SEM (Hitachi 570) at 20 KV and 100 mA and photographed. Five to ten eggs were used for each species.

Egg size measurements.—Less than 24 h old eggs were measured at $25\times$ with a dissecting microscope and an ocular micrometer. *Philonthus* eggs increased in size during the incubation period (Tawfik et al. 1976a, b, c), because they became permeable to water one day after there was an appreciable secretion of serosal cuticle (Hinton 1981b). The length and width were measured for ten eggs of each species. Each sample of ten eggs was produced by 2–5 females. Mean egg length of species was compared using analysis of variance (ANOVA) and Duncan's multiple range test (SAS 1990). Measurements are presented as ranges followed by the mean and one standard deviation.

Terminology.—The terms for morphological description used in this paper follow those of Hinton (1981b), including ridges, processes, projections, tubercles, and aeropyles. Terms that were not provided by Hinton were adopted from Endris et al. (1987) for connected ridges, and Woodruff (1973) for granules.

RESULTS

General.—Most eggs were laid under the cotton ball or at the edge of Petri dishes under the paper towel. Female *P. longicornis* often tried to bury their eggs under macerated paper towel. Cannibalism of eggs by adult females was observed for all five species, especially for *P. longicornis*.

The eggs of all species are oval, with sculptures on the surface of the exochorion (Figs. 1A–E). The sculpture includes high

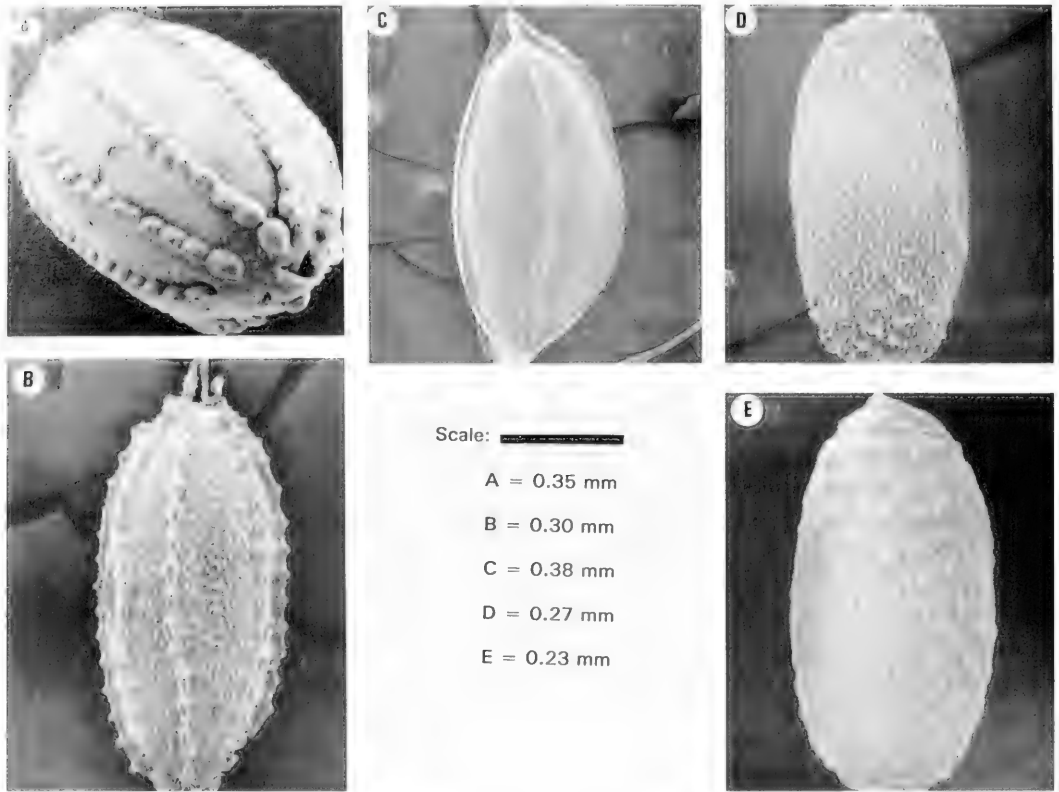


Fig. 1. Scanning electron micrographs of lateral view of the whole egg. (A) *P. longicornis*; (B) *P. flavolimbatus*; (C) *P. ventralis*; (D) *P. sericans*; (E) *P. hepaticus*.

longitudinal ridges, low connecting ridges, tubercles, granules and cone-shaped structures resembling volcanoes. When newly deposited, the eggs are pale yellow in color; twenty-four h later, the color becomes darker, the size increases, and the sculpture becomes more distinct. The incubation period lasts 2–4 days. From the second day, the embryo can be seen easily through the transparent chorion, and the eye spots attain a pale brown color. Descriptions of eggs of each species follow.

P. longicornis Stephens.—Size: length, 1.07–1.20 (1.13 ± 0.03) mm; width, 0.52–0.57 (0.55 ± 0.02) mm. The egg is extended anteriorly into a club-shaped tube-like process of ca. 0.4–0.6 mm long and posteriorly with a small projection. The exochorion has 7–8 high longitudinal ridges. The ridges are well developed (continuous; Fig. 1A) and

consist of 19–35 tubercles on each ridge. The distance between the ridges across the middle line of the egg is 0.24–0.41 mm. The surface of the exochorion between the ridges is covered by scattered blunt tubercles that are 6–9 μm long (Fig. 2A). Aeropyles occur on the tubercles of the ridges.

P. flavolimbatus Erichson.—Size: length, 0.79–0.88 (0.83 ± 0.03) mm; width, 0.39–0.50 (0.44 ± 0.03) mm. The egg is extended anteriorly into a club-shaped, tubular process and posteriorly with a small projection. The exochorion has 7–8 high longitudinal ridges. Compared to *P. longicornis*, the ridges are not so well developed. They are narrower and discontinuous between some tubercles (Fig. 1B). Each ridge has 16–21 tubercles. The distance between the ridges across the middle line of the egg is 0.14–0.21 mm. The surface of the exochorion

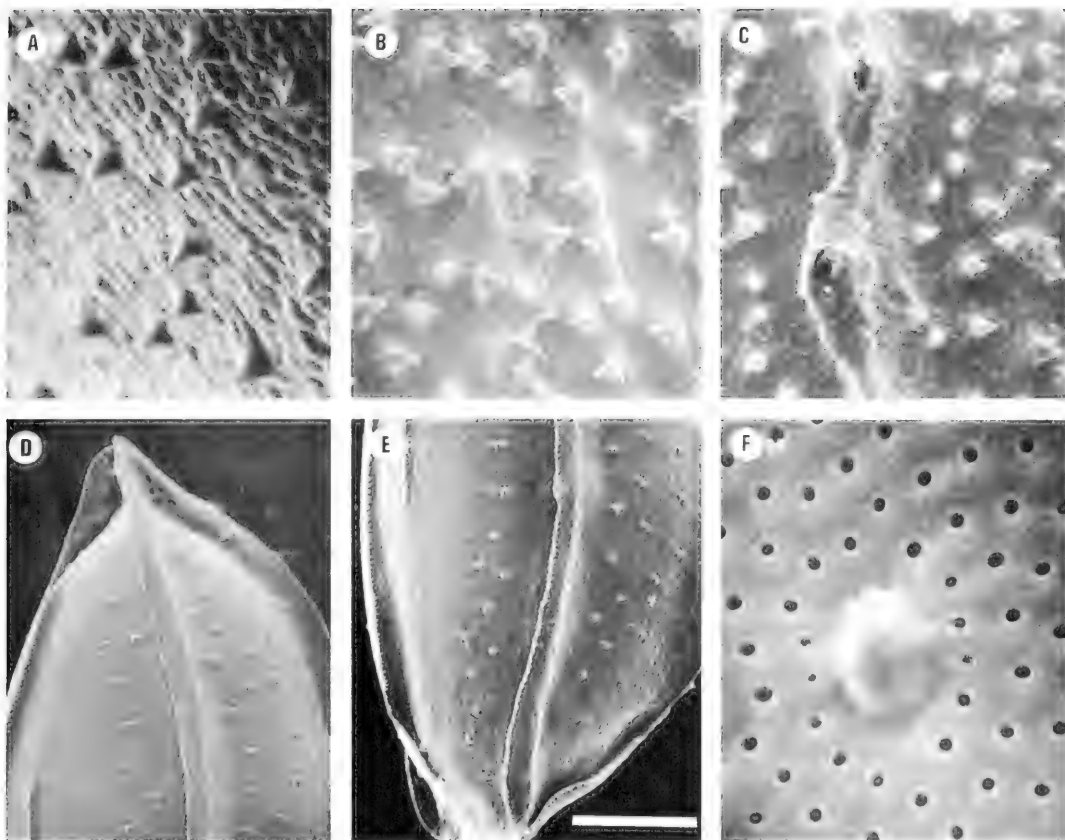


Fig. 2. Scanning electron micrographs of lateral view of egg structures. (A) *P. longicornis*, showing blunt tubercles; (B) *P. flavolimbatus*, showing sharp teeth; (C) *P. flavolimbatus*, showing aeropyles on ridges; (D–F) *P. ventralis*: (D) anterior end; (E) posterior end; (F) Showing a tubercle and aeropyles. Magnifications are based on scale bar in E: A = 23 μm , B = 30 μm , C = 42 μm , D = 0.18 mm, E = 0.18 mm, F = 15 μm .

between the ridges is covered by densely distributed sharp teeth, which are 6–10 μm long (Fig. 2B). The aeropyles occur on the tubercles of the ridges (Fig. 2C). They are elongated with a size of approximately $18 \times 15 \mu\text{m}$.

P. ventralis (Gravenhorst).—Size: length, 1.04–1.21 (1.13 ± 0.06) mm; width, 0.48–0.59 (0.54 ± 0.03) mm. The egg is extended anteriorly into a pointed process and posteriorly with a projection (Figs. 1C, 2D, E). The egg is asymmetrical dorso-ventrally, dorsally domed, and ventrally somewhat flat. The exochorion has 4–5 high longitudinal ridges, with two on the dorsal surface, one on each side, and one or none on the ventral surface. The ridges are well devel-

oped (Fig. 1C) and have many small cross-ridges (Figs. 2D, E). The distance between the ridges across the middle line of the egg is 0.21–0.32 mm. The surface of the exochorion between the ridges is covered by scattered tubercles (Figs. 2D, E) and compact aeropyles (Fig. 2F). Each tubercle is 14–17 μm in diameter, and each aeropyle is 1.5–2.5 μm in diameter.

P. sericans (Gravenhorst).—Size: length, 0.79–0.91 (0.83 ± 0.04) mm; width, 0.38–0.50 (0.46 ± 0.04) mm. The egg is extended anteriorly into a club-shaped, tubular process, and lacks a process toward the posterior end (Fig. 1D). The exochorion has low and thin ridges which consist of minute granules. The ridges are flat in the middle

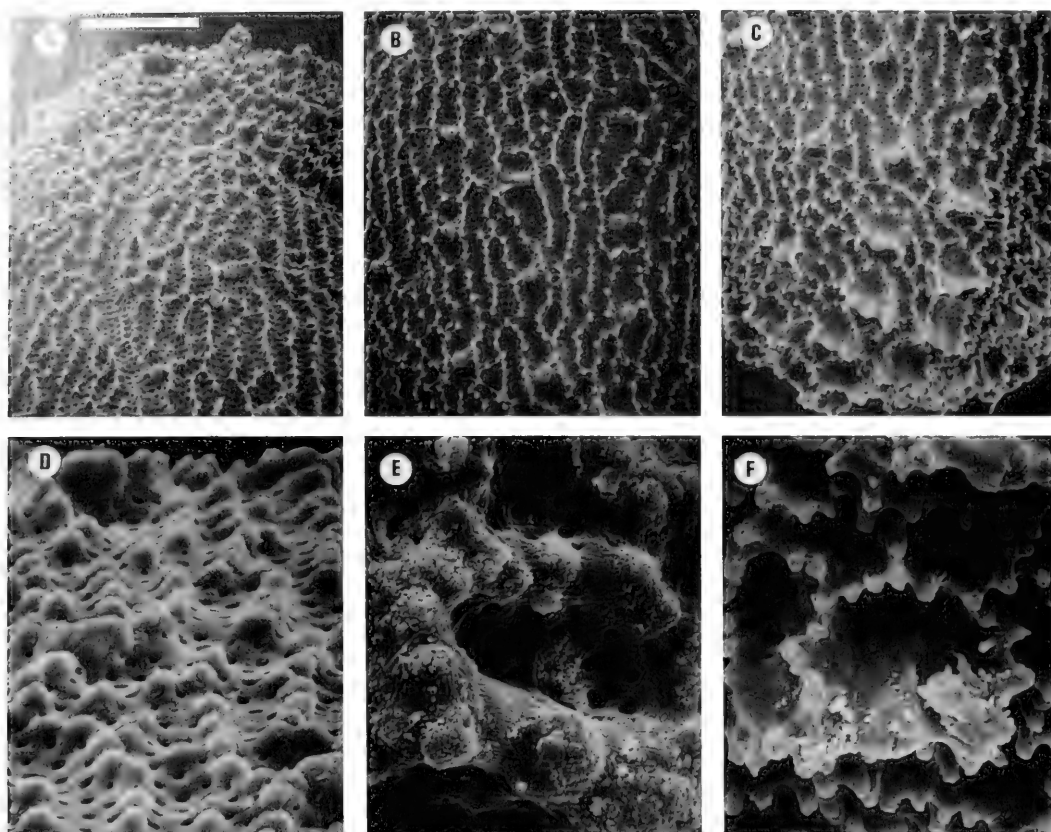


Fig. 3. Scanning electron micrographs of *P. sericans* eggs. (A) lateral view of anterior end, showing compact granular ridges; (B) lateral view of middle portion, showing flat connected ridges; (C) lateral view of posterior end, showing strengthened and compact ridges; (D) anterolateral view, magnification of aligned minute granules on front end; (E) lateral view, showing toe-like granules of circular structure on the middle portion; (F) posterolateral view, showing tooth-like granules on a circular structure. Magnifications are based on scale bar in A: A = 0.1 mm, B = 0.1 mm, C = 0.1 mm, D = 25 μ m, E = 23 μ m, F = 15 μ m.

portion of the egg, and are parallel and connected by cross-ridges (Fig. 3B). High magnification shows that the granules of the flat ridges are toe-like (Fig. 3E). At the anterior end they become higher and compact (Figs. 3A, D). At the posterior end they are highest, and form a circular structure (7–30 μ m in diameter; Fig. 3C). The granules on the thin ridges of the posterior end are tooth-like (Fig. 3F). The surface of the exochorion between the thin ridges is covered by scattered enlarged granules (Figs. 3A–C) and compact aeropyles (Figs. 3A–F). The enlarged granules are 10–15 μ m in diameter and the aeropyles are 1.5–2 μ m in diameter.

P. hepaticus Erichson. — Size: length, 0.79–

0.88 (0.83 \pm 0.03) mm; width, 0.39–0.50 (0.44 \pm 0.03) mm. The egg is extended anteriorly into a small projection (Figs. 1E, 4A) and lacks a process toward the posterior end (Figs. 1E, 4B). The exochorion is covered by compact minute granules and scattered irregular enlarged granules. These enlarged granules are alternated with pits, forming cone-shaped structures resembling volcanoes (Figs. 1E, 4A, B) which are evenly distributed over the entire surface (Fig. 1E). The minute granules on the enlarged ones are short and scattered (Fig. 4C), but tooth-like and aligned into lines between the cone-shaped structures (Fig. 4D). The granules form no precise patterns.

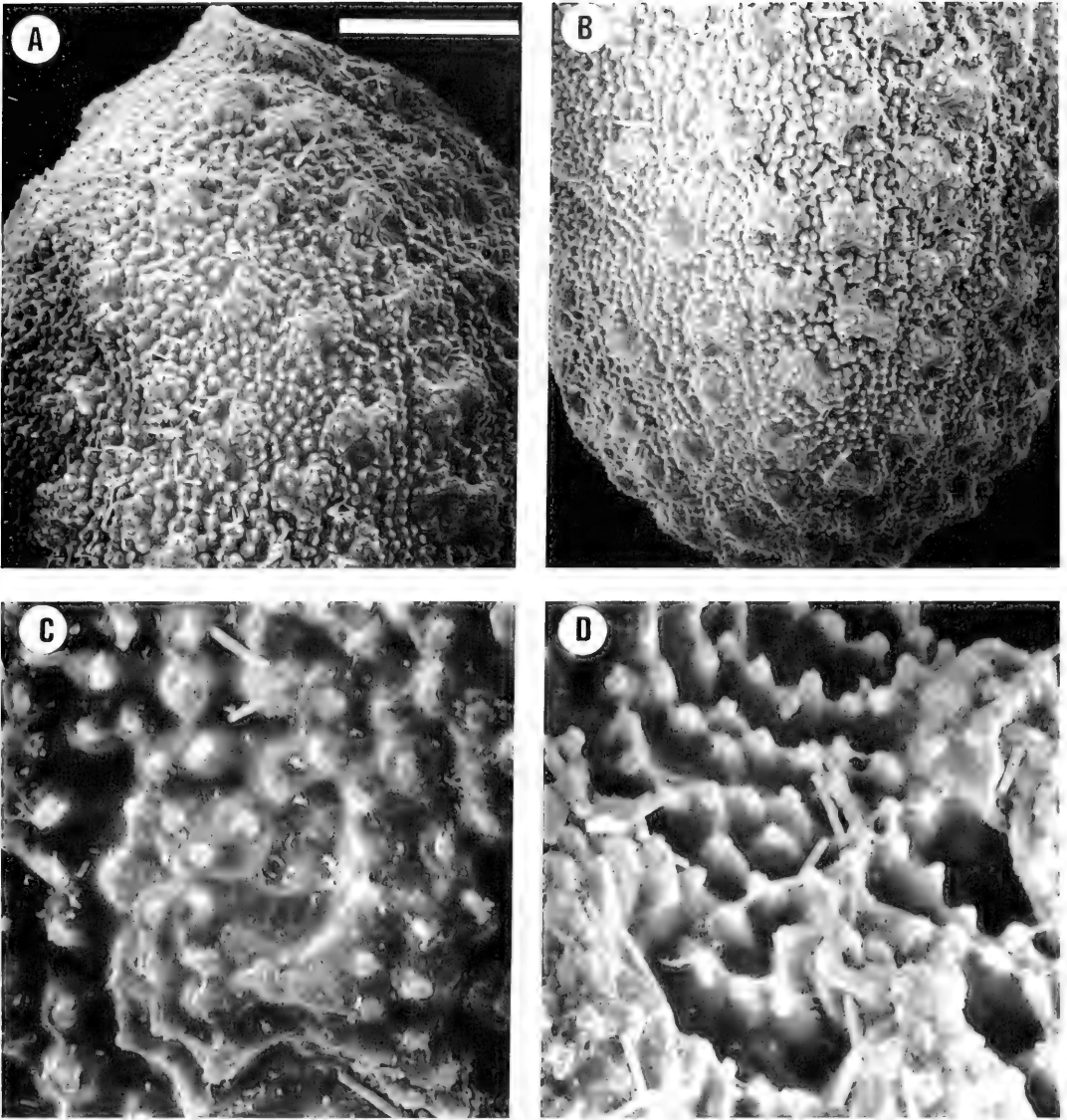


Fig. 4. Scanning electron micrographs of *P. hepaticus* eggs. (A) anterolateral view; (b) posterolateral view, showing volcano-like structure; (C) lateral view, showing minute granules on the enlarged ones; (D) lateral view, showing minute granules on the egg surface between the enlarged ones. Magnifications are based on scale bar in A: A = 0.10 mm, B = 0.10 mm, C = 20 μ m, D = 20 μ m.

KEY TO THE EGGS OF DUNG-INHABITING PHILONTHUS IN NORTHCENTRAL FLORIDA

- | | | | |
|--|--------------------------------|--|-------------------------------|
| 1. Exochorion with strong, longitudinal ridges (Figs. 1A-C) | 2 | - With 7-8 ridges; exochorion between ridges covered by tubercles or granular teeth | 3 |
| - Exochorion without strong longitudinal ridges (Figs. 1D, E) | 4 | 3. All ridges well-developed (continuous); tubercles present on the exochorion between the ridges (Fig. 2A) | <i>longicornis</i> Stephens |
| 2. With 4-5 ridges; exochorion between ridges covered with aeropyles and scattered tubercles (Fig. 2F) | <i>ventralis</i> (Gravenhorst) | - Not all ridges well developed (discontinuous); granular teeth present on the exochorion between the ridges (Fig. 2B) | <i>flavolimbatus</i> Erichson |
| | | 4. Exochorion with weak and thin granular ridges | |

and enlarged granules over the entire surface (Figs. 3A-C). *sericans* (Gravenhorst)
 - Exochorion with compact minute granules and scattered enlarged granules which are alternated with pits, forming cone-shaped structures over the entire surface (Figs. 1E, 4A, B)
 *hepaticus* Erichson

Egg size. — Mean egg length was found to vary significantly between species ($F = 167.08$; $df = 4,45$; $P < 0.01$). Duncan's multiple range test determined that the eggs of *P. longicornis* and *P. ventralis* were statistically similar to each other yet significantly larger (longer) than those of *P. flavolimbatus*, *P. sericans* and *P. hepaticus*. Egg of *P. flavolimbatus*, *P. sericans* and *P. hepaticus* did not differ significantly in size.

DISCUSSION

Alcohol fixation and desiccation were tried using staphylinid eggs of several species from three subfamilies. Most eggs of *Philonthus* and those of *Neohypnus pusillus* (Sachse) (Staphylininae) did not collapse, but almost all the eggs of *Aleochara notula* and *Atheta* sp. (Aleocharinae) and *Platystethus americanus* Erichson and *Anotylus insignitus* (Gravenhorst) (Oxytelinae) collapsed. This may be because the egg chorion of *Philonthus* spp. and *N. pusillus* is thicker than that of the other species and is sculptured over the entire outer surface. The sculpture forms supportive structure for the egg shells and may help the eggs resist external pressure and substances from decaying dung. The egg chorion of *A. notula*, *Atheta* sp. and *P. americanus*, however, is thin and smooth, without any surface sculpture.

Egg size is not a reliable character for separating eggs of these five species of *Philonthus*, because the size is similar for *P. longicornis* and *P. ventralis*, and for *P. flavolimbatus*, *P. sericans* and *P. hepaticus*. Microsculpture is the only egg character that can be used for species determination of *Philonthus* studied here. These include patterns and presence of ridges, tubercles, processes and projections, granular teeth, granules, cone-shaped structures and aeropyles.

The egg of *P. cruentatus* Gmelin was described by Hunter et al. (1989). Its shape and ridge characteristics are similar to those of *P. longicornis*. Further detailed study is needed for separating these two species because they have overlapping distribution (Blume 1985).

Tiny holes evenly cover the egg surface of *P. ventralis* and *P. sericans*, and open on the tubercles of the egg ridges of *P. longicornis* and *P. flavolimbatus*. These holes were named aeropyles by Hinton (1970, 1981a, b), because they are used for absorbing oxygen from the ambient air. Aeropyles are common on the eggs of terrestrial insects (Hinton 1970).

Philonthus eggs were most abundant in field-collected dung of about 7 d old.

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NEW AMISEGINE WASPS FROM SOUTHEAST ASIA
(HYMENOPTERA: CHRYSIDIDAE)

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Abstract.—Six new species of Amiseginae (Chrysididae) are described from southeast Asia, including *Atoposega decorata* (New Caledonia), *Bupon thailandicus* (Thailand), *Bupon bicornutus* (Vietnam), *Magdalium orchidense* (Taiwan); *Magdalium lucidum* (Malaya), and *Perissosega flavipes* (Thailand).

Key Words: Amiseginae, Chrysididae, *Atoposega*, *Bupon*, *Magdalium*, *Perissosega*

Additional collecting with flight intercept, malaise, and pan traps in southeast Asia has demonstrated how little we know about the fauna of amisegine chrysidids in this region. Recently studied material that was collected in this fashion, and deposited in the Canadian National Insect Collection and Bishop Museum, clearly indicates how our knowledge of these genera is still in a primitive state.

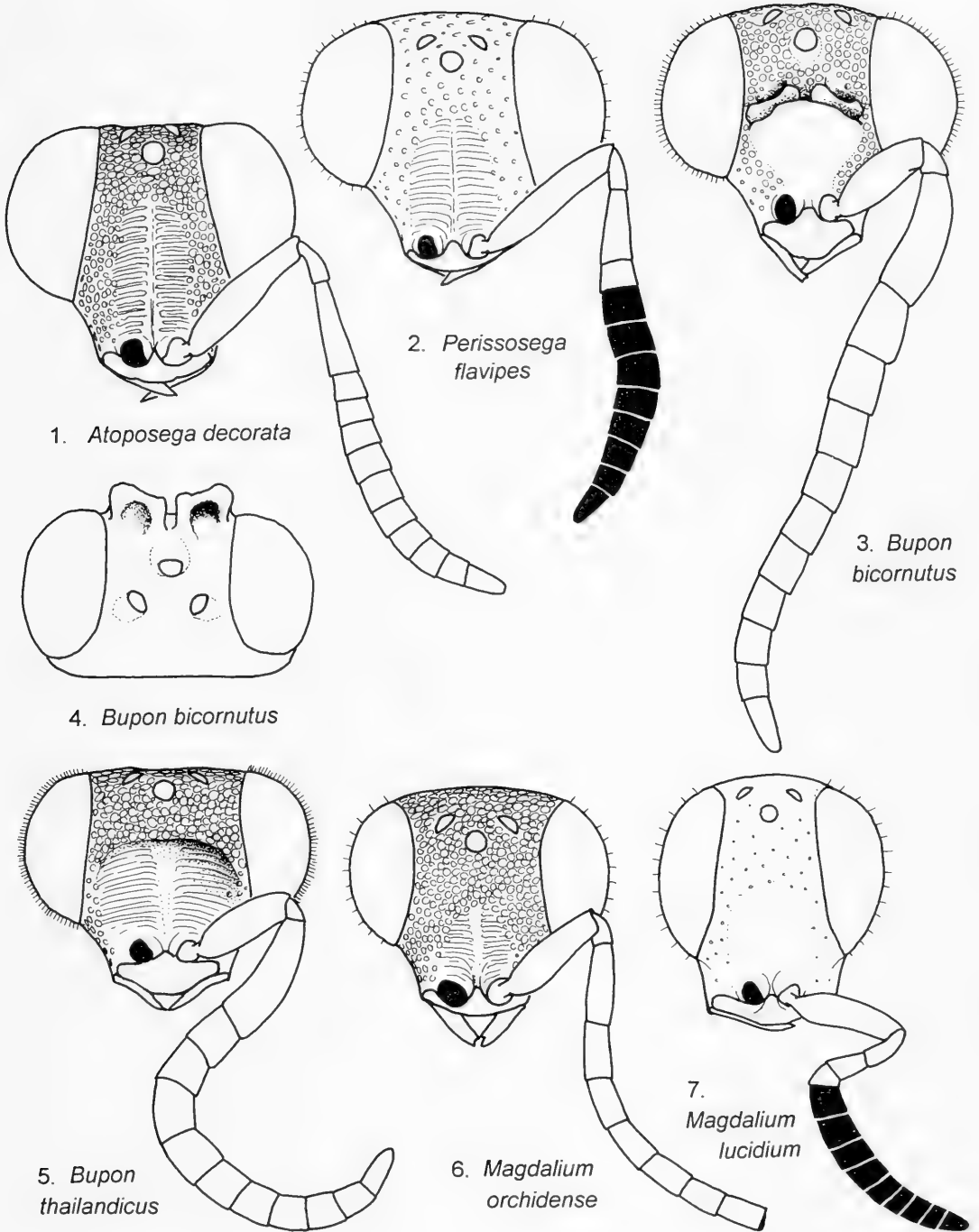
Generic distributions are clearly more widespread than recorded in Kimsey and Bohart (1991). *Bupon* was previously known from a single Malaysian species. The new species described below are from Thailand and Vietnam. *Magdalium* is another genus known from one Malaysian species, and has now been collected from Orchid Island, Taiwan, along with a second species from Malaya. *Baeosega*, known from Sri Lanka, is recorded below from southern Japan. *Perissosega*, previously described from Sri Lanka, is recorded below from Thailand. Finally, an additional, spectacularly blue-colored species of *Atoposega* is described below from New Caledonia. The other three spe-

cies in this genus are from Malaysia and the Philippines.

Specimens described below were obtained from and/or deposited in the following collections. Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, J. M. Carpenter, S. R. Shaw, (CAMBRIDGE); Canadian National Insect Collection, Ottawa, Ontario, L. Masner (OTTAWA); Bohart Museum of Entomology, University of California, Davis, S. L. Heydon (DAVIS); Bernice P. Bishop Museum, Honolulu, Hawaii, G. Nishida (HONOLULU), and U. S. National Museum, Washington, D.C. (K. V. Krombein). Repositories given below are indicated by the city name of the collection in capital letters enclosed in parentheses as above.

Atoposega decorata Kimsey, NEW SPECIES
Fig. 1

Description.—*Female (holotype):* Body length 5 mm. Face (Fig. 1): scapal basin clearly delimited and evenly cross-ridged, malar space 2.8 midocellus diameters long; head slightly wider than long; midocellus



Figs. 1-7. 1-3, 5-7, Front view of face. 4, Dorsal view of male head.

1.5 midocellus diameters from ocular margin; subantennal distance 2.8 midocellus diameters long; flagellomere I length $2.9\times$ breadth; flagellomere II $0.7\times$ as long as broad; pronotum slightly shorter than median length of scutum; vertex and pronotum with punctures sunken between irregular, polished, longitudinal welts, pronotum and scutum with punctures sunken between coarse longitudinal ridges; pronotal posterolateral lobe polished and nearly impunctate; mesopleuron with large nearly contiguous punctures, scrobe not apparent; scutellum with dense, deep, contiguous punctures; metanotal length $0.8\times$ that of scutellum; forewing densely setose except for medial band traversing wing from stigma to posterior margin, wing darkly and stained and with dark setae, except pale medially and around apex extending in along stained remnant of Rs, including setae at base; hindfemur with minute punctures; propodeal angle digitate and pale apically; terga highly polished with few small widely scattered punctures, without striae or "scratches" laterally. Head and thorax generally metallic blue, scutum, metanotum and propodeum more purple, scutellum greener; legs metallic blue on coxae, femora medially and mid- and hindtibiae; forefemur entirely blue except apex pale yellow, foretibia pale yellow with blue tints; tarsi brown; remainder pale yellow to cream-colored; tergum I brown with blue tints, posterolateral corners pale yellow to cream-colored; remainder of abdomen brown with blue tints.

Male. Unknown.

Type material.—Holotype, female, NEW CALEDONIA: Ciu, near Mt. Canala, 300 m, E. O. Wilson (CAMBRIDGE).

Etymology.—The name refers to the decorative coloration of this species.

Discussion.—This is the most brilliantly colored species of *Atoposega*. The bright blues and purples will readily distinguish *decorata* its congeners, *simulans* Kimsey, *rieki* (Krombein) and *lineata* (Krombein).

It has the smooth forefemur, terga without fine "scratches", patterned wings and large size of *simulans* and *lineata*, and metallic coloration more typical of *rieki*.

***Bupon bicornutus* Kimsey, NEW SPECIES**

Figs. 3, 4

Description.—*Male (holotype)*: Body length 4 mm. Face (Fig. 3); scapal basin highly polished, and deeply concave below strongly projecting bilobate brow; brow produced into two large flattened, and dorsally concave projections; vertex convex; head and thorax covered with coarse contiguous punctures; eye encircled by obsolescent carina, clypeal apex broadly rounded; subantennal distance 1.5 midocellus diameters long; malar space 3 midocellus diameters, with vertical sulcus; hindocellus 1 diameter from ocular margin; midocellus 2.2 midocellus diameters from ocular margin; flagellomere I $2.6\times$ as long as broad and arched; flagellomere II $1.3\times$ as long as broad; occipital carina complete; pronotum as long as scutum, with obscure oblong depression posteromedially and small pit on lateral lobe; mesopleuron without scrobal sulcus, propodeal posterior surface coarsely and densely rugose, lateral angle short and blunt; terga relatively sharp-edged laterally, with dense, small punctures, 0.5–1 puncture diameter apart or less. Body black; with bluish highlights on terga; antennae dark brown; legs dark brown with pale joints, and fore- and midtarsi pale; wings brown tinted.

Female unknown.

Paratypes differ in length from the type varying from 4–5 mm.

Type material.—Holotype, male, VIETNAM: Fyan, 900–1000 m, 11 July–9 Aug. 1961, N. R. Spencer (HONOLULU). Paratypes: 1 male, Mt. Lang Bian, 1500–2000 m, 19 May–8 June 1961, N. R. Spencer (HONOLULU), 1 male, 17 km s Dilinh, 1300 m, 6–13 Oct. 1960, C. M. Yoshimoto (DAVIS).

Etymology.—The species name refers to the strongly projecting bilobate frontal carina.

Discussion.—The most distinctive features of this species are the exaggerated frontal carina, which is produced and modified into two excavated, subtruncate lobes, and the strongly concave and smooth scapal basin. Otherwise *bicornutus* resembles *thailandicus* in most respects, with the same general coloration and density of punctuation.

***Bupon thailandicus* Kimsey, NEW SPECIES**
Fig. 5

Description.—*Male (holotype)*: Body length 4 mm. Face (Fig. 5); scapal basin deeply concave and sunken below strongly projecting carinate brow, with coarse cross-ridges; vertex convex; head and thorax covered with coarse contiguous punctures; eye encircled by obsolescent carina, clypeal apex broadly rounded; subantennal distance 1.2 midocellus diameters long; malar space 2.5 midocellus diameters long, with vertical sulcus; hindocellus 0.8 diameter from ocular margin; midocellus 2.5 midocellus diameters from ocular margin; flagellomere I $3\times$ as long as broad and arched; flagellomere II $1.3\times$ as long as broad; occipital carina complete; pronotum $0.5\times$ combined lengths of scutum, scutellum and metanotum, with oblong pit posteromedially and small pit on lateral lobe; mesopleuron without scrobal sulcus, propodeal posterior surface coarsely and densely rugose, lateral angle short and blunt; terga relatively sharp-edged laterally, with dense, small punctures, 0.5 puncture diameter apart or less. Body black with bluish tints on abdominal dorsum; antennae dark brown; legs dark brown with pale joints, and fore- and midtarsi pale; wings brown tinted.

Female unknown.

Paratypes differ somewhat from the type in size, ranging from 3–4 mm.

Type material.—Holotype, male, THAI-

LAND: 70 km sw Chiang Mai, 800 m, Doi Inthanon National Park, Vachiratharu Falls, *Cerocarpus* forest, April–May 1990, B. V. Brown (OTTAWA). Paratypes: 8 males, same data as type (HONOLULU, DAVIS, WASHINGTON); one male: THAILAND: Korat, Pakchong, Musi, Vil. 9, Khlong Yai, 25 May 1969, G. R. Balmer (HONOLULU).

Etymology.—This species named after its country of collection, Thailand.

Discussion.—The two other species described in this genus are *pashoanus* Kimsey and *bicornutus*. *Bupon thailandicus* can be distinguished from *pashoanus* by the dark legs (yellow in *pashoanus*), convex vertex, and arched flagellomere I, and from *bicornutus* by the simple frontal carina.

***Magdaliium lucidum* Kimsey, NEW SPECIES**
Fig. 7

Description.—*Female (holotype)*: Body length 4 mm. Face (Fig. 7); scapal basin highly polished and impunctate; malar space 3 midocellus diameters long, with vertical sulcus; subantennal distance slightly longer than 1 midocellus diameter; flagellomere I $1.6\times$ as long as broad; flagellomeres II–III $0.9\times$ as long as broad; occipital carina present dorsally; midocellus 2 diameters from ocular margin; vertex and frons with small, widely separated punctures, 2–5 puncture diameters apart; hindocellus 0.8 diameter from ocular margin; pronotum only slightly longer than scutum, with thin sulcus extending anteriorly along medial line and pit on lateral lobe; mesopleuron with subalar fossa, short oblique mesopleural carina and scrobal sulcus, scrobal sulcus parallel-sided and about $6\times$ as wide as long; thoracic punctures 0.5–1.0 puncture diameter apart dorsally and 1–2 puncture diameters laterally; notauli deep and straight; metanotum as long as scutellum; propodeum with short blunt posterolateral corner; tergal punctures 0.5–1.0 puncture diameter apart, except for impunctate medial line. Head, thorax and

abdomen shiny black, except pale oblique medial line traversing terga; antenna yellow, except dorsum of apical nine flagellomeres dark brown; legs entirely yellow, except hindfemur brown medially on inner and outer surfaces; wing membrane brown tinted. Body with short erect pale setae.

Male. Unknown.

Type material.—Holotype, female, MALAYA: Sentine Tea Estate, vii–viii 1985, W. Budenberg (OTTAWA).

Etymology.—The species name refers to the highly polished, sparsely punctate, "shining" integument.

Discussion.—This species differs from *cuneifacialis* and *orchidense* below by the shorter pronotum, entirely pale legs, metallic dorsal tints and flagellum with erect bristling red setae. *Magdaliium lucidum* is a slender species with the pronotum considerably longer than the scutum.

***Magdaliium orchidense* Kimsey,**

NEW SPECIES

Fig. 6

Description.—*Male (holotype)*: Body length 4.5 mm. Face (Fig. 6); scapal basin with polished medial stripe and coarse cross-ridges laterally, punctures 0.5–1 puncture diameter apart; malar space 3 midocellus diameters long, with vertical sulcus; subantennal distance 0.3 midocellus diameter; flagellomere I 2.5× as long as broad; flagellomere II length 1.8× breadth; occipital carina present dorsally; midocellus 2.3 midocellus diameters from ocular margin; vertex with impunctate medial welt 1.5 midocellus diameters long; hindocellus 1 diameter from ocular margin; pronotum only slightly longer than scutum, with thin sulcus extending anteriorly along medial line, with pit on lateral lobe; mesopleuron with subalar fossa, short oblique mesopleural carina and scrobal sulcus long, narrow and parallel-sided; notal punctures nearly contiguous to 1 puncture diameter apart, larger and further apart on head and pronotum than scutum; notauli deep and straight posteriorly;

metanotum as long as scutellum; propodeum with short blunt posterolateral corner; tergum II punctures sparse and 2–4 puncture diameters apart, except for impunctate medial stripe; terga III–V with posterior band of punctures. Head, thorax and abdomen black with greenish bronze tints on vertex and thoracic nota; scape and pedicel red; flagellum black; legs pale brown. Body with erect brown setae.

Female: Same as male, except malar space 4 midocellus diameters long; flagellomere I 1.9× as long as broad, flagellomere II 0.8× as long as broad; scape and pedicel red, flagellomere I pale greyish; rest of flagellum black; legs reddish brown; wings brown stained, and propodeal corners prominent and acute.

Type material.—Holotype, male, TAIWAN: Orchid Is. (Batel Tobago), 5–9 July 1991, C. K. Starr (OTTAWA). Paratypes: 1 female, 5 males, same data as type (OTTAWA, DAVIS).

Etymology.—This species is named after the site of collection, Orchid Island.

Discussion.—This species has a shorter pronotum than other species where the pronotum is considerably longer than the scutum, entirely pale legs, metallic dorsal tints and flagellum with erect bristling red setae, which will immediately distinguish it from *cuneifacialis* and *lucidum*. These are much more slender species with the pronotum considerably longer than the scutum.

***Perissosega flavipes* Kimsey, NEW SPECIES**

Fig. 2

Description.—*Female (holotype)*: Body length 4.5 mm. Face (Fig. 2); scapal basin with coarse cross-ridges laterally, punctures 1–2 puncture diameters apart; malar space 3.5 midocellus diameter long, with vertical sulcus; subantennal distance 0.5 midocellus diameter; flagellomere I 2.4× as long as broad; flagellomere II length 0.7× breadth; occipital carina present dorsally; midocellus 2 midocellus diameters from ocular margin; hindocellus 1 diameter from ocular margin;

pronotum only slightly longer than scutum, with thin sulcus extending anteriorly along medial line, with pit on lateral lobe; mesopleuron with subalar fossa, omaulus present; scrobal sulcus long, narrow and parallel-sided, about 7× as long as wide; punctures on vertex and notum 0.5–1 puncture diameter apart; notauli deep and straight posteriorly; metanotum three-fourths as long as scutellum; propodeum with long slender posterolateral spines; tergum II punctures small and 0.5–1.5 puncture diameters apart, except for impunctate medial stripe; terga III–V with posterior impunctate. Head, thorax and abdomen black; coxae, except basally, and rest of legs bright yellow; scapal apex yellow, rest of scape brown; pedicel and flagellomere I yellow, remaining flagellomeres dark brown; tegula and basal wing veins yellow, apical wing veins dark brown; wing membrane brown tinted.

Type material.—Holotype, male, THAILAND, 180 km ne Bangkok, Khao Ysi Natl. Park, 780 m, 11–18 April 1990, malaise trap, B. V. Brown (OTTAWA).

Etymology.—The name *flavipes*, refers to the bright yellow legs.

Discussion.—This is the second species placed in *Perissosega*. It differs from *venablei* Krombein in a number of major features, including the presence of a scrobal sulcus and omaulus, larger size (4.5 mm versus 3 mm), and the wings are evenly brown tinted instead of maculate. In addition, the legs are bright yellow instead of black or brown as in *venablei*.

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A REVIEW OF THE GENUS *REMENUS* RICKER
(PLECOPTERA: PERLODIDAE), WITH THE DESCRIPTION OF
TWO NEW SPECIES

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Abstract.—The formerly monotypic Nearctic genus *Remenus* is revised to include three species: *R. bilobatus* (Needham and Claassen), Appalachian in distribution; *R. kirchneri* n. sp., from Virginia; *R. duffieldi* n. sp., from Georgia. The male and female are described for each species, and the descriptions are supported by illustrations and SEM photomicrographs.

Key Words: Plecoptera, stoneflies, Perlodidae, *Remenus*, Nearctic

Since Ricker's (1952) classic review of the Perlodinae, the Nearctic genus *Remenus* has been considered monotypic. Stark and Szczytko (1984) assigned *Remenus* to the Diploperlini based on typical turtle-shaped eggs and the male seventh sternum which is produced into a distinct lobe. The only species, *R. bilobatus* (Needham and Claassen), has been reported along the Appalachians from Connecticut to South Carolina and Georgia (Stark, Szczytko and Baumann 1986). During the preparation of a chapter on the Perlodinae of Eastern North America for an upcoming publication, it became apparent that more than one form was involved.

Morphology and terminology follow Stark and Szczytko (1984). Abbreviations for depositories of specimens are: Cornell University Insect Collection, Ithaca, New York (CUIC); C. P. Gillette Museum of Arthropod Diversity, Colorado State University (CSU); National Museum of Natural History (USNM); Charles H. Nelson Collection (CHN); Bill P. Stark Collection, Mississippi College, Clinton (BPS); and Virginia

Polytechnic Institute and State University (VPI).

Remenus bilobatus
(Needham and Claassen)
Fig. 1-3, 8a, 8b, 11, 12

Perla bilobata Needham and Claassen, 1925:
95. Holotype male: New York: Old Forge,
7-19 July 1905 (CUIC, #1153), examined.

Description.—*Male:* Length of forewing 8-9 mm; length of body 7-9 mm. General body color in alcohol light brown (pale yellow-brown in life). Head and pronotum with light brown pattern (Fig. 1). Wings hyaline; veins light brown.

Male genitalia: Tenth tergum weakly cleft for 1/3 of its length; hemitergal lobes short, clothed with short setae and sensilla basiconia (Fig. 3). Ninth tergum with short setae and sensilla basiconia (Fig. 3). Paraprocts reduced. Lateral stylets absent. Epiproct covered basally with dense yellow spinulae, enclosed by a golden setae-lined pocket, terminating in a threadlike lash (Figs. 2, 3).

Female: Length of forewing 10–11 mm; length of body 9–10 mm. General color and external morphology similar to the male. Subgenital plate broadly rounded to more narrowly rounded, produced $\frac{2}{3}$ the length of the 9th sternum, with basal lateral crease (Figs. 8a, 8b).

Egg: Turtle shaped. Chorion relatively smooth with keel extending from lid to posterior $\frac{2}{3}$; lid with irregular follicle cell impressions (Figs. 11, 12).

Diagnosis.—Males of *R. bilobatus* are easily distinguished from both *R. kirchneri* n. sp. and *R. duffieldi* n. sp. by the threadlike lash of the epiproct apex (Figs. 2, 3). The length of the lash varies, reaching to the seventh or eighth tergum when fully extended. Most preserved specimens have only a short length of the lash exposed as figured by Hitchcock (1974, Fig. 309) or partially extended as illustrated by Kondratieff and Voshell (1982, Figs. 26–27). Additionally, the fragile terminal lash is occasionally broken and missing from the golden setae-covered basal portion of the epiproct in preserved specimens. Females can usually be distinguished by the large subgenital plate with an incomplete basal transverse crease (Fig. 8a, 8b).

Remarks.—Needham and Claassen (1925) originally described *Perla bilobata* from “many specimens” from Old Forge, New York and Black Mountain, North Carolina. The Black Mountain specimens are typical *R. bilobatus*. Apparently this small perlodine ranges from New England to Alabama and Tennessee along the Appalachians and into the Piedmont Plateau Physiographic province. *Remenus bilobatus* occurs in small to medium-sized cool streams. Adults are active from May to July, but never commonly collected.

Material examined.—ALABAMA: Cleburne Co., small stream above lake, Cheaha State Park, 14 May 1988, B. Kondratieff and R. F. Kirchner, 3 males, 3 females (CSU). CONNECTICUT: Tolland Co. Storrs, 18 June 1954, J. A. Slater, 1 male,

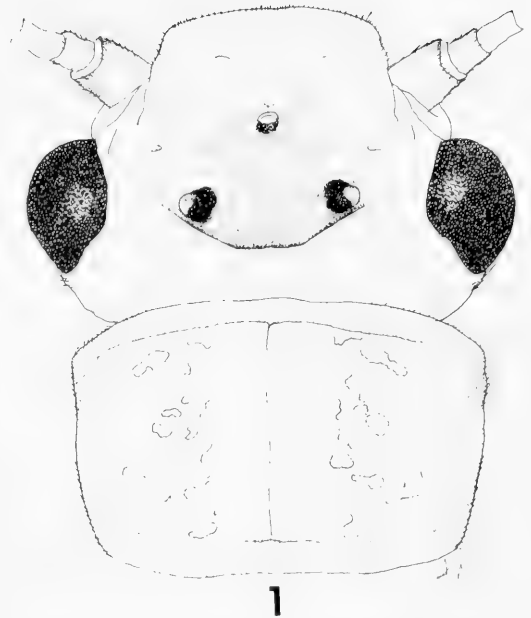
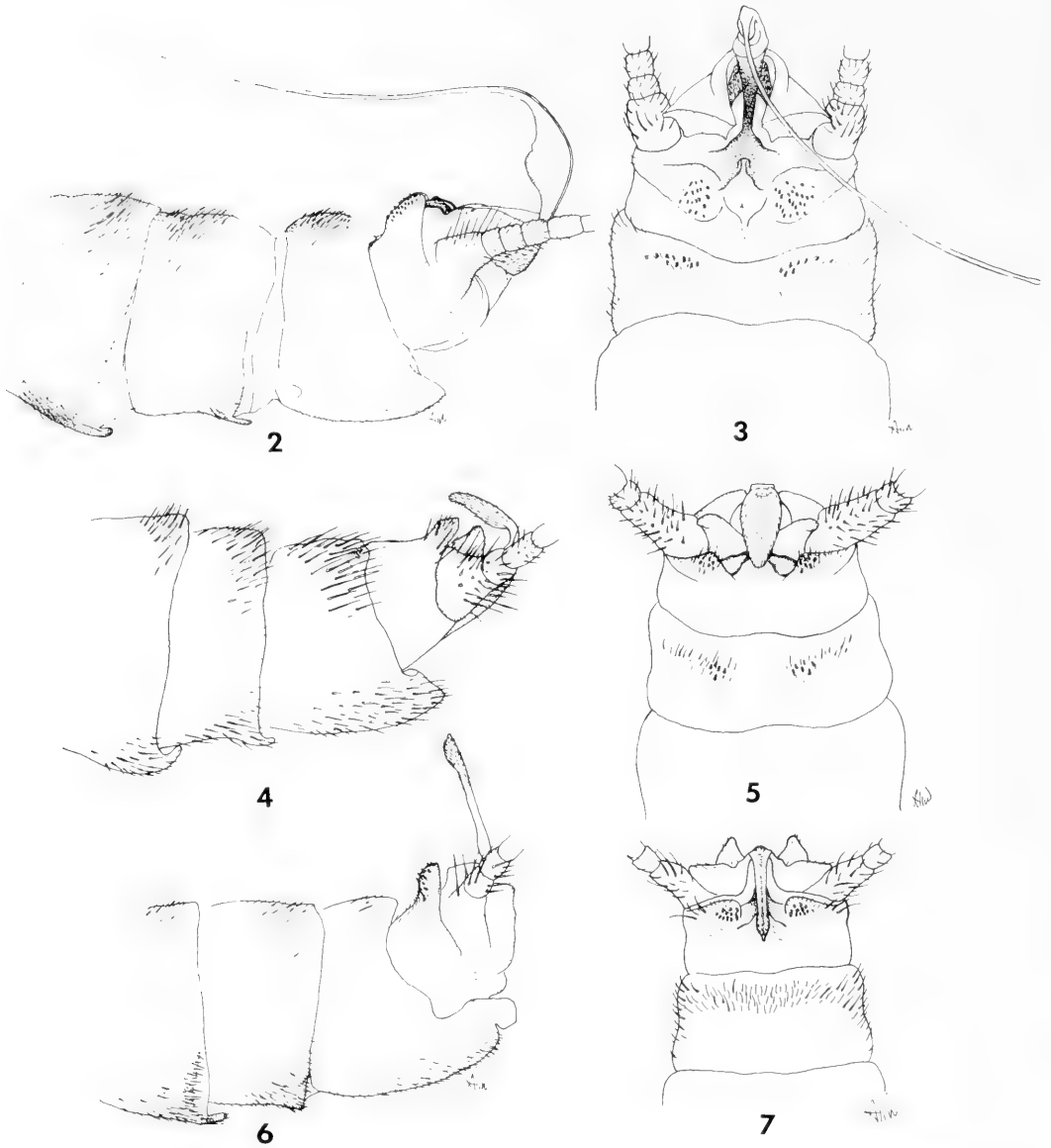


Fig. 1. *Remenus bilobatus*, head and pronotum.

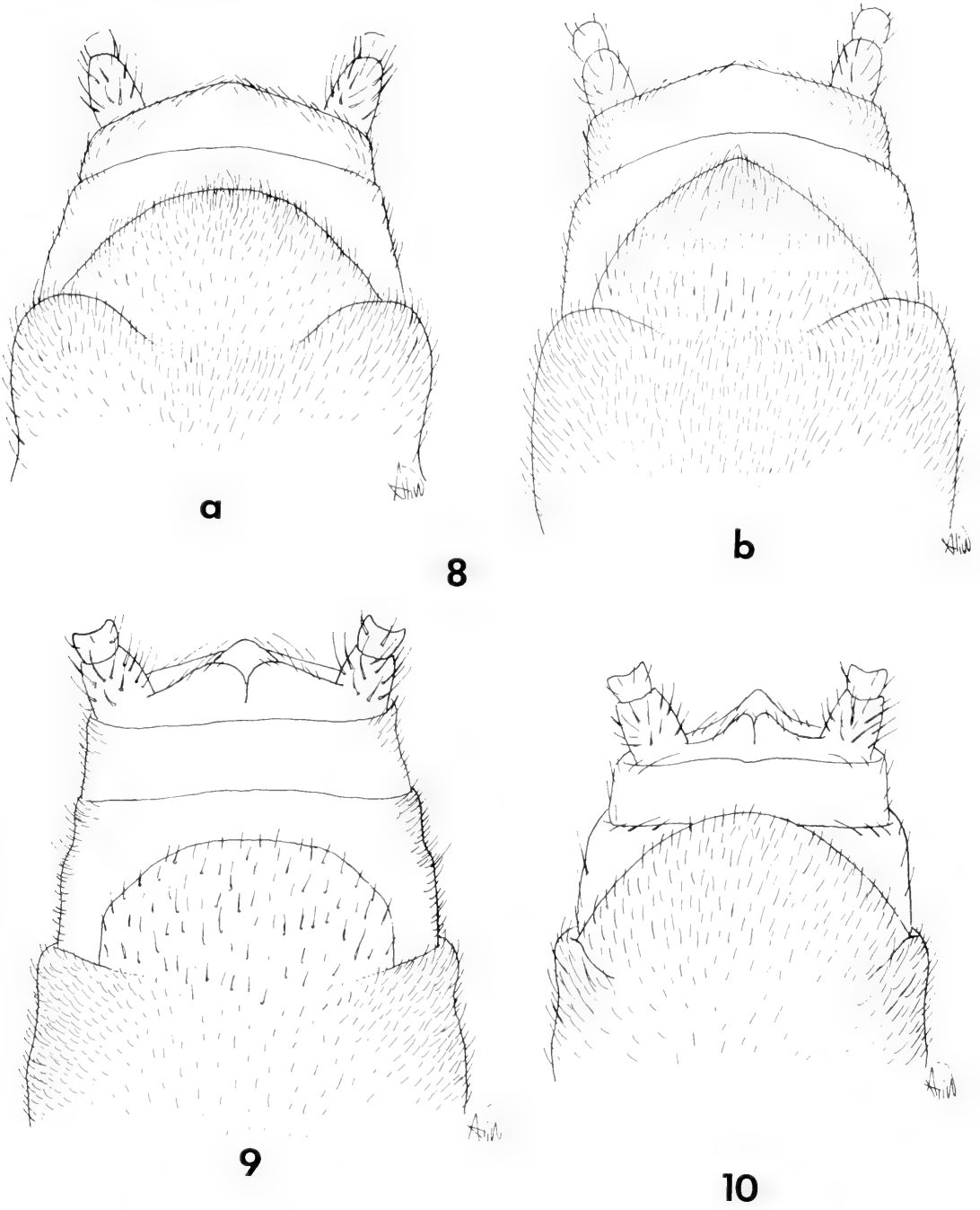
1 female (USNM); brooklet crossing Rt. 48, Killingworth, 18 June 1965, S. W. Hitchcock, 4 males (USNM); Madison, near Rt. 80, 18 June 1965, S. W. Hitchcock, 1 male (USNM). MARYLAND: Fredrick Co., Big Hunting Creek, Thurmont, 4 June 1987, R. M. Duffield, 1 male (CHN); same but 22 June 1988, 1 female (CHN). NORTH CAROLINA: Black Mountain, July–Aug. 1912, Beutenmuller, 2 males (previously cleared), 1 female (CUIC, Paratypes #1153); Haywood Co., Sterling Creek, Rt. 23 (Rd 1397), GSMNP, 10 July 1983, B. Kondratieff and R. F. Kirchner, 2 females (VPI); Macon Co., Jarrett Creek, Arrowwood Glade, Nantahala National Forest, 25 May 1993, B. Kondratieff and R. F. Kirchner, 1 male (CSU); Transylvania Co., South Fork of Mills River, FR 1206 off Rt. 276, 8 July 1981, B. Kondratieff and R. F. Kirchner, 2 males, 3 females (VPI). PENNSYLVANIA: Adams Co., near Fairfield, 18 June 1950, D. G. Shappiro, 2 males (USNM). SOUTH CAROLINA: Oconee Co., Townes Creek, Road 710, Sumter National Forest, 24 May 1993,



Figs. 2-7. *Remenus*, male terminalia. 2. *R. bilobatus*, lateral (epiproct fully extended). 3. *R. bilobatus*, dorsal. 4. *R. kirchneri*, lateral. 5. *R. kirchneri*, dorsal. 6. *R. duffieldi*, lateral. 7. *R. duffieldi*, dorsal.

Kondratieff and Kirchner, 1 female (CSU); Pickens Co., Wildcat Creek, 9 km NW Clemson, 24 May 1981, B. P. Stark et al., 6 males (BPS); TENNESSEE: Polk Co., GoForth Creek, Rt 64, Cherokee National Forest, 3 June 1993, C. H. Nelson, 1 male (CHN); VIRGINIA: Bland Co., Wolf Creek, Rt. 61, 10 June 1978, B. Kondratieff, 1 male

(VPI); Montgomery Co., Toms Creek, Rt. 655, 29 May 1978, B. Kondratieff, 1 male (reared) (VPI); small spring flowing into Craigs Creek, 2.7 km off Rt. 460 on Rt. 621, 17 June 1980, B. Kondratieff, 1 male (VPI); Tazewell Co., East Fork Cove Creek, Rt. 662, 12 June 1983, B. Kondratieff and R. F. Kirchner, 1 male (VPI).



Figs. 8-10. *Remenus*, female subgenital plate. 8a. *R. bilobatus*, Maryland. 8b. *R. bilobatus*, South Carolina. 9. *R. kirchneri*. 10. *R. duffieldi*.

Remenus kirchneri Kondratieff and Nelson,
NEW SPECIES
Figs. 4, 5, 9

Description.—*Male*: Length of forewing 8–9 mm; length of body 8–9 mm. General body color in alcohol light brown (pale green-brown in life). Head and pronotum with light brown pattern similar to Fig. 1. Wings hyaline; veins light brown.

Male genitalia: Hemitergal lobes short, clothed with short setae and few sensilla basiconia (Fig. 5). Ninth tergum with long setae and few scattered sensilla basiconia (Fig. 5). Paraprocts reduced. Lateral stylets absent. Epiproct in dorsal view, pear-shaped (Fig. 5), covered with fine appressed spinulae; in lateral view, subparallel, slightly constricted at apex (Fig. 4).

Female: Length of forewing 10–11 mm; length of body 9–10 mm. General color and external morphology similar to the male. Subgenital plate broadly rounded, produced $\frac{2}{3}$ length of 9th sternum, with basolateral margins parallel for at least $\frac{1}{2}$ of plate length (Fig. 9).

Egg: Unknown.

Types.—HOLOTYPE male: Virginia, Patrick Co., Little Rock Castle Creek, Rock Castle Gorge National Recreation Area, 24 May 1990, B. Kondratieff and R. F. Kirchner. PARATYPES: Same as holotype, 1 male, 1 female; Floyd Co., spring-fed stream entering Little River, Rt. 686, 8 June 1978, B. Kondratieff, 1 male (VPI); small spring seep, Rt. 221, Roadside Park, $\frac{1}{4}$ mile S of Floyd, 6 July 1980, B. Kondratieff, 2 males (CHN); small spring-fed stream, 6 miles E of Floyd, Rt. 221, 28 June 1981, B. Kondratieff, 1 male, 1 female (VPI); Patrick Co., spring-fed tribs. of Little Rock Castle Creek, Rt. 605, 10 May 1983, B. Kondratieff, 1 male (VPI); small spring-fed stream into Tallant Reservoir, Dan River, 2 August 1982, B. Kondratieff, 1 female (VPI).

The holotype will be deposited in the USNM. Paratypes will be deposited in CSU, CHN, and VPI collections.

Etymology.—The authors take great

pleasure in naming this species for our friend, Ralph F. Kirchner, Huntington, West Virginia, in recognition of his many contributions to the study of North American stoneflies.

Diagnosis.—Males of *R. kirchneri* are easily distinguished from *R. bilobatus* by the absence of a terminal epiproctal lash, and from *R. duffieldi* n. sp. by the pear-shaped epiproct (Fig. 5). The smaller subgenital plate with parallel basolateral margins (Fig. 9) distinguishes the females from the other two species.

Remarks.—This species is only known from small headwater spring-fed streams or seeps of the lower Blue Ridge physiographic province of Virginia. At the type locality, another apparently endemic stonefly species of this area, *Sweltsa voshelli* Kondratieff and Kirchner is found. Other common stoneflies at the type locality are *Peltoperla tarteri* Stark and Kondratieff and *Tallaperla maria* (Needham and Smith).

Remenus duffieldi Nelson and Kondratieff,
NEW SPECIES

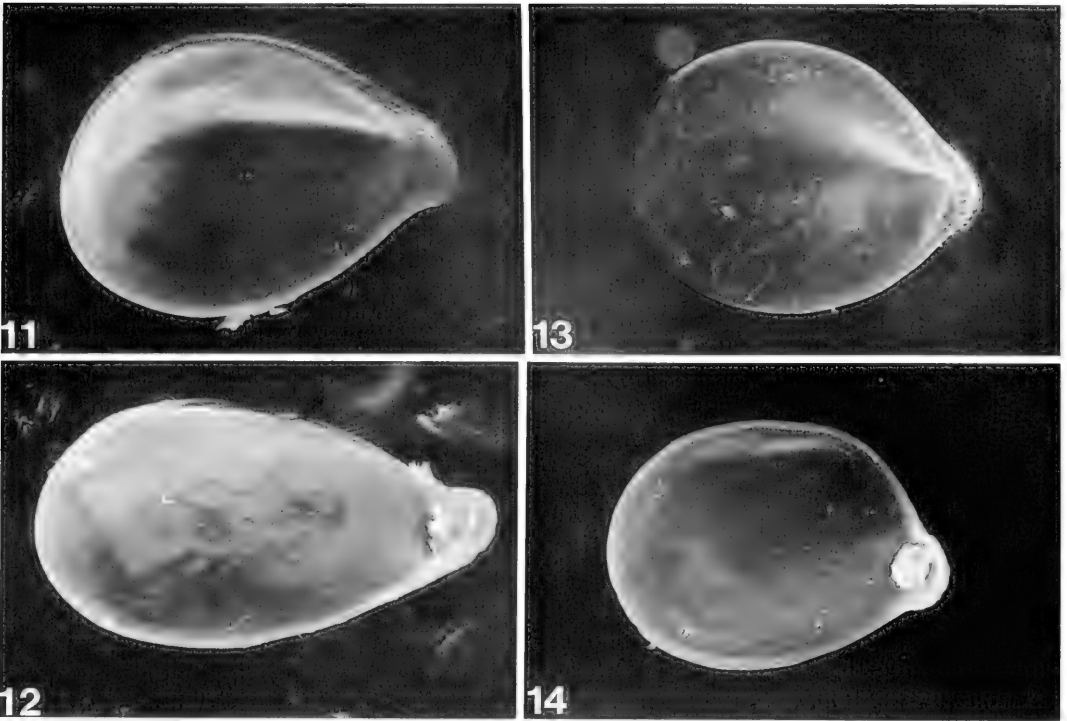
Figs. 6, 7, 10, 13, 14

Description.—*Male*: Length of forewing 8–9 mm; length of body 8–9 mm. General body color in alcohol light brown (pale green in life). Head and pronotum with light brown pattern similar to Fig. 1. Wings hyaline; veins light brown.

Male genitalia: Hemitergal lobes short, clothed with short setae and few sensilla basiconia (Fig. 7). Ninth tergum with long setae (Fig. 7). Paraprocts reduced. Lateral stylets absent. Epiproct elongate, slightly expanded apically (Figs. 6, 7) with long hair-like spinulae on apex, with dorsal sclerite long, narrow, reaching apex (Fig. 6).

Female: Length of forewing 10–11 mm; length of body 9–10 mm. General color and external morphology similar to male. Subgenital plate broadly rounded, produced to posterior margin of 9th sternum (Fig. 10).

Egg: Turtle-shaped. Chorion with weak follicle cell impressions and dorsal keel ex-



Figs. 11–14. *Remenus* eggs. 11. *R. bilobatus*, dorsal (203 \times). 12. *R. bilobatus*, ventral (230 \times). 13. *R. duffieldi*, dorsal (186 \times). 14. *R. duffieldi*, ventral (178 \times).

tending from lid to near middle; lid covered with irregular follicle cell impressions (Figs. 13, 14).

Types.—*HOLOTYPE* male: Georgia: Towns Co., Soapstone Creek, Rt 180 near junction Owl Creek Road, Chattahoochee National Forest, 8 June 1994, C. H., C. P., B. A. Nelson. *PARATYPES*: Same as holotype, 2 males (CHN); Union Co., Slaughter Creek, Rt. 180, Chattahoochee National Forest, 30 May 1994, C. H. Nelson, 1 female (CHN); Rock Creek, junction Rt 69, 1.5 miles W High Tower Gap, Chattahoochee National Forest, 29 May 1990, R. M. Duffield, 2 males (CHN); Soapstone Creek, Junction 180, Chattahoochee National Forest, 26 May 1990, R. M. Duffield, 1 male (CHN); White Co., Andrews Creek, Rt 17/75, Andrews Cove Campground, Chattahoochee National Forest, 8 June 1994, C. H. Nelson, 1 male, 3 females, 1 nymph (CHN).

The holotype will be deposited in the USNM. Paratypes will be deposited in CSU and CHN collections.

Etymology.—This species is named for Dr. Richard Duffield, Howard University, Washington, D.C. who first collected specimens of this interesting new species.

Diagnosis.—Males of *R. duffieldi* are easily distinguished from both *R. bilobatus* and *R. kirchneri* by the elongate almost club-like epiproct (Figs. 6, 7). Females of *R. duffieldi* can be separated from both *R. bilobatus* and *R. kirchneri* by the broadly rounded subgenital plate reaching the posterior margin of ninth sternum (Fig. 10).

Remarks.—The nymph of *R. duffieldi* is similar to the nymph of *R. bilobatus* as described and figured by Stewart and Stark (1988). Like *R. bilobatus*, *R. duffieldi* is found in small to mid-sized montane Appalachian streams. Other stonefly species collected with this new species were *Pteronarcys scotti*

Ricker, *Tallaperla cornelia* (Needham and Smith), *Acroneuria abnormis* (Newman), *Yutania bulbosus* (Frison), *Alloperla usa* Ricker, *Sweltsa lateralis* (Banks), *Amphinemura wui* (Claassen), *Leuctra biloba* Claassen, and *Leuctra alexanderi* Hanson.

With the inclusion of the two new species, *R. duffieldi* and *R. kirchneri*, adult males of the genus *Remenus* are defined by the following combination of characters: (1) tenth tergum cleft, $\frac{1}{3}$ of its length producing short hemitergal lobes, (2) well-developed ventral lobes on sterna seven and eight and (3) eastern Nearctic in distribution. Females of the genus are difficult to distinguish from other Perlodidae, without associated males, especially *Isoperla*, but the combination of the dorsal head pattern, small size (body length 9–10 mm), and subgenital plate form are usually diagnostic.

KEY TO *REMENUS* SPECIES

- 1. Epiproct of male terminating in a threadlike lash (Figs. 2, 3); subgenital plate of female broadly to narrowly rounded, with basal transverse crease incomplete (Figs. 8a, 8b) *R. bilobatus*
- Epiproct without terminal lash (Figs. 4, 5 and 6, 7); apex of subgenital plate broadly rounded, without basal crease (Figs. 9, 10) 2
- 2. Epiproct in dorsal view, pear-shaped (Fig. 5); subgenital plate not reaching posterior margin of 9th sternum, with sides subparallel (Fig. 9) *R. kirchneri*
- Epiproct, in dorsal view elongate, sides almost parallel (Fig. 7); subgenital plate, reaching posterior margin of 9th sternum, broadly rounded (Fig. 10) *R. duffieldi*

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R. bilobatus. We are also grateful to Oliver S. Flint, Jr., National Museum of Natural History, Washington, D.C.; Bill P. Stark, Mississippi College, Clinton, Mississippi; and J. Reese Voshell, Virginia Polytechnic Institute and State University, Blacksburg, Virginia for the loan of valuable material. Bill P. Stark, and Richard W. Baumann, Brigham Young University are thanked for reviewing the manuscript. Alison Anderson-Williams provided the illustrations. Dr. Robert E. Lee, Department of Anatomy and Neurobiology, Colorado State University, graciously provided the SEM photomicrographs.

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TAXONOMIC REVIEW OF APPLE-FEEDING SPECIES OF
PHYLLONORYCTER HÜBNER (LEPIDOPTERA, GRACILLARIIDAE) IN
NORTH AMERICA

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Abstract. — Four species of *Phyllonorycter* whose larvae mine apple leaves are recognized in North America: *P. blancardella* (F.), *P. crataegella* (Clemens), *P. elmaella* Doğanlar and Mutuura, and *P. mespilella* (Hübner). The former two species are widely distributed in the eastern United States and southeastern Canada. We confirm the presence of *P. blancardella* in the Pacific Northwest, earliest records being from Oregon in 1985, Washington in 1986, and British Columbia in 1987. *Phyllonorycter mespilella* occurs over much of western North America, from California north to British Columbia, and east to Utah and New Mexico. *Phyllonorycter elmaella* is known from Oregon, Washington, and British Columbia. *Lithocolletis malimalifoliella* Braun is synonymized under *P. crataegella*. Records of *Phyllonorycter sorbi* (Frey) in North America and of *P. scudderella* (Frey and Boll) on apple are regarded as erroneous. *Phyllonorycter deceptusella* (Chambers), also wrongly mentioned as feeding on apple is here regarded as a *nomen dubium*. We provide keys based on external features and on genitalia of adults, as well as diagnoses and notes on the geographical distribution and biology of each species.

Key Words: Lepidoptera, taxonomy, biology, distribution, apple, tentiform leaf miner, North America, Gracillariidae, *Phyllonorycter*

With nearly 80 described species (Davis 1983) and dozens of as yet undescribed entities, the genus *Phyllonorycter* is one of North America's most taxonomically diverse genera of leafmining Lepidoptera. The larvae feed on a variety of woody perennials, usually forming tentiform mines on the underside of leaves (Needham et al. 1928). Eight species have been reported to feed on apple leaves in North America: *P. blancardella* (F.), *P. crataegella* (Clemens), *P. malimalifoliella* (Braun), *P. sorbi* (Frey), *P. mespilella* (Hübner), *P. elmaella* Doğanlar and Mutuura, *P. deceptusella* (Chambers), and *P. scudderella* (Frey and Boll) (Stultz 1964, Pottinger and LeRoux 1971:

6-9, Doğanlar and Mutuura 1980, Weires et al. 1980). *Phyllonorycter blancardella*, *P. crataegella*, and *P. elmaella* have often been reported as orchard pests. A fourth species, of European origin, *P. mespilella*, occurs abundantly on apples and related rosaceous plants, yet its presence in western North America has been all but overlooked. Our studies indicate that *P. mespilella* has been established in the western United States for at least 50 years, and that recent literature treating *P. elmaella* (e.g. Weires and Forshey 1978, Orphart 1982, Hoyt 1983, Barrett and Jorgensen 1986, Barrett and Brunner 1990, Jones 1991) likely refers to *P. mespilella*.

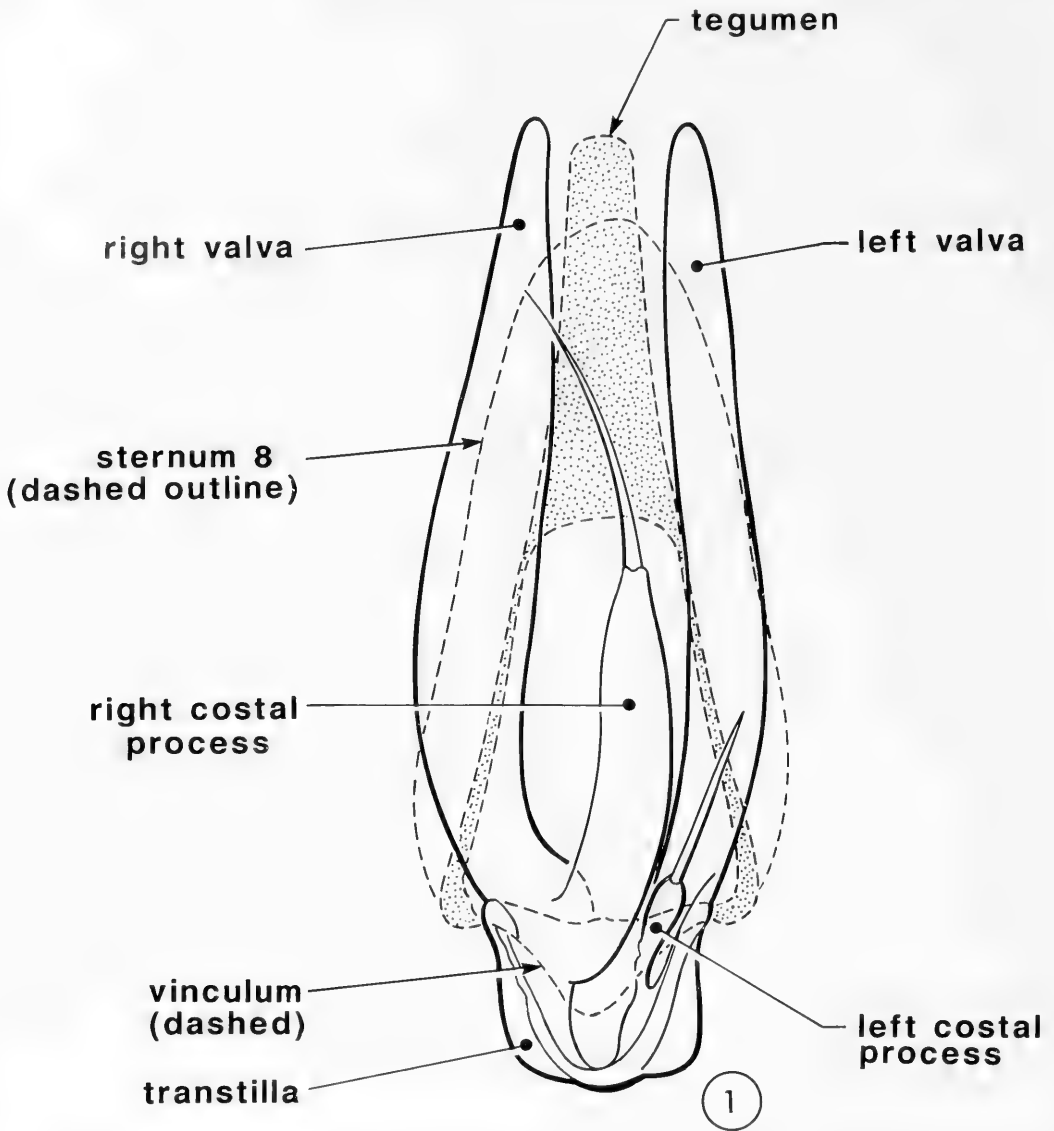


Fig. 1. Male genitalia of *Phyllonorycter* species, unspreadd, showing the position of tegumen (stippled) and sternum VIII (dashed); aedeagus omitted.

Pottinger and LeRoux (1971) comprehensively reviewed literature on the apple-feeding *Phyllonorycter* in North America up to 1964. They pointed out that there was much confusion, particularly among economic entomologists, as to what species they actually worked with, and that virtually all papers lacked reliable determinations. All the apple-feeding species are superficially

very similar to one another. There are small differences in coloration and pattern among species, but these are often muddled by pronounced intraspecific, especially brood-related, variation. Stultz (1964) provided the first North American work in which male genital characteristics of *P. blancardella* and *P. crataegella* were compared and illustrated. Pottinger and LeRoux (1971) distin-

guished and illustrated the male genitalia of *P. blancardella*, *P. crataegella*, and *P. mespilella*. Neither work compared the female genitalia of these species. Doğanlar and Mutuura (1980) provided illustrations of both the male and female genitalia of *P. elmaella* but they did not compare them to other apple-feeding *Phyllonorycter*.

In order to clear the taxonomic confusion surrounding the apple-feeding species of *Phyllonorycter* in North America, we present diagnoses of adults, keys for separating them based on genital features and on adult coloration, and summaries of biological and distributional data for the species. We regard as valid four species for which we have examined specimens reared unequivocally from larvae mining apple (*Malus* spp.) leaves: *P. blancardella*, *P. crataegella*, *P. elmaella*, and *P. mespilella*. The first and the last are introduced from Europe; the other two are believed indigenous species, which transferred to apple from *Crataegus* and other native Rosaceae. Of the remaining species reported in the literature, one is a junior synonym [*P. malimalifoliella* (Braun, 1908a) = *P. crataegella* (Clemens, 1859), new synonymy], two are thought to have been reported in error [*P. sorbi* (Frey) and *P. scudderella* (Frey and Boll)], and the status of one remains uncertain [*P. deceptusella* (Chambers)]—it most resembles cherry feeding members of the genus.

MATERIALS AND METHODS

Specimens were examined from the following collections:

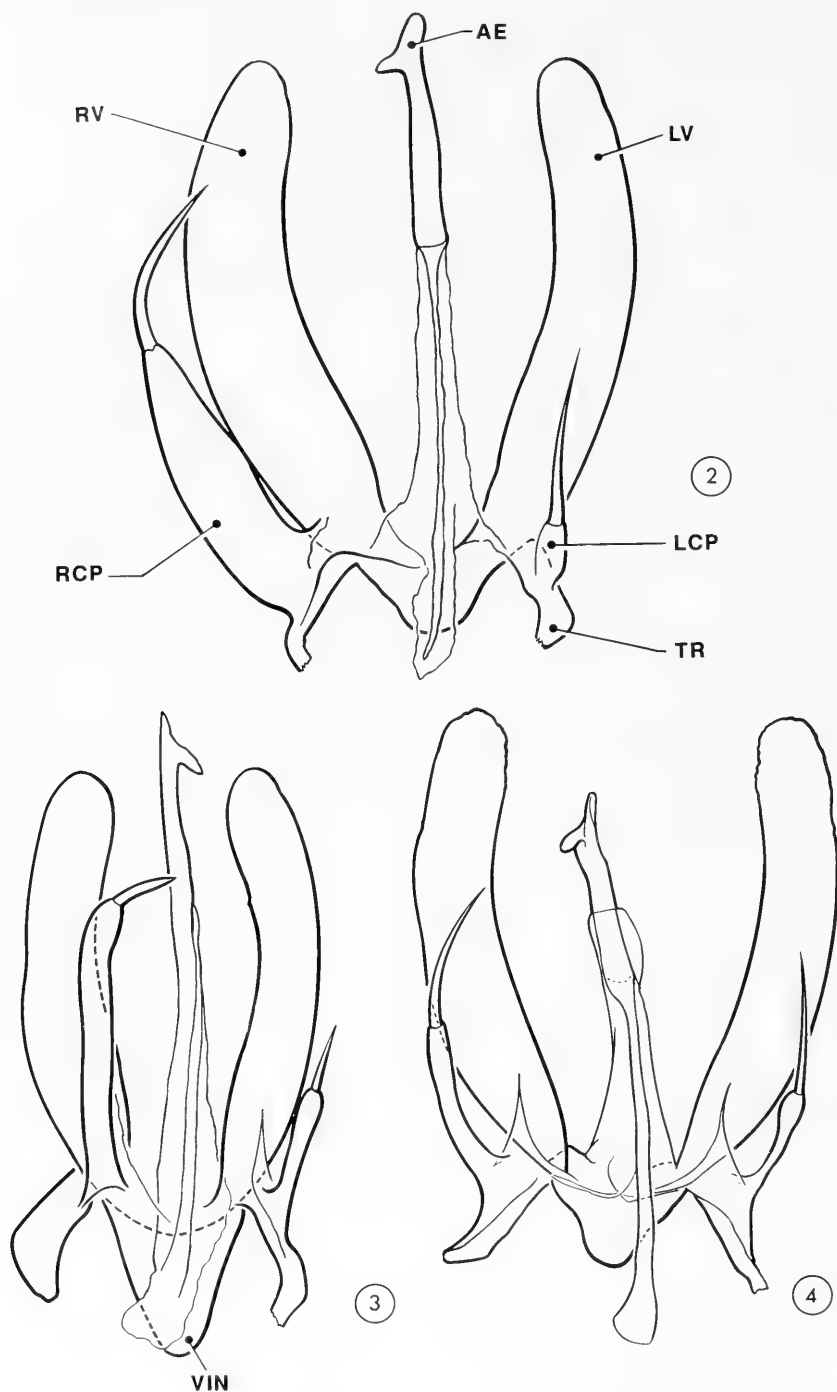
- ANSP Academy of Natural Sciences of Philadelphia, 19th & Parkway, Logan Square, Philadelphia, PA 19103 (D. Azuma).
 CNCI Canadian National Collection, Agriculture Canada, Centre for Land and Biological Resources Research, C.E.F., Ottawa, Ontario K1A 0C6 (J.-F. Landry).
 DESC Gerfried Deschka Collection (pri-

vate), Resselstrasse 18, A-4400 Steyr, Austria.

- LEMC Lyman Entomological Museum, Macdonald College, 21111 Lakeshore Drive, Ste-Anne-de-Bellevue, Québec H9X 1C0 (C.-C. Hsiung).
 MCZC Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts 02138 (P. D. Perkins).
 OSUO Oregon State University, Corvallis, Oregon 97331 (J. D. Lattin).
 CISC Essig Museum, Wellman Hall, University of California, Berkeley, California 94720 (J. A. Powell).
 UCON University of Connecticut, Storrs, Connecticut 06269 (D. L. Wagner).
 USNM United States National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560 (D. R. Davis).

We have studied the types of *P. crataegella* (Clemens), *P. deceptusella* (Chambers), *P. elmaella* Doğanlar and Mutuura, and *P. malimalifoliella* (Braun) as well as specimens of European origin of *P. blancardella*, *P. mespilella*, *P. sorbi*, and *P. cydoniella* (F.), and the Japanese apple-feeding *P. ringoniella* (Matsumura).

Genitalia were dissected following the standard method described by Robinson (1976), stained with both Orange G (in 30% ethanol; enhances sclerites) and chlorazol black (in 70% ethanol; enhances membranes), and mounted in Euparal. In mounting most male genitalia, the tegumen and sternum VIII were left attached to the abdomen. The rest of the genitalia (vinculum-valvae-aedeagus) were separated and mounted dorsal side up after severing the transtilla medially and prying the valvae apart, in order to expose dorsally the costal processes, thereby providing a diagnostic view of the genitalia (e.g. Figs. 2–4). Female



Figs. 2-4. Male genitalia of *Phyllonorycter* species, dorsal aspect, with tegumen, sternum VIII, and setae of valvae omitted; transtilla cut medially with valvae and their processes spread flat; posterior end oriented towards top of page. Abbreviations are as follows: AE, aedeagus; LCP, left costal process; LV, left valva; RCP, right costal process; RV, right valva; TR, transtilla; VIN, vinculum. 2, *mespilella* (slide MIC 2071); 3, *crataegella* (slide JFL 785); 4, *elmaella* (slide JFL 860).

genitalia were left within the abdomen and mounted ventral side up (removing the genitalia can cause much distortion or damage).

Records that we mention below have been confirmed by genital dissections and are deposited in the collections indicated in parentheses.

Drawings were prepared with a drawing tube mounted on a Nikon Optiphot compound microscope, at magnifications of 100× or 200×. Drawings were prepared from single specimens whenever possible, but parts have been re-arranged slightly on some drawings to compensate for distortions present in slide preparations. In the illustrations, the posterior end is directed upward on the page. Male genitalia are shown in dorsal aspect, females in ventral aspect; hence in male illustrations, the actual right side appears on the left. Positions of the costal processes are affected by preparation and therefore are not indicative of specific differences.

Photographs of the adults were taken with a Nikon F3 camera fitted with a Leitz 63 mm objective, using Kodak Technical Pan film (set at 12 ASA) and processed in Kodak Technidol.

GENERAL ASPECTS OF LIFE HISTORY

The species in this group have closely similar life histories. The eggs, about 0.3 mm in length, are flat and oval, and laid on the lower leaf surface. All species have three sap-feeding and two tissue-feeding larval instars. The legless sap-feeding instars expand the mine to its full extent, separating the lower leaf surface from the overlying parenchymic tissues. From below the mine appears waxy white to greenish; the early instar mine is not visible from above.

The fourth and fifth tissue-feeding instars are legged with a fully developed spinneret that they use to lay down silk within the mine, that pulls the edges of the mine inwards, drawing the mine into an elongate tentiform bubble. The lower leaf surface is

drawn into a set of four to numerous closely set creases. The larvae remove small patches of tissue up to the upper leaf surface, giving the upper side of the leaf a shot-hole or skeletonized appearance, and hence the common name for the group, the "spotted tentiform leafminers." The size of the mines may vary depending on the host, e.g. on apple cultivars with thick leaves the mine may average considerably smaller. The fifth instar spins a sparse cocoon against the upper side of the mine and pupates within a few days. The pupa is extruded through the lower leaf surface prior to eclosion of the adult.

The species in this group are multivoltine with pupae overwintering within the mines. At least two broods and as many as five broods, are inferred. For example, in California, *P. mespilella* has up to five generations in the Central Valley, three to four broods in coastal areas, and as few as two generations in higher elevation apple and pear orchards in the Sierra Nevada (L. Varela, in litt. 1993). Three broods are reported for both *P. crataegella* and *P. blancardella* in the northeastern United States (Maier 1985, Maier and Davis 1989). The presence of summer-diapausing sap-feeding instars is reported for second-generation individuals of *P. blancardella* (Laing et al. 1986) and probably occurs in other members of the group as well (Maier and Davis 1989). For more information on biology, consult Pottinger and LeRoux's (1971) monographic treatment of *P. blancardella*; much contained therein is likely applicable to the other apple-feeding species.

Some populations of *Phyllonorycter crataegella* and *P. blancardella* have developed insecticide resistance in sprayed orchards in eastern North America (Maier 1983, Pree et al. 1986, Barrett and Brunner 1990). In California *P. mespilella* has developed resistance to both guthion and vygate (L. Varela, in litt.). Thus, accurate species identification may be necessary if effective control is intended.

We have acquired numerous collections of active mines throughout our study from apple trees growing in Arkansas, British Columbia, California, Connecticut, New York, Ontario, Oregon, Utah, Vermont, and Washington, and in only one case has a collection yielded more than a single species. This is surprising in that both *P. blancardella* and *P. crataegella* are broadly sympatric over much of eastern North America and *P. blancardella*, *P. elmaella*, and *P. mespilella* over the Pacific Northwest. Weires et al. (1980) reported several sites in New York where both *P. crataegella* and *P. blancardella* co-occurred although the latter species predominated in most orchards.

Early collections from Nova Scotia (pre-1950) were all *P. crataegella*, but beginning in 1957, *P. blancardella* began outbreaking in Nova Scotia (Stultz 1964). All recent collections from eastern Canada in the CNCI have been of *P. blancardella*. Stultz (1964), in his studies of apple-feeding *Phyllonorycter* in Nova Scotia, was unable to locate a single population of *P. crataegella* on apple during the several years of his survey efforts. In Europe, *P. blancardella* tends to replace other species of *Phyllonorycter* once established in an area (G. Deschka, in litt. 1993). If competitive displacement is a common outcome among these apple-feeding species, the situation in the Pacific Northwest should prove especially interesting in that both *P. blancardella* and *P. mespilella* are introduced—the former presumably has been present little more than a decade. Indeed, *P. elmaella* may have been common on apple prior to the arrival of these two moths, but presently we do not know of a single orchard where *P. elmaella* can be reliably obtained.

Related to the above may be the fact that the apple-feeding species may respond to a common, or at least to common components of the female sex pheromone. A female-produced sex attractant of *P. blancardella*, identified by Roelofs et al. (1977) as

(E10)-Dodecenyl acetate, has also been used to survey for adults of *P. mespilella* (Cosentine and Jensen 1992, Gries et al. 1993). However, it is scarcely, if at all, attractive to males of *P. crataegella* (Weires et al. 1980). In Europe Deschka (in litt. 1993) noted that related Rosaceae-feeding species of *Phyllonorycter* (but not all of them) have one and the same pheromone, and the males of two or more species may be attracted to a single female.

REMARKS ON IDENTIFICATION

External characters.—Considerable phenotypic differences occur both within and between broods such that it is virtually impossible to identify reliably all adults using only scaling characters. But because color characters have been used extensively in the past, we provide a discussion of features that have diagnostic value. Series rather than individuals should be examined whenever possible. Antennal and hindleg coloration applies to the scaling of the dorsal surfaces. The white scales of the mesoscutellum are easily abraded during the process of pinning.

Individuals of the overwintering or spring brood tend to be larger and more darkly marked. In some specimens of *P. blancardella* the orange forewing scales may be mostly replaced or overlaid with dark scales. The legs and antennae also tend to be more fuscous in the spring generation. Summer generation moths vary greatly in size, but average smaller (for each species, our measurements are based on the examination of more than 20 specimens, except where noted), black scaling is much reduced, and the orange ground color appears paler. Moths emerging in the fall display both spring (few) and summer (most) phenotypes.

Genital characters.—Reliable identification of *Phyllonorycter* species feeding on pomoid and prunoid Rosaceae should be based on examination of the genitalia. Vouchers with their dissected abdomen and genitalia should always be preserved. Whenever pos-

sible adult moths should be pinned, preferably on minutens and staged (double-mounted). They should *never* be glued on points, as this often renders removal of the abdomen for genital examination difficult or impossible. A simple and rapid method for mounting microlepidoptera is described in Landry and Landry (1994). Dry specimens from light traps or sticky specimens from pheromone traps should be relaxed and pinned, preserved in ethanol, or placed into small microvials mounted on pins. In the latter case a tiny plug of cotton within the microvial will reduce excessive movement.

To dissect and examine the genitalia, the whole abdomen (on dry specimens, easily removed by applying from beneath gentle upward pressure with fine forceps) is soaked in 20% KOH (aqueous solution) for 2–3 hours at room temperature, or for 3–5 minutes in a warm (but not boiling) water bath. The abdomen is then descaled in 30% ethanol using very fine camel hair brushes to expose the genitalia; the digested abdominal content should be extruded through the anterior (proximal) opening by gentle pushes with the brush. A less satisfactory result can be obtained by gently rolling away the abdominal contents and scales with the head of an insect pin. It is usually not necessary to separate the genitalia from the abdomen to view diagnostic characters. The genitalia may be then examined in alcohol, glycerine, or lactic acid, and stored in glycerine in a microvial kept with the specimen. Permanent slide mounts, such as in Euparal or Canada balsam, are desirable but not essential for routine identifications. For the preparator inexperienced with permanent slide mounts, glycerine preservation of dissected vouchers is preferable to poor permanent slides. Before storage into glycerine the abdomen-genitalia should be briefly soaked in lactic acid or in 30% ethanol acidified to pH 4 with a few drops of acetic acid, to ensure that all KOH is neutralized, then rinsed in water.

Terms.—Terms for genitalia are shown in Figs. 1–3 and 9, those for forewing maculation in Fig. 13. We refer to the sterigma as any sclerotized area that surrounds the female copulatory opening or ostium bursae. In *Phyllonorycter* species treated here, the sterigma derives from modification of the posterior margin of sternum VIII and the attached anterior apophyses.

Externally males can be separated from females by examining either the frenulum or the apex of the abdomen. Males have a single frenular bristle, females have two. In males the valvae, tegumen, and sternum VIII, though covered by scales, are usually discernable; ventrally a longitudinal slit is visible where the valvae come together. In females the apex of the ovipositor usually protrudes from the abdomen, appearing as a setose lobe.

KEY TO ADULTS BASED ON GENITAL CHARACTERS

- | | |
|--|------------------------|
| 1a. Males | 2 |
| 1b. Females | 5 |
| 2a. Right costal process dilated, thicker than left process. Valvae asymmetrical, right valva broader than left valva (Fig. 2) ... <i>P. mespilella</i> | |
| 2b. Right costal process slender, comparatively as thin as left process. Valvae symmetrical or nearly so, right valva as wide as left valva (Figs. 3–5) | 3 |
| 3a. Right costal process (excluding apical spine) subequal to or slightly longer than left costal process (Fig. 4) | <i>P. elmaella</i> |
| 3b. Right costal process (excluding apical spine) at least twice as long as left costal process (Figs. 3, 5–7) | 4 |
| 4a. Spines of costal processes long and slender, setiform. Left costal process very short and stubby (Fig. 5), exceptionally in few specimens left process about one-third length of right process (Figs. 6–7) | <i>P. blancardella</i> |
| 4b. Spines of costal processes short and stout, spiniform. Left costal process about half length of right process (Fig. 3) | <i>P. crataegella</i> |
| 5a. Posterior margin of sternum VIII markedly projected into truncate cone (Figs. 9–10) | <i>P. blancardella</i> |
| 5b. Posterior margin of sternum VIII not projected or only slightly protruded (Figs. 8, 11–12) | 6 |

- 6. Ostium bursae surrounded by ringlike thickening (Fig. 12) *P. mespilella*
- 6b. Ostium bursae without sclerotized ring 7
- 7a. Posterior margin of sternum VIII concave (Fig. 11). Base of ovipositor distad of ostium bursae membranous, flat. Anterior apophyses situated closer to middle of sternum VIII than to its lateral margins *P. elmaella*
- 7b. Posterior margin of sternum VIII straight or slightly convex. Base of ovipositor distad of ostium bursae sclerotized, medially elevated, laterally steeply sloped, with transverse cuticular creases just caudad of ostium bursae (Fig. 8). Anterior apophyses situated closer to lateral margins of sternum VIII than to its middle *P. crataegella*

KEY TO ADULTS BASED ON EXTERNAL CHARACTERS

This key is provided for convenience, but results should *always* be checked by examining genitalia. Some variant individuals will not key out. Diagnostic features may not be well rendered in our black and white photographs. Lastly, scale colors lighten appreciably as specimens age in collections.

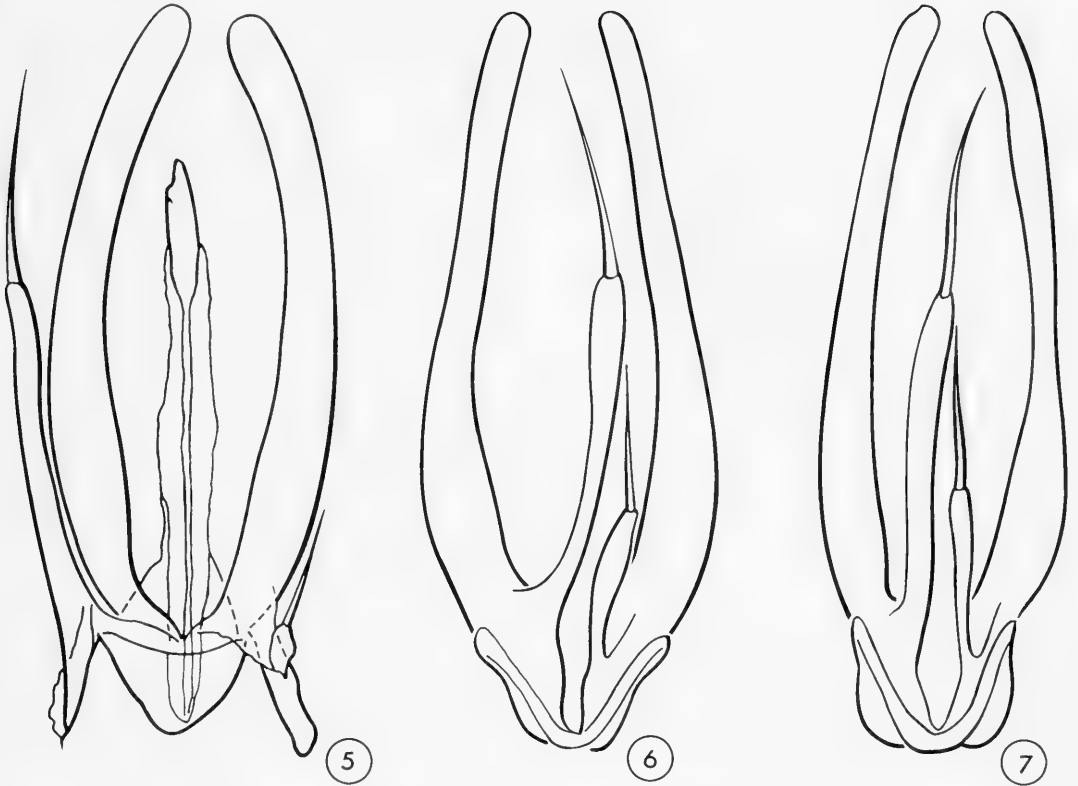
- 1a. Forewing with basal patch that tends to bulge toward basal streak (e.g. Figs. 17, 20); mesoscutellum with prominent patch of white scales; basal streak broad, of 4-6 scale rows, often subequal or exceeding width of orange-scaled area between basal streak and costa (Figs. 16-18, 20) *P. blancardella*
- 1b. Forewing with basal patch narrow, parallel to wing margin (few individuals in series with bulge); mesoscutellum with few or no white scales; basal streak narrow, of 3-4 scale rows, often subequal or much narrower than width of orange-scaled area between basal streak and costa (Figs. 22-24, 26-37) 2
- 2a. Axis of first costal strigula running to dorsal (posterior) margin, less than twice as long as broad, often touching or confluent with first dorsal strigula (Figs. 27-29); fourth costal strigula often expanded toward wing apex and broader than third; ground color orange; first metatarsomere pale white or gray scaled (rarely with subapical dark band) *P. elmaella*
- 2b. Axis of first costal strigula running to tornus or outer margin, usually more than twice as long as broad, infrequently touching or confluent with first dorsal strigula (Figs. 22-24, 26, 30-37); fourth costal strigula reduced or absent; ground color coppery, fiery or red or-

- ange; first metatarsomere with conspicuous black subapical dark band or black scaling dorsad 3
- 3a. Antenna mostly pale to fuscous, terminal articles occasionally darkened; first metatarsomere mostly pale, often with apical band of dark scales; forewing with apical row of lamelliform scales (before ciliary fringe) dark only in distal half, forming narrow iridescent blue-black band between outermost fasciae (Figs. 30-37); forewing ground color fiery orange or red orange *P. mespilella*
- 3b. Antenna mostly dark (especially dorsal surface); first metatarsomere dorsally entirely dark (some specimens with light scales apically); forewing with apical row of lamelliform scales dark for at least two-thirds of their length, forming broad iridescent blue-black band between outermost fasciae (Figs. 22-24); ground color with decided metallic or coppery luster *P. crataegella*

Phyllonorycter blancardella (F.)
Figs. 5-7, 9-10, 14-21

Tinea blancardella Fabricius, 1781: 305.
Lithocolletis blancardella (F.); Pottinger and LeRoux, 1971.
Phyllonorycter blancardella (F.); Bradley, 1972: 10. Davis, 1983: 10. Emmet et al., 1985: 319.
Lithocolletis concomitella Banks, 1899: 246.

Diagnosis.—In male genitalia (Fig. 5), *P. blancardella* is recognized by the markedly different costal processes, the right process being slender, with a slender apical spine that is about one-third the length of the process and extends nearly to the apex of the valva. The valvae are the narrowest of the species here treated. The left process is very short and stubby in most specimens (Fig. 5), but some variation occurs in its length, and exceptionally it can be up to nearly half the length of the right process (Figs. 6-7). Specimens with an unusually long left process resemble in that respect specimens of *P. elmaella*, but in the latter the right process is much shorter and the valvae are broader than in *P. blancardella*. The apical hooklike lobe of the aedeagus is barely sug-



Figs. 5-7. Male genitalia of *P. blancardella* in dorsal aspect with tegumen, sternum VIII and setae of valvae omitted; posterior end oriented towards top of page; 5, transtilla cut medially with valvae and their processes spread flat (slide MIC 2077); 6, redrawn from Pottinger and LeRoux (1971, p. 217, fig. 18-B), showing variation in length of left costal process; 7, *id.* (p. 220, fig. 21-F).

gested in *P. blancardella* (Fig. 5), whereas it is distinct in *P. elmaella* (Fig. 4).

In female genitalia (Figs. 9-10) *P. blancardella* is the most distinctive of the species. It is recognized by the markedly projected sterigma which forms a truncate cone extended far beyond the posterior margin of sternum VIII. The length and width of the conical projection vary somewhat, but the overall aspect is unlike that of any of the other species.

Forewing length: spring generation, 3.1-4.5 mm ($n = 20$); summer generation, 3.0-4.3 mm ($n = 20$). Antenna often fuscous in winter generation and pale with conspicuously darkened terminal articles in summer broods. Mesothoracic scutellum with distinct patch of white scales, 3-6 rows wide.

Forewing (Figs. 14-21) with white and black scales more or less equal in number to orange scales; black scaling especially prominent in spring brood (Figs. 18-20); white basal patch (anal macula) 2-5 scale rows wide, often bulging toward basal streak; first costal strigula usually at least twice as long as broad, axis usually intersecting tornus or outer margin, rarely confluent with first dorsal strigula (Fig. 16); fourth costal strigula often subequal to third; basal streak broad, of 4-6 scale rows, often subequal or exceeding width of orange-scaled area between basal streak and costa, in some specimens, basal streak connected to first dorsal strigula (Fig. 20); outer row of lamelliform fringe scales with distal $\frac{1}{2}$ darkened, forming narrow iridescent blue-black band be-

outermost strigulae. Hindleg: tibiae usually pale, or faintly darkened; first and second tarsomeres pale or with dark apical bands.

Distribution.—We have examined specimens of *P. blancardella* from South Carolina northward to Nova Scotia and westward to Ontario and Illinois, as well as from Oregon, Washington, and the Vancouver District of British Columbia. Records from farther south in the eastern U.S. await verification. Commonly known as the spotted tentiform leafminer, *P. blancardella* is presumably introduced from Europe and is a pest of orchards in northeastern United States and southern Canada (Pottinger and LeRoux 1971, Weires et al. 1980, Maier and Davis 1989).

The first reports of *P. blancardella* are quite old (Walsingham 1882: 202, Busck 1903: 190) and may be correct although we have not seen the adults upon which they are based. The oldest confirmed records for this species (determinations based on genital dissections) date back to 1957 from Nova Scotia (Stultz 1964), but presumably the insect was established here well before this time. The oldest specimens of *P. blancardella* that we have examined were collected in 1959 in Québec and Nova Scotia (CNCI).

The occurrence of *P. blancardella* on the West Coast is probably recent. The first confirmed West Coast specimens were collected from cultivated apple in November 1985 from Wilsonville, Clackamas Co., Oregon (UCON), August 1986 from Concrete, Skagit Co., Washington (DESC), and October 1987 from a nursery orchard in Chilliwack, Vancouver District, British Columbia (CNCI). R. Duncan (pers. comm.) of Agriculture Canada in Victoria noted that a species of *Phyllonorycter* first appeared as a pest in Victoria in 1987; specimens from infested orchards, which turned out to be *P. blancardella*, were sent DLW in the summer of 1988. Thus the western distribution of *P. blancardella* already may be more extensive than our records indicate.

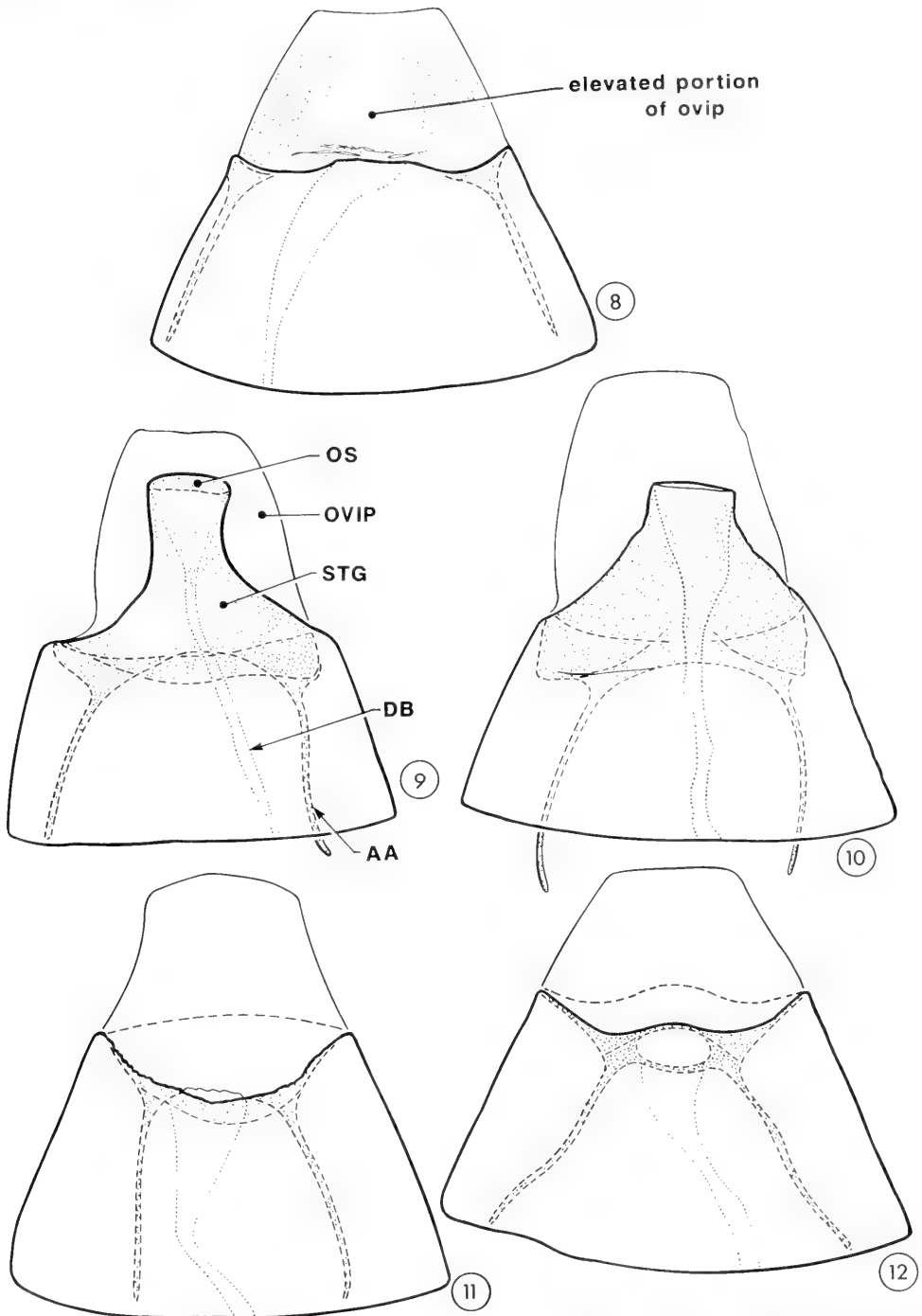
Biology.—In North America *Phyllonorycter blancardella* feeds on apple, *Malus* spp., including apple cultivars (*Malus sylvestris* (L.) Mill.) and a number of ornamental crab apple varieties. It is not known to use native *Malus* (*Pyrus*) species here. This species is triple brooded in Connecticut and southern Canada (Stultz 1964, Pottinger and LeRoux 1971, Maier 1984, Trimble 1984). A sex attractant (E10-12: OAc) for this species was identified by Roelofs et al. (1977) and is now widely used by fruit growers to monitor populations of this and related *Phyllonorycter* species. A second, even more attractive, constituent of the female sex pheromone (E4, E10-12: OAc) was recently identified by Gries et al. (1993).

Phyllonorycter crataegella (Clemens)
Figs. 3, 8, 22-24, 26

- Lithocolletis crataegella* Clemens, 1859: 324.
Busck, 1903: 190. Braun, 1908b: 301.
McDunnough, 1939: 95.
Phyllonorycter crataegella (Clemens): Davis 1983: 10.
Lithocolletis malimalifoliella Braun, 1908a: 101 (New synonymy). Braun, 1908b: 300.
McDunnough, 1939: 95.
Phyllonorycter malimalifoliella (Braun): Davis, 1983: 10.
Lithocolletes [sic] *blancardella* (F.): sensu Dyar, 1902: 551.

Diagnosis.—In male genitalia (Fig. 3), *P. crataegella* is characterized by the regularly tubular costal processes with short and stout apical spines. The left costal process is about one-third the length of the right one. The apical portion of the right costal process is slightly bent. Some specimens of *P. blancardella* with an unusually long left costal process are the only other members of the group with costal processes of approximately similar relative length as those of *P. crataegella*, but they are easily distinguished by their slender, setalike spines and narrow valvae.

In female genitalia (Fig. 8), *P. crataegella*



Figs. 8–12. Female genitalia of *Phyllonorycter* species, ventral aspect; posterior end oriented toward top of page. Abbreviations are as follows: AA, anterior apophysis; DB, ductus bursae; OS, ostium bursae; OVIP, base of ovipositor; STG, sterigma. 8, *crataegella* (slide MIC 2099); 9, *blandardella* (slide JFL 833); 10, *blancardella* (slide JFL 817); 11, *elmaella* (slide JFL 830); 12 *mespilella* (slide JFL 834).

characterized by the slight medial protrusion of the posterior margin of sternum VIII and the sclerotized and medially broadly elevated base of the ovipositor with a few transverse, sclerotized wrinkles just distad of the ostium bursae. The sides of the elevated portion are concave, giving the appearance of lateral ridges.

Forewing length: spring generation, 3.1–4.3 mm ($n = 30$); summer generation, 2.5–3.6 mm ($n = 30$), in series averaging smaller than other species, especially in summer brood and southern parts of range. Antenna uniformly dark in both generations. Mesothoracic scutellum with 2–3 rows of inconspicuous whitish scales. Forewing (Figs. 22–24, 26); ground color orange with decided metallic or coppery luster; basal area of dorsal margin with narrow line of white scales, rarely more than 2 scale rows in width; first costal strigula usually at least three times as long as broad, axis running to outer margin or apex, rarely confluent with first dorsal strigula; fourth costal strigula often subequal to third or absent (Fig. 26); basal streak narrow, seldom more than 4 scale rows in width, always subequal to width of orange-scaled area between basal streak and costa; outer row of lamelliform fringe scales dark for at least $\frac{2}{3}$ their length, forming prominent iridescent blue-black band between outermost strigulae. Hindleg: tibia black above; all tarsomeres blackened.

Individuals matching the size and forewing pattern of *P. malimalifoliella* (Fig. 26), with three rather than four costal strigulae, represent variants of the summer brood of *P. crataegella*. The genitalia are indistinguishable from those of the latter.

Distribution.—*Phyllonorycter crataegella* is widely distributed through apple-growing regions of the East, from the Atlantic Coast westward to Arkansas, northward into southern Ontario and Nova Scotia. Western North American records (Wilson 1915, Braun 1939, Pottinger and LeRoux 1971: 16) remain unconfirmed and are probably

in error. This species may be quite abundant in sprayed orchards, in those populations that have developed insecticide resistance (Maier 1983).

Biology.—*Phyllonorycter crataegella* feeds on a variety of prunoid and pomoid Rosaceae. Maier (1985) reared it from *Ame-lanchier* spp., *Aronia* spp., *Crataegus* spp., *Cydonia* spp., *Malus* spp., *Prunus* spp., *Pyrus* spp., and *Sorbus* spp. in Connecticut. Weires et al. (1980) noted that *P. crataegella* is but weakly attracted to the sex pheromone of *P. blancardella*. Populations throughout much of its range are triple brooded (Beckham et al. 1950, Maier 1981, Maier and Davis 1989).

Synonymy and type material examined.—*Lithocolletis crataegella*: Clemens gave no indication of how many specimens he had at the time of describing the species but his description of the mine as “usually [emphasis ours] limited by two leaf veins” suggests that he may have reared more than one specimen. Busck (1903) indicated that a single specimen was present in the Clemens Collection. Therefore it is advisable to designate that specimen as the lectotype.

LECTOTYPE ♂ in ANSP, here selected, labelled: [1] “26” [pink, handwritten]; [2] “Type 7506/ *Lithocolletis/ crataegella/ B. Clemens*” [red, partly printed, partly handwritten]; [3] “*Lithocolletis* Type!/
crataegella/ AB 1902 Clemens” [handwritten by A. Busck]; [4] “♂ genitalia on/ slide 2938/ D. R. Davis” [printed with number handwritten]; [5] “Lectotype ♂ / by D. Davis” [partly printed in red, partly handwritten]; [6] “LECTOTYPE ♂/ *Lithocolletis/ crataegella/ Clemens/ sel. J.-F. Landry, 1993*”. The specimen is double mounted on cork. It is badly damaged, with the head broken off and stuck to the minuten pin; only the right forewing remains attached to the specimen; the metathorax, hindwings, and hindlegs are broken off and in a gelatin capsule pinned with the specimen. The lectotype selection by Davis is unpublished. Type lo-

cality: probably Easton, Pennsylvania (see Hodges 1986: 36).

Lithocolletis malimalifoliella: Braun (1908a) did not indicate the number of specimens in her type series of *L. malimalifoliella*. In Braun's collection at ANSP four specimens bear her red type labels but without indication of a species name. One male and one female are from Cincinnati, Ohio, rearing lot number B88, with emergence dates of 31 August 1907 and 1 September 1907, respectively; they are undoubtedly syntypes. Another male, also from Cincinnati is from rearing lot B264 with an emergence date of 26 May 1908, and cannot be a syntype because the moth issued after the publication date of the original description (March 1908). A female (without abdomen) from Montclair, New Jersey, collected in a trap, is another syntype; Braun (1908a: 101) specifically stated that she had "flown specimens from Montclair, N.J., which are identical with the bred specimens." D. R. Davis (in litt.) has selected the B88 male as lectotype, and the B88 and Montclair females as paralectotypes. Because his designations have not been published, a lectotype is here designated following Davis' intent.

LECTOTYPE ♂ in ANSP, here designated, labelled: [1] "Cincinnati, O./ Annette F. Braun/ VIII-31. 07"; "B88/ apple"; [2] "TYPE/ Collection of/ Annette F. Braun" [red, printed]; [3] "♂ genitalia on/ slide 3283/ D. R. Davis"; [4] "LECTOTYPE ♂/ Lithocolletis/ malimalifoliella Braun/ By D. R. Davis"; [5] "Lithocolletis/ malimalifoliella/ Braun" [handwritten in Braun's hand]; [6] "Figured in/ Moths of America/ North of Mexico" [blue, printed]; [7] "LECTOTYPE ♂/ Lithocolletis/ malimalifoliella/ Braun/ sel. J.-F. Landry, 1993". The indication of a "Moths of America North of Mexico" figure added by Davis as well as Davis' lectotype selection are unpublished. The specimen is spread and double-mounted on cork. Type locality: Cincinnati, Ohio.

All three specimens bear a red label

marked: "TYPE/ Collection of/ Annette F. Braun."

Phyllonorycter elmaella Doğanlar and Mutuura

Figs. 4, 11, 27–29

Phyllonorycter elmaella Doğanlar and Mutuura, 1980: 311.

Diagnosis.—In male genitalia (Fig. 4), *P. elmaella* differs from all other species treated here in having slender subequal costal processes with slender spines that extend to about the middle of the valvae.

In female genitalia (Fig. 11), the concave, slightly crenulate posterior margin of sternum VIII, reduction of the sterigma to very narrow rim, lack of thickening of the basal part of the ductus bursae (antrum), and lack of sclerotization in the proximal part of the ovipositor are diagnostic. Reduction of the sterigma is also found in *P. crataegella*, but in this species the posterior margin of sternum VIII is slightly protruded (Fig. 8). In *P. elmaella* the proximal portion of the ovipositor is membranous, whereas it is sclerotized and has cuticular wrinkles in *P. crataegella*.

Forewing length: spring generation, 4.0 mm (n = 1); summer generation, 3.1–4.0 mm (n = 20). Antenna uniformly fuscous in both generations. Mesothoracic scutellum with inconspicuous patch of white scales, 2 or 3 rows wide. Forewing (Figs. 27–29); ground color coppery to pale orange; basal area of dorsal margin with narrow line of white scales, rarely more than 3 rows in width; first costal strigula often less than twice as long as broad, axis usually intersecting dorsal margin before tornus, often touching or confluent with first dorsal strigula (Fig. 27); fourth costal strigula often expanded toward wing apex and broader than third; basal streak narrow, 3–4 scale rows, always subequal to width of orange-scaled area between basal streak and costa; outer row of lamelliform fringe scales dark

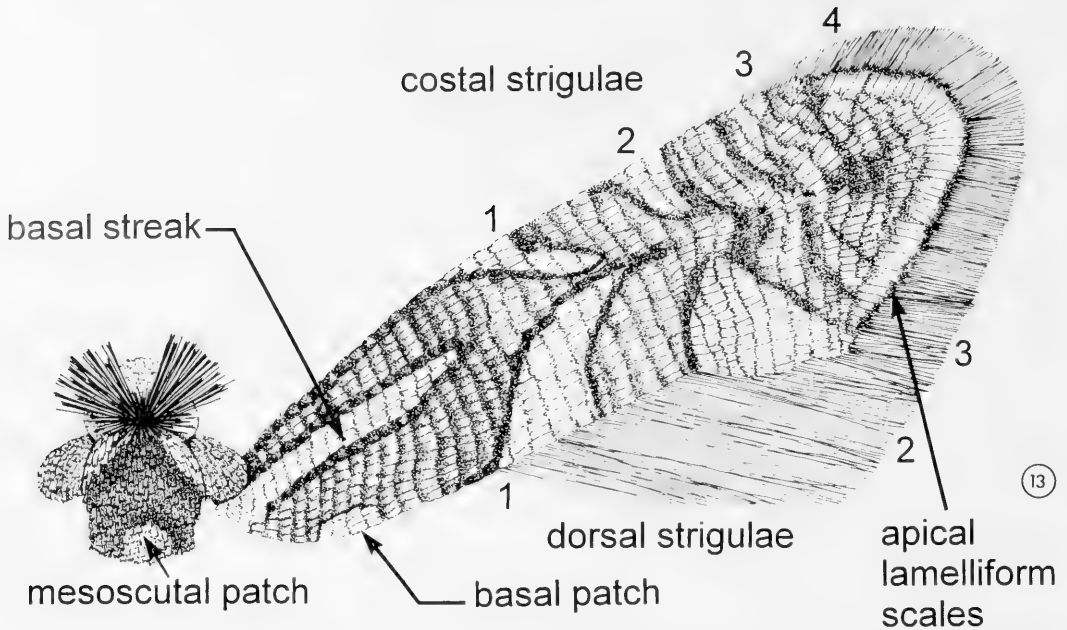


Fig. 13. Dorsal aspect of *Phyllonorycter* species illustrating forewing pattern, with terms used to designate markings.

for about $\frac{1}{2}$ their length, forming narrow black band without iridescent blue-black reflections. Hindleg: coloration varying from straw colored to pale fuscous, if present, fuscous scales cover entire dorsal surface of tibia and at least first two tarsomeres.

Remarks.—The forewing pattern of *P. elmaella* illustrated by Doğanlar and Mutuura (1980) is not diagnostic. Considerable variation is present in the type series, which includes individuals from two generations. The wing pattern shown by Doğanlar and Mutuura is that of the dark spring form, in addition to being a variant in which the first dorsal and first costal strigulae are broadly confluent medially.

The narrow slender valvae of the male genitalia described and illustrated by Doğanlar and Mutuura (1980) is the result of a preparation artifact and is misleading the valvae are not flattened in their preparations (in CNCI, examined), but merely shown on edge. The valvae do not afford a diagnostic difference from those of the European *P. sorbi*, as may be interpreted from

their figure of the latter, which shows the valvae mounted flat. The valvae of *P. elmaella* are subspatulate and very similar to those of *P. sorbi* when both are compared in flat view. Differences between *P. sorbi* and *P. elmaella* are as follows. In the male of *P. elmaella*, the costal processes extend to one-third the valva length and the apical spines are nearly as long as the processes; in the male of *P. sorbi*, the costal processes are relatively longer and extend to about the middle of the valvae and the apical spines are proportionally shorter, at most one-third the length of the costal processes. In the female of *P. elmaella*, the posterior margin of sternum VIII is concave, finely serrate, and the sclerotization reduced to a very narrow margin; in the female of *P. sorbi*, the posterior margin of sternum VIII has a broader sclerotization and is medially produced into a short, blunt cone. There are no significant differences in the signum between these two species, contrary to Doğanlar and Mutuura's (1980) statement. Furthermore Doğanlar and Mutuura erro-



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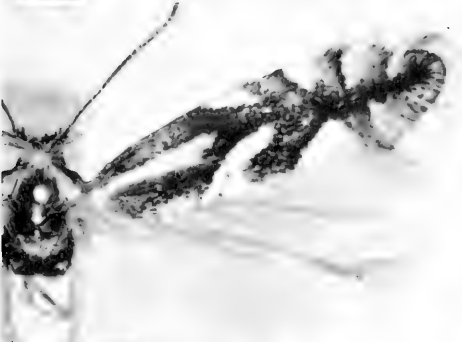
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Figs. 14–21. Forewings of apple-feeding *Phyllonorycter blancardella*. 14, Vancouver, B. C., ex crab apple 4.viii.1992 (CNCI); 15, Mecklenburg, Germany, ex *Malus sylvestris*, 6.vii.1948 (CNCI); 16, Ottawa, Ontario, ex *Malus* sp., 9.viii.1984 (UCON); 17, Shenandoah Nat. Pk., Virginia, ex cultivated apple, 12–22.viii.1976 (DESC); 18, Wilsonville, Oregon, ex *Malus sylvestris*, 23.ii.1986 (UCON); 19, Hamden, Connecticut, ex apple, iv.1989 (UCON); 20, Ste. Anne de Bellevue, Québec, ex cultivated apple, 19.v.1963 (CNCI); 21, Ellington, Connecticut, ex ornamental apple, 12.vii.1993 (UCON).



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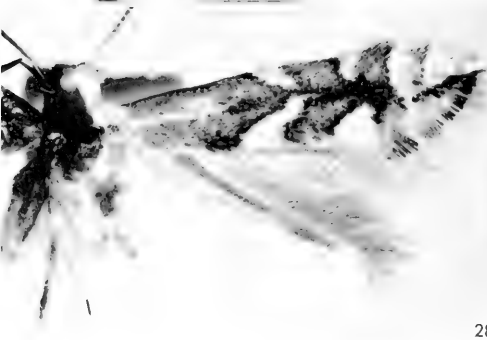
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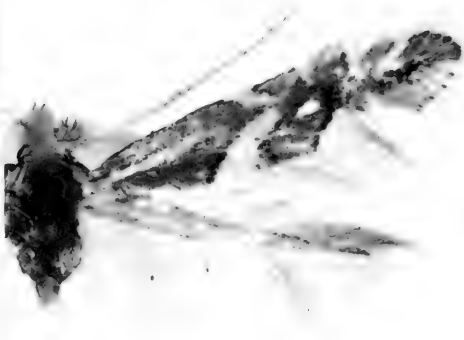
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Figs. 22–29. Forewings of apple-feeding *Phyllonorycter crataegella* and *P. elmaella*. 22, *crataegella*, Southington, Connecticut, ex apple, 10–17.iii.1988 (UCON); 23, *crataegella*, Wallingford, Connecticut, ex ornamental apple, 14–15.vii.1993 (UCON); 24, *crataegella*, Wallingford, Connecticut, ex ornamental apple, 14–15.vii.1993 (UCON); 25, *deceptusella*, Kentucky, holotype (MCZC); 26, *crataegella*, Cincinnati, Ohio, ex *Malus*, 31.viii.1907, lectotype of *Lithocolletis malimalifoliella* Braun (ANSP); 27, *elmaella*, Burnaby, British Columbia, ex *Malus*,

neously referred to Fig. 5 of Kumata (1963) as showing the female genitalia of *P. sorbi*, but the latter species is not even mentioned in Kumata's paper. As noted in the Introduction, *P. sorbi* is not known to occur in North America.

Distribution.—*Phyllonorycter elmaella* is presently known only from the Pacific Coast region from central Oregon to southern British Columbia. Doğanlar and Beirne (1980) reported that *P. elmaella* occurred commonly on unsprayed apple in 1976 and 1977 in the Vancouver District. Except for 13 specimens from the type series (in CNCI), of which six examples were collected in 1978, no other specimens seem to exist to support their contention that *P. elmaella* was in fact the infesting species throughout the Vancouver District. No voucher material is deposited at Simon Fraser University in Burnaby (where Doğanlar did his work), and no additional specimens could be found in the CNCI.

DLW reared four specimens from *Crataegus* sp. near Wilsonville, Clackamas Co., Oregon, in June 1982 (UCON). In addition, we have examined photographs of genitalia of a male from Concrete, Skagit Co., Washington, reared from cultivated apple in July 1986 (DESC).

We examined the eight specimens from Monroe, Oregon, reared from apple foliage in July and August 1954 by Jones and Goeden (OSUO), referred to as *P. sorbi* by Pottinger and LeRoux (1971: 35). We examined a further 18 specimens from near Dallas, Polk Co., Oregon, reared from apple foliage in August 1970 and July 1971 by S.C. Jones (OSUO). Reports of *P. elmaella* from western apple orchards (e.g. Weires and Forshey 1978, Orphart 1982, Hoyt 1983, Barrett and Jorgensen 1986, Barrett and Brunner 1990, Jones 1991) likely refer to misidentifications of *P. mespilella*.

Biology.—Specimens have been reared from domestic apple cultivars, *Malus* spp. (CNCI, DESC, OSUO), and hawthorn, *Crataegus* sp. (UCON). The relative scarcity of this species from recent apple collections in Oregon and Washington may indicate that it is being displaced by *P. blandcardella* and *P. mespilella*. Doğanlar and Mutuura (1980) noted that the species was triple brooded in the Vancouver District. The type material (CNCI) bears dates of March, late June, and September.

Type material examined.—HOLOTYPE ♂ in CNCI, labelled: [1] "Burnaby BC/ 3.I.1978/ Doğanlar" [handwritten]; [2] "Malus/ communis" [handwritten]; [3] "HOLOTYPE/ Phyllonorycter/ elmaella Do. and Mut./ CNC No." [red, part printed, part handwritten]; [4] "genitalia on slide MIC 2094 ♂". The specimen is glued on a point, unspread. Type locality: Burnaby, Vancouver District, British Columbia.

PARATYPES: 3 ♂, 8 ♀ in CNCI. ALLOTYPE ♀, data as holotype except dated 19.VI.1978; genitalia on slide JFL 1091.

Phyllonorycter mespilella (Hübner)

Figs. 2, 12, 30–37

Tinea mespilella Hübner, [1805]: series 8, pl. 39, fig. 272.

Lithocolletis mespilella (Hübner): Rebel, 1901: 213. Povolný, 1949. Pottinger and LeRoux, 1971: 35.

Lithocolletes [sic] *blancardella* (Hübner): *sensu* Dyar, 1902: 551.

Phyllonorycter mespilella (Hübner): Bradley, 1972: 10. Emmet et al., 1985: 317.

Lithocolletis pomifoliella Zeller, 1839: 218.

Lithocolletis pyrivorella Banks, 1899: 252.

Diagnosis.—In male genitalia (Fig. 2) *P. mespilella* can be recognized by the large, dilated right costal process with a curved apical spine that is shorter than the process

←

3.i.1978, holotype male (CNCI); 28, *elmaella*, Burnaby, British Columbia, ex *Malus*, 3.i.1978, holotype male (CNCI); 28, *elmaella*, Burnaby, British Columbia, ex *Malus*, 19.vi.1978, allotype female (CNCI); 29, *elmaella*, Wilsonville, Oregon, ex *Crataegus*, 29.vi.1982 (UCON).

itself and the asymmetrical valvae with the right one being broader than the left one. The left costal process is short and stubby, similar to that of *P. blancardella*.

In female genitalia (Fig. 12), *P. mespilella* is easily distinguished from all other species of the group by the presence of an oval, ringlike sclerotization around the ostium bursae. The sclerotization of the sterigma is wider than in other species (except *P. blancardella*) and, with the apodemes, resembles an X.

Forewing length: spring generation, 3.3–4.5 mm (n = 30); summer generation, 2.7–3.8 mm (n = 30). Antenna uniformly fuscous, occasionally with darkened terminal articles. Mesothoracic scutellum with only small patch of white scales, 1 or 2 rows wide. Forewing (Figs. 30–37): ground fiery to reddish coppery orange, summer brood individuals often paler orange; basal area of dorsal margin with narrow line of white scales, rarely more than 3 scale rows in width; first costal strigula usually twice as long as broad, axis usually intersecting tornus or outer margin, rarely confluent with first dorsal strigula (Fig. 37); fourth costal strigula often subequal to third, rarely confluent with third costal strigula (Fig. 32), or absent (Fig. 35); white basal streak subequal to width of orange-scaled area between basal streak and costa, sometimes confluent with first dorsal strigula (Figs. 32, 35–36); outer row of lamelliform fringe scales with distal $\frac{1}{4}$ to $\frac{1}{2}$ darkened, forming narrow iridescent blue-black band between outermost strigulae. Hindleg: tibia often smoky distad; first and second tarsomeres with dark apical bands.

Distribution.—*Phyllonorycter mespilella* is currently known only in the West from California north to British Columbia and eastward into Utah and New Mexico. It is presumably introduced from Europe and was first reported in North America by Pottinger and LeRoux (1971: 35) from California. Our verification of vouchers has confirmed that Pottinger and LeRoux's (1971) identification of *P. mespilella* was

correct. The species was omitted from the most recent checklist of North American Lepidoptera (Davis 1983). A series of eight specimens in the CNCI collected at Petaluma, Sonoma Co., California by E.C. Johnston in 1936, 1937, and 1938 also belongs to *P. mespilella*. Hence the species has been present in western North America for at least 50 years. Material collected from apple leaves from several locations in California, Oregon, Washington, Utah (CISC, UCON), New Mexico (DESC), and British Columbia (CNCI, UCON) reveal that *P. mespilella* is widespread in western North America. The species referred to as undescribed *P.* near *elmaella* by Varela and Welter (1992) is *P. mespilella* (vouchers examined, UCON). With the exception of the original description, all reports of *P. elmaella* from western North America (e.g. Weires and Forshey 1978, Orphart 1982, Hoyt 1983, Barrett and Jorgensen 1986, Barrett and Brunner 1990, Jones 1991) likely represent *P. mespilella* and not *P. elmaella*.

Biology.—*Phyllonorycter mespilella* has the broadest host range of any of the North American apple-feeding *Phyllonorycter*. In the West, it commonly mines *Malus* (various cultivars as well as crab apples), *Prunus*, *Pyrus*, *Cydonia*, *Crataegus*, and *Cotoneaster* (Borden et al. 1953, DLW unpublished data). Povolný (1949) listed these same host genera for European populations of *P. mespilella*, as well as *Amelanchier* and *Mespilus*. In Great Britain, *Prunus* and *Sorbus* species are the primary hosts, although a variety of other Rosaceae are occasionally used (Emmet et al. 1985). Under outbreak densities females will oviposit on apricot but few larvae reach maturity (L. Varela, in litt. 1993). Up to five generations are produced in orchards of the Central Valley of California; three to four in coastal areas of California; three in the Okanagan Valley of southern British Columbia (Cossetine and Jensen 1992, Varela and Welter 1992). Varela and Welter (1992) used (E10)-Dodecanyl acetate to monitor the phenology of *P.*

mespilella in California. We examined specimens reared from domestic *Prunus* (cherry) cultivars from orchards in California and Oregon, which are true *P. mespilella*. However, there appears to be one or more undescribed species of *Phyllonorycter* on native *Prunus* species in the West (Deschka, in litt., DLW, unpublished data).

NOMEN DUBIUM

Phyllonorycter deceptusella (Chambers)
Fig. 25

Lithocolletis deceptusella Chambers, 1879: 73.

Phyllonorycter deceptusella (Chambers): Davis, 1983: 10.

This species was described from a single specimen, recorded as follows (Chambers 1879: 73): "Among my captured specimens of *L. crataegella* Clem. I find a specimen of this species which at the time of its capture I regarded only as a variety, but which a more attentive examination convinces me is a distinct though allied species. The abdomen and two hinder pair of legs are wanting, though otherwise the insect is in good condition, and though there is but a single specimen, I described it for the purpose of discriminating it from *crataegella*."

Lithocolletis deceptusella Chambers and *L. crataegella* Clemens were both synonymized by Walsingham (1891: 328) with the European *pomifoliella* Zeller, now a junior synonym of *mespilella* (Hübner), which at that time was confused with *blancardella* (F.). Busck (1903: 190), upon examining the type of *crataegella*, agreed with Walsingham. Of course at that time none of these authors examined genitalia, the study of which had not yet begun. *Phyllonorycter deceptusella* is listed as a valid species by Davis (1983: 10). Hagen (1884: 152) indicated that the type of this taxon was not recognizable. Braun (1908b: 298) indicated that based on color pattern, *P. deceptusella* was distinct and "not closely related to *crataegella* or the other apple feeding species."

There is no indication in Chambers' (1879) description that the species feeds on apple, rather Chambers remarked that he suspected "that it feeds on Oak" (Chambers 1879: 74). Thus the statement in Pottinger and LeRoux (1971: 5) to the effect that Braun (1908b) listed *deceptusella* as feeding on apple is in error.

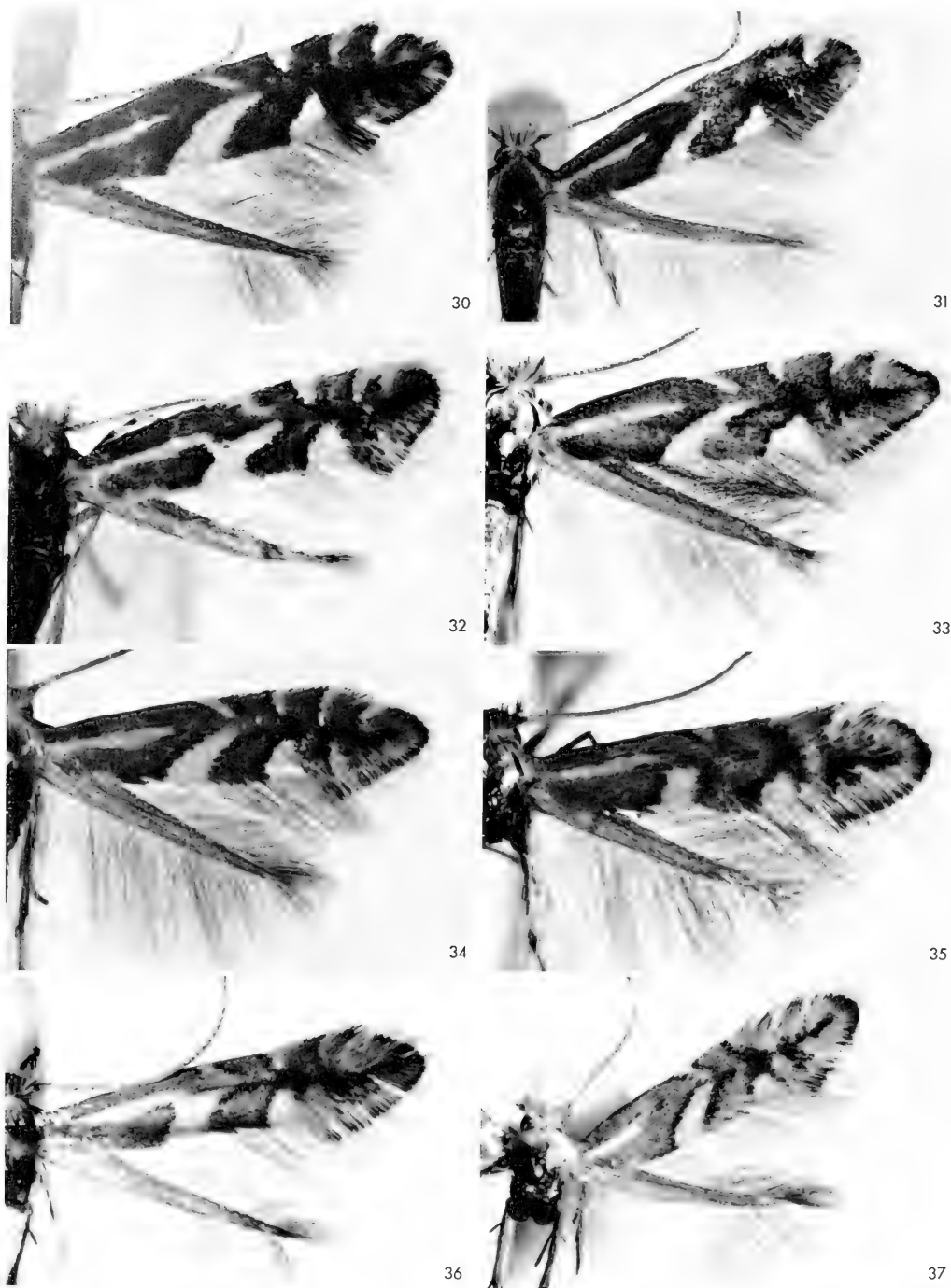
Although variants of *P. crataegella* occasionally have the basal and first dorsal strigula confluent, there are several other aspects of the forewing maculation that are inconsistent with those of *crataegella*. The first costal strigula is broader than long, and it is not obliquely angled to the outer margin as in typical *crataegella*. Nor are the white stigulae margined with black scales as they should be. This later feature and the basal displacement of the first dorsal strigula would suggest affinity to eastern cherry-feeding *Phyllonorycter* species.

Type material examined.—HOLOTYPE ♀ in MCZC, labelled: [1] "Type/1323" [red with top portion white, number handwritten]; [2] "Chambers/Kentucky" [partly handwritten, partly printed]; [3] "Lithocolletis/deceptusella Chamb" [handwritten]. The specimen is double mounted, partly spread, with the right antenna, all but two legs, and the abdomen missing.

WRONGLY RECORDED TAXA

Phyllonorycter sorbi (Frey). *Phyllonorycter sorbi* was reported from Oregon by Pottinger and LeRoux (1971: 35). Our verification of original vouchers (OSUO) indicates that their records were misidentifications of *P. elmaella*. We have seen no specimens of *P. sorbi* from North America.

Phyllonorycter scudderella (Frey and Boll). We have been unable to trace voucher specimens to check the single *P. scudderella* record on apple from Québec (LeRoux 1960: 107). We presume that it is based on a misidentification or a labelling error as the species is a willow feeder (Braun 1908b: 296, Ely 1917, Needham et al. 1928).



Figs. 30–37. Forewings of apple-feeding *Phyllonorycter mespilella*. 30, San Francisco, California, ex *Cotoneaster*, 20.i.1986 (UCON); 31, Hood River, Oregon, ex apple, 27.ii–14.iv.1990 (UCON); 32, Summerland, British Columbia, ex cultivated apple, 18–19.iii.1992 (CNCI); 33, Naramata, British Columbia, ex cultivated apple, 21–22.iii.1992 (CNCI); 34, Naramata, British Columbia, ex cultivated apple, 12.vi.1992 (CNCI); 35, Naramata, British Columbia, ex cultivated apple, 20–22.vi.1992 (CNCI); 36, Naramata, British Columbia, ex cultivated apple, 23.vi.1992 (CNCI); 37, Summerland, British Columbia, 5–21.viii.1992 (UCON).

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NOTES ABOUT VESCINAE, A KEY TO THE WORLD GENERA, AND
DESCRIPTION OF TWO NEW *CHOPARDITA*
(HETEROPTERA: REDUVIIDAE)

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Abstract.—New characters to separate Vescinae from all other Reduviidae subfamilies are discussed, a key to the World genera is presented, and the new African species *Chopardita granulosa* and *C. mimetica* are described.

Key Words: Vescinae, diagnosis, key to genera, *Chopardita granulosa*, *C. mimetica* new species, Reduviidae

China and Usinger (1948) remarked that the validity and coherence of Vescinae could be questioned. Their arguments were: a) the genitalia of the American *Vescia* Stål and the African *Chopardita* Villiers show close relationship whereas those of *Pessoia* Costa Lima are quite different; b) *Pessoia*, *Microvescia* Wygodzinsky and *Mirambulus* Breddin run to Peiratinae, c) all genera lack ocelli except *Mirambulus*, and d) *Vescia* and *Chopardita* lack claspers. They placed *Mirambulus* and *Megavescia* in two different subfamilies, unaware that these genera are synonyms. Wygodzinsky (1950) refuted the above points and stated that the "apical prolongation of the fore tibia beyond the insertion of the tarsus serves to distinguish all Vescinae."

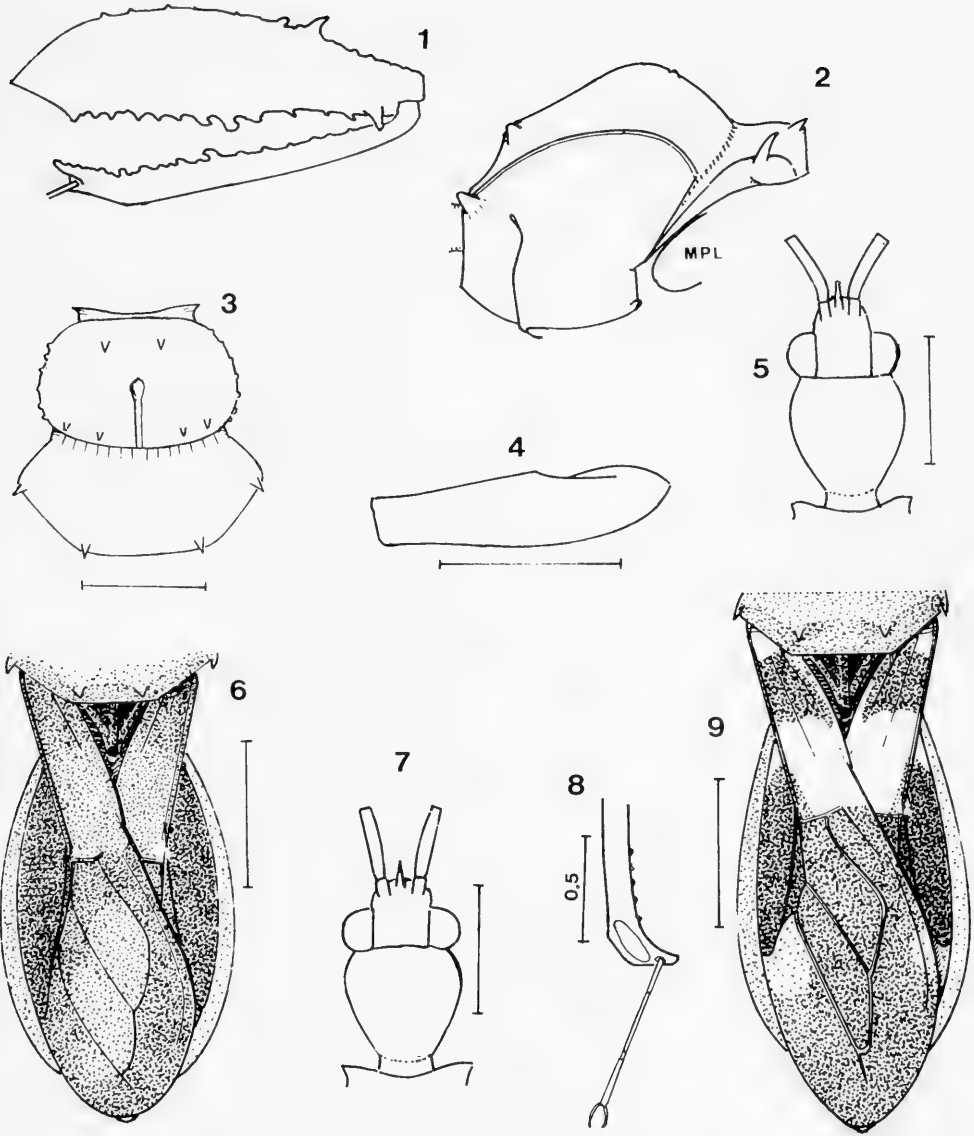
Chopardita, an African genus, is the only vespine outside the Neotropics. It is closely related to *Vescia*, an affinity that could be a result of fragmentation of Gondwanaland.

Measurements are in mm. The holotype of *Chopardita mimetica* is in the Paris Museum, France, and of *C. granulosa* in the Natural History Museum, London, England.

SUBFAMILY CHARACTERS IN VESCINAE

All genera have a flattened, glabrous area, demarcated or not by a carina, on the apical frontal face of the fore tibia. The carina may be triangular as in *Vescia* or oblong-ovate as in *Chopardita*. This area may include the insertion of the tarsi, as in *Vescia*, or the insertion may be apicad to it as in *Chopardita*. This area may be related to the flexed position of the tarsi, but not for their reception, as the tarsi are longer (Fig. 8). It is in the same position as the furrow for the reception of the tarsi in some apiomerine genera. Some apiomerine genera lack this furrow and instead have a demarcation quite similar to that of *Chopardita*. In the apiomerines this sulcus or flat area occurs also in the middle tibia but in the vespines the flattened area is limited to the protibia.

In all vespine genera the apex of the fore tibia is extended and curved backward past the insertion of the tarsi (Figs. 1, 8). Their tarsi are filiform, between $\frac{1}{2}$ (fore) and $\frac{1}{3}$ (middle and hind) the length of the corresponding tibia (Figs. 18, 19). The first segment is the shortest, the last two subequal



Figs. 1-9. 1. *Mirambulus* sp., fore leg. 2 *Vescia* sp., pronotum and mesopleura (mpl), lateral view. *Chopardita mimetica* n. sp., female, 3. pronotum, dorsal view, 4. profemur, dorsal view, 5. head, dorsal view, 6. posterior margin of pronotum and abdomen, dorsal view. *Chopardita mira*, female, 7. head, dorsal view, 8. apex of fore tibia, frontolateral view, 9. posterior margin and abdomen, dorsal view.

or the third slightly longer than the second and twice as long as the first. The claws are long, tapering, unnotched basally.

A broad triangular gena is common to all genera (Fig. 13). Its blunt apex barely reaches the margin of the clypeus. Its upper margin ends below the antenniferous tubercle

and the lower above the upper margin of the buccula. Wygodzinsky gives a partial drawing of the gena of *Microvescia* (1943: 221, Fig. 87).

The pterostigma of the Heteroptera is a slightly chitinized, more or less expanded area, at the external end of the corium. It is

limited externally by C or Sc and internally by R. Both converge to form its apex. In Vescinae it is broader and longer than in all other subfamilies. In this subfamily it starts just past the level of the apex of the scutellum, notably widens, and ends about level with the apex of the inner membranal cell. Along its apical half R runs very close to the basal veins of the membranal cells (Figs. 6, 9).

In Vescinae, veins C and Sc are not visible from above on the basal third or fourth of the fore wings. The area they occupy is bent downward, vertical to the wing blade. Vein R consequently is the first lateral vein in this area. Vein R is much thicker than the other veins. Some species of *Euagoras* Burmeister, a typical harpactorine, have a thick R parallel to the normally located C and Sc, and the latter form a narrow and short pterostigma. The fore wings of the vescines narrow to about level of the apex of the scutellum, then broaden in an oval fashion. The connexivum is exposed starting from the level of the apex of the scutellum. The constriction is less marked in *Pessoaia*. *Oncerothachelus* Stål and other saicines and the reduviine *Microlestria* Stål have a thick R that runs parallel to the costal margin and a relatively wide, but shorter pterostigma. The partially marginal, thick R vein and the long and wide pterostigma are characteristic of the vescine.

The subcircular, larger, anterior lobe and a shorter, apron-shaped, posterior lobe of the pronotum is similar in all vescine genera (Fig. 3). The anterior lobe is inflated in all genera except, *Chopardita*, but its pronotum has the typical vescine outline. The upper surface of the anterior lobe of the other genera is above the surface of the posterior lobe (Fig. 2). The conical spinules of the anterior lobe, usually two anterior and four posterior, and four anteapicals on the posterior lobe are in the same relative position in all genera (Fig. 3). In many reduviines a somewhat similarly shaped pronotum occurs, but

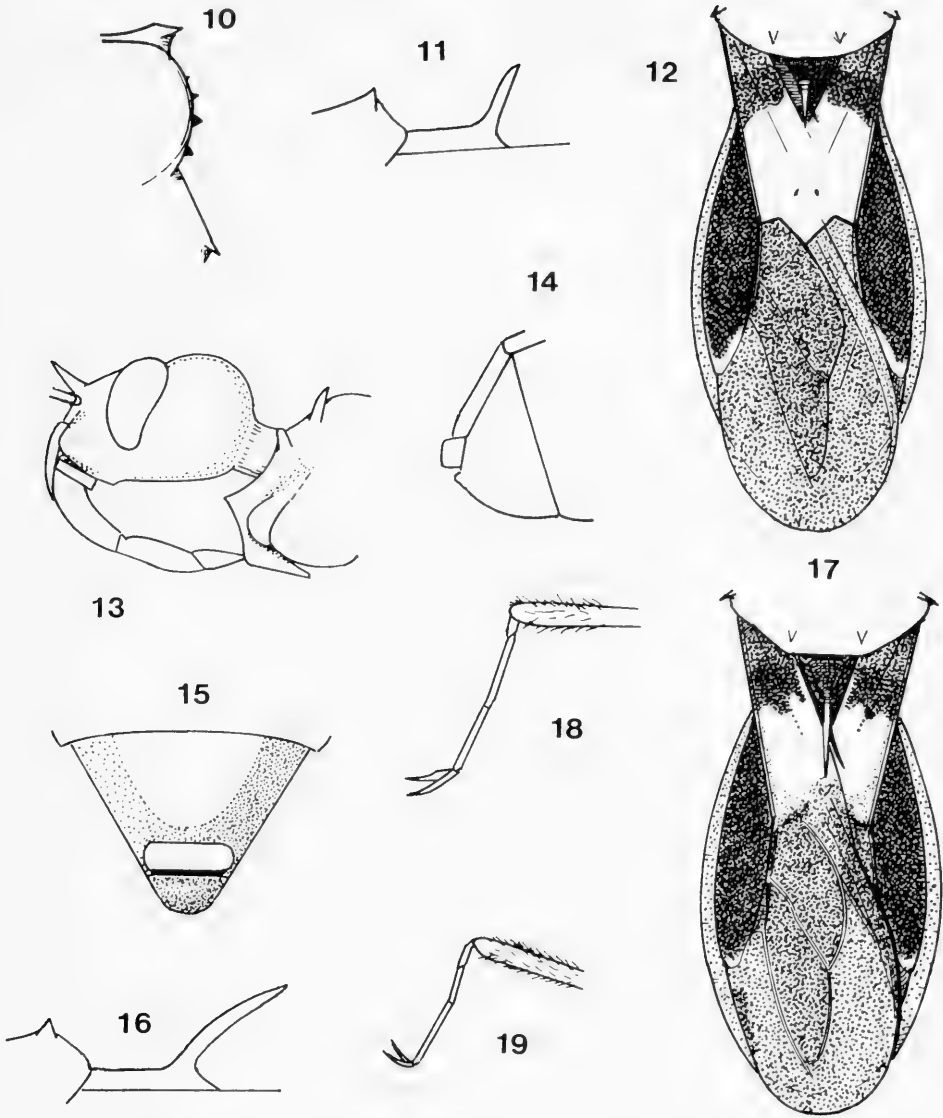
the anterior lobe is narrower, never inflated and the posterior lobe is spined differently. The inflated anterior lobe of the harpactorine *Notocyrtus* Burmeister is quite different and has no spinules. Longitudinal, short crenulations occur between both lobes of the pronotum in all vescines.

The basal half of fore femora is incrassate in all genera except *Pessoaia*. In the latter the tibiae tapers from a slightly broad base to apex. The basal half of the internal face of the fore tibia is flattened in *Vescia*, *Mirambulus*, and *Chopardita* only (Fig. 4), a character not present in other reduviids. Wygodzinsky noticed this character in *Mirambulus*. The middle and hind femora are straight, cylindrical in all vescine genera.

The armature of the anterior femora and tibiae of all vescines consists of teeth and round or spiniform tubercles, never spines (Figs. 1, 8). Middle and posterior femora are unarmed. The scutellar spine is preapical in all genera (Figs. 11, 16). Wygodzinsky (1943) noticed that the microspines of the coxae and trochanters of the fore legs are good specific characters.

The barrel-shaped fore coxae are about a third as long as the fore femora and not flattened laterally as they are in Peiratine. Elongate coxae is a relatively uncommon reduviid character. Emesines, bactrodines, and saicines also have long coxae but their overall shape is quite different from that of the vescines.

Vescine species are black, dark ferruginous or dark or pale brown. The coria may have an extensive pale area or be slightly ornamented with yellowish, ivory or whitish. The membrane is grayish or ferruginous, may have more or less extensive paler areas, and veins are brown usually. The connexivum can be either unicolorous, usually a shade of brown, or the segments may be brownish at middle and paler at sutures. The sutures separating the connexival segments are usually very tenuous (Figs. 12, 17).



Figs. 10–19. *Chopardita villiersi*, 10. pronotum, dorsal view, 11. scutellum, lateral view, 12. posterior margin of pronotum and abdomen, dorsal view. *Chopardita granulosa* n. sp., female holotype, 13. head, lateral view, 14. genital segments, lateral view, 15. genital segments, caudal view, 16. scutellum, lateral view, 17. abdomen, dorsal view. *Vescia* sp., 18. tarsi, hind leg, 19. tarsi, middle leg.

KEY TO THE GENERA IN VESCINAE

- | | |
|---|---|
| <p>1. Anteocular space shorter than postocular; first antennal segment longer than anteocular space (Fig. 5) 2</p> <p>– Anteocular space longer than postocular; first antennal segment shorter than anteocular space 4</p> | <p>2. Spine between antenniferous tubercles present; without ocelli 3</p> <p>– Spine between antenniferous tubercles absent; ocelli present <i>Mirambulus</i> Breddin 1901</p> <p>3. Anterior prantal lobe not inflated, its surface level with that of posterior lobe, with 2 short, vertical anterior and four preapical spinules; longitudinal sulcus of anterior lobe begins at 4</p> |
|---|---|

- midlength with an oval pit, reaching transverse constriction between lobes
 *Chopardita* Villiers 1944
- Anterior pronotal lobe inflated subglobularly, surface above level of posterior lobe (Fig. 2), with or without anterior short spinules; longitudinal sulcus from behind collar to level of posterior spinules of same lobe, not reaching transverse constriction between lobes
 *Vescia* Stål 1865
4. Head almost and pronotum glabrous, some species with few scattered setae, anterior lobe of pronotum with short spinules and fine corrugations; humeral angles spined or not; apex of prosternum reaching mesosternum
 *Pessoaia* Costa Lima 1940
- Head and pronotum densely pilose; anterior lobe of pronotum without spinules and corrugations; humeral angles spined; apex of prosternum not reaching mesosternum
 *Microvescia* Wygodzinsky 1943

THE GENERA AND SPECIES OF VESCINAE

For synonyms of species see Wygodzinsky (1949) or Maldonado (1990).

Miller (1951: 465) described *Eremovescia* and included it in Vescinae. Villiers (1954: 221) synonymized it with *Pasira* Stål, a Reduviinae. This genus occurs from Mauretania to the Canary Islands.

Chopardita Villiers

Chopardita Villiers 1944: 79. Type: *Chopardita mira* Villiers 1944: 80. Ivory Coast.

Chopardita mira Villiers

Villiers 1944: 80. Occidental Africa, Zaire, Oubanghi-Chari, Sudan. Figs. 7–9.

Chopardita villiersi China and Usinger

China and Usinger 1943: 509. Sudan. Figs 10–12.

Chopardita mimetica Maldonado,

NEW SPECIES

Figs. 3–6

Female.—Brown: head, first segment of rostrum, anterior femora and tibiae, posterior lobe of pronotum, abdomen ventral-

ly, connexivum above and below. Dark brown: anterior lobe of pronotum, scutellum, tubercles of fore femur and tibia. Pale brown: antenna, femora ventrally, middle and hind legs, second and third segments of rostrum. Hemelytra: basal angle and pterostigma blackish brown; inverted trapezoidal, dirty-yellow area from level of apex of scutellum, margined laterally and apically to base of inner cell of membrane by black R (Fig. 6); membrane gray, cells same color as pale area of corium, veins dark brown.

Head: length of anterior lobe 0.40, length of posterior lobe 0.62, greatest width of posterior lobe 0.59, depth of posterior lobe 0.59, interocular space 0.28, interantennal spine reaching one third of first antennal segment. Antennal segments: I. 0.43; II. 1.25; III and IV missing; glabrous. Thorax: anterior lobe—length 0.75, width 1.00, two anterior vertical spinules and 2+2 subapical triangular spinules irregularly spaced; lateral margin not carinate, with six small granules of equal size; posterior lobe: length 0.53, width 1.31, with 2+2 subapical triangular spinules. Legs—anterior femur (Fig. 4): incrassate basally, narrowing to apex, without thick laterosubapical tubercle, ventral tubercles small, in two irregular rows, internal face flattened; length 1.62, greatest thickness 0.50; tibia: curved and bent apically, length 1.53, with typical dorsal granules, tarsi missing; middle leg: femur length 1.56; tibia straight, length 1.72; hind leg: femur length 2.06, tibia straight, length 2.00. Scutellar spine broken, preapical. Hemelytra reaching apex of abdomen; pterostigma: length 1.28, width 0.37. Connexival sutures obsolete. Abdomen length 2.60, greatest width 1.53. Overall length 4.90.

Holotype-female, COTE D'IVOIRE, bords du Volta-rouge, december 1938, L. Chopard collector, in Paris Museum.

The holotype is the specimen misidentified as *Chopardita mira* by Villiers (1944: 80). It was compared by me with a specimen, correctly identified, from Republic of Tchad, Bas Chari, 13.viii.1963, environs du

Douggia, labeled by Villiers. My drawings of *C. mira* are from this latter specimen. Villiers did not declare paratypes any of these specimens. This species has the basal third of middle and hind femora, the rostrum, tibia, and apex of fore femora yellow; the abdomen is slightly longer and narrower (2.60:1.53::2.40:1.62), and the width across the eyes greater than across posterior lobe of head than in *C. mimetica* sp. nov. (0.66:0.53::0.62:0.59). In the latter species the anterior pale area of the hemelytra is limited laterally by R, whereas in *C. mira* the pale area reaches the lateral margins of the wing (Fig. 9). *C. mira* has a pale area on the membrane, caudad of the pterostigma, that is absent in *C. mimetica*.

Chopardita villiersi is pale brown. Differs from *C. mira* and *C. mimetica* by having three small spinules (Fig. 10) on the thinly carinate lateral margin of the anterior lobe of the pronotum, and a smooth vertex. The last two species have five or six lateral granules and their vertex is shagreen or smooth. These species are about 5.3 mm long.

***Chopardita granulosa* Maldonado,**

NEW SPECIES

Figs. 13–17

Female.—Black: anterior lobe of pronotum, scutellum, humeral angles of hemelytra, pterostigma, mesopleura, and metapleura. Brown: antenna, anterior lobe of head. Stramineous: second and third segments of rostrum, connexivum above, femora, scutellar spine. Sort of greenish brown: posterior lobe of pronotum, abdominal sterna. White: most of discal area of clavus. Gray: membrane, lateroposterior angles of white discal area.

Head.—minutely granulose, length 2.19, anteocular space 0.88 (to apex of head); postocular space 1.25, length of interantennal spine 0.38, length of eye 0.50; collum poorly defined, length 0.05; width across eyes 1.33, interocular space 0.56, width across widest part of posterior lobe 1.13. Antennae missing, only part of one first seg-

ment present. Rostral segments: I. 0.88; II. 0.94; III. 0.50. Pronotum-anterior lobe: globular, longitudinal sulcus beginning at midlength with a small pit, then deep to transverse constriction, margin with 6 or 7 minute granules, collar with angles projected laterally; with two vertical anterior and 2+2 posterior spinules; greatest width 1.94, length 1.50; posterior lobe: length 1.06, humeral width 2.75 (to base of spinules), finely corrugate and minutely, sparsely granulose; longitudinally crenulate between lobes. Meso- and metapleurae vertically rugose, sparsely granulose. Scutellum long triangular, basal width 0.44, length to base of spine 0.38, length to apex of spine 1.31. Abdomen: length to apex of genital segment 1.70, greatest width 2.25. Genital segments as in Figs. 14, 15. Total body length 5.39.

Holotype.—female, N. NIGERIA, Azar, 1928–1929, Dr. Ll. Lloyd collector; paratype same collection data, both in NMNH, London.

KEY TO THE SPECIES IN *CHOPARDITA*

1. Lateral margin of anterior lobe of pronotum with three spinules; fore wings as in Fig. 12 ...
..... *C. villiersi* China and Usinger
- Lateral margin of anterior lobe of pronotum with 5–7 aligned small granules; fore wings not as in Fig. 12 2
2. Posterior lobe of head and posterior lobe of pronotum very finely granulose; fore wings as in Fig. 17 *C. granulosa* Maldonado n. sp.
- Posterior lobe of head and posterior lobe of pronotum smooth or shagreen; fore wings as in Figs. 6 or 9 3
3. Femora bicolored; basal third and apex of femora, rostrum yellow; head pale brown; fore wings as in Fig. 9 *C. mira* Villiers
- Femora unicolored, pale brown; first rostral segment pale brown, last two brown; head brown; fore wings as in Fig. 6
..... *C. mimetica* Maldonado n. sp.

Microvescia Wygodzinsky

Microvescia Wygodzinsky 1943: 206, 220. Type: *Microvescia costalimai* Wygodzinsky 1943: 220. Brazil. Monotypic.

Mirambulus Breddin

- Mirambulus* Breddin 1901: 74. Ecuador.
Type: *Mirambulus niger* Breddin 1901:
75. Ecuador.
Megavescia Wygodzinsky 1947: 414. Type:
Megavescia cazieri Wygodzinsky 1947:
412, 414. Guyana. Synonymized by Wy-
godzinsky 1950: 266.

The genus includes:

- M. morio* Breddin 1903. Bolivia.
M. niger Breddin 1901. Ecuador.

Pessoaia Costa Lima

- Pessoaia* Costa Lima 1940: 487. Type: *Pes-
soaia piratoides* Costa Lima 1940: 487.
Brazil. Abalos (1945) keyed the species.
P. argentina Wygodzinsky 1943. Argen-
tina.
P. limai Usinger 1942. Costa Rica, Co-
lombia.
P. maculata Wygodzinsky 1943. Brazil.
P. parkoi Wygodzinsky 1943. Brazil.
P. piratoides Costa Lima 1940. Brazil.

Vescia Stål

- Vescia* Stål 1866: 123. Type: *Vescia spicula*
Stål 1866: 166. Brazil. In Acanthaspidi-
nae.
Geaya Villiers 1944: 81. Type: *Geaya di-
latata* Villiers 1944: 81. Venezuela. Syn-
onymized by China and Usinger (1948:
603).
Wygodzinsky (1943: 207) keyed five of
the eight species.
V. adamanta Brindley 1931. Guyana
V. angrensis Seabra & Hathaway 1942.
Brazil.
V. brachyptera Usinger 1942. Paraguay.
V. dilatata (Villiers) 1944. Venezuela.
V. minima Fracker & Bruner 1924. Bra-
zil.
V. nostratis Drake and Harris 1945. Bra-
zil.
V. penningtoni Drake 1943. Paraguay,
Brazil.
V. spiculata Stål 1866. Brazil.

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INTRAGUILD PREDATION BETWEEN SYMPATRIC SPECIES OF MANTIDS (MANTODEA: MANTIDAE)

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Abstract.—I tested the importance of predation versus competition in two congeneric sympatric species of mantids, *Tenodera aridifolia sinensis* (Saussure) and *T. angustipennis* (Saussure), during the late portion of the juvenile stage of their life cycle. *Tenodera angustipennis* abundance was reduced through predation by the larger *T. a. sinensis*, but no evidence of competition for resources was demonstrated for either species. *Tenodera a. sinensis* gained more body mass in the presence of *T. angustipennis* indicating that the benefit of consuming smaller predators may outweigh the cost of competing for resources.

Key Words: Intraguild predation, competition, *Tenodera*, Mantodea, Mantidae

Although the main factor limiting the abundance of predators is predicted to be food (Hairston et al. 1960), regulation of population size by food limitation has been difficult to demonstrate among many predatory arthropods (Riechert and Cady 1983, Polis and McCormick 1986, Wise 1981, 1993). Among generalist predators, intraguild predation seems to be a prevalent interaction and may be important in regulation of abundance (Polis et al. 1989).

In the northeastern United States three species of mantids co-occur: *Tenodera aridifolia sinensis*, *T. angustipennis*, and *Mantis religiosa* L. (Rathet and Hurd 1983). As generalist predators, they have the potential to compete for prey, but differences in their life history apparently alleviate this. *Tenodera angustipennis* and *M. religiosa* hatch later than *T. a. sinensis*, establishing a size difference that allows them to consume different prey items (Hurd 1988) *Mantis religiosa* is spatially separated from the two *Tenodera* congeners by occupying a lower height in the vegetation (Rathet and Hurd 1983). Although these characteristics can

reduce competition for prey, size differences between the species are great enough to promote intraguild predation (Hurd 1988, Hurd and Eisenberg 1990a). Since *T. angustipennis* and *T. a. sinensis* occupy the same vegetational strata, this interaction may be important for these two species.

This experiment was designed to test whether competition for prey or intraguild predation is a more important factor during the late portion of the juvenile stage (6-7 stadia) for these species and how these interactions affect the potential growth of individuals.

MATERIALS AND METHODS

The study site was an old field on the Experimental Farm of the University of Delaware. It consisted of mixed grasses and forbs with *Poa* spp. and *Solidago* spp. being the most common plants. On 2 August, 12 enclosures each measuring 1 m³ were placed in the field in a 6 × 2 array. Each enclosure consisted of a PVC frame which was covered by fine nylon mesh (Bioquip Products, Gardena, CA). The enclosures were quickly

placed on the ground to prevent the escape of resident arthropods.

From 3 to 5 August, both species of mantids (all females) were collected from a nearby field. This field has had a large population of both species for several years (personal observation). Each captured mantid was weighed (nearest 0.01 g), individually marked with nail polish and randomly assigned to a treatment group. The treatment groups were as follows: 1) three *T. a. sinensis*, 2) three *T. angustipennis*, and 3) three *T. sinensis* and three *T. angustipennis*. Each treatment consisting of four replicates was intentionally interspersed within the enclosure array. The mantids were introduced into the enclosures on 5 August. Each day following, the enclosures were inspected, and any mantid that had molted was marked again.

On 16 August, all cages were sampled by a combination D-vac and hand search. All surviving mantids were weighed to the nearest 0.01 g, and all other arthropods were separated into their respective orders.

RESULTS

At no time did more than one mantid molt during one 24 hour period. Therefore, I was able to track every surviving individual and recorded both an initial and final weight for each. The weight of the mantids at the beginning of the experiment did not differ between treatments (*T. a. sinensis* $t_{22} = 0.41$; $P = 0.68$; *T. angustipennis* $t_{22} = 1.41$; $P = 0.17$) for either species. I therefore assume that any response seen at the end of the experiment was not the result of initial bias.

Survivorship of *T. a. sinensis* was not significantly different ($t_6 = 0.52$; $P = 0.62$) between the two treatments (Table 1) while *T. angustipennis* showed decreased survivorship in treatment 3. Since there was only one surviving *T. angustipennis* in one replicate for treatment 3, it was not possible to do a statistical comparison. However, all replicates in treatment 2 had either two or

Table 1. Mean survivorship (± 1 SE) of both species of mantids in their respective treatments. Treatment 1 = *T. a. sinensis*, Treatment 2 = *T. angustipennis*, Treatment 3 = *T. a. sinensis* + *T. angustipennis*.

Species	Treatment 1	Treatment 2	Treatment 3
<i>T. sinensis</i>	2.25 (0.25)	—	2.00 (0.41)
<i>T. angustipennis</i>	—	2.25 (0.25)	0.25 (0.25)

three surviving *T. angustipennis*, while three of the four replicates in treatment 3 had no survivors.

The mean weight of individual *T. a. sinensis* was significantly greater in treatment 3 ($1.70 \text{ g} \pm 0.12$) than in treatment 1 ($1.35 \text{ g} \pm 0.06$) ($t_{15} = 2.61$; $p = 0.02$) (Fig. 1). An analysis of variance on arthropod abundance for the three treatments showed that there was no statistical significance between treatments for any order or for total abundance of arthropods (Table 2).

DISCUSSION

At the conclusion of the experiment, there were fewer surviving *T. angustipennis* in treatment 3, where *T. a. sinensis* was also present, compared to treatment 2, where *T. a. sinensis* was absent. The high mortality was most likely due to predation by *T. a. sinensis*, as there were no other arthropods large enough to capture *T. angustipennis*, and I observed several such predation events during my daily monitoring. However, the removal of *T. angustipennis* by *T. a. sinensis* did not occur immediately, as *T. angustipennis* were observed in all the treatment 3 replicates through the sixth day of the experiment. Therefore, mantid densities were elevated in treatment 3 for a large portion of the experiment.

The differences in final weight between treatment 1 and treatment 3 show *T. a. sinensis* accumulated more biomass in the presence of *T. angustipennis*. This indicates that the value of consuming *T. angustipennis* outweighed the potential cost of in-

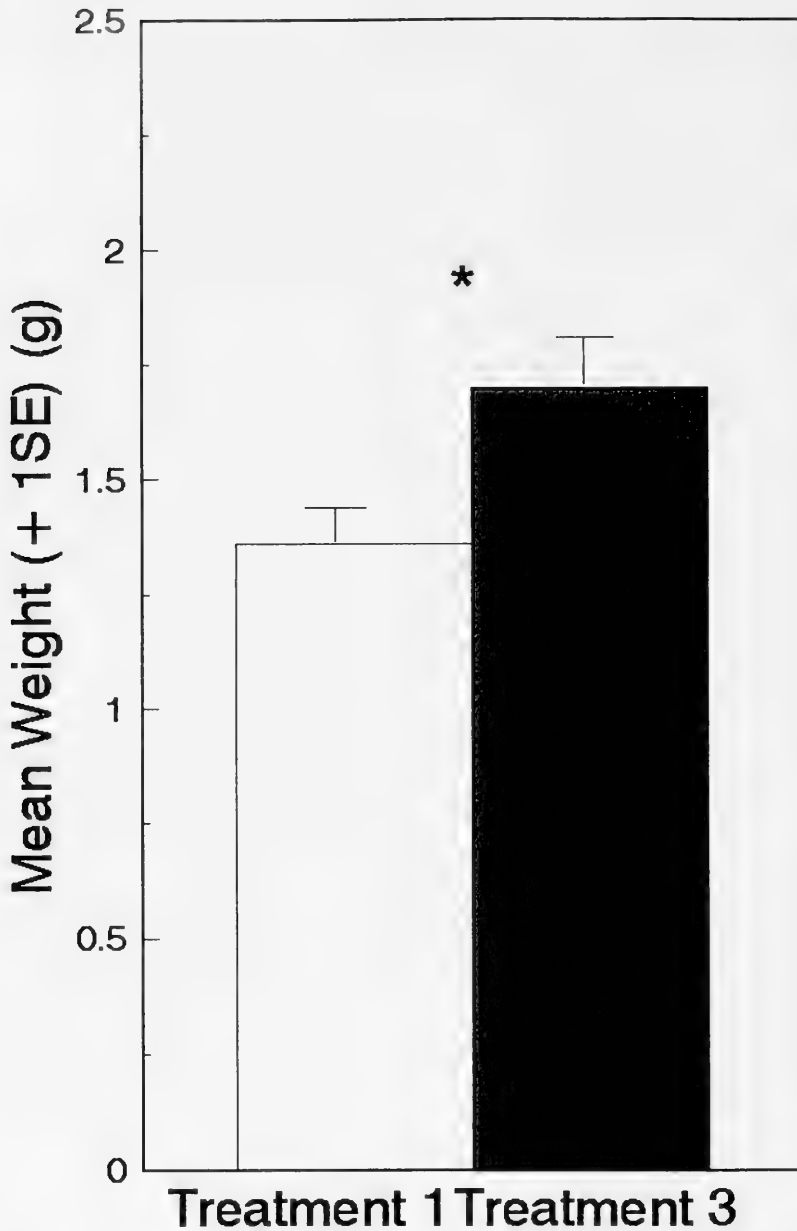


Fig. 1. Final mean weight (± 1 SE) for *T. a. sinensis* in Treatment 1 (*T. a. sinensis* only) and Treatment 3 (*T. a. sinensis* and *T. angustipennis*). * $P < 0.05$.

creased competition for prey. The amount of biomass acquired during the juvenile stages of the life cycle affects the size a mantid will reach at adulthood. This determines the maximum weight gain possible which

in turn affects the number of eggs oviposited (Eisenberg et al. 1981). Therefore, the *T. a. sinensis* individuals in the presence of *T. angustipennis* may have been able to produce more eggs.

Table 2. Arthropod abundance (\pm SE) and corresponding ANOVA analysis. Orders are arranged in descending abundance for Treatment 1 (T1). T1 = *T. a. sinensis*, T2 = *T. angustipennis*, T3 = *T. a. sinensis* + *T. angustipennis*.

Order	T1	T2	T3	F _{2,9}	P
Araneae	33.0 (8.2)	21.8 (6.5)	21.0 (5.4)	0.98	0.41
Homoptera	23.3 (4.3)	29.8 (4.9)	48.8 (10.5)	3.47	0.07
Hymenoptera	11.8 (3.8)	6.3 (1.3)	11.5 (2.3)	1.34	0.31
Diptera	7.0 (2.5)	4.8 (1.5)	5.8 (2.3)	0.27	0.77
Hemiptera	6.0 (3.3)	6.3 (3.3)	20.3 (10.4)	1.53	0.27
Thysanoptera	3.3 (2.9)	1.0 (0.0)	1.0 (1.0)	1.53	0.27
Coleoptera	0.5 (0.3)	1.3 (0.6)	2.8 (1.8)	1.06	0.39
Total	85.0 (10.9)	71.0 (8.0)	112.0 (27.8)	1.37	0.30

The analysis of the arthropod assemblage showed there was no difference between treatment groups in either total abundance or within any individual order. It would be expected that treatment 3 would have had lower abundance of arthropods, since the density of mantids was double the other treatments. Actually, the trend was for elevated arthropod density in treatment 3 although this was not significant. It has been shown in recent experiments that increasing the density of predators may have little impact on the prey density (Hurd and Eisenberg 1990b, Fagan and Hurd 1991, Wise 1993). This was a short-term experiment and significant depressions of prey in the presence of elevated predator densities may not have had time to occur. A previous experiment (Moran and Hurd 1994) indicated that important short term interactions during elevated predator densities were intraguild predation and emigration by predators small enough to be potential prey. Increased food limitation became a factor only later in the study.

This experiment showed that the major

short term interaction between these two species was predation while competition was apparently absent. That *T. a. sinensis* demonstrated greater weight gain in the presence of *T. angustipennis* indicates that top level predators may benefit from other predators being present. The benefit of using other predators as prey may therefore outweigh the cost of interspecific competition within this guild, at least in the short-term.

ACKNOWLEDGMENTS

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NEW GENERA AND SPECIES OF PERUVIAN PHYCITINAE
(LEPIDOPTERA: PYRALIDAE)

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Abstract.—Three new genera of phycitine moths from Peru are described. They are *Depeadus* n. gen. with *D. deiulus* n. sp., *Montestra* n. gen. with *M. dentata* n. sp., and *Eurythmioides* n. gen. with *E. carasensis* n. sp. Also described from Peru is *Caviana peruviensis* n. sp.

Key Words: Moths, phycitines, Peru

In 1987, O. Karsholt, of the Zoological Museum of the University of Copenhagen (ZMUC) collected a series of phycitine moths in Peru. He generously offered this material, along with a smaller amount of other Peruvian Phycitinae in the ZMUC, to me for study. Included in the loan were 4 new species, descriptions of which are given here. Most previously described Peruvian phycitines (Heinrich 1956) have been collected at low to moderate elevations, mainly along the coast. Two of the species described herein were obtained at mountainous sites of 3000, to over 4000, meters.

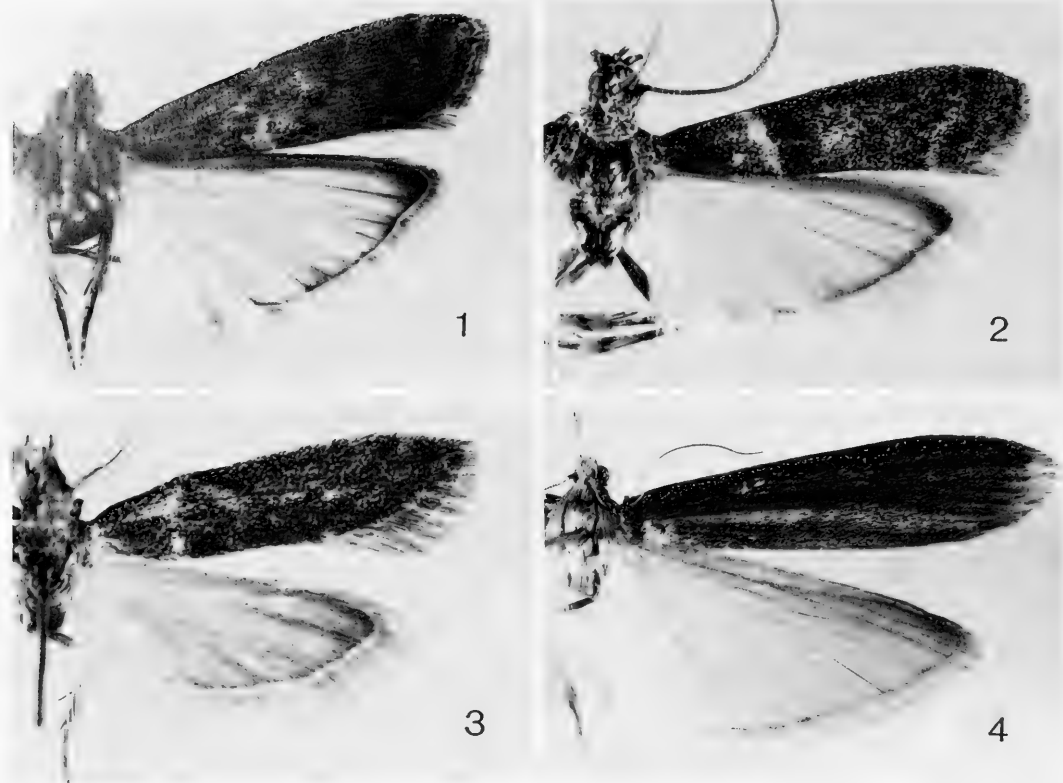
Depeadus Neunzig, NEW GENUS

Gender.—Masculine.

Type species.—*Depeadus deiulus* Neunzig.

Antenna of male (Fig. 9) with distinct sinus at base of shaft; elongate scales clothing distoanterior part of sinus; sensilla trichodea (cilia) of shaft of male moderately abundant, and near base of shaft about 1/2 as long as basal diameter of shaft. Front convex, with scales produced anteriorly. Labial palpus robust, upturned. Haustellum well developed. Ocellus present. Basal half of costa of forewing of male (Fig. 6) slightly convex; underside of male wing without costal fold.

Forewing without raised scales; with eleven veins, R₂ distant at base from R₃₊₄ and R₅ and upper outer angle of cell; R₃₊₄ and R₅ stalked for slightly over 1/2 their lengths; M₁ straight; M₂ and M₃ stalked for about 1/3 their lengths; CuA₁ from lower outer angle of cell; CuA₂ from well before outer angle of cell. Hindwing (Fig. 6) with eight veins (1A, 2A and 3A considered to be one vein); Sc + R₁ and Rs fused for about 1/2 their lengths beyond cell; M₁ from upper outer angle of cell and its basal 1/4 fused with Sc + R₁ and Rs; M₂ and M₃ fused for about 1/2 their lengths; CuA₁ fused at base with stalk of M₂ and M₃; CuA₂ from well before angle of cell; cell about 1/3 length of wing. Male abdominal segment 8 with ventral scale tufts; sclerotized element associated with tufts U-shaped and with distally swollen medial projection. Male genitalia (Figs. 19, 20) with uncus narrow, triangular, and weakly sclerotized; gnathos absent; transtilla with long, setiferous, bladelike, lateroposteriorly directed arms; juxta broadly V-shaped with lateral, setiferous protuberances; valva short, strongly knobbed, and with long, slender, costal projection at base, and large, posteriorly projecting, hooked, apically swollen and spined element; sacculus delineated from valva by

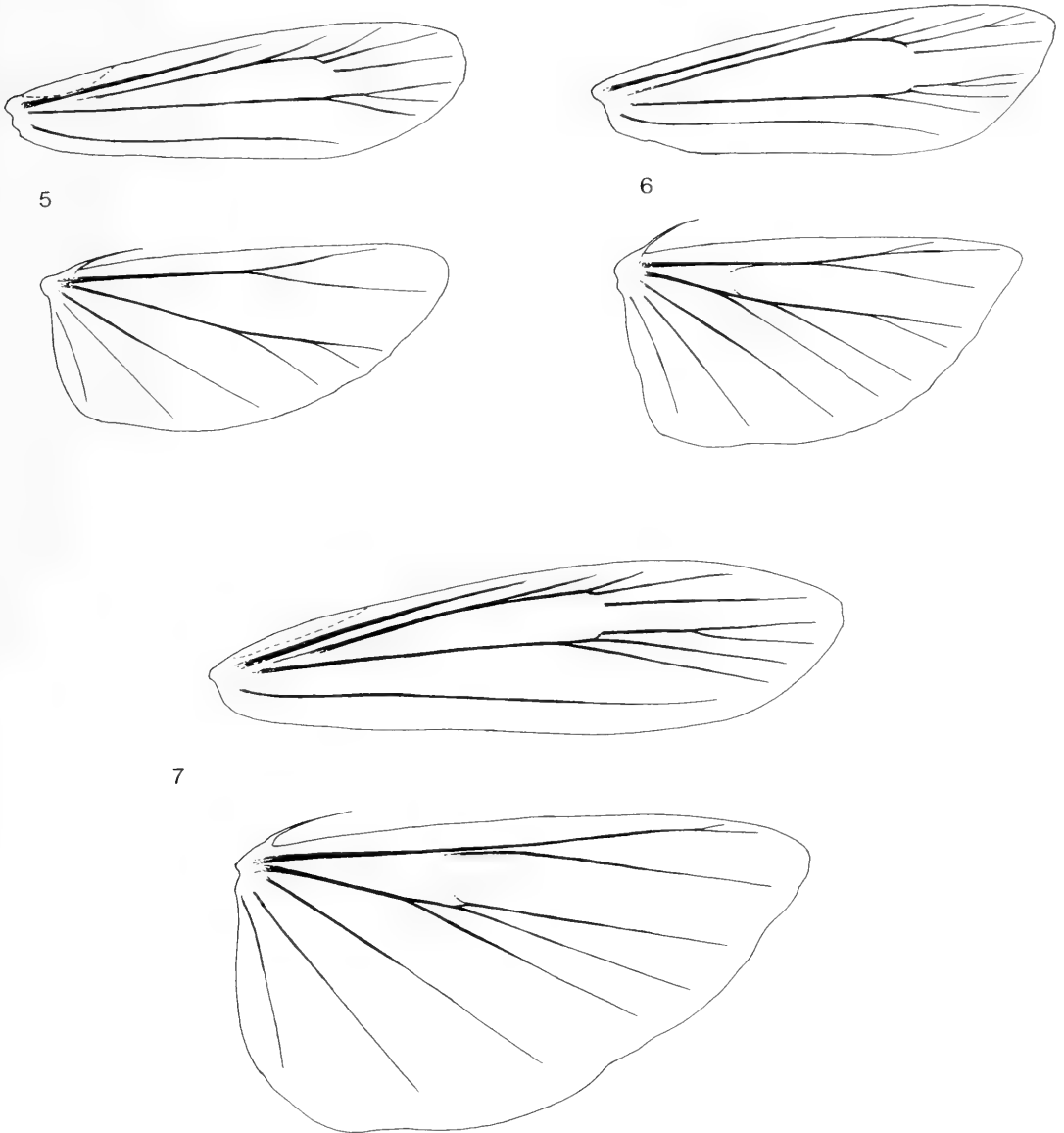


Figs. 1-4. Male adults. 1, *Depeadus deiulus* n. sp., holotype (11.5 mm). 2, *Caviana peruviansis* n. sp., holotype (6.0 mm). 3, *Eurythmioides carasensis* n. sp., holotype (5.5 mm). 4, *Montestra dentata* n. sp., holotype (20.0 mm). (Length of forewing in parentheses.)

strongly sclerotized ridge; dorsodistal surface of valva with many long, slender scales; linear aggregation of long slender scales also originating at base of valva; aedoeagus robust with apical $\frac{1}{4}$ strongly spined; cornutus a strongly sclerotized blade; vinculum longer than greatest width, anterior margin with concavity. Female genitalia (Fig. 22) with ductus bursae short, sclerotized; dorsal plate behind genital opening with granulate, pocketlike, lateral lobes; corpus bursae elongate, about $2\frac{1}{2} \times$ longer than ductus bursae, membranous, and with posterior $\frac{1}{3}$ to $\frac{1}{2}$ with numerous spines and scobinations; signum absent; ductus seminalis attached to corpus bursae near junction with ductus bursae.

Depeadus shares the following features with *Peadus* Heinrich: (1) forewing with

eleven veins, and hindwing with eight veins; (2) male antenna with sinus at base of shaft; (3) male genitalia with uncus greatly reduced, gnathos indistinguishable, valva short, sacculus bearing large scale tufts, aedoeagus spined at apex; (4) female genitalia with ductus bursae sclerotized and much shorter than corpus bursae, and with sclerotized dorsal plate behind genital opening. Differences between the two genera include: (1) M_2 and M_3 of forewing separate in *Peadus*, stalked for basal $\frac{1}{3}$ in *Depeadus*; (2) $Sc + R_1$ and R_s of hindwing briefly fused at base in *Peadus*, fused for $\frac{1}{2}$ their lengths beyond cell in *Depeadus*; (3) male genitalia without transtilla, and with divided valva in *Peadus*, with well developed transtilla, and entire valva in *Depeadus*; (4) female genitalia with corpus bursae with single



Figs. 5-7. Male wing venation. 5, *Eurythmioides carasensis* n. sp. (5.5 mm). 6, *Depeadus deiulus* n. sp. (11.5 mm). 7, *Montestra dentata* n. sp. (20.0 mm). (Length of forewing in parentheses.)

thornlike spine (signum) in anterior $\frac{1}{2}$ in *Peadus*, without signum, but with numerous spines in posterior $\frac{1}{3}$ - $\frac{1}{2}$ in *Depeadus*.

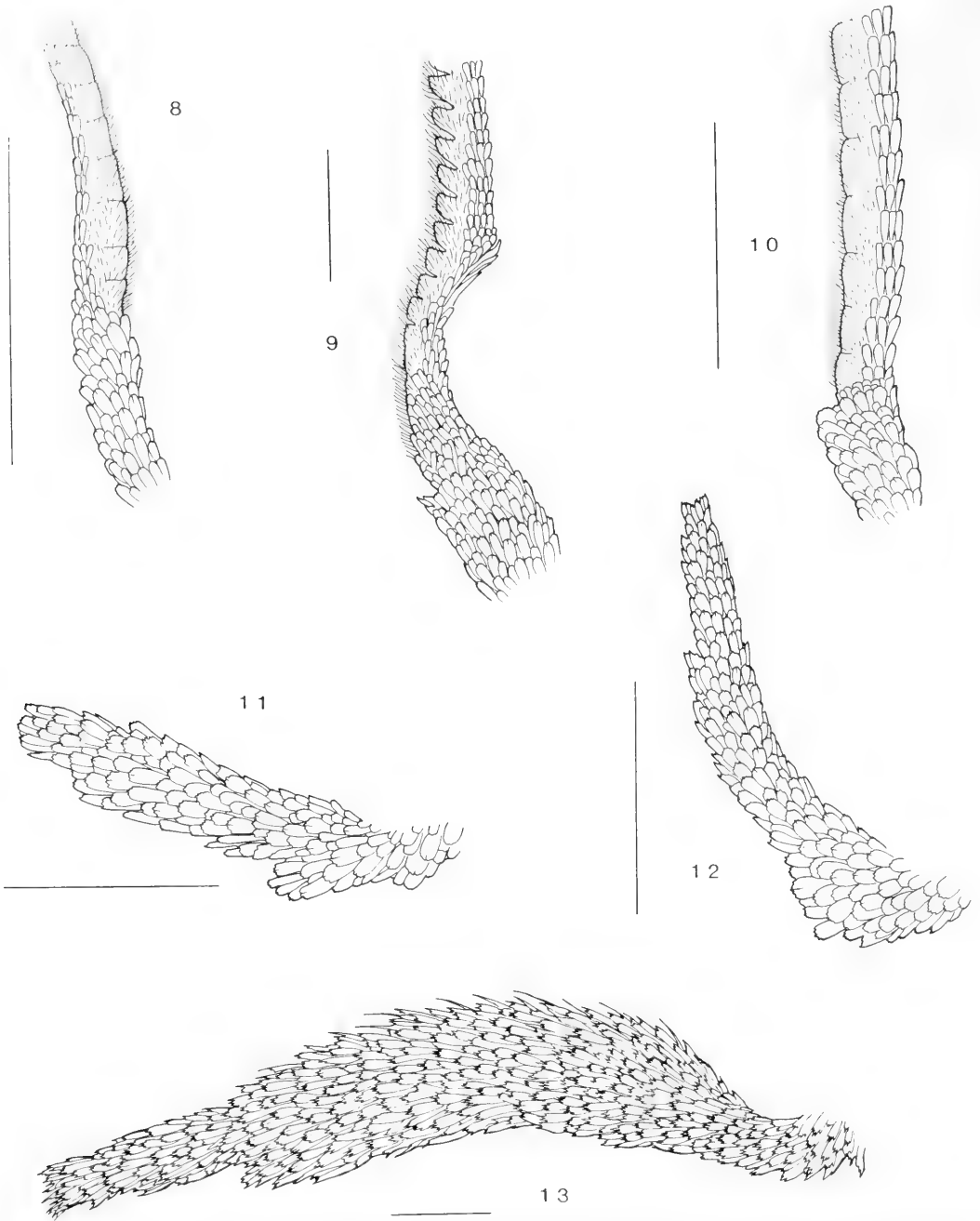
***Depeadus deiulus* Neunzig, NEW SPECIES**

Figs. 1, 6, 9, 19, 20, 22

Type locality.—5 km E. Limbani, 3000 m, Dept. Puno, Peru.

Diagnosis.—The slender, bladelike, lateral arms of the transtilla, and the long costal projection, and large, hooked and spined element, on the valva of the male genitalia are diagnostic.

Description.—Length of forewing 11.5 mm. Head with frons and vertex pale brown and white with a few reddish brown and



Figs. 8-13. Male antennae and labial palpi. 8, *Eurythmioides carasensis* n. sp., frontal view of basal segments. 9, *Depeadus deiulus* n. sp., frontal view of basal segments. 10, *Caviana peruviansis* n. sp., frontal view of basal segments. 11, *Eurythmioides carasensis* n. sp., lateral view. 12, *Caviana peruviansis* n. sp., lateral view. 13, *Montestra dentata* n. sp., lateral view. (All scale lengths 0.5 mm.)

dark brown scales in male, pale brown and white in female; labial palpus mostly pale brown with some reddish brown and dark brown to black scales in both sexes; maxillary palpus mostly pale brown with dark brown at base. Thorax dorsum and collar mostly pale brown to pale reddish brown (most scales paler at tip) with scattered dark brown, black, red and reddish brown scales. Forewing with ground color pale brown dusted with white, with scattered ochre and dark brown to black scales; antemedial line white to brownish white, moderately distinct in posterior half of wing; patches of black at costa basad of antemedial line and basad and distad of antemedial line in posterior half; postmedial line weakly developed, best defined in costal half where patches of black scales establish its proximal and distal borders; patches of, and a few isolated, red or reddish brown, scales, mostly in distal half; discal spots dark brown to black, moderately distinct. Underside of forewing of male without sex-scaling. Hindwing pale smoky brown, darker on veins and near costal and outer margins. Male and female genitalia as given under generic description.

Distribution.—Known only from southeastern Peru.

Holotype.—♂—5 km E. Limbani, 3000 m, Dept. Puno, Peru, 28.iii.1987, O. Karsholt leg., genitalia slide 3450 HHN (ZMUC).

Paratype.—♀—Same collection data as holotype, genitalia slide 3451 HHN (ZMUC).

Caviana Neunzig and Dow, 1993

Caviana peruviansis Neunzig, NEW SPECIES

Figs. 2, 10, 12, 14, 15

Type locality.—15 km N. Carás, Rio Salta Valley, ca. 2000 m, Ancash, Peru.

Diagnosis.—*C. peruviansis* has the following combination of features: a shallow, mostly exposed depression on the frons just anterior to the antennae; male genitalia with a distally attenuated uncus and a dorsally directed spur on the valva.

Description.—Length of forewing 6.0 mm. Head with frons with shallow concavity partially covered anteriorly by dome of posteriorly and mesially projecting black and white scales; surface of concavity with many, white microscales; vertex white, fuscous and black; male antenna (Fig. 10) simple; labial palpus (Fig. 12) upcurved, extending above vertex, mostly fuscous and black, white at base of first and second segments and at tip of second and third segments; maxillary palpus simple, fuscous, black and white. Thorax dorsum and collar fuscous and black, dusted with white. Forewing mostly fuscous and black, dusted with white; antemedial line distinct, white, extending diagonally from costa distally to posterior margin; postmedial line indistinct, white; small patches of pale reddish brown scales sub-basally, near posterior margin and in medial area adjacent to antemedial line; discal spots not apparent, blending with black and white pattern of wing. Underside of wing of male with elongate costal fold. Hindwing mostly white, fuscous near costal and outer margins. Male abdominal segment 8 simple. Male genitalia (Figs. 14, 15) with uncus strongly tapered and slender distally; gnathos with distal part a single, short, straplike element; transtilla incomplete; juxta a plate with slender, lateral lobes; valva with sub-apical, dorsoposteriorly directed spur on costa; vinculum slightly longer than greatest width; aedoeagus robust with platelike, folded cornutus. Female unknown.

C. peruviansis differs most noticeably from *Caviana fuscella* Neunzig and Dow, the only other known species in the genus, in having: (1) a strongly developed, straight antemedial line (rather than an indistinct, dentate antemedial line), and (2) a projection at the apex of the costa of the valva that is robust, blunt and directed dorsoposteriorly (rather than an apical, costal projection that is spinelike and curved ventrally).

Distribution.—Known only from northwestern Peru.

Holotype.—♂—15 km N. Carás, Rio Salta

Valley, ca. 2000 m, Dept. Ancash, Peru, 19–21.ii.1987, O. Karsholt, genitalia slide 3469 HHN (ZMUC).

Montestra Neunzig, NEW GENUS

Gender.—Feminine.

Type species.—*Montestra dentata* Neunzig.

Antenna simple in both sexes; sensilla trichodea (cilia) of male moderately abundant and at base of shaft about $\frac{3}{4}$ as long as basal diameter of shaft. Frons convex. Labial palpus (Fig. 13) porrect, long, extending, in both sexes, beyond head about $4\times$ length of head. Maxillary palpus simple. Haustellum well developed. Ocellus absent. Forewing, of male, (Fig. 7) with basal half of costa slightly convex; underside of wing, of male, with costal fold; with ten veins; R_{3+4} and R_5 completely united; M_1 from well below upper angle of cell; M_2 and M_3 stalked for slightly less than $\frac{1}{2}$ their lengths; CuA_1 from lower angle of cell; CuA_2 from well before lower angle of cell. Hindwing (Fig. 7) with seven veins (1A, 2A and 3A together considered as one vein); $Sc + R_1$ and Rs fused for most of their lengths; M_1 originating slightly below upper angle of cell; M_2 and M_3 completely fused; CuA_1 from slightly before lower angle of cell; CuA_2 from well before lower angle of cell; cell less than $\frac{1}{2}$ length of wing. Male abdominal segment 8 without scale tufts. Male genitalia (Figs. 18, 21) with uncus subtriangular, broadly rounded apically; distal process of gnathos a short, bluntly pointed hook; transtilla complete, triangularly shaped; juxta a narrow U-shaped band with very short, setiferous lobes; valva with short, costal tooth; aedeagus with elongate, thin cornutus; vinculum about as long as greatest width. Female genitalia (Fig. 23) with ductus bursae sclerotized for slightly over $\frac{1}{2}$ its length; corpus bursae membranous, with moderately distinct signum consisting of a loose aggregation of 5–6 thornlike spines; ductus sem-

inalis joined to corpus bursae just anterior to signum.

The male and female genitalia of *Montestra* resemble those of *Vitula* Ragonot and *Volatica* Heinrich—in all three genera the males have a short, simple, distal hook on the gnathos, a complete, triangularly shaped transtilla, and a juxta with short setiferous arms, and the females have the ductus bursae sclerotized for about $\frac{1}{2}$ its length and a membranous corpus bursae. Nevertheless, the transverse markings on the forewing characteristic of *Vitula* and *Volatica* are completely lacking in *Montestra*; instead *Montestra* has longitudinal bands on a narrower forewing. Also, *Montestra* differs from both *Vitula* and *Volatica* in that the costa of the valva has a distinct, dorsally directed toothlike element, a feature lacking in the other genera. Furthermore, the elongate labial palpi of *Montestra* are similar to those of *Volatica*, but the number of veins in the forewing are fewer in *Montestra* than in *Volatica*; the number agrees with the venation found in *Vitula*, but *Vitula* has rather short labial palpi.

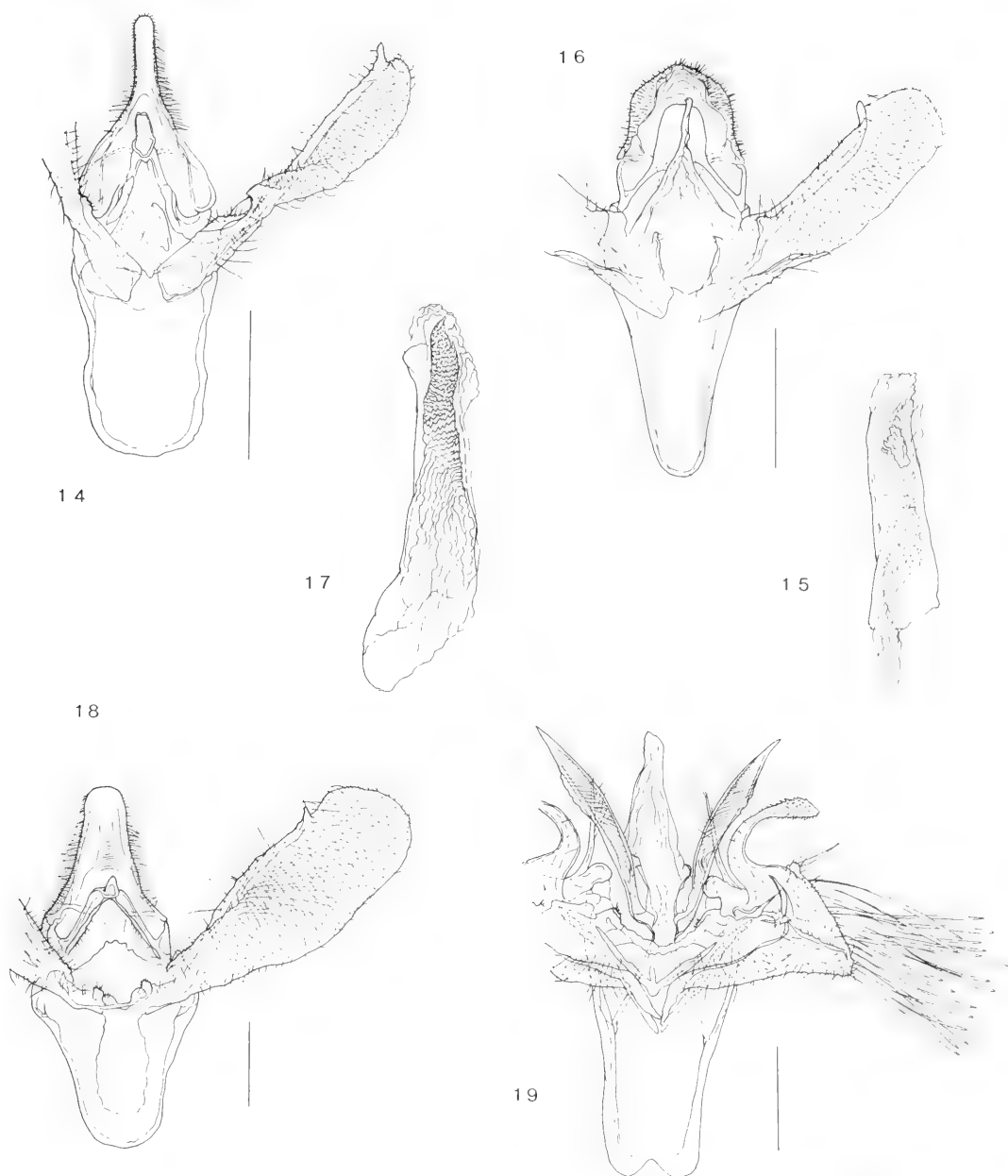
Montestra dentata Neunzig, NEW SPECIES

Figs. 4, 7, 13, 18, 21, 23

Type locality.—35 km SE. Huaráz, Dept. Ancash, Peru.

Diagnosis.—*M. dentata* is a rather large phycitine (average forewing length of eight specimens 18.0 mm) with longitudinally streaked forewings, long, porrect labial palpi, and a costal tooth on the valva of the male genitalia.

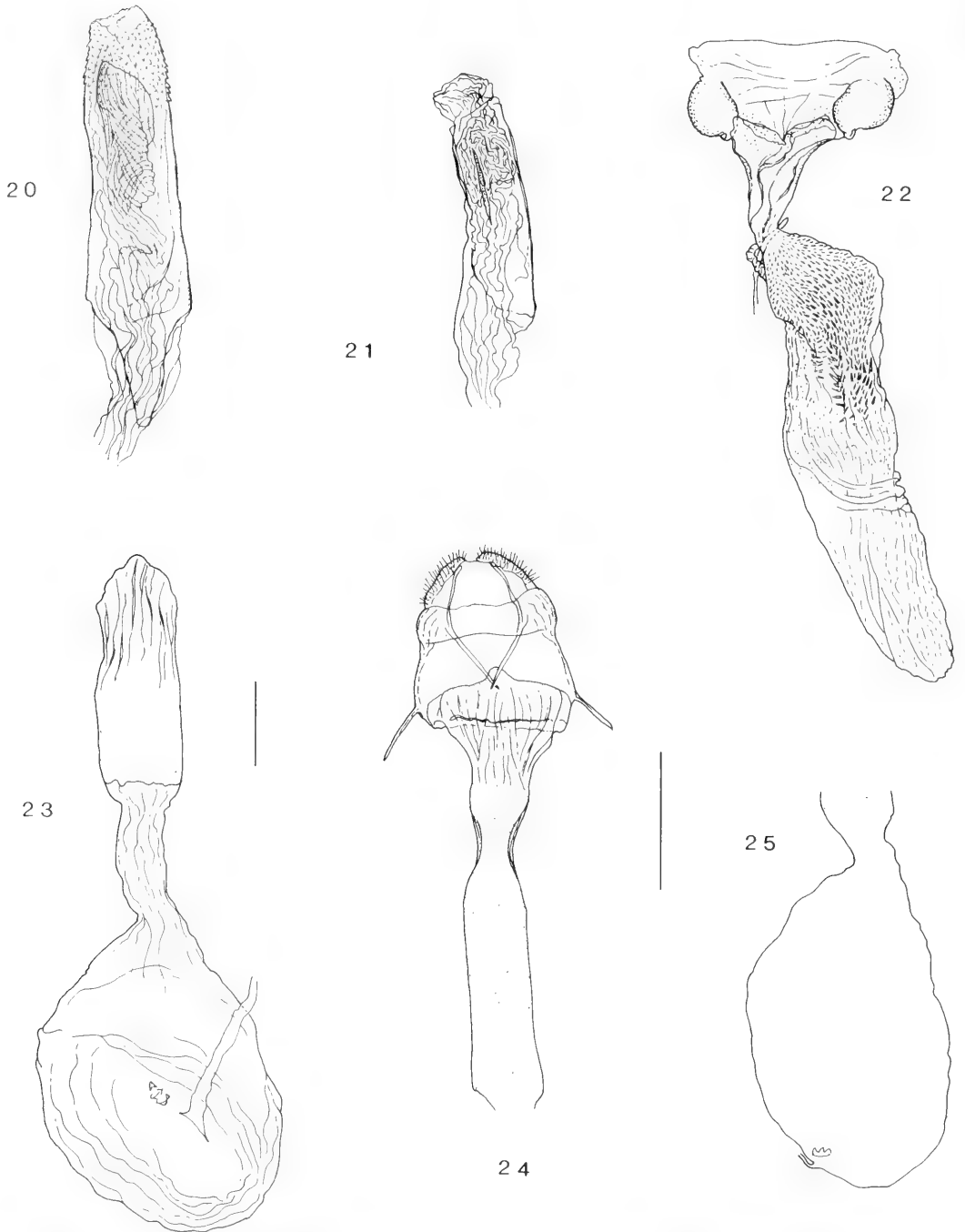
Description.—Length of forewing 14.0–20.0 mm. Head with frons and vertex pale brown to pale reddish brown; labial palpus (Fig. 13) brown to pale brown dusted with white (venter of segments, particularly basal segments, sometimes completely white); maxillary palpus brownish white. Thorax with dorsum and collar pale brown to pale reddish brown. Forewing usually mostly pale brown to pale reddish brown with broad



Figs. 14–19. Male genitalia. 14, *Caviana peruvienis* n. sp., aedeagus omitted. 15, aedeagus. 16, *Eurythmioides carasensis* n. sp., aedeagus omitted. 17, aedeagus. 18, *Montestra dentata* n. sp., aedeagus omitted. 19, *Depeadus deiulus* n. sp., aedeagus and some scales omitted. (All scale lengths 0.5 mm.)

brown to dark brown subcostal and median longitudinal streaks and yellowish white pale scales between streaks; forewing of some (like the holotype) with darker scales over

almost entire surface, obscuring most longitudinal streaks; antemedial and postmedial lines not present; discal spots dark brown to black, moderately distinct to ob-



Figs. 20–25. Male and female genitalia. 20, *Depeadus deiulus* n. sp., aedoeagus. 21, *Montestra dentata* n. sp., aedoeagus. 22, *Depeadus deiulus* n. sp., ventral view of ductus bursae, corpus bursae and ductus seminalis. 23, *Montestra dentata* n. sp., ventral view of ductus bursae, corpus bursae and ductus seminalis. 24, *Eurythmioides carasensis* n. sp., ventral view of posterior part. 25, ventral view of anterior part. (All scale lengths 0.5 mm.)

scure. Underside of forewing, of male, without sex-scales. Hindwing pale smoky fuscous. Male and female genitalia as given under description of genus.

Distribution.—collected at 3240 to 4100 m in the Peruvian Cordillera Negra and Cordillera Vilcabamba.

Holotype.—♂—Quabrada Pucavado, Cerro Cahuish, 35 km SE. Huaráz, 4100 m, Dept. Ancash, Peru, 15–18.ii.1987, O. Karsholt leg., genitalia slide 3463 HHN (ZMUC).

Paratypes.—2 ♀, same collection data as holotype, genitalia slides 3464, 3465 HHN (ZMUC); 2 ♀, 5 km E. Laguna Pomacanchi, 40 km NW. Sicuani, 3240 m, Dept. Cuzco, Peru, 24.iii.1987, O. Karsholt leg. (ZMUC); 3 ♀, Pueblo Quichas, Quabrada Quichas, 10 km N. Oýon, 4000 m, Dept. Lima, Peru, 24–26.ii.1987, O. Karsholt leg (ZMUC).

Eurythmioides Neunzig, NEW GENUS

Gender.—Masculine.

Type species.—*Eurythmioides carasensis* Neunzig

Antenna of both sexes simple (Fig. 8). Front convex with most scales directed anteriorly to form a conelike projection. Labial palpus oblique (Fig. 11). Maxillary palpus simple. Haustellum well developed. Ocellus ?present. Basal half of costa of forewing of male (Fig. 5) slightly convex; underside of wing of male with costal fold. Forewing without raised scales; with nine veins; R_{3+4} and R_5 completely fused; M_1 from below upper angle of cell; fused M_{2+3} stalked with CuA_1 for slightly more than $\frac{1}{2}$ their lengths; CuA_2 from close to lower angle of cell. Hindwing (Fig. 5) with six veins (1A, 2A, and 3A considered together to be one vein); $Sc + R_1$ and R_s completely fused; M_1 from upper angle of cell; M_{2+3} and CuA_1 stalked for about $\frac{1}{2}$ their lengths; CuA_2 from close to lower angle of cell; cell about $\frac{1}{2}$ length of wing. Male abdominal segment 8 with scale tufts; some scales forming tufts straight, others sinuous. Male genitalia (Figs. 16, 17) with uncus broadly triangular; gna-

thos distally a broad, tonguelike plate; transtilla complete, with slender, distal hook; juxta a U-shaped plate with short, setiferous lateral lobes; valva with costa strongly sclerotized for about $\frac{3}{4}$ its length and with sclerotized part terminating in short, slightly curved, dorsal projection; inner base of valva with setiferous, triangular lobe; aedoeagus enlarged at base and with a well-sclerotized, saw-toothed, spiral element; vinculum longer than greatest width. Female genitalia (Figs. 24, 25) with very short apophyses posteriores and apophyses anteriores; ductus bursae longer than corpus bursae, sclerotized and granulate for about $\frac{7}{8}$ its length with a strongly sclerotized shield behind genital opening, and with a sclerotized band posterior to opening; ductus bursae membranous, oval, with signum a fused cluster of a few thornlike spines near anterior end of ductus bursae; ductus seminalis attached to corpus bursae close to signum.

The female genitalia of *Eurythmioides*, especially the very short apophyses, are like those of *Ephesiodes* Ragonot, but, the greatly reduced wing venation, and the complete transtilla and toothed and spiraled cornutus of the aedoeagus of the male genitalia of the former genus differ from those of the latter group and, therefore, suggest that *Eurythmioides* is more closely allied to *Eurythmia* Ragonot.

Eurythmioides carasensis Neunzig, NEW SPECIES

Figs. 3, 5, 8, 11, 16, 17, 24, 25

Type locality.—15 km N. Carás, Rio Salta Valley, ca. 2000 m., Ancash, Peru.

Diagnosis.—The platelike distal element of the gnathos, and the slender, distal hook of the transtilla, of the male genitalia are diagnostic.

Description.—Length of forewing: 5.5–6.5 mm. Head with front and vertex brown, some scales, particularly near eyes, brownish white or tipped with brownish white; labial palpus brown and brownish white, palest on basal segment; maxillary palpus

brownish white. Thorax with dorsum pale brown to brown, some brown scales faintly tipped with brownish white, collar generally slightly paler than dorsum. Forewing with ground color brown to dark brown dusted with white and brownish white; weakly developed reddish brown streaks or patches mostly in posterior half; costal half of basal area with obscure pale longitudinal streak; antemedial and postmedial lines indistinct, white and brownish white; discal spots dark brown to black, obscure. Hindwing smoky fuscous, darker along veins and near costal and outer and posterior margins. Male and female genitalia (Figs. 16, 17, 24, 25) as in description of genus.

Distribution.—Known only from northwestern Peru. The few specimens collected have been taken near a river or in a river valley at low to moderate elevations.

Holotype.—♂—Rio Salta Valley, ca. 2000 m., 15 km N. Carás, Dept. Ancash, Peru, 19–21.ii.1987, O. Karsholt leg., genitalia slide 3470 HHN. (ZMUC)

Paratypes.—2 ♀—Same collection data as holotype, genitalia slides 3471, 3473 HHN. (ZMUC). 1 ♂—7 km E. Oगतun, 100 m. E. side of Rio Zaña, 35 km SE. Chiclayo, Dept. Lambayeque, Peru, 18.v.1987, N. Krabbe leg., genitalia slide 3481 HHN (ZMUC).

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NOMENCLATURAL AND SYNONYMICAL NOTES ON THE GENERA
DIPLONYCHUS LAPORTE AND *APPASUS* AMYOT AND SERVILLE
(HETEROPTERA: BELOSTOMATIDAE)

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Abstract.—The genus *Appasus* Amyot and Serville is resurrected from synonymy, and *Muljarus* Lee placed as a junior synonym (new synonymy). Revised synonymies are given for the genera *Appasus* and *Diplonychus* Laporte, and for *Diplonychus annulatus* Fabricius. *Diplonychus heeri* Polhemus, New Name, is proposed as a replacement name for *Diplonychus rotundatus* Heer, 1853, a junior secondary homonym of *Diplonychus rotundatus* (Laporte, 1833). *Diplonychus indicus* Venkatesan and Rao, 1980 is placed as a junior synonym of *Diplonychus rusticus* (Fabricius, 1781).

Key Words: Heteroptera, Belostomatidae, *Diplonychus*, *Appasus*, taxonomy, synonymy

**Genus *Appasus* Amyot and Serville 1843,
REVISED STATUS**

Naucoris Fabricius, 1803: 111 (in part)
Appasus Amyot and Serville, 1843: 430.

Type species: *Appasus natator* Amyot and Serville, 1843: 431 (= *Naucoris nepoides* Fabricius 1803: 111), Monobasic.

Amyotella Spinola, 1850: 48 (no included species). Type species: [*Appasus*] *natator* Amyot and Serville, 1843: 431 (= *Naucoris nepoides* Fabricius, 1803: 111); fixed by Kirkaldy, 1906.

Muljaris Lee, 1991: 10. Type species: *Appasus japonicus* Vuillefroy, 1864: 141 (as *Diplonychus japonicus*). Original designation. New Synonymy.

Fabricius (1803) described the new species *nepoides* under *Naucoris*. However he retained both *annulata* Fabricius, 1781, and *rustica* Fabricius, 1781, under *Nepa*.

Lee (1991) proposed the genus *Muljaris* to hold *Diplonychus japonicus* Vuillefroy and *Diplonychus major* Esaki, which he separated from *Diplonychus* on the basis of a number of characters. A new generic entity was unnecessary because the type species of

Appasus, *Naucoris nepoides* Fabricius, has all of the characters used to separate the group containing *japonicus* and *major*, thus *Muljaris* must fall as a junior synonym of *Appasus*. Lee failed to analyze the described species previously held under *Diplonychus* and place them into their respective genera, or undoubtedly he would have realized that a genus group name was already available for his newly conceived group. A review of the genera germane to this work was accomplished by examination of specimens in the Polhemus Collection, which currently holds all described species except *stali* Mayr, placed by Lee with the species retained in *Diplonychus*, a placement that seems correct.

Lee's separation of *Diplonychus* into two genera seems to be well founded on both somatic and male genitalic characters. However several of the characters need modification or clarification, e.g. the morphological differences of the hemelytral membrane, and the "lips marks" (sic) on the scutellum.

The purported generic differences of the hemelytral membrane (Lee, 1991, figs. 3A,

(B) actually represent wing morphs found in a single population of *D. rusticus* (F.) from Viet Nam that also contains an intermediate morph. The flightless morph with the membrane reduced or absent has in addition reduced straplike flight wings, narrowed and angulate hemelytra distally, and sharp posterolateral pronotal angles. The fully alate morph has a well-developed membrane with veins in addition to the transparent margin present in all morphs, normally rounded hemelytra distally, fully developed flight wings, and the posterolateral pronotal angles sloping anteriorly. This phenomenon of linked characters in different flight morphs is also common in Naucoridae.

The "lips marks" of the posteroapical angle of the scutellum, said to be present in the "*rusticus* group," but absent in the "*japonicus* group" is an inconsistent color character that, in my view, should not be used to separate genera.

Other differences given by Lee are useful, and found in the key couplet that follows. For details of the male genitalic structures, see figures in Lee (1991). In addition to the differences given by Lee, *Appasus* species have prominent eyes, very different from those of *Diplonychus* species, in which the eyes are "streamlined" and flush with the lateral margins of the head.

KEY TO *APPASUS* AND *DIPLONYCHUS*

1. Lateral eye margins flush with lateral margin of head, not protruding laterally. First antennal segment equal to or longer than the lateral prolongations of segments II and III, and segment IV. Male pygophore tapering more or less evenly between basal portion and apical semitubular portion. Lateral arms of phallic basal plate each with a low angular medial projection; phallus laterally flat, exophallotheca with sclerotized lateral rhomboid plates; endosoma laterally flat, hatchet-shaped. *Diplonychus* Laporte
- Lateral eye margins not flush with lateral margin of head, prominent, protruding laterally. First antennal segment shorter than the lateral prolongations of segments II and III, and segment IV. Male pygophore with an abrupt sculptured shoulder between basal portion and

apical semitubular portion. Lateral arms of phallic basal plate without projections, smooth; phallus tubular, exophallotheca with narrow sclerotized lateral plates; endosoma tubular, not hatchet-shaped. . . . *Appasus* Amyot and Serville

The following species are now assigned to *Appasus*, with original genus given in brackets if applicable:

- ampliatius alluaudi* (Montandon, 1914). [*Diplonychus*]. New Combination
ampliatius ampliatius (Montandon, 1914). [*Diplonychus*]. New Combination
capensis (Mayr, 1871). [*Diplonychus*]. New Combination
grassei ghesquieri (Poisson, 1940). [*Diplonychus*]. New Combination
grassei grassei (Poisson, 1937). [*Diplonychus*]. New Combination
grassei luitikilae (Poisson, 1968). [*Diplonychus*]. New Combination
kjellanderi (Menke, 1962). [*Diplonychus*]. New Combination
japonicus Vuillefroy, 1864. Restored Combination
major (Esaki, 1934). [*Diplonychus*]. New Combination
nepoides (Fabricius, 1803). [*Naucoris*]. Restored Combination
procerus divoi (Poisson, 1968). [*Diplonychus*]. New Combination
procerus procerus (Gerstaecker, 1873). [*Diplonychus*]. New Combination
quadrivittatus Bergroth, 1893. Restored Combination
stappersi (Montandon, 1916). [*Sphaeroderma*]. New Combination
urinator sudanensis (Linnavuori, 1971). [*Diplonychus*]. New Combination
urinator urinator Dufour, 1863. Restored Combination
wittei (Poisson, 1949). [*Diplonychus*]. New Combination

Genus *Diplonychus* Laporte, 1833

- Nepa* Fabricius, 1781, vol. 2: 333 (in part)
Diplonychus Laporte, 1833: 18. Type species: *Nepa rustica* Fabricius, 1781, vol. 2:

- 333 (= *Nepa plana* Sulzer, 1776: 92). Monobasic.
- Sphaerodema* Laporte, 1833: 18 (as subgenus of *Diplonychus*). Type species: *Sphaerodema rotundata* Laporte, 1833: 18 (= *Nepa annulata* Fabricius, 1781: 333). Monobasic. Synonymized by Kirkaldy, 1906: 151.
- Diplonychcha* Spinola, 1837: 53 (variant spelling).
- Atomya* Spinola, 1850: 48 (no included species). Synonymized by Kirkaldy, 1906: 151.
- Nervinops* Dufour, 1863: 348. Type species: *Nepa rustica* Fabricius, 1781, vol. 2: 333 (= *Nepa plana* Sulzer, 1776: 92). Monobasic. Synonymized by Kirkaldy, 1906: 151.
- Cyclodema* Dufour, 1863: 397 (suggested new name for *Sphaerodema* Laporte). Synonymized by Kirkaldy, 1906: 151.
- Nectocoris* Mayr, 1871: 432. Type species: *Nectocoris stali* Mayr, 1871: 432. Monobasic. Synonymized by Lauck and Menke, 1961: 649.

Polhemus (1994) has shown that the type species of *Diplonychus* Laporte, *Nepa rustica* Fabricius, 1781, is a junior synonym of *Nepa plana* Sulzer, 1776, and a primary homonym of *Nepa rustica* Fabricius, 1775. A petition has been made to the ICZN to preserve the name *Nepa rustica* Fabricius (Polhemus and Kerzhner, 1995). Therefore, I continue here to use *Nepa rustica* Fabricius as the type species of the genus *Diplonychus*.

I have studied specimens of *Diplonychus indicus* Venkatesan and Rao, 1980, kindly furnished by Dr. Venkatesan, and find that this species is inseparable from *Diplonychus rusticus* (Fabricius) and, therefore, must fall as a junior synonym (New synonymy).

Lauck and Menke (1961) gave the synonymy of *Diplonychus* along with an extensive discussion. However, at that time *Appasus* was a synonym. The above synonymy gives the current status of the synonyms still

remaining under *Diplonychus* with the removal of *Appasus*.

The following species are now assigned to *Diplonychus*, with original genus given in brackets if applicable:

- annulatus* (Fabricius, 1781) [*Nepa*]
eques (Dufour, 1863) [*Appasus*]
esakii Miyamoto and Lee, 1966
rusticus (Fabricius, 1781) [*Nepa*] = *planus*
 (Sulzer, 1776) [*Nepa*] = *indicus* Venkatesan and Rao, 1980.
stali (Mayr, 1871) [*Nectocoris*]

- Diplonychus annulatus* (Fabricius, 1781)
Nepa annulata Fabricius, 1781: 333; type locality, "in Coromandel Mus. Dom. Banks" (= Coromandel Coast, Madras area, South India); types in London (1) and Copenhagen (2).
Belostoma marginata Gray, 1832: 248, pl. 93, fig. 4; type-locality "China." Synonymized by Mayr, 1871: 434.
Sphaerodema rotundata Laporte, 1833: 18; type-locality not given. Synonymized by Mayr, 1871: 434.
Diplonychus annulatus: Lauck and Menke, 1961: 649.
Abedus sangameswari Rupavathi, 1985: 169; type-locality Guntur District, Andhra Pradesh, India (manuscript species; nomen nudum).

See also:

- Sphaerodema annulatum*: Distant, 1906: 35 (brief redescription).
Sphaerodema annulatum: Hoffmann, 1941: 8 (catalog; synonymy; distribution).

This species has a much more restricted distribution than *D. rusticus* (Fabricius); however, the two species are geographically sympatric in southern India. The two species are easily distinguished, as the latter is much smaller and less rotund.

The synonymy above places the species *Sphaerodema rotundata* Laporte in the ge-

as *Diplonychus*, and establishes the secondary homonym discussed below.

***Diplonychus heeri* Polhemus, NEW NAME**

Diplonychus rotundatus Heer, 1853: 85 (Tertiary fossil). Junior secondary homonym of *Diplonychus rotundatus* (Laporte, 1833: 18) = *Nepa annulata* Fabricius, 1781: 333.

Diplonychus rotundatus Heer, 1853 is a junior secondary homonym of *Sphaerodema rotundata* Laporte, 1833. The latter and its senior synonym *Nepa annulata* Fabricius, 1781 were placed in the genus *Diplonychus* by Lauck and Menke (1961) when they synonymized *Sphaerodema* (see synonymy of *Diplonychus* above). This leaves *Diplonychus rotundatus* Heer without a name; thus, for this taxon I propose the name *Diplonychus heeri* Polhemus.

Another fossil, *Sphaerodema jurassicum* Oppenheimer, 1888, was transferred by Handlirsch (1906: 543) to his new genus *Sphaerodemopsis*, and is presently placed in Naucoridae.

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THE IDENTITY OF *PELOCORIS BIIMPRESSUS* MONTANDON AND
SYNONYMY OF *PELOCORIS* SPECIES IN THE SOUTHWESTERN
UNITED STATES (HETEROPTERA: NAUCORIDAE)

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Abstract. — *Pelocoris shoshone amargosus* La Rivers 1956 is synonymized with *Pelocoris biimpessus* Montandon 1898, NEW SYNONYMY; a lectotype is designated for the latter. *Pelocoris femoratus* (Palisot de Beauvois) 1820 is compared to *P. biimpessus* and discussed, and a neotype is designated.

Key Words: Insecta, Heteroptera, Naucoridae, synonymy

A recent review (JTP in prep.) of the genus *Pelocoris* Stål revealed that *P. biimpessus* Montandon is the most common species in northern Mesoamerica with a range extending from Guatemala northward into Texas, Louisiana, Arizona, Nevada and California, and that *Pelocoris shoshone amargosus* La Rivers 1956 is a synonym.

To characterize species of this difficult genus, several morphological characters have been found to be useful in addition to those used by La Rivers (1948, 1956) and Nieser (1975) (e.g. shape of male ventral laterotergites VI and VII, shape of female ventral laterotergite VI, sculpturing of male tergite V, dentition of female ovipositor lobes, shape and setiferation of male parameres). The characters used by La Rivers (loc. cit.) to separate species include the morphology of the female sternum VII (subgenital plate), male aedeagus, male dorsal aedeagal plate, coloration of dorsum, and body size; Nieser added the coloration of the fore femora and hemelytra, and development of spines on the connexiva. Some, but not all, of these

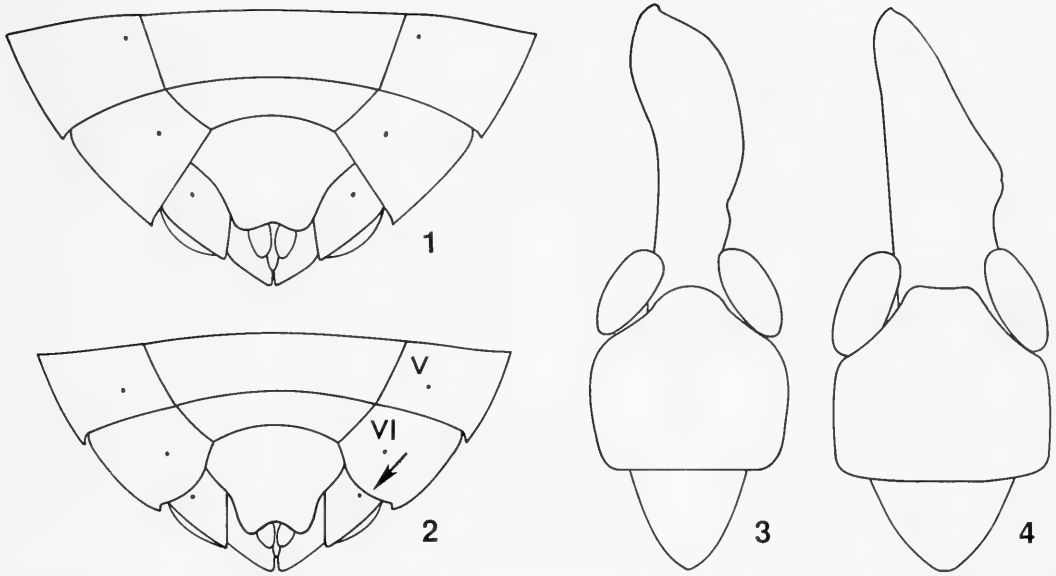
characters are used below in distinguishing North American species.

This contribution is intended to clarify the status of the *Pelocoris* species of the central and southwestern United States, from Louisiana and Texas westward; therefore, the voluminous Mexican and Mesoamerican material in the Polhemus Collection is not treated here, except for a few examples. The resolution of *Pelocoris* species-group problems in the southeastern United States (particularly Florida), and Mesoamerica plus northern South America are beyond the scope of this paper, and will be treated in future publications.

Pelocoris biimpessus biimpessus
Montandon

Pelocoris biimpessus Stål in litt.; see Montandon 1898: 285, and Champion 1901: 360. Manuscript name, unavailable.

Pelocoris biimpessus Montandon 1898. Bull. Soc. Sci. Buc.-Roum. 7: 285. Lectotype, male, here designated, Mexico, in Stockholm Museum.



Figs. 1-4. 1, Abdominal venter of female *Pelocoris biimpresus*. 2, Abdominal venter of female *Pelocoris femoratus* (arrow, posterior margin of laterotergite VI). 3, Male genitalia of *Pelocoris biimpresus*. 4, Male genitalia of *Pelocoris femoratus*.

Pelocoris biimpresus, Van Duzee 1916.
Check List Hem., p. 52.

Pelocoris shoshone amargosus La Rivers
1956. Wasmann J. Biol. 14: 155.
NEW SYNONYMY.

Diagnosis.—Females of *P. biimpresus* can easily be distinguished from those of *P. femoratus* by the shape of the posterior margin of ventral laterotergite VI: straight in the former (Fig. 1), distinctly curved in the latter (Fig. 2, arrow). Males can be distinguished by the shape of the aedeagus (Figs. 3, 4) (see also La Rivers 1948, Figs. 1 M, N). *Pelocoris femoratus* ordinarily is somewhat smaller in stature and lighter in color than is *P. biimpresus*, which is particularly noticeable in the region where the species co-occur. Both color and size are extremely variable over the larger geographic range of each species and indeed even within a single series and are thus unreliable as key characters over most of the range. Possibly, with better methods to discriminate species, each of these taxa will be further subdivided, as they are morphologically polytypic com-

pared to South American species known to us. The ranges overlap only in Texas and Louisiana as far as is now known, but future collecting will undoubtedly increase the known range of both species.

Distribution.—*P. biimpresus* occurs as far south as Guatemala (Polhemus, in prep.); Montandon (1898) reported *biimpresus* from Guatemala, Mexico and Uruguay, but his diagnosis was based primarily on color thus his records are potentially unreliable. *P. poeyi*, as defined by Nieser (1975), occurs in northern South America; Sites (1990) has recently reported that it ranges from Cuba through the Antilles into South America to Ecuador, therefore it is quite possible that the ranges of these two species overlap. Unfortunately the species are difficult to identify. Although there is a slight difference in the male genitalia, the females are very similar in appearance, including the shape of female sternum VI.

Discussion.—Montandon (1898) and Champion (1901) treated *biimpresus* as a variety of *femoratus*, and did not discuss the locality of any type material. Van Duzee

1916, 1917), Hungerford (1920), La Rivers (1948, 1971) and Polhemus and Polhemus (1988) treated *biimpessus* as a valid species without significant comment. La Rivers (1948) briefly discussed the species in connection with his proposal of *P. shoshone* from warm springs in Nevada, but in spite of the realization that *P. biimpessus* was a North American species, he made no attempt to recognize it or compare it with his *P. shoshone*, and as a consequence described a synonym.

During a survey of the collections of Europe, JTP noted a syntype series of *Pelocoris biimpessus* consisting of two specimens in the Natural History Museum at Stockholm. This is Stål's (1876) manuscript species referred to by Montandon (1898) and Champion (1901). Through the kindness of Dr. Per Lindskog we have been able to study these two females. The first of these bears the following labels: "Mexico"; "Sallé"; "biimpessus Stål" handwritten; "Typus" on red card. Without a previous lectotype designation, this is not a holotype, but only a syntype; we here designate this female as lectotype. The second female bears the labels: "Mexico"; "Stål"; "Paratypus" on red card; this specimen is designated a paralectotype.

Material examined.—UNITED STATES: Arizona: Santa Cruz Co.: 1 male, 1 female, cattle pond 1 mi. W. of Peña Blanca L., 17-X-78, C. Olson (JTPC). California: San Bernardino Co.: many males and females, Saratoga Springs, CL 278, 21-II-64, J. T. Polhemus (JTPC); 4 males, 2 females, Saratoga Springs, 27-I-57, Menke & Stange (JTPC); 13 males, 8 females, Death Valley Nat. Mon., Saratoga Springs, 22-XI-90, J. A. Back (UMC); 6 males, 2 females, Saratoga Springs, Death Valley Nat. Mon., El. 61 m, water temp. 28°C, CL 2902, 22-VII-92, J. T. & D. A. Polhemus (JTPC). Inyo Co.: many males and females, warm spring near Tecopa, CL 280 22-II-64, J. T. Polhemus (JTPC); 1 male, 1 female, Tecopa Hot Springs, El. 533 m, water temp. 37°C, CL 2903, 29-VI-93, J. T. & D. A. Polhemus

(JTPC). Louisiana: Iberville Par.: 1 female, St. Gabriel Exp. Sta., 26-IX-84, C. B. Barr (JTPC); Tangipahoa Par.: 1 female, 11-III-77, J. E. Barr Sr. (WDSC). Nevada: Nye Co.: many males and females, stream below Point of Rock Springs, Ash Meadows, CL 269, 20-II-64, J. T. Polhemus (JTPC); 3 males, 3 females, 1 nymph, Purgatory Well, Ash Meadows NWR, El. 716 m, water temp. 33.5°C, CL 2718, 22-VII-92, J. T. & D. A. Polhemus (JTPC); 3 males, Mary Scott Spring, Ash Meadows NWR, El. 716 m, water temp. 28°C, CL 2719, 22-VII-92, J. T. & D. A. Polhemus (JTPC); 1 female, Shaft/Chalk Spring, Ash Meadows NWR, no date, D. Threlloff (JTPC); 2 females, Claypit Spring, Ash Meadows NWR, no date, D. Threlloff (JTPC). Texas: Victoria Co.: 1 female, det. *Pelocoris biimpessus*, Montandon 1909, Victoria, J. D. Mitchell (USNM). GUATEMALA: Progreso: 2 males, 1 female, Jutiapa, pond, # 632, 23-VI-1957, D. R. Lauck (JTPC). MEXICO: Jalisco: 1 female, Atentique, 5-XII-48, E. S. Ross (JTPC); 2 males, S. of Guadalajara, pond, # 671, 11-VIII-1957, D. R. Lauck (JTPC). Sonora: 1 male, 1 female, Rio Sonora, E. of Ures, CL 714, 3-III-1975, J. T. Polhemus (JTPC). Veracruz: 3 males, 4 females, Rio Blanco, La Tinaja, CL 504, 4-I-1971, J. T. & M. S. Polhemus (JTPC); 3 males, 2 females, S. of Guiterrez Zamora, CL 519, 7-I-1971, J. T. & M. S. Polhemus (JTPC). State unknown: 1 female, Sallé (lectotype), 1 female (paralectotype) (SMNH) (see discussion above).

***Pelocoris biimpessus shoshone* La Rivers,
NEW COMBINATION**

Pelocoris shoshone La Rivers 1948. Ann. Entomol. Soc. Am. 61: 371.

Pelocoris shoshone shoshone La Rivers 1956. Wasmann J. Biol. 14: 155.

The subspecies *P. shoshone shoshone* was characterized by La Rivers as being smaller, of lighter color, and with a lighter colored yellowish scutellum in comparison to *P. shoshone amargosus* (now *P. biimpessus*

biimpressus), which is dark in coloration and typically has a brownish black scutellum except the yellowish tip. These differences have not been seen to intergrade in the populations studied so far, therefore the subspecies status is retained for the present. However, the variation in size and color over the range of *P. biimpressus* in Mexico and Mesoamerica encompasses both forms described by La Rivers under *P. shoshone*, and the variation shows no clear geographic separation except for the consistently lighter colored scutellum of *P. b. shoshone*, thus the subspecies status of these taxa may eventually be suppressed.

In California and Nevada, La Rivers' subspecies *amargosus* is restricted to springs in the Amargosa River system proper, which begins in the Bullfrog Hills and on Pahute Mesa northwest of Beatty, Nevada and flows (during wet periods) into the southern end of Death Valley, whereas at all other localities, including Grapevine Springs at the north end of Death Valley, the White River system, and Railroad Valley, the only form so far seen is the subspecies *shoshone*. The Grapevine Springs drain into the same endorheic basin as the Amargosa River, but are separated by a highly saline sink in central Death Valley. The presence of *P. biimpressus biimpressus* at the south end of the valley, and *P. biimpressus shoshone* at the north end indicates that in the past these areas were connected to separate drainage systems, but more recent tectonic downwarping has caused them to flow to a common terminus.

The localities given below are only for *P. biimpressus shoshone* in the United States.

Material examined.—UNITED STATES: California: Inyo Co.: 1 female, Grapevine Springs, nr. Scotty's Castle, Death Valley Nat. Mon., D. Threlloff, II-93 (JTTC); 1 male, 1 female, Grapevine Springs, nr. Scotty's Castle, El. 838 m, water temp. 35°C, CL 2901, 28-VI-93, J. T. & D. A. Polhemus (JTTC). Nevada: Nye Co.: 7 males, 5 females, 10 nymphs, Railroad Valley, Duckwater, Big Warm Spring, El. 1768 m, water

temp. 33°C, CL 2893, 27-VI-93, J. T. & D. A. Polhemus (JTTC); many males and females, Railroad Valley, Duckwater, Little Warm Spring, El. 1768 m, water temp. 33°C, CL 2894, 27-VI-93, J. T. & D. A. Polhemus (JTTC). Lincoln Co.: 6 males, 1 female, Ash Warm Springs, elev. 1143 m, water temp. 36°C, CL 2711, 21-VII-92, J. T. & D. A. Polhemus (JTTC); 2 males, 4 females, 6 nymphs, Ash Springs, 26-27-VIII-89, algal mats in slow water, J. A. Back (UMC). Clark Co.: 12 males, Moapa Warm Springs, N. of Moapa, El. 550 m, water temp. 32°C, CL 423, 16-IV-68, J. T. Polhemus (JTTC); 4 males, 14 nymphs, Warm Springs, 32°C, algal mats in slow water, 27-VIII-89, J. A. Back (UMC); 2 males, 2 females, 13 mi. S. Overton, Blue Point Spring, 12-XII-86, W. D. Shepard (WDSC, JTTC).

Pelocoris femoratus femoratus
(Palisot de Beauvois)

- Naucoris femorata* Palisot de Beauvois 1820. Ins. Afr. Amer. 14: 237, pl. 20, fig. 4. Type-locality "États-Unis d'Amérique." Neotype, male, New Jersey, here designated.
- Pelocoris femoratus*, Stål 1876. Svenska Vetensk. Akad. Handl. 14: 144.
- Naucoris poeyi*, Uhler 1876. Bull. U. S. Geol. Surv. Terr. 1: 71. Misidentification.
- Pelocoris femoratus*, Montandon 1898. Bull. Soc. Sci. Buc.-Roum. 7: 284-286. Diagnosis, synonymy.
- Pelocoris carolinensis*, Hungerford 1927. Bull. Brook. Entomol. Soc. 22: 77. Life history. Misidentification.

Distribution.—*Pelocoris femoratus* apparently is restricted to the eastern part of the United States and Canada. We have not yet seen specimens from Mexico, although it is common in eastern Texas (Sites and Polhemus, in press). The distribution given by Polhemus and Polhemus (1988) included extralimital records from the literature that must now be reconfirmed. Montandon (1898) cited localities in the United States and Panama; the latter record certainly per-

tains to another species. The infraspecific *Pelocoris femoratus balius* La Rivers is known from only Florida.

A neotype is here designated in order to stabilize the nomenclature of *Naucoris femoratus* Palisot de Beauvois, as the type material has never been located and is presumed lost. It is a male from New Jersey, Somerset Co., Basking Ridge, CL 384, 31 May 1967, J. T. Polhemus, in USNM. The type locality is here restricted to New Jersey.

Distributional data for this species was given by Polhemus & Polhemus (1988), and amplified by Sites and Polhemus (in press) for the state of Texas where the ranges of *P. biimpressus* and *P. femoratus* overlap, therefore these data are not repeated here.

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THE CHEWING LOUSE GENUS *AOTIELLA*
(PHTHIRAPTERA: GYROPIDAE) FROM SOUTH AMERICAN
NIGHT MONKEYS, *AOTUS* (PRIMATES: CEBIDAE)

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Abstract.—The single previously recognized species of *Aotiella* Eichler, *A. aotophilus* (Ewing), and a second species, *A. hershkovitzi* new species, are described and illustrated. The type host for the former is a red-necked night monkey, *Aotus azarai* (Humboldt), from Bolivia and Argentina, and for the latter a gray-necked night monkey, *A. trivirgatus* (Humboldt), from Venezuela. The host and louse distributions are discussed.

Key Words: Phthiraptera, Gyropidae, *Aotiella*, Cebidae, *Aotus*

The only previously recognized species of the chewing louse genus *Aotiella* Eichler (Phthiraptera: Amblycera: Gyropidae) is *A. aotophilus* (Ewing), which was described by Ewing (1924:25) as a *Tetragyropus* Ewing from a single immature specimen collected off a monkey "*Aotes boliviensis* . . . taken in Bolivia by W. E. Moore some time before 1859." Not only was this species based on a single individual thought by Ewing to be the "last nymph," but that specimen subsequently was determined to be only a second-instar nymph. Ewing justified the new species description from a nymph because of the uniqueness of its being from a primate and the certainty of its breeding on that host.

Subsequent collecting from night monkeys (genus *Aotus* Illiger) has confirmed that they are indeed hosts for this louse genus. Werneck (1936) presented a detailed description of both sexes and of nymphal stages of what he presumed to be *Gyropus aotophilus* based on specimens from *Aotus trivirgatus* (Humboldt) from Brazil. Werneck even sent Ewing a nymph to compare with

the holotype and Ewing replied that Werneck's lice were indeed *T.* (= *Gyropus*) *aotophilus*.

Eichler (1949) seized upon the uniqueness of this louse taxon and described the new genus *Aotiella* for it, although he almost certainly did not actually examine specimens. He was especially impressed with the characteristic chaetotaxy of the female and, no doubt, with the unusual primate host. Hopkins and Clay (1952) accepted the validity of the genus *Aotiella*, but erroneously listed *Gyropus* Nitzsch as the original genus instead of the correct one, *Tetragyropus*. Emerson and Price (1975) perpetuated the error of *Gyropus* as the original genus as given by Hopkins and Clay (1952). They did, however, provide excellent illustrations of both sexes of what they assumed to be *A. aotophilus* based on abundant material from seven specimens of *Aotus trivirgatus* captured in Venezuela.

All previous workers apparently had been so fixated on the existence of a single species of *Aotiella* on night monkeys of the genus

lotus that they failed to examine critically the available material. Had they done so, they would perhaps have found what we have—mainly, that there are two distinctly different species of *Aotiella* on these hosts, one which occurs south of the Amazon and one north of the Amazon. For this reason, we are herewith describing the adult of *Aotiella aotophilus* for the first time and naming and describing a second species of this genus.

In the following descriptions, all measurements are in millimeters. The scientific names of the hosts follow those of Hershkovitz (1983) and updates by Groves (1993). The holotype of the new species will be deposited in the U.S. National Museum of Natural History (Washington, D.C.) and paratypes will be located in the collections of that museum and those of the University of Minnesota (St. Paul) and Oklahoma State University (Stillwater). Acronyms designating museum collections where specimens of the host are deposited are as follows: AMNH = American Museum of Natural History, New York; USNM = U.S. National Museum of Natural History.

Aotiella aotophilus (Ewing 1924)

Figs. 1–5

Tetragyropus aotophilus Ewing 1924: 23.

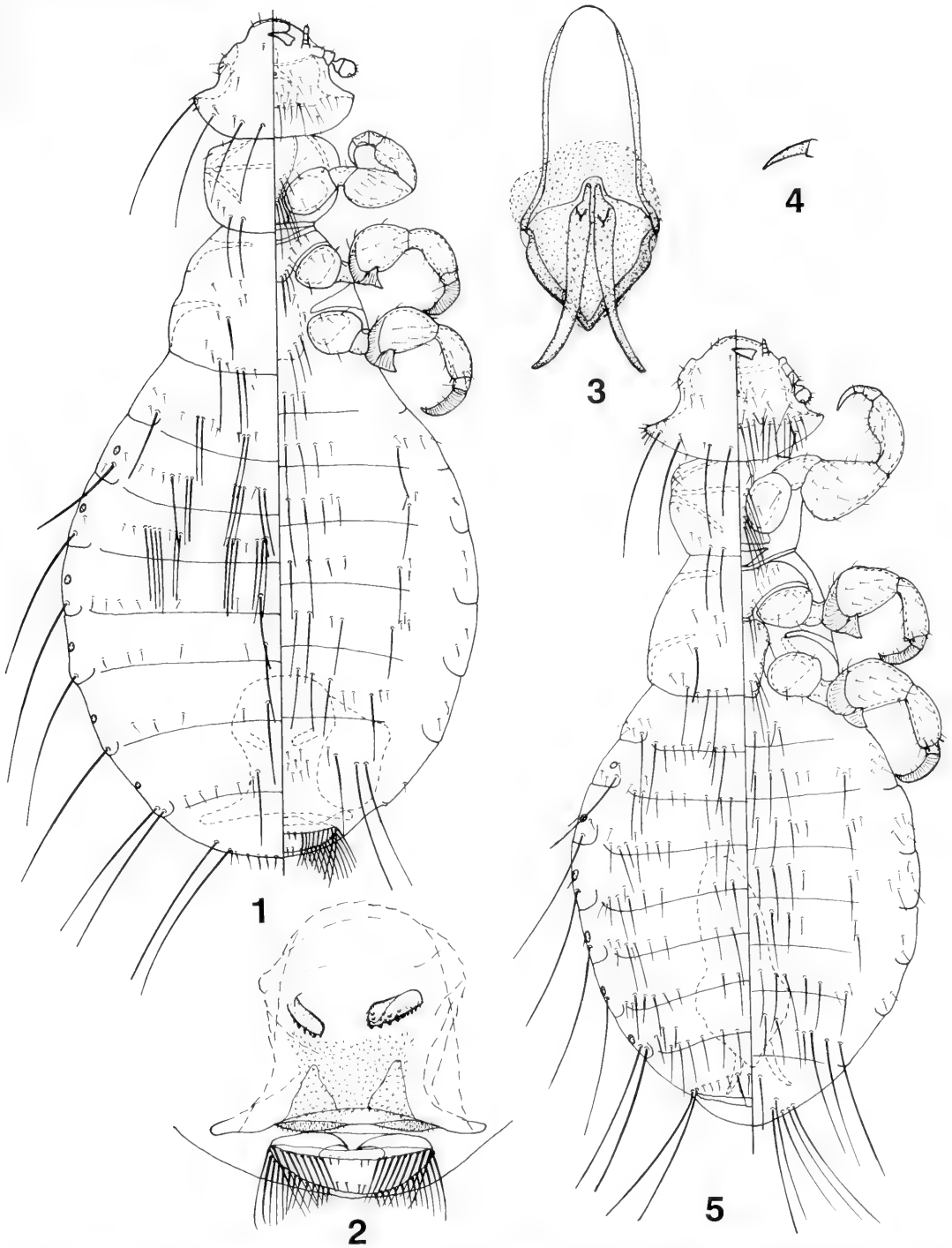
Type host: *Aotus boliviensis* Elliot = *A. azarai* (Humboldt).

Female.—As in Fig. 1. Head with dorsal temple having 8 long to very long setae; few minute to short dorsal setae, numerous ventral setae; head width, 0.39–0.41; head length, 0.28–0.31. Pronotum with 4 long setae posteriorly, no central setae; prosternal plate with 12 or so medium to long setae; prothorax width, 0.32–0.34. Pteronotum with 5–6 long posterior setae, 2 long median setae, and shorter setae as shown; mesosternal and metasternal plates with chaetotaxy as in Fig. 1; pteronotum width, 0.44–0.50. Legs with tarsus on I much smaller than those on II–III, with latter bearing re-

ceptacle on base of femur for insertion of tarsus. Abdomen with terga II–IV having clusters of long setae, with total number of long setae being: II, 4–7; III, 11–18; IV, 16–20. Terga V–VIII each with pair of median long setae. Total number of other setae on these segments: II, 5–14; III–IV, 5–10; V–VI, 7–12; VII, 6–8; VIII, 4–8. Pleura II–III each with single long seta, IV–VII each with single very long seta, and VIII with pair of very long setae, in addition to sparse short setae. Spiracles on segments III–VIII. Abdomen width at V, 1.01–1.05. Last segment dorsally with pair of very long setae on each side, row of short setae between them. Sternal setae, with lengths as shown: II, 7; III–IV, 12–18; V–VI, 11–15; VII, 14–16; VIII, 22–27. Anus (Fig. 2) ventrally with 5–10 longer setae on each side and 4 short median setae, dorsally with 8–14 longer setae on each side and 4 short median setae. Internal genital chamber structure as in Fig. 2, with evident spination on wall limited to posterior portion, as shown. Total body length, 2.06–2.15.

Male.—As in Fig. 5. Head and thorax much as for female. Tarsus I (Fig. 4) with smooth posterior margin. Head width, 0.40–0.41; head length, 0.26–0.29. Prothorax width, 0.29–0.33. Pterothorax width, 0.44–0.48. Abdominal terga with chaetotaxy of intermixed short to long setae: II, 11–17; III, 17–26; IV, 20–26; V–VIII, 14–22. Abdomen width at V, 0.81–0.85. Last tergum with 2 very long lateral setae on each side and row of 10–12 shorter setae between them. Sternal setae with lengths much as for female: II, 7–8; III, 12–15; IV, 15–16; V–VIII, 10–17. Last sternum with group of very long posterior setae on each side. Genitalia as in Fig. 3; parameres slender, gently curved outward; mesomere broadly tapered to point; sac without conspicuous larger spination; width, 0.19–0.22; length, 0.49–0.51. Total body length, 1.77–1.88.

Discussion.—This species is readily recognizable by the combination of only up to 20 long setae on each of female abdominal



Figs. 1-5. *Aotiella aotophilus*. 1, Female. 2, Female genital chamber and anus. 3, Male genitalia. 4, Male first tarsus. 5, Male.

terga III–IV (Fig. 1), shape and spination of the female genital chamber (Fig. 2), small size and features of the male genitalia (Fig. 3), male first tarsus with a smooth posterior margin (Fig. 4), and both sexes with only up to six long posterior setae on the pteronotum.

Since Ewing (1924) based the original description only on a single nymph and the adults described and illustrated by Werneck (1936) and Emerson and Price (1975) were based on what they mistakenly held to be *Aotiella aotophilus*, our description of *A. aotophilus* represents the first for adults of this species. Only the single species of *Aotus*, *A. azarai* (*A. boliviensis* is a junior synonym), occurs in Bolivia and there is no reason to suspect that Ewing's nymph was not from that host taxon.

Material examined.—Holotype, 2nd instar, ex *Aotus azarai* (USNM 3335), Bolivia: no specific locality. Additional material: 2 ♀, 3 ♂, ex *A. azarai* (AMNH 211460), Bolivia: Beni, Mamore River; 3 ♀, 2 ♂, ex *A. azarai*, Bolivia: no specific locality; 2 ♀, 2 ♂, ex *A. azarai* (Brit. Mus. 1976-263), Argentina: Formosa: Pirané and Grande Guardia.

***Aotiella hershkovitzi* Price and Timm,**

NEW SPECIES

Figs. 6–10

Type host: *Aotus trivirgatus* (Humboldt).

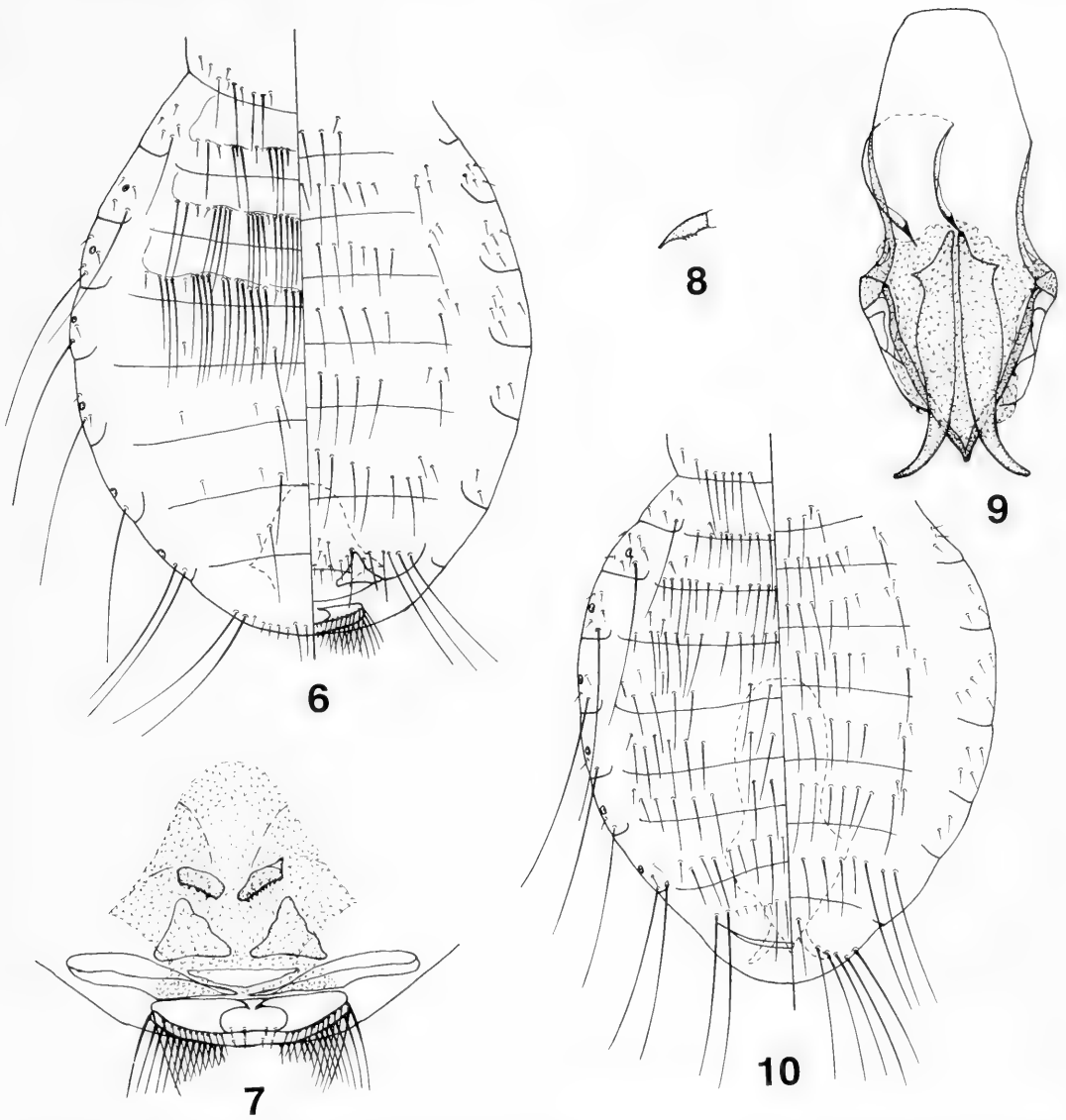
Female.—Head and thorax essentially as for *A. aotophilus* (Fig. 1). Head width, 0.41–0.44; head length, 0.28–0.32. Prothorax width, 0.32–0.38. Pteronotum with at least 8 long setae posteriorly, in addition to short setae; pteronotum width, 0.48–0.55. Abdomen (Fig. 6) close to that of *A. aotophilus*, except as follows. With more long setae on terga II–IV: II, 8–12; III, 30–39; IV, 33–47. Total of other shorter setae on these segments: II, 12–18; III–IV, 5–9; V–VI, 4–8; VII, 2–4; VIII, 2. Pleura III each with single very long seta. Abdomen width at V, 1.09–1.20. Sternal setae, with lengths as shown: II, 6–9; III–IV, 15–19; V–VI, 14–17; VII,

17–26; VIII, 25–37. Anus (Fig. 7) ventrally with 9–11 longer setae on each side and 4 short median setae, dorsally with 12–17 longer setae on each side and 4 short median setae. Internal genital chamber structure as in Fig. 7, with evident spination covering entire wall, as shown. Total body length, 2.09–2.25.

Male.—Head and thorax much as for *A. aotophilus* (Fig. 5). Tarsus I (Fig. 8) with serrated posterior margin. Head width, 0.45–0.47; head length, 0.28–0.31. Prothorax width, 0.35–0.43. Pterothorax width, 0.50–0.55. Abdomen as in Fig. 10. Terga with chaetotaxy of intermixed short to long setae: II, 19–23; III, 28–35; IV, 27–32; V–VIII, 15–20. Abdomen width at V, 0.94–1.04. Pleura II each with long to very long seta, III with very long seta. Last tergum with 2 very long lateral setae on each side and row of 11–17 short to long setae between them. Sternal setae with lengths as in Fig. 10: II, 8–9; III, 17–22; IV, 19–22; V–VIII, 14–21. Genitalia as in Fig. 9; parameres relatively broad, abruptly curved outward; mesomere narrowly tapered to point; sac with conspicuous pair of large spines; width, 0.27–0.31; length, 0.63–0.71. Total body length, 2.05–2.19.

Discussion.—This distinctive species is readily separable from *Aotiella aotophilus* by having at least 30 long setae on each of female abdominal terga III–IV (Fig. 6), a different shape and extensive spination of the female genital chamber (Fig. 7), the unique structure and considerably larger dimensions of the male genitalia (Fig. 9), the first male tarsus with a serrate posterior margin (Fig. 8), and both sexes with at least eight long posterior setae on the pteronotum.

Prior to our recognition and description of *Aotiella hershkovitzi*, only a single species of the genus had been recognized and it was believed to be widely distributed across all taxa of *Aotus*. In fact, this is likely what led Werneck (1936) and Emerson and Price (1975) to describe and illustrate improperly



Figs. 6–10. *Aotiella hershkovitzi*. 6, Female posterior pteronotum and abdomen. 7, Female genital chamber and anus. 8, Male first tarsus. 9, Male genitalia. 10, Male posterior pteronotum and abdomen.

identified lice as *A. aotophilus*. A large number of excellent characters separating these two louse species were overlooked by previous workers.

We have seen only a single female *Aotiella* from Brazil. We note its similarity to our Venezuelan type series and tentatively include it in the material examined for *A. hershkovitzi*, but, given the potential diver-

sity of the host taxa, we are reluctant to conclude that it is definitely conspecific with that species.

Material examined.—Holotype ♀, ex *Aotus trivirgatus*, Venezuela: Amazonas, Río Manapiare, San Juan, 155 m, 24 July 1967, Tuttle Team, #28550. Paratypes: 6 ♀, 2 ♂, same data as holotype; 18 ♀, 9 ♂, same, except 5 July 1967, #19989, 19990, or 19966;

. 2 ♂, same, except 12 July 1967, #26214;
 . 11 ♂, same, except Raya, 32 km SSE
 Puerto Ayacucho, 135 m, 11 Oct 1967,
 #31686; 2 ♂, same, except Yaracuy, Carabobo,
 19 km NW Urama, 525 m, 27 Oct
 1965, Peterson Team, #1998. Additional
 material: 1 ♀, ex *A. trivirgatus*, Brazil: Pará,
 1935, F. L. Werneck.

Etymology.—This species is named for Philip Hershkovitz, Curator Emeritus of Mammals, Field Museum of Natural History, Chicago, in recognition of his many contributions to Neotropical mammalogy. Phil has often created controversy when none existed previously, but he certainly has pushed our science forward and was correct in assessing that the night monkeys are much more complicated than was believed previously. His published contributions, flavored by his colorful writing style, and outstanding collections will keep generations of scientists busy.

Type species of *Aotiella*.—Eichler (1949: 11), in erecting the genus *Aotiella*, stated that it was “. . . monotypisch auf *Gyropus* (*Tetragyropus*) *aotophilus* Ewg. 1924 sensu Werneck 1936 . . . ab *Aotus trivirgatus*.” He did not indicate having seen any specimens, but likely acted solely on the basis of the description by Werneck (1936). Even though Eichler (1949) referred to the Werneck (1936) material as the type species of *Aotiella*, he did so only because this was the first description of adult specimens and no one suspected that they were anything other than true *A. aotophilus*. By emphasizing the monotypical nature of the new genus and by his belief that he was referring to *A. aotophilus*, we see no reason not to regard this species as the type species of *Aotiella*. This action is consistent with all citations in the literature and to do otherwise would needlessly confuse matters. If Eichler had any suspicion that it was anything other than *A. aotophilus*, he most certainly would have described the new species himself.

Host/louse discussion.—Night monkeys are the only cebid primates not naturally

susceptible to infection by malaria protozoans (*Plasmodium*), and, hence, are of great interest to medical researchers. Because of this, some aspects of their biology have received intense study, especially genetics, behavior, and blood biochemistry. However, there have been few reports of ectoparasites on free-ranging night monkeys, in part because they are nocturnal, secretive, and seldom observed in the wild, and now also because all populations are protected under international CITES conventions and treaties. Our discovery of a new species of chewing louse on night monkeys is of interest not only because it documents the species diversity of night monkey parasites, but also because it provides another independent line of evidence further supporting recent taxonomic changes within the genus *Aotus* that suggest the genus is more diverse than was realized previously.

Night monkeys are widely distributed in the Amazon Basin of South America, with one species also occurring in Central America in Panama and perhaps in Costa Rica (Hershkovitz 1983, Timm 1989). They can be quite common locally, although there are not many specimens in museum collections. Ecology and distribution of night monkeys are poorly known, in part because they are seldom observed clearly and are difficult to study. They are the only truly nocturnal Neotropical monkeys and they are strictly arboreal, foraging only in the canopy, rarely, if ever, coming to the ground.

Traditionally, most authors regarded all populations of night monkeys as the single widespread species *Aotus trivirgatus*. However, in a recent revision, Hershkovitz (1983) recognized nine allopatric species of *Aotus*, based on differences in chromosome numbers and in pelage coloration. Subsequently, a tenth species, *A. herskovitzi* Ramirez-Cerquera, has been described.

Hershkovitz (1983) divided the genus *Aotus* into two species groups, the gray-necked species, which occur primarily north of the Rio Amazonas, and the red-necked

species, which occur primarily south of the Rio Amazonas. He recognized four species within the gray-necked group: *A. brumbacki* Hershkovitz in eastern Colombia; *A. lemurinus* (I. Geoffroy) in Panama, Colombia, and Ecuador; *A. trivirgatus* in Venezuela and Brazil; and *A. vociferans* (Spix) in Colombia, Ecuador, and Brazil. He recognized five species within the red-necked group: *A. azarai* in Bolivia, Paraguay, and northern Argentina (see Groves 1993 for correction of Hershkovitz's original spelling), *A. infulatus* in southern Brazil; *A. miconax* Thomas in eastern Peru; *A. nancy-maeae* Hershkovitz (see Groves 1993 for correction of the original spelling) in eastern Peru; and *A. nigriceps* Dollman in western Brazil and adjacent Peru. *Aotus herskovitzi* is a member of the gray-necked species group and is known only from the type locality in eastern Colombia.

The distributions of the two known species of *Aotiella* are such that *A. aotophilus* is found on the red-necked night monkey species group in Bolivia and Argentina, and *A. herskovitzi* is on the gray-necked group in Venezuela and possibly Brazil. Whether these will ultimately prove to be the only species of *Aotiella* or whether other species exist must await additional collections of lice from other *Aotus*.

ACKNOWLEDGMENTS

We thank Oliver S. Flint, Jr., and Nancy Adams, U.S. National Museum of Natural History; John Chemsak, University of California, Berkeley; and Christopher H. C. Lyal, The Natural History Museum, for the generous loan of material that contributed

to the success of this paper. Our appreciation also goes to Hans-Peter Schultze and Marcus Vieira, University of Kansas, for their assistance in translating, respectively, selected passages of German and Portuguese literature. This study was partially supported by Project No. Min-17-015, Minnesota Agricultural Experiment Station, St. Paul, Minnesota 55108, and has been assigned Paper No. 21,179, Scientific Journal Series.

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A REVISION OF THE SHORE-FLY GENUS *RHYSOPHORA* CRESSON
(DIPTERA: EPHYDRIDAE)

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Abstract.—The New World genus *Rhysophora* Cresson, now placed in the tribe Discomyzini (subfamily Discomyzinae), is revised. Four species, including *R. griseola* (type locality: Costa Rica. Guanacaste: Colorado), which is newly described, are included. The phylogenetic relationships of the species of *Rhysophora* are reanalyzed, and brief comments are provided on the relationships of the genus within the tribe. A key to the genera of the tribe is included.

Key Words: Diptera, Ephydridae, shore flies, *Rhysophora*, phylogeny

The subfamily Discomyzinae, presently comprising two tribes, 22 genera, and nearly 200 species (Zatwarnicki 1992, Mathis and Zatwarnicki, in preparation), is one of the smaller subfamilies of shore flies. One of the tribes, Discomyzini, with half of the genera (11) but only one-fourth of the species (ca. 50), includes the genus *Rhysophora* Cresson, the subject of this revision.

Cresson (1924) described *Rhysophora* as a monotypic genus with *R. robusta* Cresson as its type species. Cresson (1946) later transferred two previously described species, *Psilopa umbrosa* Loew and *P. caeruleiventris* Loew, to *Rhysophora*. Mathis and Wirth (1977), however, placed the latter two species in *Nesopsilopa* Mathis and Wirth, which is now recognized as a subgenus of *Guttipsilopa* Wirth (Mathis and Zatwarnicki 1990). Since the original description of *Rhysophora*, most references to the genus have been part of generalized studies, such as keys to genera (Cresson 1942, Sturtevant and Wheeler 1954, Wirth and Stone 1956) or regional catalogs (Wirth 1965, 1968). An exception is Mathis' (1977) revision of the genus, which included two new species, *R. ardeoceras* and *R. liropus*, and provided the

first phylogeny for the species. Mathis' phylogenetic analysis resulted in two basal lineages that were recognized as species groups: the *ardeoceras* group (*R. ardeoceras*) and the *robusta* group (*R. robusta* and *R. liropus*) as sister groups. A sister group to *Rhysophora* was not identified.

The phylogenetic relationships *Rhysophora* has with related genera within Discomyzini remain largely unresolved, although Zatwarnicki (in litt.) is now investigating them. Previously, Zatwarnicki (1992) accorded subfamilial status to Discomyzinae and reconstituted the two included tribes with *Rhysophora* and 10 other genera being moved from Psilopini to Discomyzini.

Information on the natural history and distribution of *Rhysophora* is meager. Adults are collected infrequently, resulting in a paucity of specimens and locality records. Some species are associated with plants of the family Pontederiaceae, perhaps as herbivores. Virtually nothing is known about the larval stages, behavior, or life history of *Rhysophora*. The species of *Rhysophora* are known thus far only from the New World.

The purpose of this study is to revise the

species, including the description of a new species, and to reanalyze the phylogeny of the species. We also discuss, albeit briefly, the position of *Rhysophora* within the tribe Discomyzini.

Methods.—The descriptive terminology, with the exceptions noted in Mathis (1986) and below, follows that published in the *Manual of Nearctic Diptera* (McAlpine 1981). The species descriptions are composite and not based solely on the holotypes. We have discovered or reinterpreted a majority of the characters used in this study, especially those from the male post-abdomen, and for that reason we are providing descriptions of all species. Four head and two venational ratios used in the descriptions are defined below (all ratios are averages of three specimens (the largest, smallest, and one other), except *R. ardeoceras* for which two specimens were measured):

1. Frons width-to-length ratio is the frons width divided by the frons length. The length is measured from the anterior margin of the frons to the posterior margin of the posterior ocelli. Width is measured at the level of the anterior ocellus.
2. Face width-to-height ratio is the narrowest width between the eyes divided by the height.
3. Gena-to-Eye ratio is the genal height measured at the maximum eye height divided by the eye height. In previous publications, this ratio was designated as the “eye-to-cheek ratio.”
4. Eye width-to-height ratio is the eye width divided by the eye height, where both measurements are the longest distances taken with the eye oriented laterally.
5. Costal vein ratio is the straight line distance between the apices of R_{2+3} and R_{4+5} divided by the distance between the apices of R_1 and R_{2+3} .
6. M vein ratio is the straight line distance along M between crossvein dm-cu and

r-m divided by the distance apicad of crossvein dm-cu.

The phylogenetic analysis was performed with the assistance of Hennig86 (Farris 1988), a computerized algorithm that produces cladograms by parsimony. Before analysis, character data were arranged in transformation series and then polarized, primarily using outgroup procedures.

Terminology for structures of the male terminalia are provided directly on the illustrations of *R. ardeoceras* and *R. griseola* (Figs. 22–25, 30–33). Note that the term “postgonite,” as used in Mathis (1993), is changed to “clasper,” as in Zatwarnicki (1992) and Mathis (1994). This structure is part of the surstylur complex. The terminology is not repeated for comparable illustrations of other species.

Although most specimens for this study, including the primary types, are in the National Museum of Natural History (USNM), additional specimens were borrowed and studied from the Academy of Natural Sciences of Philadelphia (ANSP), Pennsylvania (Dr. Jon K. Gelhaus, Mr. Don Azuma); American Museum of Natural History (AMNH), New York, New York (Dr. David A. Grimaldi); Canadian National Collection (CNC), Ottawa, Canada (Dr. J. E. O’Hara, Mr. Bruce Cooper); University of Guelph (GUE), Guelph, Ontario, Canada (Dr. S. L. Marshall).

ANNOTATED KEY TO GENERA OF THE TRIBE DISCOMYZINI

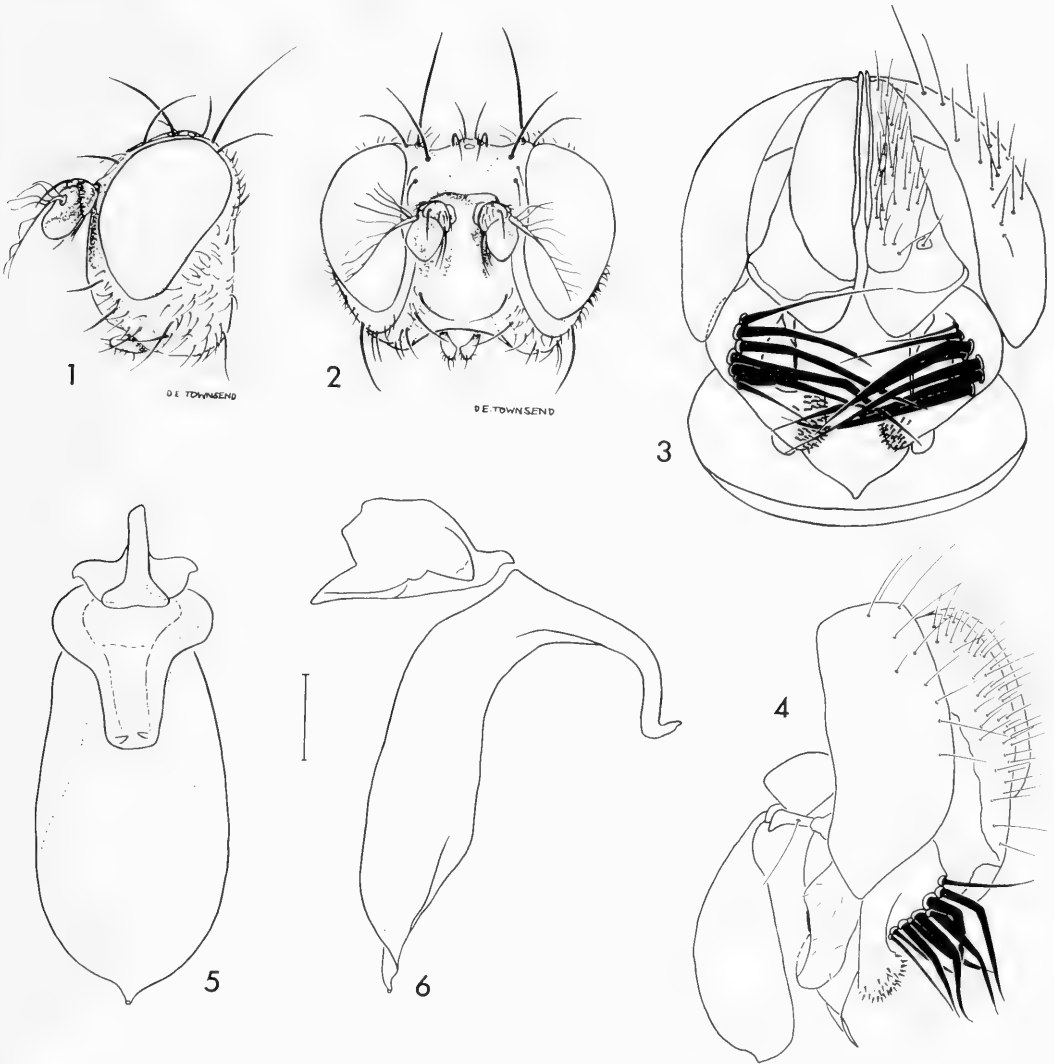
1. Wing spotted, usually white or hyaline spots on a dark background 2
- Wing hyaline or with anterior margin darkened but not spotted 5
2. Supra-alar setae absent
 *Trypetomima* de Meijere
 [4 species; Old World (Australasian/Oceanian and Oriental)]
- Supra-alar seta present, size of seta moderate to well developed 3
3. Facial setae 2, dorsal seta well developed; arista bearing 7–8 dorsal rays; tibia or tarsus generally lighter colored than femur 4

- Facial setae 4, all well developed; arista bearing 14–16 dorsal rays; legs unicolorous, usually dark *Actocetor* Becker
[11 species; Old World (Afrotropical and Oriental)]
4. Vein R_{2+3} basad of crossvein r-m bearing 3–4 black setulae; tibiae yellowish white with brown bands *Eremomusca* Mathis
[1 species; *E. nussbaumi* Mathis 1985; Old World (Palearctic); Mathis 1985]
– Vein R_{2+3} basad of crossvein r-m bare; tibiae blackish brown, tarsi yellow with apical tarsomere dark
..... *Guttiopilopa* Wirth (subgenus *Guttiopilopa*)
[1 species; *G. (G.) haydeni* Wirth 1956; New World (Neotropical)]
5. Alula well developed 6
– Alula weakly developed, very narrow 9
6. Intrafrontal seta present; fronto-orbital setae 4 (anterior 2 setae proclinate, 3rd laterocline, 4th laterorecline) ... *Paratissa* Coquillett
[4 species; Old and New Worlds (Afrotropical, Australasian/Oceanian, and Neotropical); Mathis 1993]
– Intrafrontal seta absent; fronto-orbital setae 2–3 7
7. Arista bearing 9–10 dorsal branches; supra-alar seta well developed, length subequal to postalar seta *Rhysophora* Cresson
[4 species; New World (Nearctic and Neotropical)]
– Arista bearing 3–5 dorsal branches, rarely 6; supra-alar seta moderately well developed, length about half postalar seta 8
8. Vein R_{2+3} basad of crossvein r-m bearing 3–4 black setulae; legs unicolorous; maxillary palpus brown *Hostis* Cresson
[1 species; *H. guamensis* Cresson 1945; Old World (Afrotropical and Australasian/Oceanian); Mathis 1993]
– Vein R_{2+3} basad of crossvein r-m bare; legs dark with yellow tarsus, apical tarsomere dark; maxillary palpus usually pale colored
..... *Guttiopilopa* Wirth (subgenus *Nesopsilopa* Mathis and Wirth)
[5 species; New World (Nearctic and Neotropical); Mathis and Wirth 1977]
9. Supra-alar seta present; prescutellar acrostichal seta absent; presutural seta minute and poorly developed; katapisternal seta 1; facial setae 3 pairs, all small and poorly developed *Discomyza* Meigen
[9 species; Old and New Worlds (Afrotropical, Australasian/Oceanian, Nearctic, and Palearctic)]
– Supra-alar seta greatly reduced or absent; prescutellar acrostichal seta present; presutural seta well developed; katapisternal setae 2, dorsal seta larger; facial setae 3 pairs, dorsal pair cruciate, ventral pair poorly developed 10
10. Legs dark with yellow tarsi, apical tarsomere dark; alula narrow and bearing long, fine setae along margin *Mimapsilopa* Cresson
[5 species; New World (Nearctic and Neotropical); Lizarralde de Grosso 1982]
– Legs unicolorous; alula reduced or absent .. 11
11. Arista bearing 6–7 dorsal rays; anepisternal setae 2, ventral seta slightly less than twice length of dorsal seta; femur setulose, setae in rows *Helaeomyia* Cresson
[2 species; New World (Nearctic and Neotropical); Lizarralde de Grosso 1982]
– Arista bearing 8–10 dorsal rays; anepisternal setae 2, ventral seta more than twice the length of the dorsal seta; femur bearing 2–3 prominent setae near the apex *Clasiopella* Hendel
[2 species; Old World (Afrotropical, Australasian/Oceanian, Oriental); 1 species introduced to New World (Nearctic and Neotropical); Mathis 1994]

Genus *Rhysophora* Cresson

Rhysophora Cresson, 1924: 159. Type species: *Rhysophora robusta* Cresson, 1924, monotypy. — Cresson, 1942: 105, 123 [key, review]. — Sturtevant and Wheeler, 1954: 160 [key]. — Wirth and Stone, 1956: 465 [key]. — Wirth, 1965: 743 [Nearctic catalog]. — Mathis, 1977: 921–945 [revision].

Diagnosis. — Specimens of *Rhysophora* are similar to those of *Guttiopilopa* and other genera of Discomyzini but can be differentiated by the following combination of characters: outer vertical seta usually half or less length of inner seta, but never equal; proclinate fronto-orbital setae 1–2, inserted anteriorly of median, reclinate seta; intrafrontal setae lacking; arista bearing 8–15 dorsal rays; face generally with prominent antennal grooves (antennal grooves in *R. ardeoceras* and *R. griseola* are very shallow); supra-alar seta well developed; wing generally hyaline or faintly infuscate; vein R_{2+3} lacking setulae basad of crossvein r-m; alula well developed; hind basitarsus of male slightly swollen, with a ventral groove that bears a row of angularly recurved, pale setae.



Figs. 1-6. *Rhysophora liropus*. 1, Head, lateral view. 2, Same, anterior view. 3, Male genitalia, posterior view. 4, Same, lateral view. 5, Aedeagus and aedeagal apodeme, dorsal view. 6, Same, lateral view. Scale = 0.1 mm.

Description.—Moderately small to moderately large shore flies, length 2.4 to 4.4 mm; usually blackish brown.

Head: Frons wider than long; mesofrons generally triangular, with base towards vertex and anterior angle at ptilinal suture; triangle shape and size variable among species; fronto-orbits and mesofrons concolorous; ocellar triangle slightly raised with ocelli forming equilateral or isosceles tri-

angle; pseudopostocellar setae inserted close together just posteromedial of posterior ocelli; ocellar setae proclinate, well developed, inserted wide apart just posterolaterad of anterior ocellus; ocellar setae greater than twice length of pseudopostocellar setae; 2 poorly developed, minute setulae inserted anteromedial of rear ocelli; intrafrontal setae lacking; inner vertical seta large, usually twice or more length of outer seta;

rostocular setulae minute, inserted posterior of either vertical seta, extended along eye posterior margin; fronto-orbital setae 2–3, posterior seta reclinate, 1–2 proclinate setae inserted anterior of reclinate seta; median fronto-orbital seta often reduced or missing. Antenna oriented anterolaterad; pedicel sparsely setulose, bearing 4–6 smaller setae along ventral edge with 1 seta long, prominent; arista inserted on dorsal base of velvety appearing, macropubescent flagellomere 1. Face higher than wide; presence of antennal grooves and facial carina variable; face usually convex in profile, bearing 2–4 inclinate facial setae along lateral margin parallelling parafacials; facial setae inserted just below midfacial height; genal seta 1, prominent, inclinate; gena and postgena setulose; occipital setae small, running along occiput. Eye higher than wide; gena-to-eye ratio less than 0.25. Mouthparts small; maxillary palpus sparsely setulose.

Thorax: Generally unicolorous or lighter colored laterally; scutellum parabolic, slightly convex with disc setulose. Chaetotaxy as follows: prescutellar acrostichal seta inserted slightly anterior of larger, laterally displaced dorsocentral seta; postalar seta large, subequal in length to dorsocentral seta; supra-alar seta 1; apical scutellar setae 1; subapical scutellar setae weakly developed; basal scutellar seta 1; notopleural setae 2, both inserted at same level just dorsad of ventral notopleural crease; postpronotal seta 1; anepisternal setae along posterior margin 2, ventral seta longer; katepisternum lightly setulose, bearing 1 large katepisternal seta, usually curved upward. Legs setulose with small setae; mid femur bearing 1 prominent spinelike seta on posteroventral margin, located at apical $\frac{1}{3}$; tibia bearing 1 prominent spine at apex, especially prominent on mid leg; hind basitarsomere of male slightly swollen, bearing a row of distinctive, pale, recurved setae arising from ventral groove; coxa with 1 larger seta along anterior margin and a whorl of small setae, prominent on mid coxa. Wings usually hyaline to yellow-

ish brown; halter yellowish white; costal vein ratio variable; M vein ratio usually close to 1; costal margin near basicosta and tegula bearing 2 larger setae; subcostal margin lined with stout, black setae and indented at vein R_1 ; smaller, black setae along costal margin ended at vein R_{4+5} ; alula very narrow; vein R_{2+3} basad of crossvein r-m lacking setulae.

Abdomen: Usually dark brown to black, setulose; posterior tergites slightly larger; posterior and lateral margins of tergites usually bearing larger setae; 4th and 5th tergites sometimes bearing semierect, larger setae. Male terminalia: symmetrical; epandrium broadly U-shaped in posterior view, usually becoming wider subventrally in lateral view; cercus with ventral margin gradually merged with membrane; surstylus variable, greatly reduced or prominent, variously shaped depending on species; clasper with 1 or 2 processes, each longer than wide; pregonite small (could be the fused pre- and postgonites), usually closely associated with hypandrium, bearing 1–2 long setulae; aedeagal apodeme L-shaped to triangular in lateral view; aedeagus variously shaped, depending on species; hypandrium concave or very shallowly depressed, nearly flat.

Distribution.—The genus is known thus far only from the New World, with greater diversity in the tropics.

Natural history.—Two species, *R. liropus* and *R. robusta*, are associated with plants of the family Pontederiaceae, more commonly known as pickerel weed (species of the genus *Pontederia* L.) and anchored water hyacinth (species of the genus *Eichhornia* K. Kunth). These often abundant plants are sometimes considered weeds, and the phytophagous species of *Rhysophora* may offer some measure of biological control. Adult flies are often collected by sweeping species of Pontederiaceae.

Discussion.—Although *Rhysophora* is well characterized and its monophyly reasonably well established, we remain relatively ignorant about its phylogenetic relationships within the tribe Discomyzini. This

tribe, which was only recently recharacterized, has received inadequate attention from the standpoint of phylogenetics, and the available information on relationships is limited to recent revisionary studies that are of limited scope and that do not impinge directly on *Rhysophora* (Mathis 1993, 1994). Moreover, one of the only synapomorphies that may indicate a sister group for *Rhysophora* is ambiguous. The species of *Rhysophora*, like *Guttiipsilopa*, lack setulae on the dorsum of vein R_{2+3} . This is apparently a secondary reversal of a synapomorphy for the tribe (Zatwarnicki 1992). Although this character may indicate a sister-group relationship between these two genera, the loss could also have arisen independently in each genus. Zatwarnicki (personal communication) is now investigating these and other issues germane to the phylogeny of Disco-myzini and Psilopini, and for the present we defer to his study and analysis. We did consult with Zatwarnicki (personal communication), who suggested, albeit provisionally, that we use *Helaeomyia* as an outgroup.

Although the evidence for the monophyly of *Rhysophora* is rather compelling (see "Phylogenetic Considerations"), the included species, with the exception of *R. liropus* and *R. robusta*, are comparatively heterogeneous in external features. Casual observation could easily lead one to wonder if the species are indeed closely related, especially *R. ardeoceras*, which has many pleiomorphic external features and is quite similar to other taxa in the tribe.

KEY TO SPECIES OF *RHYSOPHORA* CRESSON

- 1. Antennal grooves and facial carina weakly differentiated, grooves very shallowly impressed; ventral margin of face nearly flat; face height-to-width ratio 0.64 to 0.70; mid femur bearing 2-4 setae, including 1 prominent spinelike seta on posteroventral margin near apical 1/3; clasper a single process 2
- Antennal grooves and facial carina between antenna distinct; ventral margin of face broadly and deeply emarginate; face height-to-width

- ratio 0.75 to 0.81; mid femur bearing 1 prominent spinelike setae on posteroventral margin about apical 1/3; clasper with 2 fingerlike processes, posterior process of clasper bearing a row of long, conspicuous setae along posterior margin 3
- 2. General coloration blackish brown, without whitish microtomentum; pseudopostocellar setae well developed; flagellomere 1 longer than wide, pointed apically; presutural seta present; costal vein ratio 0.58 to 0.65; surstylus small, a narrow, bandlike, transverse process *R. ardeoceras* Mathis
- General coloration blackish brown with whitish microtomentum; pseudopostocellar setae greatly reduced or absent; flagellomere 1 bluntly rounded; presutural seta absent; costal vein ratio 0.31 to 0.35; surstylus large, conspicuous in lateral view as a bootlike process *R. griseola*, new species
- 3. General coloration black; antennal grooves very deep and distinct; ventral portion of face rugose; flagellomere 1 black; gena-to-eye ratio 0.09 to 0.11; color of tarsi sexually dimorphic: ♂ tarsi black; ♀ mid and hind tarsi yellow, fore tarsus blackish *R. robusta* Cresson
- General coloration grayish tan; antennal grooves less well defined; ventral margin of face not rugose; flagellomere 1 yellowish orange; gena-to-eye ratio 0.20 to 0.21; tarsi of ♂ and ♀ concolorous, yellowish brown with apical tarsomere black *R. liropus* Mathis

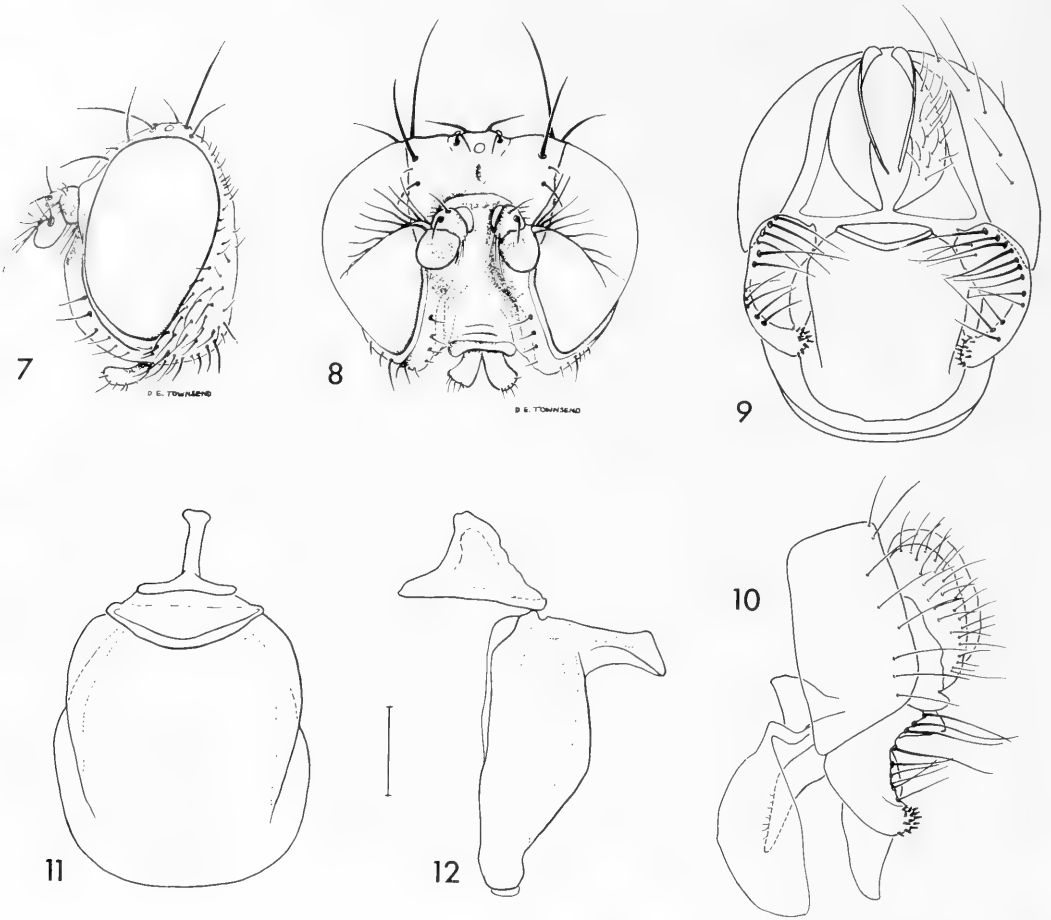
Rhysophora liropus Mathis
Figs. 1-6, 26

Rhysophora liropus Mathis, 1977: 931 [Argentina. Buenos Aires: Campana; HT ♂, USNM (75359)].

Diagnosis.—This species is closely related to *R. robusta* but can be distinguished by its generally grayish tan coloration; yellowish orange flagellomere 1; relatively smooth ventral margin of face, not rugose; wide gena (gena-to-eye ratio about 0.20); tarsi of ♂ and ♀ yellowish brown with apical tarsomere black.

Description.—Generally light gray to tan; medium-sized to moderately large sized shore flies, length 3.6-4.2 mm.

Head (Figs. 1-2): Frons width-to-length ratio 0.64-0.66; mesofrons rust brown, microtomentose, forming a lighter, raised pa-



Figs. 7-12. *Rhyssophora robusta*. 7, Head, lateral view. 8, Same, anterior view. 9, Male genitalia, posterior view. 10, Same, lateral view. 11, Aedeagus and aedeagal apodeme dorsal view. 12, Same, lateral view. Scale = 0.1 mm.

rabola with bluntly arched apex dorsal to parabolic ptilinal suture; frons between 2 raised portions slightly darker, depressed; inner vertical seta inserted close to outer seta, length of inner seta twice or more that of reduced outer seta; fronto-orbital plate narrow, slightly raised, wider at insertions of fronto-orbital setae; fronto-orbital setae 3; reclinate dorsal fronto-orbital seta approximately same length as ocellar setae; median seta slightly displaced laterally, proclinate and poorly developed; ventral fronto-orbital seta proclinate and twice length of median seta. Pedicel same color as frons but darker brown at base; pedicel bearing 2

setae, 1 proclinate spinelike seta on anterodorsal edge and 1 ventral seta slightly larger and better developed; flagellomere 1 yellowish orange with darker apex; flagellomere 1 short, subequal to combined length of scape and pedicel. Face width-to-height ratio 0.79-0.81; face golden gray and velvety; facial carina distinct; face emarginate and arched along ventral margin; lunule recedes inward to ptilinal suture at an angle; antennal grooves prominent but not deep; facial carina broad, not clearly defined; dorsal portion of face between antenna convex; face convex ventrally; parafacial crease clearly defined; facial setae 2-3, with 3-4

smaller setulae; minute setulae running along lateral margin of face parallel to parafacial; eye width-to-height ratio 0.71–0.73; gena-to-eye ratio 0.20–0.21; maxillary palpus brown, lighter ventrally.

Thorax: Greenish gray; dorsum with 4 dark brown lines faded anterior of transverse suture; 1 presutural seta; anepisternal setae 2; ventral seta twice as long as dorsal seta, both setae oriented slightly away from thorax. Femora and tibiae greenish gray, sometimes dark brown apically; tarsi light brown to yellowish with apical tarsomere darker brown to black; fore femur bearing 2–4 rows of long, fine setae on posterior margin. Wing brownish yellow; anterior margin relatively straight; costal vein ratio 0.61–0.63; M vein ratio 0.96–1.0; subcostal margin posterior to vein R₁ bearing 1 prominent seta; vein CuA₁ ends before fusing with margin. Halter brownish yellow.

Abdomen: Grayish green to grayish brown; anterior portion of tergites 3–5 brownish; 4th sternite of male completely sclerotized, lacking a membranous center. Male terminalia (Figs. 36) as follows: epandrium in lateral view becoming slightly wider ventrally with ventral margin broadly and bluntly rounded; cercus relatively long, occupying most of height of cercal cavity; surstylus greatly reduced, as a horizontal, narrow, bandlike process just ventrad of ventral margin of cerci; clasper well developed, deeply bifurcate a 2 fingerlike processes; posterior process of clasper (Figs. 3–4) narrowed medially, with linear dorsal lobe and spatulate ventral lobe, dorsal lobe bearing 8–10 robust, long setae along posterior margin, ventral lobe bearing numerous spine-like, short setae; anterior process of clasper (Fig. 4) nearly straight, relatively wide, with sub-basal enlargement on anterior margin, apex bluntly rounded, bearing numerous short setulae on anterior surface; aedeagal apodeme (Figs. 5–6) with extended keel rounded in lateral view; aedeagus (Figs. 5–6) about twice as long as wide, L-shaped in lateral view, with short, narrow, postero-

dorsal arm, larger arm narrowly rectangular in posterior view with apical margin shallowly mucronate; hypandrium concave, broadly rounded, wider than long, shallowly and narrowly emarginate at juncture with aedeagal apodeme.

Specimens examined.—ARGENTINA. Buenos Aires: Campana, Frente all astillero (on *Pontederia* as pupa), A-361, Nov 5 1973 (1 ♂; USNM); Dique Luján: Pupas de Dique Lujan (*Eichhornia azurea*), Acc. A-358c, 6 Nov 1973 (1 ♀; USNM).

Distribution (Fig. 26).—Neotropical: Argentina. Buenos Aires Province. This species is only known from the type series.

Natural history.—The allotype female was collected from anchored water hyacinth (*Eichhornia azurea* (Sw.) Kunth), and H. A. Cordo (in litt.) reared this species from a species of *Pontederia* in Argentina.

Rhysophora robusta Cresson

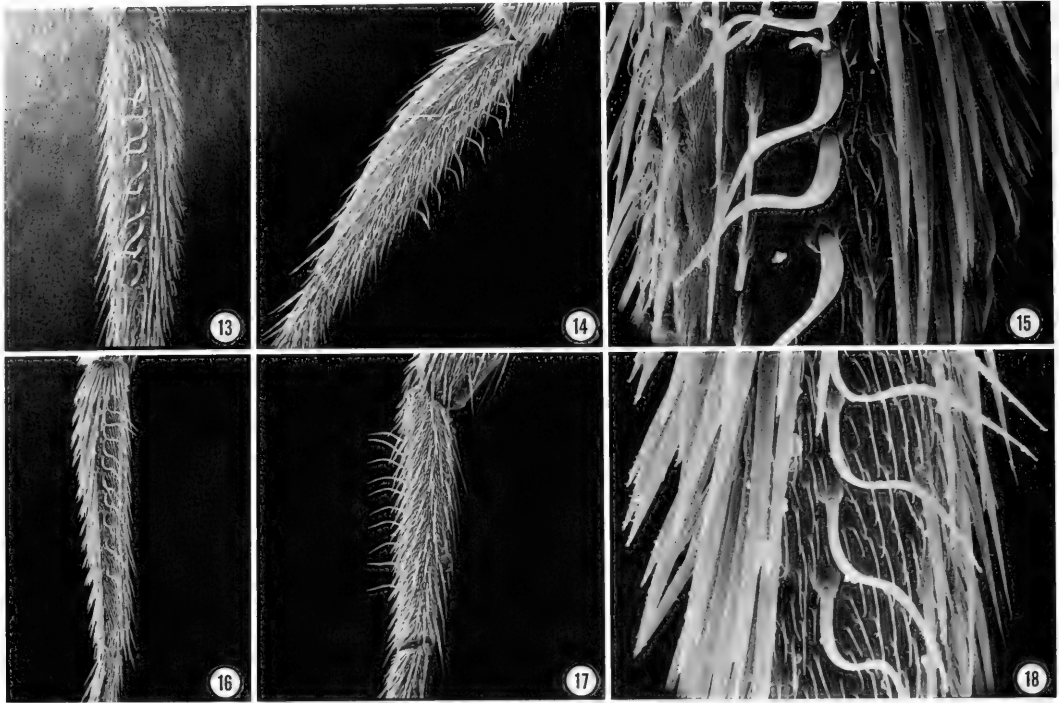
Figs. 7–15, 19

Rhysophora robusta Cresson, 1924: 159 [USA. Virginia: Fairfax Co., Dyke; HT ♂, USNM (56453)]; 1942: 123 [review].—Wirth, 1965: 743 [Nearctic catalog].—Mathis, 1977: 927–931 [revision].

Discocerina magna Coquillett in Johnson, 1910: 806 [nomen nudum].—Wirth, 1965: 743 [synonymy].

Diagnosis.—This species is closely related to *R. liropus* but can be differentiated by its generally black coloration, including flagellomere 1; rugose ventral portion of the face; short gena (gena-to-eye ratio about 0.10); and coloration of tarsi sexually dimorphic: ♂ black, ♀ with mid and hind legs yellow, foreleg black.

Description.—Generally black to brownish black; moderately small to moderately large shore flies, length 2.6–4.4 mm. Head (Figs. 7–8): Frons width-to-length ratio 0.48–0.59; frons black and indented ventrally; mesofrontal triangle lightly microtomentose with apex of triangle dorsad of ptilinal suture, ventral portion of triangle bearing a



Figs. 13–18. Scanning electron micrographs of *Rhysophora robusta* and *R. ardeoceras*. 13, Hind basitarsus, ventral view. 14, Hind basitarsus, lateral view. 15, Hind basitarsus, enlargement of ventral view. *R. ardeoceras*: 16, Hind basitarsus, ventral view. 17, Hind basitarsus, lateral view. 18, Hind basitarsus, enlargement of ventral view.

slight indent; parafrons velvety, minutely microtomentose; pseudopostocellar seta well developed; inner vertical seta inserted close to outer seta, length of inner seta twice or more that of reduced outer seta; fronto-orbital plate narrow, slightly raised, wider at insertions of fronto-orbital setae; fronto-orbital setae 3, all inserted close together; large reclinate fronto-orbital seta inserted dorsally, about same length as outer vertical seta; proclinate fronto-orbital setae as large as pseudopostocellar seta; median fronto-orbital seta proclinate, often reduced or very minute; ventral seta proclinate. Pedicel black, bearing 2 prominent, spinelike, subequal setae on dorsal portion; posterior seta lateroclininate, anterior seta proclinate; arista bearing 9–10 long, dorsal rays; flagellomere 1 bluntly rounded at apex; flagellomere 1 as long as of slightly smaller than combined

length of scape and pedicel. Face width-to-height ratio 0.75–0.81; face black, similar to mesofrontal triangle; facial carina distinct; ventral margin of face broadly emarginate, arched and strongly rugose; lunule recedes inward almost horizontally to ptilinal suture; antennal grooves deep with a prominent, raised facial carina; face convex and velvety dorsal to facial carina; black parafacial crease divides velvety whitish parafacial from face; facial setae 4, inserted along lateral margin; 2–3 smaller, facial setae inserted anteriorly to 4 well-developed, inclinate facial setae. Eye width-to-height ratio 0.65–0.71; gena-to-eye ratio 0.09–0.11; maxillary palpus black.

Thorax: Generally black, unicolorous; presutural seta; anepisternal setae 2; dorsal seta less than $\frac{1}{2}$ length of ventral seta, 2–4 smaller setae inserted between and near these

2 seta. Legs black, concolorous; female mid and hind tarsi yellowish, with mid tarsus often brownish yellow; apical tarsomeres 1–3 of female blackish; male mid and hind tarsus black, sometimes lighter ventrally. Wings yellowish brown but darker dorsally; anterior margin relatively straight; costal vein ratio 0.58–0.62; M vein ratio 0.82–0.96; 1 stout spine along subcostal margin posterior to vein R_1 . Halter yellow.

Abdomen: Generally black, subshiny; 4th and 5th tergites lacking longer, dorso-oblique setae along posterior margin; 4th sternite of male completely sclerotized, lacking a membranous center. Male terminalia (Figs. 9–12) as follows: epandrium in lateral view becoming slightly wider ventrally with ventral margin broadly and bluntly rounded; cercus relatively long, occupying most of height of cercal cavity; surstylus greatly reduced, as a horizontal, narrow, bandlike process just ventrad of ventral margin of cerci; clasper well developed, deeply bifurcate as 2 fingerlike processes; posterior process of clasper (Figs. 9–10) somewhat L-shaped, anterior margin angulate in lateral view, posterior margin concave, rounded in lateral view, bearing numerous, long setae in row along concave, posterior margin, ventral apex broadly rounded, bearing numerous, short, spine-like setae apically; anterior process of clasper (Fig. 10) slightly angulate to curved and tapered gradually to apex in lateral view, in posterior view digitiform, broadly rounded, parallel sided, bearing numerous, short setulae along anterior surface; aedeagal apodeme (Figs. 11–12) triangular in lateral view; aedeagus (Figs. 11–12) longer than wide, L-shaped in lateral view, with posterodorsal arm shorter, roundly rectangular in posterior view with apical margin shallowly and broadly rounded; hypandrium concave, broadly rounded, wider than long, shallowly and widely emarginate at juncture with aedeagal apodeme.

Specimens examined.—CANADA. Ontario: Algonquin Park, 28 Jul, J. Mc-

Dunnough (3 ♂, 3 ♀; CNC, ANSP); Eagle Lake (*Pontederia*), 21 Jul 1976, S. L. Miller (1 ♂; GUE); Elgin, Hart Creek (*Pontederia*), 14–21 Jul 1977, S. L. Miller (1 ♂, 4 ♀; GUE); Lake Opinicon (*Pontederia*), 26 Jun 1977, S. L. Miller (1 ♂; QUE); Ottawa, 1 Jul 1958, A. L. Melander (4 ♂; ANSP, USNM); Sparrow Lake (*Pontederia*), 19 Jul 1976, S. L. Miller (1 ♂; GUE). Quebec: Lac Bernard, 7 Aug 1938, G. E. Shewell (1 ♂, 1 ♀; CNC); Perkins Mills, 14 Aug 1938, G. E. Shewell (6 ♂, 3 ♀; CNC); St. Pierre de Wakefield (on flowers of *Pontederia cordata* L.), 28 Jul 1961, J. R. Vockeroth (8 ♂, 10 ♀; CNC, USNM). UNITED STATES. Connecticut: Fairfield Co., Redding, 16–23 Jul 1930, 1932, A. L. Melander (4 ♂, 4 ♀; ANSP, USNM). District of Columbia: Anolston Island (Theodore Roosevelt Island), Laittle River (flowers of *Pontederia cordata*), 15 Jul 1916, H. L. Viereck (1 ♀; USNM). Florida: Dade Co., Royal Palm Park, 12–18 Apr 1923 (1 ♂; AMNH). Highlands Co., Archbold Biological Station (8 km W), 15 Apr 1989, W. & D. Mathis (11 ♂, 10 ♀; USNM); Highlands Hammock State Park, 20 Mar 1954, H. V. Weems, Jr. (1 ♀; USNM); Venus, 4 May 1961, H. V. Weems, (1 ♀; USNM). Marion Co., 10 May 1956, H. V. Weems Jr. (1 ♀; USNM). Putnam Co., Crescent City, 20 Apr 1908, VanDuzee (1 ♀; AMNH). Maine: Hancock Co., Bar Harbor, 5 Jul 1930, C. W. Johnson (1 ♂; USNM). Maryland: Prince Georges Co., Hyattsville, 1 Sep 1912, F. Knab, J. R. Malloch (1 ♂; USNM). Massachusetts: Barnstable Co., Pocasset, 26 Jul 1950, A. H. Sturtevant (2 ♂; USNM). Plymouth Co., Rochester, 21 Jul 1950, A. H. Sturtevant (1 ♂; USNM). Michigan: Mecosta Co., 24 Jul 1946, R. R. Dreisbach (1 ♀; USNM). New Jersey: Burlington Co., Riverton, Aug 1917, C. W. Johnson (1 ♂; USNM). New Hampshire: Cheshire Co., Keene, 4 Aug 1956, A. H. Sturtevant (1 ♂, 2 ♀; USNM). New York: Richmond Co., Staten Island, 1923 (1 ♂; USNM). Suffolk Co., Long Island, Riverhead, 4–16 Jun 1951, Roy Latham (4 ♀; USNM); Long Island,

ent, 2 Sep 1954, Roy Latham (1 ♀; USNM); Long Island, Montauk, 11 Sep 1954, Roy Latham (1 ♂; USNM). West Nyack, 11 Jul 1920 (1 ♂; ANSP). Texas: Bastrop Co., Bastrop, 11 May 1954, L. D. Beamer (1 ♂, 1 ♀; USNM). Virginia: Fairfax Co., Mt. Vernon, 27 Jun 1915, W. L. McAtee (1 ♂; USNM); Dyke Marsh, 16 Jul 1916, W. L. McAtee (2 ♀; ANSP, USNM); Alexandria, 29 Jun 1952, W. W. Wirth (1 ♀; USNM). New Kent Co., Lanexa at Chickahominy River, 9 Jun 1984, W. E. Steiner, J. E. Lowry, A. G. Gerberich, D. S. Bogar (3 ♂, 1 ♀; USNM).

Distribution (Fig. 19).—Nearctic: Canada (ON, QB), USA (CT, DC, FL, ME, MD, MA, MI, NH, NJ, NY, TX, VA).

Remarks.—The coloration of the tarsi in this species is sexually dimorphic, with the tarsi of males being dark colored, mostly blackish, whereas the mid and hind tarsi of females are mostly yellow.

Rhysophora ardeoceras Mathis

Figs. 16–18, 20–26

Rhysophora ardeoceras Mathis, 1977: 936 [Costa Rica. Guanacaste: Tilaran (14 km NE); HT ♂, USNM (75360)].

Diagnosis.—This species is similar to *R. griseola* but is distinguished by the generally blackish brown coloration; fronto-orbital setae 2 (2nd proclinate seta lacking); elongate and pointed flagellomere 1; well-developed presutural seta; and short vein R_{2+3} (costal vein ratio about 0.60).

Description.—Generally blackish brown; moderately small to medium-sized shore flies, body length 2.4–3.3 mm.

Head: Frons width-to-length ratio 0.50–0.55; frons black and slightly indented ventrally; mesofrontal triangle subshiny with slightly arched vertex at straight ptilinal suture; ventral portion of triangle near vertex slightly shallow and lightly indented; fronto-orbital plate wide and slightly raised above level of triangle; dorsal fronto-orbital plate wide and fused with base of triangle;

parafrons velvety and minutely microtomentose between triangle and fronto-orbital plate, gently inclined dorsally; paler along ventral portions, bearing minute setulae; inner vertical seta inserted close to outer seta, relatively long, about 3 times longer than outer seta; fronto-orbital setae 2–3, inserted moderately close together; larger dorsal fronto-orbital seta reclinate, slightly larger than ocellar seta; median seta reduced or absent; ventral fronto-orbital seta proclinate, less well developed, $\frac{1}{2}$ length of dorsal seta. Antenna oriented laterally; pedicel blackish brown with 2 prominent spinelike setae on dorsal surface; posterior seta small and slightly latero-clinate, $\frac{1}{2}$ the length of anterior seta; anterior seta slightly smaller than enlarged ventral seta, well developed and proclinate; black arista bearing 12–15 long dorsal rays; flagellomere 1 yellowish orange near base, darker along margins; apex very acutely rounded, almost pointed; flagellomere 1 nearly twice as long as combined pedicel and scape. Face width-to-height ratio 0.64–0.70; face black, lighter and velvety ventrally; face lightly emarginate along ventral margin; lunule receded inward to ptilinal suture at a slight angle; antennal grooves very reduced or absent; facial carina absent; face convex between antenna; face wide and convex centrally; whitish parafacials on either side of raised face sloping ventrad to eye; facial setae 3; dorsal seta well developed and cruciate; ventral pair small, reduced; line of minute setulae running dorsal to black parafacial margin; eye width-to-height ratio 0.71; gena-to-eye ratio 0.10–0.11; gena whitish and heavily setulose but darker near post gena; clypeus and clypeal membrane brown; brown maxillary palpus long and slender; mouthparts brownish but reddish brown and lighter ventrally.

Thorax: Generally subshiny, blackish brown; presutural setae 1, about $\frac{1}{2}$ the length of supra-alar seta; anepisternal setae 2; dorsal seta oriented along thorax, ventral seta about three times as large as dorsal seta.

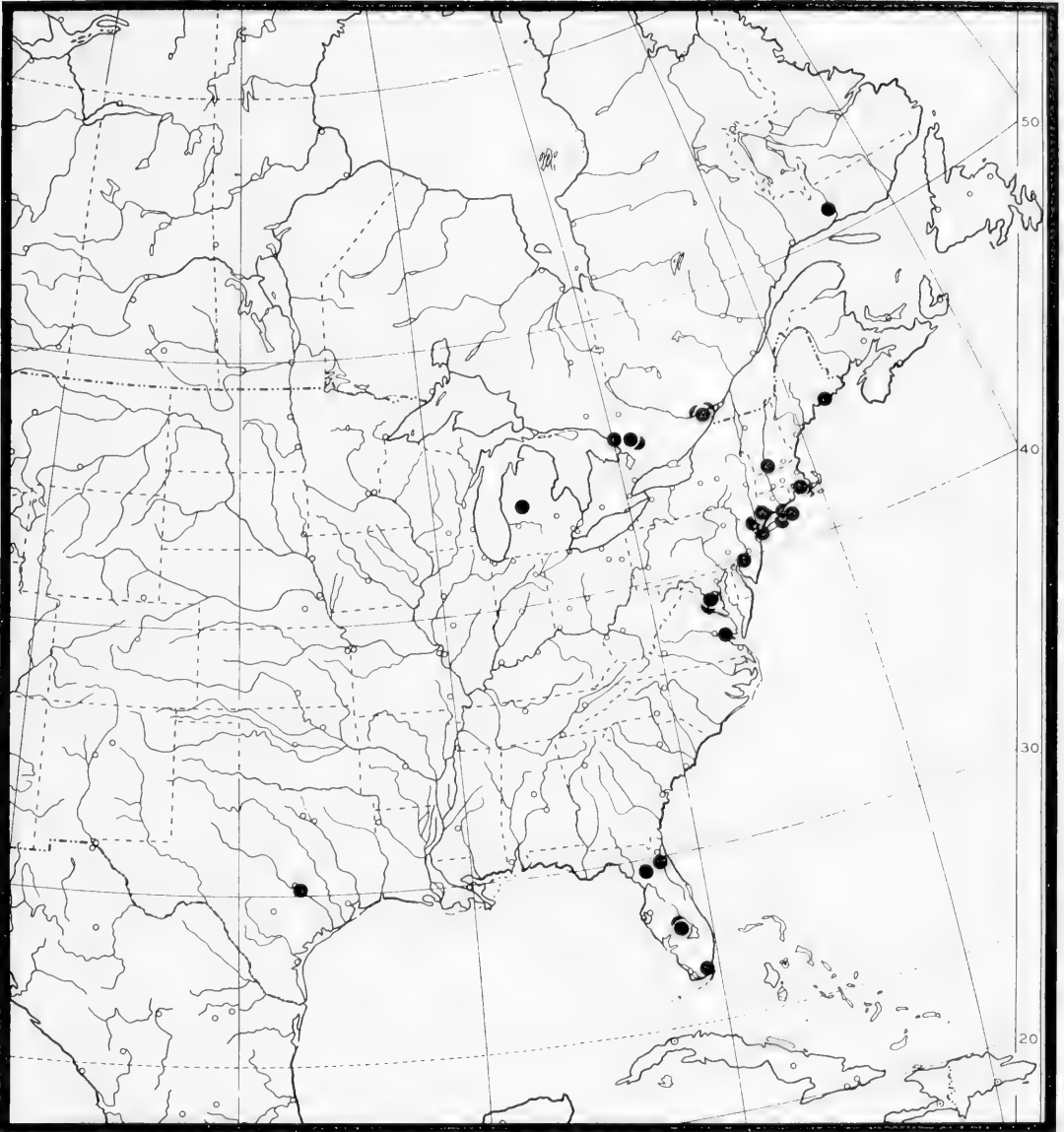
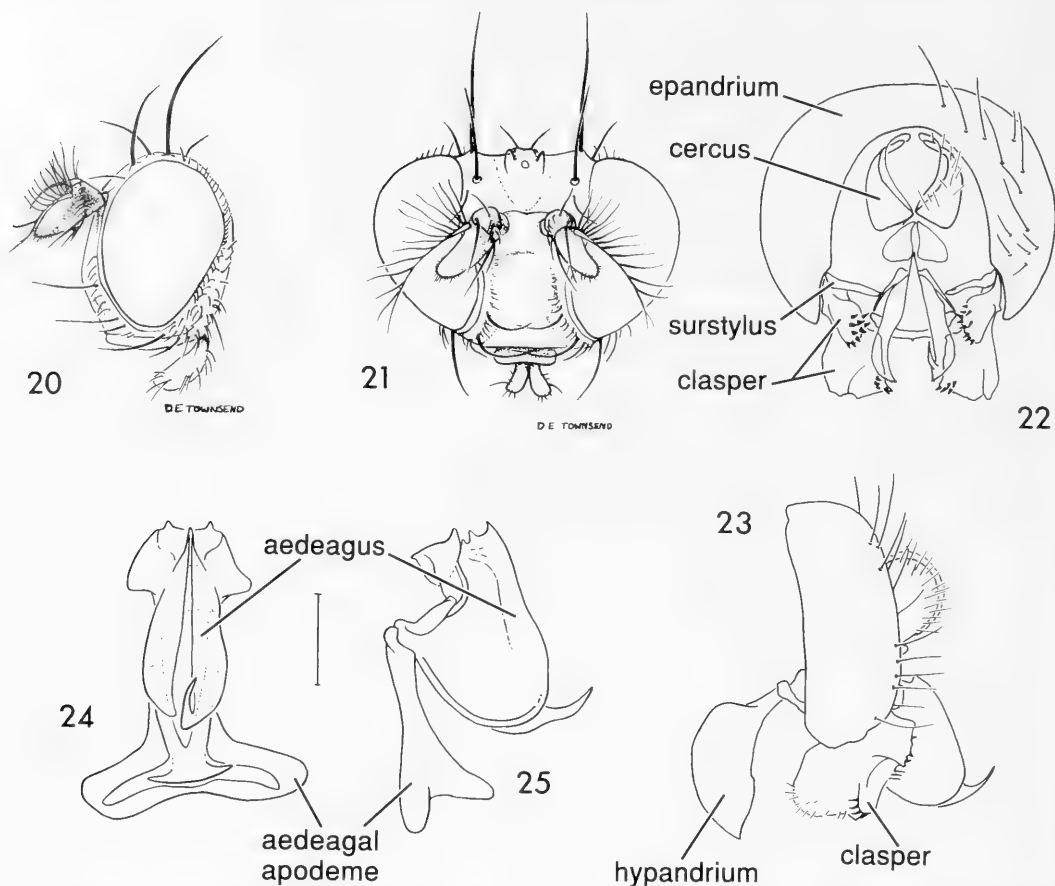


Fig. 19. Distribution map of *Rhyssophora robusta*.

Legs brownish black with yellowish tarsi; apical tarsomere blackish brown; mid femur bearing 3–4 prominent spinelike setae on posteroventral margin with 1 usually very well developed. Wings infumate and yellowish brown; costal vein ratio 0.58–0.65; M vein ratio 0.85–0.88; subcostal margin posterior to vein R_1 bearing 1 stout spine. Halter pale yellow.

Abdomen: Generally dark brown to black, subshiny; tergites 4 and 5 bearing several large dorso-obliquely oriented setae along posterior margin; 4th sternite of male with a membranous oval in center. Male terminalia (Figs. 22–25) as follows: epanandrium in lateral view parallel sided, slightly tapered on ventral $\frac{1}{4}$ to rounded ventral margin; cerci relatively short, occupying



Figs. 20–25. *Rhysophora ardeoceras*. 20, Head, lateral view. 21, Same, anterior view. 22, Male genitalia, posterior view. 23, Same, lateral view. 24, Aedeagus and aedeagal apodeme, dorsal view. 25, Same, lateral view. Scale = 0.1 mm.

about half height of cercal cavity; surstylus greatly reduced, horizontal, narrow, band-like process, situated just ventrad of cerci; clasper well developed (Figs. 22–23) relatively complex, bilobed with small cleft posteriorly, smaller dorsal lobe truncate posteriorly with posterior margin bearing numerous, short, spinelike setae; ventral lobe of clasper much larger, rounded anteriorly and ventrally, posterior margin truncate, with dorsal half bear several short, pale setulae in a comblike row, also bearing few setulae at posteroventral angle, especially along median surface; pregonite barlike, bearing 1 long seta, inserted medially; ae-

deagal apodeme (Figs. 24–25) relatively flat, lacking a conspicuous keel but with long lateral extensions; aedeagus (Figs. 24–25) tubular with dorsal slit, longer than wide, broadly rounded apically, with an apical, curved, narrow process oriented posteroventrally, aedeagus in posterior view narrow, helmet shaped dorsally; hypandrium concave, broadly rounded, wider than long, shallowly and widely emarginate with a short projection at apex of each side of emargination, bearing a median, short keel along midline on internal surface.

Specimens examined.—COLOMBIA. Buenaventura, 2 Nov 1950, A. E. Michel-

bacher, E. S. Ross (2 ♂; USNM). COSTA RICA. Guanacaste: Tilaran (14 km NE), 5 Jun 1973, T. L. Erwin, G. H. Hevel (2 ♂, 1 ♀; USNM). EL SALVADOR. Santa Tecla (12 km NW; also known as Nueva San Salvador), Oct 1953, W. B. Heed (1 ♂; USNM). MEXICO. Jalisco: Barranquillas, 3 Feb 1964, E. I. Schlinger (1 ♀; USNM). Chiapas: Rio Izapa (near Tapachula), 21 Apr 1983, W. N. Mathis (1 ♂, 1 ♀; USNM). SURINAM. Paramaribo, Feb 1968, F. D. Bennett, H. Zwolfer (1 ♀; USNM).

Distribution (Fig. 26).—Neotropical: Suriname and Mexico (CHI, JAL, TEP) south through El Salvador and Costa Rica to Colombia.

Remarks.—Externally this species differs rather markedly from its congeners (see diagnosis and key). Despite its heterogeneity, it is apparently the sister group of the lineage giving rise to *R. liropus* and *R. robusta* (see “Phylogeny Considerations”).

***Rhysophora griseola* Rao and Mathis,**

NEW SPECIES

Figs. 26–33

Diagnosis.—Specimens of *R. griseola* are similar to those of *R. ardeoceras* but are distinguished by the generally blackish brown coloration with some whitish microtomentum; short and slightly rounded flagellomere 1; presutural seta lacking; and vein R_{2+3} long (costal vein ratio about 0.33).

Description.—Generally grayish black to black; medium-sized shore flies, length 3.3 to 3.9 mm.

Head: Frons width-to-length ratio 0.48–0.49; black frons deeply indented ventrally; mesofrons triangular, subshiny black with rounded vertex at crescent-shaped ptilinal suture; ventral portion of triangle near vertex shallow and indented; fronto-orbital plate wide and raised above mesofrons; dorsal portion of fronto-orbital plate wider, fused with base of mesofrons; parafrons appearing velvety and minutely microtomentose between mesofrons and fronto-orbital plate; pseudopostocellar seta greatly re-

duced or lacking (a pair of narrowly latero-proclinate setulae present, subequal in length to setulae within ocellar triangle); inner vertical seta inserted moderately close to outer vertical seta; outer vertical seta relatively long, about $\frac{2}{3}$ length of inner seta; fronto-orbital setae 3; reclinate fronto-orbital seta slightly shorter than outer vertical seta; median proclinate fronto-orbital seta minute and inserted slightly laterad; ventral proclinate fronto-orbital seta about $\frac{1}{2}$ length of reclinate seta. Antenna extended outward laterally; pedicel black with 2 prominent spinelike setae, posterior seta smaller, slightly latero-clinate, stronger anterior seta proclinate; arista black, bearing 8–10 dorsal rays; flagellomere 1 lighter along margins with apex bluntly rounded; flagellomere 1 slightly longer than combined length of scape and pedicel. Face width-to-height ratio 0.58–0.60; face with whitish microtomentum ventrally, dorsal areas near lunule and sometimes central areas blackish brown and microtomentose; ventral margin of face shallowly emarginate but mostly flat; lunule flat, receded inward to ptilinal suture at a slight angle; antennal groves very reduced or absent; facial carina absent; face slightly convex between antenna; face broadly convex centrally; white parafacials slanted ventrad, paralleling eye on either side of raised face, bearing setulae, becoming more densely, whitish microtomentose ventrally; facial setae 2–5, sometimes asymmetrical and displaced dorsally; eye width-to-height ratio 0.67–0.70; gena-to-eye ratio 0.11–0.15; gena with whitish microtomentose, especially along posterior margin; clypeus and clypeal membrane swollen; maxillary palpus blackish brown.

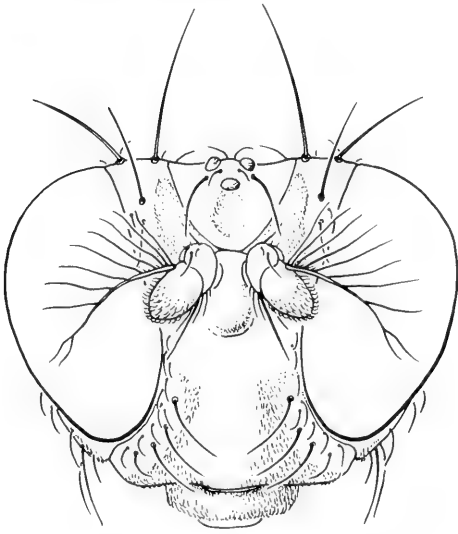
Thorax (Fig. 29): Blackish brown; scutellum with lighter triangular area, base at scutoscutellar suture and vertex near scutellar apex; pleurae grayish and velvety; anepisternum, katapisternum, and parts of notopleuron covered by white microtomentum; presutural setae lacking; prescutellar acrostichal setae about half that of dorso-



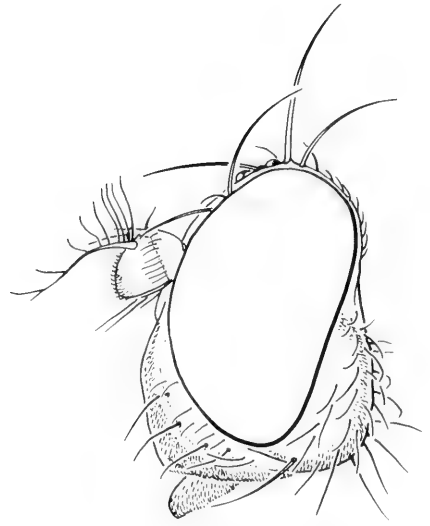
Fig. 26. Distribution map of *Rhyssophora liropus* (diamond), *R. ardeoceras* (triangle), and *R. griseola* (dots).

central setae; notopleuron bearing 2 smaller, weakly developed setulae dorsally. Legs blackish brown; fore coxa with whitish microtomentum; microtomentum of fore femur and tibia lightly whitish; tarsi lighter,

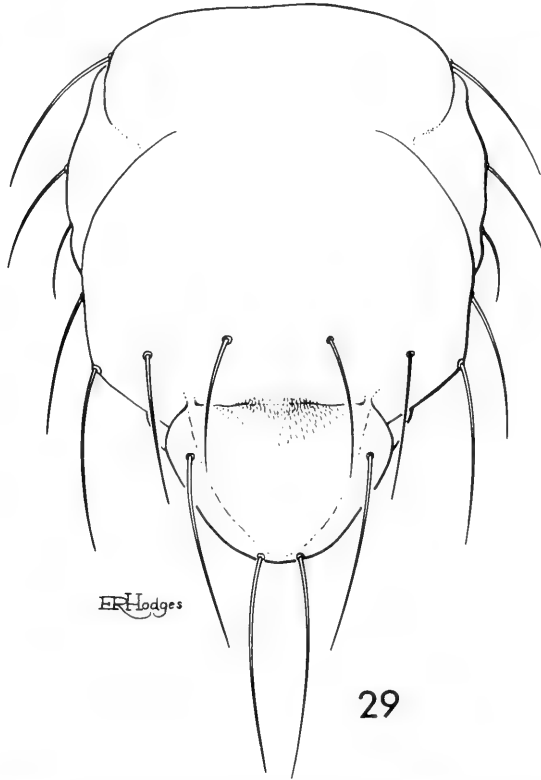
almost yellowish along ventral margin; mid femur bearing 3–6 prominent spinelike setae along posteroventral margin, usually with 1 seta enlarged. Wing with anterior margin relatively flat; yellowish brown and



27



28



29

Figs. 27-29. *Rhyssophora griseola*. 27, Head, anterior view. 28, Same, lateral view. 29, Thorax, dorsal view. Scale = 0.5 mm.

slightly darker dorsally; halter white; costal vein ratio 0.31–0.35; M vein ratio 0.94–0.98; vein CuA₁ ends before margin.

Abdomen: Generally dark brown, subshiny; 4th sternite of male completely sclerotized, lacking a membranous center. Male terminalia (Figs. 30–33) as follows: epanthrium in lateral view becoming slightly wider subventrally, broadly and bluntly rounded ventrally, bearing a prominent seta along posterior margin just below midheight; cerci relatively long, occupying most of height of cercal cavity; surstylus well developed (Figs. 30–31) essentially bare of setae, shape angulate at about a right angle with ventral footlike portion enlarged and oriented posterolaterally, with a small, pointed tooth on mediodorsal surface; pregonite papillalike, bearing 2 long, apical setulae; clasper (Fig. 31) bare of setae, extended anteroventrally, tapered ventrally with apical $\frac{1}{3}$ enlarged, curved posteroventrally, and pointed apically; aedeagal apodeme (Figs. 32–33); aedeagus (Figs. 32–33) as wide as long, apical margin with 3 points, 2 lateral projections short, median point more prominent in posterior view; hypandrium very shallowly concave, appearing almost flat.

Type material.—The holotype male is labeled "COSTA RICA[,] Guanacaste Prov. Colorado[,] 31 March 1988/W. E. Steiner[,] J. M. Hill[,] J. M. Swearingen[,] J. M. Mitchell/HOLOTYPE ♂ *Rhysophora griseola* Rao & Mathis USNM [red; species name and gender symbol handwritten]." The allotype female and 14 other paratypes (3 ♂, 11 ♀; USNM) bear the same label data as the holotype. Other paratypes are as follows: MEXICO. Chiapas: Rio Izapa (near Tapachula), 21 Apr 1983, W. N. Mathis (1 ♂, 1 ♀; USNM). The holotype is double mounted (paper triangle), is in good condition, and is deposited in the USNM.

Other specimens examined.—ECUADOR. H. A. Parrish, 1914 (2 ♀; USNM). VENEZUELA. Anzoategue: Bergantin swamp near creek (river rocks), 7 May 1988, S. A.

Marshall (2 ♂; GUE). Federal District: Caracas, 3 Sep 1942, D. A. Iriarte (1 ♀; USNM).

Distribution (Fig. 26).—Neotropical: Mexico (CHI) south through Costa Rica to Venezuela and Ecuador.

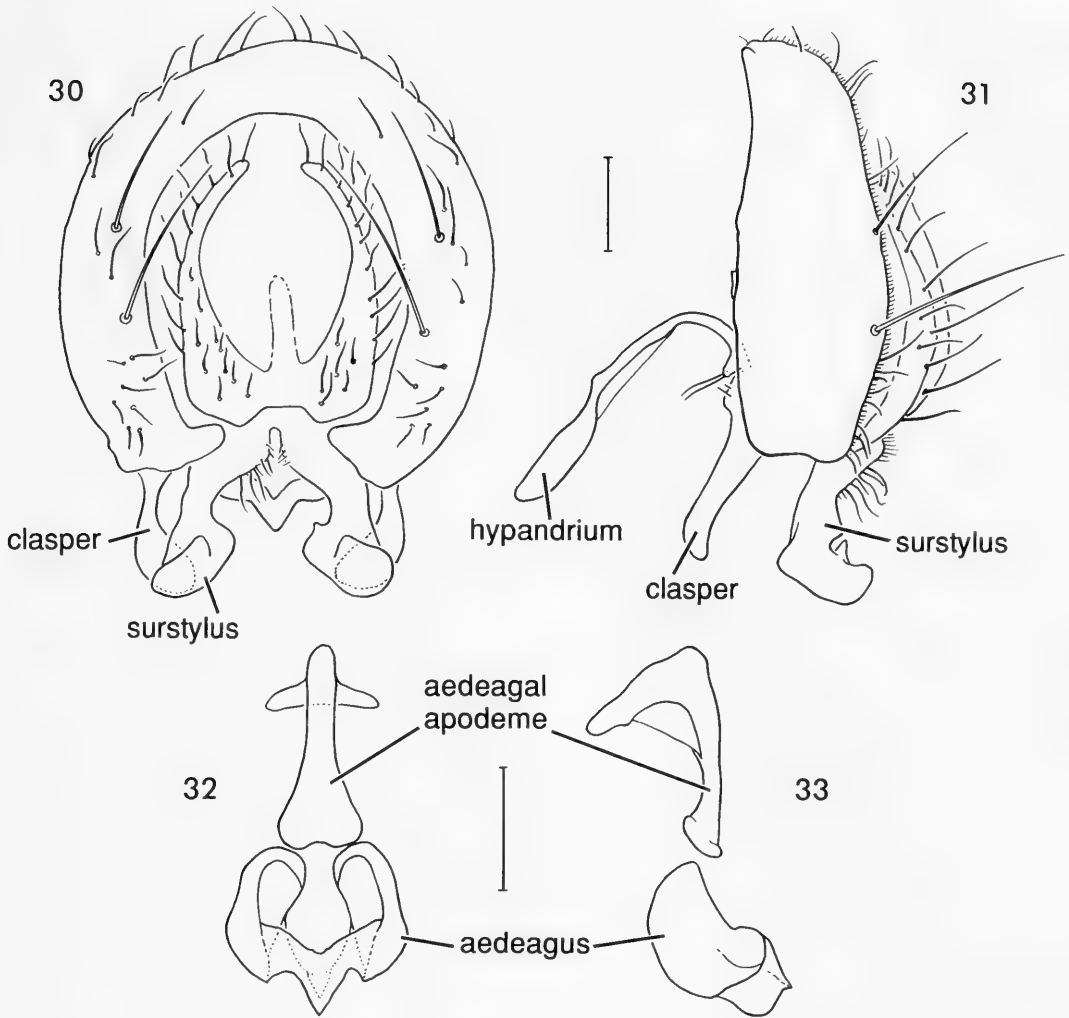
Etymology.—The specific epithet, *griseola*, is a Latinized adjective that refers to the whitish gray microtomentum, especially on the lateral margins of the face, post gena, and fore coxa.

Remarks.—This species is the basal lineage of *Rhysophora* according to the results of our phylogenetic analysis, differing from the remaining species in several characters.

PHYLOGENETIC CONSIDERATIONS

Rhysophora is one of 11 genera that comprise the tribe Discomyzini (Zatwarnicki 1992; *Clanoneurum* Becker, which was included in Discomyzini, has been returned to Psilopini (Zatwarnicki, personal communication)). Potential outgroups for phylogenetic analysis and the search for a sister group for *Rhysophora* were limited to the other 10 genera. We used four outgroups in the various analyses (*Guttipsilopa*, *Helaeomyia*, *Discomyza*, and *Mimapsilopa*,) and in the final analysis decided upon the former two, in part based on Zatwarnicki's recommendation (personal communication). These two genera are similar and probably closely related to *Rhysophora*. In our analysis, *Guttipsilopa* is indicated to be the sister group of *Rhysophora*, although that relationship must be considered tentative, as the only supportive synapomorphy is the secondary loss of setulae on vein R₂₊₃, which may be homoplasious. Regardless of the outgroup used, however, our analysis and the topology of the cladogram indicate that *Rhysophora* is monophyletic.

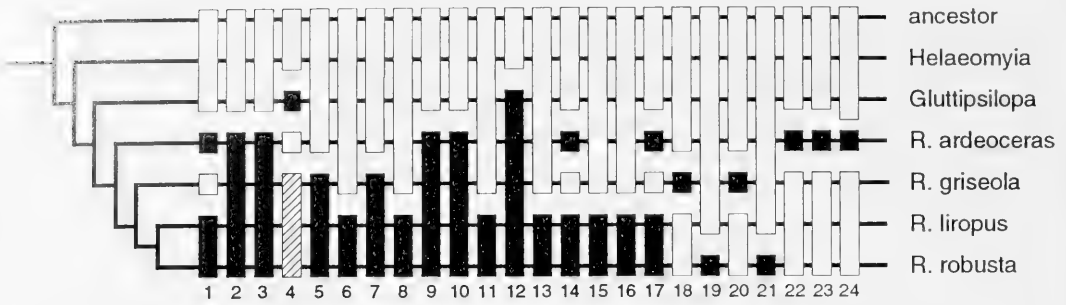
Before proceeding with the analysis of species relationships within *Rhysophora*, it is important to establish the monophyly of the genus. Unlike the unresolved sister-group relationships, the monophyly of *Rhysophora* is well established with synapo-



Figs. 30–33. *Rhysophora griseola*. 30, Male genitalia, posterior view. 31, Same, lateral view. 32, Aedeagus and aedeagal apodeme, dorsal view. 33, Same, lateral view. Scale = 0.1 mm.

morphies as follows: hind basitarsus slightly swollen; hind basitarsus of male with a ventral groove that bears a distinctive row of pale, recurved setulae; outer vertical seta shorter than inner seta, usually less than one-half the length of the latter (*R. griseola* is an exception, with the outer seta about $\frac{2}{3}$ the length of the inner seta); and pseudopostocellar setulae lateroreclinate. With the monophyly of *Rhysophora* established, we now focus on the phylogenetic relationships among the included species.

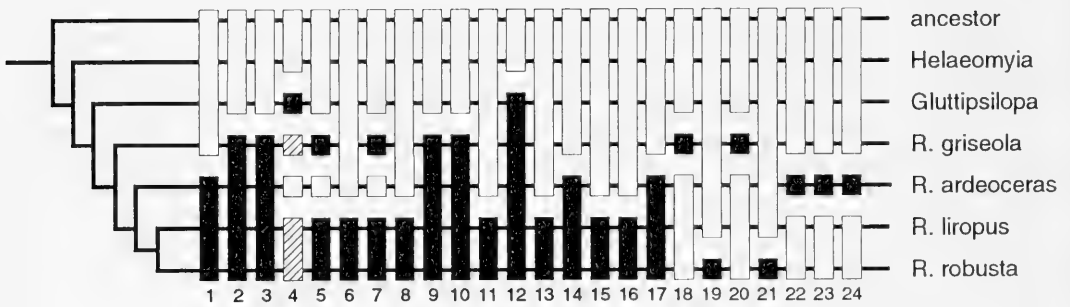
In the presentation on species relationships that follows, the characters used in the analysis are noted first. Each character is immediately followed by a discussion of its states or any qualifying comments. After the presentation of information on characters, an hypothesis of the cladistic relationships is presented and discussed. The cladograms (Figs. 34–35) are the primary mode for conveying these relationships; the discussion is a supplement to the cladogram and is intended only to complement the latter. In the



Length of 23 steps; Consistency Index 0.86; Retention Index 0.88.

Character:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
Steps:	2	2	1	2	1	1	1	1	1	1	1	1	2	1	2	1	2	
CI:	50	100	100	100	100	100	100	100	100	100	100	100	100	100	50	100	100	50
RI:	50	100	100	100	100	100	100	100	100	100	100	100	100	100	50	100	100	50

34



Length of 23 steps; Consistency Index 0.86; Retention Index 0.88.

Character:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
Steps:	1	2	1	3	2	1	2	1	1	1	1	1	2	1	1	1	1	
CI:	100	100	100	66	50	100	100	100	100	100	100	100	100	100	50	100	100	100
RI:	100	100	100	50	50	100	100	100	100	100	100	100	100	100	50	100	100	100

35

Figs. 34-35. Cladograms depicting hypothetical phylogenetic relationships among species of the genus *Rhyssophora* (with analysis and statistics of cladogram and characters). 34, With *R. griseola* as the sister group to *R. liropus* and *R. robusta*. 35, With *R. ardeoceras* as the sister group to *R. liropus* and *R. robusta*. CI = Consistency Index, RI = Retention Index.

discussion of character data, a "0" indicates the more plesiomorphic state (blank bars on the cladograms), with "1" (black bars on the cladogram) and "2" (hatched bars on the cladograms) indicating respectively more

derived states. The coding for nonadditive characters is reviewed on a character by character basis as indicated in the text. The numbers used in the presentation are the same as those on the cladogram (Fig. 34),

and the sequence is the same as noted in the character matrix (Table 1).

CHARACTERS USED IN THE PHYLOGENETIC ANALYSIS

Head

1. Comparative lengths of inner and outer vertical setae: (0) vertical setae subequal in length, frequently with the outer seta slightly shorter; (1) outer vertical seta much shorter than inner seta, usually half or less. In most shore flies, including members of *Discomyzini*, the outer seta is slightly shorter than the inner seta, and the greatly reduced outer seta, as found in three of the species of *Rhysophora*, represents a synapomorphy.
2. Orientation of pseudopostocellar setae: (0) latero-clinate; (1) lateroreclinate; (2) lateroproclinate. The more typical condition found in *Discomyzini* and *Psilopini* is for the pseudopostocellar setae to be reduced in length and widely latero-clinate. In species of *Rhysophora*, these setae are usually well developed, and with a narrowly latero-clinate orientation. In specimens of *R. griseola* these setae are greatly reduced, with a slightly divergent, proclinate orientation, or lacking.
3. Shape of ptilinal suture: (0) somewhat flattened medially with curved lateral margins; (1) strongly arched, almost crescent shaped.
4. Shape of flagellomere 1: (0) apex narrowly pointed; (1) apex rounded; (2) apex bluntly rounded. The first flagellomere is generally conspicuously pointed, as found in *R. ardeoceras*. The rounded and bluntly rounded states are synapomorphies. Lacking an indication as to the transformation series for this character, we treated it as a nonadditive character.
5. Comparative lengths of flagellomere 1 and combined length of the scape and pedicel: (0) flagellomere 1 larger than the combined length of the scape and pedicel; (1) flagellomere 1 equal or slightly

Table 1. Matrix of characters and taxa used in the phylogenetic analysis (numbers for characters correspond with those used in text).

Taxa	Characters						
	1	2	3	4	5	6	7
Ancestor	0	0	0	0	0	0	0
<i>Helaeomyia</i>	0	0	0	0	1	0	0
<i>Guttipsilopa</i>	0	0	0	1	0	2	0
<i>R. ardeoceras</i>	1	1	1	0	0	1	1
<i>R. griseola</i>	0	2	1	2	1	0	0
<i>R. liropus</i>	1	1	1	1	1	1	1
<i>R. robusta</i>	1	1	1	1	1	1	1

shorter than the combined length of the scape and pedicel.

6. Antennal grooves and facial carina: (0) weakly developed or absent; (1) distinct, with relatively deep grooves and a well-defined carina. The generalized condition in the tribe is either a relatively flat face or with very shallow antennal grooves. The relatively deeply formed grooves of *R. liropus* and *R. robusta* are a synapomorphy.
7. Size and orientation of dorsal facial setae: (0) setae large, at least dorsalmost pair cruciate; (1) setae reduced in size, usually not cruciate. The generalized condition is for one, frequently the dorsalmost seta, or more of the facial setae to be cruciate. Although the facial setae in most species of *Rhysophora* are inclinate, they usually do not cross.
8. Shape of ventral facial margin: (0) nearly flat or very shallowly emarginate; (1) deeply emarginate.

Thorax

9. Row of distinctive, pale, curved setae inserted along anteroventral surface of male hind basitarsus: (0) setae absent; (1) setae present. This is a sexually dimorphic character and one of the primary synapomorphies to indicate the monophyly of the genus.
10. Size of male hind tarsus: (0) hind tarsus equal in size to mid and fore tarsi; (1)

hind tasu slightly swollen. Like the preceding character, this is a synapomorphy of the genus.

11. Spinelike setae along posteroventral margin of mid femur: (0) mid femur bearing 3–6 prominent setae; (1) mid femur bearing 1 prominent seta.
12. Setulae on dorsum of vein R_{2+3} basad of crossvein r-m: (0) setulae absent; (1) 3–4 setulae present; (2) setulae secondarily lost. The presence of setulae on the base of R_{2+3} is a synapomorphy for the tribe, and Zatwarnicki (1992) has interpreted their absence in *Rhyso-phora* and *Guttipsilopa* to be a secondary development.
13. Anterior wing margin: (0) shallowly arched, giving the overall appearance of a somewhat ovate wing; (1) somewhat flattened with anterior and posterior margins largely parallel.

Abdomen

14. Shape of surstylus: (0) well developed, although shape variable; (1) greatly reduced as a horizontal, narrow, bandlike process near the ventral margin of the cerci.
15. Shape of clasper: (0) simple, primarily a single process; (1) bifurcate, frequently deeply, resulting in 2 processes.
16. Setation of posterior process of the clasper: (0) a few setulae and at most a few setae present; (1) a row of long, conspicuous setae along posterior margin. The derived state is apparently unique to *R. liropus* and *R. robusta*.
17. Shape and setation of pregonite: (0) papillalike, bearing 2 long, apical setulae; (1) barlike, bearing 1 long seta, inserted medially.

AUTAPOMORPHIES NOT USED IN THE PHYLOGENETIC ANALYSIS

18. Development of pseudopostocellar setae: (0) pseudopostocellar setae well developed; (1) pseudopostocellar setae re-

duced and poorly developed. The derived state is unique to *R. griseola*.

19. Sculpturing of ventral portion of face: (0) similar to dorsal portions of face, generally relatively smooth; (1) rugose.
20. Presutural seta: (0) strongly developed; (1) seta absent. Most members of the tribe have a well developed presutural seta, and its apparent absence (or great reduction) in specimens of *R. griseola* is unique to that species.
21. Tarsal coloration: (0) males and females similarly colored; (1) sexually dimorphic, female mid and hind tarsi yellow, male mid and hind tarsi dark brown, concolorous with tarsus of foreleg.
22. Setae along posterior margin of tergites 4 & 5: (1) setae oriented along abdomen; (1) setae dorso-oblique.
23. Fourth male sternum: (0) 4th sternum entirely and evenly sclerotized; (1) 4th sternum with median, oval, membranous area.
24. Dorsal rays of arista: (0) 8–10 dorsal rays; (1) 12–15 dorsal rays.

Table 1 is the character matrix. From this matrix and using the implicit enumeration (ie) option of Hennig86, two trees (Fig. 34) of equal, "most parsimonious" length resulted (length of 23 steps, overall consistency index of 0.86, and a retention index of 0.88). Using the successive weighing technique (xsteps w, ie, cc), we further analyzed the characters to determine the goodness of fit for the two tree topologies. After successive weighing the same two trees resulted, and each character had a weight of 10. Other statistics of each character are cited with the cladograms (Figs. 34, 35).

The cladograms for the species of *Rhyso-phora* indicate that the genus is monophyletic (synapomorphies 2, 3, 9, 10, and 12). They also corroborate the monophyly of *R. robusta* and *R. liropus* (synapomorphies 6, 8, 11, 12, 13, 15, and 16), which was formerly recognized as a species group,

as a well-established monophyletic group that is the most derived lineage within the genus. Within the latter lineage, the species *R. robusta* is characterized by two autapomorphies (19, 21).

Our analysis indicates that the sister group giving rise to *R. liropus* and *R. robusta* is ambiguous, with either *R. ardeoceras* (synapomorphies 1, 14, 17), or *R. griseola* (synapomorphies 5, 7) being equal candidates. Of the two possibilities, we advocate *R. ardeoceras* (Fig. 34) as the better choice. The synapomorphies that demonstrate this relationship are based on structures of the male genitalia and are more reliable in our opinion than the shape of flagellomere 1, which is known to vary somewhat within the subfamily Discomyzinae. The species *R. ardeoceras* is distinguished by three autapomorphies (22, 23, and 24), and *R. griseola* is distinguished by two autapomorphies (18, 20).

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A NEW SPECIES OF *TOWNSENDIA* WILLISTON (DIPTERA: ASILIDAE)
FROM FLORIDA WITH NOTES ON ITS ASSOCIATION WITH
PERDITA GRAENICHERI TIMBERLAKE (HYMENOPTERA: ANDRENIDAE)

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Abstract.—A new species of asilid fly belonging to the genus *Townsendia* is described and figured. Flies were collected in association with a species of ground-nesting bee, *Perdita graenicheri* Timberlake at the Archbold Biological Station, Highland County, Florida. Behavioral observations of flies and speculation on their occurrence near bee burrows are given.

Key Words: Asilidae, Andrenidae, *Townsendia*, *Perdita*, ground-nesting

A detailed study of the small (4–5 mm), gregarious, ground-nesting bee, *Perdita graenicheri* Timberlake, was conducted at the Archbold Biological Station (ABS), Highlands County, Florida in 1989 (Norden et al. 1992). During that study, a very small species of *Townsendia* (Diptera: Asilidae) was often observed perching on vegetation near bee nest openings. The flies appeared to be watching the bees as they entered or exited their burrows. Specimens of the fly were collected, and later were determined to be a new species. During a second trip to the Station, 10–17 August 1992, additional flies were collected and observations were made on their behavior.

MATERIALS AND METHODS

Study site.—Nesting *Perdita graenicheri* were found at several ABS sites. Deyrup (pers. comm.) noted that *Townsendia ar- enicola*, n. sp. is the most common asilid in the scrub and nearby open xeric areas. We found that, the fly was often abundant in

association with the bees on the sunny, exposed sand at the northeastern end of Lake Annie. All of our (BNN & KVK) observations and collections were made at this site.

Behavioral observations.—Flies were found only on sunny days and were observed throughout the day (0800–1700 h, EST) during both still and breezy conditions. Sand surface temperatures ranged between 38–52°C. Notes were taken of perch selection, behavior of the flies at perches and flight behavior. Selected blades of grass and twigs (perches) were occasionally removed from the area and the subsequent changes in asilid behavior were recorded. Observation time totaled ca. five hours and included approximately 30 different flies.

RESULTS

Flies used a series of perches having one or more bee nest openings located roughly in their center. Flights from these perches were short (ca. 5–15 cm) in distance, and about 1–5 cm above the sand. Flights were

more hovering than darting in nature. Flies always positioned themselves atop their perches in a horizontal position with the head facing in the direction of a bee nest. Removal of perches seemed to temporarily confuse flies who would attempt to land where a perch had previously been located. Only occasionally would flies land on the sand near bee nest openings. Movement between perches appeared to increase during particularly windy days.

Since flies were much smaller than the stockier bees, we doubted that adults preyed on bees but we watched closely for any foraging behavior. We observed no obvious attempt by the flies to chase or to attack bees or other insects in the vicinity. However, one specimen in the ABS collection was pinned with its presumptive prey, a species of frit fly (Diptera: Chloropidae). Small ants were occasionally followed for a short distance from the perch, as were other *T. arenicola* that flew near a perched individual.

Most of the flies observed were females and they appeared to be watching the *Perdita* burrow openings. They turned their heads from side to side, as if to scan the area around the burrow. In 1992, two females were observed entering burrows only seconds after the female bees exited. Since little is known about the biology of these flies, we (Norden et al. 1992) suggested that these fly larvae might feed upon the bee larvae and that adult flies were entering nests to oviposit. Though information on the dietary habits of asilid larvae are sparse (Woods 1981), observations suggest that they are predaceous on soil-dwelling insects.

However, the bees were still provisioning their nests during these observations, and bee larvae probably were not present yet. Melin (1923) suggested that some asilid larvae may feed on non-insect diets. If this is so then a pollen mass of *P. graenicheri* could provide sufficient food for one or more *T.*

arenicola larvae. It is also plausible that the larvae are general opportunists, feeding on both pollen and bee larvae.

Though we are uncertain of the significance of the association of *T. arenicola* with bee burrows, three other asilids sometimes frequent vertebrate burrows. Lavigne (1968) reported (as *Asilus*) *Machimus formosus* (Hine) and *M. gilvipes* (Hine) in badger and ground squirrel burrows, and Bullington and Beck (1991) reported *M. polyphemi* Bullington & Beck in gopher tortoise burrows. Large burrows of such vertebrates probably serve as important retreats from harsh environmental conditions, oviposition and larval developmental sites, and/or mating sites for these flies. Mating pairs of *M. gilvipes* often alight and rest on the walls of burrows (Lavigne 1968). Perhaps females of *T. arenicola* select perches near burrows or other land marks to attract mates.

Townsendia Williston

Townsendia Williston, 1895: 107. *Townsendia minuta* Williston. Type Locality, Mexico.

Diagnosis.—Small flies, 3–4 mm long, head much wider than high, broad in lateral view; eyes with anterior facets unusually large; face narrow, vertex shallow and wide, front strongly divergent; wings basally narrow with only four posterior cells, anal angle and alulae absent, and vein M_3 absent with only four posterior cells.

The genus *Townsendia* Williston is restricted to the New World, with eight species from Mexico (Martin 1966), two from the United States (Williston 1895, Back 1909), and one from Puerto Rico (Curran 1926). Both species found in the United States were described from a single female (Back 1909). The type locality for *T. nigra* Back is New Jersey and that for *T. pulcherrima* Back is Texas. Martin (1966) referred to two undescribed species from the United States, one from Arizona and the

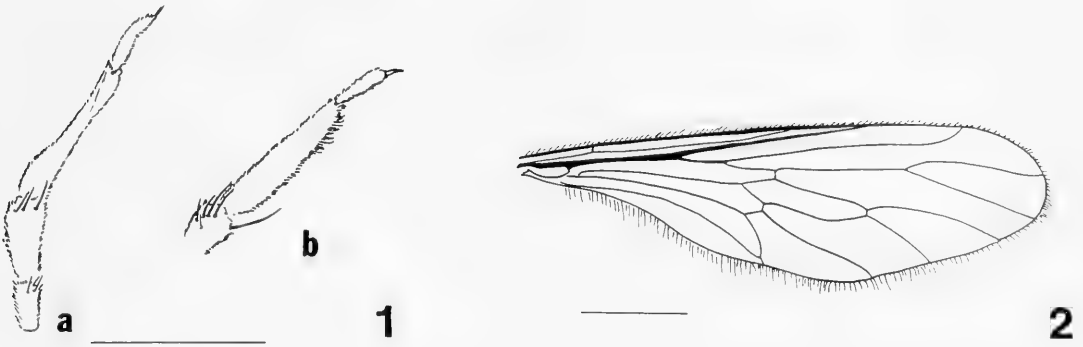


Fig. 1. Right antenna of male *Townsendia arenicola*, n. sp., a. dorsal view, b. lateral view. Scale = 0.2 mm.

Fig. 2. Right wing of *Townsendia arenicola*, n. sp. Scale = 0.4 mm.

other from Florida. The following new species from Florida is probably the one referred to by Martin.

DESCRIPTION OF SPECIES

Townsendia arenicola Scarbrough,

NEW SPECIES

Figs. 1-5

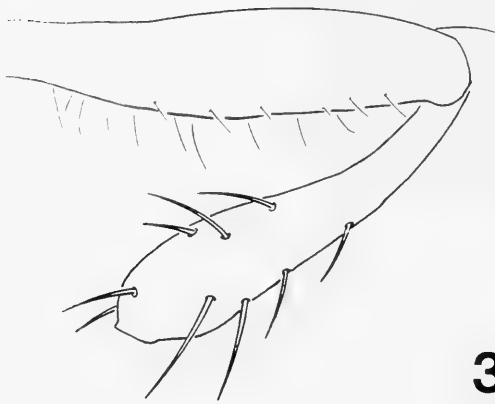
Male.—Head and thorax dark brown to black; abdomen dark brown with a slight tint of orange. Length, body 2.7–3.4 mm; wing 2.1–2.4 mm. Face, front, and occiput gray to slightly yellowish-gray tomentose; a small, light brownish tomentose spot present adjacent to each posterior ocellus. Oral margin of face with a row of six to seven short, thick, yellowish bristles. Palpus and short proboscis with short, fine yellowish vestiture. Front narrow basally, wide above with strongly divergent sides, one to two dark brown setae present; basally, three long grooves present, with the outer two divergent beyond the sides of ocellar tubercle, the middle groove about twice as deep as the other two. Antenna with brown vestiture, basal two segments combined about two-thirds as long as flagellum; flagellum flat laterally with a median constriction anteriorly, basal width slightly greater than apical width, ventral margin slightly narrowed to apex; stylus one-half as long as and two-thirds as

wide as flagellum, with a short, lateroapical spine, the latter one-fourth to one-third as long as stylus. Vertex shallow, three to four times wider than front basally. Occiput dorsally with six to seven short, brown post-ocular bristles, laterally and ventrally with shorter, thinner, yellow bristles.

Thorax mostly gray to slightly yellowish gray tomentose; scutum medially with a wide brown stripe that extends posteriorly to supra-alar bristles. A large lateral brown spot and sometimes a much smaller, less distinct brownish tomentose spot present on each side of median stripe. Vestiture on thoracic dorsum sparse, of short, thin, brown bristles; posteriorly dorsum with one, rarely two pairs of long dorsocentral bristles and three pairs of thick lateral bristles. Scutellum flat, margin with four to six long, brown setae, each alternating with one to two shorter setae. Pleuron usually with two thick, brown tergosternal bristles, sometimes a weaker pale seta also present. Halter basally brown, knob entirely and stalk partly yellowish.

Wing iridescent, often largely yellowish, with dense microtrichia. Veins R_4 and R_5 widely divergent with R_4 ending before and R_5 well behind wing apex. Apically cell d and basally cell m_1 unusually narrow; cell m_1 at wing margin contrastingly wide, with veins M_1 and M_2 strongly divergent.

Coxae usually dark brown, sometimes



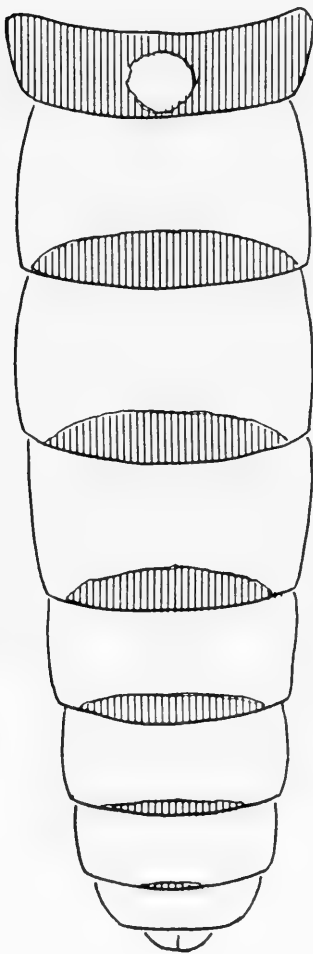
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apices narrowly yellowish, with yellowish vestiture. Trochanters, fore- and midfemora, fore- and midtibiae, and basal three to four tarsomeres of all tarsi yellow to slightly brownish yellow; fore- and midfemora ventrally with a long, thin, yellowish seta, seta below forefemora thickest and longest; all femora dorsoapically with two to three brown bristles. Hindfemora and hindtibiae largely yellow-brown to brown, usually yellow basally; hindfemora only slightly clavate with several long, thin, brownish or yellowish setae posteroventrally. Tibiae and tarsi with several thick, yellowish bristles; hindtibiae strongly clavate, sometimes posteriorly with two or three brown bristles. Apical segment of each tarsus brown; basotarsomere of hind tarsi swollen, remaining tarsomeres more slender.

Abdomen shiny, basal two and apical two to three segments dark reddish brown or orangish brown, with mostly brown vestiture; tergite 1 mostly and tergites 2-6 apically with a dense gray tomentose band, each band in succession from tergite 2 to 6 decreasing in width, making band on tergite 2 the widest and that on tergite 6 narrowest; sternites sparsely gray tomentose. Sternite 8 apically with abundant black setae.

Terminalia dark brown to black. Epanthrium undivided dorsally, sides dome-like and covering most of terminalia laterally, apical corners strongly pointed. Gonostylus flat, long, digitate. Hypandrium medially with a deep emargination and abundant, short, pale setae. Aedeagus as in Figure 1d.

Female.—Differs from the male as follows. Length, body 3.2–4.3 mm; wing 2.6–2.7 mm. Hind legs yellow to light brownish yellow; hind tibiae only slightly clavate, apical three tarsomeres of all tarsi yellowish brown to brown with the apical segment



4

←

Figs. 3–4. 3. Left femur and left tibia of male *Townsendia arenicola*, n. sp. Scale = 0.4 mm. 4. Abdomen of *Townsendia arenicola*, n. sp. Scale = 0.4 mm.

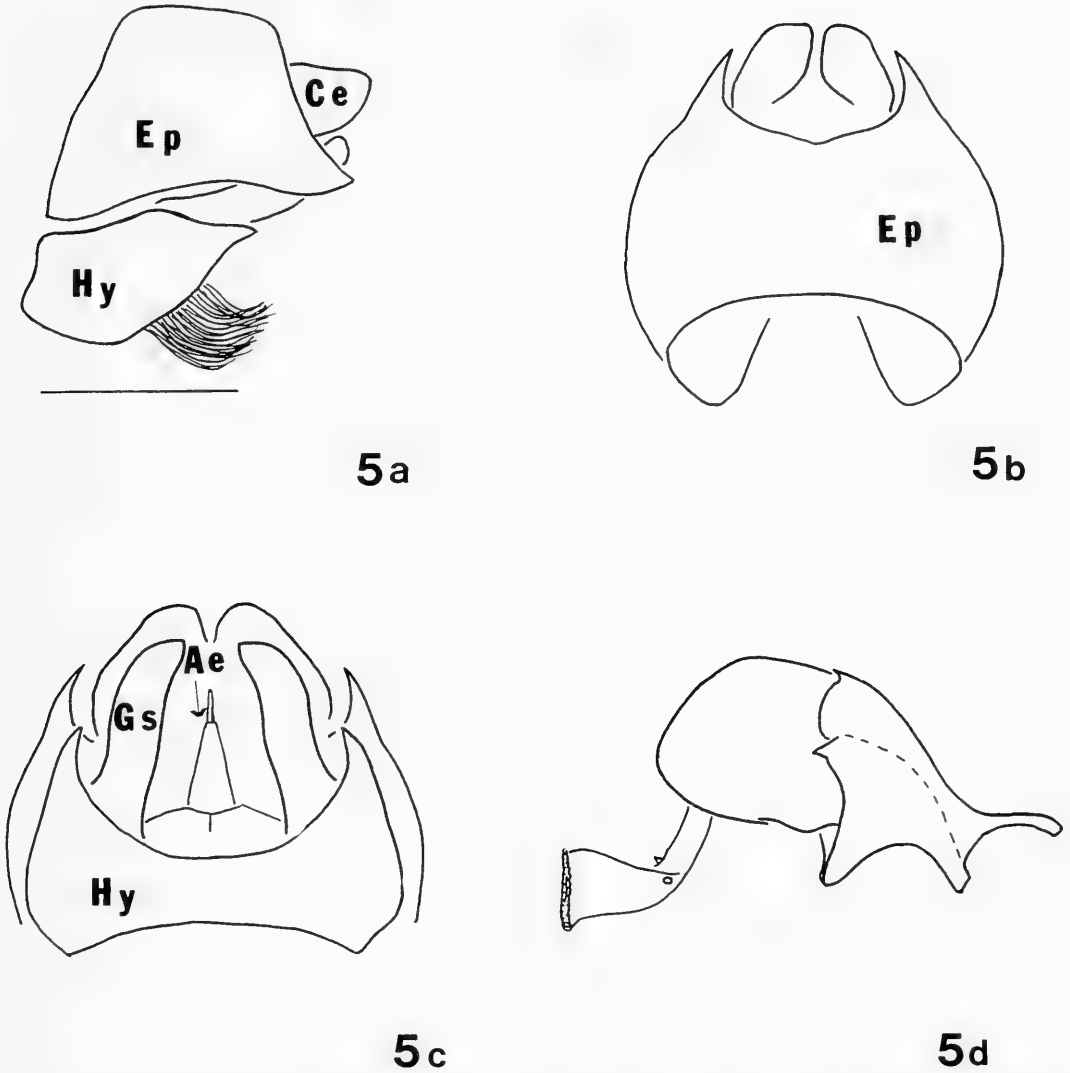


Fig. 5. Male terminalia of *Townsendia arenicola*, n. sp., a. lateral, b. dorsal, and c. ventral views; d. aedeagus, lateral. Scale = 0.4 mm. Abbr. Ae = Aedeagus, Ep = Epandrium, Ce = Cercus, Hy = Hypandrium, Gs = Gonostylus.

dark brown. Wings almost entirely iridescent yellow. Abdomen shiny with all of segments 1 and 9, narrow base of segment 2, and narrow apex of segment 8, dark brown to black or sooty blackish yellow, remaining segments contrastingly lighter, often partially sooty, usually brownish yellow to yellow. Sternite 8 narrowly divided medially with incision reaching apical third. Spermatheca long, extending posteriorly to apical margin of segment 3; apically each sper-

matheca tubular, darkly sclerotized, loosely coiled one and one-half times, darkly sclerotized, with apex slightly tapered; base of each ductus separate, not fused, and about as wide in diameter as spermatheca. Terminalia apically with eight black acanthopore spines.

Holotype ♂ FLORIDA: Archbold Biol. Sta., LK Placid, Highlands Co., Rosemary shrub, 21.VI.1988, M. Deyrup; allotype ♀, same data except 18.VI.1992. Paratypes, 23

♀, same location, along various trails, firelanes, sand surfaces, and on a flowering *Paronychia chartacea*, 1 with chloropid prey, 4.VI-8.IX.89-92, B. Norden/M. Deyrup.

Voucher material.—Holotype ♂ & allotype ♀, deposited in the National Museum of Natural History, Smithsonian Institution (USNM); paratypes in the National Museum of Natural History, the Archbold Biological Station, and the Towson State Museum of Zoology.

Etymology.—Latin *arenicola*, meaning frequenting or living in sandy areas, referring to the habitat of the species.

Remarks.—*Townsendia arenicola*, n. sp. is easily separated from other known species in this genus by the wide gray tomentose bands on the apical margins of abdominal tergites 2–6, and by the dense gray and brown tomentose pattern on the scutum. The general color of the abdomen of females of *T. arenicola* and *T. pulcherrima* are essentially identical, but the latter species lacks the gray tomentose bands. In addition, the antennal spine of *T. pulcherrima* is subapical, short, and hidden in the long pubescence, whereas this spine in *T. arenicola* is apical, long and exposed. In females of *T. niger*, the abdomen is wholly blackish with the sides beyond the middle strongly tapered to a pointed apex. In *T. arenicola*, the abdomen is much lighter in color, largely brownish yellow to yellow, with parallel sides and a broad, rounded apex. It also differs from *T. niger* in having only sparse, short vestiture on the front, ocellarium and scutum. In both *T. pulcherrima* and *T. niger*, the vestiture of the head and scutum is much longer and more abundant than in *T. arenicola*. The former species have three to five prominent tergosternal bristles whereas *T. arenicola* has only two such bristles.

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RESPONSE OF GYPSY MOTH (LEPIDOPTERA: LYMANTRIIDAE) LARVAE TO STICKY BARRIER BANDS ON SIMULATED TREES

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Abstract.—The behavioral response of gypsy moth, *Lymantria dispar* (L.), unfed first instars to intact and defective sticky barrier bands was determined. The barrier bands were installed on simulated trees in a laboratory arena. Defects incorporated into the barrier bands were: gaps in the sticky material (2 mm, 4 mm, and 8 mm width), tunnels under the band (3 mm and 6 mm height) and bridges across the sticky material (cross sections of 1 mm² and 2 mm diameter). The defects allowing the highest percentage of larvae to cross were the 2 mm diameter bridge (55.3%) and the 6 mm high tunnel (46.6%). Other defects also allowed crossing. These findings indicate the importance of frequent inspection and repair of sticky barrier bands that are used for gypsy moth control.

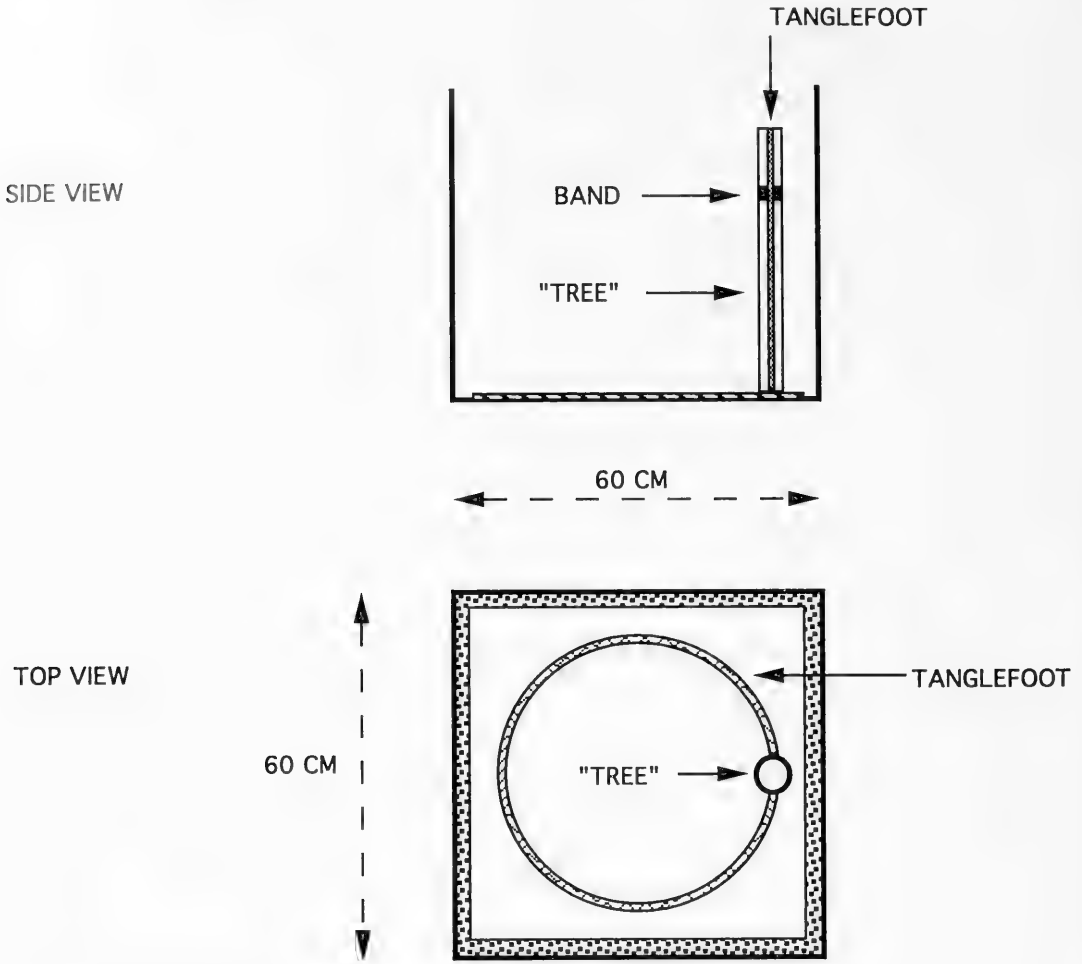
Key Words: *Lymantria dispar*, barrier bands, behavior

Sticky barrier bands are used to protect trees against various pests, including the gypsy moth, *Lymantria dispar* (L.). Originally, barrier bands were made by applying sticky substances formulated with materials which included coal tar derivatives and rosin oil. These sticky substances were applied directly to the bark (Burgess 1930, Collins and Hood 1920, Forbush and Fernald 1896). Recently, other types of sticky materials have been applied on top of tape bands on tree boles (Blumenthal 1983, Blumenthal and Hoover 1986, Webb and Boyd 1983). Such barriers are still used by homeowners and managers of small tracts of land (Miller and Lindsay 1993). Success of this method depends upon the ability of the barrier to prevent the return of larvae to the canopy after ballooning or silking down (Burgess 1930, Leonard 1971, McManus 1973). In the field, barrier band efficacy may be reduced by gaps in the sticky material from uneven application, tunnels under the tape caused by texture or contour of the tree bark, and dirt, debris or leaves that become stuck

in the material creating bridges. Blumenthal (1983) made useful observations on the response of gypsy moth larvae when they encountered barrier bands, however, these observations were generally of older larvae, and did not include responses to damaged or otherwise compromised bands. Thorpe et al. (1993) found barrier bands reduced larval numbers in groups of trees, but only by about 28%. The present study involved the quantitative analysis of larval response to intact and compromised sticky bands through controlled laboratory experiments. Results lead to a better understanding of possible causes of variable performance of these devices (Blumenthal and Hoover 1986, Thorpe et al. 1993).

METHODS

Test arena, bole, and band treatments.—A corrugated cardboard carton was used to form the walls of the arena (60 cm³) (Fig. 1). The box was lined on the inside with white drawing paper to reduce directional bias due to light sources and extraneous sil-



(NOT TO SCALE)

Fig. 1. Test arena with artificial bole ("tree") assembly in place. Graphics were generated with MacDraw II® (Schutter et al. 1988).

houettes, both of which influence larval movements (Ludwig and Schneider-Hempel 1954, Roden et al. 1992, Zanforlin 1970). The simulated bole was constructed of a cardboard mailing tube 92 mm outside diameter and 597 mm height (Alperstein Bros., Inc., Silver Spring, MD). The yellow paper sheathing on the tube was peeled off to expose the unbleached, undyed cardboard. The

tube was attached to a corrugated cardboard base (approximately 58 cm²) by anchoring it with two straight pins and sealing the seam with acrylic latex caulk plus silicone (DAP Inc., Dayton, OH). Caulk was allowed to dry at ambient room temperature and relative humidity for a minimum of 24 hrs. before the apparatus was used for testing. Placement of the artificial bole was approx-

imately 1 cm from the edge of one side and on center relative to that side. A band of Tanglefoot® (Tanglefoot Co., Grand Rapids, MI) was applied in a circle (approximately 50 cm diameter) on the base to prevent larvae from leaving the test arena. This containment band bisected the bole longitudinally so that larvae were restricted to one half of the bole facing the center of the arena. New bole and base assemblies were used for each replicate for each treatment in order to eliminate any possible influence from silk trails and chemical cues from previous tests.

The barrier band was constructed of duct tape (ServiStar®, SSR20340, SERVISTAR Corp., Butler, PA) 5.08 cm wide that was wrapped around the bole with the lower edge of the tape approximately 43 cm from the base. In all treatments, a sticky layer was formed by masking a 1 cm band in the center of the duct tape with Scotch™ Magic™ Tape (3M Commercial Office Supply Division, St. Paul, MN), applying Tanglefoot along the unmasked area and then smoothing the Tanglefoot with a glass microscope slide to give a thin, uniform layer that was 1 cm wide after removing the tape. All treatments were modifications of this basic configuration (Fig. 2).

Treatments using gaps in the sticky layer were formed by masking with a piece of Magic™ Tape of the appropriate size. Three widths of gaps were tested: 2 mm (approximately 2× the width of a first instar head capsule), 4 mm, and 8 mm. Treatments using tunnels were formed by placing a plastic form on the duct tape band and securing it with another layer of duct tape; the Tanglefoot band was then applied on the top layer of duct tape. Two sizes of tunnels were tested. The form for the smaller tunnel (low tunnel) was made from a plastic soda straw that was bisected lengthwise and trimmed to 5.08 cm (duct tape width); the tunnel space was 3 mm wide at the base and 3 mm high at the center. The larger tunnel (high tunnel) was made from a piece cut from a

polystyrene container (thickness: 0.3–0.5 mm) and bent to form a tunnel with a base width of 10 mm and center height of 6 mm. Two sizes of bridges were tested. One type (1 mm bridge) was formed from a flat wooden toothpick (Forster Mfg. Co., P.O. Box 657, Wilton, ME) that was trimmed to the dimensions 1.22 ± 0.02 mm \times 1.25 ± 0.04 mm \times 30 mm. The other bridge (2 mm bridge) was a 30 mm section of a wooden applicator stick (Fisher Brand®, Cat. # 01-340) (diameter: 2.18 ± 0.01 mm). The 1 cm band of Tanglefoot® was sufficient to hold the bridges in place.

Test insects.—Gypsy moth egg masses were provided by the Otis Methods Development Center, US Department of Agriculture, APHIS, Otis ANG, MA. They were from generations F37, F38, and F40 of the New Jersey Standard Strain (NJSS). They were stored at 4°C until three to five days before testing. They were then placed in a sealed plastic bag at ambient room temperature (20–25°C) with moist paper towels to maintain high humidity. Egg masses were checked daily. When the larvae began moving off the egg mass, that egg mass was used for tests. Larvae were introduced to the arena by placing the entire egg mass in the center of the base allowing approximately 50–100 individuals to crawl off (Fig. 1), and then promptly removing the egg mass with the remaining larvae. All test insects were unfed first instars.

Validation of test arena.—A series of preliminary tests were conducted to determine if test insects behaved in the arena in a manner consistent with that described in the literature. Tropism and behavior of larval gypsy moths are well documented (Doan & Leonard 1975, Roden et al. 1992, Weseloh 1990, Zanforlin 1970) and it was desirable to verify that behavior in the arena was similar to that previously reported. A variety of images were presented to larvae in the arena, including a solid black panel covering one side of the arena, both black and white vertical bars on contrasting backgrounds,

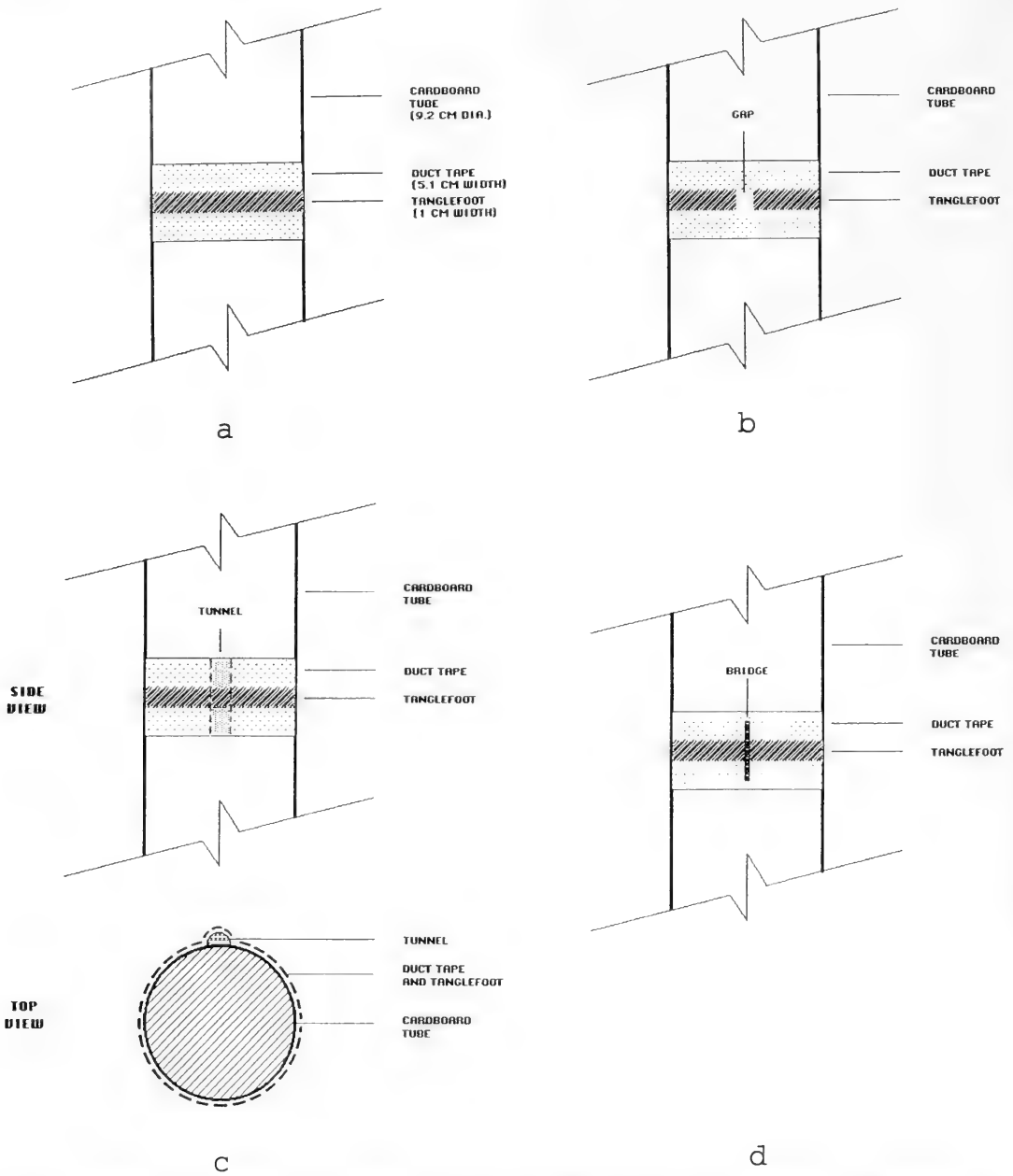


Fig. 2. Barrier band treatments as installed on artificial boles. In the one hour laboratory tests treatments included a) duct tape band with an unbroken sticky layer b) three sizes of gaps tested and c), d) two sizes each for the tunnels and bridges. Graphics were generated with Desk Paint[™] (Garipey 1988).

and cardboard mailing tubes of the type later used in the barrier band tests. Groups of 50 to 100 larvae were observed for periods of 30 minutes or longer and their movements were recorded on video tape. The

initial observations and later review of the video tapes indicated that the larvae were strongly attracted to black vertical bars of various widths on a white background. This is consistent with earlier reports of this be-

havior (Roden et al. 1992, Zanforlin 1970). Larvae also readily moved toward and climbed the cardboard mailing tubes placed in the arena.

Barrier band tests.—Tests were conducted for 1 hour, which began at the time that the egg mass was removed from the center of the arena. The test was observed continuously, and every 10 minutes the following information was recorded: number of larvae that crossed the barrier band, total number of larvae on the bole, number that walked back down below barrier band, and number that silked down past the barrier or simply dropped.

The first series of tests consisted of seven treatments: 1) duct tape banding with no Tanglefoot, 2) a barrier band with a continuous band of Tanglefoot, gaps in Tanglefoot of 3) 2 mm, 4) 4 mm, and 5) 8 mm, and the two different sizes of tunnels that were 6) 3 mm and 7) 6 mm high in the center. The second series of tests consisted of four treatments: 1) duct tape without Tanglefoot, 2) and 8 mm gap, and two sizes of bridges that were 3) approximately 1 mm² × 30 mm and 4) approximately 2 mm diameter × 30 mm. Each series was analyzed as a Latin Square design, with artificial boles and time periods as separate effects (Cochran and Cox 1957, SAS Institute 1987).

RESULTS AND DISCUSSION

The percentages of larvae that actually found and climbed on the bole during the 1 hour tests were 87.7% for series 1 and 78.1% for series 2. Analyses indicated no effects of treatment, bole, or time period for finding the bole. Numbers that either walked down or silked down below the barrier band during the test period were very low (typically three or less out of 50–100) and typically occurred in the last 10–20 minutes of the test period; these categories were not statistically analyzed. Notable exceptions occurred in two trials, both control treatments in series 2. In these trials, 28 and 18 larvae moved below the duct tape-only

Table 1. Percentage of unfed first instar larvae crossing barrier bands.

Treatment	Series 1	Series 2
Tape only	93.5 a	82.4 a
High tunnel	46.6 b	—
8 mm gap	31.4 c	23.9 c
Low tunnel	5.8 d	—
4 mm gap	2.8 d	—
2 mm gap	0 d	—
Unbroken band of Tanglefoot	0 d	—
2 mm bridge	—	55.3 b
1 mm bridge	—	27.5 c

(SE = 2.5) (SE = 5.3)

¹ Numbers within a column followed by the same letter are not significantly different at a 0.05 comparison-wise error rate (LSD test).

bands by either walking or silking down. We suspect this behavior was promoted, at least in part, by crowding around the top edge of the bole. Apparently many of these larvae re-crossed the band walking upward which resulted in reporting of greater than 100% crossing during the test. Because of this anomaly, these two data points were entered as 100% crossing for purposes of analysis.

The frequency with which larvae were able to cross the band was calculated as a proportion of the numbers that actually found the bole during the tests (Table 1). There were significant treatment effects observed in both series of test (series 1: $F = 194.1$; $df = 6,30$; $P = 0.0001$; series 2: $F = 26.7$; $df = 3,6$; $P = 0.0007$). No bole effects were seen in either series. No time effect was seen in series 1, however the time effect was significant in series 2. This may have been due to some environmental factor or difference in handling of the group of egg masses used for tests.

The high tunnel and the 8 mm gap both allowed substantial numbers of larvae to cross the barriers (46.6% and 31.4%, respectively) (Table 1). In contrast, no larvae successfully passed through the 2 mm gap, which, based on measurements of the larvae, is wide enough to allow passage without touching the sticky material. Some larvae were observed entering the 2 mm gap,

sometimes as far as half their body length, and then backing out of the gap.

The comparison of bridges and the 8 mm gap indicated that a bridge of approximately 1 mm width reduced the effectiveness of the barrier bands as much as an 8 mm gap in the sticky material (Table 1). Doubling of the bridge width in this test allowed a two-fold increase in the proportion of larvae that crossed the barrier.

Bridges were more detrimental to the efficacy of barrier bands than were gaps and tunnels of similar size, based on those sizes tested in these experiments (Table 1). The 2 mm bridge allowed strikingly more neonates to cross than did the 2 mm gap and the low tunnel. It should be remembered that these test periods were limited to 1 hour. Since more time is available to larvae in the field it is reasonable to expect more individuals to cross bands having defects. This indicates the importance of frequent inspection and repair of these devices to optimize their performance.

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**COCCINELLA NOVEMNOTATA IN NORTHEASTERN NORTH AMERICA:
HISTORICAL OCCURRENCE AND CURRENT STATUS
(COLEOPTERA: COCCINELLIDAE)**

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Abstract.—A review of the literature documents that the native lady beetle *Coccinella novemnotata* Herbst (C9) was once common in the northeastern United States and Canada. Despite extensive recent fieldwork and surveys for coccinellids, only five collection records of C9 in the Northeast have been located since the mid-1980s. Its apparent decline in numbers and possible local extirpation could be the result of factors such as changes in land-use and cropping patterns, decline in aphid populations, parasitism, or disease. The factor most often suggested is possible adverse effects from the Old World *C. septempunctata* L. (C7), whose establishment in North America was detected in 1973. New World populations of C7 may have resulted from previous releases for the biological control of aphids or an unintentional importation with commerce. Without a cause-and-effect relationship having been established, proposed detrimental impacts of C7 on native coccinellids are based solely on anecdotal evidence and speculation. Even though C7 was extensively recolonized in North America by biological control specialists, the C7 project does not typify classical biological control. If C7 has had a negative effect on C9, it is more appropriately considered displacement of an indigenous species by a polyphagous nonindigenous species than an example of unintended effects of classical biological control.

Key Words: Insecta, lady beetles, biological control, faunal change

For several years we have realized that the native lady beetle *Coccinella novemnotata* Herbst (hereafter C9) has become increasingly difficult to find in the Northeast and may even be locally extirpated. One hypothesis proposed to account for its apparent decline in numbers is adverse effects from the establishment in North America of a more aggressive congener, the Old World *C. septempunctata* L. (hereafter C7).

In this paper we will demonstrate that *C. novemnotata* was once a widespread and sometimes abundant coccinellid in northeastern North America (Delaware, Maryland, and New Jersey north to Ontario and

Quebec) and that it has been collected only once during surveys and extensive fieldwork in the Northeast in the 1990s. Our intent is (1) to document what others have suspected: that C9 is no longer a common species in the Northeast; (2) to stimulate entomologists, ecologists, and conservation biologists to search for C9 populations in the Northeast and to deposit voucher specimens in major entomological collections; (3) to encourage workers in western North America, where C7 has become established more recently, to begin, or continue, to monitor populations of C9; and (4) to increase interest in documenting the effects of

adventive species—whether intentionally or unintentionally introduced—on indigenous species.

C7 IN NORTH AMERICA

The first U.S. releases of this well-known Old World coccinellid (e.g. Hodek 1973) were made by the U.S. Department of Agriculture (USDA) in California in 1957, based on material from India. Adults were recovered after a month but no further individuals were collected, and no eggs or larvae were observed. From 1958 to 1973, beetles from India, France, Italy, Norway, and Sweden were released (nearly 150,000) for aphid control in eastern and western states by the USDA (Angalet et al. 1979, Schaefer et al. 1987). In eastern Canada small numbers were released in New Brunswick during 1959–1960 (Clark et al. 1971, Schooley et al. 1984). A particular effort was made to establish C7 in Maine for suppression of potato-infesting aphids; about 80,000 individuals were released in test plots at Presque Isle (Shands et al. 1972). Although the F1 generation was recovered at several localities, these releases apparently did not lead to permanent colonization in the United States or Canada (Angalet and Jacques 1975, Angalet et al. 1979, Schaefer et al. 1987).

C7's detection in New Jersey (Angalet and Jacques 1975) and Quebec (Larochelle and Larivière 1979) in 1973 renewed interest in this predator and led to redistribution efforts during 1974–1978 (Angalet et al. 1979). More than 500,000 beetles were released in 20 states and the District of Columbia (Schaefer et al. 1987), and in Canada they were redistributed in Nova Scotia (Kelleher 1984). The beetle's natural dispersal from the area of detection in New Jersey was considered slow: by 1975 records were available only for 10 counties in Connecticut, New Jersey, and New York; its presence in Delaware was considered the result of recolonization (Angalet et al. 1979). But C7's rapid spread began to be documented (Hoe-

beke and Wheeler 1980). Natural spread, aided by successful recolonization in Georgia, Ohio, and Oklahoma, resulted in recoveries from 15 states by the end of 1979 (Schaefer et al. 1987 and references therein).

By 1986, C7 was established in 34 eastern and central states and in 5 Canadian provinces (Schaefer et al. 1987). In Iowa and Missouri this recently established predator was still less abundant than any of the native coccinellids found in croplands, abandoned fields, and roadsides (Obrycki et al. 1987).

Additional releases were planned for the western two-thirds of the United States (Comis and Heppner 1986). Detection of the Russian wheat aphid, *Diuraphis noxia* (Mordvilko), in Texas in 1986 (Stoetzel 1987) further emphasized the need to redistribute C7 in the West (Olkowski et al. 1990, Gordon and Vandenberg 1991). This project was led by the USDA-Animal & Plant Health Inspection Service's National Biological Control Laboratory in Niles, Michigan, and redistribution of C7 in four western states was initiated in 1989 (Flanders et al. 1993). It is now the most commonly collected species of *Coccinella* east of the Rocky Mountains (Gordon and Vandenberg 1991), one of the dominant coccinellids of agricultural crops in Michigan (Maredia et al. 1992), and is known from all 48 contiguous states (Prokrym et al. 1992; see also Rice 1992). In western Canada it occurs in the Prairie Provinces and in central British Columbia (Humble 1991, McNamara 1991). Gene diversity of North American populations is similar to that among Eurasian C7, such a broad genetic basis being characteristic of other successful adventive insects in the New World (Krafsur et al. 1992).

The origin of North American populations of C7 remains in doubt. It was first suspected that the beetles found at the Hackensack Meadowlands in New Jersey were associated with disposal of trash at sites near Kennedy International Airport (Angalet and Jacques 1975). C7's collection in

Quebec, however, suggested separate introductions with transoceanic commerce—along the St. Lawrence Seaway in Quebec and the Upper Bay of the Hudson River and at New Jersey ports of entry (Schaefer et al. 1987). Although an unintentional introduction with ship traffic remains a strong possibility (Schaefer and Dysart 1988, Day et al. 1994), an alternative hypothesis should be considered: that classical biological control releases of C7 made during 1958 to 1973 led to its establishment in the East (Schaefer et al. 1987). Studies of genetic diversity in North American populations have not discriminated between these two hypotheses (Krafsur et al. 1992).

C9 IN NORTH AMERICA

Widespread in North America, this native lady beetle ranges from Maine, Ontario, and Quebec to Florida and west to British Columbia and southern California (Dobzhansky 1931, Gordon 1985) and occurs in all northeastern states (Dobzhansky 1931, Procter 1946, Belicek 1976). In Canada it is found north to 46° in Quebec, 45°30' in Ontario, and 62° in the Northwest Territories (Brown 1962).

Recorded prey includes numerous aphid species (Thompson and Simmonds 1965), and in laboratory evaluations C9 fed more on aphids than on spider mites or lepidopteran eggs (Putman 1957). Larvae and adults similarly preferred aphids to larvae of the alfalfa weevil, *Hypera postica* (Gyllenhal), or leafhopper nymphs (Yadava and Shaw 1968). Although C9 has been considered an important natural enemy of the European corn borer, *Ostrinia nubilalis* (Hübner) (Sparks et al. 1966), more recent work indicates that predation on corn borer eggs is unimportant (Andow 1990). Feeding has also been observed at extrafloral nectaries (Putman 1964, Pemberton and Vandenberg 1993; see also van den Bosch and Telford 1964: Fig. 92).

C9 is especially common in gardens and

other cultivated lands (Leng 1903, Blatchley 1910, Stehr 1930, Chapin 1974, Belicek 1976), occurring in field crops such as alfalfa (Fluke 1925, Goodarzy and Davis 1958, McMullen 1967a, Neuenschwander et al. 1975; see also Hodek 1973), clover (Folsom 1909, Smith 1958), corn (Everly 1938, Bartholomai 1954, Smith 1971, Wright and Laing 1980), cotton (Bell and Whitcomb 1964, Whitcomb and Bell 1964, van den Bosch and Hagen 1966), potatoes (Leonard 1963, Day 1965, Mack and Smilowitz 1980), small grains (Kirk 1970, Shade et al. 1970, Bernal et al. 1993), and soybeans (Blickenstaff and Huggans 1962, Dumas et al. 1964, Tugwell et al. 1973). In Connecticut (Britton 1914) and Minnesota (Stehr 1930), C9 has been ranked as one of the coccinellids of greatest economic importance. C9 can also be collected on weeds in disturbed areas (e.g. McMullen 1967a, Richerson and DeLoach 1973, Dailey et al. 1978, Lago and Mann 1987, Maredia et al. 1992), as well as on apple (Smith 1958, LeRoux 1960, Oatman et al. 1964, Hagley 1975, Travis et al. 1978, Carroll and Hoyt 1984), peach (Putman 1964, Kirk 1970), conifers, and hardwood trees (Felt 1906, Smith 1958, Gagné and Martin 1968, Drooz 1985).

Detailed life history studies of C9 have not been conducted, although Burgess (1903) and Palmer (1914) provided information on fecundity and duration of life stages in the laboratory. Data on preoviposition period, fecundity, and longevity were obtained by McMullen (1967b) and duration of egg and larval stages by Gagné and Martin (1968). Studies on the sex ratio, weight, and size of adults have also been conducted (Smith 1966). Its relative abundance, seasonal history, adult behavior, and factors inducing diapause were studied in California (McMullen 1967a, b). This predator is apparently univoltine in Ontario (Gagné and Martin 1968) and bivoltine in Colorado (Palmer 1914). An important mortality factor may be parasitism by the Holarctic braconid *Dinocampus coccinellae* (Schränk)

(Hudon 1959, Richerson and DeLoach 1973).

Historical occurrence before establishment of C7.—C9 is referred to as frequent throughout Indiana (Blatchley 1910), one of the most abundant coccinellids in Oregon (Ewing 1913), common in Iowa prairies (Hendrickson 1930), and the most common species of *Coccinella* found in Minnesota and the Upper Mississippi Valley (Stehr 1930, Wingo 1952). Occurring statewide in North Carolina (Brimley 1938), South Dakota (Kirk and Balsbaugh 1975), and several northeastern states (see Table 1), C9 is included in many field guides and general references (e.g. Lutz 1948, Jaques 1951, Zim and Cottam 1956, Dillon and Dillon 1961, Swan 1964, Borror and White 1970, Swan and Papp 1972, Milne and Milne 1980, Arnett and Jacques 1981, Arnett 1985, Boyd 1991). In fact, C9 is used as the lead illustration for the coccinellid sections in Arnett (1968) and Borror and White (1970) and in 1989 was designated the official state insect of New York (see Hoffmann and Frodsham 1993). In addition, the USDA's *Cooperative Economic Insect (later Plant Pest) Report* contains numerous references to C9 on various crops. Examples of these state reports include: "Extremely active" on crimson clover, vetch, and cotton in Mobile Co., Alabama (Seibels et al. 1963); "extremely heavy feeding" on woolly apple aphid, *Eriosoma lanigerum* (Hausmann), on apple in Tallapoosa Co., Alabama (Webb et al. 1965); and the most abundant coccinellid in alfalfa (75–100/100 sweeps) in Lafayette Co., Arkansas (Boyer 1970). At one time C9 was routinely collected in the Northeast (Table 1; see also locality records in Dobzhansky 1931).

C9 in the Northeast, 1973–1985.—After C7's detection in North America, C9 continued to be collected in insect surveys in the Northeast during 1973 to 1985. From 1974 to 1978, C9 was scarce at the Hackensack Meadowlands, where C7 had become the dominant coccinellid, and it was also much less numerous than C7 at a near-

by site in Connecticut in 1978 (Angalet et al. 1979; see also Table 2). When C7's establishment was first reported in Pennsylvania, similar numbers of both coccinellids were obtained in limited sweepnet samples (Hoebeke and Wheeler 1980; Table 2). Two years earlier, large numbers of C9 had been found on apple in Pennsylvania (Travis et al. 1978; Table 2).

C9 was not found in surveys of managed, abandoned, and "organic" apple orchards in New York, Pennsylvania, Virginia, and West Virginia during 1983 and 1984, although C7 was present (Brown et al. 1988). Three specimens of C9, however, were collected in Jefferson Co., West Virginia, in 1982, 1984, and 1985 (2 in blacklight traps, 1 in an unsprayed orchard); this species has not since been collected on apple in Jefferson Co. (M. W. Brown, pers. comm. 1994). C9 also was not among the 10 coccinellid species, including C7, collected during a survey of corn insects in the Connecticut Valley of Massachusetts from 1982 to 1984 (Eaton 1984).

C9 in the Northeast since 1985.—We are aware of only five collections of C9 since 1985 (Table 3). One adult was collected at each of two localities in Maryland in 1986 during a survey of coccinellids associated with nursery stock from 1986–1988; C7, however, was taken at 87 of the 186 locations and was the most abundant of the 28 species collected (Staines et al. 1990). C9 has not been seen in Maryland since 1986 (C.L. Staines, Jr., pers. comm. 1994). Populations of the aphid *Cinara pilicornis* (Hartig) were monitored on spruce (*Picea* spp.) seedlings and transplants in a southcentral Pennsylvania nursery during 1987–1988, and two C9 adults were observed on 13 May 1987. But it was C7 that was the most abundant coccinellid associated with aphid-infested spruce (Wheeler 1989 and unpubl. data). In Delaware during a census of overwintering Coccinellidae in a 0.5 ha plot containing >1000 grass clumps, 27 C9 adults were found at Delaware City in winter 1987–

Table 1. Examples of historical occurrence of *Coccinella novemnotata* (C9) in Northeast before establishment of *C. septempunctata* (C7).

State/Province	Remarks	Reference
Connecticut	Common throughout state; of >30 coccinellid spp. recorded, among the 12 considered most economically important	Britton 1914
	Very common at Meriden	Johnson 1915
Maine	Scarce in Mount Desert Region	Procter 1946
Massachusetts	On white birch at Malden, feeding on aphid eggs, 1898	Burgess 1903
	Common on Nantucket Island	Johnson 1930
	Present in cranberry bogs	Franklin 1950
New Jersey	Common throughout state	Smith 1910
	Larvae, adults on <i>Hibiscus moscheutos</i> L.	Weiss and Dickerson 1919
	On <i>Oenothera biennis</i> L., feeding on aphids	Dickerson and Weiss 1920
	On <i>Asclepias syriaca</i> L., <i>A. tuberosa</i> L.	Weiss and Dickerson 1921
New York	Abundant on <i>Pinus rigida</i> Mill. at Karner (Albany Pine Bush)	Felt 1906
	A common species on Staten Island	Leng and Davis 1924
	4th in abundance of 8 coccinellid spp. on alfalfa at Ithaca: 8 adults collected during 10 min. of sampling; one of most abundant coccinellids at Ithaca	Pack 1925
	More localities listed than for any of the other 66 coccinellids recorded from state	Leonard 1928
	Present in small numbers on collards at Ithaca, 1957–1958; 1966–1968	Pimentel 1961, Root 1973
	2nd most numerous coccinellid on potatoes on Long Island, 1956–1958 (19% of family); sometimes abundant late June–early July	Leonard 1963, Day 1965
	On cruciferous crops on Long Island, 1960–1963	Sutherland 1966
	Present in low densities on alfalfa at Ithaca, 1966–1969	Pimentel and Wheeler 1973
	Present in 100-sweep samples of alfalfa in Columbia, Orange, and Steuben counties, May–Aug.; largest number/100 sweeps = 12 in Columbia Co., 15 July 1970	A.G.W., unpublished data
Ontario	Ranked 3rd in abundance among 9 most numerous coccinellid spp. in survey of forages, weeds, and trees; 13% of 2300 specimens collected, 1957	Smith 1958
	Ranked 6th of 10 coccinellid spp. collected, 1948–1960, on peach; 2.9% of 888 specimens identified	Putman 1964
	Represented 19.1% of coccinellids associated with establishment stage of red pine, 1964; numbers dropped drastically in 1965	Gagné and Martin 1968
	Represented 20% of coccinellids (6 spp.) on corn, 1963	Smith 1971
Pennsylvania	Very abundant on oak, feeding on <i>Archips semifera</i> (Walker)	Nichols 1971
Quebec	On apple at Rougemont, 1951–1955 and 1955–1957; predacious on aphids	LeRoux 1960, Parent 1967
	Known historically from 24 localities	Larochelle 1979
Vermont	Known historically from 25 collections	Parker et al. 1976

Table 2. Examples of occurrence of *Coccinella novemnotata* (C9) in Northeast, 1973–1985, after establishment of *C. septempunctata* (C7).

State/Province	Remarks	Reference
Connecticut	16 adults collected (vs. 175 for C7) during survey at Hammonasset, Aug. 1978	Angalet et al. 1979
New Jersey	Scarce at Hackensack Meadowlands, 1974–1978; C7 the most abundant of 17 coccinellid spp. occurring at site	Angalet et al. 1979
Ontario	Common in Pine Barrens On apple at Vineland, 1969–1974 On <i>Onopordum acanthium</i> L., 1976 “Never numerous” in corn, 1977–1978	Boyd and Marucci 1979 Hagley 1975 Judd 1978 Wright and Laing 1980
Pennsylvania	High population levels on apple, 1977; aided significantly in reducing aphid numbers Occasionally common on <i>Euonymus alatus</i> (Thunb.) Sieb. infested with <i>Aphis fabae</i> Scopoli, 1977 10 adults/300 sweeps of weeds in ruderal site (vs. 12 for C7), Harrisburg, 1979 Collected 4 times (vs. 5 for C7) on soybeans, 1980–1982 Larva reared from aphid-infested shoots of <i>Physocarpus opulifolius</i> (L.) Maxim., 1979	Travis et al. 1978 Wheeler and Stimmel 1979 Hoebeke and Wheeler 1980 Wheeler and Stimmel 1983 Wheeler and Hoebeke 1985
Quebec	Collected at 5 localities (vs. 43 for C7), 1979	Larochelle and Larivière 1980
Vermont	On apple in Chittenden Co., 1973–1974	Hauschild 1975

1988; this survey yielded 3000 C7 adults (P. W. Schaefer, pers. comm. 1993). In a study in Maine, C9 was the second most abundant coccinellid (C7 was most abundant) found in potato plots and the second most numerous lady beetle in barley plots adjacent to potato in 1992. C9 was not encountered in either crop in 1993 (F. A. Drummond, pers. comm. 1994), which could reflect normal year-to-year fluctuations in density rather than an actual decline in numbers.

No detections of C9 were made in the Northeast during 1993 coccinellid surveys conducted as part of the USDA's Cooperative Agricultural Pest Survey program. In Connecticut, an alfalfa field in each of 4 counties was sampled 6 times (400 sweeps/visit) from 10 June to 19 August and once in September; supplemental 200-sweep samples were taken at 16 sites in 4 counties during June to September (D. Ellis, pers. comm. 1993). New York surveys consisted of 1500 sweeps taken 4–5 times in alfalfa

or clover fields in each of 4 counties (1 was sampled only 3 times) from 15 July to 9 September; additional samples from forages and goldenrod were taken in 5 counties during August and September (J. J. Knodel, pers. comm. 1993). In Pennsylvania, 3 alfalfa fields in 3 counties were each monitored 6 times (400 sweeps/visit) from 18 June to 1 September; 52 additional fields or disturbed weedy sites were surveyed in 18 counties from June to August. Similar coccinellid surveys in various disturbed habitats in Pennsylvania (136 sites in 23 eastern counties) were also negative for C9 in 1994 (A.G.W., unpubl. data).

Moreover, C9 was not observed during an extensive survey for the adventive *Hippodamia variegata* (Goeze) in the Northeast in 1992. Nearly 600 adults of 8 coccinellid species, including 66 C7, were collected in 8 states (Wheeler 1993). We have not seen C9 in general collecting since 1985 or in our surveys of disturbed and relatively undisturbed habitats ranging from urban vacant

Table 3. Known records of *Coccinella novemnotata* (C9) in Northeast since 1985; see text for additional information on collections.

State	Remarks	Reference
Delaware	27 adults at Delaware City, winter 1987–1988	P. W. Schaefer, pers. comm.
Maine	Common on barley and potatoes in study plots at Presque Isle, 1992	F. A. Drummond, pers. comm.
Maryland	Two collections during 1986–1988: 1 adult on nursery stock in Allegany Co., another in Carroll Co.	Staines et al. 1990
Pennsylvania	Two adults on spruce transplants in Cumberland Co. nursery, May 1987	Wheeler 1989, unpubl. data

lots to pitch pine-scrub oak barrens, serpentine barrens, and shale barrens. No recent records of C9 were available in the insect collections that were checked: American Museum of Natural History, New York; Canadian National Collection, Ottawa; Carnegie Museum of Natural History, Pittsburgh; Cornell University, Ithaca, N.Y.; Florida State Collection of Arthropods, Gainesville; National Museum of Natural History, Washington, D.C.; Ohio State University, Columbus; Pennsylvania State University, University Park; University of Maine, Orono; and University of New Hampshire, Durham.

DISCUSSION

Adverse effects from the establishment of C7 is only one possible explanation for the apparent decline in C9 populations. Other factors that could be involved are changes in land-use and cropping patterns, decline in aphid densities, parasitism, disease, or even global warming. It is C7, however, that has been proposed most often as the likely cause of C9's decline.

Soon after C7's establishment in eastern North America, its possible detrimental effects on native coccinellids began to be noted. There was no evidence for C7's replacement of native coccinellids in Georgia within three years of its release and establishment for suppression of pecan aphids (Teddners and Angalet 1981), but by the early 1980s a possible "antagonistic relationship with *C. novemnotata* appeared to be

developing" in Ontario (W. Y. Watson, letter to A.G.W., 11 Feb. 1983). The need to evaluate the effects of the rapidly spreading C7 on the native coccinellid fauna became apparent (Schaefer et al. 1987). When field surveys were conducted during a three-year period in Maryland (186 localities), the once "very common" C9 was collected only twice. Competitive displacement by C7 was suggested as a reason for the apparent diminished numbers of C9 in Maryland (Staines et al. 1990). Ehler (1990) also emphasized C7's potential for affecting nontarget species (see also Evans 1991, Tedders 1992, Elliott et al. 1993, and Wheeler 1993). The seven-spotted lady beetle's possible effects on endangered lycaenid butterflies have recently been evaluated in Ohio. Although their population declines coincided with increases in C7 and this coccinellid fed on lycaenid eggs in the laboratory (Horn 1991), no field data are available to substantiate any adverse effect of C7 on these endangered lepidopterans.

Populations of C9 in the Northeast seem to have declined sharply during the 1980s and 1990s, a period when the Old World C7 was undergoing rapid range expansion. Our after-the-fact evidence for the adverse effects of C7 on C9 must be considered circumstantial. Populations of C9 were not monitored systematically during the time when C7 was becoming established in the Northeast and assuming dominance among coccinellids in disturbed and relatively undisturbed communities. Coccinellid densi-

its often fluctuate widely from year to year (e.g. Foott 1974, Elliott and Kieckhefer 1990, Kieckhefer and Elliott 1990, Elliott et al. 1993). Quantitative data from sampling at several sites over a 10- to 15-year period—beginning even before the establishment of C7 in the local fauna—would therefore be needed to assess accurately C7's role among various other factors that may be responsible for a decline in populations of C9.

Except in classical biological control of weeds programs, rarely are such quantified data available assessing the effects of adventive species on indigenous organisms; however, there are incomplete baseline data documenting the presence and abundance of C9. Literature references adequately support the view that C9 was once routinely collected or observed in the Northeast, often in considerable numbers. If C9 were still relatively common, it should have been detected during recent surveys for Old World coccinellids in the Northeast or in our extensive fieldwork involving agricultural crops, herbaceous weeds, shrubs, and trees since 1987. Adults of C9 are conspicuous because of their size (Britton 1914). Even though adults somewhat resemble those of C7, the two species are easily recognized. The head of C9 has a solid white rectangle instead of two white dots, and the anterior pronotal margin has a narrow white border, which is lacking in C7. C9's recognition in the East is not complicated by the pronounced color polymorphism that characterizes certain native or naturalized lady beetles in our fauna; only the fully maculate nine-spotted morph occurs in eastern North America (Belicek 1976, Gordon and Vandenberg 1991). As evidence for a recent decline in C9 populations, data from extensive fieldwork probably should be weighted more heavily than the absence of new material in collections (museum accessions sometimes are not processed for several years).

The seven-spotted lady beetle is a voracious, nearly ubiquitous aphidophage in the

Old World that can also be characterized as eurytopic, polyphagous, and ecologically plastic (Hodek 1973). The aggressive adults (see Miller 1992) will attack early-instar chrysopid larvae, even when other prey are available (Şengonca and Frings 1985). For a summary of studies on its foraging behavior, see Kareiva (1986) and Andersen and Kareiva (1993). C7 is an active flier and an aggressive colonizer that has become established on Sable Island, Nova Scotia, which is isolated in the Atlantic about 175 km from the nearest land (Schaefer et al. 1987), and also at high elevations (nearly 3500 m) in the Rocky Mountains (Rice 1992).

The only evidence available that C9 might be susceptible to interspecific competition is the possibility that its gradual disappearance from establishment-stage red pine in Ontario was the result of competition from other coccinellids (Gagné and Martin 1968). Competitive displacement and interspecific predation by C7, as well as pesticide use and changes in land management, could contribute to declining populations of C9 in the Northeast. Determining the precise nature of C7's detrimental effects on C9 would prove difficult.

C7's explosive colonization of North America provides an opportunity for evaluating the effects of an aggressive polyphagous predator on nontarget organisms. Ehler (1990) found "it difficult to believe that this introduction will not have an impact on non-target species in the United States," and Evans (1991) suggested that C7 "may have profound impact on the ladybeetle fauna native to North America through complex interactions of Old and New World ladybeetles." Indeed, uncommon coccinellids temporarily disappeared from cropfields in South Dakota following the invasion and establishment of C7 (Elliott et al. 1993), although C7 was not shown to be a direct cause of their decline; factors other than C7's establishment could be involved.

C9 is still common in parts of western

North America. In fact, its relatively high densities (and those of *Hippodamia convergens* Guérin-Ménéville) may have hindered or delayed C7's establishment in California (Flanders et al. 1993). At most, C9 may be only locally extirpated in the East. Workers in the Northeast and even the Southeast (C9 appears at least to have declined in Alabama and Mississippi during the past five years; P. M. Estes and R. L. Brown, pers. comm. 1994, 1995) are encouraged to look for this native species. Workers in areas where C7 is a more recent invader may want to begin, or continue (Elliott et al. 1993), to monitor its potential effects on C9 and other native coccinellids, as well as document a decline in populations of injurious aphids (see Kauffman and Schwalbe 1991). There is also a need to determine if other recently established Eurasian lady beetles—*Harmonia axyridis* (Pallas), *Hippodamia variegata*, and *Propylea quatuordecimpunctata* L.—are affecting native coccinellids in the East (see Day et al. 1994).

Most people will not be concerned if an introduced predator having superior attributes reduces pest populations more than do indigenous natural enemies. So many plant and animal species have been affected by the needs of human society (e.g. Soulé 1990) that a decline in numbers of one or a few native predators will be viewed as inconsequential. Local extirpation or extinction of C9 would elicit more concern.

It is likely that C9 will find habitats in which it can coexist with C7; such populations, as yet undetected, may exist in the Northeast. Its populations may again build to sizable levels. The current low densities of C9 in the Northeast may actually be similar to those that existed before the advent of agroecosystems, which facilitated increases in aphid numbers, allowing C9 perhaps to reach population levels greater than before human intervention.

The benefits of C7's presence in the Neartic fauna may outweigh any costs to the environment. Use of pesticides against an

important crop pest may actually pose more of an environmental threat than does the release of some biological control agent (e.g. Nechols et al. 1992). The establishment of C7 can be viewed as representing a continuum of ecological changes. We have discussed C7 as a principal factor contributing to a decline in populations of C9, although the evidence is speculative and anecdotal. But C7 may even be having positive effects on other nontarget organisms.

The importation of any biological control agent is an experiment. Most introduced species fail to become established, relatively few provide substantial suppression of target pests, and fewer still cause serious environmental problems (e.g. Hall and Ehler 1979, Hall et al. 1980, Samways 1988, Ehler 1990). Whether any environmental disruption associated with C7's establishment is considered acceptable should await the results of long-term ecological monitoring, preferably at sites where C7 and C9 do and do not co-occur, and critical evaluation of the accumulated quantitative data. Even then, an evaluation of the program to recolonize C7 in North America will be influenced by one's environmental, political, and social views.

SUMMARY AND CONCLUSIONS

Classical biological control has traditionally been favorably received by conservationists and environmentalists (Samways 1988) but is under increasing pressure from such groups (Howarth 1983, 1991, Nechols and Kauffman 1992, Simberloff 1992, Lockwood 1993, Miller and Aplet 1993, U.S. Congress 1993). We realize the introduction of biological control agents has been viewed as part of the larger problem of environmental disruption resulting from invasion of nonindigenous species (Howarth 1983, 1991, Samways 1988, Ehler 1990, 1991, Miller and Aplet 1993). Moreover, we support the need to analyze and evaluate biological control projects, but the data used and conclusions reached should have a

and scientific basis and avoid inference and speculation.

We cannot document a cause-and-effect relationship between the establishment of C7 and the decline of C9. What can be stated with reasonable certainty is that C7 has increased and, at the same time and in some of the same places, C9 has decreased. Proposed adverse effects of C7 on native coccinellids, such as *Hippodamia convergens* (Teddars 1992) and *C. transversoguttata richardsoni* Brown, are now based entirely on speculation.

That all forms of pest control—biological as well as chemical—pose some environmental risk is well known (Taylor 1955, Elton 1958, Turnbull and Chant 1961, Ehler and van den Bosch 1974, Beirne 1975, Pimentel et al. 1984, Carruthers and Onsager 1993, Drea 1993, Miller and Aplet 1993). Consequently, biological control practitioners generally, especially those involved with weeds, have attempted to minimize potential environmental problems (e.g. Zwölfer and Harris 1971, Harris 1973, Goeden 1983, Klingman and Coulson 1983).

It is tempting to look at the case of C7 and C9 within the context of classical biological control. Even though C7 was recolonized extensively by biological control specialists, this project does not typify classical biological control. Initially there was no target pest (e.g. Comis and Heppner 1986); only later was the Russian wheat aphid identified as the target aphid for redistribution. It is also uncertain whether the successful invasive genotype of C7 should be attributed to intentional releases in North America or to an accidental introduction with commerce. If C7 has indeed adversely affected C9, that interaction is more appropriately viewed as displacement of an indigenous species by a polyphagous, aggressive nonindigenous species. It should not be cited as an example of negative effects of classical biological control. Instead it reemphasizes the continuing need to assess host (and prey) specificity of all agents consid-

ered for release in classical biological control programs.

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**LIFE HISTORY AND LABORATORY REARING OF
HYDROMETRA HUNGERFORDI TORRE-BUENO
(HETEROPTERA: HYDROMETRIDAE) WITH
DESCRIPTIONS OF IMMATURE STAGES¹**

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Abstract.—The life history of *Hydrometra hungerfordi* Torre-Bueno was investigated in southern Illinois during April–November 1992 and 1993, and the immature stages were described. The bug was reared from egg to adult under controlled laboratory conditions. This apparently bivoltine species occurred along the stream banks on the water surface, root mats, and floating detritus. Adults overwintered in leaf litter and became active in April. Eggs were found in May, June, and July above the water level in root mats, tree snags, and associated detritus along the stream bank. Seasonal occurrences of adults and nymphs are discussed. Adults were last observed in early November. This species was reared under a 16L:8D photoperiod and $28 \pm 1^\circ\text{C}$. The incubation period averaged 8.81 days. Durations of the five nymphal stadia averaged 2.52, 2.48, 2.68, 3.39, and 4.68 days, respectively.

Key Words: Water measurer, Hydrometridae, southern Illinois, life history, laboratory rearing, immature stages, descriptions

The family Hydrometridae, which contains about 110 species and seven genera (Smith 1988) in three subfamilies (China and Usinger 1949, Smith 1988), occurs worldwide, although most species are found in the tropics and subtropics (Smith 1988). The largest of the subfamilies, Hydrometrinae, also occurs worldwide and includes the genus *Hydrometra*, the only genus found in America north of Mexico (hereafter referred to as North America). *Hydrometra* is represented in North America by seven to nine species; *H. australis* Say may be con-

specific with *H. martini* Kirkaldy, and the supposed occurrence of *H. lillianis* Torre-Bueno, reported only from California, may be in error (Polhemus and Chapman 1979).

Hydrometrids, commonly called marsh treaders or water measurers, are fragile-appearing stiltlike insects with long threadlike legs and antennae, slender bodies, and elongate heads. In North America, they are generally found on or near emergent or floating vegetation associated with still or slowly moving bodies of freshwater, but may move onto open water if disturbed. *H. australis* has occasionally been found in saltwater tide pools in Florida (Herring 1949) and in brackish ponds in Texas (Polhemus and Chapman 1979). Marsh treaders are predaceous, feeding on dead or dying insects

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and other microinvertebrates on or within the water film or on floating vegetation (Smith 1988).

Most of the North American species have a limited distribution, the exceptions being *H. martini*, *H. australis*, *H. wileyae* Hungerford, and *H. hungerfordi* Torre-Bueno. Not surprisingly, the species with the widest distribution, *H. martini*, is also the species that has been most intensively studied (Polhemus and Chapman 1979).

H. martini occurs from Quebec and Maine south to Florida and west to British Columbia, Oregon, and Arizona (Smith 1988). If *H. australis* is conspecific, then it has also been collected in California, Mexico to Central America, and the West Indies (Smith 1988).

The most thorough studies of *H. martini* are those of Hungerford (1920) and Sprague (1956). Sprague (1956), Polhemus and Chapman (1979), and Bennett and Cook (1981) provide excellent reviews of the earlier literature.

Adults of *H. martini* overwinter in trash surrounding the water, and emerge in early spring (Hungerford 1920). The eggs are about 2 mm long, slender, spindle shaped, sculptured, and stalked. They are laid singly on almost any object above the water surface, and each is affixed at the base of the stalk with a sticky secretion. Eggs are white at oviposition but soon darken.

There are five instars, as in most Heteroptera. Hungerford (1920) stated that the complete life cycle from egg to egg, under the most favorable conditions, was 15 days. Torre-Bueno (1905) and Polhemus and Chapman (1979) stated, respectively, that 25 to 35 days and 21 to 35 days was typical.

Adults generally live seven to nine months under laboratory conditions (Sprague 1956), although Torre-Bueno (1905) reported adults in his laboratory lived up to one year, and one lived 15 months.

H. martini has been reared in the laboratory under unspecified conditions (Martin 1900, Torre-Bueno 1905, Hungerford 1920,

Sprague 1956). The egg was first described and illustrated by Martin (1900); it and the instars were subsequently described and illustrated by Hungerford (1920) and Sprague (1956).

H. hungerfordi, as noted above, is also widely distributed. It occurs from Maine south to Florida and west to Kansas and Louisiana (Smith 1988). However little is known about its biology. It has been found in heavily shaded, cool, clear streams with little or no aquatic vegetation (Gonsoulin 1973, Harp 1985) and in slow moving streams, rivers, and swamps (Bobb 1974). Adults have been collected from May through August (Bobb 1974).

This paper presents information on the field life history in southern Illinois and laboratory rearing of *H. hungerfordi* and includes descriptions of the immature stages.

MATERIALS AND METHODS

Study site.—In summer 1991, a population of *H. hungerfordi* was discovered on Cooper's Creek in Alexander Co., IL. The numbers observed and accessibility of the site suggested a life history study was possible. Therefore, a study was conducted from spring 1992 to fall 1993.

The study site is located in the Mill Creek quadrangle 7.5' topographic (T145, R1W, N $\frac{1}{2}$ of N $\frac{1}{2}$ of NW $\frac{1}{4}$ of Sec. 6). Cooper's Creek at this point is classified as a third order stream (Horton 1945). The substrate consists of cobble and gravel with some sand. The width and depth at the center of the channel during spring 1993, when flow was greatest, averaged 6.0 and 0.6 m, respectively. During midsummer, as the water level receded, the stream was reduced to isolated pools. The banks were generally steep sided and undercut, with exposed root mats. Very little emergent vegetation was present. The site was bounded by a riparian zone containing *Acer negundo* L., *Betula nigra* L., *Celtis occidentalis* L., *Juglans nigra* L., *Ostrya virginiana* (Miller), *Prunus serotina* Ehrhart, *Carya cordiformis* (Wangen-

heim), *Staphylea* sp., *Ranunculus* sp., *Polygonum* sp., *Plantago* sp., *Cirsium* sp., and *Dicentra* sp. Much of this zone was limited to a width of 10–15 m on either side because of agricultural use of the surrounding land.

Life history.—Samples of 10 individuals (adults and/or nymphs) were taken weekly from early spring through early fall. Specimens were hand picked or, for early instars, collected with an aspirator. The few eggs collected (11) were not included in the counts. Adults were identified and released. Immatures were preserved in 75% EtOH and taken to the laboratory for closer examination and to determine the instars. Confirmation of instars was based on comparisons with laboratory reared specimens because published keys were not available for identification. Prey items were also preserved in 75% EtOH.

Laboratory rearing.—Ten pairs of adults were collected from the field and placed in 1 qt Mason jars (1 ♂, 1 ♀/jar). Each jar contained about 200 ml of distilled water and a section of Styrofoam (2 × 1.5 × 1 cm); this floating square provided an additional substrate for walking and served as an oviposition site. The jar was closed with wire screen and secured with the band of the 2-piece mason jar lid. Each pair was fed 5–6 frozen *Drosophila melanogaster* Meigen daily, and the carcasses were removed the following day.

The squares were examined daily for eggs. Eggs were removed and placed in covered petri dishes (about 9 cm diam, 2 cm deep) lined with moistened filter paper on the bottom; distilled water was added as needed to keep the paper moist. Each first instar was placed in a round plastic container (4 cm diam, 5 cm deep). Each container was filled with about 2 cm of distilled water. A wedge of Styrofoam (4 × 3 × 2 cm, 30° angle) was added to serve as an additional substrate for walking. The container was closed with standard fiberglass screening secured with a rubber band. As the immatures developed, molts were recorded and the exuviae re-

moved. First through third instars were fed 2 fruit flies, and fourth through fifth instars 3–4 fruit flies, daily. The containers were kept in incubators maintained at $28 \pm 1^\circ\text{C}$ and a photoperiod of 16L:8D (3 florescent "daylight" lamps, about 2800 lux). Distilled water was added to the mason jars and containers as needed to maintain water levels.

Descriptions of immature stages.—The description of each stage is based on 10 individuals. Eggs were selected from those deposited in the laboratory by field collected adults, first through fifth instars from field collected individuals. All had been preserved in 75% EtOH. Drawings were made with the aid of a camera lucida, measurements with an ocular micrometer. Dimensions are expressed in mm as $\bar{x} \pm \text{SE}$ (SE < 0.005 listed as 0.00).

RESULTS AND DISCUSSION

Life history.—*H. hungerfordi* overwinters as adults. The one adult (female) collected during the winter was found in leaf litter about 2 m from the water edge in early December 1992. Adults emerged in mid-April (Fig. 1A, B); air temperature when they first were observed (11 April 1992), based on data collected at the Anna, Alexander Co., weather station, ranged between 14 and 27°C during the 24 h. They were found continuously during the season near the banks on the detritus and root mats associated with the banks and undercut areas. They and nymphs were never observed in the open channel.

Copulating adults were found throughout the season. Precopulatory behavior was noted on eight occasions; at no time was the male observed to antennate the female. He usually approached her from the side until he was almost in contact and then reoriented until his body was parallel to hers. Upon contact, he would mount her from the side, grasp her with his pro- and mesothoracic legs, extend his genital capsule, and lower the tip of his abdomen to make contact with her genitalia. Pairs were observed in copulo-

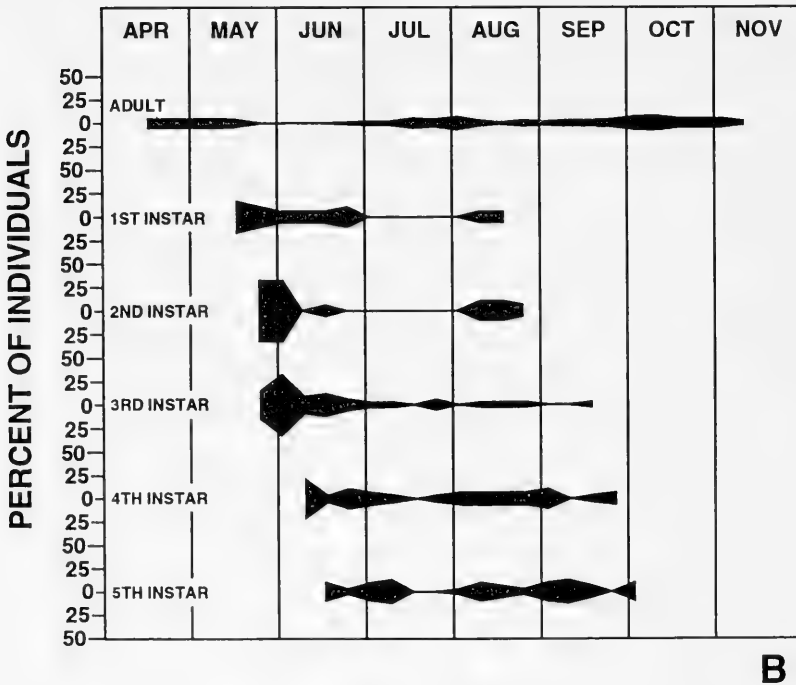
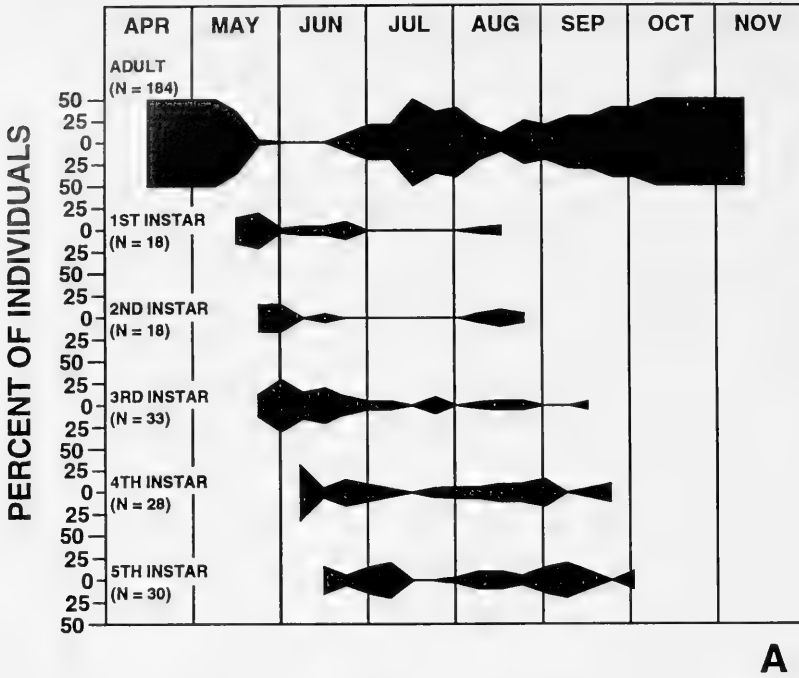


Fig. 1. Field life cycle of *Hydrometra hungerfordi*. A, Percent of individuals of each stage per sample during 1992 season in Alexander Co., IL. B, Percent in each sample of total individuals of same stage collected during the 1992 season in Alexander Co., IL.

up to 5–6 minutes. During this time, females would often move about and feed if prey were located. On one occasion, a copulating male was physically dislodged by another male. The second male then attempted, repeatedly, to mount the female. She prevented his attempts by dislodging him with her legs and finally left the area.

Eggs were found in early May (4), late June (2) and mid-July (5). They were laid on root mats, tree snags, and associated detritus. Generally, they were laid 6–10 cm above the water surface in dark, moist areas and always affixed to the substrate by the base of the egg.

First instars were found from mid-May to mid-August, second instars from late May to late August, third instars from late May to mid-September, fourth instars from early June to late September, and fifth instars from mid-June to early October (Fig. 1A, B).

First and second instars were often found in the back reaches of the undercut bank. If they were disturbed when in more exposed areas, they would invariably flee beneath the bank. Third, fourth, and fifth instars were generally found in the more open areas, but never far from the bank.

H. hungerfordi, as evidenced by the peaks in abundance of the adults and nymphs, is apparently bivoltine in southern Illinois (Fig. 1A, B).

Several prey items were noted during this study (Table 1). The hydrometrids were observed to actively capture small prey (i.e., collembolans), but only noted feeding on larger prey.

H. hungerfordi adults and nymphs were occasionally observed attempting to feed on nymphs. In one instance, an adult was noted antennating a third or fourth instar. It then extended its beak and attempted to probe the nymph, which then fled.

As *H. hungerfordi* walked across the surface film and floating detritus, it moved its antennae from side to side. When it encountered potential prey, it positioned its antennae over the specimen. If the speci-

Table 1. Feeding records of *Hydrometra hungerfordi* from a stream in Alexander Co., IL, in 1992 and 1993.

Taxon	No. of specimens
Collembola	
Isotomidae	
<i>Isotomurus palustroides</i> Folsom ^a	2
Entomobryidae	
<i>Entomobrya socia</i> Denis ^a	1
<i>Tomocerus flavescens</i> Tullberg ^a	1
Ephemeroptera	
Leptophlebiidae	
<i>Paraleptophlebia</i> sp. ^a	1
Coleoptera	
Dytiscidae	
<i>Hydaticus</i> sp. ^b	1
Diptera	
Culicidae	
<i>Anopheles crucians</i> Wiedemann ^a	1
Chironomidae	
<i>Polypedilum</i> sp. ^b	1
Cyprinodontiformes	
Fundulidae	
<i>Fundulus</i> sp. ^c	1

^a Adult.

^b Larva.

^c Egg.

men was acceptable, the beak was extended and used to probe and then pierce the prey. If the prey was small, the hydrometrid lifted the now impaled prey and, generally, carried it near or onto the stream bank.

The use of the antennae to locate prey has also been reported in other hydrometrid species by Andersen (1982). He noted an invagination at the apex of the fourth antennal segment bordered by modified hairs and suggested this area may have an olfactory function.

An encounter between an adult *H. hungerfordi* female and a lycosid spider was observed on one occasion. The spider grabbed and pulled the female towards its mouth and then immediately flung it away. The female was observed for about 10 minutes and appeared unharmed by the encounter.

Sprague (1956) felt there probably was little or no predation on adult *H. martini* because of the hard exoskeleton, fusion of

Table 2. Duration (in days) of each immature stage of *Hydrometra hungerfordi* under controlled laboratory conditions.

Stage	Number completing stadium	Range	$\bar{x} \pm SE$	Cumulative mean age
Egg ^a	181	8-10	8.81 \pm 0.05	8.81
Nymph				
1st instar	178	1-4	2.52 \pm 0.05	11.33
2nd instar	178	1-6	2.48 \pm 0.05	13.81
3rd instar	143	2-4	2.68 \pm 0.06	16.49
4th instar	103	2-5	3.39 \pm 0.08	20.88
5th instar	41	3-7	4.68 \pm 0.13	25.56

^a 200 eggs were laid.

body parts, and lack of thin intersegmental membranes.

H. hungerfordi usually flees when disturbed. If it is unable to do so, it often will drop to the surfaces of the detritus and root mats with the prothoracic legs and antennae directed anteriorly and the meso- and metathoracic legs directed posteriorly, all appendages in line with the body, and remain motionless. This behavior was noted on seven occasions. During these times, the animal was difficult to see.

Laboratory rearing.—Eggs were laid 2-3 cm above the water surface on the walls of the mason jars and on the upper surface of the Styrofoam. They were laid singly with the base of the stalk attached to the surface. The female would touch the tip of her abdomen to the surface and then slowly move away as she extruded the egg.

The egg was white when first laid, but darkened to light brown within eight hrs. Eye spots were visible within five days. The egg burster was visible one to two days later. The incubation period averaged 8.81 days (Table 2).

The first instar emerged through a longitudinal slit along one side at the cephalic end of the egg. Emerging nymphs were transparent except for their red eyes. They were observed feeding within three to four hours.

The first through fifth stadia averaged 2.52, 2.48, 2.68, 3.39, and 4.68 days, respectively (Table 2). The total developmen-

tal period averaged 25.56 days. Highest mortality occurred during the fifth stadium and resulted primarily from incomplete ecdysis.

Descriptions of immature stages.—*Egg* (Fig. 2A-D): Length, 1.90 \pm 0.02; width, 0.28 \pm 0.01. Egg fusiform; comprised of distal micropylar projection, central region, and basal pedicel. Eggs laid singly, glued at base of pedicel to living or dead plant material; white at oviposition, becoming gold to brown during maturation. Chorion of micropylar projection and of most of pedicel with scalelike sculpturing; each scale apparently with several pores. Apex of micropylar projection with single micropyle. Central region with alternating ridges and furrows.

Nymphal instars: The first instar is described in detail, but only major changes from previous instars are described for subsequent instars. Length is measured from tip of head to tip of abdomen, width across pronotum. Additional measurements are given in Table 3.

First instar (Fig. 3A): Length, 1.70 \pm 0.07; width, 0.24 \pm 0.01. Body slender, elongate, greatest width at prothorax; general ground color of head and thorax light brown dorsally and laterally, yellowish to white ventrally; ground color of abdomen usually yellowish to white on all surfaces; ecdysial line evident dorsomedially, yellowish white, arising at posterior margin of head, bifurcating near anterior margin of eyes; body sparsely setose dorsally and laterally,

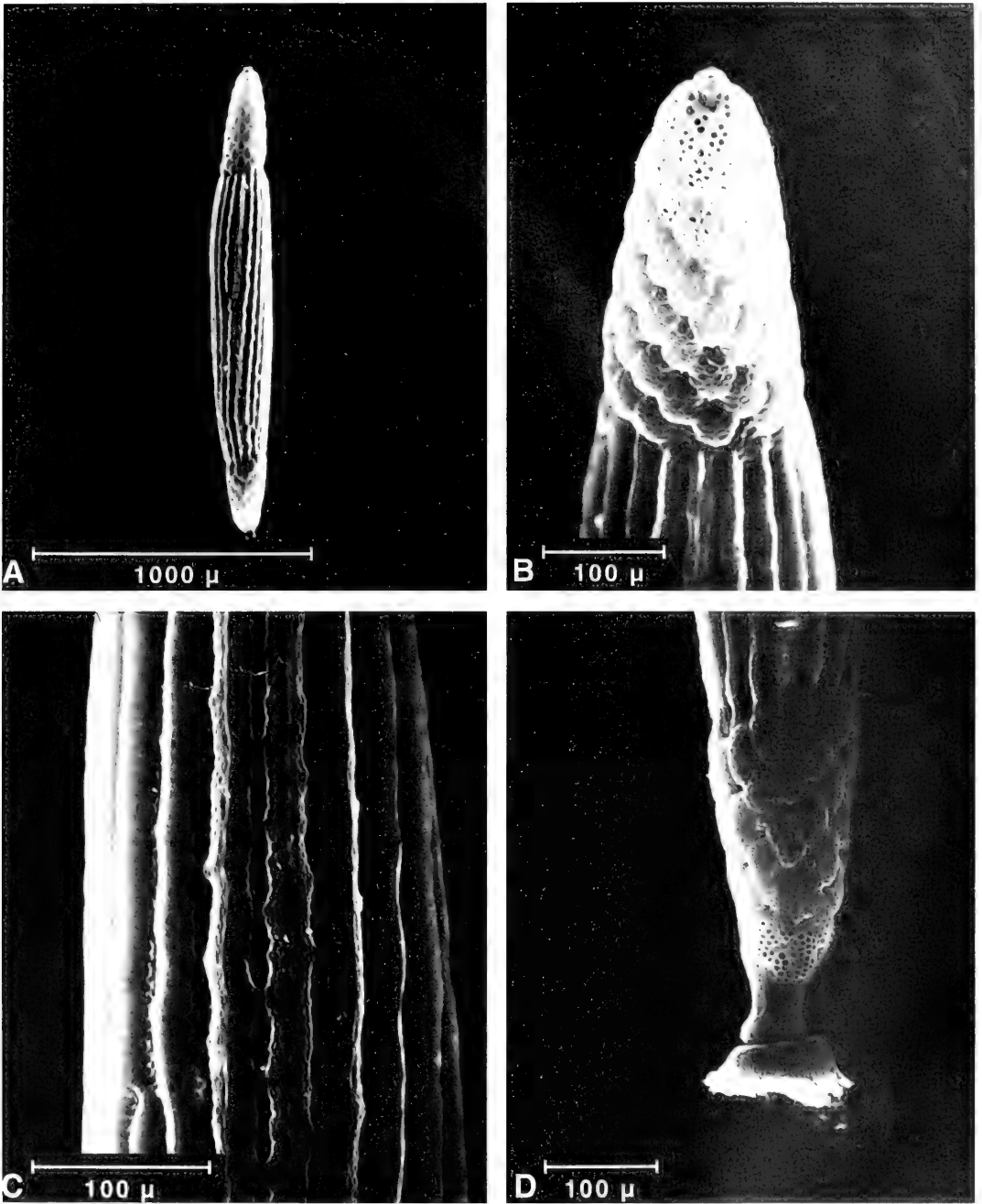


Fig. 2. Scanning electron micrographs of egg of *Hydrometra hungerfordi*. A, Egg. B, Micropylar region. C, Central region, D, Basal region.

more heavily setose ventrally except on head posteroventral to eyes where setae are absent.

Head sclerotized, elongate, narrow; an-

teocular area subrectangular, constricted just anterior to eyes, area about 1.4× length of postocular area; postocular area narrowing anteriorly. Anteclypeus rectangular, sub-

Table 3. Measurements (mm)^a of *Hydrometra hungerfordi* instars^b.

	Nymph				
	1st instar	2nd instar	3rd instar	4th instar	5th instar
Body length ^c	1.70 ± 0.07	2.31 ± 0.10	3.54 ± 0.13	5.46 ± 0.15	7.97 ± 0.10
Head length ^c	0.61 ± 0.01	0.85 ± 0.02	1.11 ± 0.01	1.67 ± 0.03	2.45 ± 0.03
Anteocular	0.28 ± 0.01	0.43 ± 0.01	0.63 ± 0.01	0.95 ± 0.02	1.47 ± 0.02
Postocular	0.20 ± 0.00	0.28 ± 0.01	0.44 ± 0.02	0.54 ± 0.01	0.76 ± 0.01
Width across eyes	0.23 ± 0.00	0.25 ± 0.01	0.30 ± 0.01	0.35 ± 0.01	0.43 ± 0.01
Synthlipsis	0.09 ± 0.00	0.09 ± 0.00	0.10 ± 0.00	0.11 ± 0.01	0.12 ± 0.01
Antennal segs.					
1st	0.14 ± 0.00	0.18 ± 0.00	0.22 ± 0.00	0.30 ± 0.00	0.38 ± 0.01
2nd	0.19 ± 0.00	0.29 ± 0.01	0.39 ± 0.01	0.56 ± 0.01	0.80 ± 0.01
3rd	0.73 ± 0.02	1.06 ± 0.01	1.45 ± 0.02	1.88 ± 0.02	2.42 ± 0.00
4th	0.86 ± 0.01	0.99 ± 0.01	1.13 ± 0.01	1.26 ± 0.01	1.41 ± 0.01
Notal lengths ^c					
Pronotum	0.17 ± 0.01	0.20 ± 0.01	0.28 ± 0.00	0.44 ± 0.00	0.74 ± 0.01
Mesonotum	0.14 ± 0.01	0.21 ± 0.01	0.30 ± 0.01	0.40 ± 0.01	0.42 ± 0.01
Metanotum	0.07 ± 0.00	0.09 ± 0.00	0.10 ± 0.01	0.23 ± 0.01	0.52 ± 0.01
Width at pronotum	0.24 ± 0.01	0.26 ± 0.01	0.28 ± 0.01	0.34 ± 0.01	0.40 ± 0.01
Abd. length	0.71 ± 0.06	0.96 ± 0.10	1.75 ± 0.12	2.72 ± 0.12	3.84 ± 0.09
Leg lengths					
Profemur	0.56 ± 0.01	0.79 ± 0.01	1.09 ± 0.01	1.48 ± 0.03	2.16 ± 0.03
Protibia	0.74 ± 0.01	1.04 ± 0.01	1.43 ± 0.02	1.93 ± 0.02	2.74 ± 0.02
Protarsus	0.27 ± 0.00	0.30 ± 0.01	0.36 ± 0.01	0.44 ± 0.01	0.59 ± 0.01
Mesofemur	0.58 ± 0.01	0.85 ± 0.01	1.18 ± 0.01	1.66 ± 0.03	2.45 ± 0.02
Mesotibia	0.78 ± 0.01	1.12 ± 0.01	1.56 ± 0.01	2.12 ± 0.03	3.02 ± 0.02
Mesotarsus	0.27 ± 0.00	0.31 ± 0.00	0.39 ± 0.01	0.48 ± 0.01	0.64 ± 0.01
Metafemur	0.78 ± 0.01	1.15 ± 0.02	1.49 ± 0.12	2.19 ± 0.04	3.14 ± 0.03
Metatibia	1.08 ± 0.02	1.60 ± 0.03	2.23 ± 0.02	3.07 ± 0.05	4.33 ± 0.03
Metatarsus	0.27 ± 0.00	0.31 ± 0.01	0.38 ± 0.01	0.47 ± 0.01	0.62 ± 0.01

^a $\bar{x} \pm SE$.

^b Based on 10 individuals per instar.

^c Measured at midline.

truncate apically, extending beyond bases of antennae. Area ventrolateral of anteclypeus and anterior to antennal sockets not readily divisible into maxillary plate and ventral lobe. Labrum narrow, transverse, located just anterior to anteclypeus. Beak 4-segmented; segments 1 and 2 short, narrow, subequal in length; segment 3 longest of segments, about 6.0 × length of segment 1 and 2 combined; segment 4 about 0.4 × length of segment 3. Eyes red, granular, located laterally about midway along length of head. Three pairs of trichobothria; first pair at base of anteclypeus close to midline, second pair dorsolateral and posterior to antennal bases; third pair dorsolateral, near

posterior margin of head; each trichobothrium arising from tubercle. Antennae 4-segmented, filiform, segment 4 slightly fusiform distally; segment 1 shortest; ratio of antennal segment lengths about 1:1.3:5.1:6.

Thoracic nota sclerotized; middorsal, longitudinal ecdysial line continuous with that of head. Pronotum quadrangular; anterior margin overlapping posterior margin of head; posterior margin straight laterally, convex medially. Mesonotum at midline about 0.8 × length of pronotum; subquadrangular; posterior margin slightly convex. Metanotum at midline about 0.5 × length of mesonotum; rectangular; posterior margin slightly concave. Thoracic pleura visa-

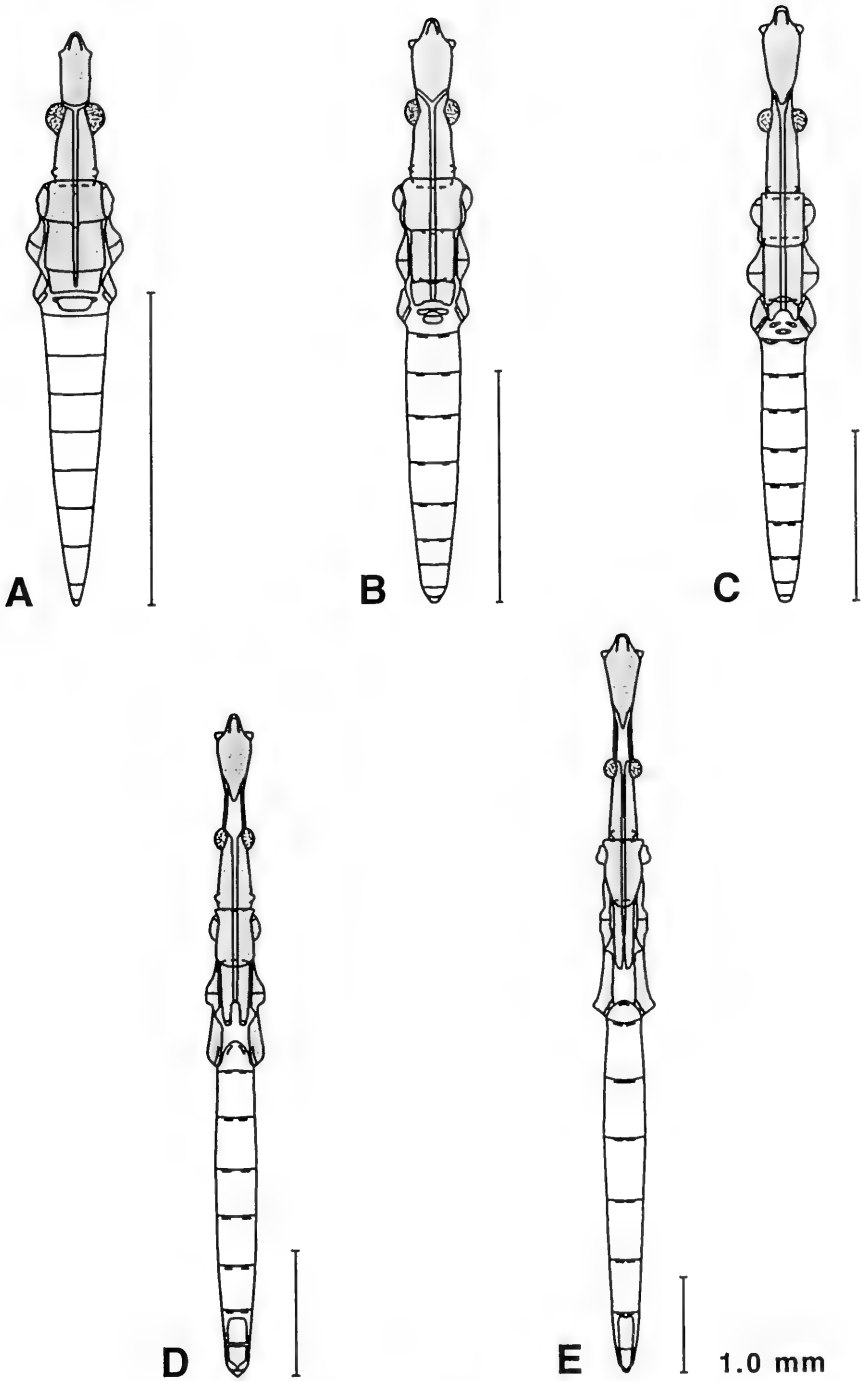


Fig. 3. Nymphal stages of *Hydrometra hungerfordi*. A, First instar. B, Second instar. C, Third instar. D, Fourth instar. E, Fifth instar.

in dorsal view, particularly those of meso- and metathoraces; each pleuron divided by suture into episternum and epimeron. Thoracic sterna lightly sclerotized; sclerotization best developed on prosternum; prosternum narrowest of thoracic sterna. Thoracic spiracles present; spiracle 1 present on proepisternum adjacent to intersegmental line; spiracle 2 present on mesoepisternum near intersegmental line.

Legs light brown; coxae subconical; trochanters cylindrical; femora, tibiae, and tarsi slender, elongate, each increasing in length on pro-, meso-, and metathoraces, respectively; tarsi 1-segmented, each terminating in two claws.

Abdomen yellowish to white, occasionally with red, red often present as dorsolateral stripes; tergum 1 with subtrapezoidal tergal plate; terga 2–6 membranous; terga 7–10 with dorsal surface sclerotized, sclerotization on terga 9–10 occasionally extending to and including ventral surface. Sternum 1 intimately associated with metasternum; sterna 1 and 2 not readily distinguishable from each other; sterna 3–8 membranous; sterna 9–10 membranous or sclerotized. Spiracles present on segments 1–8; those on segment 1 located dorsolaterally, those on segments 2–8 ventrolaterally.

Second instar (Fig. 2B): Length, 2.31 ± 0.10 ; width, 0.26 ± 0.01 . Antecular area widest at antennal bases, narrowest just anterior to eyes; about $1.5 \times$ length of postocular area; postocular area narrowest at posterior margin of eyes, widening to base of head; area ventrolateral of anteclypeus partially divided into maxillary plate and ventral lobe; maxillary plate adjacent to anteclypeus, dorsal to ventral lobe. Ratio of antennal lengths about 1:1.6:5.9:5.5.

Pronotum with posterior margin subtruncate, overlapping anterior margin of mesonotum. Mesonotum at midline about $1.1 \times$ length of pronotum; rectangular; posterior margin subtruncate, overlapping anterior margin of metanotum. Metanotum at midline about $0.4 \times$ length of mesonotum;

rectangular, posterior margin more concave; wing pads evident at posterolateral corners.

Abdominal tergum 1 with 2 sclerotized plates; anterior plate narrow, transverse, constricted medially; posterior plate transverse, elliptical. Terga 2–7 with paired small, transverse, linear plates adjacent to intersegmental lines.

Third instar (Fig. 3C): Length, 3.54 ± 0.13 ; width, 0.28 ± 0.01 . Antecular area about $1.4 \times$ length of postocular area. Area ventrolateral to anteclypeus divided into maxillary plate and ventral lobe. Area posteroventral to eyes with few, scattered setae. Ratio of antennal segment lengths about 1:1.8:6.5:5.1.

Pronotum narrower, rectangular. Mesonotum at midline about $1.1 \times$ length of pronotum; rectangular; posterior margin concave; wing pads well developed, slightly overlapping metanotum. Metanotum at midline about $0.3 \times$ length of mesonotum; posterior margin strongly concave; wing pads well developed.

Abdominal tergum 1 with 3 sclerotized plates; first 2 as anterior pair, small, oblique; third plate posterior, transverse, elliptical.

Fourth instar (Fig. 3D): Length, 5.46 ± 0.15 ; width, 0.34 ± 0.01 . Ecdysial line still linear posterior to eyes, broader between and anterior to eyes to basal $\frac{1}{4}$ of antecular length before bifurcating. Setae more numerous posteroventral to eyes. Antecular area about $1.8 \times$ the length of postocular area. Ratio of antennal segment lengths about 1:1.9:6.3:4.2.

Pronotum with posterior margin rounded, slightly overlapping mesonotum. Mesonotum at midline about $0.9 \times$ length of pronotum; wing pads well developed, extending over and usually covering metanotal wing pads. Metanotum at midline about $0.6 \times$ length of mesonotum; sclerotized or membranous; wing pads often hidden by mesonotal wing pads, occasionally exposed apically.

Abdominal tergum 1 with 3 sclerotized

plates; first two as anterior pair, small, oblique; third plate posterior, weakly developed or absent. Abdominal terga 1–6 with continuous, white, mediolongitudinal stripe bordered on either side by red stripe. Tergum 7 with rectangular, sclerotized plate. Tergum 8 with medial projection on posterior margin of sclerotized plate; projection generally larger in females. Sternum 8 occasionally with small, medial plate of variable shape.

Fifth instar (Fig. 3E): Length, 7.97 ± 0.10 ; width, 0.40 ± 0.01 . Body more setose. Anteocular area about $1.9 \times$ length of postocular area. Ventral lobe more developed, reaching beak segment 1. Ratio of antennal segment lengths about 1:2.1:6.4:3.7.

Pronotum with posterior $\frac{1}{3}$ narrowing posteriorly, rounded apically. Mesonotum at midline about $0.6 \times$ length of pronotum; wing pads covering metanotal wing pads. Metanotum at midline about $1.2 \times$ length of mesonotum; membranous other than wing pads.

Tergum 8, in males, with dorsomedial projection that does not exceed tip of abdomen. Tergum 9 narrow, collarlike, extending and widening laterally where it reaches abdominal sternum 9. Sternum 7 with pair of longitudinal, rectangular plates. Sternum 8 with quadrangular plate, no split present. Sternum 9 large, cuplike. Sternum 10 either lost or associated with formation of ventral side of proctiger.

Tergum 8, in females, with dorsomedial projection that extends to or beyond abdominal tip. Sternum 7 with pair of longitudinal, rectangular plates. Sternum 8 with quadrangular plate that reaches lateral margin; plate with mediolongitudinal split; split varying from complete to limited to distal $\frac{1}{2}$, widening posteriorly. Sternum 9 with pair of small quadrangular plates; plates continuing laterally and dorsally as sclerotized ring. Sternum 10 either lost or associated with formation of ventral side of proctiger.

Diagnosis. — The five nymphal instars, in addition to size, can be readily separated by

the relative proportion of the anteocular and postocular areas; presence or absence, and degree of development, of wing pads; and length of metafemora. There is a progressive increase of the anteocular area relative to the postocular area through all the instars. Wing pad development becomes apparent in the second instar with progressive development in the subsequent instars: mesonotal wing pads begin to overlap the metanotum in the fourth instar and completely cover the metanotal wing pads by the fifth instar. Finally, all leg segments progressively increase in length through the instars, but increase is most readily seen in the metafemur.

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NOTE

Distribution of *Harmonia axyridis* (Pallas) (Coleoptera: Coccinellidae) in North Carolina and Virginia

The multicolored Asian lady beetle, *Harmonia axyridis* (Pallas), was first reported to be established in the United States in Louisiana and Mississippi (Chapin and Brou. 1991. Proceedings of the Entomological Society of Washington 93: 630-635). This entomophagous lady beetle feeds on a wide variety of aphids, especially arboreal aphids, as well as some coccids and other insects (Teddars and Schaefer. 1994. Entomological News 4: 228-243). *Harmonia axyridis* was released in the United States as early as 1916 in California, and between 1978 and 1982, large numbers were released in the United States and Canada. The majority were released along the Atlantic Seaboard, including over 87,000 released near Byron, Georgia for control of aphids on pecan, but releases were also made in Louisiana, Mississippi, and Washington state (L. R. Ertle, in litt.).

The first collections of *H. axyridis* in North Carolina occurred in the fall of 1992. Reports of lady beetles aggregating on and inside houses, churches, and other structures were received through the Cooperative Extension Service, North Carolina State University. Specimens were subsequently identified by D. L. Stephan of the Plant Disease and Insect Clinic, NCSU. By December, reports had been received from 7 counties, all but one of which is in the mountain or western piedmont region of the state (Fig. 1). During the spring and summer of 1993, individual beetles were collected, coincidental with other field work, on a variety of host plants and at lights in 7 counties in NC. Fall aggregations had been reported from 2 of these counties, Cleveland and Clay (Fig. 1). Host plants in North Carolina included thistle (*Cirsium vulgare*) (Savi) Tenore, ironweed (*Vernonia* sp.), *Erigeron*

strigosus Muhl. ex Willd., dock (*Rumex* sp.), wheat (*Triticum* sp.) and cotton (*Gossypium* sp.). Unidentified aphid species were seen on wheat and dock, but insect hosts were not always found associated with the lady beetles. The beetles may have been feeding on nectar from floral or extrafloral nectaries or pollen; these substances are commonly fed upon by coccinellids (Hagen. 1962. Annual Review of Entomology 7: 289-326). First reports of aggregations in Virginia came from Lee County in January 1993. *Harmonia axyridis* was collected 3 August 1993 in alfalfa during a coccinellid survey in Augusta County, VA. This is approximately 375 km (as the crow flies) from the first collection reported in Virginia. Lady beetles were also observed feeding on *Myzus persicae* (Sulzer) on tobacco (*Nicotiana* sp.) in Nottoway County, VA.

In anticipation of fall 1993 aggregations, county offices of the North Carolina Cooperative Extension Service were contacted and asked to report activity. Initial reports were received from the western counties in mid-October and continued through the end of November, with activity shifting from west to east. On Monday 18 October, county agents from Macon County, NC to Rappahannock County, VA (a distance of about 630 km) were inundated with reports of aggregations that suddenly appeared the previous day. In the piedmont regions noticeable activity began 25 October in VA and 30 October in NC. Although to date beetles have been reported in eastern VA (to 76°30'W longitude), no reports have been received from east of about 78°W in NC.

Based on reports of homeowners and other observers, aggregating lady beetles came suddenly in large numbers, and landed on buildings, apparently searching for suitable

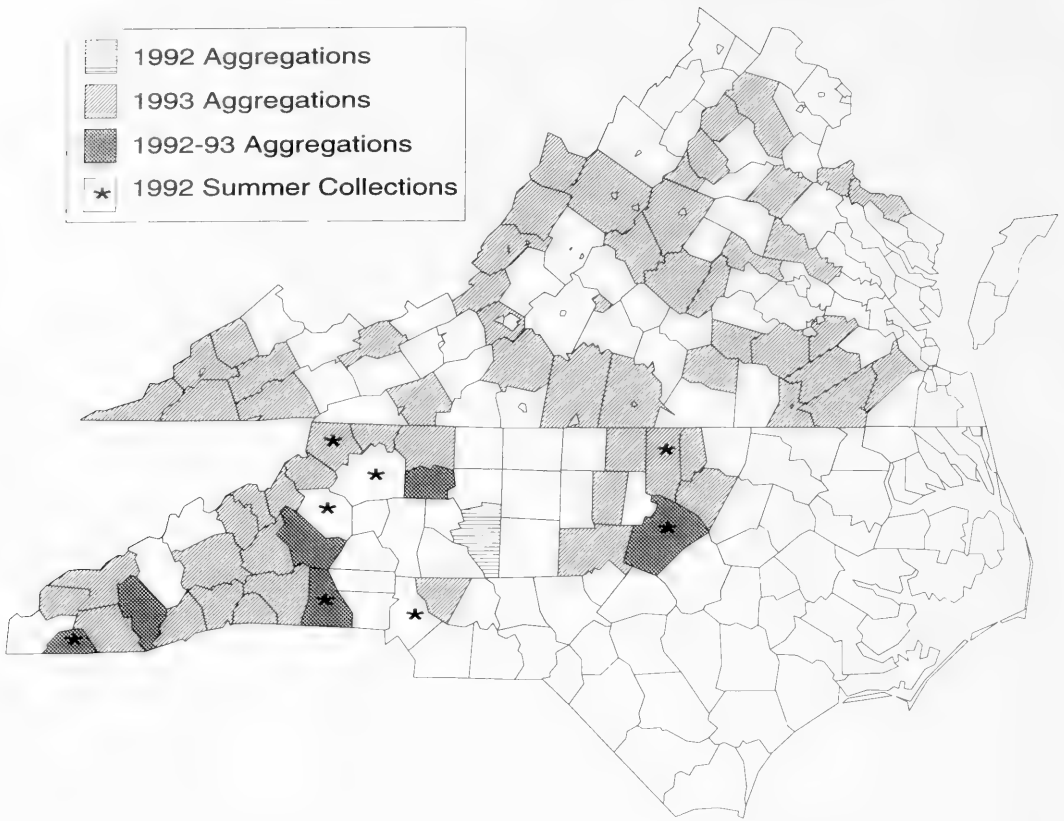


Fig. 1. Distribution of *Harmonia axyridis* Pallas in Virginia and North Carolina, 1992–1993.

overwintering sites. After the initial appearance, most of the beetles disappeared within a short time, but others were seen on walls or windows for several days, becoming active as the temperature warmed during the day. In Alleghany County, NC, a man was packing his car 17 October, which required periodic trips into his house. In an interval of about 15 minutes, the white doors of a two-car garage became covered with “20–40,000” beetles. He continued packing and watched the beetles. Within 1.5 hours, most beetles had left, but their ultimate destination was unknown. A few were observed inside the garage and on the outside trim 26 October. A woman in Henderson County, NC, described the activity as “like a swarm of bees” as the beetles left a stand of large white pines to the east of her house.

Beetles were most often found on light-colored walls and trim or on reflective surfaces such as large windows. Usually they were found on the southwest, west, or south-facing sides of buildings, which were the sunniest areas during the warmer afternoon hours. A few of the houses where *H. axyridis* aggregated were close to others in subdivisions or residential areas, but often were on a rise or hill and isolated with open spaces on one or more sides. Reported overwintering sites included: inside houses on vaulted or cathedral ceilings, under doorframes, in insulated attics, behind molded plastic shutters on houses, in soffit vents, and in root cellars. The beetles are able to get into small cracks and crevices, and undoubtedly overwinter in many other places, undetected. In Japan, *H. axyridis* reportedly over-

winters in many places including the cracks and crevices of rocks on mountains, with a tendency to go toward white or light colored objects (Obata, 1986, Kontyu 54: 218–223). Tedders and Schaefer (1994) showed that white traps were more effective at attracting this species than dark, less reflective colors. We observed a variety of plants associated with the aggregation sites, with white pines, loblolly pines, Fraser firs, and apple trees found most frequently.

This species is polymorphic with melanic and non-melanic forms (Komai, 1956, *Advances in Genetics* 8: 155–188, Ayala, 1978, *Scientific American* 239: 56–69). All *H. axyridis* collected in North Carolina were the non-melanic form, and elytral color varied from brick-red to brownish-yellow. Elytral spots varied in number from 0 to 20 and in size from small dots to large, sometimes fused spots. This supports the findings of Chapin and Brou (1991) in Louisiana and Mississippi, and Tedders and Schaefer (1994) in Georgia, Florida, Alabama, and South Carolina populations.

Since the first reports of *H. axyridis* in NC and VA, the lady beetle has become widespread across these states. We can only assume that it will continue to spread throughout both states within a few years. With its wide host range and preference for arboreal aphids, it has the potential to provide beneficial biological control, but its

habit of aggregating inside houses and other buildings is viewed by many residents to be a nuisance.

Acknowledgments: We thank the numerous county agents of the Cooperative Extension Service who assisted in the collection of beetles and information and the many homeowners who shared anecdotes and allowed us to collect in their homes.

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Note Added in Proof

In the summer of 1994, adults of *H. axyridis* were found in cotton fields in the coastal plain (Perquimans County in the northeast and Onslow County in the southeast) of North Carolina. In the fall of 1994, aggregations were reported in the western two-thirds of the state, but activity remains highest in the far western counties. Based on the estimates of homeowners, aggregating beetles were more numerous than in the past.

NOTE

Validation of *nomina nuda* of Nearctic Tethinidae,
Scathophagidae, and Muscidae proposed in Manual of
Nearctic Diptera

In the *Manual of Nearctic Diptera*, Volume 2 (1987), I proposed several new generic and specific names that were not then validated. Three were combinations of new generic and new specific names (one in Tethinidae, two in Scathophagidae), which were not validated with the term "n.g., n.sp." or the equivalent, as required by Article 13(c) of the International Code of Zoological Nomenclature. One was a specific name in the Muscidae. These names are validated here and type material is recorded where appropriate.

Four additional new generic names were proposed for four previously described species of Scathophagidae. As distinguishing characters for each genus were given in the key to genera, and as only one species was referred to each, the requirements of Article 13(a)(i) and 68(d) of the Code were met and the generic names were validated at the time of their publication. They are listed below to draw attention to them and, in one case, to give distribution records not cited in the 1965 catalog (*A catalog of the Diptera of America north of Mexico*, USDA Handbook 276). Acronyms for depositions cited in this paper are BMNH (British National History Museum, London); CAS (California Academy of Science, San Francisco); CNC (Canadian National Collection, Ottawa); LACM (Los Angeles County Museum, Los Angeles, California); and USNM (United States National Museum of Natural History, Washington, D.C.).

Tethinidae

***Masoniella richardsi* Vockeroth,**
NEW GENUS, NEW SPECIES

Masoniella richardsi Vockeroth, 1987: 1075
[*nomina nuda*; differentiating characters

for the genus and species are indicated in key to genera (p. 1075) and are illustrated (Figs. 101.2, .8, .9, .13, and .14)].

Specimens examined.—Holotype ♂, Healdale [San Bernardino Co.], Cal., 18.V.1955 (W.R. Richards) (CNC). Paratypes (36 ♂, 22 ♀; BMNH, CAS, CNC, LACM, USNM); same data as holotype (5 ♂); same locality and date as holotype but collected by W. R. M. Mason (5 ♀). California. Inyo: China Ranch, 30.V.1955 (J. Belkin et al.) (9 ♂, 3 ♀). Los Angeles: Duarte, 20.XI.1950 (N. Ehmann) (21 ♂, 13 ♀). San Bernardino: Victorville, 16.V.1995 (W. R. M. Mason) (1 ♂, 1 ♀).

Distribution.—USA. California (Inyo, Los Angeles, and San Bernardino counties).

Etymology.—The genus (feminine) and species are named in honor of my former colleagues W. R. M. Mason and W. R. Richards both of whom, although students of Hymenoptera and Homoptera respectively, consistently collected large numbers of Diptera.

Scathophagidae

***Dromogaster incompta* Vockeroth,**
NEW GENUS, NEW SPECIES

Dromogaster incompta Vockeroth, 1987:
1096 [*nomina nuda*; differentiating characters for the genus and species are indicated in key to genera, p. 1096].

Specimens examined.—Holotype ♂, Bilby, Alta., June 1, 1924, D. Bryant (CAS). Paratypes (CAS, CNC, USNM): same data as the holotype (2 ♂, 2 ♀). CANADA. Alberta: 14 mi W. Banff (4500'), 11.VIII.1955, J. R. McGillis (5 ♀). Saskatchewan: Attons Lake, Cut Knife, 3.VI.1940, A. R. Brooks (1 ♀).

Distribution.—Canada. Alberta, Saskatchewan.

Etymology.—The name *Dromogaster* (feminine) is derived from the Greek words *dromos* (a type of ship) and *gaster* (belly) because of the large, boat-shaped sternite 7 of the female. The name *incompta* is derived from the Latin word *incomptus* (unadorned) because of the lack of distinctive external characters of the species.

***Huckettia nearctica* Vockeroth,
NEW GENUS, NEW SPECIES**

Huckettia nearctica Vockeroth, 1987: 1095 [nomina nuda; differentiating characters for the genus and species are indicated in key to genera, p. 1095].

Specimens examined.—Holotype ♂, Beaverhill Lake, N.W.T., 66°44'N, 104°20'W, 29.VI.1966 (G. E. Shewell) (CNC). Paratypes (169♂, 158♀; collection dates 19.VI to 3.VIII; BMNH, CAS, CNC, Lund, USNM, St. Petersburg): CANADA. Yukon Territory: Herschel Island (J. S. Waterhouse). Northwest Territories: Kidluit Bay, Richards Island (J. R. Vockeroth); Fraser Lake, 68°45'N, 120°36'W (G. E. Shewell); Salmity Mines, 64°05'N, 111°15'W (J. G. Chillcott); near Beechey Lake, 69°14'N, 106°50'W (Shewell); Ford Lake, 63°11'N, 107°19'W (Shewell); Beaverhill Lake (Shewell); Baker Lake (Chillcott); Spence Bay (Chillcott, A. E. R. Downe); Chesterfield [Inlet] (Chillcott, Vockeroth); Geillini Lake, 60°18'N., 95°35'W (C. D. Bird, Chillcott); 65°15'N, 89°30'W (Chillcott); Cambridge Bay, Victoria Island (E. H. N. Smith, G. K. Sweatman); Clyde, Baffin Island (J. E. H. Martin, Shewell); Hazen Camp, Ellesmere Island, 81°49'N, 71°18'W (R. E. Leech). Manitoba: Farnworth Lake near Churchill (Bird). Quebec: Payne Bay (E. E. MacDougall, W. R. Mason); Sugluk (H. Huckett). USA. Alaska: Naknek (J. B. Hartley).

Distribution.—Canada. Manitoba, Northwest Territories, Quebec, Yukon. USA. Alaska.

Etymology.—The genus (feminine) is

named in honor of H. C. Huckett, who published extensively on Nearctic Muscidae and Anthomyiidae from 1921 to 1977 and was one of the first to collect Diptera in northern Europe in order to compare them with Nearctic specimens. The species name indicates the wide distribution of the species in the northern part of the Nearctic Region.

Brooksiella Vockeroth

Brooksiella Vockeroth, 1987: 1094. Type species: *Microprosopa varicornis* Curran, 1927, monotypy. Name validated when published (Art. 13(a)(i), (b); Art 68(d). Differentiating characters for the genus are given in the key to genera (p. 1094).

Specimens examined.—2 ♂, 15 ♀ (including holotype ♀).

Etymology.—The genus (feminine) is named in honor of A. R. Brooks, who had an unrivalled knowledge of the insects of the prairies and parklands of Central Canada and whose preliminary manuscript revision of Nearctic Scathophagidae was of great value to me when I began studying this family.

Neorthacheta Vockeroth

Neorthacheta Vockeroth, 1987: 1096. Type species: *Orthocheta dissimilis* Malloch, 1924, monotypy. Name validated when published (c.f. *Brooksiella*). Differentiating characters for the genus are given in the key to genera (p. 1096).

Specimens examined.—33 ♂, 46 ♀ (including holotype ♀).

Biology.—The larva feeds on young leaf shoots of *Iris* (H. J. Teskey, personal communication).

Etymology.—The generic name (feminine) is a combination of the Greek word *neos* (new) and the generic name *Orthacheta* Rondani.

Peratomyia Vockeroth

Peratomyia Vockeroth, 1987: 1096. Type species: *Hexamitocera vittata* Coquillett,

1898, monotypy. Name validated when published (c.f. *Brooksiella*). Differentiating characters for the genus are given in the key to genera (p. 1096).

Specimens examined.—18 ♂, 15 ♀ (including the holotype ♂).

Etymology.—The generic name (feminine) is formed from a combination of the Greek words *peratos* (west) and *myia* (fly) because of the western distribution of the single species.

Synchysa Vockeroth

Synchysa Vockeroth, 1987: 1096. Type species: *Coenosia tricincta* Loew, 1869, monotypy. Name validated when published (c.f. *Brooksiella*). Differentiating characters for the genus are given in the key to genera (p. 1096).

Specimens examined.—25 ♂, 30 ♀ (including a syntype ♂).

Distribution.—The known range has been extended from that given in the Nearctic catalog to southeast British Columbia (Fernie), in the West, and to Cape Breton Island, Nova Scotia, in the East.

Etymology.—The generic name (feminine) is derived from the Greek word *synchisis* (confusion) because of the previous confusion concerning both family and generic relationships.

Muscidae

Hydrotaea ponti Vockeroth

Hydrotaea ponti Vockeroth, 1987: 1123.

The specific name, *ponti*, is a *nomen nudum*. It was intended as a replacement name for *curvipes* Stein, 1920 (*Trichopticus*), a

species referred by Hockett (1965, Memoir of the Entomological Society of Canada 42: 317) to *Phaonia* but which, because of the presence of a strong proclinate upper orbital bristle in the female, is referable to the genus *Hydrotaea*. This makes the name *Hydrotaea curvipes* (Stein, 1920) a secondary homonym of *Hydrotaea curvipes* (Fallén, 1825, *Musca*), which is in turn a primary homonym of *Musca curvipes* Gmelin, 1790. *Hydrotaea curvipes* (Fallén) is considered a senior unavailable synonym of *Hydrotaea meridionalis* Portschinsky, 1882, but is still a senior homonym of *Hydrotaea curvipes* (Stein). The latter is here renamed *Hydrotaea ponti* Vockeroth, *nomen novum*, in recognition of the very large contribution to taxonomy of Muscidae made by A. C. Pont.

The paper referred to as Vockeroth, 1984, in the footnote on page 1118 of the Manual of Nearctic Diptera (volume 2), has not been published. It was to have discussed some of the generic synonyms listed in the footnote.

Acknowledgments: I thank Drs. W. N. Mathis (USNM), F. C. Thompson and C. W. Sabrosky (Systematic Entomology Laboratory, ARS, USDA, Washington, D.C.) for reviewing the manuscript. Dr. B. Brown (LACM) kindly loaned numerous specimens of *Masoniella richardsi*, which are designated herein as paratypes. Dr. P. H. Arnaud, Jr. (CAS) loaned the holotype and paratypes of *Dromogaster incompta* from Bilby, Alberta.

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BOOK REVIEW

The Gall Midges of the Neotropical Region. R. J. Gagné. 1994. Cornell University Press. Ithaca, New York, USA. 352 pp. \$52.50 (cloth).

A wide range of topics is covered on the taxonomic status and biology of more than 450 Neotropical gall midges (Diptera: Cecidomyiidae). The first chapter contains short bibliographies of eleven entomologists who contributed to early taxonomic knowledge of gall midges and Gagné's gentle assessment of the historic value of their work. I found this chapter a good read. It renewed my appreciation of the difficulties endured by early researchers working, sometimes, under less than ideal conditions. Chapters two and three discuss distribution, external anatomy and biology of gall midges at each life stage. A full-page, halftone drawing of dorsal and ventral views of a third instar larva greatly aids understanding of larval taxonomy. The entire family is evenly discussed and well summarized. In addition to the gall feeders, less commonly known primitive fungal feeders, inquilines, and predators are also discussed.

Larvae, pupae, adults, and galls all contribute to the identification of gall midges and need to be properly preserved. Chapter four presents the preferred techniques for collecting, rearing and preparing specimens. Such essential information is too often omitted from taxonomic presentations. Chapter five comprises about onehalf of the book. It contains a taxonomic overview of the Cecidomyiidae and lists all genera and species known from the Neotropical Region. Useful information such as distribution, diagnostic characters, and references are presented here. Relationships among three subfamilies of Cecidomyiidae and the supertribes of Cecidomyiinae are distinguished by a cladogram of 18 anatomical characters. Illustrated keys, including one to genus, are easy to use although, depend-

ing on the group, the three life stages larvae, pupae, and male or female adults are needed to reach some identifications. Line drawings are well done. An exception that I found was in figure 9 where the first tarsomere was so small that it was difficult to identify.

Chapter six discusses the importance of plant hosts and gall types in identifying gall midges. It presents a key to cecidomyiids based on all known published records of their damage to plants even if the insects have not been described. If aware of only the plant name and gall type or shape, researchers and general biologists alike can easily use this key to identify an unknown gall midge.

To facilitate use by a wide range of readers, the author has avoided technical terms whenever possible. The glossary is brief but adequate. The extensive bibliography contains over 400 citations and is thorough and current.

This book is a companion to *The Plant-Feeding Gall Midges of North America*, 1989, Cornell University Press, also by Gagné. Together, these volumes provide a comprehensive and exceptionally well-written summary of present knowledge of the new world cecidomyiids. Both are hard-bound and printed on acid-free paper. The two-column format affords wide margins and is easy to read. Over 300 clear, uncluttered drawings illustrate each book and make it easier to use the keys. Gagné has succeeded in presenting useful keys and descriptions of all the known gall midges of the New World and in reviewing gall midge biology, taxonomy, and current literature. He encourages the interested biologist and student, as well as the professional, by providing a clear assessment of the current status of knowledge and indicating relevant areas for further study of these insects.

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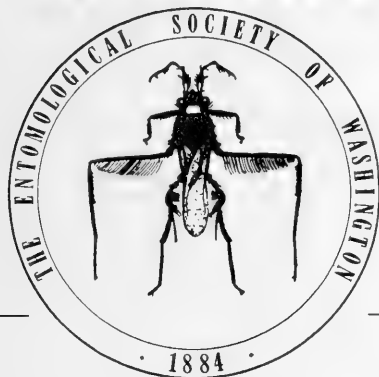
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**THREE NEW SPECIES OF CAMILLIDAE (DIPTERA) FROM THE
SOUTHWESTERN NEARCTIC REGION, THE FIRST SPECIES OF THE
FAMILY DESCRIBED FROM THE NEW WORLD**

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Abstract.—The first endemic species of Camillidae are described from the New World and the Nearctic Region. Three new species are described: *Afrocamilla arizona* (southeastern Arizona); *A. bispinosa* (southern California); and *Camilla arnaudi* (Baja California, Mexico). All species are illustrated and a key to the endemic Nearctic species of Camillidae is presented. *Camilla glabra* (Fallén, 1823), previously introduced to Canada from Europe, is likely to be no longer extant in the Nearctic Region. The biology of Camillidae is briefly reviewed.

Key Words: Diptera, Camillidae, *Afrocamilla*, *Camilla*, Nearctic Region

The Camillidae are a small family of drosophilid-like acalyptrate Diptera in the superfamily Ephydroidea (see McAlpine 1989). Prior to this study, the family was thought to be an exclusively Old World group, being widespread in the temperate and tropical parts of the Palearctic and Afrotropical Regions, but not yet recorded from Madagascar. The extant Palearctic fauna comprises 11 species of *Camilla* Haliday, 1838, centred in the Mediterranean subregion and widely distributed through Europe into the northwest of the Russian Federation and Mongolia. Recent work on the Afrotropical fauna (Barraclough 1992, 1993) has shown that Camillidae are likely to be widespread in Africa. Three species of *Camilla* (one undescribed) are known only from South Africa. The other three Afrotropical genera, *Afrocamilla* Barraclough, 1992, *Katacamilla* Papp, 1978, and *Teratocamilla* Barraclough, 1993, were previously thought to be endemic to Africa, albeit widespread (except *Teratocamilla*).

The only published record of Camillidae in the New World was a population of the Palearctic species *Camilla glabra* (Fallén, 1823), reported from Ottawa, Canada (McAlpine 1960), and apparently an accidental introduction from Europe (McAlpine 1987: 1023). There are 25 specimens of *C. glabra* in the Canadian National Collection of Insects (Ottawa), all taken at or near the Central Experimental Farm in Ottawa between 1954 and 1965. The specimens may have been breeding in droppings in a turkey pound located on the Farm; when the turkeys were removed from the farm, the *C. glabra* population also disappeared.

It was surprising, therefore, when we discovered specimens of two congeneric species of Nearctic Camillidae in the Canadian National Collection of Insects. During 1993 several specialists and Diptera collections in North America were consulted about additional camillid specimens, but only one further specimen (belonging to a second genus) was located. Despite the paucity of

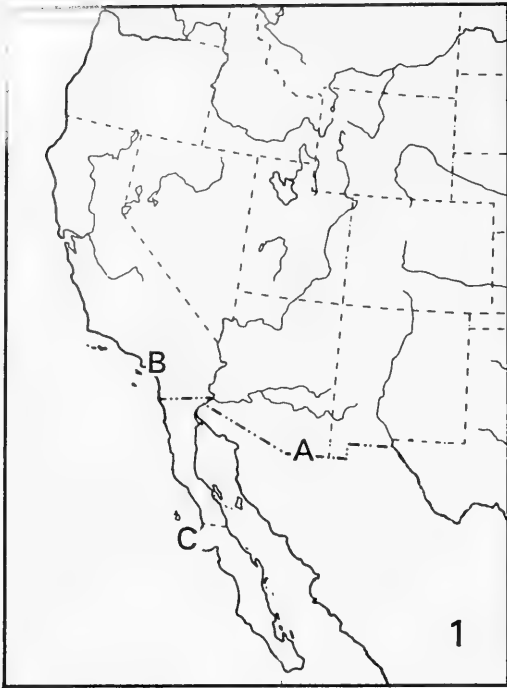


Fig. 1. Type localities of Nearctic Camillidae. *Afrocamilla arizona* (A), *A. bispinosa* (B), *Camilla arnaudi* (C).

material (each species is known from only one specimen), all three species are described, given the zoogeographic implications of their discovery. They represent the first endemic species of Camillidae from the New World. Two species, from Arizona and California, are described in *Afrocamilla*. The third species, from Mexico, is described in *Camilla*. All three species should exit at Camillidae in the key to families (adults) of Nearctic Diptera by McAlpine (1981), although the preapical dorsal bristle on the mid tibia is absent in one species of *Afrocamilla*.

MATERIALS AND METHODS

Specimens examined are deposited in the following institutions (acronyms in parentheses): California Academy of Sciences, San Francisco, USA (CASC); Canadian National Collection of Insects, Ottawa, Canada (CNCI). Holotype label data are cit-

ed exactly as they appear, with supplementary information in brackets; a slash denotes the end of a line of print and a semicolon separates data on different labels.

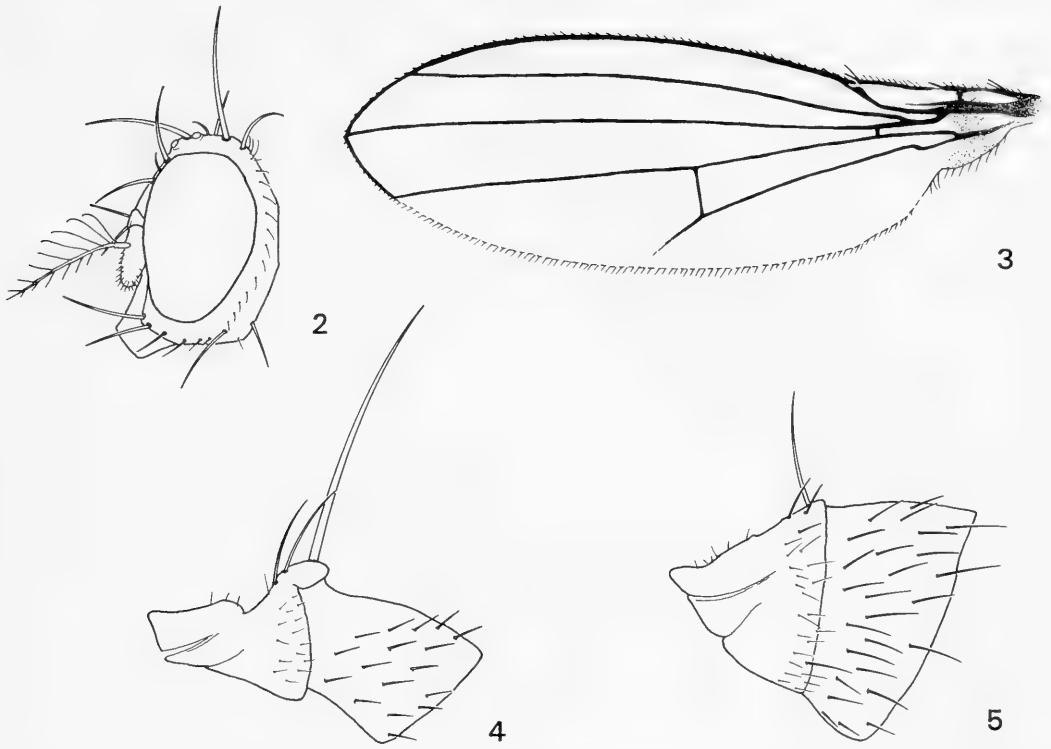
Abdomens were detached at or near their base and macerated in warm to hot 80–85% lactic acid or hot 10% KOH. After examination, dissected terminalia and associated abdominal parts were stored in glycerin in a microvial pinned beneath each source specimen.

Morphological terminology mainly follows Barraclough (1992, 1993); abbreviations are not used, except for tergum (T). Bilaterally symmetrical structures are described in the singular. Head/thorax length was measured from the anterior margin of the third antennal segment to the abdominal base. Wing length was measured from the humeral crossvein to the wing-tip.

KEY TO NEARCTIC SPECIES OF CAMILLIDAE

Camilla glabra is likely to be no longer established in North America and is omitted from this key.

1. Palpus dark brown. Scutellum with apical bristles longer and stronger than basal pair. Abdomen with paired median marginal T2 bristles shorter than length of T1+T2 (Fig. 5). T2 unmodified, not exerted above level of T3, and base of T3 not invaginated beneath posterior margin of T2 (Fig. 5) *Camilla arnaudi* n. sp.
- Palpus yellow or yellow-brown. Scutellum with apical bristles noticeably shorter than basal pair. Abdomen with paired median marginal T2 bristles much longer than length of T1 + T2 (Fig. 4). T2 modified, exerted above level of T3, and base of T3 invaginated beneath posterior margin of T2 (Fig. 4) 2
2. Head and thorax predominantly dark brown, mesonotum sparsely pollinose. One vibrissa. Apical scutellar bristles about one-third length of basal pair. Mid tibia without dorsal preapical bristle *Afrocamilla arizona* n. sp.
- Head and thorax predominantly yellow-brown, mesonotum shining. Two vibrissae. Apical scutellar bristles about two-thirds length of basal pair. Mid tibia with dorsal preapical bristle *Afrocamilla bispinosa* n. sp.



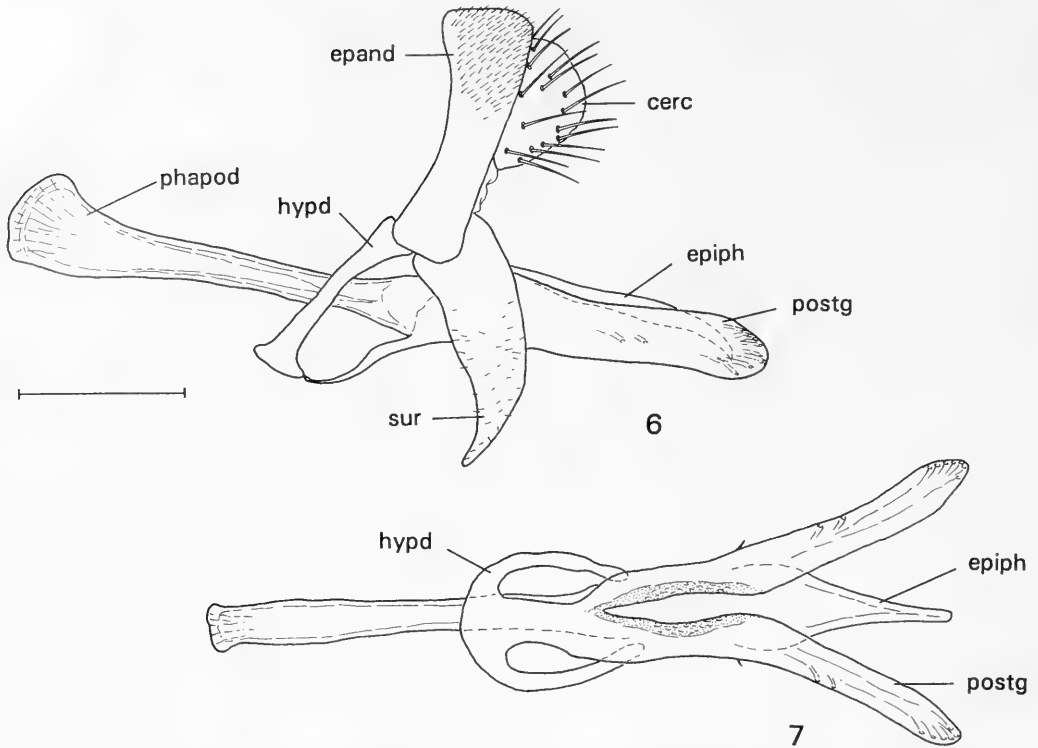
Figs. 2-5. External characters of Nearctic Camillidae. 2, *A. bispinosa*, head (lateral). 3, *A. arizona*, wing. 4, *A. arizona*, abdominal terga 1-3 (lateral). 5, *C. araudi*, abdominal terga 1-3 (lateral).

***Afrocamilla arizona* Barraclough and
Wheeler, new species**

Figs. 3-4, 6-7

Description (based on ♂ holotype, ♀ unknown).—*Size*: Head/thorax length 1.2 mm; wing length 2.2 mm. *Color*: Head mainly dark brown to black; cheek, proboscis, palpus, antenna, upper facial region and lower parafacial yellow or yellow-brown; sparse silver pollinosity on occiput and face. Thorax dark brown, pleuron slightly paler, humeral callus and propleuron mostly yellowish; yellow to pale brown pollinosity present on mesonotum, sparse on posterior section of pleuron, dense on scutellum. Both fore legs missing; mid leg yellow, apical half of femur and basal third of tibia brown; hind leg yellow, femur partly brown-tinged on middle and tibia brown on basal two-fifths. Wing membrane mostly slightly smoky, but with pale brown transverse basal fascia, which is narrow anteri-

orly and expanded to about twice this width at posterior margin. Veins pale yellow. Abdomen dark brown to black with metallic reflections, pale at extreme base; T1 and T2 with sparse brown pollinosity. *Head*: Eye margin smoothly rounded anterodorsally in profile. Width of face and parafacials, at mid-height, subequal to length of antenna. Antenna with arisal vestiture barely discernible, but apparently shorter than in *A. bispinosa* (see below). Upper orbital plate inconspicuous anteriorly, width here about $0.6\times$ that of ocellar triangle. Postocellar bristles relatively well developed, length about $1.5\times$ that of ocellar triangle. Ocellar triangle not unusually elevated above upper eye margin in profile, distance less than length of second antennal segment. Proclinate fronto-orbital bristle present, anterior reclinate fronto-orbital about $0.25\times$ length of proclinate bristle. One vibrissa present. Cheek height in profile about $0.25\times$ length



Figs. 6-7. *Afrocamilla arizona*. 6, male terminalia (lateral). 7, hypandrium and phallic complex (ventral, distiphallus omitted). Scale bar = 0.1 mm. Abbreviations: epand—epandrium; hypd—hypandrium; cerc—cercus; sur—surstylus; phapod—phallopodeme; epiph—epiphallus; postg—postgonite.

of third antennal segment. *Thorax*: Apical scutellar marginal bristles weakly developed, about one-third length and strength of basal marginals. Fore femora missing (femoral armature unknown). Mid tibia without dorsal preapical bristle. Wing not unusually slender; without any slightly longer ventral spinules differentiated on costa between R_1 and R_{2+3} . *Abdomen*: T2 modified, exerted above level of T3, and base of T3 invaginated beneath posterior margin of T2; T2 with paired median marginal bristles much longer than length of T1 + T2 (Fig. 4). Spiracles 1-5 in membrane near lateral margins of terga. *Male postabdomen*: T6 reduced to slender lateral vestiges, narrowly separated dorsally, spiracle 6 in tergum near ventral margin. Epandrium narrow, rectangular in profile, anterior margin concave (Fig. 6). Cerci well developed, closely approximated, about 1.5× higher than broad,

with short setae. Hypandrium narrow laterally, broader anteromedially, convex anteriorly, pregonites connected to anterior region of hypandrium via a broad ventral strip (Figs. 6-7). Epiphallus and postgonites relatively closely approximated in profile, epiphallus elongate, very narrow along much of length and tapered apically in profile (Fig. 6); postgonite unusually elongate and of uniform width along much of length, smoothly rounded apically in profile (Fig. 6). Surstylus approximately as long as height of epandrium, broad basally, narrowed and curved anteriorly at apex (Fig. 6).

Type material.—Holotype ♂ (CNCI), "Ramsey Canyon [31°27'N, 110°17'W] / Huachuca Mts. [Mountains] / 13.m[iles].s[outh]. Sierra Vista / Cochise Co[unty]. ARIZ[ona], U.S.A.] / Mar. 7-11.1967 / R. F. Sternitzki [sic = Sternitzky]" [all hand-written]; "HO-

LOTYPE ♂ / AFROCAMILLA / ARIZONA / Barraclough & Wheeler" [Red ink on white card, with red perimeter]. In fair condition: left antenna missing, some cephalic bristles missing, fore legs, distal part of right mid leg, and left hind leg missing. Left wing and abdomen dissected and stored in microvial pinned below specimen.

Etymology.—The species name is a noun in apposition referring to the state of Arizona, the source of the holotype.

Remarks.—*Afrocamilla arizona* is distinguished from both named Afrotropical species, as well as *Afrocamilla bispinosa* and *Camilla arnaudi* in having only one vibrissa and the apical scutellar marginal bristles much shorter and weaker than the basal pair (typically longer and stronger in the Afrotropical species). The presence of only one vibrissa in *Afrocamilla* is unusual. The male terminalia, most notably the length and shape of the postgonite, are also distinctive.

All Afrotropical species dissected by the senior author have the hypandrium quite different in shape in ventral view (cf. McAlpine 1987: 1024: Fig. 2) to that of *A. arizona*. In *A. arizona* the hypandrium is much narrower and also more smoothly rounded anteriorly.

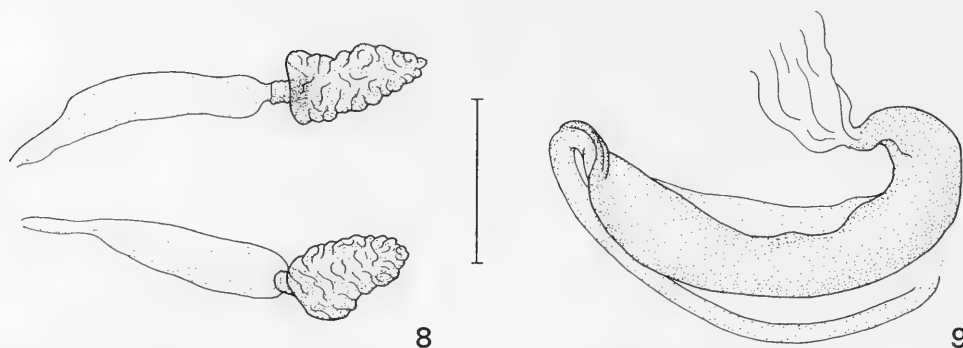
Afrocamilla bispinosa Barraclough and Wheeler, new species

Figs. 2, 8–9

Description (based on ♀ holotype, ♂ unknown).—**Size:** Head/thorax length 1.3 mm; wing length 1.8 mm. **Color:** Head mainly yellow-brown, face and much of occiput paler; proboscis, third antennal segment and arista brown to dark brown; sparse pale yellow pollinosity on face and occiput. Thorax yellow to yellow-brown, legs paler, particularly coxae and trochanters which are pale yellow; sparse pollinosity present on anterior margin of mesonotum and posterior part of pleuron, denser, silver pollinosity on scutellum. Wing membrane mostly hyaline, but with pale yellow transverse basal fascia, which is uniformly narrow across base of wing. Veins pale yellow.

Abdomen yellow to pale brown; T1 and T2 with sparse brown pollinosity. **Head** (Fig. 2): Eye margin relatively abruptly angled anterodorsally in profile. Width of face and parafacials together, at mid-height, about 1.2× length of antenna. Antenna with short ventral rays along apical three-quarters of arista, longest dorsal rays 1.1× length of third antennal segment. Upper orbital plate inconspicuously developed anteriorly, width about half that of ocellar triangle. Postocellar bristles relatively well developed, length about 1.3× that of ocellar triangle. Ocellar triangle unusually elevated above upper eye margin in profile, distance more than length of second antennal segment. Proclinate fronto-orbital bristle present, anterior reclinate fronto-orbital about 0.25× length of proclinate bristle. Two vibrissae present. Cheek height in profile about 0.4× length of third antennal segment. **Thorax:** Apical scutellar marginal bristles relatively well developed, about two-thirds length and strength of basal marginals. Fore femur with 2 well-developed anteroventral spines on apical third, length about 0.6× maximum femoral diameter; posterodorsal and posteroventral bristles irregularly developed. Mid tibia with dorsal preapical bristle. Wing probably rather slender (folded in holotype); with 7–8 slightly longer ventral spinules differentiated on costa between R_1 and R_{2+3} . **Abdomen:** T2 modified, exerted above level of T3, and base of T3 invaginated beneath posterior margin of T2; T2 with paired median marginal bristles much longer than length of T1 + T2 (as in Fig. 4). T5 about half length of T4; segments 5 and 6 with spiracles small, just discernible. **Female postabdomen:** Two sclerotized spermathecae present, small, rugose, broader at base, sclerotized portion of spermathecal duct short, membranous portion of spermathecal duct expanded (Fig. 8). Ventral receptacle C-shaped, narrowed at mid-length and at each extremity, with slender, tubular, non-sclerotized appendage at one end (Fig. 9).

Type material.—Holotype ♀ (CNCI),



Figs. 8-9. *Afrocamilla bispinosa*. 8, spermathecae. 9, ventral receptacle (lateral). Scale bar = 0.05 mm.

“[U.S.A.: California] San Dimas Can[on]. [34°08'N, 117°46'W] / Los Angeles Co[unty]. / II-2-1958 / Reared III-10-58”; “Collector / R.E. Ryckman”; “HOLOTYPE ♀ / AFROCAMILLA / BISPINOSA / Barraclough & Wheeler” [Red ink on white card, with red perimeter]. In fairly good condition, right wing mostly missing and two fronto-orbital bristles detached. Abdomen dissected and stored in microvial pinned below specimen.

Etymology.—The species name refers to the two anteroventral spines on the fore femur (*L. bi* = two, *spinosa* = spine).

Remarks.—Although this species possesses the three major character states defining *Afrocamilla* (basal wing fascia, elongate T2 median marginal bristles, T2 apex and base of T3 modified), it differs from all known African species in two significant characters. The first of these, the presence of two anteroventral spines on the fore femur, is possibly unique in *Afrocamilla* (the fore legs of the unique holotype of *A. arizona* are missing) and also distinguishes *A. bispinosa* from *Camilla arnaudi*. Intra-generic variation in femoral armature does occur in other camillid genera (e.g. *Katacamilla*). The second character is the well-sclerotized spermathecae. In all African material examined by the senior author the spermathecae are less strongly sclerotized than the ventral receptacle.

In addition to the above characters *Afrocamilla bispinosa* is distinguished from

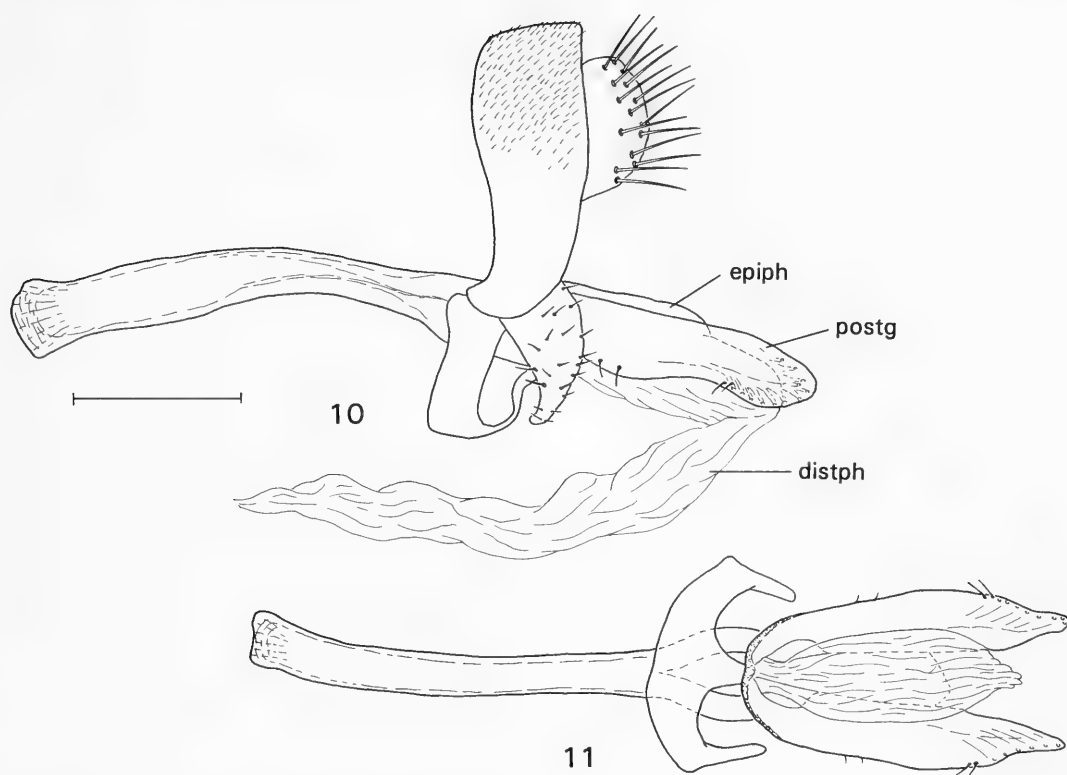
all other species of the genus by the dorsal preapical bristle on the mid tibia. *A. bispinosa* is an unusually pale species, although the senior author has seen a comparable South African species, apparently not closely related. The color of *A. bispinosa* appears to be fully developed.

The holotype was reared by R. E. Ryckman from material collected in southern California (Fig. 1). There is no further information associated with the specimen but it may have been reared from the nest of a wood rat (*Neotoma* sp., Cricetidae) (V. F. Lee, personal communication).

Camilla arnaudi Barraclough and Wheeler, new species

Figs. 5, 10-11

Description (based on ♂ holotype, ♀ unknown).—**Size:** Head/thorax length 1.4 mm; wing length 2.5 mm. **Color:** Head dark brown, cheek and anterior margin of frons slightly paler and antenna (except arista) partly yellowish; pollinosity silver to pale brown, most evident on occipital region. Thorax dark brown, dense, golden pollinosity present on scutellum. Legs yellow to yellow-brown, tarsi slightly darker. Wing hyaline, veins pale yellow. Abdomen dark brown to black with metallic appearance; brown pollinosity present on T1 and T2. **Head:** First antennal segment concealed, not visible in profile or frontal view. Third antennal segment smoothly and evenly rounded apically, dorso-apical section



Figs. 10–11. *Camilla araudi*. 10, male terminalia (lateral). 11, hypandrium and phallic complex (ventral). Scale bar = 0.1 mm. Abbreviations: distph—distiphallus; epiph—epiphallus; postg—postgonite.

without noticeably longer pubescence. Arista with inconspicuous ventral rays along apical two-thirds to three-quarters, length of these at most subequal to width of arista at base, longest dorsal rays subequal in length to width of third antennal segment in profile. Width of face and parafacials together, at mid-height, just less than length of antenna. Two vibrissae (both missing in type), peristomal bristles mostly missing. Vibrissal angle not prominent, about coincident with anterior extent of profrons in profile. Facial region somewhat excavate, epistomal margin upturned towards antennal bases. Cheek height in profile about $0.9\times$ length of third antennal segment. Occiput with upper half extensively excavate. *Thorax*: Anterior sternopleural bristle not evident (sternopleurals detached). Scutellar marginal bristles of similar strength, apical bristles slightly longer than basal bristles. Fore fe-

mur with small anteroventral spine (femur crumpled, length of spine relative to femoral diameter not measurable). Mid tibia with dorsal preapical bristle. Wing moderately broad, not pointed apically. Costal vestiture between R_1 and R_{2+3} relatively short and sparse, longer spinules not differentiated. *Abdomen*: T2 with paired median marginal bristles, these distinctly longer and stronger than other tergal bristles, length $0.6\text{--}0.7\times$ length of T1 + T2 (Fig. 5). Spiracles 1–5 in membrane near lateral margins of terga. *Male postabdomen*: T6 reduced to 2 slender sclerites, narrowly separated dorsally, spiracle 6 in tergum near ventral margin. Epandrium narrow, width at junction with surstylus about two-thirds that at dorsal margin (Fig. 10). Cerci well developed, closely approximated, about $1.5\times$ higher than broad, with short setae. Hypandrium narrow laterally, broader anteriorly,

anteriorly, pregonites connected to the anterior region of hypandrium via a broad ventral strip (Figs. 10–11). Epiphallus inconspicuous, downcurved from postgonite in profile. Distiphallus long, membranous (Fig. 10). Postgonite not splayed outwards, well developed and elongate (almost twice surstylus length), straight and finger-like, slightly tapered apically, length about $5.0 \times$ width (Fig. 10). Surstylus approximately half as long as height of epandrium, broad basally, narrowed and curved anteriorly at apex (Fig. 10).

Type material.—Holotype ♂ (CASC): “San Bartolome / Baja Calif[ornia]. MEX[ico]. / III-12-1953”; “Sefton Orca Exped[ition]. / to Gulf of Calif[ornia]. / P. H. Arnaud, coll[ector].”; “HOLOTYPE ♂ / CAMILLA ARNAUDI / Barraclough & Wheeler” [Red ink on white card, with red perimeter]. In fair condition, left arista mostly missing, vibrissae and many frontal and mesonotal bristles detached. Abdomen dissected and stored in microvial pinned below specimen.

Etymology.—This species is named for the collector of the holotype, Dr. P. H. Arnaud, Jr.

Remarks.—At first examination, this species appeared to be an unusually robust *Afrocamilla*. However, dissection of the abdomen showed T2 and T3 to be unmodified, and the wing does not have a transverse basal fascia. The T2 median marginal bristles are unusually well developed for *Camilla*, but are substantially shorter and weaker than in *Afrocamilla*, in which they are usually longer than the length of T1 + T2. It is likely that there is correlation between the development of these bristles and the modification of T2 and T3, as the bristles and associated musculature in the modified T2 and T3 are probably used to move the folded wings (Barraclough 1992). We are not aware of any other named *Camilla* species with similarly developed bristles. However, the senior author has seen 1 ♂ and 1 ♀ of a cavernicolous *Camilla* species from the northern Cape Province of South

Africa. That species is in poor condition (in alcohol) and cannot be described, but is distinguished from *C. arnaudi* by having a yellow to yellow-brown head and thorax and no dorsal preapical bristle on the mid tibia.

In Papp's (1985) key to the world species of Camillidae, *C. arnaudi* runs closest to the Palearctic species *C. glabra* (Fallén, 1823), *C. flavicauda* Duda, 1922, *C. sabroskyi* Papp, 1982 and *C. mathisi* Papp, 1985. The long T2 median marginal bristles are distinctive for *C. arnaudi*, as are the male terminalia, particularly the shape and form of the surstylus, postgonite and epiphallus (see also figures of male terminalia in Papp (1982)). Both South African species of *Camilla* (see Barraclough 1993) differ in lacking a dorsal preapical bristle on the mid tibia and an anteroventral spine on the fore femur. *Camilla arnaudi* differs from the two Nearctic species of *Afrocamilla* in having the palpus dark brown, the scutellum with the apical bristles longer and stronger than the basal pair and the abdomen with the paired median marginal T2 bristles shorter than the length of T1 + T2.

The large distiphallus in this species may be apparent only in specimens cleared in lactic acid. The distiphallus is often overcleared or lost in specimens cleared in KOH.

DISCUSSION

Information about the biology of Camillidae has been limited for many years, but has recently been supplemented by further data by Barraclough (1992, 1993). In southern Africa, Camillidae have been reared from the droppings of the rock hyrax, *Procavia capensis* (Pallas) (Procaviidae), and have been shown to have a close association with the latrines of this small mammal in the subregion, and a *Procavia* species in Kenya (Barraclough, unpublished data). Southern African Camillidae have also been collected near droppings of Chiroptera or in areas inhabited by bats (Barraclough, unpublished data). It appears that African Camillidae are coprophagous and live in as-

sociation with the nests and droppings of a variety of mammals. In the Palearctic Region, Camillidae have been collected near the entrances to rabbit burrows, and in association with rodent nests (Barracough 1992).

Although there are no definite biological data associated with the Nearctic species, the holotype of *Afrocamilla bispinosa* was reared, possibly from the nest or droppings of a wood rat (*Neotoma* sp.). The fact that Camillidae have not previously been collected from the United States may be due to a close association with the droppings, nests and burrows of small mammals. These habitats are often inaccessible or overlooked by many insect collectors. More specialized collecting techniques used in these habitats may show that Camillidae are more abundant and diverse in the southwestern Nearctic Region than previously supposed. The fact that Camillidae have not been collected in greater numbers in the Nearctic Region may also be due to the phenology of the species. The types of all three species were collected in late winter and early spring (February/March), a time when there is generally much less collecting effort in North America.

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LABORATORY EVALUATION OF PREDATORY CAPABILITIES OF A
COMMON WOLF SPIDER (ARANEAE: LYCOSIDAE) AGAINST TWO
SPECIES OF TICKS (ACARI: IXODIDAE)

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Abstract.—Black-legged ticks, *Ixodes scapularis* Say and adult American dog ticks, *Dermacentor variabilis* (Say) were readily attacked by the wolf spider, *Schizocosa ocreata* (Hentz) in petri dish bioassays. Younger (4–5 mm body length) *S. ocreata* were less successful in their attacks (66.7%) against *I. scapularis* adults than individuals with body lengths of 7–9 mm, which killed 100% of the *I. scapularis* adults. Against adults of *D. variabilis* the attacks of even the larger *S. ocreata* were generally ineffectual, killing only 14.3% of the larger tick. The *S. ocreata* were able to lift the *D. variabilis* from the substrate, but may have been deterred from further attack by defensive secretions known to be produced by the latter.

Key Words: Predation, *Schizocosa ocreata*, *Ixodes scapularis*, *Dermacentor variabilis*, Lycosidae, Ixodidae

Wolf spiders (Lycosidae) constitute a major group of arthropod predators on the forest floor in northern temperate regions (Clark and Grant 1968). Like most spiders they are generalists in their choice of prey and because of their foraging activities on the leaf litter are likely to encounter host-seeking and recently fed ticks. Black-legged ticks, *Ixodes scapularis* Say, and American dog ticks, *Dermacentor variabilis* (Say) are three-host ticks; the former typically a woodland species (Ginsberg and Ewing 1989) and the latter somewhat more of a woods-edge inhabitant at least in the adult stage (Sonenshine and Levy 1972). Larval and nymphal *I. scapularis* and *D. variabilis* seek hosts on the leaf litter (Ginsberg and Ewing 1989, Smith et al. 1946) and, although the adults of both species may quest for hosts as high as 1 m above ground level (Harlan and Foster 1990), they are exposed to wolf spider predation when

moving to, or changing, questing sites. After each engorgement (three for females) both species of tick are vulnerable to attack when they leave their hosts to find molting sites or oviposition sites.

There are few accounts of arthropod predation upon ixodid ticks (e.g. Barre et al. 1991) and even fewer mention spiders. The common theridiid spider *Achaearanea tepidariorum* (C. L. Koch), which often infests buildings, has been observed preying upon the lone star tick, *Amblyomma americanum* (Linnaeus) (Guarisco 1991). In Kenya, Mwangi et al. (1991) reported that (unidentified) spiders killed engorged *Rhipicephalus appendiculatus* Neumann in the laboratory. Wilkinson (1970) found that the wolf spider *Lycosa godeffroyi* Koch preyed upon engorged females of the cattle tick, *Boophilus microplus* (Canestrini), in Australia.

According to Riechert and Lockley (1984) generalist spider predators can make

a significant contribution toward biological control of insect pest species. To determine whether wolf spider predation might have any impact on the populations of two medically important tick species, a series of laboratory feeding bioassays was conducted.

METHODS

Wolf spiders were collected by pitfall traps and in vials by hand in mixed oak-beech woodlands and woods edges in Prince George's County, Maryland. Spider collection sites were habitats where *I. scapularis* and *D. variabilis* occurred. In the laboratory spiders were maintained in petri dishes (5 cm diameter) containing moist tissue paper and were fed larvae of the European corn borer, *Ostrinia nubilalis* (Hubner) (Lepidoptera, Pyralidae). Ticks were collected with a 1-m² flannel drag, and kept in high humidity (99% R.H. for *I. scapularis* and 94% for *D. variabilis*) at 22–26°C and natural photoperiod.

Schizocosa ocreata, the species of wolf spider collected in the greatest numbers, was used in the predation tests. Because an *O. nubilalis* larva constituted a large meal, spiders were tested 4 days after being fed. A single tick was placed in the petri dish with a spider and the initial encounter and activities for the next 5 min were observed. They were checked again after a second 5 min and again at 48 h after the tick was placed in the petri dish to determine tick mortality. As a reference for background tick mortality, ticks were placed in petri dishes containing moist tissue paper and checked at 48 h and 1 wk.

Unfed male and female *I. scapularis* adults, unfed *I. scapularis* nymphs and engorged *I. scapularis* larvae were tested. The engorged nymphs dropped from their laboratory rat hosts <48 h before testing and were still actively crawling when confined with the spiders. Spiders of two size ranges (4–5 mm and 7–9 mm body length) were tested. Only unfed adult female *D. variabilis* (about twice the size of *I. scapularis* females) were tested. Spiders and ticks

Table 1. Proportion of encounters between wolf spiders, *S. ocreata* and ticks, *I. scapularis* and *D. variabilis*, confined together in petri dishes in which the tick was killed.^a

Body Length of <i>S. ocreata</i> (mm)	<i>I. scapularis</i>				<i>D. variabilis</i> Adult Female
	Adults		Unfed Nymph	Fed Larvae	
	Male	Female			
7–9 ^b	1/1	18/18	1/3		2/14
4–5 ^c	5/7	5/8	2/2	26/27	

^a Tick dead within 48 h after introduction in petri dish with spider. Each spider and tick only used in one test.

^b Spiders collected in spring contemporaneously with adult *I. scapularis* and *D. variabilis* and early *I. scapularis* nymphs.

^c Spiders collected in late summer and fall contemporaneously with adult and larval *I. scapularis*.

were tested just once. Success of *S. ocreata* predation against *I. scapularis* versus *D. variabilis* and between size classes of *S. ocreata* against adult *I. scapularis* were analyzed by Student's *t*-test.

RESULTS

Almost all *S. ocreata* (i.e. 46 of 48) attacked the adult ticks (*I. scapularis* and *D. variabilis*) confined with them upon their first encounter. The outcomes of these attacks varied. *I. scapularis* adults were all killed when confined with the larger (7–9 mm body length) *S. ocreata*, whereas 10 of 15 (66.7%) unfed *I. scapularis* adults were killed by the smaller (younger) *S. ocreata* (4–5 mm body length) (Table 1). *S. ocreata* belonging to the smaller size class were significantly less successful in killing female *I. scapularis* than were ($t = 2.762$, $P < 0.02$) the larger spiders. With one exception attacks upon the engorged *I. scapularis* larvae all ended with the tick eaten (Table 1). Unfed *I. scapularis* nymphs were also attacked, but because of their small size they soon found their way into cracks and crevices (e.g. between the petri dish and lid, or in the wad of moist tissue) inaccessible to the spiders. The larger *S. ocreata* had difficulty in killing the unfed *D. variabilis*

of 14, 14.3%) females. Although all were *S. ocreata* but one were observed attacking significantly fewer ($t = 4.969$, $P < 0.01$) *D. variabilis* females than *I. scapularis* females were killed by *S. ocreata*.

Attacks were occasionally triggered by the tick wandering into the spider, but in most cases the spider apparently detected the tick at distances of 5 to 10 mm, re-oriented itself, approached the tick and pounced upon it. Invariably ticks of both species responded to the attacks by drawing in their legs, appressing them close to their bodies and ceasing movement. Successful attacks usually involved a spider's lifting the tick from the substrate. This gave the spider access to the tick's venter, where there were more opportunities for the spider's fangs to penetrate the tick's intersegmental membranes at the articulations of its legs. The *S. ocreata* were able to lift the *D. variabilis* females from the substrate, but the *D. variabilis* were usually released by the spiders within 10 sec, and the ticks remained motionless for several minutes. *S. ocreata* were observed holding *I. scapularis* adults >30 min after attacking, which suggests that feeding was involved. Also exsuccous remains of fed *I. scapularis* nymphs were found in the petri dishes 24 h after the start of confinement of the nymphs with *S. ocreata*.

DISCUSSION

Multiple host ticks may be most vulnerable to predation by lycosids as well as many other predators just after having completed engorgement and having dropped from their hosts. At this point they are still mobile and would attract the attention of a wolf spider. Furthermore, the tick's recent blood meal would have stretched its opisthosomal integument quite thin, presumably making it more easily bitten through by a spider than in its unfed configuration. This period of vulnerability is relatively brief, perhaps a matter of minutes or hours until the fed tick is ensconced in the leaf litter. Many fed larval *I. scapularis* are thought to

drop off in the nests of their hosts, predominantly white-footed mice, *Peromyscus leucopus*, and therefore safer from lycosids (Mather and Spielman 1986).

The discrepancy between the two size classes of *S. ocreata* in their ability to kill *I. scapularis* adults may be due to several possible factors. One obvious explanation is size related. The larger spiders could be expected to be stronger, have longer fangs and have the capacity to inject more venom into their prey. The problems the *S. ocreata* had with the *D. variabilis* females may have been due to their inability to penetrate the tick's integument. A similar situation was reported for the jumping spider, *Corythalia canosa* Hentz (Salticidae), a specialist predator of ants (Edwards et al. 1974). *C. canosa* were unable to kill the heavily sclerotized ants *Trachymyrmex septentrionalis* (McCook) and *Cyphomyrmex minutus* Rower, which like ticks pull in their legs and remain motionless when attacked.

A different, or additional, explanation may account for the low success rate (two of 14, 14.3%) of *S. ocreata* against the American dog ticks they attacked. Yoder et al. (1993) found that *D. variabilis* adults produced a waxy secretion on their dorsal surfaces when attacked by ants, or were otherwise similarly disturbed. The secretions caused the ants to cease their attacks, thereby protecting the ticks, a scenario reminiscent of the attacks by *S. ocreata* on *D. variabilis*.

S. ocreata is common throughout woodlands in the eastern United States (Dondale and Redner 1978, Stratton 1991), and was abundant in habitats where both species of tick occurred. In view of the relatively low abundance of ticks compared to other potential prey of *S. ocreata*, it is unlikely that a wolf spider such as *S. ocreata* will encounter successive ticks before finding another meal. Therefore, tests were not conducted to determine the maximum number of ticks an *S. ocreata* is capable of eating. Further evaluation of the impact of *S. ocreata* and other common wolf spiders on

I. scapularis populations is warranted. Also spiders, such as crab spiders (Thomisidae), that frequent adult *I. scapularis* questing sites on vegetation up to 1 m high should be considered as potentially important predators of black-legged ticks.

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**FALSE-PARASITIZED COCOONS AND THE BIOLOGY OF AIDIDAE
(LEPIDOPTERA: ZYGAENOIDEA)**

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Abstract.—Two or four holes in the outer mesh of cocoons in Aididae appear to mimic exit holes of parasitic Hymenoptera. Cocoon construction in *Aidos amanda* (Stoll) from Venezuela is described and documented with photographs, along with notes on its biology. *Annona puniceifolia* is reported as a larval hostplant of *A. amanda*. Literature on the cocoons and biology of Aididae are reviewed. Citations of Guyaba as a larval hostplant of *A. amanda* are considered to be erroneous based on misidentified larvae. Scenarios for the evolution of cocoon construction in Aididae are discussed, as are possible functions of the false exit holes in their cocoons.

Key Words: Lepidoptera, Aididae, cocoon construction, predator avoidance, false-parasitized cocoons

The small Neotropical family Aididae (6 species), previously placed as a subfamily of Megalopygidae, is an important link in the understanding of the relationships among Limacodidae, Megalopygidae and Dalceridae (Epstein in press). Larval aidids differ from many larval megalopygids in lacking plumose setae on the dorsum, and in absences of verrucae below the spiracles and of large membranous pads on the abdominal prolegs (Epstein in press). Their two rows of urticating bristles on the dorsum of the abdomen are sunken in repose and splayed out in rosettes when stimulated (Hopp 1935; Epstein in press).

The earliest known description of aidid cocoons was given in a letter by Moritz (published in Klug 1836). They were described and figured by Dewitz (1878: 20-26; pl. 1, figures 17-18), based on notes and specimens from Gollmer. Hopp's (1930, 1935) descriptions were based on those of the earlier workers, though they were not cited in his later publication (Hopp

1935). Cocoons of *Aidos amanda* (Stoll) were described as "... spun on the underside of leaves of different trees, look like the webs of ichneumon-flies [perhaps meaning a parasitized wasp cocoon], especially since also their hiding places [emergence holes of braconids—from earlier literature; see discussion] are copied" (Hopp 1935:1072; english version). Forbes (1942:396) described the cocoon as "... with trap door, silken stem for suspension and one or two pairs of rounded depressions in the sides (varying in individuals of a single batch of *A. amanda*)."

Descriptions of the cocoon and other immature stages of *A. amanda* by Hoffmann (1932) were based on misidentified Megalopyginae. This is deduced from features of the larvae described by Hoffmann, which occur in megalopygids and not in aidids. These include (1) matted wool covering the eggs (from the caudal end of the female abdomen); (2) plumose setae, and a fleshy knob behind every spiracle in the larva; and (3) larval setae woven into the cocoon.

Along with photographic documentation, I will describe the cocoon construction of a species believed to be *A. amanda*. I also report its life history, update the hostplant literature on aidids, discuss alternative functions of the false exit holed cocoons, and present evolutionary scenarios that may have brought them about.

METHODS

I reared a single aidid larva from Venezuela (see locality data below). It was recognized as an aidid from the description in Hopp (1935) and from specimens examined at the Natural History Museum, London (BMNH). Although the larva perished in its cocoon as a prepupa, I tentatively identified the species as *A. amanda* based on adult males and females collected from the same locality in September 1990, a location where only one species of *Aidos* is known to occur. These specimens closely match the types of *A. amanda* figured in Stoll (1782, pl. 383, figs. C, D). The genitalia of the Venezuelan and other aidid species examined appear to be rather uniform. However, further evidence in support of the identity of this population as *A. amanda* is found in the labial palpus, which has only two segments; three are found in other aidid species and in museum specimens labelled as *A. amanda* from outside of Venezuela and the Guianas. The two-segmented palpus matches those of a specimen believed to be *A. amanda* from Guyana (Cornell University Coll.), the closest locality of any specimen examined to its Surinam type locality. Voucher specimens of adults, the larva and its skins are deposited in the entomological collection of the National Museum of Natural History, Washington, D.C. (USNM). Although the cocoon was lost, another cocoon from the same locality in Venezuela is placed in the USNM collection. Additional aidid specimens examined and the institutions where they are deposited, include: adults (USNM, BMNH, and Universidad Central de Venezuela, Maracay); larvae (BMNH);

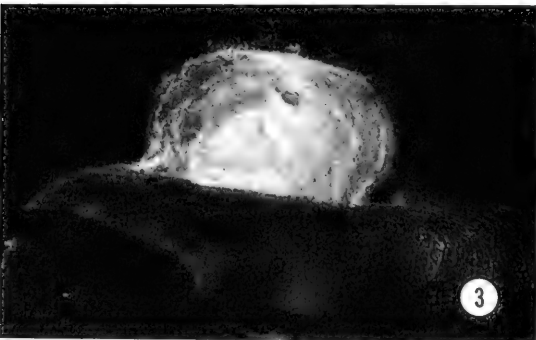
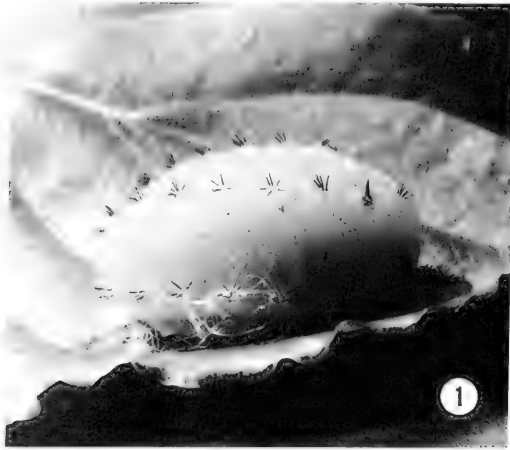
and cocoons (USNM, BMNH and Cornell University).

LIFE HISTORY

The presumed larva of *A. amanda* was found in the Venezuelan llanos at Hato Masaguaral, Edo. Guarico, 45 km S. Calabozo (8.57°N, 67.58°W), 75 m elevation on 9 July 1989 (Fig. 1). The larva was feeding on a leaf of *Annona puniceifolia* Triana and Planch at ca. 1400 h in cloudy conditions during a light rain. The larva was attached to the underside of the leaf, with its prothorax visible from above at the consumed leaf apex. The *Annona* bush was on the edge of a savanna that is often undated during the rainy season (Fig. 2). In a plastic rearing container, the larva spun silk trails when moving between leaves and a silk pad on the leaf it was feeding on. When pulled from a leaf the larva would often remain motionless in the bottom of the container, with silk hooked to its crochets. Locomotion is described in Epstein (in press).

The larva had seven or eight instars, based on the assumption that it was a second or third instar when first discovered (Table 1). Stadia lasted from at least six to thirteen days, though the larva was reared under a wide range of climatic conditions. It was fed the native hostplant *A. puniceifolia* until the fifth or sixth instar when it was switched to oak (*Quercus* spp.). It preferred oak when later given a choice of leaves of an annonaceous tree during its final stage.

Cocoon construction.—On 9 September the prepupa began spinning the cocoon between two leaves (Fig. 6) in figure-eight fashion. The final frass pellet was light brown and the prepupa became wetted down, similar to what occurs with Limacodidae (McNaulty, 1967; Epstein in press). By 10 September the prepupa had spun a thin outer mesh with one small oval hole on each side (approx. 1 mm). Each hole had a more dense reinforcement of silk around its edges, roughly a third the distance from



Figs. 1-5. 1, late instar larva of *Aidos amanda* (photo by K. V. Sandved); 2, habitat and *Annona puniceifolia*, hostplant of *A. amanda*, at Hato Masaguaral, Venezuela; 3, recently completed cocoon of *A. amanda* (hatch end); 4, laterodorsal view of four-holed aidid cocoon with emerged pupal exuvia (photo by V. Krantz); 5, detail of aidid cocoon, hatch above (hole above 3 mm across) (photo by L. Minor-Penland).

Table 1. Life history of *Aidos amanda* (Stoll). Dates of molting, approximate instar and host for one individual reared to prepupa.

Date	Specimen	Instar/ Cocoon	Host
09 vii		2-3	Annona
15 vii	—	3-4	Annona
22 vii	skin	4-5	Annona
04 viii	skin	5-6	Annona/Quercus
12 viii	skin	6-7	Quercus
25 viii	prepupa	7-8	Quercus
9-12 ix		cocoon	

one end of the cocoon (Fig. 7). From inside the cocoon the emerald green prepupa made the holes very apparent. On 11 September the larva constructed a u-shaped escape hatch on the end of the cocoon near the holes, reinforcing the edge of the hatch with silk in much the same manner as the holes. The "holes" were sealed on the inside of the cocoon by 700 hrs on 12 September.

Other hostplant records for Aididae.—Gollmer reported *A. amanda* on sweet orange (from Dewitz 1878). Since Hoffmann (1932) misidentified a megalopygid as *A. amanda*, it follows that his hostplant record for *Aidos* on Guyaba (probably *Inga* sp.) is also incorrect. Hoffmann's hostplant record was later cited in Hopp (1935:1072, 1098) and Lima (1945). An adult specimen of *Aidos yamouna* (Dognin) from Peru in the USNM collection was reared on *Cinchona ledgeriana*, Moens. 1876 (Rubiaceae). This is a quinine-yielding tree, with leaves "perfectly glabrous on both surfaces," originally from Rio Mamore, Bolivia (Trimen 1881).

DISCUSSION

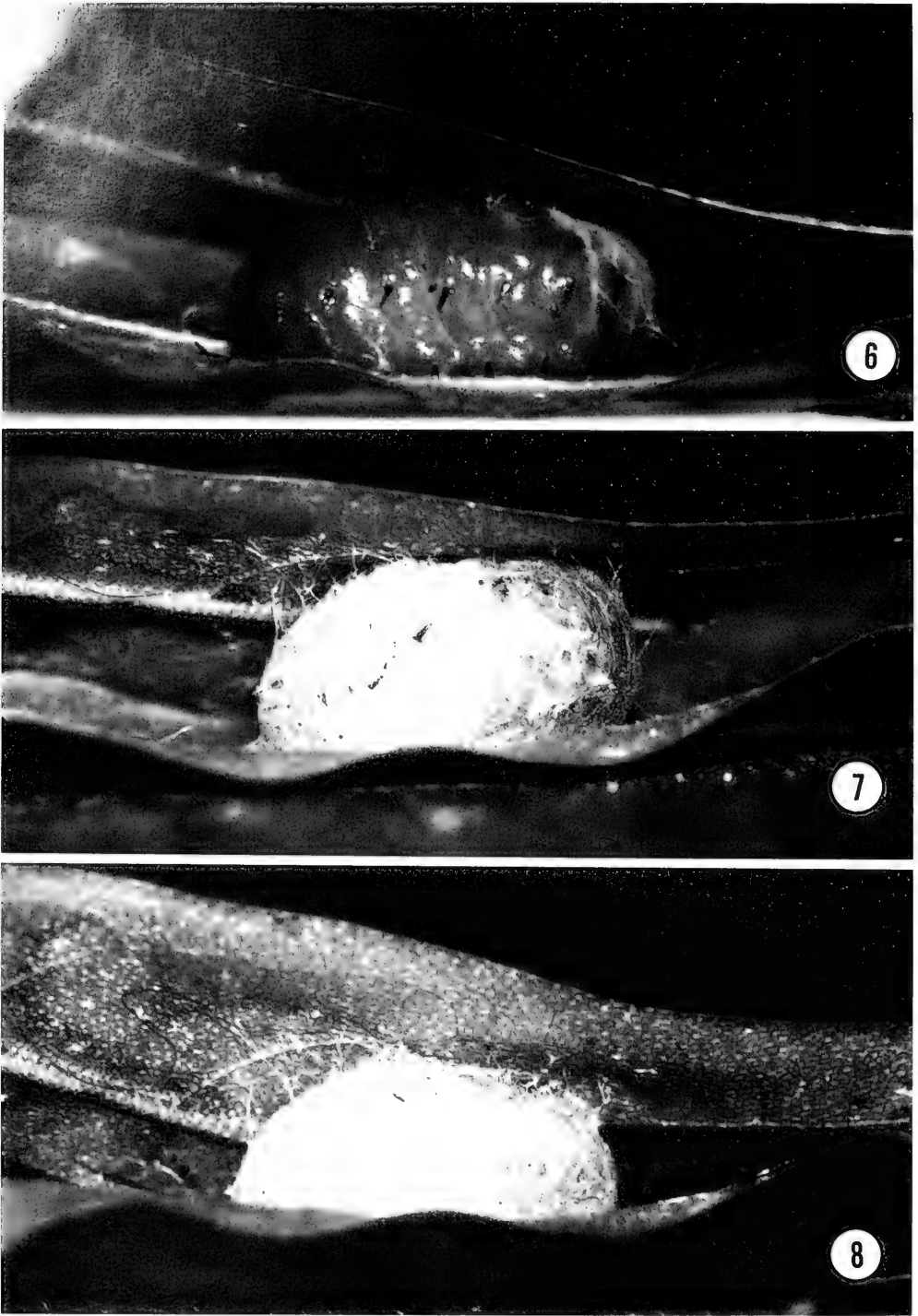
The close resemblance of their false exit holes to emergence holes of parasitic Hymenoptera may protect aidid cocoons from vertebrate predators. If vertebrates indeed learn that parasitized cocoons have little or no food to offer, as suggested by Hinton (1955), then it is also reasonable to hypothesize that they would tend to avoid cocoons constructed with false holes. This view was

expressed by Dewitz (1878) as it related to the cocoons of *A. amanda*.

Hinton's (1955) review of protective devices in Endopterygote pupae did not include *A. amanda*, from the literature mentioned above, or other examples of "false exit holes" in Lepidoptera cocoons. His one example of a chrysalis considered it to mimic parasitized galls (*Agriolaus maesa*, Lycaenidae) (from Eltringham 1923:89-90). Hinton's other examples of possible predator-avoidance mechanisms included moth cocoons that appear to have parasitoid wasp cocoons extruding from them (e.g. *Deilemera antinorii* Oberthur; see Eltringham 1923:83, figure 32). Similarly, some species of ichneumonids build a false cocoon outside of the skin of their larval host, complete with a false emergence hole, while their true cocoon is inside the dead host (e.g. *Hyposoter parorgyiae* and *H. rubiginosa*; Finlayson 1966 and R. Carlson pers. comm.).

The characterization of aidid cocoons as having the appearance of "webs of ichneumon-files" in the earlier literature is confusing (e.g. Hopp 1935), since ichneumonids do not build webs other than cocoons. The "webs" may refer to large ichneumonid cocoons, or groups of smaller braconid cocoons with emergence holes in them, as suggested in Klug (1836). Dewitz (1878: 24) thought they resembled a parasitized cocoon of a tenthredinid.

The evolutionary development of false exit holes in aidids may have been an offshoot of hatch construction. This is plausible because two holes in all examples are in close proximity to the hatch, and the prepupa appears to reinforce both holes and hatch in similar fashion. The cladogram of the limacodid group (Epstein in press) indicates that hatch construction in Aididae is plesiomorphic, and that false exit holes are uniquely derived (autapomorphic). Another autapomorphic feature in aidids, the flexible and amorphous apex of the spinneret (Figs. 10-12), may be useful in shaping and reinforcing the silk around the holes.



Figs. 6-8. Cocoon construction sequence of *Aidos amanda*: 6, wetting down and beginning of spinning between two leaves; 7, at first visible sign of holes (note spines visible through hole); 8, outer mesh near completion, prior to filling in of holes.

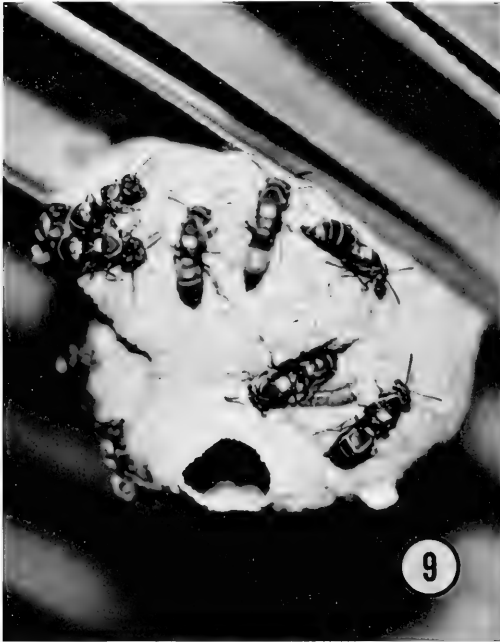
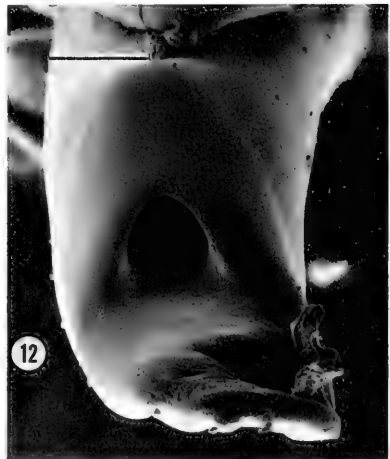
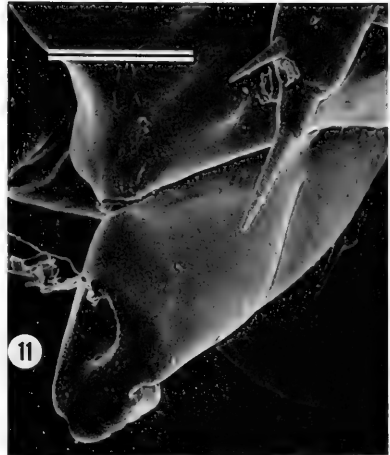
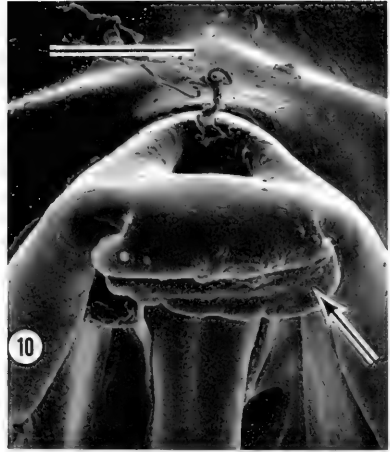


Fig. 9. Nest of *Polybia occidentalis bohemani* in Costa Rica.

The false exit holes may be functionally related to hatch construction in the following way. They allow the prepupa to view the immediate environment to select optimal hatch placement for future adult emergence. This “window” hypothesis is supported by my observations that the prepupa constructs the holes prior to the hatch. Moreover, in cocoons examined with a single pair of holes, the hatch is constructed at the same end of the cocoon. This suggests that with proper stimuli, no further holes are made. Even if the holes were to function in selecting hatch placement, this would not preclude them from having a predator-avoidance function as well.

Forbes’s (1942) observations, quoted above, suggest a flexibility in the number of holes constructed within *A. amanda*. However, the hole arrangement of a four-holed cocoon (USNM, no data or adult voucher) suggests that the number of holes may be fixed in an individual. In this cocoon one of two hole sites proximate to the



Figs. 10–12. Spinneret of larval Aididae (exuviae from two specimens) (scale length in parentheses): 10–11, Aidid sp. from Brazil (BMNH); 10, ventral view of spinneret, flexible apex is folded down (arrow), silk pore with silk is above (46 μm); 11, dorsolateral view (100 μm); 12, Aidid sp. from Brazil (BMNH), dorsal view of spinneret, apex is extended (20 μm).

hole was apparently blocked by a stem at the time of construction. The prepupa constructed a smaller hole between the two holes posterior to the hatch, perhaps to compensate for the missing hole in the usual location.

False holes may also give aidid cocoons the appearance of being small nests of vespid, or of other nest-building wasps, that are built on the undersides of leaves (e.g., *Polybia occidentalis bohemani*; Fig. 9). The "holes" on the cocoons could appear as nest entrances, though smaller in size (1 to 3 mm compared to approx. 9 mm for nest entrance in Fig. 9).

Experimental studies are needed to determine whether there is less predation on aidid cocoons compared to similar cocoons without false exit holes (e.g., in megalopygids). Other future research should be undertaken to determine whether the number of holes are fixed or flexible in a given species or between species of Aididae.

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A RECONSIDERATION OF THE *CYLINDRICUS* GROUP OF THE GENUS
ANOPLIUS DUFOUR (HYMENOPTERA: POMPILIDAE)

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Abstract.—Three names are removed from the synonymy of *Anoplius* (*Pompilinus*) *cylindricus* (Cresson). These are *Arachnophila brevihirta* Banks, *Pompilinus subtruncatus* Dreisbach, and *P. truncatus* Dreisbach. *Pompilinus hispidus* Dreisbach is regarded as a synonym of *P. subtruncatus* Dreisbach, while *P. clavipes* Dreisbach continues to be considered a synonym of *A. (P.) cylindricus* (Cresson). *Anoplius* (*Pompilinus*) *cylindricus* is restricted to the southwestern United States and is clearly distinct from other members of this complex. The remaining three species are closely related and show some evidence of intergradation; two of them, *A. (P.) subtruncatus* and *A. (P.) truncatus*, occupy more limited ranges within that of the transcontinentally distributed species *A. (P.) brevihirta*. Some of the variation in *A. (P.) brevihirta* is analyzed. This species is restricted to broad areas of open sand, and populations in different sandy areas have in some cases diverged slightly in structure and color; there are also broadly geographic trends in structure and color.

Key Words: Spider wasps, Pompilidae, *Anoplius*, synonymy, distribution, variation

Retirement should provide time to re-think some of the problems in one's past research in which the solutions proposed seem naggingly unsatisfactory. Many years ago (Evans 1951) I placed four names in the synonymy of *Anoplius* (*Pompilinus*) *cylindricus* (Cresson); a fifth name was later added to the synonymy (Evans 1966). Evidence to support this lay in the apparent continuous variation in features of the male genitalia. Further collecting in the western half of the United States in recent years has convinced me that such a simplistic solution to this complex is not satisfactory. Here I propose that four species be recognized in this complex, with two other names being retained in synonymy.

Day (1974) placed the subgeneric name *Pompilinus* Ashmead (generotype *Pompilus cylindricus* Cresson) in the synonymy of the subgenus *Arachnoproctonus* Howard

(generotype *Psammochares marginalis* Banks). I regard *Pompilinus* as a probably monophyletic New World offshoot of the widely distributed *Arachnoproctonus*. In 1951 I erroneously placed the European *Anoplius viaticus* (L.), under the name *A. fuscus* (L.), in *Pompilinus*; more properly it belongs in *Arachnoproctonus*.

Whether *Pompilinus* deserves subgeneric status can be argued, but it is a large group divisible into at least three species-groups, so it is convenient to retain it as a subgenus. The most useful distinguishing features of this group are the fact that the transverse median vein of the fore wing meets the media beyond the origin of the basal vein, the third submarginal cell is petiolate, and the spines of the female tarsal comb rarely exceed the width of the basitarsus. The species of this group are difficult to separate in the female sex, and the males can be sep-

known with assurance only by study of the genitalia. In 1951 I recognized two species-groups in *Pompilinus*, the *subcylindricus* and *cylindricus* groups. Here I restrict the *cylindricus* group to that species and three forms previously considered synonyms of it. The remaining members of the former *cylindricus* group of Evans (1951) may be considered to constitute the *marginatus* group.

The following are the distinguishing features of members of the *cylindricus* group as here defined. *Females*: eyes widely spaced, middle interocular distance 0.60 to 0.65 times transfacial distance; vertex passing straight across between tops of eyes; ocellar triangle broad and flat; propodeum convex, with a steep, oblique declivity, and bearing at least a few short hairs (may be quite hairy); femora usually hirsute; fore basitarsus with a comb of three or four spines, these spines one to two times as long as width of basitarsus; one or more basal tergites banded with orange. *Males*: subgenital plate slender, acute, hirsute (Figs. 5–8); genitalia with squamae at base of parameres prominent; digiti clothed with short setae, many of which are bent apically, except latero-apically with longer, straight setae; digiti broadly truncate apically (one exception) (Figs. 1–4); basal tergites with or without orange markings.

In 1951 I characterized *A. cylindricus* as a sand dune species, and various papers on behavior published under this name all apply to sand dune populations. All of these indicate that females prey on immature *Geolycosa* spiders occurring in sandy situations, using the spider's burrow in which to construct their own nest cells (Krombein 1953, Kurczewski and Kurczewski 1968, 1973, Gwynne 1979, Kurczewski 1981). The name *A. brevihirta* (Banks) is here applied to these populations.

Other elements in the species-group are by no means restricted to sandy places, but are often taken on plains or prairies. Unfortunately females cannot at present be associated with certainty with any of these

forms, so of course nothing can be said concerning their predatory or nesting behavior. Males taken away from sandy areas tend to be larger than *A. brevihirta* and are all black. These males can be sorted into groups equivalent to Dreisbach's species *Pompilinus subtruncatus* and *P. truncatus* and to Cresson's *Pompilus cylindricus*. On at least one occasion these three forms have been taken in one locality on the same date (Tornillo, El Paso Co., Texas). Two of them have been taken together on at least six occasions (localities in Texas, New Mexico, Colorado, Illinois, and Michigan). However, each of these forms (and *A. brevihirta*) is subject to variation in features of the male genitalia and subgenital plate, variation that in some cases blurs any lines that might be drawn between species.

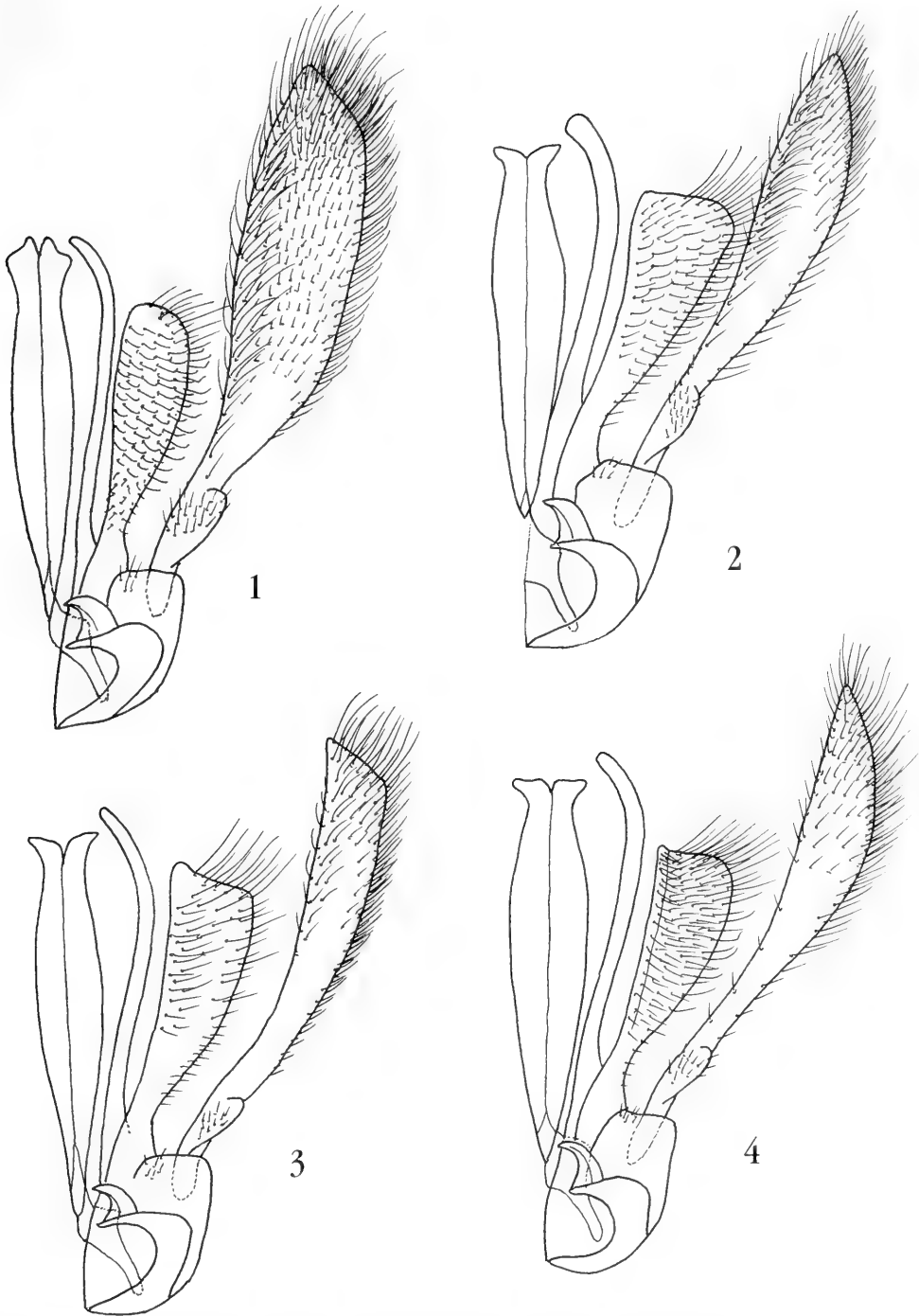
An exception is *A. cylindricus* itself. Study of the genitalia of the lectotype places this as a member of a population restricted to parts of the Southwest. The genitalia are quite distinctive, and I have seen no specimens intermediate with other members of this complex. These other members, *A. brevihirta*, *A. subtruncatus*, and *A. truncatus*, show evidence of intergradation, the latter two forming populations (not restricted to sand dunes) within the broad range of the dune-inhabiting *A. brevihirta*.

Anoplius (*Pompilinus*)
cylindricus (Cresson)

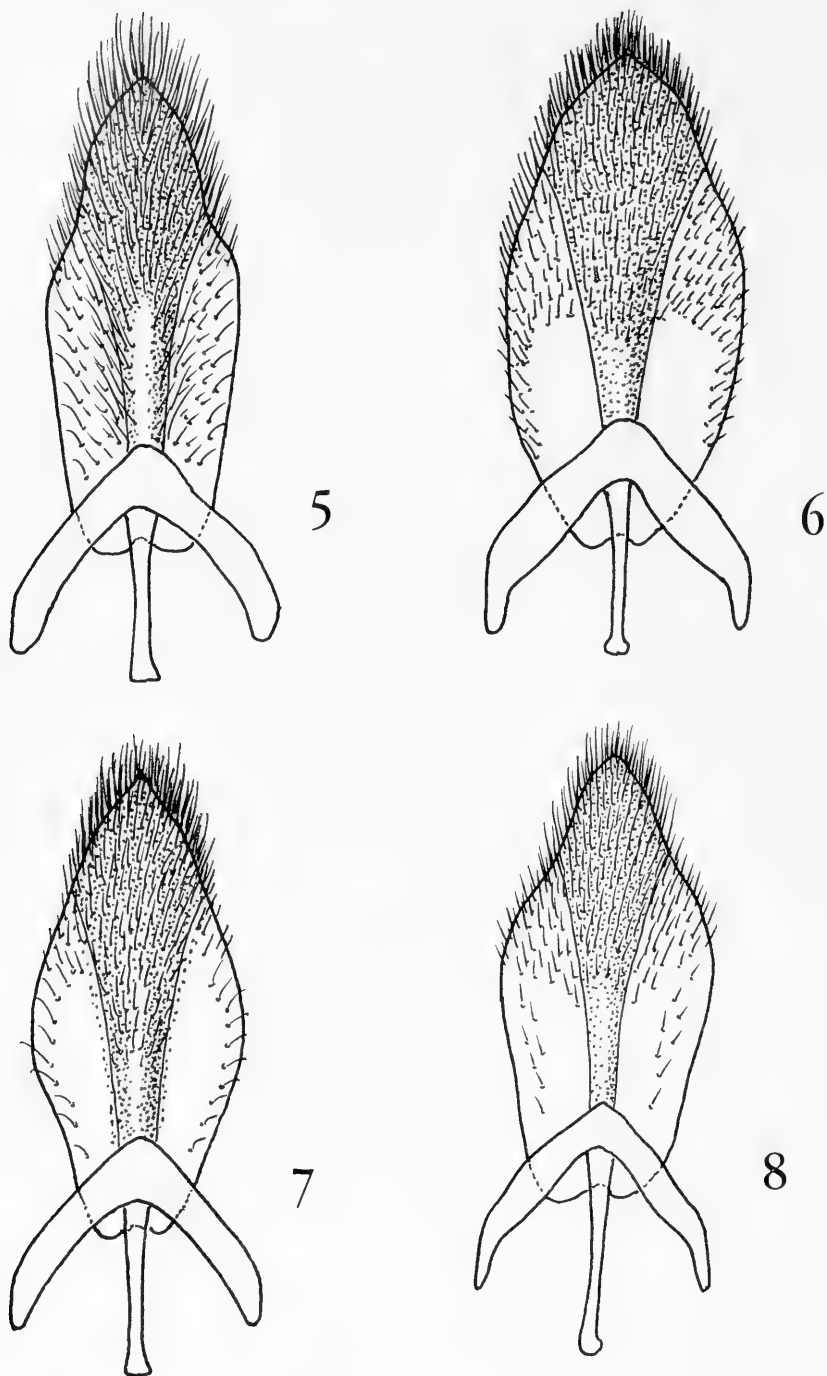
Pompilus cylindricus Cresson, 1867, p. 92.
(Lectotype: ♂, Texas, ANSP).

Pompilinus clavipes Dreisbach, 1958, pp. 61–63. (Holotype: ♂, Texas: Conlon [? Conlen, Dallam Co.], 8 Aug. 1952, R.R. Dreisbach, MCZ).

The lectotype of Cresson's *Pompilus cylindricus* has genitalia and a subgenital plate virtually identical to those figured for *Pompilinus clavipes* by Dreisbach, and as figured here (Figs. 1, 5). This lectotype was designated many years ago, prior to the studies of Dreisbach (1949) and Evans (1951). The other 12 specimens in Cres-



Figs. 1-4. Male genitalia (right half, ventral aspect) of *Anoplius* (*Pompilius*) species. 1, *cylindricus* (Cresson). 2, *subtruncatus* (Dreisbach). 3, *truncatus* (Dreisbach). 4, *brevihirta* (Banks).



Figs. 5-8. Male subgenital plates (ventral aspect) of *Anoplius (Pompilinus)* species. 5, *cylindricus* (Cresson). 6, *subtruncatus* (Dreisbach). 7, *truncatus* (Dreisbach). 8, *brevihirta* (Banks).

son's type series are all assignable to other species. Other males before me are from Kansas: Reno Co. (MCZ, NMNH); Texas: El Paso, Jeff Davis, and Pecos counties (CU, CSU); New Mexico: Chaves Co. (CSU); and Colorado: Prowers Co. (CSU). All have essentially identical genitalia and subgenital plates. All are all black, with a fore wing length from 6.0 to 8.5 mm. The genitalia are distinctive in that the parameres are broadly spatulate and heavily setose along the mesal margin; the digiti are rounded apically, rather than truncate as in other members of this complex.

I have seen several females that very probably belong here. All have a small amount of short erect hair on the propodeum, but the femora have only scattered, very short hairs. The comb spines on the fore basitarsus are short, no longer than width of the basitarsus; the basitarsus bears 3 such spines (in one specimen 4). All have the first two tergites orange; fore wing length varies from 7.7 to 10.8 mm. The strongest evidence that this association is correct is to be found in a series of 3 females and 13 males, all taken by myself on 7 July 1953 at Medora, Reno Co., Kansas (MCZ, NMNH) (the males are all paratypes of Dreisbach's *Pompilinus clavipes*). Other females are from Kansas: Riley Co. (CU); Oklahoma: Grant Co. (MCZ); and Texas: Bastrop, Bee, Brewster, Dimmit, Travis, Kenedy, and Kleburg counties (BFL, CSU, CU, MCZ).

Anoplius (Pompilinus) subtruncatus
(Dreisbach) New Status

Pompilinus subtruncatus Dreisbach, 1949, pp. 17–18, figs. 58, 59. (Holotype: ♂, Nebraska, Lincoln, 14 June 1909, C.H. Gable, Univ. Nebraska).

Pompilinus hispidus Dreisbach, 1949, pp. 23–24, figs. 47, 48. (Holotype: ♂, Michigan, Tuscola Co., 20 Aug. 1940, R.R. Dreisbach, MCZ).

Anoplius hispidus, Evans, 1970, p. 482. (Teton Co., Wyoming).

The type specimens of *Pompilinus subtruncatus* and *P. hispidus* do indeed appear quite different. The former has the hairs on the subgenital plate short and depressed and the inner apical margins of the digiti not angularly extended. The latter has the hairs on the subgenital plate erect and bristling and the inner apical angles of the digiti projecting angularly. However, other specimens combine these two features differently. Dreisbach pointed out two small groups of setae near the midline of the subgenital plate of *P. hispidus*, but these are not present in specimens I have seen other than the type.

Variation in the condition of the hairs on the subgenital plate is striking. In some specimens they are wholly decumbent, in others only a few are erect, and in still others most are erect. In a male from Hialeah, Florida (NMNH), these hairs are especially long and bristling. A paratype of *P. hispidus* from Baldwin, Kansas (NMNH), has a strongly hirsute subgenital plate but the digiti lack an angulate process on the inner, apical margin. There are other examples that, to me, suggest that this is a single species subject to discordant variation in seemingly important features of the male abdomen. Some specimens have fewer setae along the mesal margin of the parameres than figured, suggesting possible intergradation with *A. brevihirta*. Smaller specimens fall within the size range of that species; overall size range (fore wing length) varies from 5.3 to 9.0 mm. I have been unable to associate any females with this species with any certainty. Males are all black, but it is probable that females are marked with orange as in other members of this complex.

This species is widely distributed throughout the United States from the Rockies eastward. I have seen specimens from the following localities: Florida: Hialeah (NMNH); Maryland: Bowie (NMNH); Louisiana (without further data) (NMNH); Michigan: Tuscola Co. (MCZ); Iowa: Sioux City (NMNH); Kansas: Baldwin (NMNH),

Co. (NMNH); Nebraska: Chadron Univ. (NMNH); Colorado: Boulder, Lincoln, Neligh Univ. (NMNH); Nebraska: North Dakota: Beach (NMNH); Wyoming: Teton Co. (MCZ); Colorado: Bent, Elbert, Larimer, Otero, and Weld counties (CSU); Texas: Jeff Davis (CU), El Paso (MCZ), and Presidio (ANSP) counties.

Anoplius (Pompilinus) truncatus
(Dreisbach) New Status

Pompilinus truncatus Dreisbach, 1949, pp. 15, 16, figs. 40, 41. (Holotype: ♂, Michigan, Gratiot Co., 2 Aug. 1947, R.R. Dreisbach, MCZ).

As the species name implies, the parameres of the male genitalia are obliquely truncate apically (Fig. 3). An additional useful character is the absence of setae from the center of the disc of the digitus. The subgenital plate (Fig. 7) tends to be more slender and pointed than in the preceding species, but this is a subtle and not wholly dependable character; the sides of the plate are less sinuate than in *Anoplius cylindricus* (Fig. 5) and *A. brevihirta* (Fig. 8). The mesal margin of the paramere is relatively sparsely setose, much as in *A. brevihirta* but in contrast to *A. cylindricus* and *A. subtruncatus*.

In a series of 6 males from Tornillo, Texas (CSU), taken on the same day, some agree well with *A. truncatus* and others with *A. brevihirta*, while one has the left paramere truncate (as in *A. truncatus*), the right paramere acute (as in *A. brevihirta*). In a series of 4 males from Great Sand Dunes National Monument, Colorado (CSU), taken on the same day, three have genitalia typical of *A. brevihirta*, while the fourth has truncate parameres (although the digiti are fully clothed with setae and the subgenital plate is sinuate laterally). These specimens, and others, suggest that there is some interbreeding between these two species. Males of *A. truncatus* are all black and average larger than those of *A. brevihirta*, fore wing length varying from 5.5 to 7.2

mm. I have been unable to associate any females with this species.

Anoplius truncatus appears to have a more restricted range than *A. subtruncatus*, occurring from Texas and New Mexico to Illinois and Michigan. Dreisbach's paratypes are from Manistee and Midland counties, Michigan, Carlinville, Illinois, and Roswell, New Mexico. Other males I have seen are from Colorado: Bent, Larimer, Prowers, and Weld counties (CSU); New Mexico: Hidalgo Co. (CSU); and Texas: El Paso (CSU) and Jeff Davis (ANSP) counties.

Anoplius (Pompilinus) brevihirta
(Banks) New Status

Arachnophila brevihirta Banks, 1945, p. 105. (Holotype: ♀, Chicago, Illinois, July, C.T. Brues, MCZ).

Anoplius (Pompilinus) cylindricus, Evans, 1951, pp. 294-297, figs. 91, 123. (In part).

This is the most widely distributed member of this complex, ranging from coast to coast and from Canada deep into Mexico. It is the form most often identified as *A. cylindricus*, under which name there have been several reports on its biology (as discussed above). It is characteristic of areas of open sand, and virtually every system of dunes I have visited has a population of these wasps. Males average smaller than those of the preceding three species, fore wing length varying from 4.0 to 7.0 mm. The genitalia have the parameres acute, their mesal margins sparsely setose; the digiti are fully clothed with setae and the distal, mesal angle is prominent (Fig. 4). The subgenital plate is slender, with sinuate margins, and is clothed ventrally with subrecumbent setae (Fig. 8).

Even with the removal of the three preceding species from synonymy, this remains a very variable species. About 75% of the males I have seen have one or more basal tergites marked with orange. All-black males cannot always be distinguished

from those of other members of this complex without examining the genitalia. Even so, occasional specimens are puzzling. A male from Mt. Vernon, Missouri (CSU), has the parameres very slender, almost linear. A few males have the parameres somewhat truncate apically; two such specimens were cited under *A. truncatus*.

Females vary in fore wing length from 4.5 to 9.5 mm. Those from any one locality often differ greatly in size, suggesting that they have developed on spiders of different sizes. Females also differ in the number of spines on the fore basitarsus and in the amount of erect hair on the femora and the propodeum. Females have at least the second tergite banded with orange, sometimes part or all of the first and third tergites and some of the basal sternites. Since sand dune systems tend to be widely spaced in nature, it is possible that local populations have diverged slightly in structure and color.

Some of the variation also has a broadly geographic component (Table 1). Males from the eastern coastal states invariably have orange coloration on the abdomen, and this is true of males from Kansas, Texas, and eastern Colorado. Females from these same areas usually have only 3 comb spines on the fore basitarsus, while those from Michigan and from south central Colorado usually have 4 comb spines (in these two areas males are usually all black). Females from many western sites tend to have much more hair on the propodeum and femora than those from eastern localities, which may be almost devoid of such pilosity.

It is not clear why there are resemblances between the population at Great Sand Dunes in Colorado (represented by a series at CSU) and that at Warren Dunes, Michigan (represented by a series at MCZ) (Table 1). The latter site is subject to cooling winds from Lake Michigan, such that certain microclimatic conditions may approximate those at a much higher elevation (2440 m) in Colorado; however, the Colorado site has a much lower annual precipi-

Table 1. Geographic variation in male coloration and the number of comb spines on the fore basitarsus of females of *Anoplius (Pompilius) brevihirta* (Banks).¹

Locality	No. of Males		No. of Females	
	Marked with Orange	All Black	3 Comb Spines	4 Comb Spines
MA and CT	7	0	17	0
NJ and MD	3	0	17	0
NC	17	0	64	0
FL	20	0	48	0
NY and PA ²	0	3	11	1
MI ³	5	15	3	16
KS	10	0	19	7
E. TX	1	0	6	0
W. TX	3	0	1	11
E. CO	8	0	14	7
S. CO ⁴	1	8	11	44
NM	1	0	4	9
Totals	76	26	215	95

¹ Includes only localities with a sample size of 5 or more. States are combined when records are consistent; states are divided when separate parts differ.

² Three localities on Lakes Erie and Ontario: Erie Co., PA, Oswego and Jefferson Co., NY.

³ Warren Sand Dunes State Park, Berrien Co.

⁴ Great Sand Dunes National Monument, Alamosa Co.

tation than the Michigan site. Specimens from Kansas, eastern Colorado, and a smattering of localities in the Great Plains, tend to approximate eastern specimens.

A comparison of the females from two widely separated areas of extensive sand is especially interesting (Fig. 9). In coastal North Carolina there is evidently a spring generation in which females are larger and have only 1–1.5 tergites orange. This is followed by a summer generation of females that are smaller and have 2 or 3 basal tergites orange. (These data are based on a long series of specimens from Nags Head and Kill Devil Hills in NMNH.) Presumably the large females of the spring generation result from the fact that females of the preceding summer took more mature *Geolycosa* spiders, while the small females of the summer generation developed on less mature spiders. At Great Sand Dunes National Monument the season is much short-

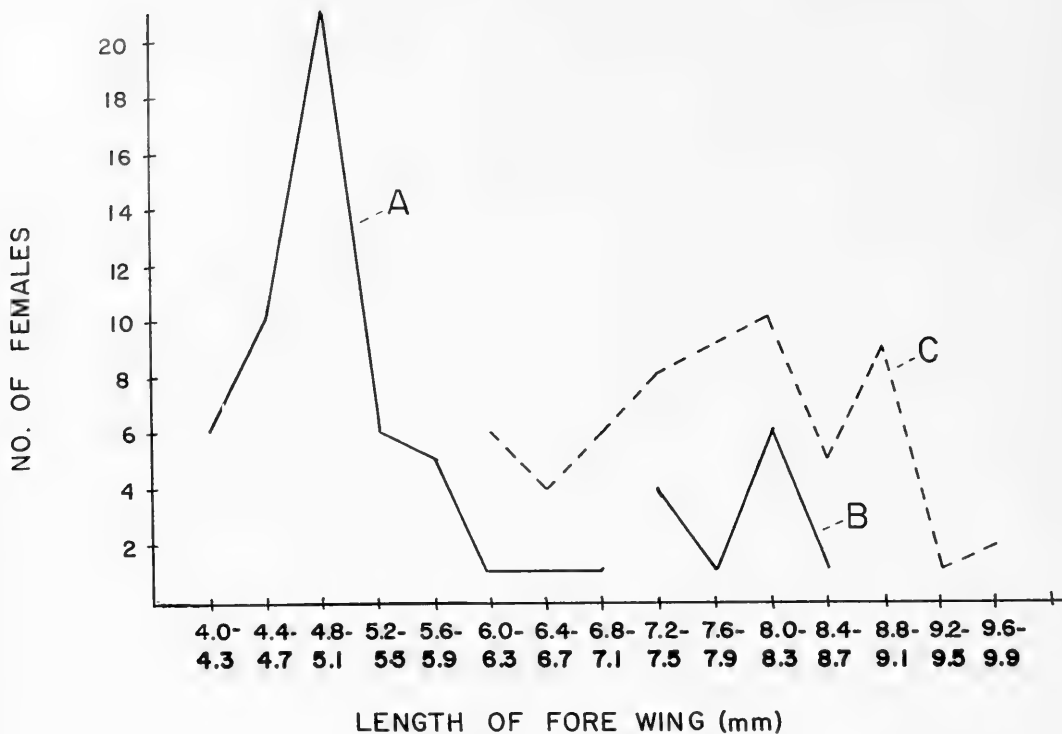


Fig. 9. A size and color comparison of two generations of *Anoplus (Pompilinus) brevihirta* (Banks) from coastal North Carolina and the single generation from southern Colorado at 2440 m elevation. A, Kill Devil Hills, NC, 23 June to 14 Sept.: 2-3 tergites orange. B, Kill Devil Hills, NC, 24 May to 22 June: 1-1.5 tergites orange. C, Great Sand Dunes National Monument, CO, July-August: 1-1.5 tergites orange.

er; here the females approximate in size and coloration members of the spring generation in coastal North Carolina. However, these females have much more body hair and a stronger tarsal comb. It is possible that the more extensive orange coloration of the second generation in North Carolina is the result of summer heat on the pupal stage, as occurs in other Hymenoptera. Males from Texas, New Mexico, and eastern Colorado are almost invariably marked with orange, and there is a corresponding tendency for females from these areas to be more extensively marked with orange. Clearly we are far from explaining the observed variation in this species, but it must be recognized when one attempts to circumscribe this species as distinct from others.

KEY TO MALES OF THE
A. CYLINDRICUS GROUP

1. Digni rounded apically; parameres broadly spatulate (Fig. 1) *cylindricus* (Cresson)
- Digni broadly truncate apically; parameres less broadly expanded apically 2
2. Parameres obliquely truncate apically; center of disc of digni devoid of setae (Fig. 3) *truncatus* (Dreisbach)
- Parameres more or less acute apically; center of digni covered with short setae 3
3. Mesal margin of parameres heavily setose (Fig. 2); subgenital plate somewhat broader, sides gradually tapered, often bearing erect setae (Fig. 6); all black *subtruncatus* (Dreisbach)
- Mesal margin of parameres more sparsely setose (Fig. 4); subgenital plate more slender, with sinuate lateral margins (Fig. 8); basal tergites with or without orange coloration *brevihirta* (Banks)

CONCLUSIONS

Members of the *A. cylindricus* species-group occur throughout much of North America and have commonly been considered to constitute a single variable species. However, four populations can be distinguished on the basis of the male genitalia. While the differences between them are slight, they seem sufficiently discrete to suggest that to a considerable degree they breed independently of one another. This is especially true of *A. cylindricus* itself, which is restricted to the southwestern states. Two others, *A. subtruncatus* and *A. truncatus* (both known from males only), occupy limited ranges within that of the very widely distributed *A. brevihirta*. The last is characteristic of broad areas of open sand, where females prey on *Geolycosa* spiders. While two or three of these species have sometimes been taken at the same time and place and remain recognizable, occasional specimens are somewhat intermediate in characters of the genitalia. Both *A. subtruncatus* and *A. truncatus* occur primarily on plains and prairies and may intergrade with *A. brevihirta* on the periphery of the sand dune habitats of the latter. Further collecting and data on nesting behavior are needed to fully clarify the components of this complex. Molecular studies might be useful both for associating the sexes and for better understanding the degree to which interbreeding occurs.

A. brevihirta, even as restricted here, is a very variable species. Populations in widely spaced sand dune systems have diverged slightly in features of structure and color, and there are also broadly geographic tendencies relating to the length and number of comb spines on the fore basitarsus of the females, the length and abundance of body pilosity, and the amount of orange coloration on the abdomen. Further collecting of larger series from more sand dune areas may serve to fill out details in the spatial distribution of these variable characters.

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**THE GALL MIDGES (DIPTERA: CECIDOMYIIDAE) OF *BACCHARIS* SPP.
(ASTERACEAE) IN THE UNITED STATES**

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Abstract.—The gall midge fauna of *Baccharis* in the United States now includes 12 species. Four species were previously known to attack *Baccharis* in the United States: three species of *Neolasioptera*, *N. baccharicola* Gagné, *N. lathamii* Gagné, and *N. rostrata* Gagné, and *Rhopalomyia californica* Felt. Three new species and a new genus to contain one of them are described: *Asphondylia bacchariicola* Gagné, *Rhopalomyia sulcata* Gagné, and *Xipholasioptera* Gagné and its monotypic type species *Xipholasioptera ensata* Gagné. Five other species, three species of *Asteromyia*, a *Contarinia* sp., and a *Dasineura* sp., are placed only to genus because of insufficient material for further determination. *Rhopalomyia baccharis* Felt is considered a junior synonym of *R. californica*. A key is given to the feeding niche for the 12 species.

Key Words: Diptera, gall midges, Cecidomyiidae, fauna of *Baccharis*

Baccharis (Asteraceae), a genus endemic to the New World, contains 21 species that occur in the United States. These plants are woody, 0.5–4.0 m in height, and dioecious. Three species, *Baccharis halimifolia* L., *B. neglecta* Britt., and *B. pteronioides* DC., are weedy shrubs of economic importance. They invade pastures, rangelands, and recreation areas, and are unpalatable or toxic to livestock. *Baccharis halimifolia*, introduced into Australia as an ornamental but turned pest because of its invasive nature, has been controlled there to some extent by *Rhopalomyia californica* Felt, a gall midge introduced from California. Cultivated varieties of two other species, *Baccharis sarothroides* Gray and *B. pilularis* DC., are valuable for xeroscaping and are commercially available in western United States (Boldt 1989).

In this paper we review the gall midge

fauna of *Baccharis* in the United States. Twelve species are treated, including three new to science and several others that remain undescribed. Most of the newly recorded species and specimens in this study were collected by one of us (PEB) as part of a general survey of the phytophagous insects on *Baccharis* in southwestern United States (Boldt and Robbins 1994). The gall midges we list, except possibly the *Contarinia* sp. and the *Dasineura* sp., appear to be specific to *Baccharis* and belong to species groups or genera restricted to Asteraceae.

METHODS

The field work for this paper was done under the direction of P. E. Boldt, the taxonomy by R. J. Gagné. Galls were collected from *Baccharis* in southwestern United States from 1986 to 1993 and gall midges obtained by P. E. Boldt. Galls were re-

removed from affected plants and dissected to obtain larvae, or held in small containers until adults emerged. Specimens for study were killed and preserved in 70% ethanol. All the specimens listed are in the National Museum of Natural History (USNM), Washington, D.C. Study specimens were slide mounted for identification and scientific study using the method outlined in Gagné (1989, 1994). Terminology for adult morphology follows usage in McAlpine et al. (1981); that for larval morphology follows Gagné (1989).

KEY TO LARVAL NICHE OF NEARCTIC GALL MIDGES INFESTING *BACCHARIS*

Details on each species in the key are under the alphabetically arranged generic and species headings that follow.

- 1. In or on mature flowers 2
 - In unopened buds, leaves or stems 3
- 2. Free in flowers
 - *Contarinia* sp. and *Dasineura* sp.
 - In swollen flower receptacles
 - *Neolasioptera rostrata*
- 3. Conical or spherical complex galls on buds or leaves 4
 - Simple swellings of leaves or stems 6
- 4. Spherical, spongy bud galls (Fig. 3)
 - *Rhopalomyia californica*
 - Conical or columnar galls (Figs. 1, 4-5) 5
- 5. Conical apical gall formed by fused apical bud leaves and usually surrounded by rosette of leaves (Fig. 1) *Asphondylia baccharioli* and *Xipholasioptera ensata*
- Conical or columnar galls (Figs. 4-5)
 - *Rhopalomyia sulcata*
- 6. Swollen leaves or epidermis of green stems *Asteromyia* spp.
- Swollen stems of branchlets (Fig. 2) 7
- 7. Irregular swelling, often soft when young and often on upper part of stem (Fig. 2)
 - *Neolasioptera lathamii*
 - Spherical, hard, woody stem swelling at base of plant *Neolasioptera baccharicola*

NEARCTIC GALL MIDGES OF *BACCHARIS*

Asphondylia baccharioli Gagné,
new species

Adult (female only).—Head: Antenna: scape cylindrical, ca. 1.8 times length ped-

icel; pedicel about as wide as long; first flagellomere about 2.3 times length of scape, evenly cylindrical. Eye facets close together, hexagonoid. Frons with 15–20 setae per side. Labellum (Fig. 6) hemispherical, laterally with 18–20 setae. Palpus (Fig. 6) with three segments, segments two and three each longer than the preceding.

Thorax: Wing length, 3.2–3.4 mm. Scutum with 2 dorsocentral and a lateral row of setae on each side, mixed with setiform scales. Anepisternum with scales on dorsal half, anepimeron covered with setae and scales. Claws of all legs subequal in size and similar in shape, as long as empodia (Fig. 7).

Abdomen: Ovipositor about 1.8 times as long as seventh sternite.

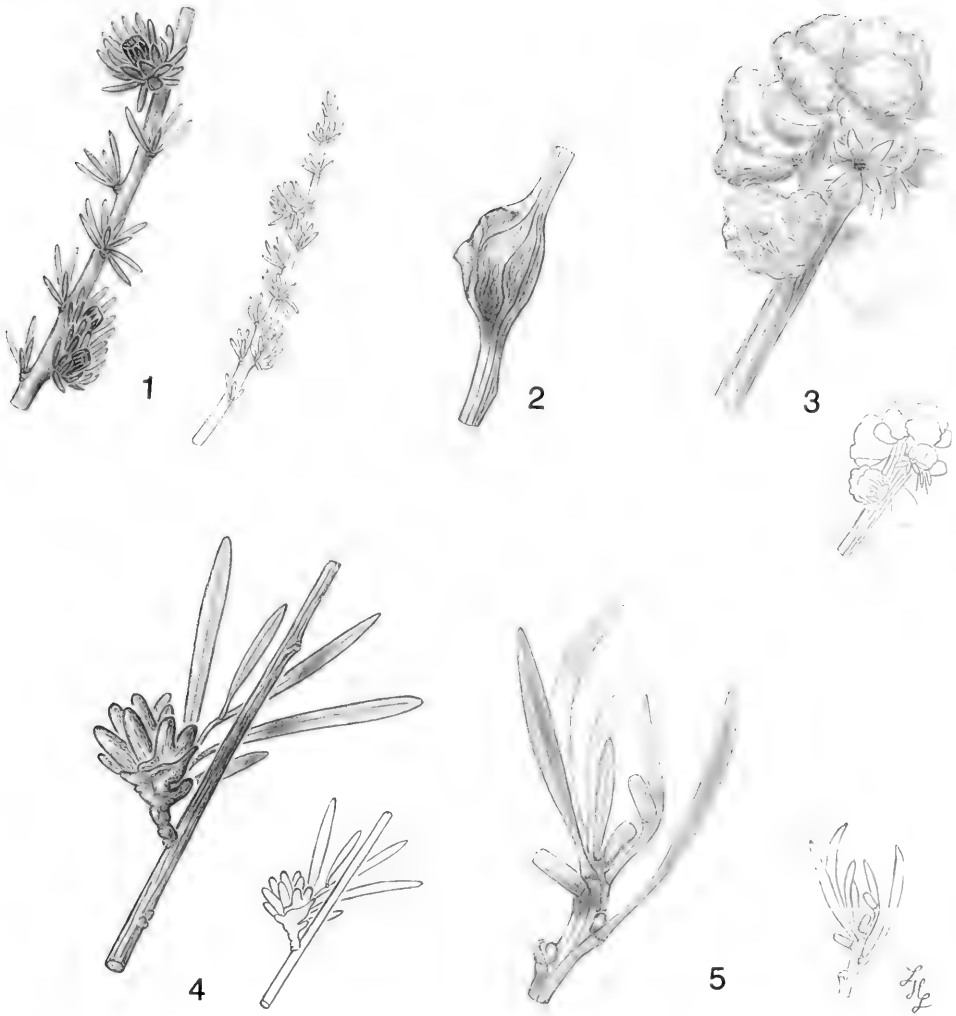
Pupa (Figs. 8–10).—Antennal horns blunt at apex in frontal view. Frons with bifid upper horn and trifold lower horn. Spines of seventh and eighth abdominal segments arranged as in Fig. 10.

Larva.—Third instar: Spatula and associated papillae as in Fig. 13; 3–4 lateral papillae present on each side of spatula (specimen shown with 4 on one side, 3 on the other); terminal segment (Figs. 11–12) with 8 papillae, 2 of them corniform, the remaining each with tiny seta.

Holotype.—Third instar, from apical leaf fascicle gall of *Baccharis pteronioides*, Appleton-Whittel Research Ranch, 4 mi. S Elgin, Santa Cruz Co., Arizona, 13-VII-1988, T. O. Robbins, deposited in USNM.

Paratypes.—Arizona: 3 pupal exuviae, 5 ♀, same data as holotype; first instar, same data as holotype except collected on 16-V-1989. Texas: 1 pupal exuviae, *Baccharis pteronioides*, CDRI Arboretum, 4 mi. SE Ft. Davis, Jeff Davis Co., 3-V-1988, P. E. Boldt; Texas: third instar, 2 pupal exuviae, 4 ♀, *Baccharis pteronioides*, Frijole Visitor Center, Guadalupe Mts. National Park, Culberson Co., 21-VIII-1988, P. E. Boldt.

Additional material.—Arizona: galls, same data as holotype; galls, pupae, *Baccharis pteronioides*, Cochise Co., Hwy 82, 5 mi W junction Hwy 90, 28-IV-1994, T.

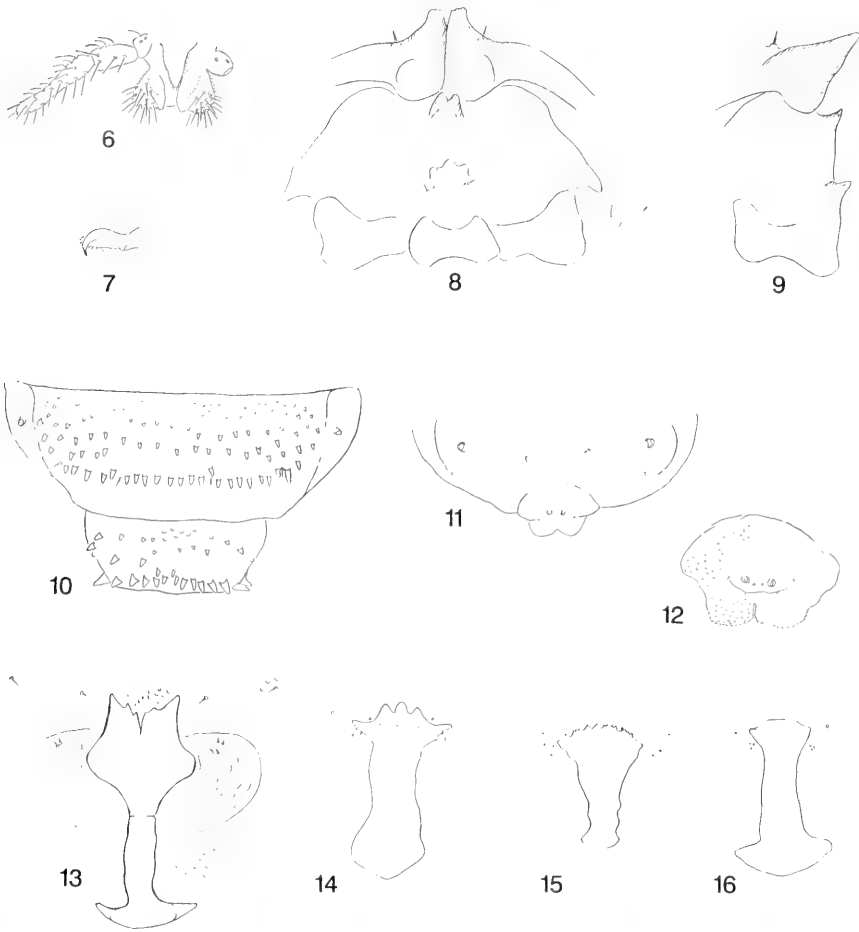


Figs. 1–5. Cecidomyiid galls of *Baccharis* spp. 1, *Asphondylia bacchariola* on *B. pteronioides*, Elgin, AZ (1 and 2×). 2, *Neolasioptera lathami* on *B. halimifolia*, Orient, NY (1×). 3, *Rhopalomyia californica* on *B. pilularis*, Alameda Co., CA (1 and 2×). 4, *Rhopalomyia sulcata* on *B. salicifolia*, nr. Carlsbad, NM (1 and 2×). 5, *Rhopalomyia sulcata* on *B. neglecta*, nr. Iraan, TX (1 and 2×).

O. Robbins. Texas: gall, *Baccharis pteronioides*, CDRI Arboretum, 4 mi. SE Ft. Davis, Jeff Davis Co., 3-V-1988, P. E. Boldt; galls, *Baccharis pteronioides*, 20 mi. W Ft. Davis, Jeff Davis Co., 21-III-1990 and 10-V-1990, T. O. Robbins; gall, *Baccharis pteronioides*, Frijole Visitor Center, Guadalupe Mts. National Park, Culberson Co., 21-VIII-1988, P. E. Boldt; galls, one with pupal exuviae, *Baccharis pteronioides*, Frijole Visitor Center, Guadalupe Mts. National Park, Culberson Co., 15-VI-1989, T. O.

Robbins. Additional galls from *Baccharis bigelovii* similar to those from *B. pteronioides* but without gall midge specimens are tentatively referred to *A. bacchariola*: Arizona: gall, Ash Canyon, Huachuca Mts., Cochise Co., 14-VIII-1990, P. E. Boldt; galls, Coronado National Memorial, Huachuca Mts., Cochise Co., 14-VIII-1990, P. E. Boldt.

Etymology.—The name *bacchariola* is an adjective combining the name of the plant host genus with a diminutive suffix.



Figs. 6-16. Figs. 6-11, *Asphondylia bacchariola*. 6, Adult mouthparts (incomplete). 7, Foretarsal claw and empodium. 8, Pupal head, ventral. 9, Same, lateral. 10, Pupal seventh and eighth abdominal segments, dorsal. 11, Larval eighth and terminal abdominal segments, dorsal. 12, Detail of larval terminal segment, dorsal. 13, Larval spatula and associated papillae. Figs. 14-16, *Asteromyia* spp., larval spatulae. 14, *Asteromyia* sp. 1 from *B. angustifolia*. 15, *Asteromyia* sp. 2 from *B. pteronioides*. 16, *Asteromyia* sp. 3 from *B. salicina*.

Gall (Fig. 1).—Each gall is made up of several leaves forming a conical, one-celled cylinder about 4 mm long and contains a single larva or pupa. Galls appear singly at the apices of branches, are green at first, but turn brown after the single larva in each gall changes to the pupal stage. The interior gall surface is covered with a white fungal mycelium while the larva is alive.

Distribution.—Arizona and western Texas.

Hosts.—*Baccharis pteronioides* and possibly *B. bigelovii*. The gall is similar on

both plants but no gall midge specimens were found on the latter host to make a positive identification.

Remarks.—*Asphondylia* is a cosmopolitan genus with some 260 described species that mostly form galls in flowers and fruit of many families of plants. This new species falls within a group of *Asphondylia* that occur on Asteraceae and are characterized by having the adult labella setose and the pupal upper frontal horn bifid. A thorough comparison of this new species with other western Nearctic species from Asteraceae is

not possible because most named species were described only on the basis of the adult stage. Adults of *Asphondylia* species have few diagnostic characters (Hawkins et al. 1986, Gagné and Waring 1990). Larvae of none of the western species from Asteraceae have been described; pupae are known only from *Asphondylia chrysothamni* Felt and *Asphondylia enceliae* Felt and are similar to that of the new species. The ovipositor of *A. chrysothamni* is somewhat longer at 2.1 times the length of the seventh abdominal sternite, and the tarsal claws of *A. enceliae* are longer and thinner than on the new species.

Asphondylia baccharis Kieffer and Herbst (1905) is known from Chile from a plant tentatively identified as *Baccharis* sp. The gall is reportedly a deformed floret 2.5–3.0 mm long, black, thin walled, and covered with hairs. The adult and pupa were only sketchily described and are presumed lost (Gagné 1994), so it is impossible to compare this species with *A. bacchariola*.

Asteromyia spp.

This genus belongs to the supertribe Lasiopteridi and tribe Alycaulini (Gagné 1994). Larvae of *Asteromyia* spp. are found in blister galls of leaves or green stems of various Asteraceae. Larvae are flattened and ovoid and have a generally reduced number of papillae with short setae. There are only three lateral papillae on each side of the spatula and only four terminal papillae.

Gagné (1968) considered a larval specimen from *Baccharis* in Texas to be *Asteromyia gutierreziae* because it was similar to larvae of that species. Two other kinds of larvae based on differences in the spatulae (Figs. 14–16) have since been found. Without pupae and adults, nothing more can be done to identify these. Because the spatulae are so different, the larvae are placed here as *Asteromyia* sp. 1, sp. 2, and sp. 3.

Analogous blister galls on *Baccharis* in the Neotropics are formed by *Geraldiesia*

spp. (Gagné 1994). Adults of *Geraldiesia* are superficially similar to *Asteromyia*, but larvae of *Geraldiesia* are elongate and cylindrical instead of ovoid and flat and pupae are pigmented and sclerotized instead of hyaline and soft as in *Asteromyia*.

Asteromyia sp. 1, near *gutierreziae* Felt

This segregate is known from a single larva with a three toothed spatula (Fig. 14) similar to that found in *A. gutierreziae*. It was placed under *A. gutierreziae* in Gagné (1968). The specimen was taken from a blister leaf gall on *Baccharis angustifolia* (probably = *salicina*) collected in Kenedy Co., Texas, 20-XII-1940 by R. Runyon and found in the botanical collections of the USNM.

Asteromyia sp. 2

The larval spatula (Fig. 15) of this segregate has many fine serrations along the anterior edge. It is known from two specimens from Texas, each from a different species of *Baccharis*: *B. pteronioides*, Frijole Ranch, Guadalupe Mountains National Park, Culberson Co., Texas, X-16-1990, P. E. Boldt; and *B. bigelovii*, Point of Rocks, 12 mi. W Ft. Davis, Jeff Davis Co., Texas, VI-12-1990, P. E. Boldt.

Asteromyia sp. 3

The larval spatula of this segregate has a smooth anterior edge (Fig. 16). The single known larva was taken from a blister gall of *B. salicina*, Greenbelt Reservoir, 4 mi. N Clarendon, Donley Co., Texas, X-5-1988, P. E. Boldt and T. O. Robbins.

Contarinia sp.

Contarinia is a very large genus of some 250 species in the world. Larvae of most species live in leaf rolls or bud galls, but many live freely and gregariously among flower heads, as does the species on *Baccharis* spp. Most are known from one host species, some feed on more than one species of a genus, and at least one is polyphagous (Gagné 1995). *Contarinia* larvae

have been taken in flower heads of several species of *Baccharis* spp. but have not been reared to the adult stage. Many *Contarinia* spp. that live in flower buds, including the species reared from *Baccharis* spp., have the hind spiracles situated on posteriorly directed lobes, as shown in Gagné (1989).

Specimens in the USNM collected from *Baccharis* flower heads are as follows: *Baccharis glomeruliflora*, Miami, Florida, 12-XI-1970, C. E. Stegmaier, Jr., 3 larvae; *Baccharis halimifolia*, Cambridge, Dorchester Co., MD, 14-X-1984, V. Krischick; *Baccharis pteronioides*, Lincoln National Forest, Carlsbad, Eddy Co., New Mexico, 21-V-1989, P. E. Boldt & R. J. Gagné, 5 larvae; *B. pteronioides*, Rt. 137, 1 mi. S junction to Sitting Bull Falls, Carlsbad, Eddy Co., New Mexico, 21-V-1989, P. E. Boldt & R. J. Gagné, 10 larvae; *B. pteronioides*, Hwy. 45, 7 mi. E Durango, Durango, Mexico, 4-VIII-1988, P. E. Boldt, 5 larvae; *Baccharis salicina*, Sitting Bull Falls, Lincoln National Forest, Eddy Co., New Mexico, 16-VIII-1989, T. O. Robbins.

Dasineura sp.

Dasineura is a large, catchall genus with over 350 species described in the world. Many species form simple galls, including leaf rolls and swollen buds, but many live gregariously in flower heads. Larvae of an unidentified species were collected in association with *Contarinia* sp. larvae on flower heads of *B. halimifolia*, Cambridge, Dorchester Co., MD, 14-X-1984, by V. Krischick, and from *B. salicina*, Sitting Bull Falls, Lincoln National Forest, Eddy Co., New Mexico, 16-VIII-1989, by T. O. Robbins. A typical *Dasineura* sp. larva is figured on page 67 of Gagné (1989).

Neolasioptera spp.

Neolasioptera is a large American genus of about 175 described species that live mainly in stem, petiole, or midrib swellings of various plants, but also in achenes or other flower parts of Asteraceae. Three North

American species are known from *Baccharis*, as follows:

Neolasioptera baccharicola Gagné

This species forms a hard, woody gall at the base of the stem of *B. halimifolia*. It is known only from a series reared from galls taken at Virginia Beach, Virginia, V-1960, by F. D. Bennett (Gagné 1971).

Neolasioptera lathami Gagné

Galls (Fig. 2) of this species can be found near the base of the plant as well as among apical branches of *B. halimifolia*, *B. neglecta*, *B. salicina*, and *B. sarothroides*. This species has two or more generations per year. It is known from New York south to Florida and west to Texas and Arizona (Gagné 1989). Palmer and Bennett (1988) recommended this species for introduction into Australia to control *B. halimifolia*, and Diatloff and Palmer (1987) reported on its biology and host specificity.

Neolasioptera rostrata Gagné

This species forms galls in receptacles of both male and female flowers (Gagné and Boldt 1989). It is widespread in the United States, from Maryland, Florida, Texas, and New Mexico where it occurs on *B. glomeruliflora*, *B. halimifolia*, *B. salicina*, and *B. neglecta*. It also occurs in the Dominican Republic on *B. myrsinites* (Gagné and Boldt 1989), and P. E. Boldt has found it also in Argentina on *B. pingraea* and *B. spartioides* (Gagné 1994).

Rhopalomyia spp.

Rhopalomyia is a large, worldwide genus of about 150 gallforming species that mostly occur on Asteraceae. Two species have been described from *Baccharis pilularis* from California, but one, *Rhopalomyia baccharis* Felt, is considered here a junior synonym of *R. californica*. A new species is described from several species of *Baccharis* growing in Texas to Arizona.

Rhopalomyia californica Felt

This species forms lobed, succulent, usually leafy bud galls (Fig. 3) on *B. pilularis* in California. It was imported into Australia as a potential biocontrol agent of *B. halimifolia* in 1969 and 1982. The gall midge took hold only after the 1982 introduction and since then has effectively established itself in Queensland and New South Wales (McFadyen 1985, Julien 1992, Palmer et al. 1993). It was also introduced into Texas in 1985 to control *B. halimifolia* and *B. neglecta*. Typical galls were observed on *B. neglecta* at Belton, Texas in 1986, but none was subsequently found (Boldt, unpub. data). The ecology of this species and its parasites has been investigated by Ehler (1982, 1987, 1992) and Ehler and Kinsey (1990, 1991, 1993). This species is very similar to *Rhopalomyia sulcata* Gagné. Differentiation between the two species is made under *R. sulcata*.

Rhopalomyia baccharis (Felt 1908) is here considered a junior synonym of *R. californica*. *Rhopalomyia baccharis* was reportedly reared from unspecified stem galls collected in December, 1885 on *B. pilularis*, presumably in California but unstated (Felt 1908, 1915). The two syntypes, one of each sex, that Felt studied are labelled “#3849, Dec. 19, 85” and “Type No. 29333 U.S.N.M.” They differ from most specimens of *R. californica* in having two instead of one segmented palpi. The gonostylus of the male syntype of *R. baccharis* appears more bulbous than in *R. californica* because it is laterally compressed on the slide mount. In the USNM collection are pinned specimens with the same first label as the types and an additional one that reads, “C.V. Riley Collection.” Four males were slide-mounted to compare them properly with the syntype. Their gonostyli do not appear bulbous as in the syntype but are similar to that shown for *R. californica* (Fig. 20). In addition, two of the specimens have two-segmented palpi like the syntypes, but two have one-segmented palpi.

Specimens reared from *R. californica* galls usually have one-segmented palpi, but occasional specimens are found with two-segmented palpi. L. E. Ehler (in litt.) writes that in outbreak conditions, galls commonly occur all along the shoots, especially when the terminals of the shoots are already galled. The unspecified “stem gall” made by this *R. baccharis* could have come from such a gall. It appears, then, that there is no reason to maintain *R. baccharis* as a distinct species.

Rhopalomyia sulcata Gagné,

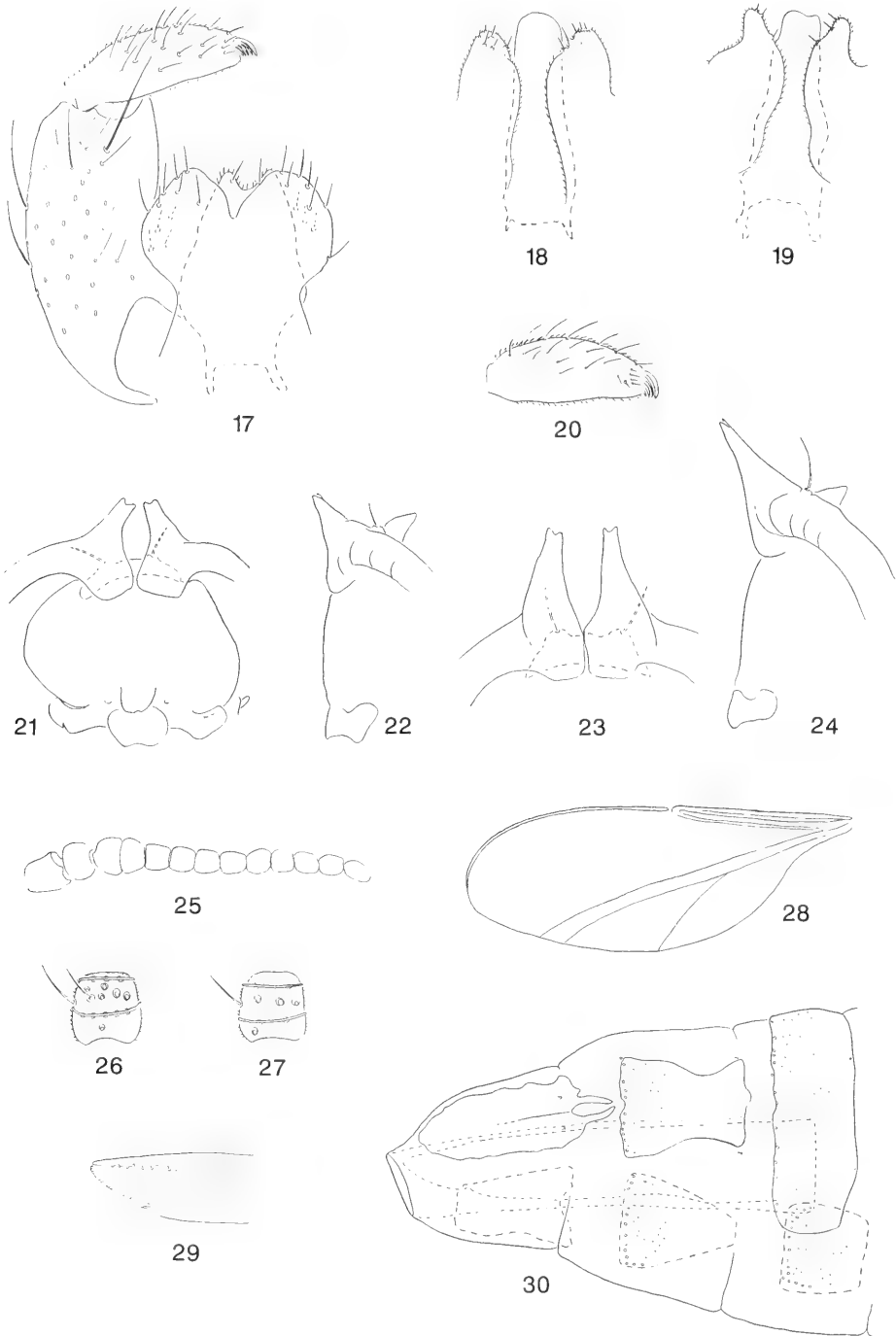
NEW SPECIES

Adult.—Head: Eyes joined, about 5 facets long at vertex. Male antenna with 16–17 flagellomeres, neck of third flagellomere about $\frac{1}{2}$ length of node. Female antenna with 15–16 flagellomeres without distinct necks. Frontoclypeus with 5–12 setae per side. Labellae fused, each with 1–10 setae. Palpus of one short, elliptical segment with 2–10 setae.

Thorax: Wing length, ♂ 2.9–3.3 mm; ♀, 2.2–2.5 mm. Anepimeron with 12–20 setae. Claws simple. Empodia slightly longer than claws. Pulvilli about $\frac{2}{3}$ length claws.

Male abdomen: Tergites 1–7 rectangular, with mostly single row setae on posterior margin intermixed with a few scales, a group of several setae laterally, and pair of anterior trichoid sensilla. Tergite 8 narrower and with sparser to no setae posteriorly and laterally but with pair of anterior trichoid sensilla. Pleura with scales. Sternites 2–8 covered with setae except for a small area about $\frac{2}{3}$ distance from anterior edge, all with anterior pair of trichoid sensilla. Genitalia (Figs. 17–18): Gonocoxite cylindrical. Gonostylus elongate-cylindrical, tapering to narrow, toothed apex. Cerci rounded apically with several setae on disk and along apex. Hypoproct convex apically with 1–2 pairs of apical setae. Claspettes and aedeagus blunt tipped, aedeagus about as long as hypoproct.

Female abdomen: Tergites 1–6 rectangular, with mostly single row of setae on



Figs. 17-30. Figs. 17-18, *Rhopalomyia sulcata*. 17, Genitalia, dorsal. 18, Claspettes and aedeagus, dorsal. Figs. 19-20, *Rhopalomyia californica*. 19, Claspettes and aedeagus, dorsal. 20, Gonostylus, dorsal. Figs. 21-22, *Rhopalomyia sulcata*. 21, Pupal head, ventral. 22, Same, lateral. Figs. 23-24, *Rhopalomyia californica*. 23, Pupal antennal horns and prothorax. 24, Pupal head, lateral. Figs. 25-30, *Xipholasioptera ensata*, female. 25, Antenna. 26, Third flagellomere, ventral. 27, Same, dorsal. 28, Wing. 29, Tip of ovipositor, including hypoproct and fused cerci. 30, Abdomen, sixth segment to end, dorsoventral.

posterior margin, rarely with scales intermixed, 1 to several setae laterally, and a pair of anterior trichoid sensilla; tergite 7 narrower than preceding tergite, with double row of posterior setae and pair of anterior trichoid sensilla; tergite 8 wedge shaped, narrower but longer than preceding tergite and narrowest posteriorly, with several short setae on posterior third. Pleura with scales. Sternites 2–7 with sparser setae than in male, setae present only posteriorly and anteromesally, each with pair of trichoid sensilla anteriorly. Distal half of ovipositor about 3 times length of seventh tergite, fused cerci bulbous, covered with setae and setulae.

Pupa.—Head as in Figs. 21–22. Antennal horns moderately elongate, bifid in frontal view. Face without horns. Prothoracic spiracle short.

Larva.—Unknown.

Holotype.—From columnar gall on *B. salicina*, Pecos R., Loving, Eddy Co., New Mexico, 12-IV-1990, T. O. Robbins, emerged 22-IV-1990, deposited in USNM.

Paratypes.—All from columnar galls: same data as holotype, pupa, 9 ♂, 5 ♀; same data as holotype except 19-VII-1990, ♂, pupal exuviae; same data as holotype except 20-V-1989, P. E. Boldt; *B. salicina*, Pecos R., Iraan, Pecos Co., Texas, 11-IV-1990, T. O. Robbins, pupa; *B. neglecta*, Pecos R., Iraan, Pecos Co., Texas, 2-II-1990, emerged 7-II-1990, T. O. Robbins, 3 ♂ on slides; *B. pteronioides*, Appleton-Whittel Research Ranch, 4 mi. SE Elgin, Santa Cruz Co., Arizona, 8-III-1991, emerged 18 to 20-III-1991, P. E. Boldt and T. O. Robbins, 2 pupae, 4 ♂, 1 ♀; *B. salicina*, Sitting Bull Falls, Lincoln National Forest, Eddy Co., New Mexico, 22-VIII-1988, P. E. Boldt, 2 ♀; *B. halimifolia*, greenhouse, Temple, Texas, 21-III-1988, T. O. Robbins, 4 ♂, 2 ♀, 3 pupal exuviae.

Other material examined.—Same data as holotype, 3 galls; *B. neglecta*, Pecos R., Iraan, Pecos Co., Texas, 2-II-1990, emerged 7-II-1990, T. O. Robbins, 2 ♂, 3 ♀, 5 galls on pins; *B. pteronioides*, Appleton-Whittel

Research Ranch, 4 mi. SE Elgin, Santa Cruz Co., Arizona, 8-III-1991, gall; *B. pteronioides*, Hwy 61, 8 km N La Ascension, Nuevo Leon, Mexico, 28-IV-1990, P. E. Boldt, gall; *B. heterophylla*, Hwy 23, 7 mi S Durango, Durango, Mexico 5-VIII-1988, P. E. Boldt, galls; *B. salicina*, Rt. 31, under Pecos R. bridge, near Carlsbad, New Mexico, 20-V-1989, P. E. Boldt, ♀, galls; *B. neglecta*, Hwy 190, 1 mi. E Iraan, Pecos Co., Texas, 11-I-1990, T. O. Robbins, 10 galls; *B. neglecta*, Eagle pass, Maverick Co., Texas, 17-V-1994, T. O. Robbins, galls; *B. sarothroides* in greenhouse, Temple Texas, T. O. Robbins and P. E. Boldt, pupae and galls; *B. sarothroides*, Sierra Vista, Cochise Co., Arizona, galls.

Etymology.—The name *sulcata* is an adjective meaning furrowed, with reference to the furrowed surface of the gall.

Distribution.—United States: Arizona, New Mexico, western and southern Texas; Mexico: Durango, Nuevo Leon.

Hosts: This species is reported from *B. halimifolia*, *B. heterophylla*, *B. neglecta*, *B. pteronioides*, *B. salicina*, and *B. sarothroides*. The record on *B. heterophylla* is based only on similarity of the galls, but the other host records are based on adults and/or pupae. A generation of *R. sulcata* was reared from *B. halimifolia* and *B. sarothroides* in a greenhouse from a generation that came from field-collected galls on *B. salicina*.

Remarks.—Males from *B. pteronioides* differ slightly from males from *B. halimifolia*, *B. neglecta*, and *B. salicina* in the shape of the hypoproct. The apex in dorsoventral view is convex in specimens from *B. pteronioides*, concave in the other hosts, but for now all specimens are considered to be the same species.

Rhopalomyia sulcata differs from *R. californica* in the male genitalia and the pupa. *Rhopalomyia californica* has a shorter gonostylus, apically oblique instead of blunt claspettes (compare Figs. 17–18 with 19–20), and longer pupal antennal horns (compare Figs. 21–22 with 23–24).

Xipholasioptera Gagné, NEW GENUS

Adult (female only).—Head: antenna (Figs. 25–27) with 11 flagellomeres; first and second flagellomeres connate, as wide as pedicel, the remaining flagellomeres narrower, cylindrical. Palpus four segmented. Labella short, hemispherical.

Thorax: Wing (Fig. 28): R5 joining C near midlength of wing; M 3 + 4 and Cu weak. Scutum with four longitudinal rows of setae and scales, the rows of scales almost contiguous. Anepisternum with scales on dorsal third; mesepimeron covered with setae and scales; katepisternum bare. Tarsal claws with large tooth; empodia as long as claws.

Abdomen (Figs. 29–30): First through sixth tergites rectangular, more than twice as wide as long, with anterior pair of trichoid sensilla, posterior margin with single, sparse row of setae, and otherwise covered with scales; seventh tergite rectangular, about twice as long as wide, with anterior pair of trichoid sensilla, posterior margin with single row of setae, and covered with scales on posterior two-fifths; eighth tergite elongate, pointed posteriorly, about twice as long as wide, not including the narrow, anterior extensions, with anterior pair of trichoid sensilla as only vestiture; second to sixth sternites square, without anterior pair of trichoid sensilla but with setae laterally and posteriorly and scales elsewhere; seventh sternite triangular, narrowest anteriorly, somewhat longer than wide, posterior margin with single row of setae, and covered with scales on posterior two-fifths; eighth sternite about twice as long as wide, narrowing posteriorly, without vestiture; ovipositor elongate, posterior half bilaterally flattened, strongly sclerotized, pointed apically.

Pupa and larva.—Unknown.

Type species.—*Xipholasioptera ensata* Gagné.

Etymology.—The name *Xipholasioptera* combines the Greek “xiphos” for sword, with reference to the shape of the oviposi-

tor, and “lasioptera” for the scale-covered wing. The latter segment is a common suffix in the tribes Alycaulini and Lasiopterini. The name is feminine.

Remarks.—This genus belongs to the tribe Alycaulini of the supertribe Lasiopteridi, as defined in Gagné (1994), because of the thick covering of scales, the very short R5 wing vein, the short antenna, and the lack of two lateral groups of large setae on the eighth abdominal segment. This genus differs from all known Alycaulini in the shape of the postabdomen and ovipositor (Fig. 30) and in the lack of the anterior pair of trichoid sensillae on each of the abdominal sternites. The strongly modified abdomen so obscures relationships that the closest relative of *Xipholasioptera* is not apparent. All other genera of Alycaulini except *Protaplonyx* and *Edestosperma* have soft, cylindrical ovipositors. *Protaplonyx*, known from one species on a *Sarcobatus* (Chenopodiaceae), has only the eighth abdominal tergite of the female modified and has a very different, short, strongly sclerotized ovipositor (Gagné 1969); *Edestosperma*, known from one species reared from seeds of a grass, has the seventh and eighth tergites and eighth sternite modified and a short, bilaterally flattened, but soft ovipositor (Gagné 1969).

Xipholasioptera ensata Gagné, NEW SPECIES

Adult (female only).—Antenna as in Figs. 25–27. Wing length, 1.7 mm, venation as in Fig. 28. Abdomen as in Figs. 29–30; dorsal area of fused cerci weakly striate, devoid of setae; a longitudinal row of setae present on each side, below which cerci pitted and not so strongly pigmented; hypoproct short, narrow, with apical pair of short setae.

Pupa and larva.—Unknown.

Etymology.—The name *ensata* is a Latin adjective meaning swordlike, after the shape of the ovipositor.

Holotype.—Female, ex branch apex of *Baccharis pteronioides*, Pine Springs, Gua-

dalupe Mountains National Park, Texas, V-2-1988, P. E. Boldt, deposited in U.S. National Museum.

Remarks.—The single known specimen was taken in association with leaf fascicle galls made by *Asphondylia bacchariola*. Although this species is known from a single female, it is certainly distinctive and likely to be found again on *Baccharis*. The ovipositor is shaped for piercing and, therefore, the eggs are presumably laid in plant tissue.

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**LIFE HISTORY AND DESCRIPTION OF IMMATURE STAGES OF
UROPHORA TIMBERLAKEI BLANC AND FOOTE (DIPTERA: TEPHTRITIDAE)
ON NATIVE ASTERACEAE IN SOUTHERN CALIFORNIA**

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Abstract.—*Urophora timberlakei* Blanc and Foote is a bivoltine, probably trivoltine, tephritid which develops in the flower heads of *Acamptopappus*, *Amphipappus*, *Chrysothamnus*, and *Haplopappus* spp. in southern California. For the first time, the egg, second and third instar larvae, and puparium are described, and the larvae and puparium are figured. Distinctive morphological features noted for the immature stages include eggs that are smaller and of a shape different from Palearctic *Urophora*. The third instars resemble certain described Palearctic *Urophora*, but they differ from larvae of other Nearctic tephritids in having a bluntly truncated, dark brown to black caudal segment covered by minute dome-shaped papillae and bearing several deep pits mediad and ventrad of the posterior spiracular plates. The verruciform sensilla circumscribing the prothorax and the wedge-shaped acanthae that circumscribe the meso-, metathoracic, and abdominal segments also are distinctive features. The larvae feed mainly on the ovules and soft achenes. Pupariation occurs in the larval feeding chamber among fragments of achenes. Premating and mating behaviors are described for the first time for any Nearctic *Urophora*, distinguished only by the males displaying abdominal pleural distensions throughout courtship and copulation. *Eupelmus* sp. (Hymenoptera: Eupelmidae) is reported as a solitary, endoparasitic, larval-pupal or pupal parasitoid.

Key Words: Insecta, *Urophora timberlakei*, nonfrugivorous Tephritidae, mating behavior, immature stages, Asteraceae, flower-head feeding

The genus *Urophora* (Diptera: Tephritidae) is a polyphyletic assemblage of florivorous and/or gallicolous species of fruit flies best known from the Palearctic Region, where several species infesting knapweeds and thistles [Asteraceae: Cynareae (Centarinae and Carduinae, respectively)] were extensively studied and subsequently exported to North America for biological control of weeds (Varley 1937, Zwölfer 1988, Harris 1989, Julien 1992). Known species of New World *Urophora* were depicted in a pictorial key by Steyskal (1979), and those found North of Mexico, including

eight introduced Old World species, were reviewed and distinguished by Foote et al. (1993). Little is known about the biologies of the eight indigenous North American species of *Urophora* (Foote et al. 1993); however, all seven California species are non-gallicolous, seed-feeders in flower heads of hosts in the subtribe Solidagininae of the tribe Astereae (Asteraceae) (Goeden 1987, unpublished data).

This paper describes the life history and immature stages of *Urophora timberlakei* Blanc and Foote, the first North American species of *Urophora* to be studied in any detail.

MATERIALS AND METHODS

This study began in 1989 and was based in part on dissections of selected subsamples of mature flower heads of Asteraceae infested by *U. timberlakei* from among many samples collected annually throughout California in the manner described by Goeden (1985, 1987, 1992). Adults studied were reared in wooden, 35 × 32 × 35-cm, muslin cloth-backed, glass-topped sleeve cages in the insectary of the Department of Entomology, University of California, Riverside, from 1-liter samples of mature flower heads at 14-h photophase and 27 ± 1°C. Additional adults and parasitoids were reared from larvae and puparia of *U. timberlakei* dissected from flower heads and held separately in cotton-stoppered glass shell vials within humidity chambers in the laboratory at 23 ± 2°C and 76% R.H. All larvae and five puparia dissected from flower head samples were fixed in 70% EtOH for scanning electron microscopy (SEM). Specimens for SEM later were rehydrated to distilled water in a decreasing series of acidulated EtOH, rinsed in hexanes, and post-fixed in 2% aqueous osmium tetroxide for 24 h. They were then dehydrated through an increasing series of acidulated EtOH, critical-point dried, mounted on stubs, sputter-coated with a gold-palladium alloy, and studied with a JEOL JSM C-35 scanning electron microscope in the Department of Nematology, University of California, Riverside. SEM micrographs were prepared on Polaroid® P/N 55 film at 15 kV accelerating voltage.

Most adults reared from isolated puparia, as well as overwintered adults swept from preblossom and early-blossom *Acamptopappus sphaerocephalus* (Harvey and Gray) Gray 1 km N of Snow Creek Village, San Gorgonio River flood plain, 350m elevation, Riverside Co., in April, 1992-94, were individually caged in 850-ml, clear-plastic, screened-top cages each fitted with a cotton wick and basal water reservoir and provisioned with a strip of paper toweling

impregnated with yeast hydrolyzate and sucrose. These cages were used for longevity studies and oviposition tests. Virgin male and female flies of known ages obtained from emergence vials were paired in clear-plastic, disposable petri dishes provisioned with a flattened, water-moistened pad of absorbant cotton spotted with honey for direct observations, videorecording, and still-photography of their general behavior, courtship, and copulation (Headrick and Goeden 1991). Three trials with *U. timberlakei* reared from the flower heads of *Chrysothamnus teretifolius* (Durand and Hilgard) Hall were held together for a maximum of 14 days, and observations were made as opportunity allowed throughout each day.

Plant names used in this paper follow Munz and Keck (1959) and Munz (1968, 1974); names for flower head parts follow Hickman (1993). Tephritid names and anatomical terms follow Foote et al. (1993); nomenclature used to describe the immature stages follows Headrick and Goeden (1990, 1991), Goeden and Headrick (1990, 1991a, b; 1992), and the telegraphic format of Goeden et al. (1993, 1994). Means ± SE are used throughout this paper. Voucher specimens of reared adults of *U. timberlakei* and its parasitoids reside in the research collections of RDG; preserved specimens of larvae and puparia are stored in collections of immature Tephritidae maintained by JAT.

RESULTS AND DISCUSSION

Taxonomy

Urophora timberlakei was described by Blanc and Foote (1961). Photographs of the characteristically hyaline wing occurring in both sexes of this species were provided by Foote and Blanc (1963) and Foote et al. (1993). The aculeus of the female was illustrated by Steyskal (1979). The adults of *U. timberlakei* heretofore have not otherwise been illustrated nor the immature stages described or illustrated.

Egg.—Egg body smooth, shiny, white, elongate-ellipsoidal; anterior end tapered,

bearing peg-like, 0.02 mm-long pedicel; posterior end tapered, smoothly rounded. Twenty-one ova dissected from two field-collected females were 0.55 ± 0.004 (range, 0.52–0.58) mm long and 0.15 ± 0.004 (range, 0.12–0.20) mm wide.

Wadsworth (1914) described the ova of *Urophora solstitialis* (L.) as being white, smooth, crescent-shaped, 0.70 mm long and 0.20 mm wide. Persson (1963) described *U. solstitialis* eggs as shiny white, 0.80 mm long, 0.20 mm wide, and having the same shape as those of *U. stylata*. The eggs of *U. timberlakei* are smaller in size and differ in shape from the Palearctic species described above, being more elongate-ellipsoidal than crescent-shaped.

Third instar.—Third instar elongate-cylindrical, tapering slightly anteriorly, bluntly truncated posteriorly (Fig. 1A); integument white, venter of meso-, metathorax with brown infuscation; caudal segment dark brown or black (Fig. 4B, C); minute acanthae circumscribe meso-, metathorax and abdominal segments (Fig. 1A); gnathocephalon conical, smooth, lacking rugose pads (Fig. 1B); paired dorsal sensory organs, dorsomedial of anterior sensory lobe, consist of a single dome-shaped papilla, (Fig. 1C-1, 1D-1); anterior sensory lobes separated by medial depression (Fig. 1C-2), each bearing terminal sensory organ (Fig. 1D-2), pit sensory organ (Fig. 1D-3), lateral sensory organ (Fig. 1D-4), and supralateral sensory organ (Fig. 1D-5); stomal sense organ ventrolateral of anterior sensory lobe near mouth lumen (Fig. 1C-3, 1D-6); lateral and ventrolateral sensilla verruciform with a central pore (Fig. 1B-1); mouth hooks bidentate, teeth stout, conical (Fig. 1C-4); median oral lobe tapered anteriorly, laterally flattened, attached to labial lobe (Fig. 1C-5); prothorax smooth, minute acanthae anteroventrally (Fig. 1B), verruciform sensilla circumscribe segment, arranged 3-ventral, 3-medial, 2-dorsomedial, 3-dorsolateral (Fig. 1B-2); anterior thoracic spiracles dorsolateral on posterior margin of prothorax each bearing two papillae (Fig. 1B-3,

E); lateral spiracular complex with spiracle (Fig. 1F-1) and two verruciform sensilla on meso- and metathorax, a single verruciform sensillum on abdominal segments (Fig. 1F-2); minute acanthae which circumscribe TII–AVII wedge-shaped with ovoid bases (Fig. 1F-3); caudal segment covered by minute, dome-shaped acanthae (Fig. 1G-1), and numerous deep pits located dorsomedial, medial and ventrad of posterior spiracular plates (Fig. 1G-2); posterior spiracular plates (Fig. 1G-3, H) distinct, raised, spheroid, bear three oval rimae ca. 0.02 mm in length (Fig. 1H-1), and four, spine-like interspiracular processes ca. 0.006 mm in length (Fig. 1H-2); stelex sensilla surround margin of caudal segment.

Urophora timberlakei larvae fit the general description of other *Urophora* species (Wadsworth 1914, Varley 1937, Persson 1963), and appear closely allied with *U. quadrifasciata*. Both species have anterior spiracles with two papillae, the integument roughened with minute tubercles and the posterior spiracular plates without a pattern of fine grooves or pale border (Varley 1937). *Urophora timberlakei* is different from other Nearctic, non-frugivorous, tephritid species previously examined (Goeden and Headrick 1990, 1991a, b, 1992, Goeden et al. 1993, 1994, Green et al. 1993, Headrick and Goeden 1991, 1993, Novak and Foote 1968, Steck and Wharton 1986) in having a bluntly truncated, dark brown to black caudal segment covered by minute dome-shaped papillae and bearing numerous deep pits dorsomedial, medial and ventrad of the posterior spiracular plates. The caudal segment of *Euaresia stigmatica* is brown, but smooth and rounded posteriorly (Headrick et al., in press). The posterior spiracular plates appear to be similar to other described species of *Urophora* (Wadsworth 1914, Varley 1937, Persson 1963), but differ from other Tephritidae in being distinctly raised and spheroid in shape (Goeden and Headrick 1990, Goeden et al. 1994, Green et al. 1993, Steck and Wharton 1986). The verruciform sensilla circumscribing the prothorax and the

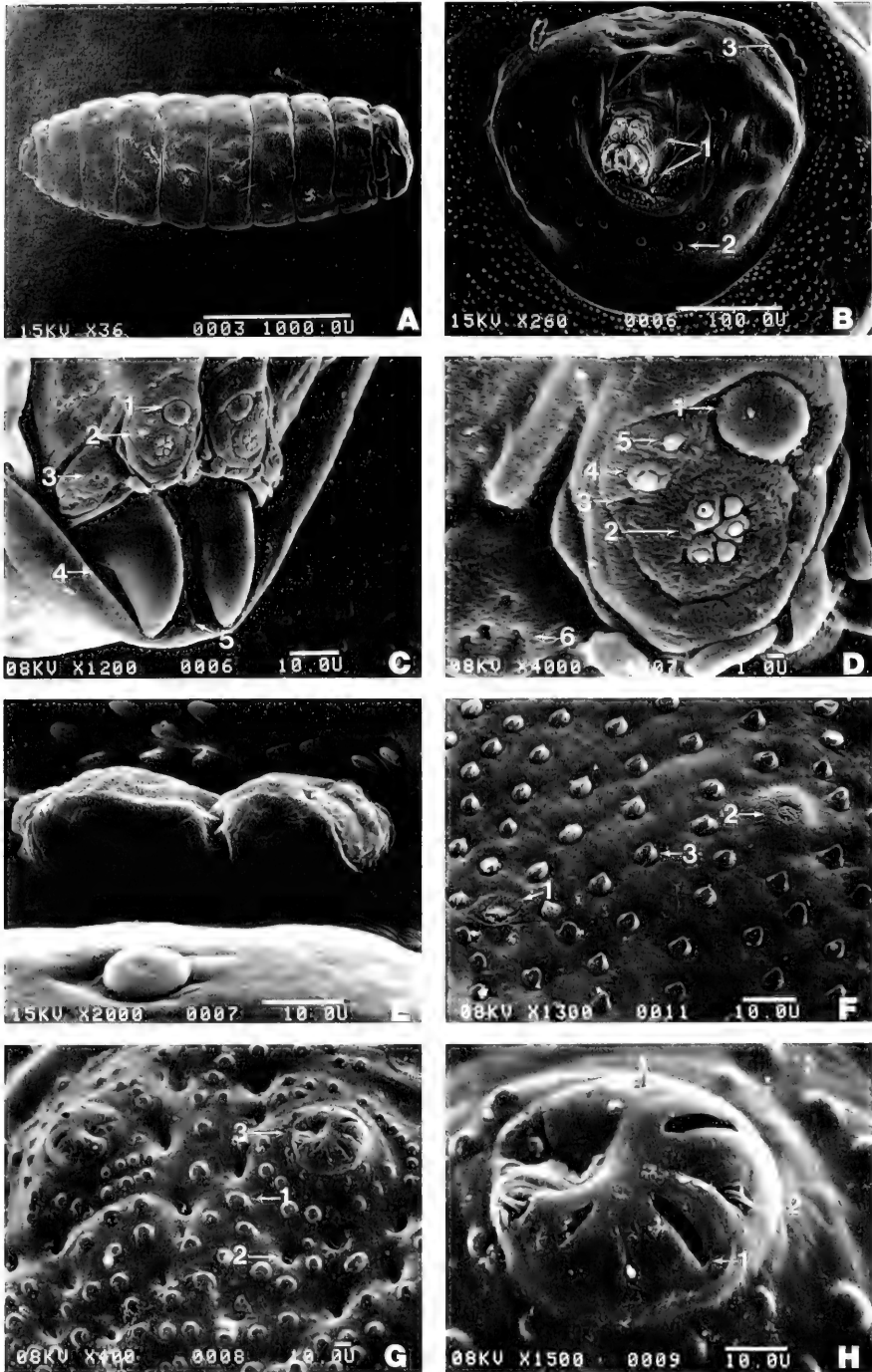


Fig. 1. Third instar larva of *U. timberlakei*: (A) habitus, anterior to left; (B) gnathocephalon, prothorax, anterior view, 1—lateral and ventrolateral sensilla, 2—verruciform sensillum, 3—anterior thoracic spiracle; (C) gnathocephalon, anterior view, 1—dorsal sensory organ, 2—anterior sensory lobe, 3—stomal sense organ, 4—mouth hooks, 5—median oral lobe; (D) anterior sensory lobe, 1—dorsal sensory organ, 2—terminal sensory organ, 3—pit sensory organ, 4—lateral sensory organ, 5—supralateral sensory organ, 6—stomal sense organ; (E) anterior thoracic spiracle; (F) lateral spiracular complex, first abdominal segment, 1—spiracle, 2—verrucci-

wedge-shaped acanthae which circumscribe the meso-, metathoracic, and abdominal segments are morphological features which may be distinctive of the North American *Urophora*.

Second instar.—Second instar cylindrical, tapered anteriorly, bluntly truncated posteriorly (Fig. 2A); integument white throughout (Fig. 4A); gnathocephalon conical, laterally flattened, smooth, lacking rugose pads (Fig. 2C); paired dorsal sensory organs consist of single round papilla, dorsomedial of anterior sensory lobe (Fig. 2B-1, 2C-1); anterior sensory lobes separated by medial depression (Fig. 2C-2), and bear terminal sensory organ (Fig. 2B-2), pit sensory organ (Fig. 2B-3), lateral sensory organ (Fig. 2B-4) and supralateral sensory organ (Fig. 2B-5); stomal sense organs indistinct, ventrolaterad of anterior sensory lobes, near mouth lumen (Fig. 2B-6, 2C-3); mouth hooks bidentate, teeth sharply curved (Fig. 2C-4); median oral lobe tapered apically, laterally flattened (Fig. 2C-5); small integumental petals dorsad of mouth lumen (Fig. 2C-6); prothorax smooth with minute acanthae ventrad of gnathocephalon; anterior thoracic spiracles consist of two papillae (Fig. 2D); lateral spiracular complex not seen; caudal segment wrinkled with several large depressions mediad of posterior spiracular plates (Fig. 2E); posterior spiracular plates bear three oval rimae ca. 0.007 mm in length (Fig. 2F-1), and four, spine-like interspiracular processes ca. 0.004 mm in length (Fig. 2F-2); stelex sensilla surround margin of caudal segment.

The second instar larva is more cylindrical than the third instar in general body shape. Most morphological features of the second instar are similar in shape and placement to those of the third instar, but not as structurally distinct as on the mature larva. The caudal segment of the second instar lar-

va differs from that of the third instar larva. In the second instar the caudal segment is truncated, white in color, wrinkled and with several large circular depressions. The caudal segment of the second instar lacks the minute dome-shaped acanthae and deep pits mediad and ventrad of the posterior spiracular plates which are present on the third instar. Because of the wrinkled nature of the second instar larvae prepared for SEM, the lateral spiracular complex and the area where prothoracic verruciform sensilla would occur were not observed.

Puparium.—Puparium light brown, anterior end dark brown, caudal segment dark brown to black; elongate cylindrical, tapering anteriorly, truncated posteriorly (Fig. 3A), minute acanthae circumscribe segments (Fig. 3A); anterior end bears the invagination scar (Fig. 3B-1), raised bilobed anterior thoracic spiracles (Fig. 3B-2), and round verruciform prothoracic sensilla (Fig. 3B-3); posterior end comprising of minute dome-shaped acanthae (Fig. 3C-1) and numerous deep pits dorsomedial, mediad and ventrad to the posterior spiracular plates (Fig. 3C-2); posterior spiracular plates bear three oval rimae ca. 0.02 mm in length (Fig. 3D-1), four spine-like interspiracular processes ca. 0.004 mm in length (Fig. 3D-2) and the ecdysial scar (Fig. 3D-3); stelex sensilla surround margin of caudal segment (Fig. 3C-3). Three puparia averaged 2.42 ± 0.62 (range, 2.33–2.54) mm in length and 0.97 ± 0.01 (range, 0.95–0.98) mm in width.

DISTRIBUTION AND HOSTS

The North American distribution of *U. timberlakei* North of Mexico was mapped by Foote et al. (1993) to include California, Colorado, Idaho, Oregon, and Utah, adding Colorado and Utah to the distribution given by Steyskal (1979).

←

form sensillum, 3—wedge-shaped acanthae; (G) caudal segment, 1—dome-shaped acanthae, 2—deep pits, 3—posterior spiracular plate; (H) posterior spiracular plate, 1—rima, 2—interspiracular process.

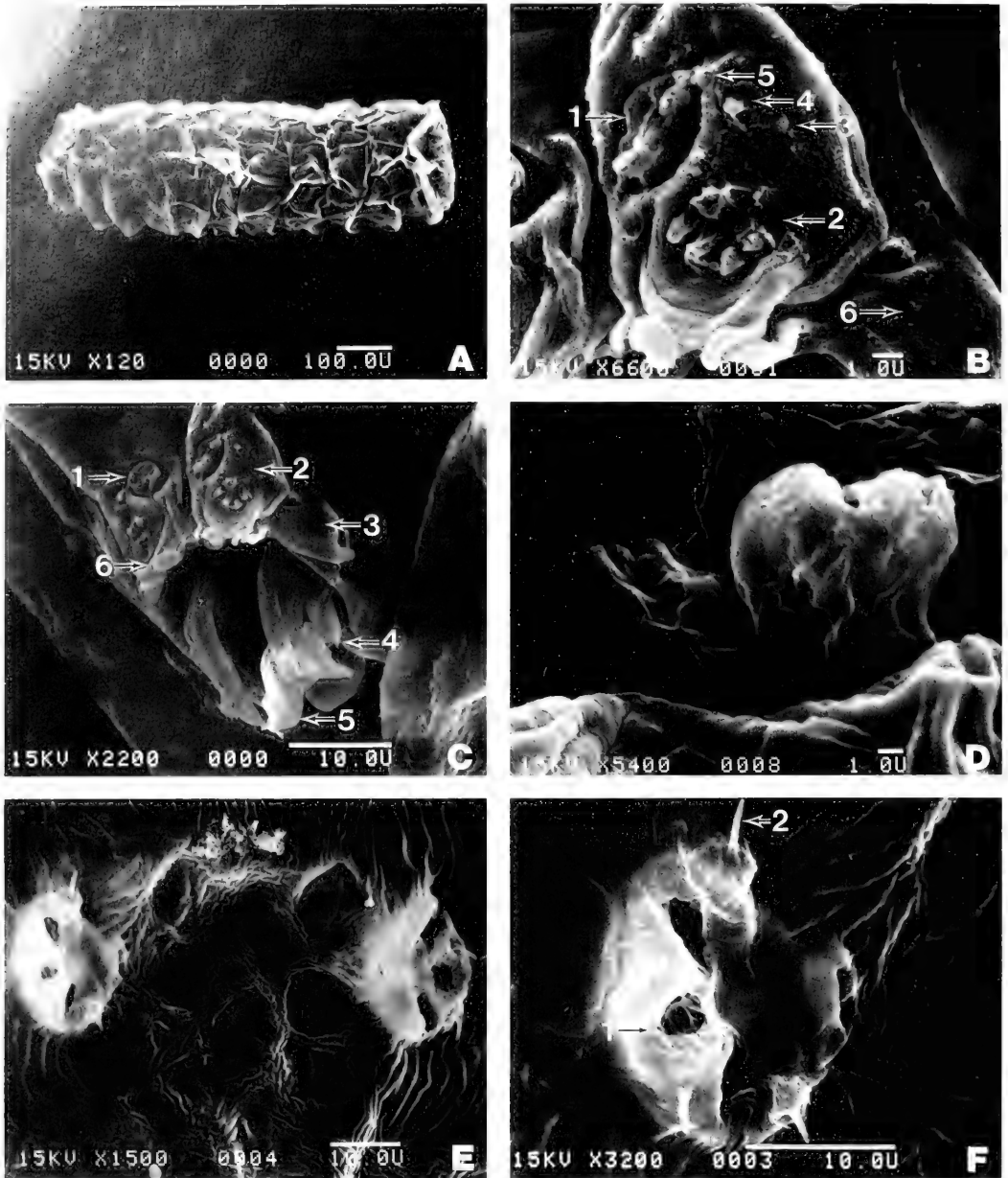


Fig. 2. Second instar larva of *U. timberlakei*: (A) habitus, anterior to left; (B) anterior sensory lobe, 1—dorsal sensory organ, 2—terminal sensory organ, 3—pit sensory organ, 4—lateral sensory organ, 5—supralateral sensory organ, 6—stomal sense organ; (C) gnathocephalon, anterolateral view, 1—dorsal sensory organ, 2— anterior sensory lobe, 3—stomal sense organ, 4—mouth hooks, 5—median oral lobe, 6—integumental petals; (D) anterior thoracic spiracle; (E) caudal segment; (F) posterior spiracular plate, 1—rima, 2—interspiracular process.

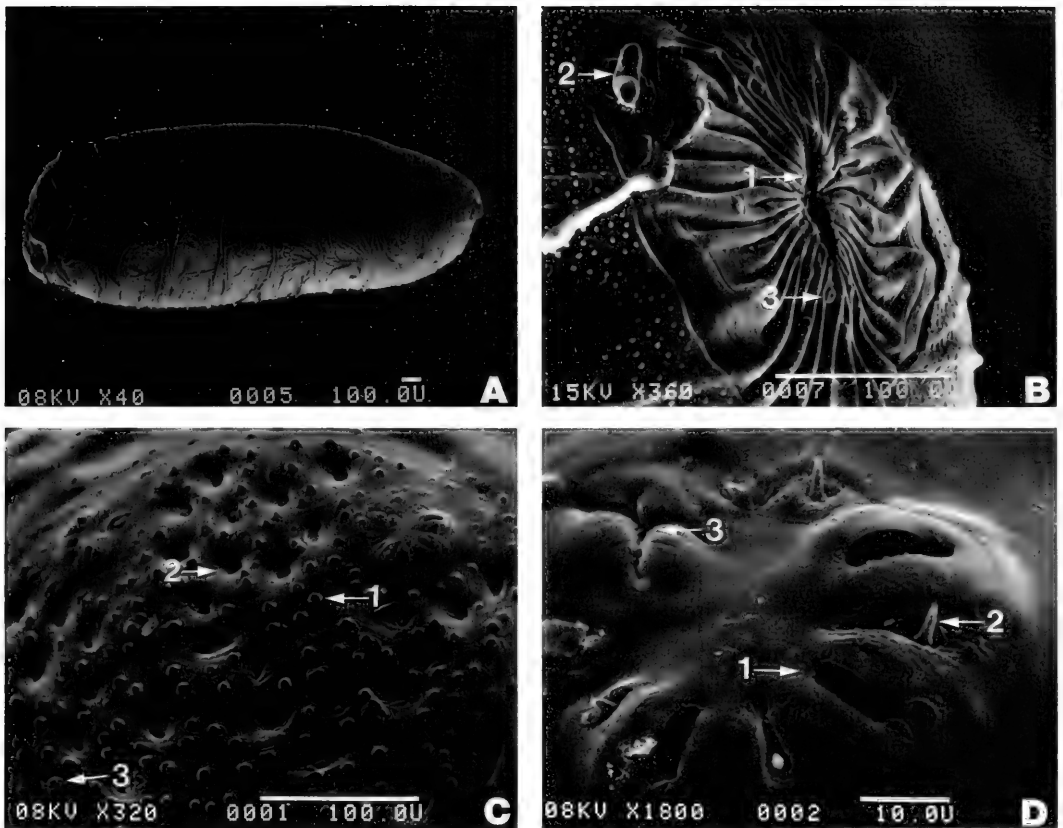


Fig. 3. Puparium of *U. timberlakei*: (A) habitus, anterior to right; (B) anterior end, 1—invagination scar, 2— anterior thoracic spiracle, 3—verruciform sensillum; (C) caudal segment, 1—dome-shaped acanthae, 2—deep pits, 3—stelex sensillum; (D) posterior spiracular plate, 1—rima, 2—interspiracular process, 3—ecdysial scar.

Goeden (1987) reported this tephritid as reared from flower heads of *Acamptopappus shockleyi* Gray, *A. sphaerocephalus*, *Chrysothamnus nauseosus* (Pallas) Britton, *C. teretifolius*, *C. viscidiflorus* (Hooker) Nuttall, *Haplopappus cuneatus* Gray, and *H. laricifolius* Gray. To these confirmed records we add the following new rearing records from ungalled flower heads: *Amphipappus freemontii* Torrey and Gray, 9 ♂ and 7 ♀, W. of Homer Mountain at 884-m elevation, NE San Bernardino Co., 5.v.1988; *C. albidus* (Jones) Greene, 2 ♀, Fish Slough, 9 km N of Bishop at 1,225 m, Inyo Co., 9.x.1990; *C. paniculatus* (Gray) Hall, 1 ♂ and 1 ♀, N of Pioneertown on N rim of Chaparrrosa Wash at 1,356 m, SW San Bernardino Co., 31.x.1990; *H. cooperi*

(Gray) Hall, 1 ♂, along Black Canyon Rd., E of Colton Hills, E. Mojave Desert at 1,200 m, NE San Bernardino Co., 30.v.1991.

As first noted by Goeden (1987), and as these new rearing records confirm, the host-plants of *U. timberlakei*, apparently like those of its native congeners in California, all belong to the Subtribe Solidagininae of the Tribe Astereae (Munz and Keck 1959). Most of these new records, like those reported by Goeden (1987), involve only a few flies reared from bulk samples each containing hundreds of flower heads of its mostly small-headed hosts. Like other oligophagous *Urophora* in California, e.g. *U. formosa* (Coquillett), *U. timberlakei* has been reared alone, but more commonly

along with other congeneric or noncongeneric species from single samples of host flower heads (synphagy), sometimes as the dominant phytophage, but more commonly subordinate to one or more species of *Neaspilota*, *Tephritis*, or *Trupanea* (Goeden 1987, unpublished data). Thus, *U. timberlakei* was only occasionally swept, reared, or otherwise encountered in nature, usually in synphagy with other species, and therefore was not easily studied, even in California, where it first was described and since has been reported most frequently (Foote and Blanc 1963, Foote et al. 1993).

BIOLOGY

Egg.—One of eight (12.5%) infested heads of *A. shockleyi*, the host with the largest-sized head in California, and only one of 61 (2%) infested smaller heads of *C. teretifolius* and *C. viscidiflorus* examined during the study period contained two larvae of *U. timberlakei*. Therefore, single eggs usually are oviposited by individual females in preblossom heads, but none was recovered during the present study.

Larva.—All second and third instar larvae observed in dissected heads had confined their feeding to ovules and soft achenes of individual flower heads (Fig. 4A, B). Larger larvae were found in feeding cavities located between adjacent achenes or were confined to individual achenes, and only partially damaged other ovules as early instars. The feeding cavities of *U. timberlakei* always appeared dry, which suggested that sap was not an important supplemental food source for this tephritid, unlike *Neaspilota viscidiflorus* Quisenberry (Goeden and Headrick 1992) and several other, ovule and soft achene-feeding tephritids studied in California to date (Headrick and Goeden 1990, 1991; Goeden and Headrick 1992). In eight (4%) infested heads of *A. shockleyi* of 200 examined, third instars attacked an average of only 1.3 ± 0.2 (range, 1–2) achenes of an average total of 38 ± 1.7 (range, 32–46) achenes, or about 3% of the achenes therein. The receptacle

was slightly scored in only one of these eight flower heads, which, again, are the largest among *U. timberlakei*'s known hosts in California. On the other hand, an average of 3.5 ± 0.4 achenes were damaged and the receptacles scored in eight, small, infested heads of *C. viscidiflorus*. Four other subsamples of 200 heads each of *C. viscidiflorus* from different locations contained only 0, 2, 3 and 4 (0%, 1%, 1.5%, and 2%, respectively) immature *U. timberlakei*. In a subsample of 400 heads of another small-headed host, *C. teretifolius*, 28 (7%) were infested by *U. timberlakei* larvae that wholly or partly damaged an average of 2.2 ± 0.12 (range, 1–4) ovules and soft achenes or about half of an average total of 5.0 ± 0.13 (range, 3–6) achenes in each head. The receptacles were slightly scored in only two (7%) of these 28 infested heads; whereas, all four achenes in each of four infested heads were completely destroyed, and three of the receptacles scored in a different subsample of 200 heads of *C. teretifolius* from a different location.

The fully grown third instar (Fig. 4C) overwinters inside the feeding cavity within the excavated head which usually remains attached to the dormant host plant, as with *N. viscidiflorus* (Goeden and Headrick 1992), but without forming a hard, protective cell like the latter species. Among florivorous, southern California Tephritidae, only *Urophora*, *Neaspilota*, and possibly *Xenochaeta* spp. mainly overwinter within dead flower heads as nonfeeding, diapausing, fully grown larvae (Goeden and Headrick 1992, Goeden and Teerink, unpublished data); whereas, most other florivorous species emerge in the spring, summer, or fall and overwinter as adults, e.g., *Neotephritis*, *Paracantha*, *Stenopa*, *Trupanea*, and *Tephritis* spp., or emerge from heads as larvae, drop to the ground, and overwinter as buried puparia, e.g., *Orellia* and many *Paroxyna* spp. (Goeden, Teerink, and Headrick, unpublished data).

Puparium.—Pupariation occurs in spring after overwintering inside the dead flower

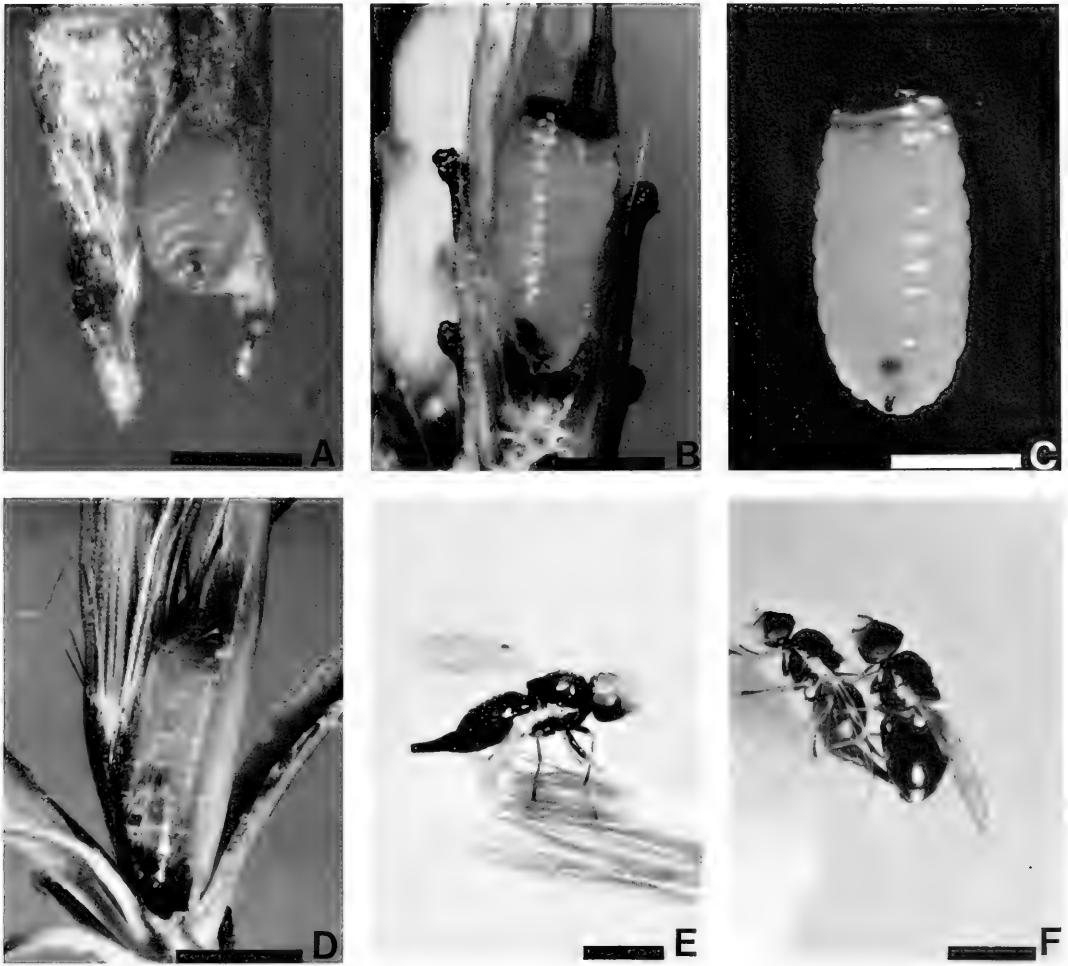


Fig. 4. Life stages of *U. timberlakei*: (A) Second instar larva in attacked immature achenes of *Chrysothamnus viscidiflorus*; (B) third instar larva feeding in flower head of *C. teretifolius*; (C) nonfeeding, overwintering, prepupal, third instar dissected from flower head; (D) empty puparium in flower head of *C. viscidiflorus*; (E) female; (F) mating pair. Bars = 1 mm.

head. The larva reverses its orientation 180° and the puparium is formed with its anterior end facing outward, away from the receptacle (Fig. 4D). The adult emerges through the pappus bristles when exiting the puparium and flower head (Fig. 4D).

Adult.—The superficial resemblance of *U. timberlakei* adults to Agromyzidae in their lack of wing pattern and in their body size, pigmentation and pattern is noteworthy as possibly representing convergence or mimicry, but otherwise remains unexplained and unaddressed by the present study (Fig

4E, F). Males and females emerged together from mid-November to mid-January in the insectary from bulk samples of flower heads collected in mid-October, 1990 and 1991, that initially contained overwintering larvae. This emergence probably was abnormally early, as the spring hosts of *U. timberlakei* first bloom in April and May. All told, 23 ♂ and 22 ♀ and 20 ♂ and 10 ♀ were reared from these two samples, respectively. The most adults ever recovered by RDG from a single sample was 42 ♂ and 31 ♀ reared from a liter sample of heads of *C. viscidiflo-*

flies collected in Landers Meadow, Sequoia Nat. Forest, Kern Co., on 3.ix.1981. These and other published (Goeden 1987) and unpublished rearing records of RDG suggested a slightly male-biased sex ratio for *U. timberlakei*. Four of five females newly emerged from heads of *C. viscidiflorus* in the insectary contained two to <60, fully formed ova; the fifth female contained immature ovaries and considerable fat stored as 0.04-0.28-mm, irregular globules in the hemolymph. This suggested that the former females may have remained inside the flower heads, perhaps still inside their puparia, for undefined periods after they had molted and sexually matured and before they emerged. Like the early insectary emergence noted above, this suspected delay may have represented laboratory behavioral artifacts.

Wing displays.—Adults exhibited hamation as described for *N. viridescens* (Goeden and Headrick 1992). The wings in both sexes were held away from the body at ca. 45° without supination when at rest, then extended back and forth through 25–30° in a plane parallel to the substrate. Both sexes exhibited this display throughout the day concurrent with other behaviors, i.e. grooming, resting and feeding. Males also maintained hamation displays while facing a female for courtship.

Swaying.—Both sexes of *U. timberlakei* occasionally displayed swaying during hamation while facing another individual. Individuals swayed less during hamation when no other fly was nearby. Swaying during hamation sometimes preceded or followed side-stepping. Both sexes side-stepped during hamation while facing other individuals as described for *N. viridescens* (Goeden and Headrick 1992). The displaying adult moves sideways, up to one body length, in a semicircle and then back while facing the other individual. This movement continued for variable times and ended with one or the other fly decamping.

Courtship.—Male aggregative displays occurred throughout the day and lasted for several hours. Males typically held their

black abdomens slightly raised with the pleura fully distended. The abdominal pleura in *U. timberlakei* males undulated in waves of contraction that moved along the pleura from anterior to posterior. *U. timberlakei* males continued to hold their pleura distended throughout courtship and copulation, unlike other tephritid males that display abdominal pleural distension (cf., Headrick and Goeden 1990, 1991, 1993, Goeden and Headrick 1992, Headrick et al. 1993). Males occasionally interrupted their courtship displays to groom or feed. Males also commonly hung upside down in arenas visually following females while displaying hamation and abdominal pleural distension. Males displayed hamation and abdominal pleural distension during all hours of the day. Courtship was brief. Males approached females and abruptly jumped onto their dorsa with or without having exhibiting any prior wing displays toward them ($n = 6$). Females resisted males and jumped away from their mounting attempts. Males that were able to maintain their grip began copulatory induction behavior ($n = 4$).

Copulatory induction behavior (CIB).—Mounted males grasped females with the front legs gripping the dorsum of the abdomen near the thorax with the foreclaws hooked into the abdominal pleura. The middle legs wrapped around the base of the oviscape and the hind legs bent underneath the oviscape. Males used their hind legs to first raise the oviscape and place its apex against the epandrium. Generally, females strongly resisted males by using their hind legs to push at them. If males remained, the hind legs were rubbed vigorously against the sides and venter of the oviscape. When viewed from above, males shook rapidly from side-to-side through 30° over the female dorsum, as described for *N. viridescens* (Goeden and Headrick 1992).

Copulation.—The oviscape of *Urophora* females is relatively longer than that of most other species studied by us, except for *Procecidochares stonei* Blanc and Foote (Green et al. 1993). This caused some

unique problems for *U. timberlakei* males, as also observed with *P. stonei*. When receptive females exerted the aculeus and the male epandrium was not situated to receive its apex, the aculeus usually slid beneath the epandrium and posteriad of the male terminalia. This typically invoked vigorous CIB by males and repositioning of the terminalia. Males rocked back and forth over the female dorsum while the females continued to struggle. Males successful in engaging the aculeus tip were pushed farther backward as females exerted the ovipositor to its full length. The front legs of the male then grasped the base of the oviscape, the middle legs grasped the apex of the oviscape, and the hind tarsi were pressed against the fully exerted aculeus. This position was difficult for males to maintain and they struggled to move forward on the female by pressing the terminalia against the aculeus. Rhythmic retraction and exertion of the aculeus then began and continued until the final copulatory position was attained (Fig. 4F) (cf., Headrick and Goeden 1995). Two copulations were timed for their full duration and lasted 1 and 1.5 h.

Seasonal history.—*Urophora timberlakei* is at least bivoltine, probably trivoltine (see below), and synovigenic in southern California. Eleven males lived an average of 39 ± 5 days (range, 18–66 days); 14 females, 31 ± 6 days (range, 8–88 days) under insectary conditions. These mean longevities are longer than those of proovigenic females, e.g., *P. stonei* (Greene et al. 1993), but shorter than other synovigenic, univoltine females, e.g. *Paracantha gentilis* Hering (Headrick and Goeden 1990), or synovigenic, bivoltine females, e.g. *Tephritis arizonaensis* Quisenberry (Goeden et al. 1993). In southern California, the F_1 generation is produced in flower heads of spring-blooming hosts (*Acamptopappus* and *Amphipappus* spp., present study and Goeden 1987); the F_3 generation utilizes fall-blooming hosts (*Chrysothamnus* and *Haplopappus* spp., present study and Goeden 1987) and overwinters, as noted above,

as non-feeding third instars in dried, senescent flower heads. The summer is passed as F_1 adults, which we have observed to oviposit first on low-altitude populations of alternate hosts such as *C. viscidiflorus*, a widespread species which successively blooms from June through September at ever higher altitudes (RDG, unpub. data; Munz 1974). Thus, the F_2 and F_3 generations of *U. timberlakei* probably is produced on these long-blooming hosts at different elevations.

Natural enemies.—Only one parasitoid was reared specifically from *U. timberlakei* during this study, i.e. a single, solitary, endoparasitic female *Eupelmus* sp. (Hymenoptera: Eupelmidae) from one of four puparia dissected from a subsample of 400 flower heads of *C. viscidiflorus*. This subsample also yielded *Procecidochares minuta* (Snow).

ACKNOWLEDGMENTS

Once again, we thank A. C. Saunders, Curator of the Herbarium, Department of Botany and Plant Science, University of California, Riverside, for identification of plants; J. LaSalle, for identification of the parasitoid while he was with the Department of Entomology, University of California, Riverside; and F. L. Blanc and A. L. Norrbom for reviewing a late draft of our manuscript.

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NEW NEARCTIC SPECIES OF *ONCOCEPHALUS* KLUG (HETEROPTERA:
REDUVIIDAE: STENOPODAINAE)

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Abstract.—The three new species *Oncocephalus mochis* from Sinaloa, Mexico, *O. peninsularis* from Lower California, Mexico, and *O. variabilis* from Arizona, California, and New Mexico are described; and *O. nubilus* Van Duzee is redescribed. A key to the species occurring in Mexico and United States of America is given.

Key Words: Reduviidae, *Oncocephalus* new species, *O. nubilus* Van Duzee, redescription, United States, key

Thanks to Norman D. Penny, California Academy of Science (CAS), the Golden Gate Park, San Francisco, California, I was able to study the specimens of *Oncocephalus* in the collections under his care. Types of the new species herein described are deposited in CAS. Giacchi (1984) keyed all nine known American and Giacchi and Maldonado (1983) added the new species *O. quadrivittatus* from Nicaragua. Many records of *O. nubilus* probably are *O. variabilis* new species. There are about 195 Old World species (Maldonado 1990).

At least among the specimens of *Oncocephalus* studied the species were found to be very variable. For example, markings on the connexival margins and segments can be absent, or they may be one or two; the postocular margins can be parallel-sided and then angularly bent or rounded to collum; the relative lengths of the lobes of the pronotum may differ, the annuli on the legs can be dark, pale or absent, the humeral width of the pronotum and the size of the lateral tubercle before the transverse pronotal constriction may vary. To aid in describing these variations, illustrations of pronota are divided in half, with each half illustrat-

ing a different color pattern. Extreme measurements and color variation for *O. variabilis* n. sp. are given in parenthesis.

The discal cell in *Oncocephalus* is open caudally, the arrow in Fig. 14 pointing to area where closing vein is lacking. This is a generic character overlooked until now. Ten Old World species examined exhibit this character. The hypopygial caudal process is located before the caudal margin and on each side, a setose process is found (Fig. 2). The caudal margin of the hypopygium exhibits a different, simple pattern of fine setae in each species (Figs. 3, 11).

As in most stenopodaine genera the fore tibia has an apical tuft of sensory hairs and a calamistrumlike organ. The eyes are large, slightly surpassing the lower surface of the head and narrowly apart underneath, more so in females.

Depth of femur is its thickness in lateral aspect. S-tubercle stands for setigerous tubercle throughout the text. The anteoctular space is the distance from the anterior margin of eye to the apex of the antennophore and the postocular space the distance from the posterior margin of eye to the insertion of the collum. All measurements are in mm.

KEY TO THE SPECIES OF *ONCOCEPHALUS* IN MEXICO AND NORTH AMERICA

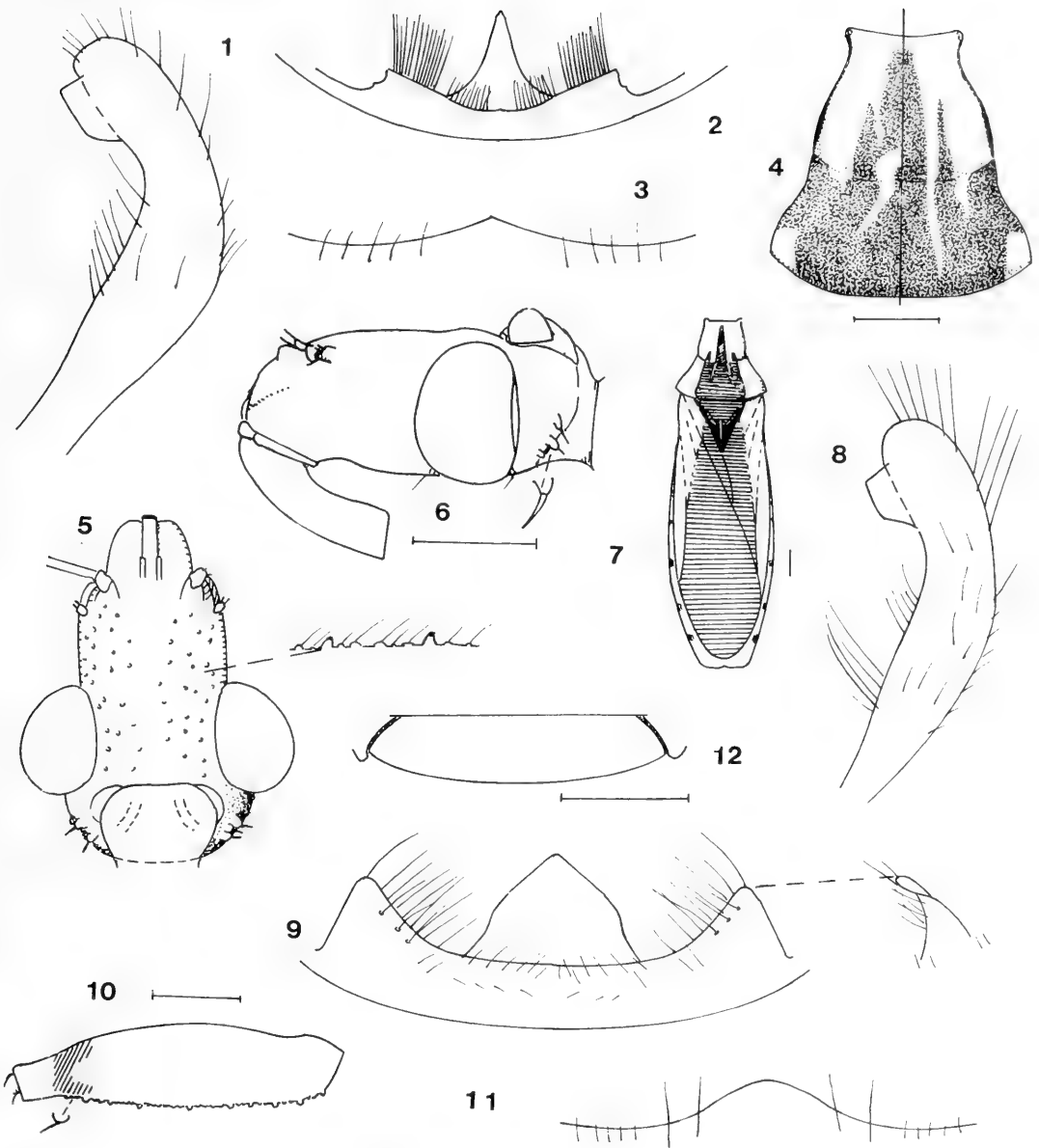
- 1. Anterior lobe of pronotum with a lateral tubercle before transverse constriction; males with pilosity of first antennite shorter than diameter of segment; discal cell of corium and outer cell of membrane with black patches 2
- Anterior lobe of pronotum without such tubercle; males with pilosity of first antennite 2× or 3× diameter of segment; discal and outer cell of membrane without patches 3
- 2. Second antennite about 2.5 times longer than first, the latter twice as long as anteocular margin; posterior tibia with dense long setae, setae 1.5–2 times as long as diameter of tibia. Color gray cinereous *O. geniculatus* Stål
- Second antennite nearly 3 times as long as first, the latter 2/5 longer than anteocular margin; posterior tibia with dense short setae, setae not much longer than diameter of tibia. Color more stramineous *O. apiculatus* Reuter
- 3. Head, pronotum, and hemelytra except laterally, black, connexivum reddish dorsally; antennite II about 2.5 times as long as first. Baja California *O. erectus* Van Duzee
- Head, pronotum and hemelytra brownish, stramineous or yellowish; connexivum not reddish, more or less stramineous with or without blackish ornamentation; antennite II variable 4
- 4. Anterior lobe of pronotum with median stripe 3× as wide as median sulcus (Fig. 4); posterior lobe mostly brown, with paramedial carinae, 1 + 1 small spots lateral to carinae, and humeral angles stramineous; hemelytra uniformly pale brown. Sonora, Mexico *O. mochis* n. sp.
- Anterior lobe of pronotum with median stripe narrow, not much broader than median sulcus; posterior lobe of pronotum less extensively brown, lateral margins stramineous; hemelytra differently colored, paler or clearly bicolored 5
- 5. Hemelytra bicolored (Fig. 7), laterally to pterostigma and outer longitudinal half of corium yellowish-stramineous, contrasting with the darker scutellum, inner longitudinal half of clavus and corium, and membrane; the yellowish area of the hemelytra continuous with the similarly colored lateral areas of pronotum *O. nubilus* Van Duzee
- Hemelytra without such contrasting areas, almost uniformly colored; the yellow areas of the pronotal margins not extending into hemelytra 6
- 6. Posterior lobe of pronotum with narrow paramedial longitudinal fasciae connected basally by a narrow transverse band, thus forming a

- thin U; corial veins usually set on stramineous stripes resulting in darker discal areas margined with stramineous; short section of vein R + M at level of discal corial cell brown, of same color as connexival marginal markings. Baja California *O. peninsularis* n. sp.
- Posterior lobe of pronotum with brown fasciae and basal band broad, not forming a thin U; corial cells uniformly colored; hemelytra and vein R + M concolorous. Southwestern United States *O. variabilis* n. sp.

DESCRIPTIONS

***Oncocephalus mochis* Maldonado,
NEW SPECIES**
Figs. 1–4

Male.—Head: anterior lobe stramineous above, with a brownish longitudinal stripe each side of median line, laterally with a longitudinal brown stripe from anterior margin of eye to apex of head; posterior lobe dark brown above, brown below; ocellar callus black. I antennite brownish, base stramineous, pilosity golden, internal setae about twice diameter of segment; II segment brownish, slightly paler than I, a long preapical stramineous band, long fine pilose, pilosity 3 times diameter of segment, gradually decreasing in length toward apex, more abundant on inner half of perimeter; III and IV segments dark gray, pilosity scarce, about twice as long as diameter of segment. Rostrum stramineous, last segment darker toward apex. Pronotum (Fig. 4): anterior lobe mostly stramineous dorsally, anterolateral angle blackish brown laterally, a relatively broad median longitudinal stripe, 1 + 1 paramedial brownish stripes; posterior lobe dorsally mostly brown, humeral angles, 1 + 1 small anterior spots, and carinae stramineous. Pronotum laterally, pleurae, coxae, trochanters, and thoracic sterna stramineous. Femora stramineous, profemur and metafemur with incomplete annulus at midlength, preapically brown; mesofemur with a preapical brown band; metatibia with short basal and middle annuli. Scutellum blackish brown, apical spine stramineous. Hemelytra pale brown,



Figs. 1-12. *Oncocephalus mochis* Maldonado n. sp., male holotype. 1, clasper, dorsal view. 2, caudal spine and dorsolateral process (dlp) of hypopygium, caudal view. 3, dorsocaudal margin of hypopygium, caudal view. 4, pronotum (two color variations), dorsal. *Oncocephalus nubilus* Van Duzee, male holotype. 5, head, dorsal view and detail of surface. 6, head, lateral view. 7, coloration of body, dorsal view. 8, clasper, dorsal view. 9, caudal spine and dlp, caudal view and lateral detail of dlp. 10, profemur, lateral view. 11, dorsocaudal margin of hypopygium. 12, female, VIII tergum.

membranal cells with scattered stramineous spots. Connexival margin with or without a long and a short brown spot; abdominal sterna yellowish stramineous, each with two brownish spots caudad to the brownish

spiracle, all three arranged in a zig-zag pattern. White scale-like setae each side of tylus, above metapleura, and suture before first abdominal sternum. Head: length to apex of collum 2.3, width across eyes 1.85,

Greatest width of anteocular lobe 1.0, width of postocular lobe behind eyes 1.3, width of eye 0.5, height of eye 0.97, length of eye 0.71, interocular space 0.8, anteocular margin 0.65; distance between eyes underneath 0.2, width of ocellar callus 0.75, length of collum 0.3. Length of antennal segments: I, 2.25; II, 4.15; III, 2.26; IV, 2.34; three s-tubercles lateroventrally behind eyes, the rest of head with minute globose s-tubercles. Pronotum: width across anterolateral angles 1.44, width across humeral angles 3.25, width at transverse constriction 2.05, length of anterior lobe 1.54, length of posterior lobe 1.40, anterior lobe with very small s-tubercles in rows and along lateral margins; median sulcus on apical third only; surface of head as in *O. nubilus* (Fig. 5); posterior margin slightly concave above scutellum. Scutellum: basal width 1.2, length to base of apical spine 1.0, length of spine 0.5, with scarce granulations and small s-tubercles. Hemelytra: M + Cu vein with or without small s-tubercles; not or slightly surpassing apex of abdomen; length 9.75, greatest width 3.38. Fore leg, lengths: coxa 1.0, trochanter 0.9, femur 4.4; depth of femur 1.16; armature consisting of 10 conical teeth alternating with 3 to 5 small s-tubercles; tibia length 3.9, setae decumbent and slightly shorter than diameter of segment; tarsi: first two together slightly longer than third, 6.5:5, claws expanded basally, curved. Middle leg, lengths: coxa 0.75, trochanter 1.0, femur slightly thicker apically, 4.25, tibia 4.62; first two tarsal segments combined as long as third, 0.65; claws and pilosity as in fore legs. Hind legs: coxa 1.24, trochanter 0.95; femur 6.90, slightly expanded apically; tibia 7.8, thinner toward apex, consequently pilosity after midlength longer than diameter of segment; first two tarsal segments together longer than third, 0.8:4.5; claws as in fore legs, less curved. External genitalia as in Figs. 1-3. Total length of body 14-15 mm.

Holotype male.—Sinaloa, Los Mochis, MEXICO, vii-20-1922, C. T. Dodds collector; 5 paratypes; all from the type locality,

July 1922, C. T. Dodds collector. One in JMC, others in CAS.

The trivial name refers to the type locality. The almost uniform pale brown color of the hemelytra makes this species stand out from nearly all of its congeners because of their mostly stramineous or clearly bicolored fore wings as in *O. nubilus*. Only *O. erectus* Van Duzee, from Baja California, has darker, but almost black hemelytra.

Oncocephalus nubilus Van Duzee

Figs. 5-12

Redescription of male holotype.—Head (Figs. 5, 6): Anterior lobe above stramineous, laterally brownish or dark brown, ventrally dark brown with a transverse figure-8 yellow spot midway from bucculae to eyes; posterior lobe, neck, and underneath between eyes brown. Ocellar elevation brown, black between ocelli. Eyes black. White scale-like setae around tylus and antennophore, in front and around eyes. Antenna: antennite I brown, paler below; II slightly paler brown than I laterally, stramineous internally, apex grayish brown; III grayish brown; IV missing. Rostrum stramineous, apex brown. Pronotum—anterior lobe: median longitudinal stripe brown; area on either side of median stripe stramineous on basal half, posterior half almost orange; disc of posterior lobe blackish brown, marginal areas stramineous (Fig. 7); mesopleura pale brown; metapleura brown. Mesosternum medianly with abundant, thick, decumbent whitish setae, narrowly margined with brown. Metasternum brown, margined laterally and anteriorly with a band of whitish setae. Scutellum blackish brown, from disc to apex of spine yellow. Legs—anterior: coxa and trochanter yellowish; femur with basal third stramineous, middle third pale brown with subcircular yellowish areas ventrally and with more extensive yellow areas dorsally, apical third brown with yellow apical margin; tibia yellowish, postbasal and about midlength brown annuli; tarsi yellowish; middle: coxa and trochanter yellowish, apical third

brown; hind: coxa brownish, trochanter stramineous, femur with a median and apical long brown annulus; tibia with basal and postbasal brown annuli. Hemelytra: base of clavus and corium yellowish, rest of wing brownish (Fig. 7). Abdomen brownish each side of ventral keel, reddish brown below line of spiracles, both bands of about same width; connexivum variable, usually yellow, margin with a central black, narrow marking.

Head: Length from interocular sulcus to apex 1.9, width across eyes 1.90, width of eye 0.55, length of eye 0.7, height of eye 1.10, interocular space 0.8, anteocular space 0.7, postocular space 0.6, width behind eyes 1.25; minutely granulose (Fig. 5); lateral margins of postocular lobe rounded to column. Antennal segments: I, 2.2; II, 4.51; III and IV missing; I with abundant long, fine setae on ventral surface, short decumbent setose dorsally; II with similar pilosity, setae gradually decreasing in length toward apex; III long pilose, hairs twice as long as thickness of segment. Rostral segments: I and II, 0.9; III, 0.6. Pronotum with moderately abundant small granules; length 3.5, width at anterior angles 1.6, width at humeral angles 3.94, length of anterior lobe 1.62; two inconspicuous carinae extending from anterior lobe to basal third of posterior lobe; posterior margin shallowly concave above scutellum. Scutellum: width at base 1.08, length to base of apical spine 1.4, length of spine 0.5, spine slight upcurved. Fore leg: coxa 0.5, trochanter 0.9, two small spines on ventrolateral edge; femur (Fig. 10): length 4.7, greatest depth at about midlength, 1.12, armature usually consisting of 10 short teeth alternating with 3 to 5 small s-tubercles; tibia length 4.70, slightly thinner apically; tarsi 0.4; 0.4; 0.9; pilosity decumbent and shorter than corresponding segment, except on tarsi where it is slightly longer than their diameter. Middle leg: coxa 0.70; trochanter 0.90; femur 5.00, slightly thicker at midlength, 0.4; tibia 4.81 long; tarsi 0.25; 0.30; 0.60; pilosity as in fore leg. Hind leg: coxa 1.10; trochanter 1.10; femur

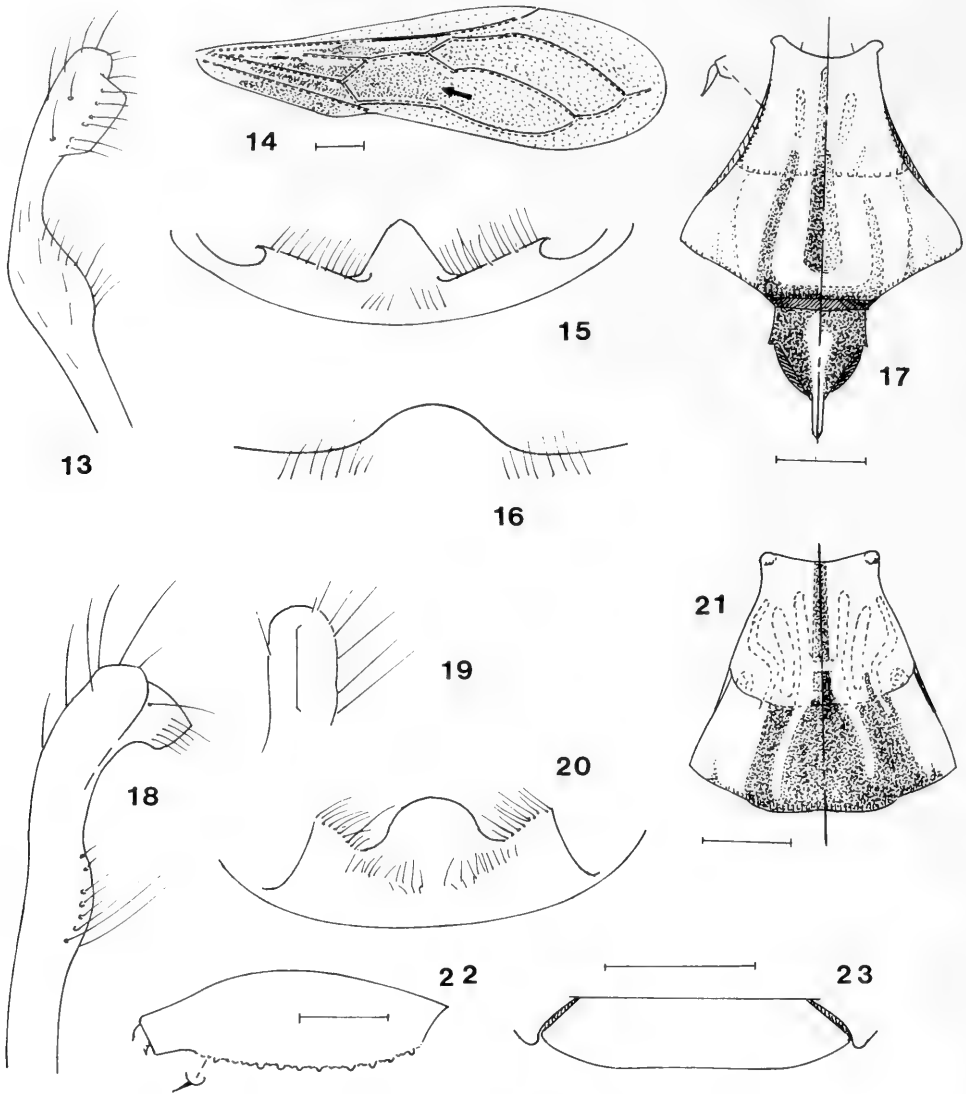
7.82, straight; tibia 9.2; tarsi 0.4; 0.4; 0.8; claws of middle and hind legs less thickened basally than on front leg; pilosity of femur and tarsi as in first two legs, setae on tibia longer than thickness of segment. Hemelytra almost reaching apex of abdomen. Abdomen keeled to base of VI sternum. External genitalia as in Figs. 8, 9, 11. Total length of body 17.5 mm. Females are very similar in morphometry and coloration; VIII tergum as in Fig. 12; overall length of body from 14 to 18 mm.

Holotype.—San Bernardino Ranch, Cochise Cty, ARIZONA, F. H. Snow collector, in Van Duzee collection at the CAS, San Francisco, California. Reported by Henry and Froeschner (1988) from Texas, Arizona, and California. Also known from northern Mexico.

Oncocephalus peninsularis
Maldonado, NEW SPECIES

Figs. 13–17

Male.—Mostly stramineous. Head: vertex with short brown dash each side of median line; laterally with poorly defined brown line not quite reaching apex of head, beneath blackish brown; posterior lobe dark brown above and laterally, below stramineous; ocellar callus black. Antenna: I antennite brown, basally stramineous, II brownish basally gradually deepening to brown apically, III and IV brown. Pronotum (Fig. 17): disc of posterior lobe with a median, relatively broad brownish stripe and a narrower stripe on each side, the median extending into anterior lobe as a narrow stripe. Scutellum dark brown, medianly from base or postbasally to apex of spine with a tapering yellowish-white stripe. Rostrum: first segment mostly yellowish, second stramineous or brownish above, third brown. Coxae and trochanters yellowish. Femora yellowish: anterior—with long apical brown annulus, annulus with irregular small yellowish areas; middle—with apical brown annulus; hind—with apical and midlength brownish annuli. Tibiae yellowish: anterior—three-annulate, the last two fused,



Figs. 13–23. *Oncocephalus peninsularis* Maldonado n. sp., male holotype. 13, clasper, dorsal view. 14, hemelytron. 15, caudal spine and dlp. 16, dorsocaudal margin of hypopygium. 17, pronotum and scutellum, dorsal view. *Oncocephalus variabilis* Maldonado n. sp., male holotype. 18, clasper, dorsal view. 19, apex of clasper, internal view. 20, caudal spine and dlp, caudal view. 21, pronotum, dorsal. 22, profemur, lateral. 23, VIII tergum of female, dorsal.

faint or incomplete; middle—similar to anterior; posterior—with apical and preapical annuli. Tarsi yellowish. Hemelytra (Fig. 14): corial veins set on stramineous stripes, thus cells with pale brown discal areas; R + M yellowish, section laterad of discal cell dark brown. Connexival segments un-

marked, marked basally or with dark brown margin.

Head.—Length from interocular sulcus to apex of head 1.35, width across eyes 1.35, width of eye 0.54, length of eye 0.65, anteocular space 0.32, postocular space 0.51, width behind eyes 1.1, anterior mar-

gin of ocellar callus at about midlength of eye, ocellar callus as wide as interocular space. Antenna: I, 2.0; II, 4.4; III, 1.13; IV, 1.21; I abundantly long pilose on outer half of perimeter, II long pilose, setae gradually shorter towards apex; III and IV scarce pilose, setae about twice as long as segment. Head—surface as in *nubilus* (Fig. 5); conspicuous s-tubercle lateral on antenniferous tubercle, 2–3 s-tubercles ventrolaterally behind eyes. Pronotum (Fig. 17): length 2.75, anterior width 1.24, humeral width 3.42, width at constriction 1.45, length of anterior lobe 1.34, carinae across constriction obsolete, anterior lobe with scarce small granulations; posterior lobe with abundant small granulations and very small globose s-tubercles; posterior margin shallowly concave above scutellum; anterolateral and humeral angles sharp but not produced. Scutellum: width 1.4, length to base of spine 1.2, length of spine 0.4. Hemelytra: length 10.5, greatest width 3.36. Abdominal sterna keeled to midlength of sixth. Fore leg: coxa length 0.6, trochanter length 0.9; femur—with scarce and short s-tubercles; length 4.2, depth 1.0; armature: 9 teeth, each one alternating with one small s-tubercle; tibia slightly thinner preapically, setae on side facing femur shorter than diameter of segment, length 4.1; tarsi: first two segments together shorter than third (0.51:0.65); claws as in *nubilus*. Middle leg—coxa length 0.3, trochanter length 1.0; femur thickness at midlength 0.32, slightly narrower preapically; tibia length 3.4. Hind leg: coxa length 0.6, trochanter length 0.75; femur decumbent setose; tibia length 7.2, long setose on apical 4/5. Genitalia as in Figs 13, 15, 16. Total length of body 15.0 mm.

Holotype male.—15 mi. N, El Refugio, LOWER CALIFORNIA, vii-1938, Michlbacher and Ross colls., in CAS. Paratypes—4, same data as holotype; 1 in JMC others in CAS.

The trivial name makes reference to the peninsula that characterizes Lower California. The key characters identify this spe-

cies; the blackish marking along R + M vein or inner vein of embolium is visible to the naked eye.

Oncocephalus variabilis
Maldonado, NEW SPECIES

Figs. 18–23

Male.—Overall color stramineous; head, pronotum, first pair of legs darker than hemelytra and last two pairs of legs; ornamented moderately with shades of brown. Head: postocular space brownish, before and after eyes brownish laterally; gular region brown; I and II antennite pale brown, same as anteocular region, the latter with short apical annulus, III and IV gray. Rostrum: segments I and II slightly paler than I antennite, III brown. Eyes and ocellar callus blackish brown. Pronotum (Fig. 21) slightly paler than head; anterior lobe—lateral margin dark brown, median longitudinal stripe and short extensions of fasciae of posterior lobe brown; posterior lobe with median subtriangular area, paramedial fasciae brown and common base brown (paratypes of both sexes show same pattern but with much wider paramedial fasciae, no two exactly alike). Meso- and metapleura with slightly darker anterior areas (these darker areas present in two paratypes only). Coxae and trochanters stramineous; femora brown apically, on anterior femora not forming an annulus; tibiae—anterior with basal, postbasal, and apical ill-defined annuli (traces of these annuli in most paratypes); last two femora with well defined apical annulus only; tarsi quite dark, an evident abnormality as these are stramineous in all other specimens.

Head: Length 2.25 (2.19–2.44), width across eyes 1.69 (1.50), interocular space 0.81 (0.68), anteocular space 1.00, postocular space 0.37; pronotum—anterior lobe length 1.56 (1.32–1.69), posterior lobe length 1.31 (1.25–1.50), humeral width 3.18 (3.00–3.25). Antennal segments—I, 1.87 (1.31); II, 3.87 (3.12); III–IV thinner and shorter than first, too twisted for accurate measurements. Rostrum I, 1.00; II,

III, 0.75; first not reaching anterior margin of eye. Scutellum as wide as long 1.8 (1.12–1.25). Legs—length of femora 3.12 (3.74–3.87), 4.37, 6.75; depth of profemur 1.12 (Fig. 22), armature consisting of 8 or 9 small tooth-like spines each alternating with 3–4 small hemispherical s-tubercles; tibiae 3.75, 4.00, 7.00; tarsi 1.75, 1.00, 1.37. Fore wing length 9.38, not quite reaching apex of abdomen, width 3.50. Genitalia as in Figs. 18–20. Overall length 14.7 (13–16 mm).

Female.—Overall coloration as in male. Dimensions fall inside the extremes given for the males. Two specimens are 17.0 long. VIII tergum as in Fig. 23.

Holotype.—Male, S. Luis Yuma, ARIZONA, viii.11.40, presented by E. C. Van Dyke, in CAS. Paratypes 27, both sexes; ARIZONA—4, same data as holotype; 4, Ehrenberg, vii.20.1946, E. C. Van Dyke collector; CALIFORNIA—1, Ft. Yuma, Aug.21.1924, E. P. Van Duzee collector; 8, Coachella, v.17.1928, E. C. Van Dyke collector; 2, Blythe, viii.3.40, J. W. Tilden coll.; 2, Blythe, v.12.37, E. P. Van Duzee coll.; 1, Lone Pine, Inyo Co., Diaz Lake,

vi.16.37, E. C. Van Dyke coll.; 1, Browley, v.1940, R. P. Allen coll.; NEW MEXICO—Carlsbad, Carera, iii.38, R. P. Allen coll.; 2 from S. L. Yuma in JMC, others in CAS.

Discussion.—The trivial name *variabilis* refers to the very variable morphometry of the species. The overall coloration and the first rostral segment not reaching the anterior margin of eye are constant characters.

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COMPARATIVE STUDY OF MOUTHPARTS OF PREDACEOUS MIDGES OF
THE TRIBE PALPOMYIINI (DIPTERA: CERATOPOGONIDAE) FROM
EASTERN UNITED STATES

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Abstract.—Mouthparts of females of 16 species and males of 13 species representing *Bezzia*, *Phaenobezzia*, and *Palpomyia* of the insectivorous tribe Palpomyiini were examined by light and scanning electron microscopy. Greatest differences among species occurred in the sclerotized mandibles of females where the mean number of coarse medial teeth ranged from 6.00 to 10.31, small basal teeth from 0.37 to 3.47, length of the tooth row in relation to length of the mandible from 14.9 to 29.8% and mean number of lateral teeth from 1.50 to 6.61. An interlocking mechanism midlength of the blade functions as a fulcrum; abduction of the base of the mandibles results in divergence of their tips and enables their strong teeth to cut the cuticle of the prey. The non-insectivorous males have mandibles with large medial non-functional teeth and lack an interlocking mechanism. Lateral teeth are present on the mandibles of some males of eight species.

The unarmored labrum, hypopharynx and lacinia are inserted into the wound made by the mandibles. The mandibles remain between the labrum and hypopharynx during feeding and serve as the floor of the food canal and roof of the salivary canal. The laciniae, which are smooth in both sexes, form the lateral proximal boundaries of the food canal. Cylindrical structures at the tip of the labrum of females are thought to be mechanoreceptors, chemoreceptors or both; they are reduced in size or absent in males and, in most species, are replaced by spicules. Labra of males and females have species specific characters, but differences are less pronounced in males. The hypopharynx of females is generically specific in its shape and species specific in distribution of its spicules. The hypopharynx of males is species specific in size and shape of its spicules which are longer than in those of conspecific females.

Sensilla on the maxillary palp sensory organ are species specific in both sexes with respect to number, points of origin on the palp of individual sensilla, shape of the head of the sensilla and total length. The number of sensilla per sensory organ is approximately equal in both sexes of a given species and they probably do not function in prey detection and/or location, which is thought to be more related to visual stimuli in predaceous midges.

Key Words: Insecta, Ceratopogonini, Palpomyiini, mouthparts

The Palpomyiini Enderlein, one of the insectivorous tribes of Ceratopogonidae Newman is comprised of the genera *Amerohalea* Grogan and Wirth, *Bezzia* Kieffer, *Clastrieromyia* Spinelli and Grogan, *Pachyhelea* (Wirth), *Palpomyia* Meigen, and *Phaenobezzia* Haeselbarth (Spinelli and Grogan 1985). Females of this tribe, as well

as those of Heteromyiini Wirth, and Sphaeromyiini Newman, and most Ceratopogonini Newman feed on Chironomidae, Chaoboridae and Ephemeroptera (mayflies), usually males, that are captured from mating swarms. In addition, in Palpomyiini, Heteromyiini and Sphaeromyiini, when the female enters mating swarms of her own species, she captures a male that she feeds upon while he is in copula with her (Downes 1977). Females of the tribe Stenoxenini Coquillett also have well developed mandibles with large teeth, thus indicating that they too are insectivorous; however, observations on their swarming, mating or feeding habits are lacking (Wirth and Ratanaworabhan 1972).

Mouthparts of both males and females of an insectivorous species of Ceratopogonidae, *Probezzia* (as *Dicrobezzia*) *venusta* (Meigen), a member of the Sphaeromyiini were described in detail by Gad (1951). All structures were present in both sexes, with male structures being smaller and less developed. Gad also presented data and drawings of some structures of other insectivorous genera, including *Bezzia* and *Palpomyia*, and compared mouthparts of insectivorous forms with hematophagous and flower-feeding representatives of the family. Downes illustrated and briefly described mouthparts of *Probezzia flavonigra* Coquillett (1971) and *Palpomyia quadrispinosa* Goetgebuuer (1978). Mouthparts of insectivorous Ceratopogoninae are characterized by large mandibular teeth and reduced, toothless laciniae, an exception being members of the insectivorous *anophelis* group of *Culicoides* Latreille subgenus *Trithecooides* Wirth and Hubert that have large mandibular teeth and toothed laciniae (Wirth and Hubert 1989). Hematophagous forms, e.g. *Culicoides* have small, closely set mandibular teeth and toothed laciniae. Gad found the tips of the mandibles, labrum, laciniae, and hypopharynx to be weakly sclerotized and without functional teeth in *Atrichopogon pavidus* (Winnertz), subfamily Forci-

pomyiinae; therefore, he considered the species to be a nectar feeder.

Many studies have used mouthpart structure to distinguish taxa. For example, Wirth and Hubert (1959) used the structures of elements of the proboscis of the subgenus *Trithecooides* (tribe Culicoidini), for identification of species and species groups. Glukhova (1982) found that each element of the proboscis of 13 species of *Trithecooides* exhibited considerable species diversity, in contrast to a high degree of similarity of other structures (wing, maxillary palpus and spermathecae), and used diversity of these elements as diagnostic characters. She found no species-specific differences in the maxillary palpus of species of *Trithecooides*, but Chaika (1978) found the palpal sensory organ to be of taxonomic significance in some other species of *Culicoides*. Endoparasitic species of *Atrichopogon* Kieff. (subfamily Forcipomyiinae), were divided into four groups by Glukhova (1981) based upon structure of the female mouthparts. She related this diversity to differences in the various insect hosts (beetles, lacewings, dragonflies, etc.) and the parts of their body upon which these ectoparasitic species feed. She found even greater diversity in mouthparts of species of the related genus *Forcipomyia* which she attributed to diversity of their hosts. Wirth and Grogan (1988) included mandibles and palpi to partially characterize genera of Ceratopogonini. In a recent comparative study of ten species representing seven genera of predaceous midges of the tribe Ceratopogonini, we found the mandibles, labrum and palpal sensory organs of females to be species specific and the hypopharynx generically specific (McKeever et al. 1991).

Descriptions of mouthparts of the predaceous midge tribe Palpomyiini (subfamily Ceratopogoninae) are few and generally confined to the mandibles. Dow and Turner (1976) presented data on the number of mandibular teeth of female *Bezzia* along with drawings of female mandibles of five of their 40 Nearctic species. Wirth (1983a)

presented data on the number of mandibular teeth of two species of *Bezzia* with a drawing of the mandible of one. In a later paper, Wirth (1983b) presented drawings, accompanied by data on the number of teeth, for mandibles of seven species of *Bezzia* females, as well as a drawing of the male mandible of one species. Wirth and Grogan (1983) gave data on the number of mandibular teeth of all species of *Bezzia*. Grogan and Wirth (1981) presented data on the number of mandibular teeth of 10 species of *Amerohelea* accompanied by drawings of the mandibles of two of the species; all of these species occur in Central and South America, and one is found in southwestern United States as well. Grogan and Wirth (1979) gave the number of mandibular teeth of female *Palpomyia* of North America and presented drawings of the mandibles of females of nine of thirty-one species and males of three species. Downes (1978) presented photomicrographs of mouthparts of female *Palpomyia quadrispinosa* Goetghebuer and discussed in detail their functions. Wirth and Grogan (1982) presented a drawing of the female mandible of *Phaenobezzia opaca* (Loew), and Gad (1951) illustrated the female mandible of *Palpomyia luteifemorata* Edwards. To date, no studies of mouthparts of predaceous Palpomyiini have employed electron microscopy. This is a report of a detailed comparative study, by light and scanning electron microscopy (SEM), of the morphology of mouthparts of females of 16 species and males of 13 species in three genera of Palpomyiini to determine whether generic differences or species-specific differences, or both, exist in any or all structures of the mouthparts.

MATERIALS AND METHODS

Females of the following species were examined: *Bezzia bivittata* (Coquillett), *B. imbifida* Dow and Turner, *B. nobilis* (Winertzt), *B. glabra* (Coquillett), *B. dorsasetula* Dow and Turner, *Phaenobezzia opaca*, *Palpomyia subaspera* (Coquillett), *P. cressoni* (Malloch), *P. lineata* (Meigen), *P. ple-*

beia (Loew), *P. rufa* (Loew), *P. pseudorufa* Grogan and Wirth, *P. basalis* (Walker), *P. flaviceps* (Johannsen), *P. scalpellifera* Grogan and Wirth, and *P. hastata* Grogan and Wirth. Males of all the foregoing species except *P. cressoni*, *P. flaviceps* and *P. hastata* were examined.

All specimens except 13 *P. nobilis* that were collected at Hatchet Creek, Alachua County, Florida, were collected on Patuxent Wildlife Research Center and Beltsville Agricultural Research Station, both near Laurel, Prince Georges County, Maryland or at Salisbury, Wicomico County, Maryland. Specimens were collected with Malaise traps or by sweeping vegetation and stored in 70% ethanol. Later, they were dehydrated in a graded ethanol series, dried in a critical point drier and dissected with tungsten needles sharpened in boiling potassium nitrate. Dissected structures were suspended horizontally from fresh micro-drops of CMC mounting medium (Turtox, Chicago) on 15 mm glass coverslips that had previously been coated with a thin film of CMC. Specimens were examined with a light microscope, measured, then gold-coated and later photographed with an ISI Super II scanning electron microscope.

Measurements of 13 characters of the various mouthparts of 127 females and 77 males were made with an ocular micrometer at 400 \times and values expressed in micrometers (μm). In addition, the number of mandibular teeth was determined at 400 \times . The number of spicules on the labrum and hypopharynx and the number of palpal sensillae were counted directly on the SEM screen. Length of the sensilla and camber and pitch of the mandibular teeth were determined from SEM photomicrographs. Statistical differences were determined by *t*-tests. Measurements were determined as in our previous study (McKeever et al. 1991) as follows.

Mandibles: (total length)—from attachment of adductor muscle at outer angle of base of mandible to tip of distal tooth; (length of tooth row)—from proximal base

Table 1. Measurements (μm) of mandibles of female Palpomyiini.

Species	Total Length			Maximum Width			Width at Basal Tooth			Length of Tooth Row		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
<i>B. bivittata</i>	142.10	13.46	13	32.12	2.86	13	18.21	4.33	13	33.04	3.98	13
<i>B. imbifida</i>	170.00	6.56	11	31.70	1.68	12	9.84	2.73	12	40.12	3.36	12
<i>B. nobilis</i>	168.77	5.32	34	36.09	1.18	37	19.44	1.35	39	50.29	32.59	38
<i>B. glabra</i>	177.72	9.99	24	37.65	2.78	26	19.58	3.54	25	49.26	5.96	25
<i>B. dorsasetula</i>	126.34	6.36	33	27.26	0.74	35	12.94	0.49	33	29.88	1.21	32
<i>Ph. opaca</i>	147.06	5.48	37	34.20	1.45	35	14.29	0.73	39	27.03	1.50	37
<i>P. subaspera</i>	232.08	—	2	43.22	—	2	25.93	—	2	64.50	—	2
<i>P. cressoni</i>	186.58	3.07	7	45.88	2.62	10	15.56	1.27	10	38.04	3.62	10
<i>P. lineata</i>	206.83	15.67	8	43.74	3.56	9	18.62	3.54	9	55.27	8.52	9
<i>P. plebeia</i>	158.20	3.01	19	30.47	0.81	22	11.91	0.56	22	33.67	0.88	22
<i>P. rufa</i>	205.66	6.99	34	39.04	1.55	34	17.11	2.07	35	43.70	2.45	35
<i>P. pseudorufa</i>	159.41	3.48	28	28.60	0.94	29	10.92	1.11	28	37.00	1.90	8
<i>P. basalis</i>	152.95	8.10	4	35.24	3.67	4	14.30	3.16	4	28.26	20.30	4
<i>P. flaviceps</i>	149.99	5.27	22	32.22	1.41	24	14.26	1.12	25	30.08	1.83	26
<i>P. scalpellifera</i>	173.23	22.05	8	36.41	4.48	8	13.96	0.59	8	25.77	1.45	8
<i>P. hastata</i>	146.96	—	2	33.21	—	2	12.46	—	2	24.60	—	2

of proximal tooth to tip of distal tooth; (maximum width)—from medial to lateral edges, near midpoint, measured at 90° to long axis of mandible; (width of basal tooth)—from proximal base of proximal tooth to lateral edges, measured at 90° to long axis of mandible; (length of longest tooth)—from tip to base; (camber of the teeth)—proximal angle between distal edge of the fifth tooth (line from tip to distal base) and a line parallel to base of the tooth row; (pitch of teeth)—proximal angle between proximal edge of the fifth tooth (line from tip to proximal base) and a line parallel to base of the tooth row.

Labrum: (length)—from junction with hypopharynx to tip; (width)—maximum immediately proximal to teeth.

Hypopharynx: (length)—from junction with labrum to tip; (width)—maximum immediately proximal to teeth.

Laciniae: (length)—from junction with maxillary palpus to tip; (greatest width)—distance between lateral edges at junction with maxillary palpus, measured at 90° to long axis of the laciniae.

Sensilla: (length)—from origin in socket to apex.

There are no voucher specimens, because

the specimens were destroyed in preparing the mouthparts for examination. Specimens of all species described herein are in the Florida State Collection of Arthropods, Gainesville, the U.S. National Museum of Natural History, Washington, D.C., and the Canadian National Collection of Insects, Ottawa. The mandible, labrum, hypopharynx, lacinia, and palpal sensillae are illustrated by SEM photomicrographs (Figs. 1–17). Size relationships of the structures are presented tabularly, as the mean and two standard errors. (Tables 1–8).

RESULTS

General Descriptions of Structures

Mandible.—The strongly sclerotized mandibles of females have an interlocking mechanism approximately midlength of the blade that is similar in structure and function to that described for *Culicoides* (Gad 1951) and the Ceratopogonini (McKeever et al. 1991). On the medial edge the distal first and usually second antrorse teeth are followed by a series of longer, coarse, retrorse teeth that may be uniform throughout or may decrease in length and size proximally (Figs. 1–5). There were 6–17 such

Table 2. Measurements (μm) and number of teeth of mandibles of female Palpomyiini.

Species	Length of Longest Tooth			No. of Coarse Medial Teeth			No. of Small Basal Teeth			No. of Lateral Teeth		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
<i>B. bivittata</i>	3.17	0.41	13	10.31	1.52	19	3.47	1.40	19	3.20	1.00	20
<i>B. imbifida</i>	2.71	0.12	12	9.42	0.99	12	2.17	0.59	12	3.75	0.61	12
<i>B. nobilis</i>	4.41	0.27	39	8.96	0.25	45	3.35	0.59	45	4.44	0.47	45
<i>B. glabra</i>	5.19	0.44	26	10.11	1.12	27	1.78	0.55	27	5.00	0.89	27
<i>B. dorsasetula</i>	2.72	0.09	33	7.71	0.27	31	2.58	0.54	31	3.64	0.55	33
<i>Ph. opaca</i>	6.27	0.33	39	7.07	0.10	45	0.89	0.30	45	6.61	3.36	44
<i>P. subaspera</i>	7.98	—	2	9.50	—	2	2.00	—	2	3.50	—	2
<i>P. cressoni</i>	5.59	0.60	39	7.10	0.63	10	2.60	0.69	10	4.09	1.04	10
<i>P. lineata</i>	5.91	0.90	9	8.29	0.79	14	4.71	0.83	14	6.57	0.43	14
<i>P. plebeia</i>	5.56	0.35	22	7.05	0.17	21	2.86	0.50	21	4.54	0.45	22
<i>P. rufa</i>	5.69	0.28	34	7.10	0.15	41	3.27	0.47	41	3.78	0.58	41
<i>P. pseudorufa</i>	4.54	0.32	28	6.97	0.13	35	2.08	0.38	35	3.09	0.54	35
<i>P. basalis</i>	3.99	0.00	4	6.00	—	8	0.37	0.89	8	3.75	0.59	8
<i>P. flaviceps</i>	3.09	0.33	26	7.06	0.34	33	1.06	0.43	33	2.27	0.69	33
<i>P. scalpellifera</i>	4.40	0.66	8	6.25	0.43	8	1.87	0.94	8	5.29	1.38	7
<i>P. hastata</i>	2.66	—	2	6.00	—	2	1.50	—	2	1.50	—	2

teeth on the distal 14.9 to 29.8% of the blade in all 16 species examined. Proximally, up to eight small basal teeth may be present. Up to 11 small, antrorse projections, considered to be accessory teeth, may occur on the lateral edge in all species, but these may be absent in some specimens. Greatest width of the mandible ranges from 18–24% of the total length among the 16

species and is attained at the point of the interlocking mechanism; little or no decrease occurs proximally. The base curves approximately 45–90° to the long axis of the blade. Muscle attachment and function are as described for the Ceratopogonini (McKeever et al. 1991).

Mandibles of males of the 13 species examined are poorly sclerotized, broad blades

Table 3. Measurements (μm) and number of spicules of labra and hypopharynx of female Palpomyiini.

Species	Labra						Hypopharynx					
	Total Length			No. of Spicules			Total Length			No. of Spicules		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
<i>B. bivittata</i>	170.24	22.40	5	19.50	6.02	4	170.05	19.02	7	20.75	11.93	4
<i>B. imbifida</i>	177.23	5.38	3	25.20	4.51	5	178.78	1.91	3	19.33	1.84	6
<i>B. nobilis</i>	189.60	10.99	18	25.14	4.42	7	199.20	10.47	16	29.27	6.37	11
<i>B. glabra</i>	209.70	16.20	12	19.64	3.91	11	219.51	17.98	12	23.36	5.62	11
<i>B. dorsasetula</i>	158.36	3.54	15	17.92	1.68	12	155.14	4.33	17	20.50	1.46	14
<i>Ph. opaca</i>	188.73	16.66	14	26.12	1.69	17	185.40	15.66	15	15.94	5.53	17
<i>P. subaspera</i>	266.00	—	1	21.00	—	1	251.37	—	1	36.00	—	1
<i>P. cressoni</i>	223.08	35.64	3	18.00	7.45	3	217.68	39.98	3	37.91	10.24	5
<i>P. lineata</i>	249.25	30.24	3	20.50	—	2	268.55	—	1	24.00	—	1
<i>P. plebeia</i>	184.37	8.59	8	23.37	3.19	7	179.81	8.95	9	—	—	0
<i>P. rufa</i>	239.09	12.19	12	15.83	3.14	6	244.40	15.62	13	11.75	6.67	4
<i>P. pseudorufa</i>	187.29	8.06	11	17.22	2.87	9	187.33	7.07	12	19.62	4.66	8
<i>P. basalis</i>	183.54	—	2	—	—	0	186.20	—	2	7.00	—	2
<i>P. flaviceps</i>	169.29	11.98	7	18.57	7.04	7	167.36	8.46	12	5.60	5.38	5
<i>P. scalpellifera</i>	198.83	39.42	4	—	—	0	197.73	71.81	3	10.00	—	2
<i>P. hastata</i>	—	—	0	18.00	—	1	—	—	0	6.00	—	1

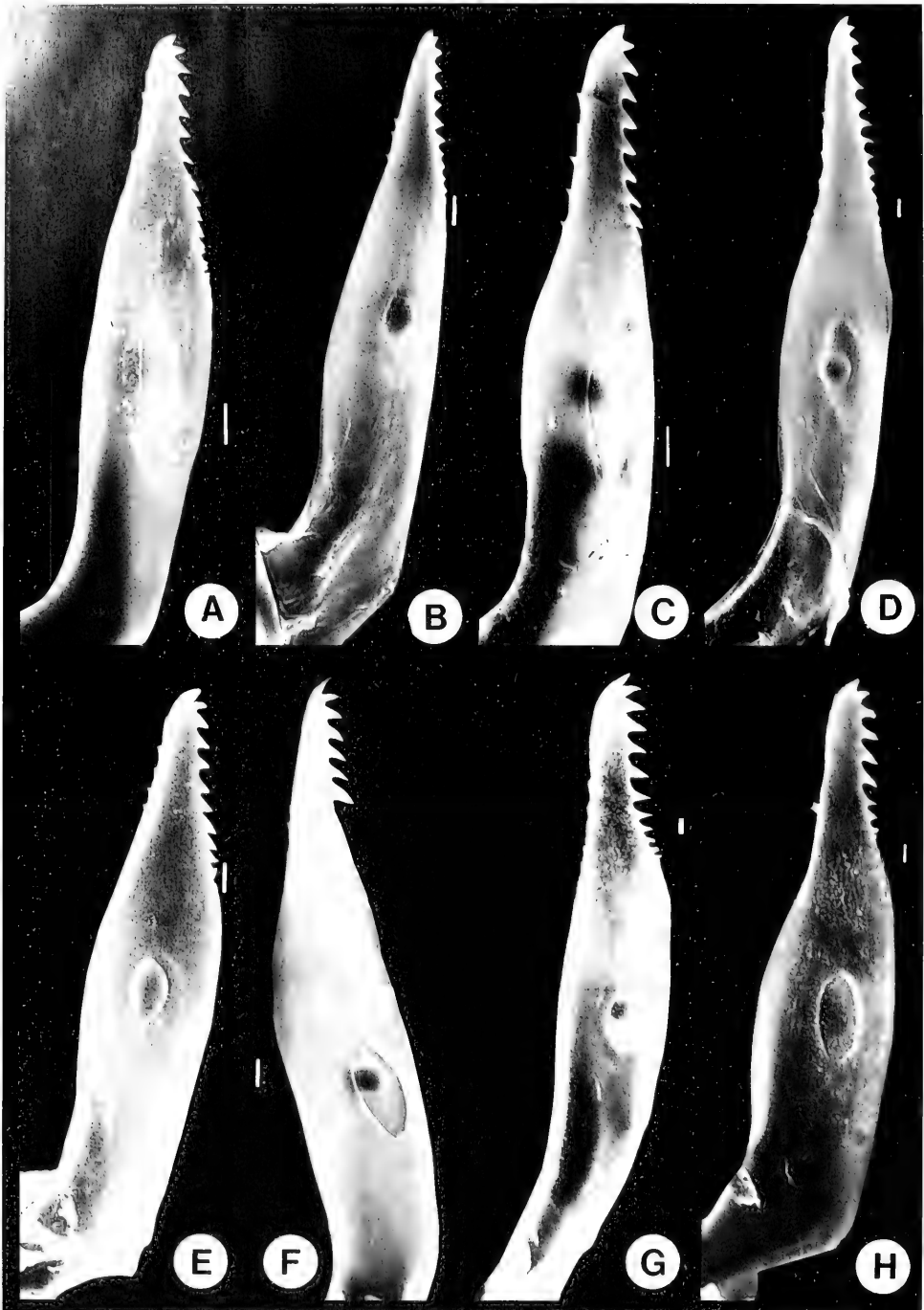


Fig. 1. SEM photomicrographs of mandibles of female. A, *Bezzia bivittata*. B, *B. imbrifida*. C, *B. nobilis*. D, *B. glabra*. E, *B. dorsasetula*. F, *Phaenobezzia opaca*. G, *Palpomyia subaspera*. H, *P. cressoni*. White bars equal 8 μ m.

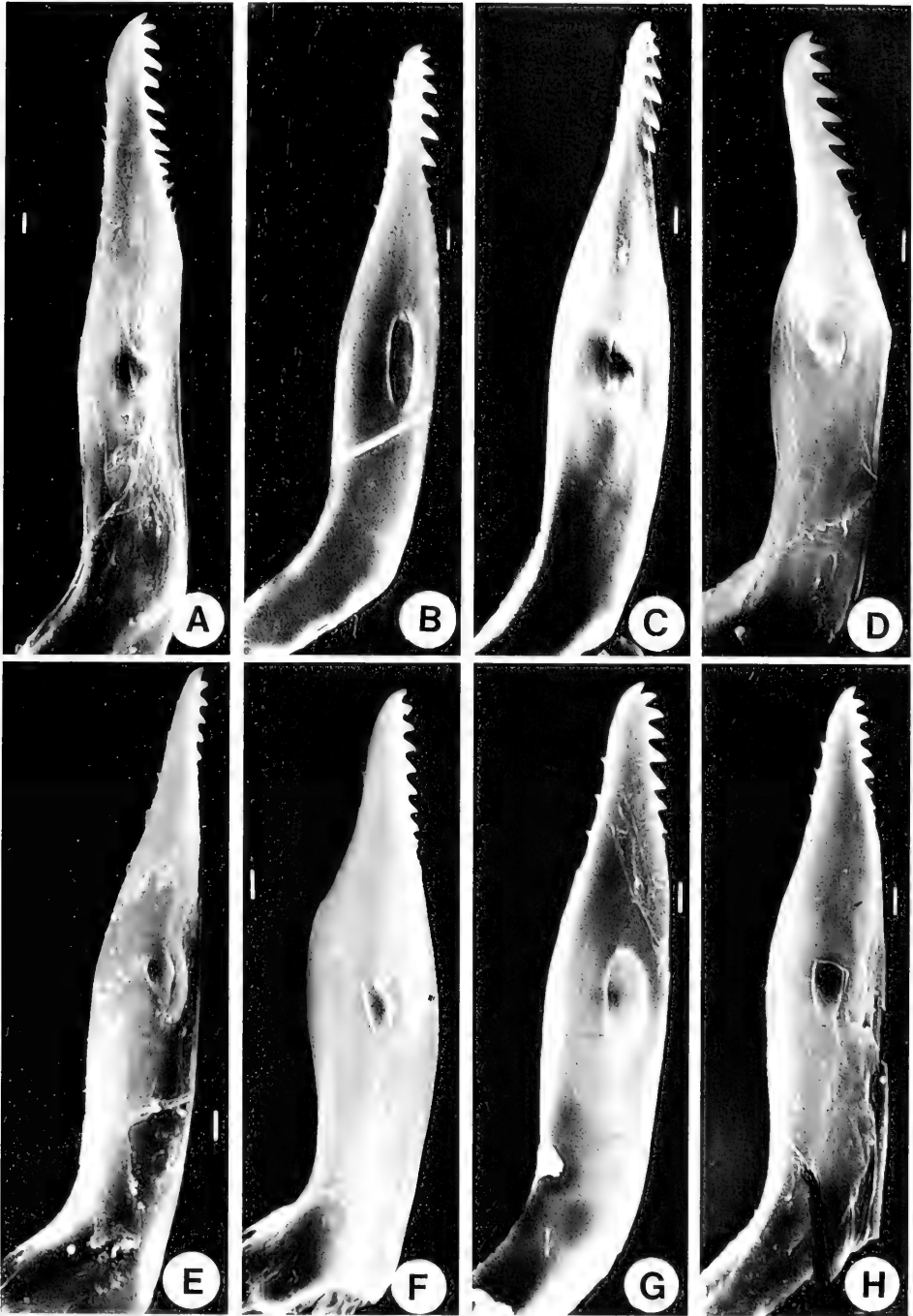


Fig. 2. SEM photomicrographs of mandibles of female. A, *Palpomyia lineata*. B, *P. plebeia*. C, *P. rufa*. D, *P. pseudorufa*. E, *P. basalis*. F, *P. flaviceps*. G, *P. scalpellifera*. H, *P. hastata*. White bars equal 8 μ m.

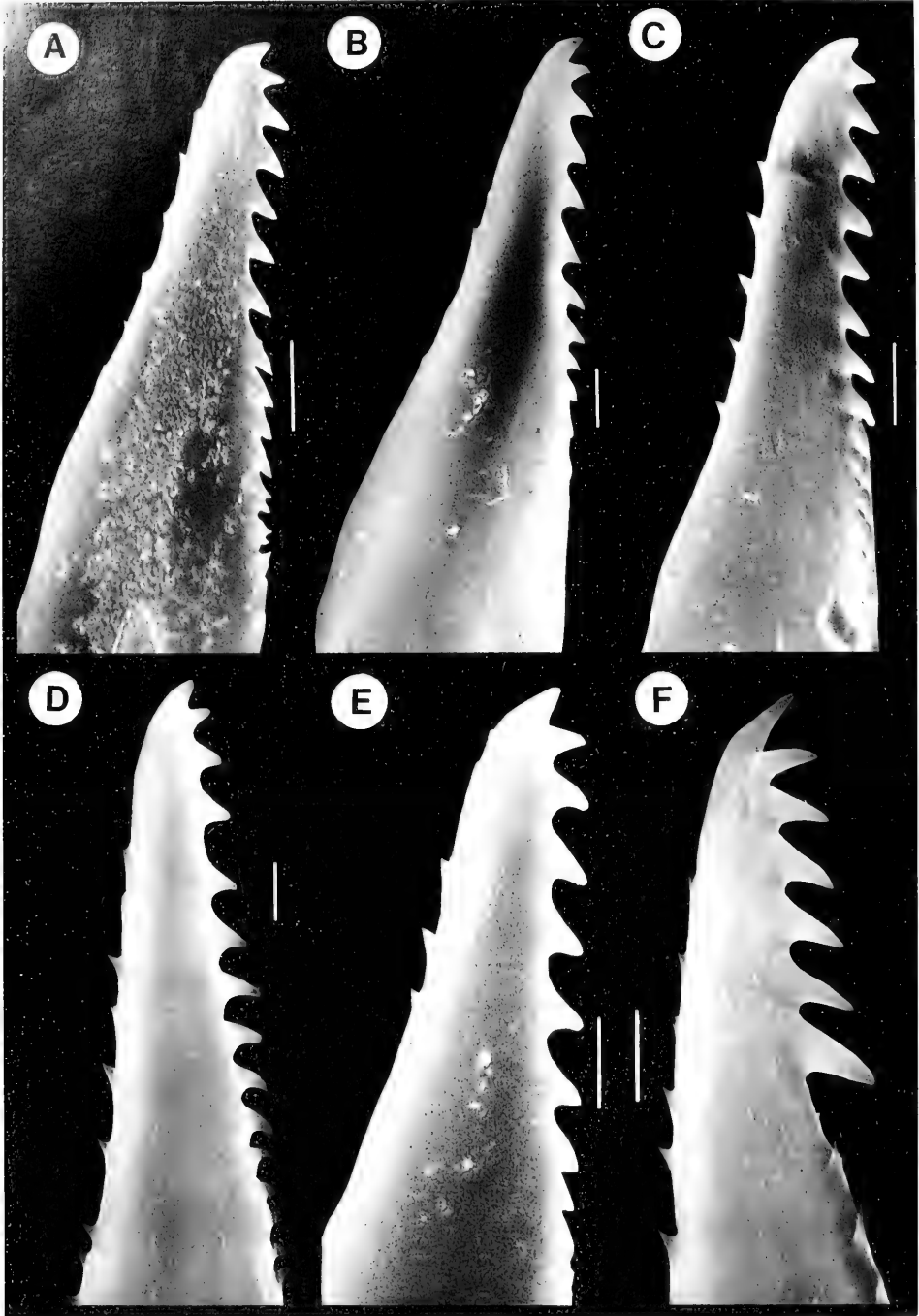


Fig. 3. SEM photomicrographs of mandibles of female. A, *Bezzia bivittata*. B, *B. imbfida*. C, *B. nobilis*. D, *B. glabra*. E, *B. dorsasetula*. F, *Phaenobezzia opaca*. White bars equal 8 μ m.

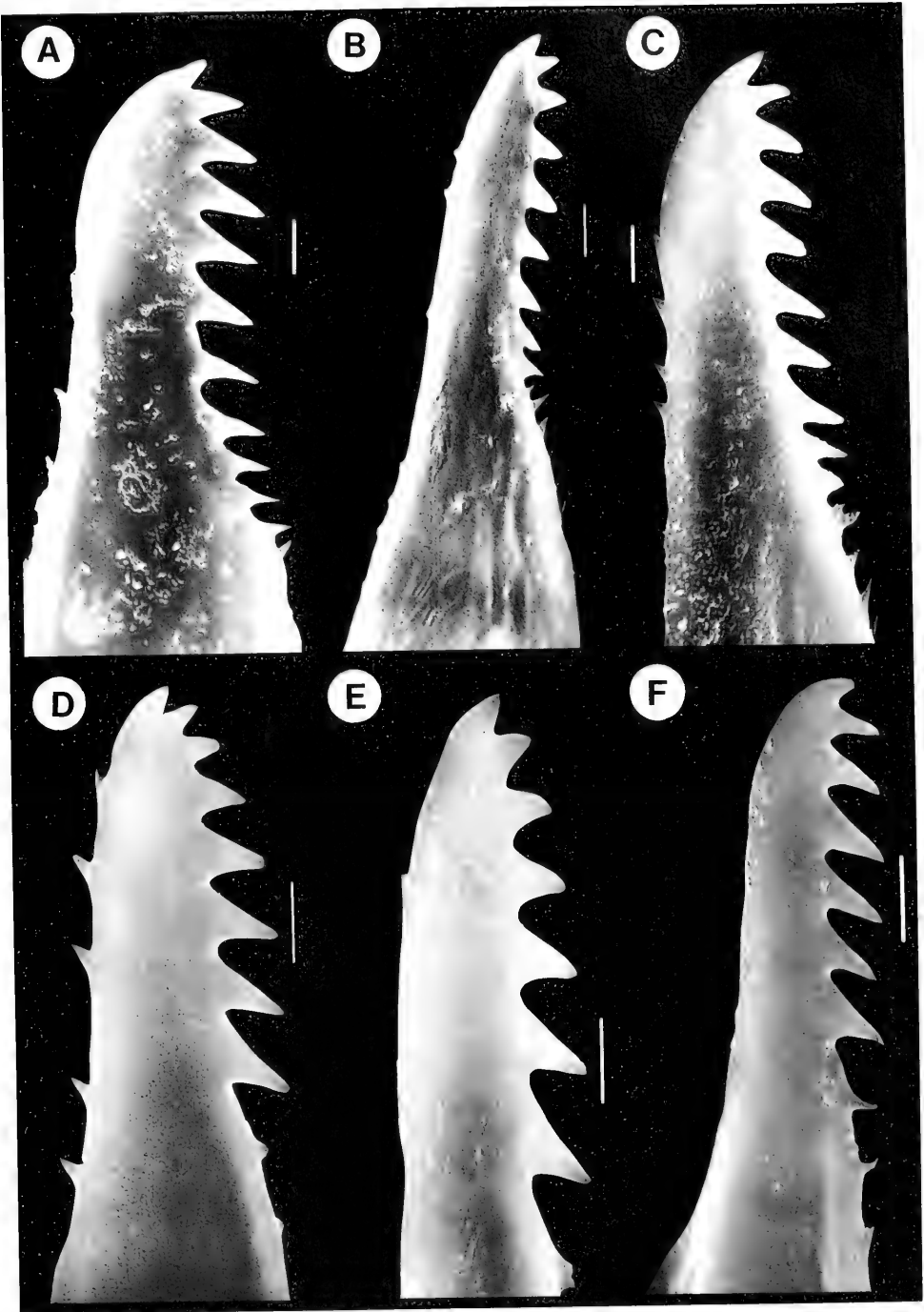


Fig. 4. SEM photomicrographs of mandibles of female. A, *Palpomyia subaspera*. B, *P. cressoni*. C, *P. lineata*. D, *P. plebeia*. E, *P. rufa*. F, *P. pseudorufa*. White bars equal 8 μm .

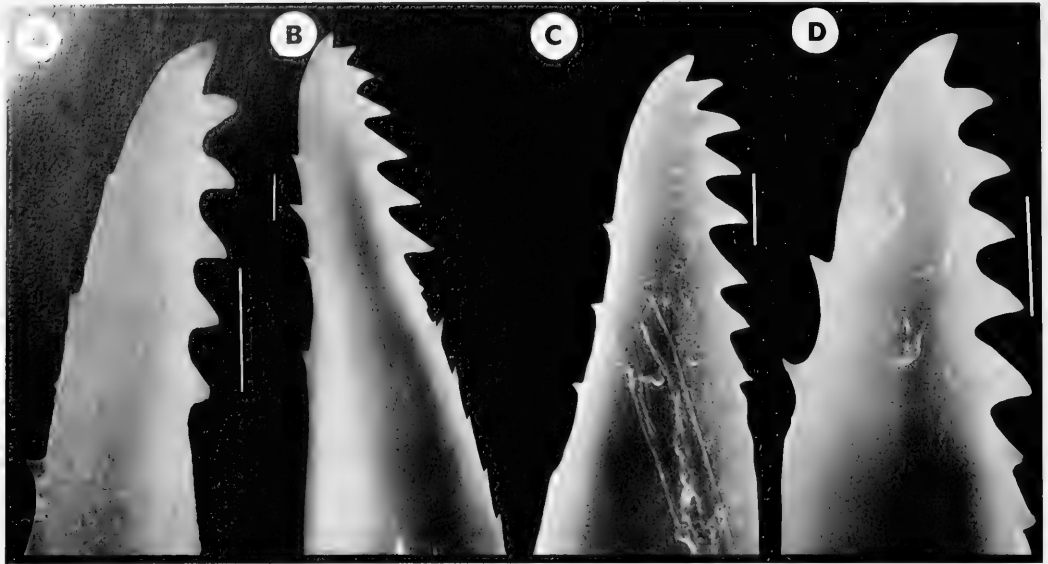


Fig. 5. SEM photomicrographs of mandibles of female. A, *Palpomyia basalis*. B, *P. flaviceps*. C, *P. scalpellifera*. D, *P. hastata*. White bars equal 8 μm .

with up to 13 long, coarse, antrorse, sometimes branched, teeth on the medial edge and, in nine species, up to 10 short antrorse teeth on the lateral edge (Figs. 6–9). Maximum width is attained at approximately mid-length of the blade and is 14.1–19.3% of their total length. There is little reduction in width proximal to mid-length. The articulating mechanism of female mandibles is absent in males. The basal portion curves approximately 45° to the long axis of the blade.

Labrum.—The labrum of both sexes is moderately sclerotized, ventrally concave in cross section and proximally joined to the hypopharynx on both sides. Two short sensilla basiconica occur in pits located asymmetrically on the ventral surface near the proximal end of the row of lateral spicules (Figs. 10, 11). In females the tip is rounded and terminates in two median short, peg-like structures with rounded points; lateral to these are three, sometimes two, rounded structures. Antrorse spicules on the distal ventrolateral surface are short triangular or stout spinelike structures that occur in a sin-

gle series on each side. The labrum of males is more pointed than in conspecific females, in most species the terminal median peg-like structures are replaced by antrorse spicules, and the lateral rounded structures are reduced in size or absent. The ventrolateral spicules are longer and more slender than those of females and occur in one to three rows.

Hypopharynx.—In both sexes the moderately sclerotized hypopharynx has a deep dorsal salivary groove located above a ventral keel; both structures become less pronounced distally and terminate proximal to the tip. Antrorse spicules of varying lengths occur on the rounded or semipointed tip of the hypopharynx of females and, in most species, extend for varying distances proximally along its lateral edges. The spicules vary in shape from tooth-like to spike-like to filiform (Fig. 12). The hypopharynx of males is less heavily sclerotized, shorter and has longer spicules than those of conspecific females (Fig. 13).

Lacinia.—In both sexes of all species examined, the laciniae are acute triangular in

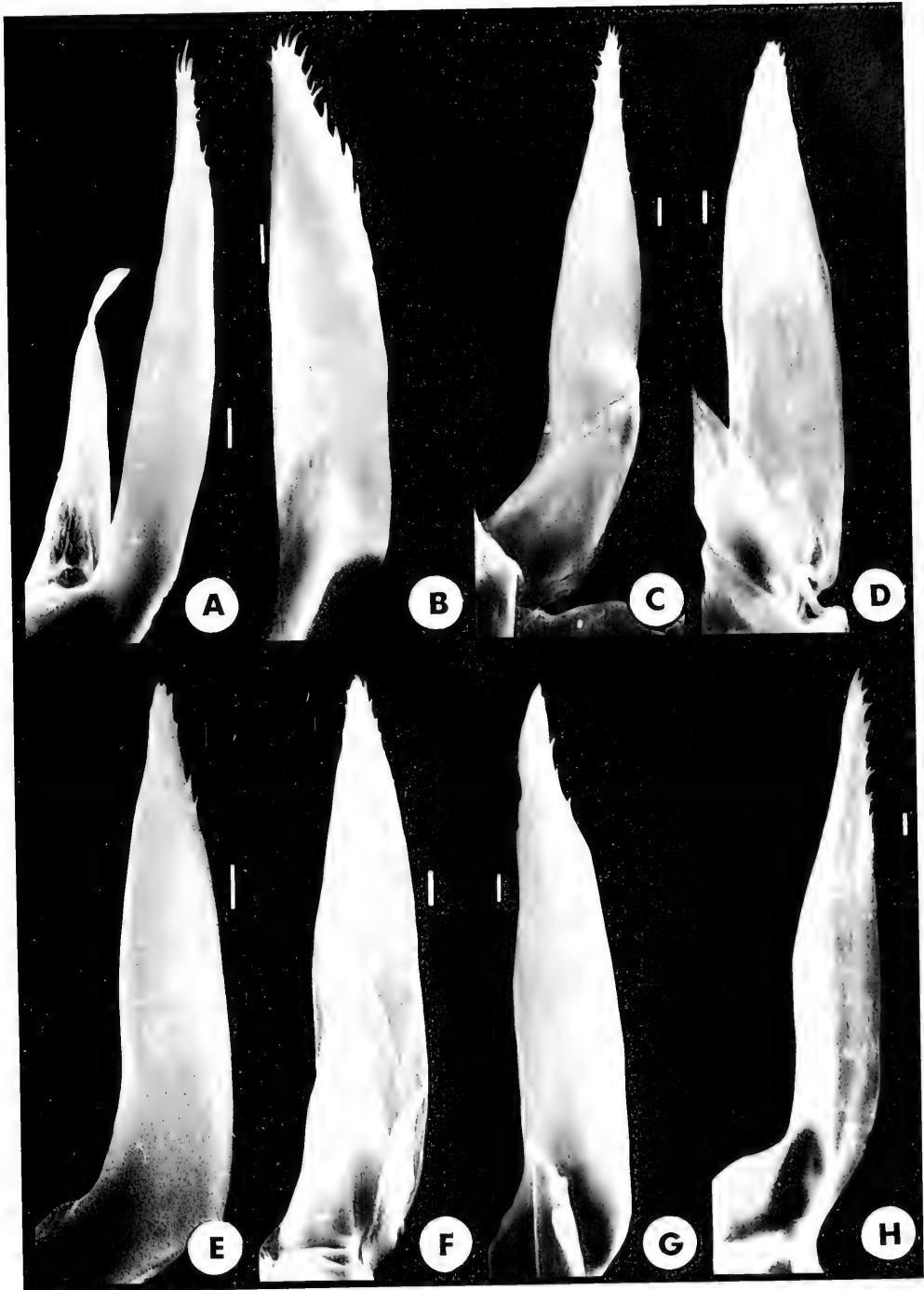


Fig. 6. SEM photomicrographs of mandibles of male. A, *Bezzia bivittata*. B, *B. imbifida*. C, *B. nobilis*. D, *B. glabra*. E, *B. dorsasetula*. F, *Phaenobezzia opaca*. G, *Palpomyia subaspera*. H, *P. lineata*. White bars equal 8 μ m.

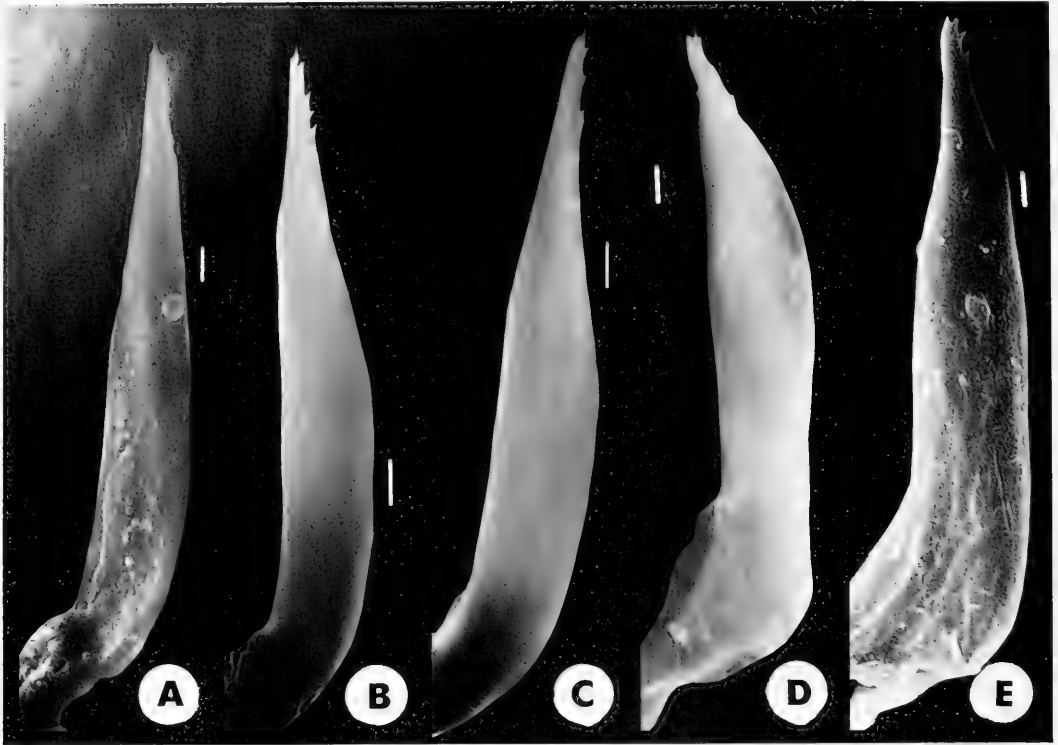


Fig. 7. SEM photomicrographs of mandibles of male. A, *Palpomyia plebeia*. B, *P. rufa*. C, *P. pseudorufa*. D, *P. basalis*. E, *P. scalpellifera*. White bars equal 8 μ m.

shape, have no teeth or spicules on either the tip or edges and are one-half to three-fourths the length of the mandibles (Figs. 14–15). Their structure indicates that they serve as the lateral boundary of the proboscis food canal. The base is thick and, on broken specimens, appears to be hollow (Fig. 14C). Laciniae of both sexes of all species are similar and do not differ distinctively in appearance from each other, but females have longer laciniae than conspecific males.

Maxillary palpal sensory organ.—In both sexes of all species the filiform sensilla, known as Newstead's sensilla or bulb organs (Lewis, 1973), that constitute the sensory organ, arise from an unindented surface on the distal end of the third palpal segment as in Corethrellidae (McKeever 1986), Ceratopogonidae (McKeever et al. 1991) and Psychodidae (Brinson et al.

1993). In contrast, the sensilla arise from a pit in *Culicoides* (Chu-Wang et al. 1975) and some Ceratopogonini where the pit ranges from shallow, as in *Alluaudomyia bella* (Coquillett), to deep, with heads of the sensilla below its rim, as in *Downshelea stonei* (Wirth) (McKeever et al. 1991). In Palpomyiini the long stalk of each sensillum originates from a recessed socket as in *Culicoides* (Rowley and Cornford 1972) and Ceratopogonini (McKeever et al. 1991) and the tip is expanded to form a head, the shape of which varies among the species (Figs. 16, 17). In some species, the sensilla are closely grouped and their heads are in approximately the same plane, but in others they originate along over half the length of the palpal segment and the stalk of one sensillum may not extend to the point of origin of a more distal one. The number of

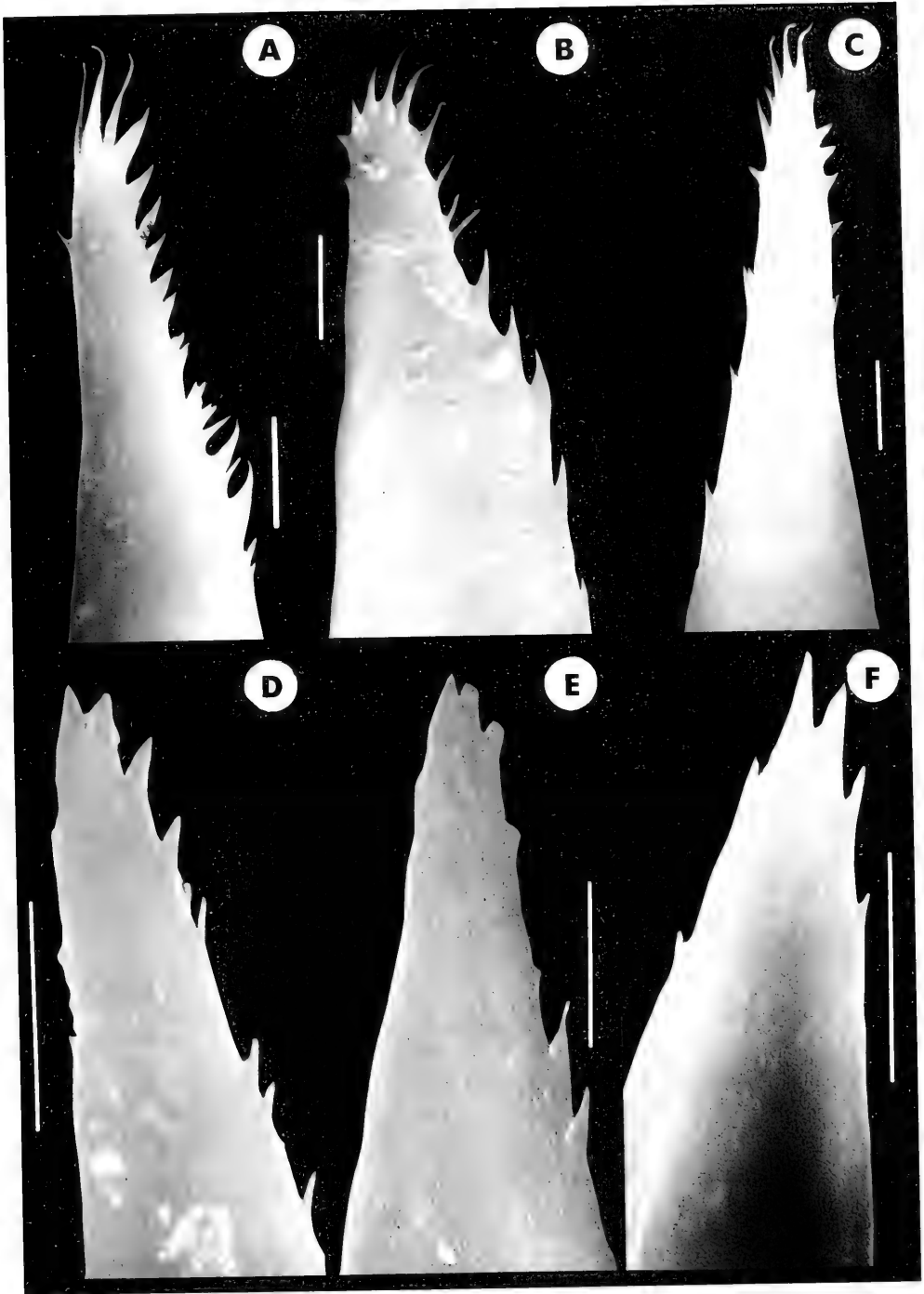


Fig. 8. SEM photomicrographs of mandibles of male. A, *Bezzia bivittata*. B, *B. imbifida*. C, *B. nobilis*. D, *B. glabra*. E, *B. dorsasetula*. F, *Phaenobezzia opaca*. White bars equal 8 μm .

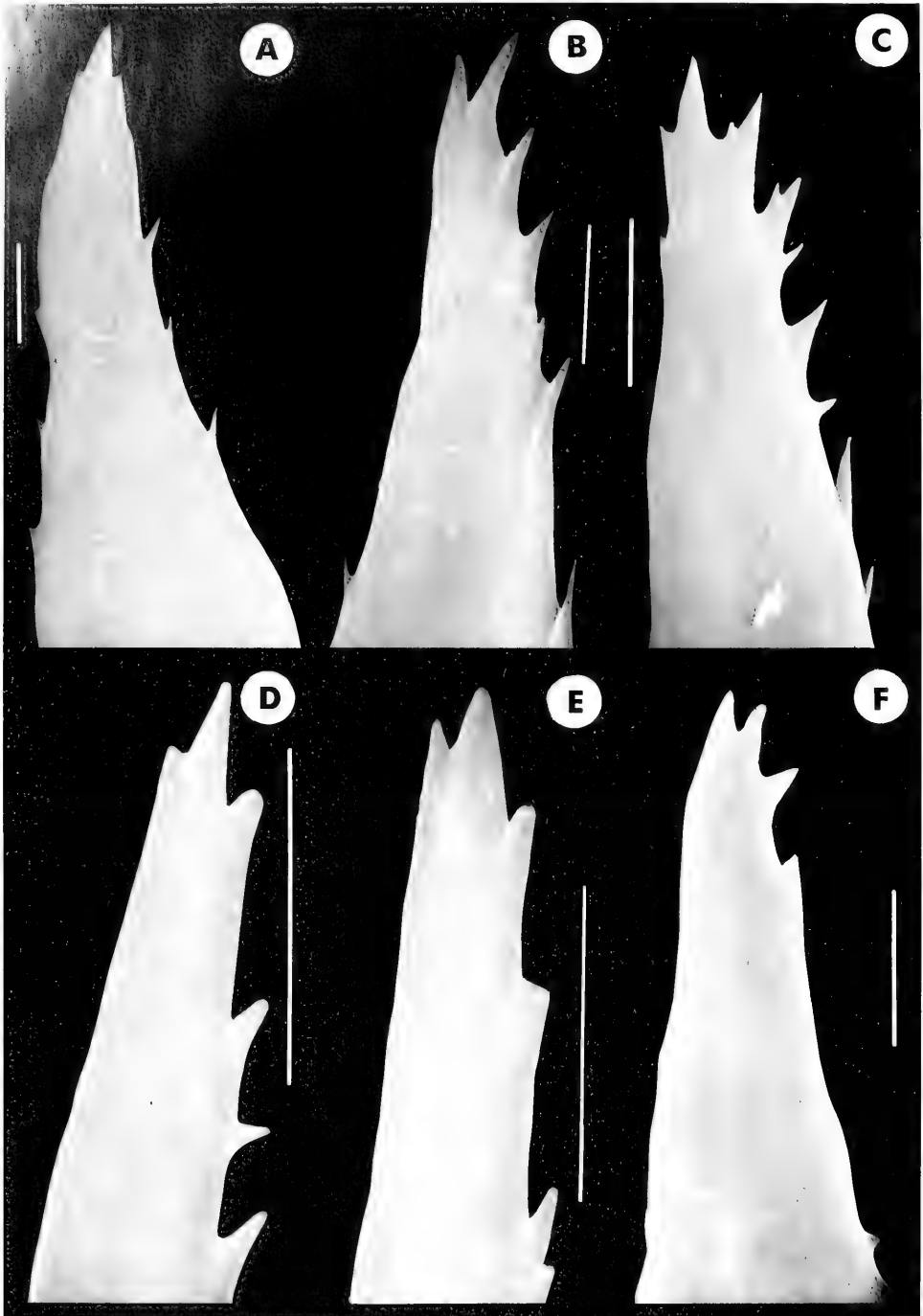


Fig. 9. SEM photomicrographs of mandibles of male. A, *Palpomyia subaspera*. B, *P. lineata*. C, *P. plebeia*. D, *P. rufa*. E, *P. pseudorufa*. F, *P. scalpellifera*. White bars equal 8 μ m.

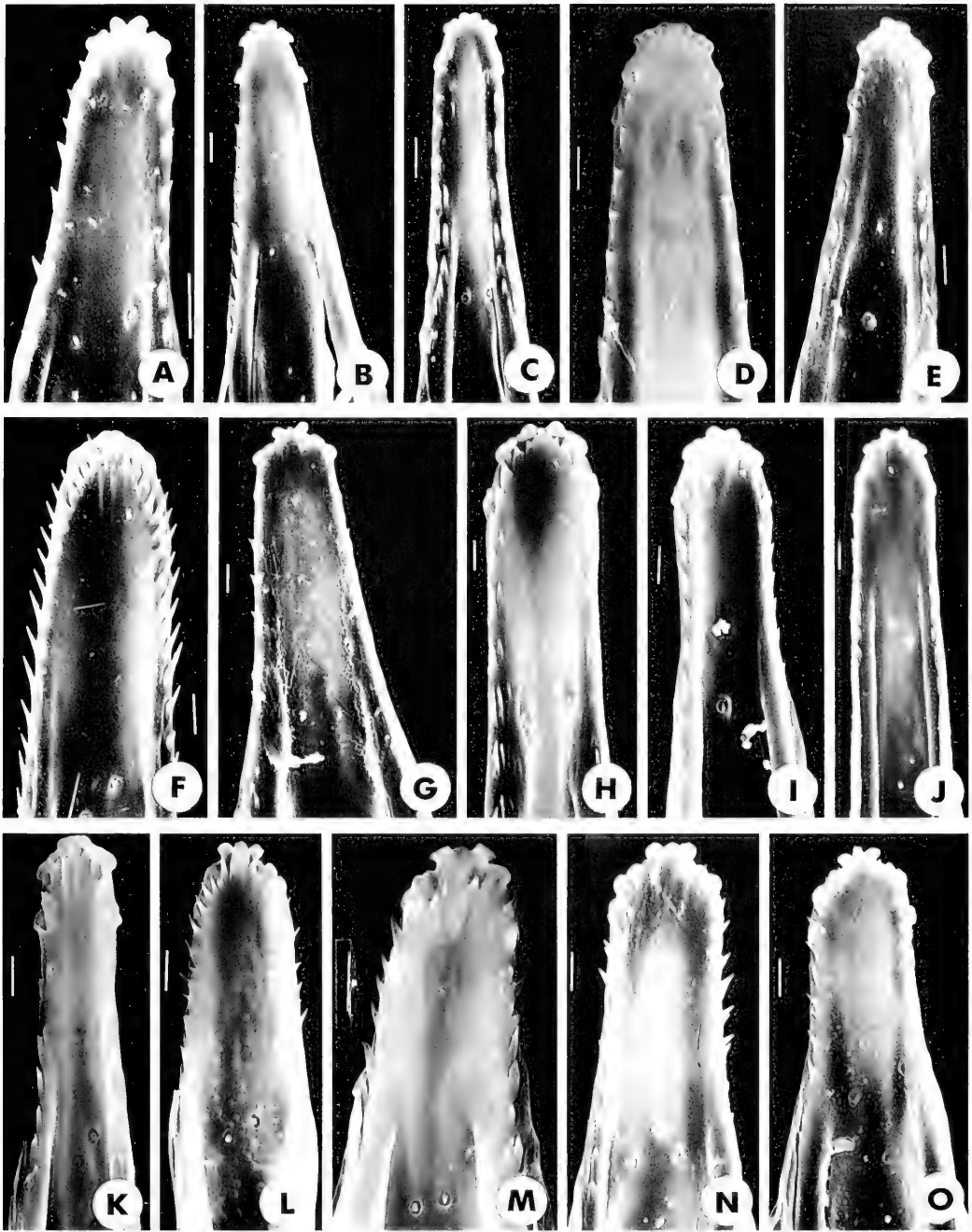


Fig. 10. SEM photomicrographs of labra of female. A, *Bezzia bivittata*. B, *B. imbrifida*. C, *B. nobilis*. D, *B. glabra*. E, *B. dorsasetula*. F, *Phaenobezzia opaca*. G, *Palpomyia cressoni*. H, *P. lineata*. I, *P. plebeia*. J, *P. rufa*. K, *P. pseudorufa*. L, *P. basalis*. M, *P. flaviceps*. N, *P. scalpellifera*. O, *P. hastata*. White bars equal 8 μ m.

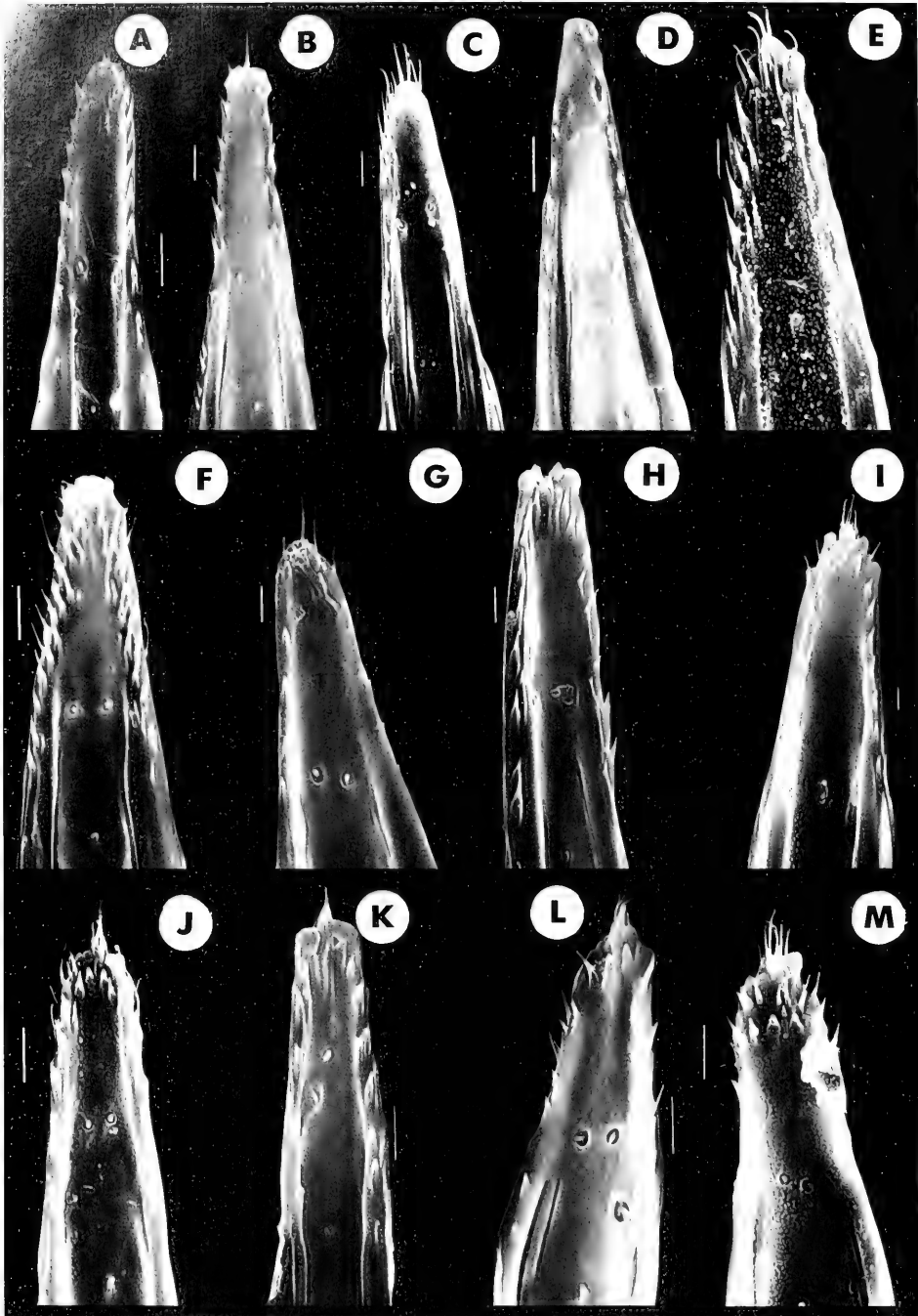


Fig. 11. SEM photomicrographs of labra of male. A, *Bezzia bivittata*. B, *B. imbrifida*. C, *B. nobilis*. D, *B. glabra*. E, *B. dorsasetula*. F, *Phaenobezzia opaca*. G, *Palpomyia subaspera*. H, *P. lineata*. I, *P. plebeia*. J, *P. rufa*. K, *P. pseudorufa*. L, *P. basalis*. M, *P. scalpellifera*. White bars equal 8 μ m.

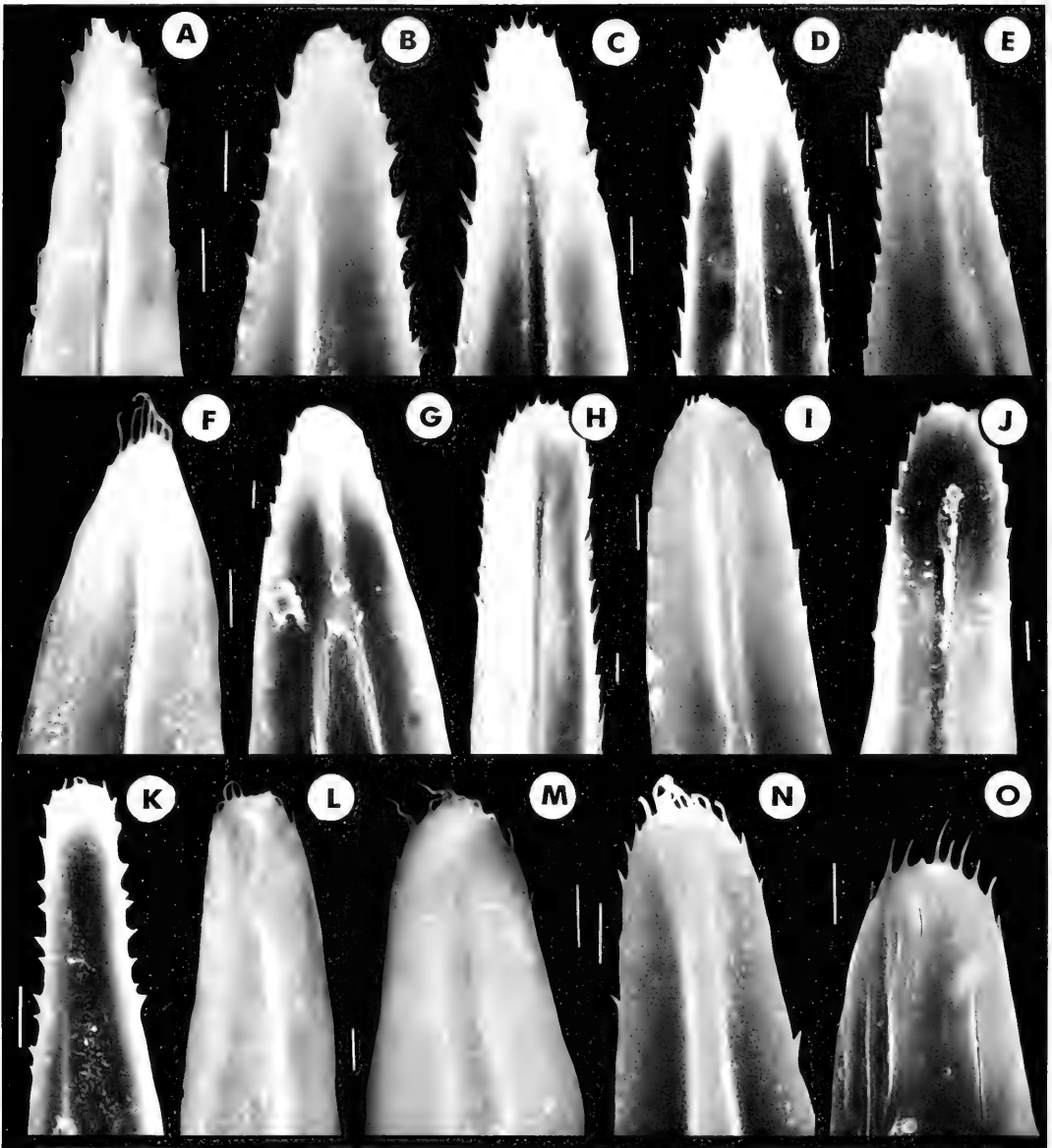


Fig. 12. SEM photomicrographs of the hypopharynx of female. A, *Bezzia bivittata*. B, *B. imbifida*. C, *B. nobilis*. D, *B. glabra*. E, *B. dorsasetula*. F, *Phaenobezzia opaca*. G, *Palpomyia cressoni*. H, *P. lineata*. I, *P. plebeia*. J, *P. rufa*. K, *P. pseudorufa*. L, *P. basalis*. M, *P. flaviceps*. N, *P. scalpellifera*. O, *P. hastata*. White bars equal 8 μm .

sensilla is approximately equal in both sexes of the same species (Tables 4, 8).

Description of Mouthparts by Species

Bezzia bivittata. Mandible (female) (Figs. 1A, 3A): 114–175 μm ($n = 13$) long, 23–37 μm ($n = 13$) wide; tooth row 23%

of total length; 7–15 ($n = 19$) small coarse medial teeth, uniform throughout, their camber 35°, pitch 71°; 0–8 ($n = 19$) small basal teeth, sometimes bifurcate; 0–6 ($n = 20$) small lateral teeth.

Mandible (male) (Figs. 6A, 8A): 121–140 μm ($n = 10$) long, 19–24 μm ($n = 10$)

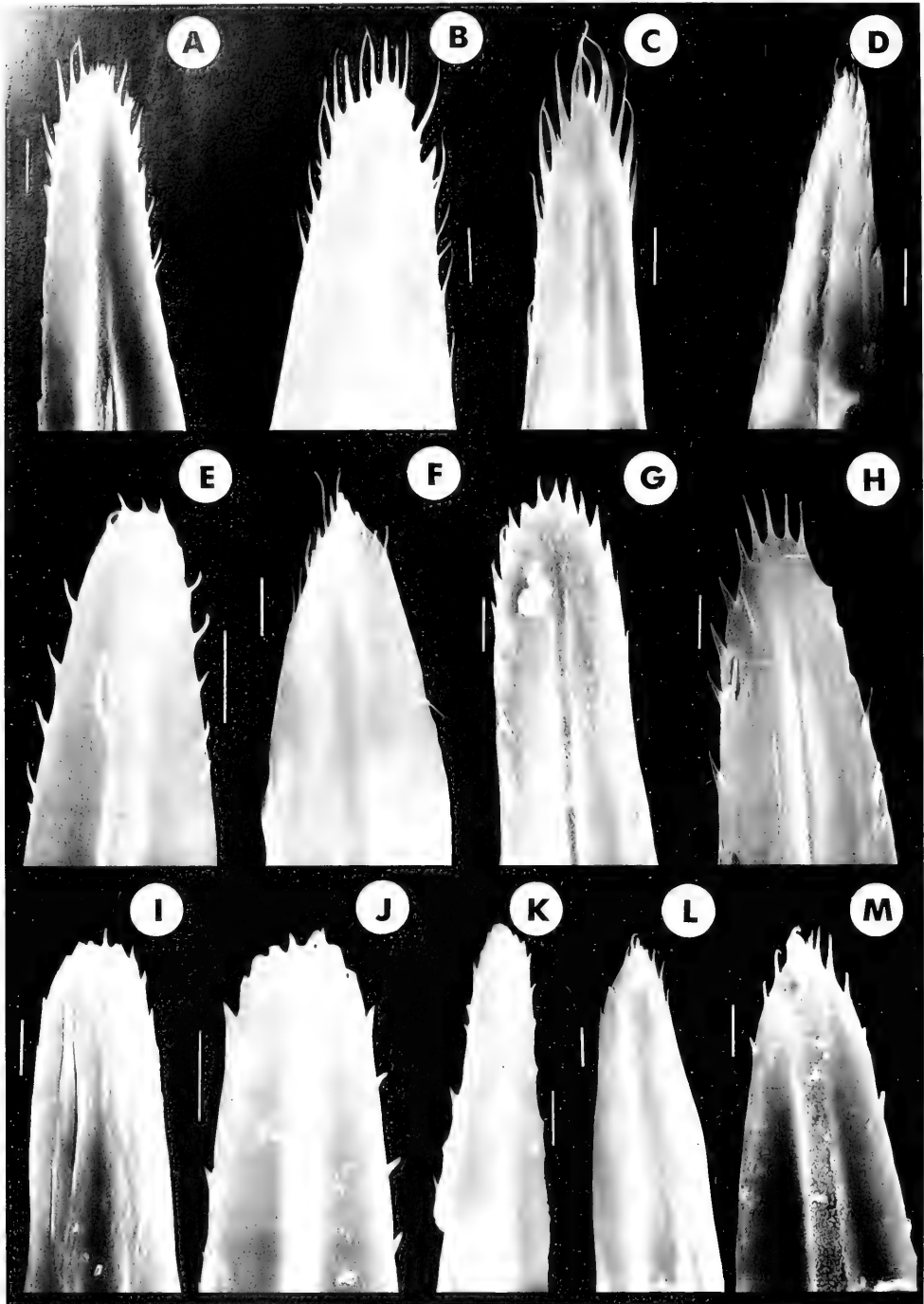


Fig. 13. SEM photomicrographs of the hypopharynx of male. A, *Bezzia bivittata*. B, *B. imbrifida*. C, *B. nobilis*. D, *B. glabra*. E, *B. dorsasetula*. F, *Phaenobezzia opaca*. G, *Palpomyia subaspera*. H, *P. lineata*. I, *P. plebeia*. J, *P. rufa*. K, *P. pseudorufa*. L, *P. basalis*. M, *P. scalpellifera*. White bars equal 8 μ m.

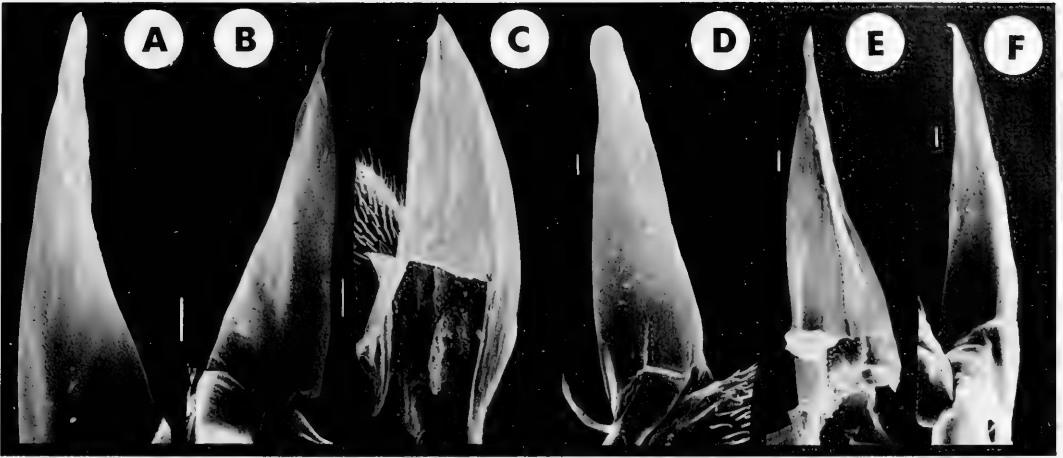


Fig. 14. SEM photomicrographs of lacinae of female. A, *Bezzia nobilis*. B, *B. dorsasetula*. C, *Phaenobezzia opaca*. D, *Palpomyia cressoni*. E, *P. lineata*. F, *P. plebeia*. White bars equal 8 μm .

wide; 4–13 ($n = 10$) large medial teeth, apical ones slender, some proximal ones may be bifurcate; 0–2 ($n = 10$) small basal teeth; 0–1 ($n = 10$) small lateral projections.

Labrum (female) (Fig. 10A): 146–189 μm ($n = 5$) long, 21–29 μm ($n = 7$) wide, 14–22 ($n = 4$) short, coarse, widely-spaced spicules.

Labrum (male) (Fig. 11A): 157–160 μm ($n = 2$) long, 16–21 μm ($n = 2$) wide; 18–20 ($n = 2$) short, coarse, widely-spaced spicules in a single row on the ventrolateral surfaces; additional spicules on the subapical ventral surface; spicules replace the terminal median projections of females.

Hypopharynx (female) (Fig. 12A): 142–200 μm ($n = 7$) long, 14–40 μm ($n = 7$) wide; 17–32 ($n = 4$) short, semi-blunt spicules on margins and apex.

Hypopharynx (male) (Fig. 13A): 142–186 μm ($n = 4$) long, 23–32 μm ($n = 4$) wide; 7–21 ($n = 3$) long, slender spicules on distal margins and apex, minute spicules on margins proximally.

Palpal sensory organ (female) (Fig. 16A): 3–4 ($n = 3$) closely grouped sensilla 14–15 μm ($n = 2$) long, heads spatulate.

Palpal sensory organ (male) (Fig. 17A): 2–6 ($n = 5$) closely grouped sensilla 16–19 μm ($n = 3$) long, heads spatulate.

Bezzia imbifida. Mandible (female) (Figs. 1B, 3B): 158–182 μm ($n = 11$) long, 27–35 μm ($n = 12$) wide; tooth row 24% of total length; 7–12 ($n = 12$) small, coarse medial teeth, diminishing in size proximally, their camber 25°, pitch 75°; 1–4 ($n = 12$) small, basal teeth; 3–6 ($n = 12$) minute lateral teeth.

Mandible (male) (Figs. 6B, 8B): 134–165 μm ($n = 10$) long, 20–23 μm ($n = 10$) wide; 6–11 ($n = 11$) large medial teeth, apical ones slender, proximal ones coarse; 0–2 ($n = 11$) small basal teeth; 0–3 ($n = 11$) minute lateral teeth.

Labrum (female) (Fig. 10B): 176–180 μm ($n = 2$) long, 28–29 μm ($n = 5$) wide; 20–30 μm ($n = 5$) coarse, closely spaced spicules.

Labrum (male) (Fig. 11B): 152–169 μm ($n = 4$) long, 19–21 μm ($n = 6$) wide; 17 ($n = 1$) sharp, widely-spaced spicules on the ventrolateral surfaces and as replacements for the median projections of females.

Hypopharynx (female) (Fig. 12B): 177–178 μm ($n = 3$) long, 19–25 μm ($n = 6$) wide; 17–22 ($n = 6$) short, sharp, irregularly spaced spicules on lateral margins, and sparse, irregularly spaced projections on apex.

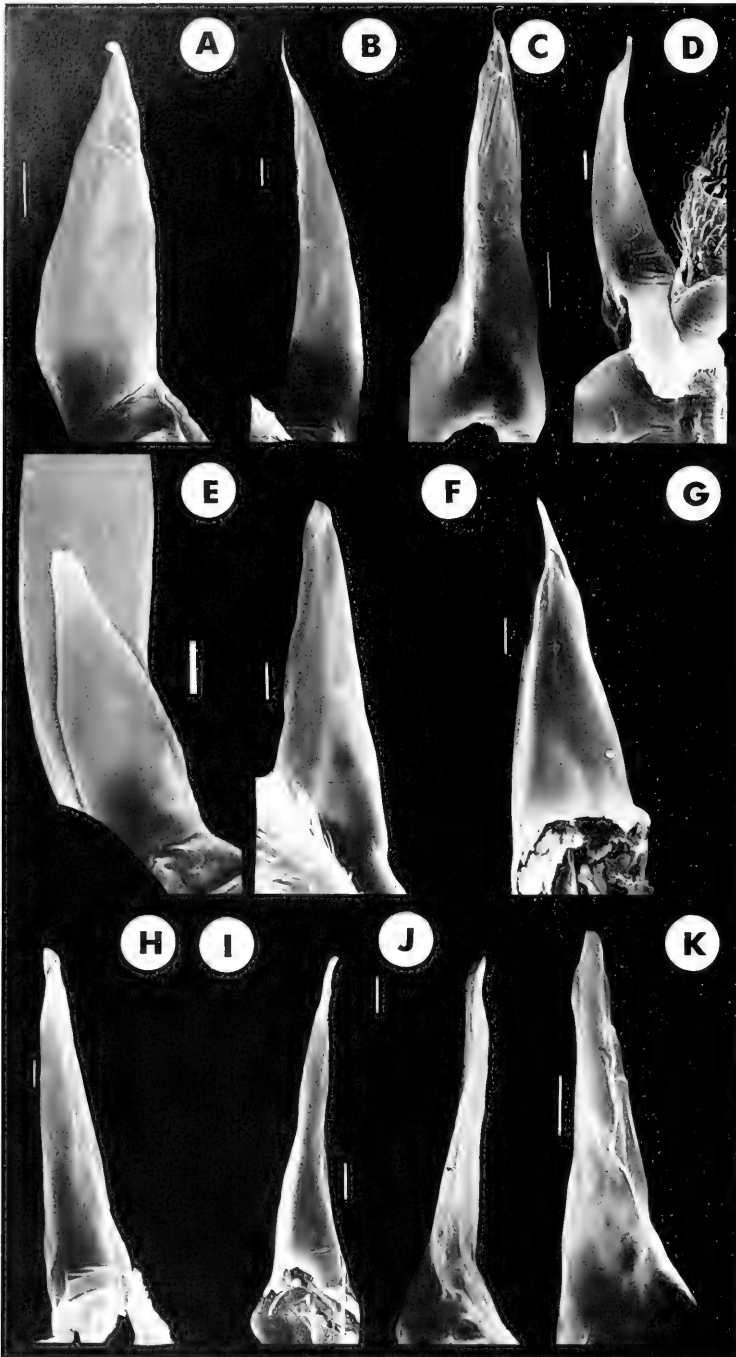


Fig. 15. SEM photomicrographs of laciniae of male. A, *Bezzia bivittata*. B, *B. imbfida*. C, *B. glabra*. D, *B. dorsasetula*. E, *Phaenobezzia opaca*. F, *Palpomyia subaspera*. G, *P. lineata*. H, *P. plebeia*. I, *P. rufa*. J, *P. pseudorufa*. K, *P. scalpellifera*. White bars equal 8 μ m.

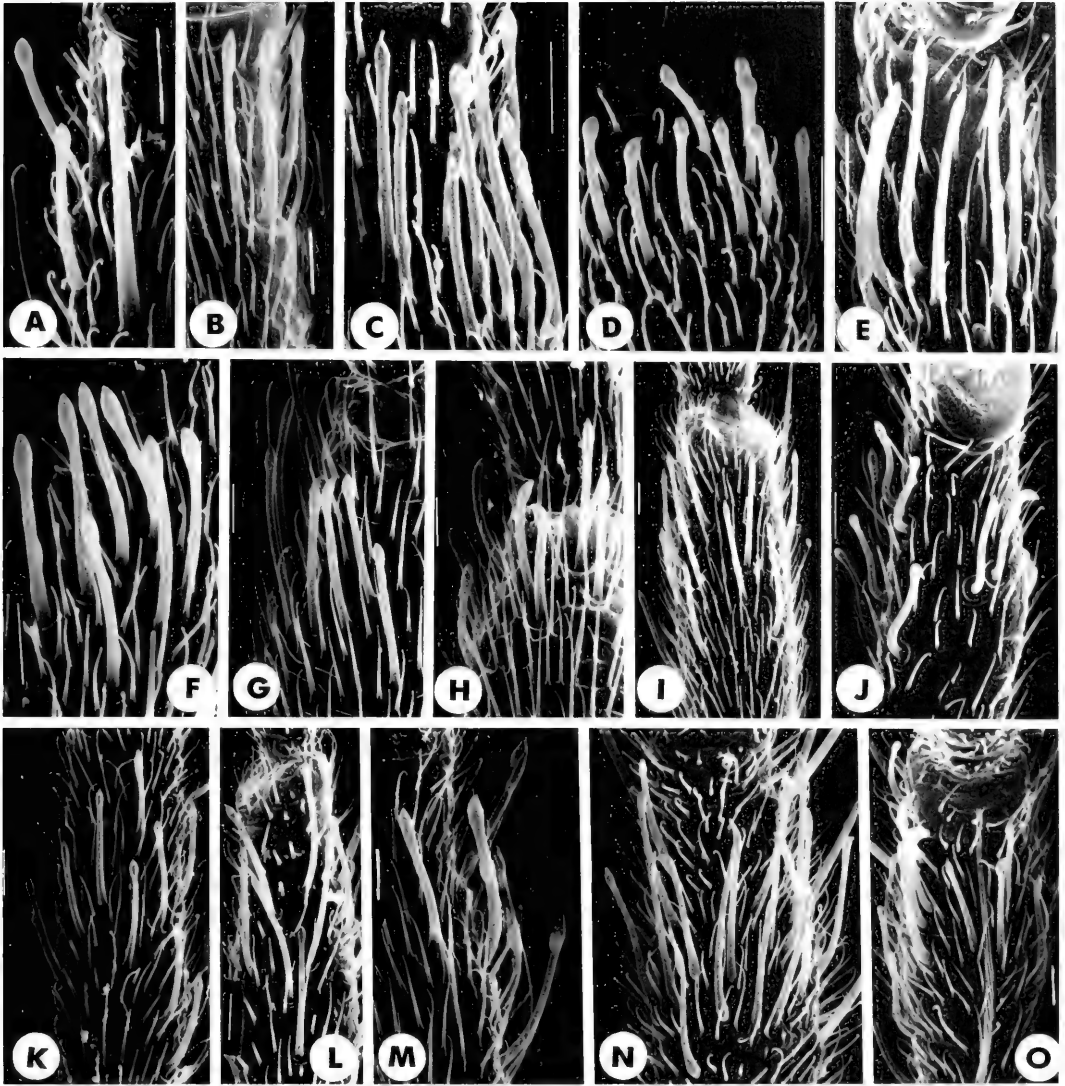


Fig. 16. SEM photomicrographs of sensilla of female. A, *Bezzia bivittata*. B, *B. imbfida*. C, *B. nobilis*. D, *B. glabra*. E, *B. dorsasetula*. F, *Phaenobezzia opaca*. G, *Palpomyia subaspera*. H, *P. cressoni*. I, *P. lineata*. J, *P. plebeia*. K, *P. rufa*. L, *P. pseudorufa*. M, *P. flaviceps*. N, *P. scalpellifera*. O, *P. hastata*. White bars equal 8 μm .

Hypopharynx (male) (Fig. 13B): 153–168 μm ($n = 3$) long, 19–20 μm ($n = 4$) wide; 11–21 ($n = 4$) long, slender, closely spaced spicules on distal margins and apex.

Palpal sensory organ (female) (Fig. 16B): 5–8 ($n = 7$) closely grouped sensilla 37.5–37.5 μm ($n = 3$) long, heads spatulate.

Palpal sensory organ (male) (Fig. 17B):

4–7 ($n = 5$) closely grouped sensilla 16–19 μm ($n = 4$) long, heads spatulate.

Bezzia nobilis. Mandible (female) (Figs. 1C, 3C): 142–196 μm ($n = 34$) long, 31–96 μm ($n = 37$) wide; tooth row 30% of total length; 7–10 μm ($n = 45$) large coarse medial teeth, diminishing in size proximally, their camber 32°, pitch 71°; 0–8 ($n =$

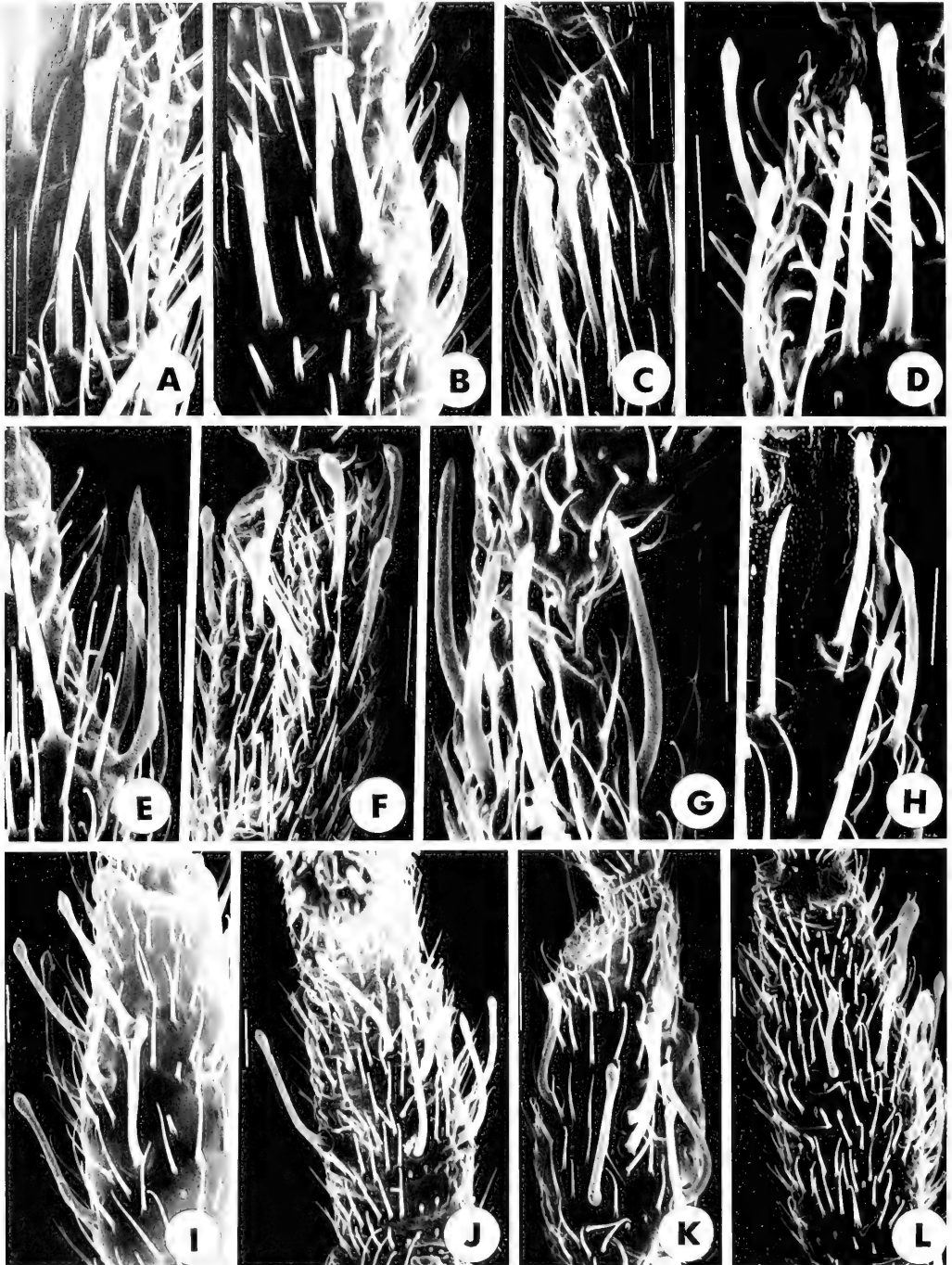


Fig. 17. SEM photomicrographs of sensilla of male. A, *Bezzia bivittata*. B, *B. imbrifida*. C, *B. nobilis*. D, *B. glabra*. E, *B. dorsasetula*. F, *Phaenobezzia opaca*. G, *Palpomyia subaspera*. H, *P. lineata*. I, *P. plebeia*. J, *P. rufa*. K, *P. pseudorufa*. L, *P. scalpellifera*. White bars equal 8 μ m.

Table 4. Measurements (μm) of laciniae and measurements and number of sensilla of maxillary palpal sensory organ of female *Palpomyiini*.

Species	Laciniae						Sensilla					
	Total Length			Maximum Width			No. per Organ			Total Length		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
<i>B. bivittata</i>	105.51	10.94	6	26.38	1.37	6	3.67	1.43	3	14.75	—	2
<i>B. imbifida</i>	106.90	7.47	8	26.27	1.95	8	6.14	1.41	7	37.50	—	3
<i>B. nobilis</i>	115.42	5.02	14	29.79	2.29	15	6.87	1.06	16	19.40	1.55	5
<i>B. glabra</i>	91.77	20.08	4	26.27	9.52	4	5.37	1.20	16	11.20	0.71	6
<i>B. dorsasetula</i>	83.09	3.63	19	25.62	0.70	16	5.42	0.43	24	19.80	2.03	5
<i>Ph. opaca</i>	81.36	5.23	18	29.65	1.89	27	6.60	0.72	15	18.47	1.85	6
<i>P. subaspera</i>	127.68	—	2	43.22	—	2	10.00	—	1	26.50	3.68	6
<i>P. cressoni</i>	142.58	21.57	5	39.37	3.80	5	7.43	1.18	7	21.83	2.24	6
<i>P. lineata</i>	110.83	76.30	3	30.15	24.35	3	12.00	—	1	28.53	2.81	6
<i>P. plebeia</i>	115.49	5.39	18	28.21	2.13	14	7.85	1.01	13	16.50	1.72	6
<i>P. rufa</i>	154.92	8.67	19	36.48	2.58	19	8.05	1.34	18	17.83	1.23	6
<i>P. pseudorufa</i>	121.47	12.74	9	25.77	1.96	9	5.29	0.51	17	20.80	0.55	5
<i>P. basalis</i>	—	—	0	—	—	0	—	—	0	—	—	0
<i>P. flaviceps</i>	97.62	24.42	5	27.04	16.63	3	5.53	0.77	17	28.00	2.77	5
<i>P. scalpellifera</i>	130.78	50.04	3	37.68	15.61	3	9.80	3.56	5	30.85	1.42	5
<i>P. hastata</i>	—	—	0	—	—	0	12.00	—	1	20.34	3.07	5

45) small, basal teeth; 2–8 ($n = 45$) prominent lateral teeth.

Mandible (male) (Figs. 6C, 8C): 120–169 μm ($n = 12$) long, 20–32 μm ($n = 15$) wide; 2–13 ($n = 15$) small short medial teeth, apical ones long and slender; 0–4 ($n = 15$) minute basal teeth; 0–3 ($n = 15$)

minute lateral teeth, proximal ones short, apical ones long and slender.

Labrum (female) (Fig. 10C): 146–225 μm ($n = 18$) long, 23–40 μm ($n = 20$) wide; 17–30 ($n = 7$) coarse, closely spaced spicules in single row distally and double row proximally on ventrolateral surfaces.

Table 5. Measurements (μm) of mandibles of male *Palpomyiini*.

Species	Total Length			Maximum Width			Width at Basal Tooth			Length of Tooth Row		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
<i>B. bivittata</i>	133.93	6.18	10	21.28	1.42	10	12.05	2.99	10	25.80	6.95	10
<i>B. imbifida</i>	147.92	8.06	9	20.80	0.72	11	11.95	0.73	11	33.12	6.03	11
<i>B. nobilis</i>	147.63	8.89	12	25.36	2.30	15	9.84	2.44	15	26.60	8.79	15
<i>B. glabra</i>	138.54	9.77	6	25.67	1.42	10	7.00	2.06	10	14.89	5.55	10
<i>B. dorsasetula</i>	114.61	2.14	17	21.87	1.35	18	11.90	0.95	18	22.24	2.72	18
<i>Ph. opaca</i>	118.51	6.14	18	24.80	1.54	20	10.83	1.29	20	17.86	2.63	20
<i>P. subaspera</i>	130.34	10.38	5	25.05	2.71	6	13.60	0.93	7	30.02	5.40	7
<i>P. cressoni</i>	—	—	0	—	—	0	—	—	0	—	—	0
<i>P. lineata</i>	146.30	11.17	14	26.78	2.52	15	11.53	1.92	15	23.76	5.46	15
<i>P. plebeia</i>	118.59	2.31	18	20.02	1.31	18	7.54	1.04	18	15.81	1.60	18
<i>P. rufa</i>	134.42	8.02	15	22.34	1.65	15	10.02	1.07	15	21.55	3.58	15
<i>P. pseudorufa</i>	113.37	3.89	22	20.31	0.80	22	7.50	0.43	22	21.70	1.71	22
<i>P. basalis</i>	105.07	—	2	19.95	—	2	—	—	0	—	—	0
<i>P. flaviceps</i>	—	—	0	—	—	0	—	—	0	—	—	0
<i>P. scalpellifera</i>	117.05	25.89	4	22.61	1.75	4	7.98	5.18	4	13.30	9.30	4
<i>P. hastata</i>	—	—	0	—	—	0	—	—	0	—	—	0

Table 6. Measurements (μm) and number of spicules of mandibles of male *Palpomyiini*.

Species	Length of Longest Tooth			No. of Coarse Medial Teeth			No. of Small Basal Teeth			No. of Lateral Teeth		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
<i>B. bivittata</i>	1.92	0.53	9	7.40	2.06	10	0.20	0.45	10	0.70	0.23	10
<i>B. imbifida</i>	2.71	0.12	12	8.36	1.24	11	0.36	0.54	11	0.45	0.70	11
<i>B. nobilis</i>	4.41	0.27	39	5.87	1.61	15	0.67	0.77	15	0.40	0.50	15
<i>B. glabra</i>	5.19	0.44	26	4.30	1.58	10	0.50	0.61	10	0.20	0.30	10
<i>B. dorsasetula</i>	1.92	0.41	18	5.94	0.47	18	0.00	—	18	0.00	—	18
<i>Ph. opaca</i>	2.24	0.47	19	4.10	0.60	20	0.00	—	20	0.55	0.72	20
<i>P. subaspera</i>	1.90	0.66	7	4.14	1.55	7	—	—	0	0.71	0.66	7
<i>P. cressoni</i>	—	—	0	—	—	0	—	—	0	—	—	0
<i>P. lineata</i>	2.75	0.59	15	5.94	1.00	16	0.31	0.42	16	0.19	0.29	16
<i>P. plebeia</i>	1.81	0.37	18	5.00	1.11	18	0.00	—	18	0.17	0.26	18
<i>P. rufa</i>	2.08	0.57	15	4.80	0.70	15	0.27	0.57	15	0.00	—	14
<i>P. pseudorufa</i>	1.99	0.27	22	4.86	0.31	22	0.00	—	22	0.00	—	22
<i>P. basalis</i>	—	—	0	—	—	0	—	—	0	—	—	0
<i>P. flaviceps</i>	—	—	0	—	—	0	—	—	0	—	—	0
<i>P. scalpellifera</i>	1.33	0	4	4.25	2.00	4	0.00	—	4	0.00	—	4
<i>P. hastata</i>	—	—	0	—	—	0	—	—	0	—	—	0

Labrum (male) (Fig. 11C): 160–186 μm ($n = 7$) long, 20–27 μm ($n = 8$) wide, 16–29 ($n = 8$) spicules, the proximal ones coarse, distal ones long and slender.

Hypopharynx (female) (Fig. 12C): 165–229 μm ($n = 16$) long, 22–37 μm ($n = 17$) wide; 15–46 ($n = 11$) short, sharp, irregularly spaced spicules on lateral margins and apex.

Hypopharynx (male) (Fig. 13C): 172–184 μm ($n = 7$) long, 17–33 μm ($n = 8$) wide; 11–22 ($n = 6$) long, slender, closely spaced spicules on distal margins and apex.

Palpal sensory organ (female) (Fig. 16C): 2–10 ($n = 16$) closely grouped sensilla 17–21 μm ($n = 5$) long, heads spatulate.

Palpal sensory organ (male) (Fig. 17C):

Table 7. Measurements (μm) and number of spicules of labra and hypopharynx of male *Palpomyiini*.

Species	Labra						Hypopharynx					
	Total Length			No. of Spicules			Total Length			No. of Spicules		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
<i>B. bivittata</i>	158.27	—	2	19.00	—	2	159.27	29.99	4	13.33	17.62	3
<i>B. imbifida</i>	158.60	11.77	4	17.00	—	1	159.15	18.79	3	16.50	6.69	4
<i>B. nobilis</i>	173.09	8.33	7	21.75	3.81	8	176.89	4.49	7	16.32	3.91	6
<i>B. glabra</i>	154.72	8.31	3	14.00	3.04	5	159.27	21.04	4	13.33	2.87	6
<i>B. dorsasetula</i>	142.16	4.75	9	18.67	4.28	6	139.92	4.59	9	15.87	1.92	8
<i>Ph. opaca</i>	141.74	11.09	7	22.75	6.79	8	137.39	9.76	10	12.12	2.66	8
<i>P. subaspera</i>	147.30	5.57	4	18.67	5.74	3	147.63	11.45	3	13.50	—	2
<i>P. cressoni</i>	—	—	0	—	—	0	—	—	0	—	—	0
<i>P. lineata</i>	171.57	22.18	5	15.50	4.78	6	175.12	15.71	6	13.30	3.36	6
<i>P. plebeia</i>	144.78	6.68	7	18.71	2.65	7	139.65	7.75	6	13.30	1.47	10
<i>P. rufa</i>	160.40	10.64	10	14.25	2.08	8	162.09	15.44	8	11.50	5.40	8
<i>P. pseudorufa</i>	129.01	6.88	8	11.11	2.29	9	129.01	5.07	11	14.82	1.46	11
<i>P. basalis</i>	143.64	—	1	16.00	—	1	140.98	—	1	11.00	—	1
<i>P. flaviceps</i>	—	—	0	—	—	0	—	—	0	—	—	0
<i>P. scalpellifera</i>	133.00	—	1	11.00	—	1	131.67	—	1	4.00	—	1
<i>P. hastata</i>	—	—	0	—	—	0	—	—	0	—	—	0

Table 8. Measurements (μm) of laciniae and measurements and number of sensilla of maxillary palpal sensory organ of male *Palpomyiini*.

Species	Laciniae						Sensilla					
	Total Length			Maximum Width			No. per Organ			Total Length		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
<i>B. bivittata</i>	88.78	16.51	4	23.61	7.60	4	3.40	2.08	5	17.48	2.79	3
<i>B. imbrifida</i>	95.91	3.45	9	20.17	2.85	6	5.50	2.05	5	16.93	1.75	4
<i>B. nobilis</i>	100.50	10.30	10	21.52	3.06	11	4.25	0.86	12	17.86	0.88	4
<i>B. glabra</i>	55.33	13.84	5	17.73	9.54	3	2.78	1.00	9	15.16	2.70	5
<i>B. dorsasetula</i>	72.61	5.18	10	20.21	2.36	10	4.25	0.87	8	19.73	2.28	3
<i>Ph. opaca</i>	73.15	9.94	7	23.37	3.00	7	4.22	0.71	18	11.29	0.87	4
<i>P. subaspera</i>	82.46	5.65	6	23.05	5.41	5	4.17	1.68	6	21.06	2.13	4
<i>P. cressoni</i>	—	—	0	—	—	0	—	—	0	—	—	0
<i>P. lineata</i>	85.56	5.09	9	28.50	3.61	7	3.86	0.64	7	17.17	0.00	3
<i>P. plebeia</i>	86.24	2.70	13	22.30	1.28	13	4.50	0.63	14	19.33	2.67	14
<i>P. rufa</i>	91.27	8.86	8	19.42	2.78	5	3.85	0.69	13	17.60	2.12	5
<i>P. pseudorufa</i>	79.92	3.44	11	15.23	1.16	11	3.00	0.59	18	19.39	1.96	5
<i>P. basalis</i>	—	—	0	—	—	0	—	—	0	—	—	0
<i>P. flaviceps</i>	—	—	0	—	—	0	—	—	0	—	—	0
<i>P. scalpellifera</i>	91.77	—	1	35.90	—	1	8.00	—	2	18.40	0.74	5
<i>P. hastata</i>	—	—	0	—	—	0	—	—	0	—	—	0

2–6 ($n = 12$) closely grouped sensilla 17–18 μm ($n = 4$) long, heads spatulate.

Bezzia glabra. Mandible (female) (Figs. 1D, 3D): 148–226 μm ($n = 24$) long, 28–50 μm ($n = 26$) wide; tooth row 28% of total length; 7–17 μm ($n = 27$) medium size medial teeth, diminishing in size proximally, distal ones widely spaced, their camber 43°, pitch 89°; 0–4 ($n = 27$) small, basal teeth; 0–10 ($n = 27$) small to prominent lateral teeth.

Mandible (male) (Figs. 6D, 8D): 128–149 μm ($n = 6$) long, 23–29 μm ($n = 10$) wide; 2–10 ($n = 10$) small to medium medial teeth, proximal ones slender; 0–2 ($n = 10$) minute basal teeth; 0–1 ($n = 10$) minute lateral teeth.

Labrum (female) (Fig. 10D): 169–269 μm ($n = 11$) long, 29–43 μm ($n = 11$) wide; 12–29 ($n = 11$) coarse, closely spaced spicules.

Labrum (male) (Fig. 11D): 152–158 μm ($n = 3$) long, 21–28 μm ($n = 6$) wide, 11–17 ($n = 5$) coarse spicules on the anteroventral surfaces, apex without spicules, similar to that of females, but structures less developed.

Hypopharynx (female) (Fig. 12D): 186–

274 μm ($n = 12$) long, 20–39 μm ($n = 12$) wide; 6–37 ($n = 11$) short, sharp, widely and regularly spaced spicules on lateral margins and apex.

Hypopharynx (male) (Fig. 13D): 149–178 μm ($n = 4$) long, 13–16 μm ($n = 5$) wide; 9–16 ($n = 6$) long, slender closely spaced spicules on most distal margins and apex, short spicules on margins proximally.

Palpal sensory organ (female) (Fig. 16D): 1–9 ($n = 15$) closely grouped sensilla 10–12 μm ($n = 6$) long, heads spatulate.

Palpal sensory organ (male) (Fig. 17D): 1–5 ($n = 9$) closely grouped sensilla 13–18 μm ($n = 5$) long, heads spatulate.

Bezzia dorsasetula. Mandible (female) (Figs. 1E, 3D): 116–144 μm ($n = 33$) long, 24–32 μm ($n = 35$) wide; tooth row 23% of total length; 6–9 ($n = 31$) large coarse medial teeth, distal ones uniform, proximal ones progressively smaller, their camber 35°, pitch 85°; 0–5 ($n = 31$) small basal teeth; 2–7 ($n = 33$) prominent lateral teeth.

Mandible (male) (Figs. 6E, 8E): 106–120 μm ($n = 17$) long, 20–31 μm ($n = 18$) wide; 4–7 ($n = 8$) medium medial teeth, lateral teeth absent.

Labrum (female) (Fig. 10E): 149–172

μm ($n = 15$) long, 21–27 μm ($n = 17$) wide; 12–23 ($n = 12$) coarse, closely spaced spicules.

Labrum (male) (Fig. 11E): 134–153 μm ($n = 9$) long, 17–24 μm ($n = 9$) wide, 15–26 ($n = 6$) long, slender spicules in 2–3 rows on the ventrolateral surfaces and apex, apical structures of females absent.

Hypopharynx (female) (Fig. 12E): 133–169 μm ($n = 17$) long, 20–24 μm ($n = 18$) wide; 18–24 ($n = 14$) very short, regularly and widely spaced spicules on lateral margins, those on the rounded apex closely spaced.

Hypopharynx (male) (Fig. 13E): 133–150 μm ($n = 9$) long, 15–20 μm ($n = 10$) wide; 12–19 ($n = 8$) short, widely and evenly spaced spicules on margins and apex.

Palpal sensory organ (female) (Fig. 16E): 3–8 ($n = 24$) closely grouped sensilla 18–22 μm ($n = 5$) long, heads filiform.

Palpal sensory organ (male) (Fig. 17E): 3–5 ($n = 8$) closely grouped sensilla 19–20 μm ($n = 3$) long, heads fusiform.

Phaenobezzia opaca. Mandible (female) (Figs. 1F, 3F): 120–180 μm ($n = 37$) long, 29–43 μm ($n = 35$) wide; tooth row 24% of total length; 7–8 ($n = 8$) large coarse medial teeth, the row terminates abruptly, proximal tooth largest, others uniform, their camber 45°, pitch 71°; 0–2 ($n = 8$) small basal teeth; 3–6 ($n = 8$) small lateral teeth.

Mandible (male) (Figs. 6F, 8F): 104–142 μm ($n = 19$) long, 20–32 μm ($n = 21$) wide; 2–6 ($n = 21$) medium medial teeth, 0–1 ($n = 21$) small lateral teeth.

Labrum (female) (Fig. 10F): 153–245 μm ($n = 14$) long, 19–39 μm ($n = 19$) wide; 21–32 ($n = 17$) long, slender, closely spaced spicules in single row on both ventrolateral and subapical surfaces. Spicules most abundant in this species of any examined.

Labrum (male) (Fig. 11F): 121–146 μm ($n = 8$) long, 19–44 μm ($n = 10$) wide; 14–36 ($n = 8$) long, slender, closely spaced spicules in 2–3 rows on the ventrolateral and subapical ventral surfaces. Spicules

most abundant in this species of any examined.

Hypopharynx (female) (Fig. 12F): 152–245 μm ($n = 15$) long, 4–37 μm ($n = 17$) wide; 0–9 ($n = 17$) long, slender spicules on the apex, absent from lateral margins.

Hypopharynx (male) (Fig. 13F): 120–156 μm ($n = 11$) long, 13–20 μm ($n = 10$) wide; 10–19 ($n = 9$) long, very slender spicules on pointed apex, absent from margins.

Palpal sensory organ (female) (Fig. 16F): 4–9 ($n = 15$) closely grouped sensilla 17–21 μm ($n = 6$) long, heads spatulate.

Palpal sensory organ (male) (Fig. 17F): 2–7 ($n = 6$) closely grouped sensilla 11–12 μm ($n = 4$) long, heads spatulate.

Palpomyia subaspera. Mandible (female) (Figs. 1G, 4A): 226–238 μm ($n = 2$) long, 40–47 μm ($n = 2$) wide; tooth row 28% of total length; 9–10 ($n = 2$) large coarse medial teeth, largest midlength of tooth row, their camber 58°, pitch 85°; 2–2 ($n = 2$) small basal teeth; 3–4 ($n = 2$) minute to small lateral teeth.

Mandible (male) (Figs. 6G, 9A): 118–140 μm ($n = 5$) long, 20–27 μm ($n = 6$) wide; 3–7 ($n = 7$) medium medial teeth, 0–2 ($n = 7$) small lateral teeth.

Labrum (female) (no Fig.): 266 μm ($n = 1$) long, 52 μm ($n = 1$) wide; 21 ($n = 1$) spicules.

Labrum (male) (Fig. 11G): 144–150 μm ($n = 4$) long, 25–27 μm ($n = 3$) wide; 16–20 μm ($n = 3$) spicules, long and slender and replace midapical structures of females, minute to short on ventrolateral surfaces.

Hypopharynx (female) (no Fig.): 251 μm ($n = 1$) long, 49 μm ($n = 1$) wide; 36 ($n = 1$) spicules.

Hypopharynx (male) (Fig. 13G): 145–156 μm ($n = 3$) long, 20–21 μm ($n = 3$) wide; 7–20 ($n = 2$) medium length slender spicules on rounded apex and distal margins.

Palpal sensory organ (female) (Fig. 16G): 10 ($n = 1$) closely grouped sensilla 22–30 μm ($n = 6$) long, heads spatulate.

Palpal sensory organ (male) (Fig. 17G):

2–7 ($n = 6$) closely grouped sensilla 20–23 μm ($n = 4$) long, heads same diameter as stalk.

Palpomyia cressoni. Mandible (female) (Figs. 1H, 4B): 181–192 μm ($n = 7$) long, 40–50 μm ($n = 10$) wide; tooth row 20% of total length; 6–9 ($n = 10$) medium coarse medial teeth, largest midlength of tooth row then rapidly diminishing in size proximally, their camber 46° , pitch 86° ; 1–4 ($n = 10$) small, basal teeth; 2–7 ($n = 10$) minute lateral teeth.

Mandible (male): no specimens.

Labrum (female) (Fig. 10G): 207–234 μm ($n = 3$) long, 32–40 μm ($n = 4$) wide; 15–21 ($n = 3$) spicules which are minute and widely spaced in a single row.

Labrum (male): no specimens.

Hypopharynx (female) (Fig. 12G): 209–230 μm ($n = 3$) long, 29–48 μm ($n = 5$) wide; 29–48 ($n = 5$) short spicules on apex and lateral margins.

Hypopharynx (male): no specimens.

Palpal sensory organ (female) (Fig. 16H): 6–9 ($n = 7$) closely grouped sensilla 20–26 μm ($n = 6$) long, heads spatulate.

Palpal sensory organ (male): no specimens.

Palpomyia lineata. Mandible (female) (Figs. 2A, 4C): 120–239 μm ($n = 8$) long, 37–49 μm ($n = 9$) wide; tooth row 25% of total length; 7–11 ($n = 14$) large coarse medial teeth, uniform on distal three-fourths of row, then diminishing rapidly; 3–8 ($n = 14$) small basal teeth; 5–11 ($n = 14$) small lateral teeth.

Mandible (male) (Figs. 6H, 9B): 120–184 μm ($n = 12$) long, 21–31 μm ($n = 11$) wide; 3–10 ($n = 16$) large medial teeth, 0–2 ($n = 16$) minute lateral teeth.

Labrum (female) (Fig. 10H): 235–258 μm ($n = 3$) long, 33–40 μm ($n = 4$) wide; 18–23 ($n = 2$) short, widely spaced spicules on ventrolateral surfaces, closely spaced on subapical surface.

Labrum (male) (Fig. 11H): 140–186 μm ($n = 5$) long, 23–33 μm ($n = 9$) wide; 9–22 ($n = 6$) medium slender to coarse spic-

ules on ventrolateral and subapical ventral surfaces, absent from apex.

Hypopharynx (female) (Fig. 12H): 269 μm ($n = 1$) long, 33–47 μm ($n = 2$) wide; 24 ($n = 1$) short, closely set spicules on rounded apex and margins.

Hypopharynx (male) (Fig. 13H): 173–186 μm ($n = 5$) long, 21–36 μm ($n = 7$) wide; 8–17 ($n = 6$) long, slender spicules on semirounded apex and distal margins.

Palpal sensory organ (female) (Fig. 16I): 11 ($n = 1$) longitudinally widely spaced sensilla 25–32 μm ($n = 6$) long, heads fusiform.

Palpal sensory organ (male) (Fig. 17H): 3–5 μm ($n = 9$) longitudinally widely spaced sensilla 17–17 μm ($n = 3$) long, heads fusiform.

Palpomyia plebeia. Mandible (female) (Figs. 2B, 4D): 146–171 μm ($n = 19$) long, 27–33 μm ($n = 22$) wide; tooth row 21% of total length; 6–8 ($n = 21$) large coarse medial teeth, largest proximal, their camber 55° , pitch 91° ; 2–5 ($n = 21$) small basal teeth; 3–6 ($n = 22$) small lateral teeth.

Mandible (male) (Figs. 7A, 9C): 110–126 μm ($n = 18$) long, 17–29 μm ($n = 18$) wide; 3–11 ($n = 18$) large medial teeth, some bifurcate; 0–2 ($n = 18$) minute lateral teeth.

Labrum (female) (Fig. 10I): 110–197 μm ($n = 8$) long, 23–32 μm ($n = 10$) wide; 20–30 ($n = 8$) medium length, closely spaced spicules.

Labrum (male) (Fig. 11I): 130–153 μm ($n = 7$) long, 12–27 μm ($n = 11$) wide; 15–23 ($n = 7$) spicules which are long and slender and replace the midapical structures of females, short and coarse on ventrolateral surfaces.

Hypopharynx (female) (Fig. 12I): 161–205 μm ($n = 9$) long, 20–29 μm ($n = 10$) wide; 13–23 ($n = 6$) minute to short spicules on rounded apex and margins.

Hypopharynx (male) (Fig. 13I): 130–148 μm ($n = 6$) long, 16–20 μm ($n = 10$) wide; 10–16 ($n = 10$) short, slender or very short blunt spicules on rounded apex, minute ones on margins.

Palpal sensory organ (female) (Fig. 16J): 2 (n = 12) longitudinally widely spaced sensilla, 14–18 μm (n = 6) long, heads spatulate.

Palpal sensory organ (male) (Fig. 17I): 3–7 μm (n = 14) longitudinally widely spaced sensilla 17–20 μm (n = 4) long, heads spatulate.

Palpomyia rufa. Mandibles (female) (Figs. 2C, 4E): 137–239 μm (n = 34) long, 32–50 μm (n = 34) wide; tooth row 21% of total length; 6–9 (n = 41) large coarse medial teeth, largest proximal, their camber 46°, pitch 90°; 0–7 (n = 41) small basal teeth; 0–7 (n = 40) minute lateral teeth.

Mandible (male) (Figs. 7B, 9D): 110–162 μm (n = 15) long, 16–27 μm (n = 15) wide; 2–7 (n = 15) large medial teeth, no lateral teeth.

Labrum (female) (Fig. 10J): 210–291 μm (n = 12) long, 27–57 μm (n = 16) wide; 12–20 (n = 10) minute, closely spaced spicules.

Labrum (male) (Fig. 11J): 142–180 μm (n = 10) long, 20–40 μm (n = 10) wide; 10–18 (n = 8) spicules, long and slender and replace the midapical structures of females, short and stout on subapical ventral surface, long and slender on ventrolateral surfaces.

Hypopharynx (female) (Fig. 12J): 189–310 μm (n = 14) long, 19–51 μm (n = 16) wide; 9–18 μm (n = 6) short spicules on rounded apex and margins.

Hypopharynx (male) (Fig. 13J): 142–192 μm (n = 8) long, 17–36 μm (n = 9) wide; 0–18 (n = 8) short spicules, blunt on apex, sharp and widely spaced on lateral margins.

Palpal sensory organ (female) (Fig. 16K): 1–12 (n = 18) longitudinally widely spaced sensilla, 16–19 μm (n = 6) long, heads spatulate.

Palpal sensory organ (male) (Fig. 17J): 2–5 (n = 13) longitudinally widely spaced sensilla 16–20 μm (n = 5) long, heads spatulate.

Palpomyia pseudorufa. Mandible (female) (Figs. 2D, 4F): 145–173 μm (n = 28) long, 23–33 μm (n = 29) wide; tooth row

23% of total length; 6–8 (n = 35) large coarse medial teeth, largest midlength of row, their camber 68°, pitch 72°; 0–4 (n = 35) small basal teeth; 0–5 (n = 35) minute lateral teeth.

Mandible (male) (Figs. 7C, 9E): 101–130 μm (n = 22) long, 16–24 μm (n = 16) wide; 4–6 μm (n = 22) large short medial teeth, no lateral teeth.

Labrum (female) (Fig. 10K): 170–210 μm (n = 11) long, 12–31 μm (n = 14) wide; 10–24 (n = 9) short closely spaced spicules.

Labrum (male) (Fig. 11K): 113–141 μm (n = 8) long, 13–20 μm (n = 8) wide; 7–17 (n = 9) spicules which are long and slender and replace the midapical structures of females, short and coarse on ventrolateral surfaces.

Hypopharynx (female) (Fig. 12K): 170–210 μm (n = 12) long, 15–25 μm (n = 9) wide; 11–26 (n = 8) medium, coarse, widely spaced spicules on flattened apex and margins.

Hypopharynx (male) (Fig. 13K): 118–140 μm (n = 11) long, 12–17 μm (n = 9) wide; 10–18 μm (n = 11) minute to short spicules on apex and margins.

Palpal sensory organ (female) (Fig. 16L): 3–6 (n = 17) longitudinally widely spaced sensilla 20–21 μm (n = 5) long, heads spatulate.

Palpal sensory organ (male) (Fig. 17K): 1–6 (n = 17) longitudinally spaced sensilla 17–21 μm (n = 5) long, heads spatulate.

Palpomyia basalis. Mandible (female) (Figs. 2E, 5A): 146–157 μm (n = 4) long, 33–37 μm (n = 4) wide; tooth row 19% of total length; 6–6 (n = 8) medium, coarse, widely spaced medial teeth, uniform size, their camber 38°, pitch 103°; 0–3 (n = 8) small basal teeth; 3–5 (n = 8) minute lateral teeth.

Mandible (male) (Figs. 7D): 102–108 μm (n = 2) long, 20–20 μm (n = 2) wide; no data on teeth.

Labrum (female) (Fig. 10L): 180–187 μm (n = 2) long, 16–40 μm (n = 2) wide;

no data on number of spicules which are short to minute.

Labrum (male) (Fig. 11L): 144 μm ($n = 1$) long, 16 μm ($n = 1$) wide; 16 ($n = 1$) short, slender spicules on ventrolateral and subapical ventral surfaces.

Hypopharynx (female) (Fig. 12L): 161–192 μm ($n = 2$) long, 13–15 μm ($n = 2$) wide; 6–8 ($n = 2$) long, slender spicules on apex, absent on margins.

Hypopharynx (male) (Fig. 13L): 141 μm ($n = 1$) long, 31 μm ($n = 1$) wide; 6–8 ($n = 2$) medium length, filiform spicules on pointed apex, absent on margins.

Palpal sensory organ (female): no specimens.

Palpal sensory organ (male): no specimens.

Palpomyia flaviceps. Mandible (female) (Figs. 2F, 5B): 125–172 μm ($n = 22$) long, 27–39 μm ($n = 24$) wide; tooth row 20% of total length; 4–9 ($n = 33$) medium coarse medial teeth, largest proximal, their camber 41°, pitch 78°; 0–3 ($n = 33$) small basal teeth; 0–5 ($n = 33$) small lateral teeth.

Mandible (male): no specimens measured.

Labrum (female) (Fig. 10M): 153–186 μm ($n = 7$) long, 24–64 μm ($n = 13$) wide; 9–29 ($n = 10$) short, closely spaced spicules on ventrolateral surfaces, sparse subapical ones.

Labrum (male): no specimens.

Hypopharynx (female) (Fig. 12M): 145–188 μm ($n = 12$) long, 13–28 μm ($n = 11$) wide; 0–10 ($n = 5$) long, filiform spicules on rounded apex, absent on margins.

Hypopharynx (male): no specimens.

Palpal sensory organ (female) (Fig. 16M): 2–8 ($n = 18$) longitudinally widely spaced sensilla 24–29 μm ($n = 5$) long, heads fusiform.

Palpal sensory organ (male): no specimens.

Palpomyia scalpellifera. Mandible (female) (Figs. 2G, 5C): 133–203 μm ($n = 8$) long, 28–44 μm ($n = 8$) wide; tooth row 15% of total length; 6–7 ($n = 8$) large coarse medial teeth, distal ones largest, di-

minishing slightly proximally, their camber 48°, pitch 90°; 1–3 ($n = 8$) small basal teeth; 3–7 ($n = 7$) small lateral teeth.

Mandible (male) (Figs. 7E, 9F): 100–132 μm ($n = 4$) long, 21–24 μm ($n = 4$) wide; 3–6 ($n = 4$) large medial teeth; no ($n = 4$) lateral teeth.

Labrum (female) (Fig. 10N): 162–217 μm ($n = 4$) long, 25–32 μm ($n = 4$) wide; no data on number of spicules which are medium and closely spaced on subventral surfaces, sparse subapical ones.

Labrum (male) (Fig. 11M): 133 μm ($n = 1$) long, 15 μm ($n = 1$) wide; 11 ($n = 1$) spicules, long and slender on tip, short and slender to stout on distal lateral and subapical ventral surfaces.

Hypopharynx (female) (Fig. 12N): 165–219 μm ($n = 3$) long, 20–28 μm ($n = 3$) wide; 9–11 ($n = 2$) long, slender spicules on rounded apex and distal margins.

Hypopharynx (male) (Fig. 13M): 132 μm ($n = 1$) long, 11–20 μm ($n = 2$) wide; 4 ($n = 1$) short to medium length spicules on pointed apex and distal margins.

Palpal sensory organ (female) (Fig. 16N): 6–14 ($n = 5$) longitudinally widely spaced sensilla 30–32 μm ($n = 5$) long, heads spatulate.

Palpal sensory organ (male) (Fig. 17L): 6–10 ($n = 2$) longitudinally widely spaced sensilla 17–19 μm ($n = 5$) long, heads spatulate.

Palpomyia hastata. Mandible (female) (Figs. 2H, 5D): 144–150 μm ($n = 2$) long, 32–34 μm ($n = 2$) wide; tooth row 17% of total length; 6–6 ($n = 2$) large coarse medial teeth, distal ones uniform size, proximal one largest, their camber 46°, pitch 97°; 1–2 ($n = 2$) small basal teeth; 0–3 ($n = 2$) small lateral teeth.

Mandible (male): no specimens.

Labrum (female) (Fig. 10O): no data on length, 29 μm ($n = 1$) wide; 18 ($n = 1$) medium, closely spaced spicules.

Labrum (male): no specimens.

Hypopharynx (female) (Fig. 12O): no data on length; 20 μm ($n = 1$) wide; 6 ($n = 1$) long slender spicules on rounded apex.

Hypopharynx (male): no specimens.

Palpal sensory organ (female) (Fig. 160): 12 ($n = 1$) longitudinally widely spaced sensilla 18–24 ($n = 5$) long, heads spatulate.

Palpal sensory organ (male): no specimens.

DISCUSSION

Mandibles of female Palpomyiini resemble those of other entomophagous ceratopogonids, e.g. Ceratopogonini (McKeever et al. 1991), Heteromyiini and Sphaeromiini (personal observations) Stenoxenini (Wirth and Ratanaworabhan 1972) of the Ceratopogoninae, and ectoparasitic *Atrichopogon meloesugans* Kieffer and *A. lucorum* (Meigen) of the Forcipomyiinae (Glukhova 1981) in having large, widely-spaced retrorse teeth. Mandibles of the subgenus *Trithecoides* of *Culicoides* (Culicoidini), as illustrated by Glukhova for *C. humeralis* (1982), have large retrorse teeth that are similar in shape and approach the size of those of some Palpomyiini and Ceratopogonini.

A second characteristic common to Palpomyiini and many members of Ceratopogonini, Heteromyiini and Sphaeromiini is the presence of antrorse teeth on the lateral edge of their mandibles. Lateral antrorse mandibular teeth also occur in *Simulium venustum* Say (Nicholson 1945) and *Culicoides (Trithecoides) anophelis* Edwards (Glukhova 1982) in *C. (T.) flavescens* Macfie, and in *C. (T.) paraflavescens* Wirth and Hubert (Wirth and Hubert 1989). Their function in all of these groups is unknown, but they may assist with enlargement of the wound in the exoskeleton of prey. A third characteristic common to each of these four tribes is their reduced, unarmed laciniae, except for members of the *anophelis* group of *Trithecoides* that feed on mosquitoes and phlebotomine sand flies and that have strong teeth on the laciniae (Wirth and Hubert 1989).

Mandibles of Palpomyiini function in the same manner as reported for Ceratopogon-

ini (McKeever et al. 1991). The initial incision in the prey's integument is made by antrorse distal mandibular teeth and enlarged by sawing action of the antrorse teeth. Mandibular action during this process is the same as that for *Culicoides* as described by McKeever et al. (1988) and Sutcliffe and Deepan (1988), and for *Simulium* Latreille as described by Sutcliffe and McIver (1984). Other elements of the proboscis enter the wound made by the mandibles, but presence of antrorse spicules on the labrum and hypopharynx and absence of armature on the laciniae preclude these structures from functioning in producing the incision.

Once the proboscis is inserted, saliva containing a strong protease flows through the salivary canal of the hypopharynx and digests the prey (Downes 1971). The digested material is drawn from the prey through the food canal formed by the labrum dorsally, the mandibles ventrally and the laciniae laterally. Thus, the mandibles separate the food canal from the salivary canal.

Although all reports indicate that Palpomyiini usually feed on male Chironomidae and Ephemeroptera, Downes (1978) reported that his few records for *B. glabra* and *P. lineata* indicated that they select moderate to large prey species from these groups. This is the only specific reference to feeding by the species that we examined. During a two-week study at Loch Lomond, Scotland in 1960, Downes (1978) found that four species of *Palpomyia*, in the *flavipes* group as defined by Grogan and Wirth (1979), fed exclusively on mayflies, while a species of *Bezzia* and another species of *Palpomyia* fed only on chironomids.

Elements of the proboscis are basically similar in females of the 16 species examined, but species specific variations exist in the mandibles, labrum and hypopharynx. Grogan and Wirth (1975, 1979) separated the Nearctic species of *Palpomyia* into four species groups, viz., *tibialis*, *lineata*, *distincta*, and *flavipes*, on the basis of their

male and female genitalia. Mandibular teeth of the first three of these groups (Figs. 4A–F) are longer and larger than those of either the *flavipes* group, viz. *P. basalis*, *hastata*, *altispina*, and *flaviceps*, (Figs. 5A–D) or of species of *Bezzia* (Figs. 3A–E), with the exception of *B. glabra* which has longer teeth than those of *P. pseudorufa*. *Phaenobezzia opaca* has the longest teeth ($\bar{x} = 6.2 \mu\text{m}$, $n = 39$) of any species studied except those of *Palpomyia subaspera* ($\bar{x} = 8.0 \mu\text{m}$, $n = 2$). Basic similarities probably are interrelated with a common method of feeding, viz., sucking the saliva-digested contents of their prey, and their food specialization, i.e. males of their own species and males of Chironomidae and Ephemeroptera. Species specific differences in the various structures probably reflect minor differences in the restricted range of prey.

In contrast to minor differences exhibited by elements of the proboscis of Palpomyiini, Glukhova (1981) reported basic similarity with marked differences in all elements of the proboscis of species of *Atrichopogon*. She attributed the differences to the diversity in prey (Coleoptera, Neuroptera, and Lepidoptera) and to their feeding on different parts of the body (wing veins, thorax, and abdomen) of their prey.

Male Nematocera belonging to species in which the females are entomophagous and hematophagous have unarmed mandibles that are smaller and less sclerotized than those of females and are thought to be nectar feeders (Downes 1971). In a later paper, Downes (1978) described the behavior of *Bezzia* feeding on honeydew and expressed the opinion that such feeding would be found to be a normal activity of both sexes of all predaceous midges. Mandibles of male Palpomyiini are fairly typical of entomophagous Ceratopogoninae. They differ from those of some other entomophagous groups, e.g. Ceratopogonini (McKeever et al. 1991) in having large antrorse, pointed teeth on their medial edge. These teeth may be as large as the retrorse teeth of females,

but their shape precludes their functioning as biting structures.

The poorly sclerotized labrum of female Palpomyiini has antrorse spicules of various shapes, rather than teeth, and is therefore not adapted for active penetration of the prey. These spicules are most abundant in *P. opaca*. The labrum functions as the dorsal wall of the food canal and the sensilla basiconica on its ventral surface probably function as chemoreceptors that monitor incoming food. In *Tabanus nigrovittatus* Macquart, similarly located sensilla have four dendrites entering each sensillum and were considered to be chemosensory by Stoffolano and Yin (1983). The two terminal peg-like structures in species of Palpomyiini resemble the pair of peg-shaped sensilla immediately proximal to the terminal tricuspid teeth of *Culicoides* (McKeever et al. 1988). Sutcliffe (1994) states that a pair of “terminal labral pegs” is present in Culicidae, Simuliidae and Ceratopogonidae and that they are equipped with both chemosensory and mechanosensory elements. The peg-like structures in Palpomyiini probably are homologous to those in the foregoing three families and are chemoreceptors, mechanoreceptors or both.

The labra of females of other species of the family may be highly sclerotized and armored; e.g. four species of mammal-feeding *Culicoides* (McKeever et al. 1988) that have two tricuspid terminal teeth with a pair of sensilla at their base. The labra of species of *Forcipomyia* Meigen (Forcipomyiinae) are highly variable, with pointed apices with short lateral spicules in caterpillar feeders, smooth rounded apices in those that feed on Odonata, smooth apices reinforced by longitudinal sclerotized thickenings in those that feed on amphibia, and apices with long bristles (spicules) on the edges and short spicules on the dorsal surfaces in those that feed on hemolymph from wing veins of various insects (Glukhova 1981).

The labra of male Palpomyiini are shorter, narrower, less sclerotized, and have lon-

and fewer spicules than conspecific females. The terminal structures present in females are smaller and reduced in number or absent. A similar relationship has been reported for Ceratopogonini (McKeever et al. 1991) and for two species of frog-feeding *Corethrella* Coquillett (McKeever 1986). Male *P. opaca* have a significantly greater number of spicules than any other species examined. Labra of males are species specific, but differences among species are less pronounced than in labra of females.

The hypopharynx of females is unarmed; its edges are either smooth or bear antrorse spicules as reported for *Forcipomyia* (Glukhova 1981) and Ceratopogonini (McKeever et al. 1991). The shape and orientation of its spicules indicate that it has no function in penetrating the prey, but enters the incision made by the mandibles and conducts saliva into the wound through its salivary duct.

The hypopharynx of females exhibits some generic differences in its shape and specific differences in distribution of its spicules. The hypopharynx of *Phaenobezzia opaca* (Fig. 12F) differs from those of species of *Bezzia* (Figs. 12A–E) and *Palpomyia* (Figs. 12G–O) in being more pointed and from species of *Bezzia* in lacking lateral spicules; males also have a more pointed hypopharynx (Figs. 13F) than species of *Bezzia* (Figs. 13A–E) and *Palpomyia* (Figs. 13G–M). Females of the *flavipes* group of *Palpomyia* differ from those of other species of the genus in lacking lateral spicules (Figs. 12L–O), but do not differ appreciably from each other. Terminal spicules are filiform in species lacking lateral spicules.

The hypopharynx of males of all species has both terminal and lateral antrorse spicules; in most species they are larger than in conspecific females. The function of these spicules is unknown for either sex, and they are completely absent in some entomophagous *Forcipomyia* (Glukhova 1981).

The weakly sclerotized, unarmored laciniae of Palpomyiini, like those of Cerato-

pogonini (McKeever et al. 1991), serve only as lateral boundaries of the food canal of the proboscis. They differ from those of some species of entomophagous *Forcipomyia* which have strongly armored laciniae similar in degree of development to those of hematophagous *Culicoides* and are thought by Glukhova (1981) to serve in piercing the integument of and attachment to the flying prey.

Sensilla in the maxillary palp sensory organ differ among species with respect to their number, points of origin on the palp of the individual sensilla, shape of their head, and their total length; a combination of these characters makes the sensory organs species specific. Thus, in females of all species of *Bezzia* (Figs. 16A–E) and in *Phaenobezzia opaca*, *Palpomyia subaspera* and *P. cressoni* (Figs. 16F–H), the sensilla originate in close proximity to each other and the heads are in approximately the same plane with respect to the long axis of the palpal segment. In the other seven species of *Palpomyia* (Figs. 16I–O) the points of origin of the individual sensilla may extend over one-half the length of the palpal segment and proximal sensilla may not extend to the point of origin of distal ones. Sensilla of females vary in mean length from 11.2 μm ($n = 6$) in *B. glabra* to 37.5 μm ($n = 3$) in *B. imbifida*. Heads of sensilla of male and female *B. dorsasetula* (Figs. 17E, 16E) and *P. lineata* (Figs. 17H, 16I) are fusiform, heads of sensilla of male *P. subaspera* (Fig. 17G) are approximately the same diameter as the stalk and those of females and males of all other species are spatulate.

Palpal sensilla are reported to be olfactory receptors, including carbon dioxide detectors, in *Culicoides* (Rowley and Cornford 1972, Chu-Wang et al. 1975) and are thought to function as host detectors. However, present evidence indicates that female Palpomyiini rely on visual rather than olfactory stimuli when hunting and capturing their prey. *Bezzia* and *Palpomyia* are able to recognize visually distinctive areas that

serve as swarm markers for their prey, even though no prey is present, and hover there for long periods until prey individuals accumulate (Downes 1978). This indicates that in predaceous Ceratopogonidae the palpal sensilla serve little or no function in locating prey. Therefore, the number of sensilla should be approximately the same in both sexes of a given species and this was true for all species we examined. In contrast, some species of female *Culicoides*, which locate their hosts by olfactory stimuli, have four-fold increase in sensilla than do males of the same species (Rowley and Cornford 1972). For example, female *C. nubeculosus* Meigen have 12–17 sensilla per organ compared with 3–7 in males (Messaddeq et al. 1989). Their function in both sexes of Palpomyiini is unknown.

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***ENALLAGMA OPTIMOLOCUS*, A NEW SPECIES OF DAMSELFLY FROM
MONTANA (ODONATA: COENAGRIONIDAE)**

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Abstract.—*Enallagma optimolocus* n. sp. is described and diagnosed from streams in western Montana. Garrison's 1984 key is modified to distinguish this species from the related *E. carunculatum* Morse and *E. civile* (Hagen). The competing aspects of two views of these specimens, i.e. full species or hybrid individuals, is discussed. The occurrence of *E. carunculatum* and *E. anna* Williamson at the collecting sites is noted. The absence of *E. civile* from the areas surrounding the range of *E. optimolocus* is noted, with Roemhild's 1975 (and Garrison's 1984) record of *E. civile* for Flathead Co., Montana, corrected to *E. carunculatum*. Illustrations of diagnostic features for the species are given.

Key Words: damselfly, Montana, taxonomy

The Odonata are perhaps the taxonomically best known Order of North American insects, with virtually all species described, and the vast majority of both sexes and nymphs known (Kosztarab and Schaefer 1990, McCafferty et al. 1990). Indeed, in an analysis of the taxonomic status of the Odonata of North America north of Mexico, McCafferty et al. (1990) suggested that most of what remained to be discovered would be species range extensions along the southern boundaries of the region. The rate of description of new species from North America has slowed to an average of less than one per year, and at that rate, known collected-but-undescribed North American species may run out before the decade is over.

This condition seems directly tied to the fact that the Odonata are second only to the butterflies and a few families of beetles in number of enthusiasts. Checklists and faunistic papers exist for most States and Provinces of the United States and Canada, including Roemhild's (1975) list for Montana damselflies. Still, there are poorly sampled

regions, especially in the central parts of the continent, where much remains to be done to document the fauna. Of the last three dragonflies described from North America (Carle 1992, Dunkle 1992, Vogt and Smith 1993) one came from the north central States, one from the Gulf Coast of Louisiana, and only one from the Texas–Mexico border area.

Montana, with a huge and diverse area of relatively intact ecosystems and a very sparse human population (including entomologists and insect collectors), represents one of the most poorly known parts of the continent. Never-the-less, it was a surprise to discover an undescribed species of *Enallagma* while conducting a survey of the Odonata of Montana.

Many Odonata are quite sensitive to water quality, and are susceptible to many pollutants (Carle 1979). McCafferty et al. (1990) list 30 North American species (of a total 415) as extinct, endangered, vulnerable, or rare. The presence of this new, rare, and possibly localized species in several of the world's most famous fishing waters bes-

needs both a healthy environment and a continuing need to protect those waters and their sources.

The genus *Enallagma* contains approximately 75 species world-wide (Garrison 1984), 36 of those in the United States and Canada (McCafferty 1990, plus a new record of a Mexican species in southern Arizona, Garrison in lit.). Garrison (1984) provided the most recent revision of the species of western North America. The eastern species are covered in regional faunistic treatments by a combination of Walker (1953), Johnson (1972) and Dunkle (1990). The description below follows the format of Garrison (1984).

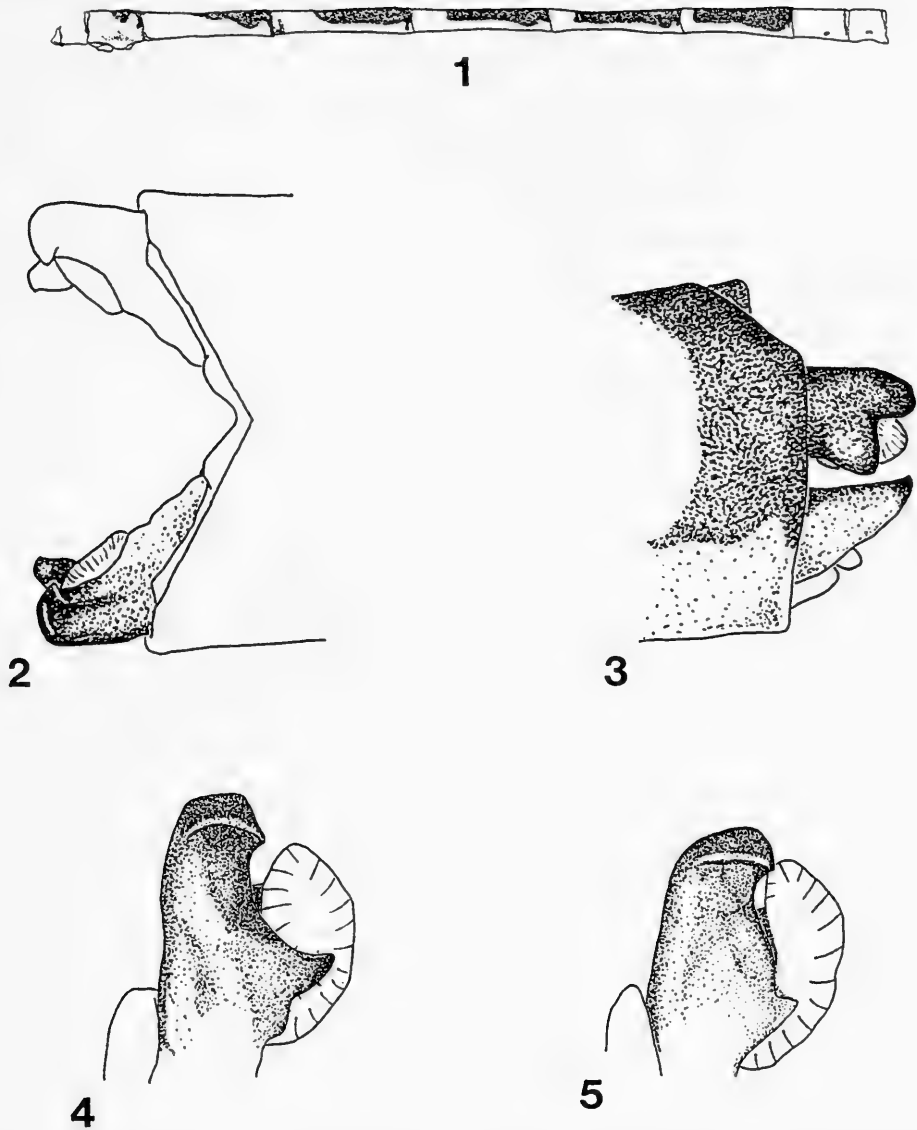
Enallagma optimolocus, NEW SPECIES

Holotype ♂: MONTANA: Flathead County, Whitefish River 4.5 km SW Whitefish, sw $\frac{1}{4}$, sw $\frac{1}{4}$ sec. 9, T. 30 N., R. 21 W., 27 July 1993, Kelly B. Miller leg. [Montana Entomology Collection, Bozeman (MTEC), on permanent loan to the California Academy of Sciences, San Francisco]. Paratypes (16 ♂♂): 8—*ibid.*; 2—*ibid.*, 07 August 1993; 2—*ibid.*, 08 August 1991; 1—*ibid.*, 24 June 1992; 1—MONTANA: Madison County, Madison River; confluence with Cherry Creek, sec. 36, T. 2 S., R. 2 E., 14 July, 1992, Kelly B. Miller leg; 1—MONTANA: Lewis and Clark Co., Beaver Creek, by river, 8/25/1993, D.W. Lundahl colr. [deposited in the MTEC (12) and the collections of K. B. Miller (2), T. Donnelly (1) and R. Garrison (1)]. All specimens were acetone-treated, and prepared in Mylar® envelopes.

Etymology.—From the Latin optimum (best) and locus (place). A shortened form of the unofficial motto of Montana, "The Last Best Place."

MALE. Head—Dorsum black with blue, subtriangular postocular spots between eyes and posterior margin of occiput; hind margin of occiput with mesal thin, blue line; rear of head light blue; face, genae blue; postclypeus black; anteclypeus, labrum and labium blue; antennae black.

Thorax—Pronotum black dorsally with lateral spots and hind margin blue; prothoracic pleura and sternum blue. Pterothorax blue with longitudinal stripes black; mesostigmal plates black mesally, light blue laterally; mid-dorsal carina and antealar crests black; mid-dorsal stripe 1.8× the width of blue antehumeral stripe; average width of humeral stripe about 0.3× the width of mid-dorsal stripe, slightly wider at base (near legs) than at apex (near wings) [one paratype (from Madison Co.) with stripe constricted to a thin line medially]; black spot at upper end of second lateral suture; remainder of thorax blue. Legs—Femur black externally, pale internally; tibia pale posteriorly, black anteriorly; tarsi pale with black apically on each tarsomere or, occasionally entirely dark; claws pale with black at tips; spines black. Wings hyaline, stigma black. Abdomen (Fig. 1).—Segment I blue, occasionally with a small, lateral black spot apically; segment II blue with dorsal black transverse spot in posterior half of segment connected to black posterior annulus; segment III blue with apical 0.50 to 0.70 black dorsally; segment IV blue with apical 0.50 to 0.75 black dorsally; segment V blue with apical 0.50 to 0.75 black dorsally; segment VI blue with apical 0.75 to 0.80 black dorsally; segment VII black dorsally with thin margin of blue proximally; segment VIII and IX entirely blue, except for occasionally a small line of black apically, and sometimes a small, elongate black spot laterally on one or both segments; segment X black dorsally. All segments blue laterally. Terminalia (Figs. 2, 3, 4, 5).—Superior appendages black; inferior appendage pale except dorsally and apically black. In lateral view, superior appendage slightly longer than inferior appendage; pale tubercle visible between upper and lower arms of superior appendage; margin of juncture of arms of superior appendage at about right angle; in dorsal view, pale tubercle visible on interior of superior appendage as longitudinal mass, not visible beyond su-



Figs. 1-5. *Enallagma optimolocus*. 1, Lateral view of abdomen. 2, Male abdominal terminalia, dorsal view. 3, left lateral view. 4-5, Right superior appendage of male genitalia, showing extremes of development of mesally pointed black tooth, lateral oblique view.

perior appendage; mesally pointed, black tooth on lower arm of superior appendage variable, present and prominent in one-third of the types, absent in one-third of the types and intermediate in one-third of the types; inferior appendages evenly curved when viewed laterally.

Length.—30.5–33.2 mm, abdomen, 23.9–27.0 mm, hind wing, 19.0–19.1 mm, hind femur 2.9–3.0 mm.

Female and nymph.—unknown.

DIAGNOSIS

The form of the male genitalia will distinguish this species from its congeners. Females are not known. The color pattern of the abdomen (Fig. 1) of *E. optimolocus* males is similar to that of *E. carunculatum* Morse, but *E. optimolocus* differs from that

species in having the superior appendage extending beyond the pale tubercle (Figs. 2, 3, 4, 5). The terminalia of *E. optimolocus* (Figs. 2, 3, 4, 5) are similar to those of *E. civile* (Hagen), but differ in the form of the superior appendage in lateral view (Fig. 3). The black tooth on the inner margin of the superior appendage is small, and usually surrounded by the pale tubercle (Figs. 4, 5). Lastly, in *E. optimolocus* the abdomen has tergites III, IV, and V with 50% or more black along the dorsum. Geographically, *E. optimolocus* is sympatric and flies together with *E. carunculatum* throughout its known range. *Enallagma civile* is rarely taken in Montana, to date only to the east of *E. optimolocus* localities, with the closest record 45 km distant (K. Miller, unpubl.). Roemhild's (1975) record of *E. civile* from Flathead Co., Montana (repeated on Garrison's (1984) distribution map), is a misidentification of a specimen of *E. carunculatum* [MTEC].

In Garrison's (1984) key *E. optimolocus* keys to couplet 7 where it fits neither choice. The following emendation of couplet 7 is required to accommodate *E. optimolocus* in Garrison's key:

- 7. In dorsal view, pale tubercle visible well beyond the upper arm of superior appendage (Fig. 63b from Garrison 1984) *E. carunculatum* Morse
- 7'. In dorsal view, pale tubercle not visible beyond the upper arm of superior appendage (Figs. 2, 3, 4) 7a
- 7a. Height of upper arm of superior appendage 1/2 to 3/4 total height of superior appendage; dorsal surface of abdominal segments III, IV, and V black in posterior one-quarter; lower arm of superior appendage with a large mesally pointed black tooth (Fig. 64b from Garrison 1984). *E. civile* (Hagen)
- 7a'. Height of upper arm of superior appendage approximately 1/2 total height of superior appendage; dorsal surface of abdominal segments III, IV, and V black in posterior one-half or more; lower arm of superior appendage moderate to obsolete mesally pointed black tooth *E. optimolocus* n. sp.

DISCUSSION

The discovery of these specimens has lead to a lively and very productive discus-

sion among colleagues about the status of these individuals. The debate centers on 2 competing hypotheses: that the specimens represent an undescribed species, and that because they exhibit characteristics somewhat intermediate between *E. carunculatum* and *E. anna* Williamson, both of which occur at all known localities of *E. optimolocus*, they represent a series of hybrids. Another suspected parent, based upon morphology, is *E. civile*, but it is unknown in the areas where *E. optimolocus* has been found (see above). We have come down on the side of those who support the full species status, and provide the following explanation for that viewpoint.

First, if non-overlapping characteristics intermediate between other species was grounds for hybrid status, several other species of *Enallagma* would have to be so considered. Hybridization in damselflies is rare, but has been observed (Williamson 1906, Leong et al. 1992, Garrison pers. com., Donnelly pers. com.). All known cases fit the normal hybridization situation, i.e. either occurring commonly in a narrow hybrid zone between 2 basically allopatric species, or very rarely in situations where sympatric species occur with one parent species very common, and the other extremely rare. This makes good biological sense, since hybridization would be selected against in widely sympatric species, increasing the development of barriers to its occurrence.

Neither of these expected situations fits this case. The locally available candidates for parents, *Enallagma carunculatum* and *E. anna*, are sympatric over most of the western USA (Garrison 1984), including all areas where *E. optimolocus* have been taken. Thousands of specimens of these 2 species have been collected within this area of sympatry, and even if hybrids were very rare, they should have turned up throughout the range. At the Whitefish River site, some 1/3 of male *Enallagma* specimens taken in 1993 were *E. optimolocus*. Of the remaining 2/3, the vast majority were evenly divid-

ed between *E. carunculatum* and *E. anna*. Only 3 damselflies were taken the day the Beaver Creek specimen was collected (D. Lundahl, pers. com.), and only a small number of specimens were taken the day the Madison River specimen was found. Because only the 1993 specimens were recognized in the field, the others represent a relatively random sample mixed in with small samples of common species. Lack of females is explained by the fact that for conservation reasons only male *Enallagma* are taken during normal collecting, as females are basically non-useful for documenting a species' occurrence, and are therefore left to breed. The species has not been seen since the need for females for a type series was recognized.

Another problem with resolving the hybridization hypothesis is the lack of phylogenetic information. Based on arrangement of species in Garrison (1984), it would appear that the 2 possible parents are not closely related within the genus. If this is supported by a cladistic analysis, hybridization would not be expected to occur between such distantly related species.

Lastly, from a conservation biology standpoint, it may be wisest to treat *E. optimolocus* as a full species until the null hypothesis can be tested.

However, the lack of females leaves the situation open to question, although female *Enallagma* are notoriously hard to distinguish (Garrison 1984). Careful biological and genetic investigations are needed as a follow up test of the hypothesis that *E. optimolocus* is indeed a good species.

BIOLOGICAL NOTES

The type locality is a slow, clear stream in a very broad, glacial valley in the Rocky Mountain Trench. The Whitefish River at that point has a silt bottom, with an abundant insect fauna, with at least twelve other Odonata species occurring at this site. Most common were *E. carunculatum*, *E. anna*, *Calopteryx aequibilis* (Say), *Aeshna umbrosa* Walker, *Ophiogomphus severus* Ha-

gen, and *Argia emma* Kennedy. The Madison River locality is at the confluence of a small stream with a broad river in an intermountain valley. The river is a freestone stream below a shallow reservoir, whereas Cherry Creek is silt-bottomed and clear. This area also possesses a very abundant insect fauna for a Montana freestone mountain stream, with six other Odonata known to occur in the immediate area. Most common were *E. carunculatum*, *E. anna*, *Ophiogomphus severus* Hagen, and *Argia emma* Kennedy.

In general, the behavior of this species was observed to be similar to that of *E. carunculatum* at the type locality, flying together with that species through the grasses and sedges emergent at the waters' edge. *Enallagma anna* was also present, but tended to fly over more open water and rest on emergent water buttercup (*Ranunculus aquatilis*). Males flew very low over the stream often landing on grasses or emergent stream vegetation very near the water. They were wary and difficult to capture.

ACKNOWLEDGMENTS

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**A NEW GENUS AND THREE NEW SPECIES OF CHEWING LICE
(PHTHIRAPTERA: PHILOPTERIDAE) FROM PERUVIAN OVENBIRDS
(PASSERIFORMES: FURNARIIDAE)**

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Abstract.—The new genus *Furnariphilus* is described to include three new species from Peruvian hosts within the passerine family Furnariidae, subfamily Furnariinae: *F. pagei*, the type species of the genus, from *Furnarius leucopus* Swainson; *F. griffithsi* from *Sclerurus mexicanus* Sclater; and *F. parkeri* from *Sclerurus caudacutus* (Vieillot).

Key Words: Ectoparasites, Peru, *Furnariphilus*, Furnariinae, Bird

Clayton et al. (1992) published a survey of chewing lice collected in 1985 from a wide array of Peruvian bird taxa. During this project, a number of undescribed louse taxa were collected from hosts in the parvorders Thamnophilida and Furnariida (Passeriformes). These taxa included a new species placed by Price and Clayton (1989) in a new genus of Menoponidae, *Kaysius*, and seven new species described by Price and Clayton (1993, 1994) in the existing philopterid genus *Rallicola* Johnston and Harrison. We have recently examined additional philopterid lice collected during the Peruvian project from members of the Thamnophilida and Furnariida. Lice from three species of ovenbirds (Furnariidae: Furnariinae) represent new species which are also members of an undescribed genus. The purpose of this paper is to name and characterize the new genus and to describe and illustrate the three new species that comprise it.

In the following descriptions, all measurements are in millimeters. Abbreviations for measured structures are explained the

first time they are used. Host classification follows that of Sibley and Monroe (1990). Holotypes of the new species will be deposited in The Field Museum (Chicago) and paratypes, as numbers allow, will be located in the collections of that museum and those of the National Museum of Natural History (Washington, D.C.), Oklahoma State University (Stillwater), and the University of Minnesota (St. Paul).

***Furnariphilus* Price and Clayton,**

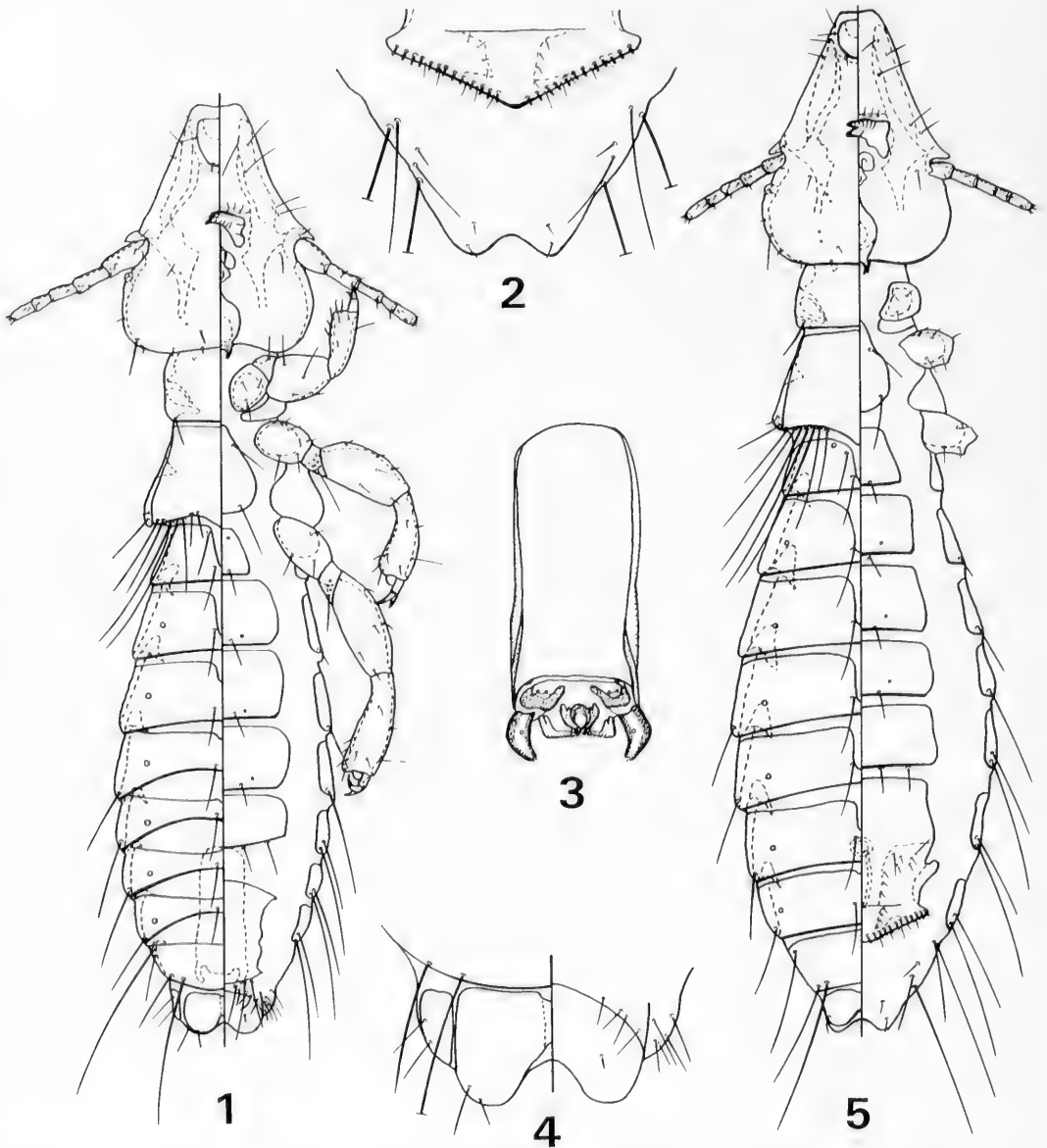
NEW GENUS

Figs. 1-10

Type species: *Furnariphilus pagei* Price and Clayton, new species.

Head (Figs. 1, 5) distinctly longer than wide, with preantennal region tapered to truncate hyaline margin; conus small; with single very short ocular seta; dorsoanterior head plate prominent, distinctly separated from remainder of head; male antenna with enlarged scape.

Prothorax (Figs. 1, 5) quadrangular, with single seta near each lateroposterior corner. Metathorax posteriorly broadened, each

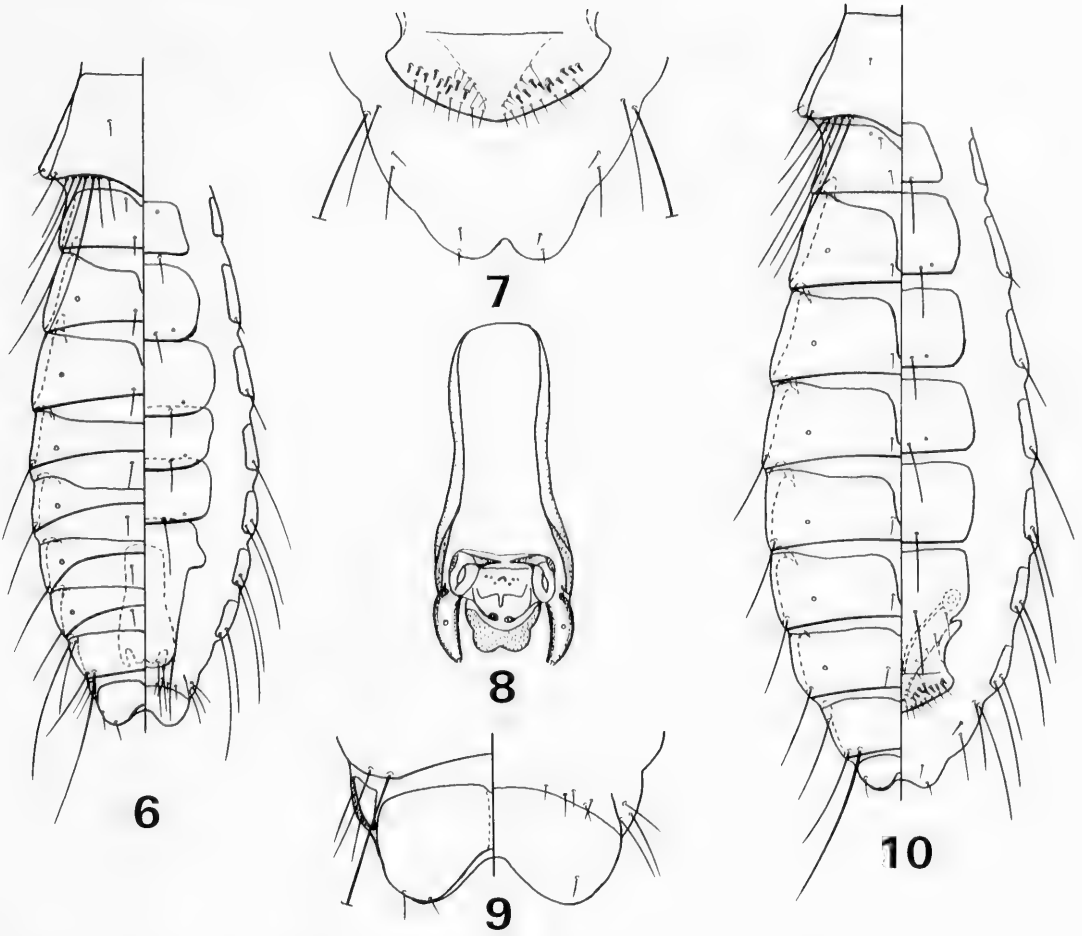


Figs. 1-5. *Furnariphilus pagei*. 1, Male. 2, Female ventral terminalia. 3, Male genitalia. 4, Male terminal segment. 5, Female.

side with row of medium to very long marginal setae; prominent large rounded sternal plate with 4 setae.

Abdomen (Figs. 1, 5, 6, 10) slender, with distinct partial median division of terga II (first apparent tergum)-VII for female, II-IV for male. Male terga V-VIII much shorter than terga II-IV. Terga II with 4 me-

dian setae, III-VIII each with 2, IX without median setae. Only terga V-IX with lateral corner setae. Without pleural seta on II, with single short seta on III, medium seta on IV, long seta on V, and pair of long to very long setae on each of VI-VIII. Sterna II-VI prominent, undivided, each of II-V with medioposterior pair of setae, VI with



Figs. 6–10. *Furnariphilus griffithsi*. 6, Male metanotum and abdomen. 7, Female ventral terminalia. 8, Male genitalia. 9, Male terminal segment. 10, Female metanotum and abdomen.

2 or 4 posterior setae. Subgenital plate of female posteriorly with regular to irregular row of short, stout spiniform setae along with finer setae posterior to them (Figs. 2, 7). Both sexes with prominent tergum IX followed by smaller sclerites associated with distinctly indented posterior margin; male with small accessory sclerite on each side of last tergal portion (Figs. 4, 9).

Male genitalia (Figs. 3, 8) distinctive, with very short, stout widely-separated parameres each bearing median sensillum and terminal minute seta, complex mesomeral structures, and broad relatively short basal apodeme.

Discussion.—This genus is easily rec-

ognized by the combination of head shape, the sexually dimorphic antenna, the large thoracic sternal plate, the anterior abdominal terga partially divided medially, the median indentation of the terminal abdominal segment, the male with a small accessory piece on each side of the last segment, the unique male genitalia with the short broad parameres and complex mesomeral structures, and the female lacking any evidence of a prominent seta-bearing tubercle lateroposterior to the subgenital plate.

Of the philopterid lice associated with birds of these two host parvorders (Table 1), *Rallicola*, the most widely distributed genus with 30 species currently recognized,

Table 1. Classification of the parvorders Thamnophilida and Furnariida with their associated philopterid lice.

Host	Lice (No. of Species)
Parvorder Thamnophilida	
Family Thamnophilidae (typical antbirds)	<i>Formicaphagus</i> (12) <i>Rallicola</i> (1)
Parvorder Furnariida	
Superfamily Furnarioidea	
Family Furnariidae	
Subfamily Furnariinae (ovenbirds)	<i>Rallicola</i> (12) <i>Furnariphilus</i> (3) <i>Picicola</i> (3) <i>Brueelia</i> (2) <i>Rallicola</i> (16)
Subfamily Dendrocolaptinae (woodcreepers)	
Superfamily Formicarioidea	
Family Formicariidae (ground antbirds)	<i>Formicaphagus</i> (3) <i>Formicaricola</i> (8)
Family Conopophagidae (gnateaters)	<i>Formicaphagus</i> sp.
Family Rhinocryptidae (tapaculos)	<i>Rallicola</i> (1)

shows certain affinities with the new genus described here. However, *Rallicola* females are characterized by the prominent seta-bearing tubercle posterior to each side of the subgenital plate, the males have genitalia with long slender parameres and relatively simple mesomer structures, and both sexes lack the marked medial indentation of the terminal abdominal portion. Additional lesser differences further support the distinction between these two genera. The only other known philopterids from hosts within the superfamily Furnarioidea are three species of *Picicola* Clay and Meinertzhagen and two species of *Brueelia* Keler (Table 1), all of which are quite different from *Furnariphilus* in gross head shape, genitalic features of both sexes, and other differences associated with structure and chaetotaxy.

Two other philopterid genera, *Formicaricola* Carriker and *Formicaphagus* Carriker, are found on hosts within the superfamily Formicarioidea and the parvorder Thamnophilida (Table 1). The former currently has eight recognized species and is restricted to hosts in the family Formicariidae, with seven known only from the genus *Formicarius*. These lice are also of the *Rallicola*-type, but lack the prominent seta-bearing

tubercles posterior to the female subgenital plate. However, they differ from *Furnariphilus* in having both sexes with a distinct complete median division of abdominal terga II–VIII and without dimorphic antennae; the males with genitalia of a grossly different type having ovoid parameres, and with a rounded posterior abdomen; and the females lacking a delineated terminal portion posterior to IX. The 15 recognized species of *Formicaphagus* are in both parvorders, with two additional unnamed series in our collection from the Conopophagidae (Table 1); these lice differ from *Furnariphilus* in having characteristic male genitalia similar to those of *Formicaricola* and both sexes with a distinctly broader head and abdomen, in addition to other differences.

***Furnariphilus pagei* Price and Clayton,
NEW SPECIES**

Figs. 1–5

Type host.—*Furnarius leucopus* Swainson.

Male.—As in Fig. 1. Preantennal head width (PAW), 0.30–0.33; temple width (TW), 0.38–0.39; head length (HL), 0.48–0.50. Prothorax width (PW), 0.26–0.28. Metanotum with 6–8 (usually 7) medium to

long setae posteriorly on each side; metathorax width (MW), 0.36–0.38. Abdominal terga with medium setae medially; sternal setae shorter, with 4 on sternum VI. Abdomen width at V (AWV), 0.42–0.45. Lateroposterior corner of IX with 2 medium to very long setae on each side. Terminal portion with proportionately large accessory piece on each side (Fig. 4). Genitalia (Fig. 3) with slightly curved parameres and complex of mesomer structures as shown; genitalia width (GW), 0.10–0.11; genitalia length (GL), 0.23–0.25; genitalic paramere length (GPL), 0.04–0.05. Total body length (TL), 1.80–1.87.

Female.—As in Fig. 5. Head (except for smaller antennal scape), thorax, and much of abdomen as for male. PAW, 0.34–0.36; TW, 0.41–0.43; HL, 0.53–0.55. PW, 0.29–0.31; MW, 0.41–0.44. Differences from male associated primarily with posterior abdominal segments. With medium and very long lateroposterior ventral setae on each side of IX; AWV, 0.54–0.59. Subgenital plate (Fig. 2) posteriorly bearing submarginal row of 10–13 short spiniform setae on each side as well as total of 9–12 fine setae posterior to them; subgenital plate width (SPW), 0.29–0.31. TL, 2.14–2.27.

Discussion.—This species is readily distinguished from others of the genus by having the male terminalia as in Fig. 4, the male genitalia with features as in Fig. 3, the female with two medium to very long setae on each ventral lateroposterior corner of IX, the configuration of the setae of the female subgenital plate much as in Fig. 2, and the abdomen of both sexes with generally longer median tergal and shorter sternal setae.

Material examined.—Holotype male, ex *F. leucopus*, Peru: Dept. Cuzco: 20 km NW Pilcopata near Rio Tono, 750 m, 25.xi.1985, D. H. Clayton #1157. Paratypes: 17 males, 15 females, same data as holotype.

Etymology.—This species is named for Roderic D. M. Page, University of Oxford, in recognition of his deep interest in and

contributions to the study of host-parasite cospeciation.

***Furnariphilus griffithsi* Price and Clayton, NEW SPECIES**

Figs. 6–10

Type host.—*Sclerurus mexicanus* Sclater.

Male.—Head and thorax much as for *F. pagei* (Fig. 1). PAW, 0.33; TW, 0.40–0.41; HL, 0.52–0.54. PW, 0.27–0.29; metanotum medially with short pair of setae (Fig. 6) and with 7–8 (usually 8) medium to very long posterior marginal setae on each side; MW, 0.40. Abdomen as in Fig. 6. With short median tergal setae; sternum VI with only single seta on each side. AWV, 0.46–0.49. Terminal segment with short accessory piece on each side (Fig. 9). Genitalia (Fig. 8) with mesomer posterior boundary bilobed and extending near end of parameres; remainder of mesomer structures as shown; GW, 0.10–0.11; GL, 0.23–0.24; GPL, 0.05. TL, 1.99–2.10.

Female.—Head and thorax much as for *F. pagei* (Fig. 5). PAW, 0.35–0.38; TW, 0.44–0.47; HL, 0.55–0.59. PW, 0.29–0.31; metanotum medially with pair of minute setae (Fig. 10) and marginally each side with 5–7 (usually 6) medium to very long setae; MW, 0.42–0.49. Abdomen as in Fig. 10. With only short medial setae on terga II–VIII; sternal setae on II–VI longer, with those on III–IV 0.06–0.09 long and extending well over following sternum. AWV, 0.56–0.66. Lateroposterior corner of IX each with only single medium ventral seta. Subgenital plate (Fig. 7) with highly irregular row of 7–12 short submarginal spiniform setae on each side, along with total of 14–17 fine setae posterior to them; SPW, 0.28–0.30. TL, 2.38–2.59.

Discussion.—This species is readily separated from *F. pagei* by the male with different genitalic parameral and mesomer structures and the smaller accessory lateral portion of the terminal abdominal segment; the female with an irregular alignment of the submarginal short spiniform setae on the subgenital plate, only a single medium

ventral seta on each side of abdominal segment IX, and longer sternal setae on II–VI; and both sexes with a pair of median metanotal setae and markedly shorter median abdominal tergal setae.

Material examined.—Holotype male, ex *S. mexicanus*, Peru: Dept. Madre de Dios: Cerro de Pantiacolla, 20.viii.1985, D. H. Clayton. Paratypes: 2 males, 3 females, same data as holotype.

Etymology.—This species is named for Richard Griffiths, University of Oxford, in recognition of his work on the molecular phylogenetics of lice and their hosts.

***Furnariphilus parkeri* Price and Clayton, NEW SPECIES**

Type host.—*Sclerurus caudacutus* (Vieillot).

Male.—Much as for *F. griffithsi*, except for consistently smaller body dimensions. PAW, 0.29; TW, 0.36; HL, 0.49. PW, 0.25; MW, 0.36. AWV, 0.41. TL, 1.90.

Female.—Much as for *F. griffithsi*, except for consistently smaller body dimensions and shorter setae on sterna III–IV. PAW, 0.33; TW, 0.41–0.42; HL, 0.53–0.54. PW, 0.27–0.28; MW, 0.40–0.41. Sterna III–IV with each seta only 0.03–0.04 long, at most extending only slightly over following sternal plate. AWV, 0.50–0.52. SPW, 0.24–0.25. TL, 2.28–2.31.

Discussion.—The non-overlapping dimensional differences between the smaller *F. parkeri* and the larger *F. griffithsi*, coupled with the shorter sternal setae on III–IV for females of the former, enable ready separation of these two species. Admittedly, these differences are not as profound as we would prefer, indicating that these series from two different host taxa within the same genus are indeed closely related, but

we believe them sufficient to justify recognition of two distinct species.

Material examined.—Holotype female, ex *S. caudacutus*, Peru: Dept. Madre de Dios: Cerro de Pantiacolla, 1030 m, above Rio Palotoa, 31.viii.1985, D. H. Clayton. Paratypes: 1 male, 1 female, same data as holotype.

Etymology.—This species is named in honor of Theodore (Ted) Parker, the world's most gifted field ornithologist, tragically killed during a 1993 field trip in Ecuador.

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**NOMENCLATURAL CHANGES IN THE PENTATOMIDAE
(HEMIPTERA-HETEROPTERA)**

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Abstract.—Numerous nomenclatural problems in the Pentatomidae (Heteroptera) are discussed and corrected. These corrections have necessitated one generic replacement name, *Keleacoris* for *Kelea* Schouteden, 1958, and seven specific replacement names: *Aelia chinensis* for *A. bifida* Hsiao and Cheng, 1978; *Aeliomorpha viridescens* for *A. viridis* Azim and Shafee, 1987; *Antestia dollingi* for *A. adspersa* (Fabricius, 1803); *Dicthyotus walkeri* for *D. aequalis* (Walker, 1867); *Holcostethus mcdonaldi* for *H. piceus* (Dallas, 1851); *Menida signoreti* for *M. parvula* (Signoret, 1858); and *Sciocoris sahelensis* for *S. australis* Linnavuori, 1975. Ten new combinations are also recognized: *Basicryptus costalis ugandana* (Linnavuori, 1982), *B. striatus* (Linnavuori, 1982), *B. upembanus* (Linnavuori, 1982), *Dalsira dallasi* (Schouteden, 1912), *D. kocki* (Schouteden, 1962), *D. maboekana* (Linnavuori, 1982), *D. mulungwana* (Linnavuori, 1982), *D. niemboana* (Linnavuori, 1982), *Keleacoris congolensis* (Distant, 1910), and *Stalius castaneus* (Distant, 1893). One new generic synonym is proposed: *Paplesia* China, 1962 as a junior synonym of *Trincavellius* Distant, 1900b.

Key Words: Pentatomidae, Heteroptera, nomenclature, systematics

While preparing a catalog of the Pentatomidae of the world, we have discovered a number of nomenclatural problems that need to be corrected. We wish to keep the number of taxonomic changes in the catalog to a minimum, so these corrections are made herein, prior to the publication of the catalog.

I. ASOPINAE

Oplomus festivus Dallas, 1851

Pentatoma marginalis Westwood, 1837: 37.

[not Herrich-Schäffer, 1836, *Roferta*, (Pentatominae)]

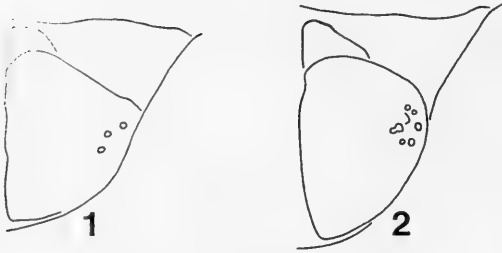
Oplomus marginalis: Dallas, 1851: 83;

Thomas, 1992: 54, 60-61.

Oplomus rutilus Dallas, 1851: 83-84.

Oplomus festivus Dallas, 1851: 85.

Herrich-Schäffer's *Pentatoma marginale* predates Westwood's usage of the binomen by a year. *Pentatoma marginale* Herrich-Schäffer has at one time or another been placed in the following genera: *Rhaphigaster* Laporte, *Strachia* Hahn, *Nezara* Amyot and Serville, and *Acrosternum* Fieber, and is currently a valid species in the genus *Roferta* Rolston. See Rolston and McDonald (1981) for the complete synonymy of *Roferta marginalis*. Nine different junior synonyms of *P. marginale* Westwood are available, the oldest being *Oplomus rutilus* Dallas, 1851: 83-84, and *O. festivus* Dallas, 1851: 85. There has been some confusion surrounding the name *rutilus*; the main source of which stems from the female type specimen. The type specimen of *festivus* is



Figs. 1–2. Right genital plates, caudo-ventro-lateral view. 1, *Stalius castaneus* (Distant). 2, *Stalius tartareus* (Stål).

a male, and there has been no problems associated with the identity of this taxon. Therefore, we select *Oplomus festivus* Dallas, 1851, as the replacement name for *Pentatoma marginale* Westwood, 1837.

II. DISCOCEPHALINAE: OCHLERINI

Stalius castaneus (Distant, 1893),
NEW COMBINATION

Melanodermus castaneus Distant, 1893: 455.

This species was omitted from the junior author's (Rolston 1992) revision of Ochlerini. The species is known only from the female holotype, which was collected in Nicaragua. It is morphologically similar to *Stalius tartareus* (Stål) excepting the form of the basal plates, and these differ considerably (Figs. 1–2).

III. PENTATOMINAE

Aelia chinensis, NEW NAME

Aelia bifida Hsiao and Cheng, 1978: 326, 327, 328, figs. 4, 5, 10, 13. [not Costa, 1847, *Neottiglossa*]

Costa (1847) described, as *Aelia bifida*, a relatively common circum-Mediterranean species now in the genus *Neottiglossa* Kirby. The primary homonymy resulting from Hsiao and Cheng's (1978) description of *Aelia bifida* as a new species necessitates the above replacement name. *Aelia chinensis* occurs in China and Inner Mongolia.

Aeliomorpha viridescens, NEW NAME

Aeliomorpha (*Distantiella*) *viridis* Azim and Shafee, 1987: 422–424, figs. E–H. [not Reuter, 1887, *Aeliomorpha*]

Reuter (1887) described *Aeliomorpha viridis* from Madagascar. Although Azim and Shafee (1987) placed their Indian *A. viridis* in a different subgenus, it is still a primary homonym and requires a replacement name.

Amyntor unicolor (Walker, 1867),
REVISED STATUS

Halys (*Dichelops*) *obscura* Dallas, 1849: 188, pl. 19 fig. 3. [not Westwood, 1837, *Sarju*; not Herrich-Schäffer, 1839, *Brochymena parva*]

Amyntor obscurus: Stål, 1867: 519; Stål, 1876: 107; Atkinson, 1888b: 154; Lethierry and Severin, 1893: 183; Distant, 1902: 144–145, fig. 85; Kirkaldy, 1909: 147; Zhang, 1985: 80–81, pl. 42 fig. 122; Hua, 1989: 43.

Bolaca unicolor Walker, 1867: 251; Atkinson, 1888a: 70; Lethierry and Severin, 1893: 161.

Amyntor unicolor: Distant, 1900a: 425, 431.

The binomen, *Halys obscura*, has been used on at least three separate occasions to represent three different species. Westwood (1837) first used the name for a species now contained in the halyine genus *Sarju*. The second species, described by Herrich-Schäffer (1839), now belongs in the halyine genus *Brochymena*, and was given the new name *B. parva* by Ruckes (1947). Finally, Dallas (1849) used *Halys obscura* to represent a species now residing in the genus *Amyntor*. The next available name is *unicolor* Walker, 1867; the proper combination, *Amyntor unicolor*, has been used only once (Distant 1900a).

Antestia dollingi, NEW NAME

Cimex adpersus Fabricius, 1803: 175. [not Thunberg, 1784: 53, Coreidae]
Antestia adpersa: Stål, 1868: 34.

Thunberg's (1784) usage of the binomen *Cimex adpersus* easily predates Fabricius' (1803) usage. *Cimex adpersus* Thunberg is probably a member of the family Coreidae. There are no currently known junior synonyms of *Cimex adpersus* Fabricius, 1803.

***Berecynthus hastator* (Fabricius, 1798),
REVISED STATUS**

Cimex delirator Fabricius, 1794: 103. [not Fabricius, 1787, Coreidae]

Cimex hastator Fabricius, 1798: 532.

Berecynthus delirator: Stål, 1868: 26.

Fabricius described two different species under the binomen *Cimex delirator*. The first (1787) is a member of the family Coreidae and a junior synonym of *Zicca nigropunctata* (DeGeer); the second (1794) is a neotropical pentatomid. The next available name for this neotropical pentatomid is *Cimex hastator* Fabricius, 1798.

Cosmopepla lintneriana Kirkaldy, 1909

Cimex carnifex Fabricius, 1798: 535; Coquebert, 1801: 81; Fabricius, 1803: 117. [not Fabricius, 1775, Lygaeidae]

Pentatoma bimaculata Thomas, 1865: 455. [not Montrouzier, 1855: 98, *Hyrmine*]

Cosmopepla lintneriana Kirkaldy, 1909: 80 [New name for *Pentatoma bimaculata* Thomas, 1865]; McDonald, 1986: 4, 5, figs. 15–27.

Cosmopepla bimaculata: Van Duzee, 1917: 49; Stoner, 1920: 96–97; Blatchley, 1926: 152–153; Leonard, 1928: 82; McDonald, 1966: 25, 51; McPherson, 1982: 73–74; Froeschner, 1988: 574.

Kirkaldy (1909) considered the name *Pentatoma bimaculata* Thomas, 1865, to be preoccupied, but did not indicate the older synonym. He proposed the new name *Cosmopepla lintneriana*. No one followed Kirkaldy's recommendation except McDonald (1986) who indicated that *P. bimaculata* Thomas, 1865, was preoccupied by *P. bimaculata* Westwood, 1837: 8, 35. Froeschner (1988) argued correctly that *P. bimaculata* Westwood, 1837, was in fact a *no-*

men nudum. However, Montrouzier (1855) (see *Hyrmine sexpunctata bimaculata*, below) also described a *P. bimaculata*, predating Thomas' description by ten years. The next available name for *Cimex carnifex* Fabricius, 1798, is *Cosmopepla lintneriana* as was proposed by Kirkaldy (1909).

***Dictyotus walkeri*, NEW NAME**

Pentatoma aequalis Walker, 1867: 310–311. [not Say, 1831, *Hymenarcys aequalis*]

Dictyotus aequalis: Distant, 1900a: 388.

Say (1831) described as *Pentatoma aequalis* a North American species currently in the genus *Hymenarcys* Amyot and Serville. Later, Walker (1867) also described as *P. aequalis* an Australian species now placed in the genus *Dictyotus* Dallas. There is no recognized junior synonym of Walker's binomen to serve as the valid name. We therefore propose *Dictyotus walkeri*, new name, for *Pentatoma aequalis* Walker.

***Halyomorpha hasani*, NEW NAME**

Halyomorpha punctata Hasan, 1993: 210, 214–215, figs. 5A–H. [not Cachan, 1952, *Halyomorpha*]

Cachan (1952) described as *Halyomorpha punctata* a Madagascan species which is still regarded as a valid species in *Halyomorpha* Mayr. Hasan (1993) apparently overlooked this earlier description in describing his new species, *Halyomorpha punctata*; thus necessitating the above new name.

Holcostethus Fieber, 1860

Holcostethus Fieber, 1860: 79 [nomen nudum]; Fieber, 1861: 333.

Peribalus Mulsant and Rey, 1866: 237, 262.

Dryocoris Mulsant and Rey, 1866: 237, 267.

Ribes and Schmitz (1992) recently divided the well-known genus *Holcostethus* Fieber into two genera, based primarily on the

length and shape of the juga. Those species in which the juga do not meet in front of the tylus were retained in *Holcostethus*, while the remaining species were placed in *Dryocoris* Mulsant and Rey. Not only is the use of the generic name *Dryocoris* in error, but we also believe there is little merit in splitting the genus based upon the form of the juga.

Dryocoris was first proposed by Amyot (1845) in his monomial system to represent the single species, *Cimex sphaelatus* Fabricius, 1794. Ribes and Schmitz (1992) were mistaken in their claim that Amyot (1845) initially included three species in *Dryocoris*. Included within the synonymy of *Dryocoris* were *sphaelatus* Fabricius, 1794; *vernalis* Wolff?, 1804; and *baccarum* Amyot and Serville, 1843. Amyot (1845) tentatively (note question mark) placed *vernalis* as a junior synonym of *sphaelatus*, and *baccarum* Amyot and Serville is not an original description. The inclusion of *baccarum* Amyot and Serville indicates that Amyot believed Amyot and Serville had misidentified the true *baccarum* Linnaeus, 1758 (a member of the genus *Dolycoris*). One problem lies in the fact that apparently Amyot (1845) based his *Dryocoris* on a misidentified type species. He states that *Dryocoris* is similar to *Pentatoma* Olivier, except that the head is larger and more rounded, and the lateral lobes meet beyond the median lobe. The true *sphaelatus* has the jugal lobes shorter, not meeting beyond the tylus. At any rate, this initial use of *Dryocoris* is invalid because the entire work (Amyot 1845) has been officially placed upon the list of rejected works because it is largely monomial.

The first valid use of *Dryocoris* in a binomial is generally credited to Mulsant and Rey (1866), who used the name in place of *Holcostethus* Fieber, 1861, apparently recognizing Amyot's prior use of *Dryocoris*. Mulsant and Rey (1866) followed Amyot (1845) in including only one species within *Dryocoris*, that being *Cimex sphaelatus* Fabricius, 1794. *Dryocoris* should be cred-

ited to Mulsant and Rey, 1866, with *Cimex sphaelatus* Fabricius, 1794, the type species by monotypy.

Holcostethus was first described by Fieber in 1860 when it was included in a key to genera; no species were included, however, so this use is a *nomen nudum*. He re-described *Holcostethus* in 1861, and included three species: *jani* Fieber, *sphaelatus* (Fabricius), and *congenor* Fieber. Although he (1861) did not designate a type species for *Holcostethus*, Mulsant and Rey (1866) effectively fixed the type for both *Dryocoris* and *Holcostethus* when they treated the two names as synonyms, and included only *sphaelatus* within *Dryocoris*. Most recent workers have considered *sphaelatus* as the type species of *Holcostethus* (Kirkaldy 1909, McDonald 1974, Froeschner, 1988). *Dryocoris* is a junior synonym of *Holcostethus*.

Mulsant and Rey (1866) also described *Peribalus*, placing in it three species: *Cimex vernalis* Wolff, *Cimex distinctus* Fieber, and *Pentatoma inclusus* Dohrn. Stål (1872a) considered *Dryocoris* to be a junior synonym of *Peribalus*. This has led most recent workers to consider both *Dryocoris* and *Peribalus* as junior synonyms of *Holcostethus*. Kirkaldy (1909) fixed *vernalis* as the type species of *Peribalus*.

If *Holcostethus* is divided into two genera, based on the form of the juga, *Peribalus* should be used for those species in which the juga are contiguous anterior to the tylus. We believe, however, that the generic separation based upon this character is unwarranted. The form of the juga in some species is quite variable with different individuals exhibiting either character state. *Holcostethus* should remain as the valid name for the genus with *Dryocoris* and *Peribalus* as junior synonyms.

Holcostethus macdonaldi, NEW NAME

Pentatoma picea Dallas, 1851: 236. [not Palisot de Beauvois, 1817, *Antiteuchus*, (Discocephalinae)]
Peribalus piceus: Uhler, 1886: 7; Gillette

and Baker, 1895: 16; Van Duzee, 1904: 34; Van Duzee, 1917: 33; Blatchley, 1926: 106.

Holcostethus piceus: Kirkaldy, 1909: 48; McDonald, 1974: 247, 252, figs. 36–43; McDonald, 1982: 5; McPherson, 1982: 48, 50; Froeschner, 1988: 581–582.

Pentatoma picea Palisot de Beauvois, 1817, easily predates Dallas's usage of the name. Palisot de Beauvois's species is a valid species in the discocephaline genus *Antiteuchus* Dallas. There is no available junior synonym for *P. picea* Dallas, 1851; therefore, we propose *Holcostethus macdonaldi*, new name.

Hyrmine sexpunctata bimaculata
(Montrouzier, 1855)

Pentatoma bimaculatum Montrouzier, 1855: 98.

Hyrmine 6-punctata var. *montrouzierana* Kirkaldy, 1909: 115. [Unnecessary new name for *Pentatoma bimaculatum* Montrouzier, 1855]

Kirkaldy (1909) apparently believed *Pentatoma bimaculatum* Montrouzier, 1855 to be preoccupied by *P. bimaculata* Westwood (1837). As Froeschner (1988) argued, *P. bimaculata* Westwood, 1837, is a *nomen nudum* appearing in a list on page 8, and a simple note that it should be deleted as a variety of *P. obscurus* [the preceding species] on page 35.

***Keleacoris*, NEW NAME**

Kelea Schouteden, 1958: 128–130; Linnavuori, 1982: 153. [not Merrem, 1818, Aves]

Schouteden's (1958) usage of the generic name *Kelea* is preoccupied by the Avian genus *Kelea* Merrem, 1818. There is no available junior synonym, therefore we propose *Keleacoris*, new name. *Keleacoris* is currently monotypic, containing only *K. congolensis* (Distant, 1910), new combination.

***Menida signoreti*, NEW NAME**

Rhaphigaster parvulus Signoret, 1858: 289. [not Dallas, 1851, *Acrosternum*]

Antestia parvula: Stål, 1865: 211; Walker, 1867: 281.

Menida parvula: Stål, 1876: 99; Lethierry and Severin, 1893: 174; Kirkaldy, 1909: 133; Linnavuori, 1982: 158, 160, figs. 258e, f, 261c; Linnavuori, 1986: 131, 135, figs. 5a, 12c–f, 13a–f.

Eurymenida parvula: Ahmad and Mohamad, 1982: 12.

Dallas (1851) described *Rhaphigaster parvulus*, which now belongs in the genus *Acrosternum*. Thomas and Yonke (1990) speculated that it may actually be a synonym of the African species, *A. heegeri* Fieber. Because there are no available junior synonyms for *R. parvulus* Signoret, 1858, we propose *Menida signoreti* as a replacement name. *Menida signoreti* is distributed in the tropical areas of west Africa (Cameroon, Guinea, Liberia, Ivory Coast, Nigeria).

***Neococalus germari*, NEW NAME**

Cimex leucogrammus Germar, 1838: 179–180. [not Gmelin, 1790: 2131, *Ancyrosoma* (Podopinae); not Gmelin, 1790: 2165, Miridae]

Sciocoris leucogrammus: Herrich-Schäffer, 1844: 788–89, fig. 756; Dallas, 1851: 134; Walker, 1867: 174.

Cocalus leucogrammus: Stål, 1861: 200; Stål, 1865: 119–120; Stål, 1876: 54; Reuter, 1884: 6; Lethierry & Severin, 1893: 11; Distant, 1898: 316; Distant, 1901: 25; Schouteden, 1910: 80, Schouteden, 1912: 107; Villiers, 1952: 303, Villiers, 1954: 916.

Neococalus leucogrammus: Linnavuori, 1975: 31, 32, figs. 14c, 17bd; Linnavuori, 1982: 75, figs. 85b, 86d.

Gmelin (1790) actually used the binomen *Cimex leucogrammus* twice in his 13th edition of *Systema Naturae*. First, he proposed *Cimex leucogrammes* as a replacement

name for *Cimex albolineatus* Fabricius, 1781, which was preoccupied by *Cimex albolineatus* Goeze, 1778. Goeze's taxon is now a species in the Miridae; Fabricius' and Gmelin's taxon is a member of the popopine genus *Ancyrosoma* Amyot & Serville. Second, he used *Cimex leucogrammus* as the name for a new species of Miridae. Germar (1838) was apparently unaware of Gmelin's earlier uses of this binomen.

Distant (1898) placed *Sciocoris clausus* Walker, 1867, in the synonymy of *Neococalus leucogrammus*. All modern workers, however, have considered *N. clausus* and *N. leucogrammus* as distinct species (Leston 1952, 1953, Schouteden 1957, 1963, Linnavuori 1975, 1982). There are no other known junior synonyms of *N. leucogrammus*, thus necessitating the above new name.

***Piezodorus flavulus* (Stål, 1853),
REVISED STATUS**

Cimex pallescens Germar, 1838: 175. [not Gmelin, 1790, Miridae; not Donovan, 1794, Miridae]

Rhaphigaster pallescens: Herrich-Schäffer, 1845: 7, 11–12; Walker, 1867: 363.

Rhaphigaster flavulus Stål, 1853: 221.

Nezara (*Piezodorus*) *pallescens*: Stål, 1865: 198.

Piezodorus pallescens: Stål, 1876: 100; Lethierry and Severin, 1893: 176; Kirkaldy, 1909: 136; Linnavuori, 1975: 123; Linnavuori, 1982: 147–148, figs. 235c, 236b, 237a.

The binomen *Cimex pallescens* has been used at least three separate times for the descriptions of three different heteropteran species. The first two (Gmelin 1790, Donovan 1794) are both members of the family Miridae, and both predate Germar's (1838) usage of the binomen for a pentatomid now placed in the genus *Piezodorus* Fieber. The next available synonym is *Rhaphigaster flavulus* Stål, 1853.

***Sciocoris sahelensis*, NEW NAME**

Sciocoris australis Linnavuori, 1975: 26–27, figs. 12a, b; Linnavuori, 1982: 65, 66, figs. a, b. [not Dallas, 1852, *Eribotes*]

Linnavuori (1975) apparently overlooked Dallas's (1852) original usage of the binomen *Sciocoris australis* when he described a new species by that name from Sudan. Dallas's species, described from Australia, now resides in the genus *Eribotes* Stål. There are no known junior synonyms of Linnavuori's species; therefore, we propose *Sciocoris sahelensis* as a replacement name.

***Thyanta humilis* Bergroth, 1891**

Pentatoma patruelis Stål, 1859: 226–227; Walker, 1867: 289. [not Stål, 1853, *Eudryadocoris goniodes*]

Thyanta patruelis: Stål, 1862: 58; Stål, 1872b: 35; Lethierry and Severin, 1893: 148; Kirkaldy, 1909: 95.

Thyanta humilis Bergroth, 1891: 225–226. *Thyanta* (*Argosoma*) *patruelis*: Rider and Chapin, 1991: 5, 6, 37–39, figs. 184–198.

Stål (1853) described *Pentatoma patruelis*, which is now a junior synonym of the African *Eudryadocoris goniodes* Dallas. He (1859) later described as *P. patruelis* a South American species that is now placed in the genus *Thyanta* Stål. The next available name is *Thyanta humilis* Bergroth, 1891.

***Trincavellius* Distant, 1900**

Trincavellius Distant, 1900b: 163.

Paposia China, 1962: 57–59. New synonymy.

Examination of Distant's (1900b) and China's (1962) descriptions, and included illustrations, leaves little doubt that *Trincavellius* Distant and *Paposia* China are synonyms. Although two of the three taxa belonging in *Trincavellius* were originally described in *Sciocoris* Fallén, this genus has generally been included within the nominate tribe of the Discocephalinae, rather than the pentatomine tribe Sciocorini. This

is probably because of the rather convex abdominal venter that differs from most sciocorines. Other characters (shape of head, explanate anterolateral pronotal margins), however, are characteristic of the Sciocorini. Additionally, most typical discocephaline characters are lacking. *Trincavellius* should, at least tentatively, be placed within the Sciocorini.

At present, three specific taxa belong in *Trincavellius*, all of which are probably conspecific. We have examined a number of specimens from various locations in Chile and Peru, as well as a male syntype of *Sciocoris kingi* Reed. All specimens examined are conspecific and differ in no appreciable manner from any of the species descriptions given by Butler, 1877 (*galapagoënsis*), Reed, 1898 (*kingi*), or China, 1962 (*ruckesi*). Any synonymization of specific names, however, should wait until appropriate type material can be examined.

IV. PHYLLOCEPHALINAE

Basicryptus Herrich-Schäffer, 1844 and
Dalsira Amyot and Serville, 1843

Dalsira Amyot and Serville, 1843, originally contained two species, both new and both eligible as type species: *marginata* and *affinis*. Stål (1876) left only one of these two species in *Dalsira* by transferring *marginata* to *Basicryptus* Herrich-Schäffer, 1844 (type species *Cimex costalis* Germar, 1838, by monotypy). Kirkaldy (1909) created lasting confusion by selecting *marginata* as the type species of *Dalsira* and creating a new generic name, *Metonymia* (type species *Dalsira affinis* Amyot and Serville, 1843, by original designation), overlooking the fact that Distant (1902) had earlier fixed *affinis* as the type species of *Dalsira*. The effect of Kirkaldy's invalid action was to replace the name *Basicryptus* with *Dalsira*, and to apply the name *Metonymia* to those species previously placed in *Dalsira*. However, since both *Metonymia* and *Dalsira* have the same type species, *Metonymia* is an objective junior synonym of *Dalsira*,

while *Dalsira* as erroneously used by Kirkaldy is synonymous with *Basicryptus*.

The genera *Basicryptus* and *Dalsira* need revising, and the two lists that follow are based on literature.

These species and subspecies appear to belong in *Basicryptus*:

1. *albidicosta* (Walker, 1868)
2. *angulatus* Schouteden, 1909
3. *antennatus* Distant, 1892
4. *atricostata* (Distant, 1910)
5. *bohndorffi* Distant, 1890
6. *brunneus* Jensen-Haarup, 1931
7. *costalis* (Germar, 1838) [type sp.]
8. *costalis ugandana* (Linnavuori, 1982), new combination
9. *distinctus* (Signoret, 1851)
10. *eburnea* Jeannel, 1913
11. *elongata* Distant, 1892
12. *frenchi* Bergroth, 1895
13. *gibbosa* (Dallas, 1851)
14. *hutereaui* Schouteden, 1916
15. *irroratus* (Westwood, 1837)
16. *maindroni* Jeannel, 1913
17. *marginatus* (Amyot and Serville, 1843)
18. *masaicus* Jeannel, 1913
19. *nigrocinctus* Jeannel, 1913
20. *nigromaculatus* Schouteden, 1904
21. *pictus* Schouteden, 1916
22. *plicatus* (Reiche and Fairmaire, 1847)
23. *projectus* Distant, 1898
24. *rugicollis* (Westwood, 1837)
25. *rugosus* (Fabricius, 1803)
26. *striatus* (Linnavuori, 1982), new combination
27. *strigosa* (Burmeister, 1835)
28. *subtruncatus* (Walker, 1868)
29. *upembanus* (Linnavuori, 1982), new combination

These species appear to belong in *Dalsira*:

1. *affinis* Amyot and Serville, 1843 [type sp.]
2. *alata* (Distant, 1898)
3. *angolana* (Schouteden, 1962)
4. *asperata* Distant, 1889
5. *atricostata* Distant, 1910
6. *bigemmis* Bergroth, 1891

7. *brunni* Schouteden, 1904
8. *crassa* Distant, 1898
9. *dallasi* (Schouteden, 1912), new combination
10. *humeralis* (Walker, 1868)
11. *icterica* (Gerstäcker, 1892)
12. *kocki* (Schouteden, 1962), new combination
13. *lentiginosa* (Stål, 1852)
14. *longiceps* (Schouteden, 1910)
15. *mabokeana* (Linnavuori, 1982), new combination
16. *maura* Distant, 1898
17. *modesta* (Fabricius, 1803)
18. *mulunguana* (Linnavuori, 1982), new combination
19. *niemboana* (Linnavuori, 1982), new combination
20. *otjimbora* (Hesse, 1925)
21. *overlaeti* (Schouteden, 1962)
22. *scabrata* Distant, 1901
23. *wagneri* Leston, 1952

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FRANCISCO DE ASIS MONRÓS: A PERSPECTIVE

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Abstract.—A biographical sketch, bibliography, and list of proposed taxa are presented for F. A. Monrós.

Key Words: Monrós, biography, bibliography, proposed taxa

Francisco Monrós was one of the most prolific chrysomelid taxonomists of the middle 1900's. His research interests covered most of the family, they have contributed greatly to chrysomelid systematics, especially many of the smaller subfamilies. His monographs on various subfamilies for Argentina are still standard works. Little of his work has been tested by modern systematic techniques, so that his longterm impact is not known.

BIOGRAPHICAL SKETCH

Francisco Monrós was born in Barcelona, Spain on 6 June 1922. He began his entomological studies at the Barcelona Museum under Francisco Español Coll. In 1938 Monrós, his parents and brother left Spain due to the Civil War and arrived in Argentina, where he began his career as an agronomy engineer with the Faculty of Agronomy of the National University of Buenos Aires.

In 1948, Monrós began his association with the Miguel Lillo Institute of the National University of Tucumán. During his tenure in Tucumán he held the following positions: Interim Director of the Entomology Institute, Technical Secretary of the Academy of Biological Sciences, Vice Dean, as well as various professorships.

In 1950 Monrós was awarded the Juana Petrocchi Award from the Argentine As-

sociation for the Progress of the Sciences for his work "Revision Sistemática de los Hispidae Argentinos." In 1952-1953 the John Simon Guggenheim Memorial Foundation awarded Monrós a scholarship to visit the principal museums in the United States. A similar scholarship was awarded in 1955-1956 by the government of France, which allowed study in the Natural History Museum of Paris, the British Museum, the Frey Museum in Munich, and other museums in Europe.

Blake (1958) and Wygodzinsky (1959) wrote obituaries which talk of Monrós as a person rather than a scientist. The picture which emerged was of a modest, self-assured, quiet person with high ideals, who handled his responsibilities efficiently. He did, however, have definite scientific opinions which were expounded in the appropriate arena.

Monrós was a keen observer of natural history. He kept field notes and sketches from his field trips. His lectures were popular and interesting and were usually accompanied by his ambidextrously executed drawings.

Monrós published 67 articles, all but five on chrysomelids. His interests covered the entire family but he did not publish on the subfamily Galerucinae. Most of his works are illustrated with his own drawings. Monrós was interested in geographical variation

of species as many of his papers discuss variation in detail.

Monrós amassed a large collection through semiannual collecting trips and exchanges with other museums. His personal collection, including his types, is now held by the United States National Museum of Natural History (Blake 1961). Much Monrós material is also present in the collection of the Instituto Fundación Migel Lillo of Tucumán University (Willink per. comm).

Monrós died on 3 May 1958. He was survived by his wife, the former María Muntañola, his daughter Silvia, and his brother Antonio.

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1943

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1947

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TAXA PROPOSED BY MONRÓS

Alticinae

Microdonacia

schmidti 57: 747

truganina 57: 748

Aulacoscelinae

Aulacoscelis

confusca 42: 336

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Janbechynea n. gen. 36: 21

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weyrauchi 35: 350

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meridionalis 40: 258

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inornata 40: 253
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- Crioceris**
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- Lema**
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(Pachylema) n. subgen. 30: 473
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Guggenheimia n. gen. 50: 52

sumatrana 50: 53

Histerogaster n. gen. 14: 198

phaleroides 14: 200

Lamprosoma

acaciae 12: 93

auricaudatum 50: 64

byrrhoides 12: 85

chorisiae 12: 92

chorisiae chaguancum 12: 93

dissectum 12: 83

incredibilis 50: 66

indigaceum 12: 91

minimum 14: 196

nassutum 50: 63

oomorphum 12: 88

podtiaguini 10: 173

subelongatum 12: 87

subhumeralis 12: 89

subnitidum 12: 90

zariategii 12: 94

Lamprosomoides n. gen. 62: 33

monticola 62: 33

Neochlamysini new tribe 62: 29

Oomorphoides n. gen. 50: 54

Oomorphus

alvargengai 62: 32

amazonicus 62: 33

caledonicus 62: 32

darlingtoni 50: 48

goiasensis 62: 33

microbius 62: 32

wittmeri 50: 50

Xenoomorphus n. gen. 50: 40

bicornutus 50: 41

cavifrons 62: 31

draconianus 62: 29

gingindhlovuanus 62: 31

innominatus 62: 31

Megalopidinae

Agathomerus

(**Agathomeroides**) n. subgen. 7: 185

(**Euagathomerus**) n. subgen. 7: 190

(**Mesagathomerus**) n. subgen. 7: 182

(**Trichagathomerus**) n. subgen. 7: 196

bichito 6: 146

varians 6: 146

Bothromegalopus n. gen. 7: 204

Mastostethus

martinezi 7: 178

minutus 7: 172

Megalopus

jacobyi apicalis 7: 214

jacobyi inhumeralis 7: 214

jacobyi pallidus 7: 214

jacobyi testaceus 7: 213

schaeferi 7: 211

vespa 7: 208

vespa inornatus 7: 211

Plesioagathomerus n. gen. 6: 149

canus 6: 152

vittatus 6: 150

Megascelidinae

Mariamela n. gen. 26: 171

wittmeri 26: 171

Megascelis

lemoides 64: 14

picturata 64: 16

yungarum 64: 15

Sagrinae

Atalasis

sagroides confluens 13: 208

sagroides nigripennis 1: 422

Coolgardica

kellerberrina 63: 45

Diaphanopsidini new tribe 63: 7

Duboulaya n. gen. 53: 1120

Mecynodera

papuana 63: 51

Megamerus

alvarengai 49: 108

Neodiaphanops

pectoralis 63: 56

Sagrinola n. gen. 53: 1120

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DESCRIPTION OF *NEOCOLOCHELYNA HAKUSANA*, SP. NOV., AND ITS
LARVA (HYMENOPTERA: TENTHREDINIDAE) FROM JAPAN

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Abstract.—The adult and larva of *Neocolochelyna hakusana*, sp. nov., from Honshu (Japan Sea coast), Japan, is described and illustrated. Larvae feed on *Actinidia arguta*. Life history notes are given.

Key Words: sawfly, *Neocolochelyna*, larva, food plant, *Actinidia arguta*, Japan

In late June of 1994, I found some adults of *Neocolochelyna* Malaise ovipositing in the leaves of *Actinidia arguta* Plauch on Mt. Hakusan, Ishikawa Prefecture, Japan, and captured three specimens. After comparing these specimens with *N. itoi* Takeuchi which occurs on the Pacific coast, I believe they represent a new species. I also found several larvae of this new species feeding on the leaves of *A. arguta*, and three larvae were collected for rearing in early July, 1994. This new species is described below, including description of the larva and biological notes.

KEY TO THE JAPANESE SPECIES

1. Female 2
- Male 3
2. Eye in dorsal view nearly as long as head behind the eyes (Fig. 1); lancet with 23 serrulae (Figs. 10 and 12) *hakusana* sp. nov.
- Eye in dorsal view slightly longer than head behind the eyes (ratio about 1.2:1.0); lancet with 25 serrulae (Figs. 11 and 13) *itoi* Takeuchi
3. Apical portion of subgenital plate slightly angulated (Fig. 14); apical portion of harpes rather bluntly rounded (Fig. 16); penis valve as in Fig. 18 *hakusana* sp. nov.
- Apical portion of subgenital plate rounded (Fig. 15); apical portion of harpes rather sharply rounded (Fig. 17); penis valve as in Fig. 19 *itoi* Takeuchi

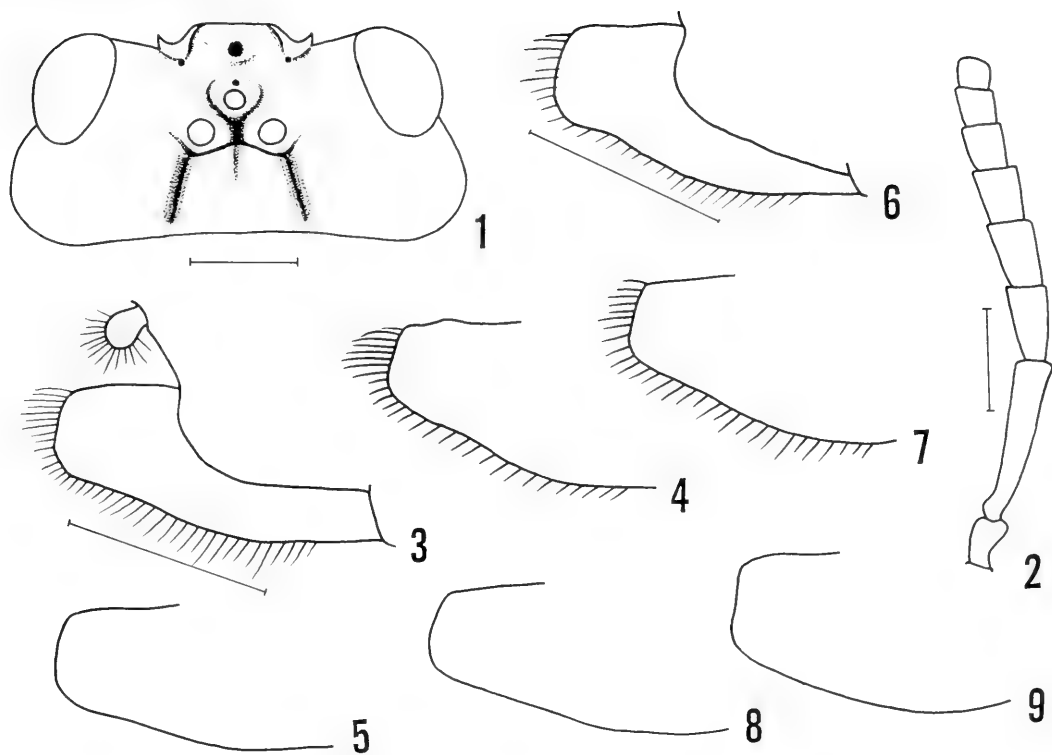
Neocolochelyna hakusana Togashi,
NEW SPECIES

Figs. 1–5, 10, 12, 14, 16, 18

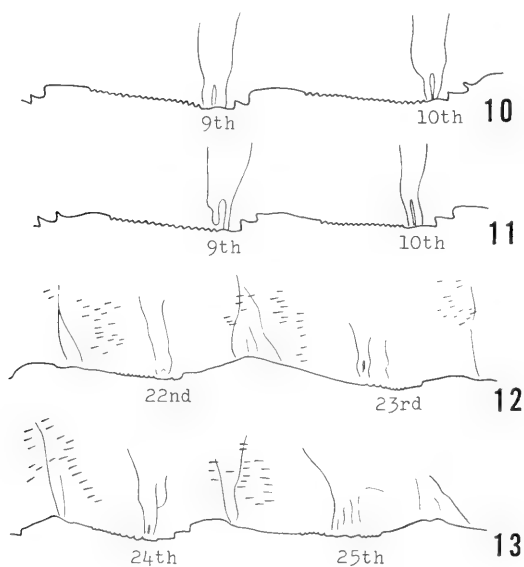
Female.—Length 17–19 mm. Robust species. Body ferruginous, with following parts dark brown to black: apical portion of mandible, lower portion of frons except for supraclypeal area, pronotum except for latero-posterior corners, triangular maculae on praescutum, posttergite, and posterior margin of propodeum. Antenna dark brown with basal three segments ferruginous. Legs: coxae and femora black, trochanters and tibiae dark brown, tarsi dirty yellow.

Head seen from above transverse, dilated behind eyes (Fig. 1); eye in dorsal view nearly as long as head behind eyes (Fig. 1); postocellar area with rather short median furrow (Fig. 1); OOL:POL:OCL = 2.8:1.0:3.3; postocellar, lateral, and interocellar furrows distinct (Fig. 1); circumocellar furrow distinct but lower portion interrupted (Fig. 1); antenna stout, nearly ½ as long as costa of forewing (or slightly longer than thorax, ratio about 1.0:0.9), relative lengths of segments about 2.2:1.0:3.6:1.8:1.4:1.4:1.1:0.7:0.8; pedicel longer than its apical width (ratio about 1.0:0.7).

Thorax: normal; hind basitarsus slightly



Figs. 1-9. 1-5. *Neocolochelyna hakusana* sp. nov. 1, head, dorsal view, 2, antenna, lateral view, except for scape, 3-5, sawsheath, lateral view. 6-9. Sawsheath of *N. itoi*, lateral view. Scale for 1-3 and 6: 1 mm.



Figs. 10-13. 10-11. 9th to 10th serrulae of lancet, 10, *N. hakusana* sp. nov., 11, *N. itoi*. 12-13. Basal two serrulae of lancet, 12, *N. hakusana* sp. nov. 13, *N. itoi*.

shorter than following 4 segments combined (ratio about 1.0:1.1-1.2).

Abdomen: sawsheath as in Figs. 3-5. Lancet with 23 serrulae (Figs. 10 and 12).

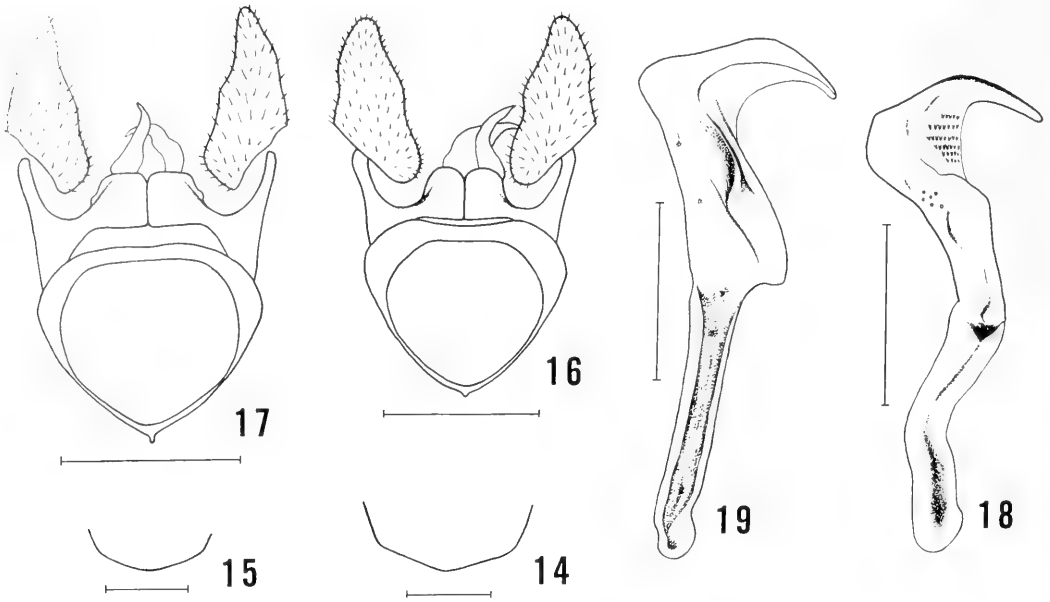
Punctuation. Head strongly, coarsely and reticulately punctured. Thorax strongly and reticulately punctured.

Male.—Length 17 mm. Coloration and structure similar to female. OOL:POL = 2.0:1.0; apical portion of subgenital plate slightly angulated (Fig. 14); apical portion of harpes rather bluntly rounded (Fig. 16); penis valve as in Fig. 18.

Distribution.—Japan (Japan Sea coast of Honshu)(Fig. 20).

Holotype: female, Mt. Hakusan (altitude about 1300 m), Ishikawa Pref., 30. VI. 1994, I. Togashi leg. Preserved in the collection of the Department of Zoology, National Science Museum (Nat. Hist.), Tokyo.

Paratypes: one female and one male, Mt.



Figs. 14-19. 14-15. Apical margin of subgenital plate, 14, *N. hakusana* sp. nov. 15, *N. itoi*. 16-17. Male genitalia, ventral view, 16, *N. hakusana* sp. nov. 17, *N. itoi*. 18-19. Penis valve, lateral view, 18, *N. hakusana* sp. nov. 19, *N. itoi*. Scale for 14-17: 1 mm; scale for 18-19: 0.5 mm.

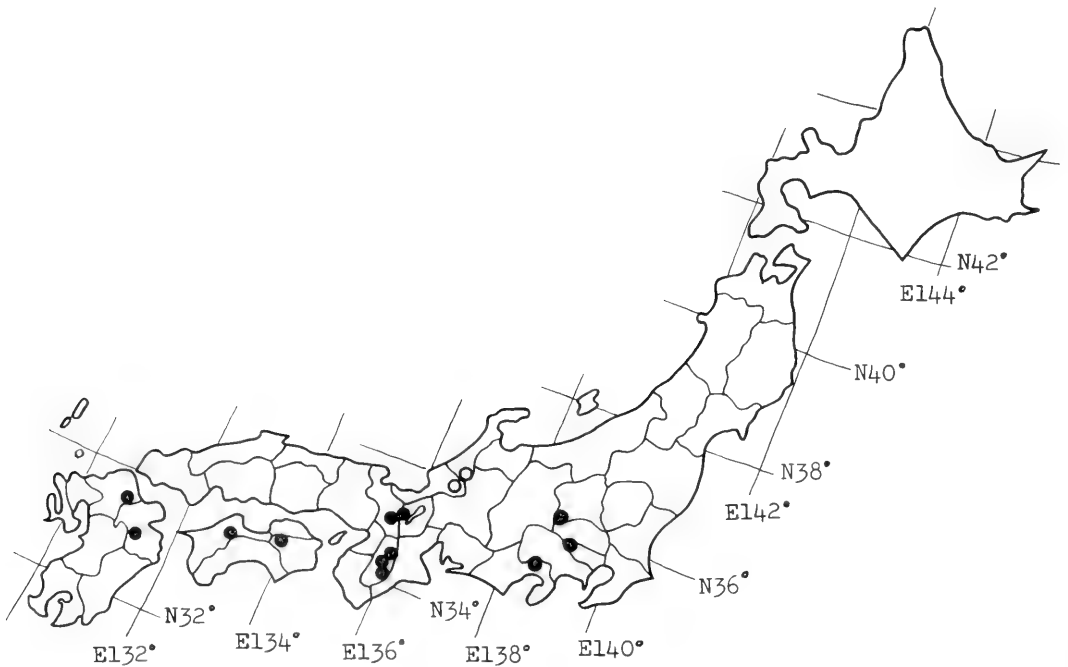
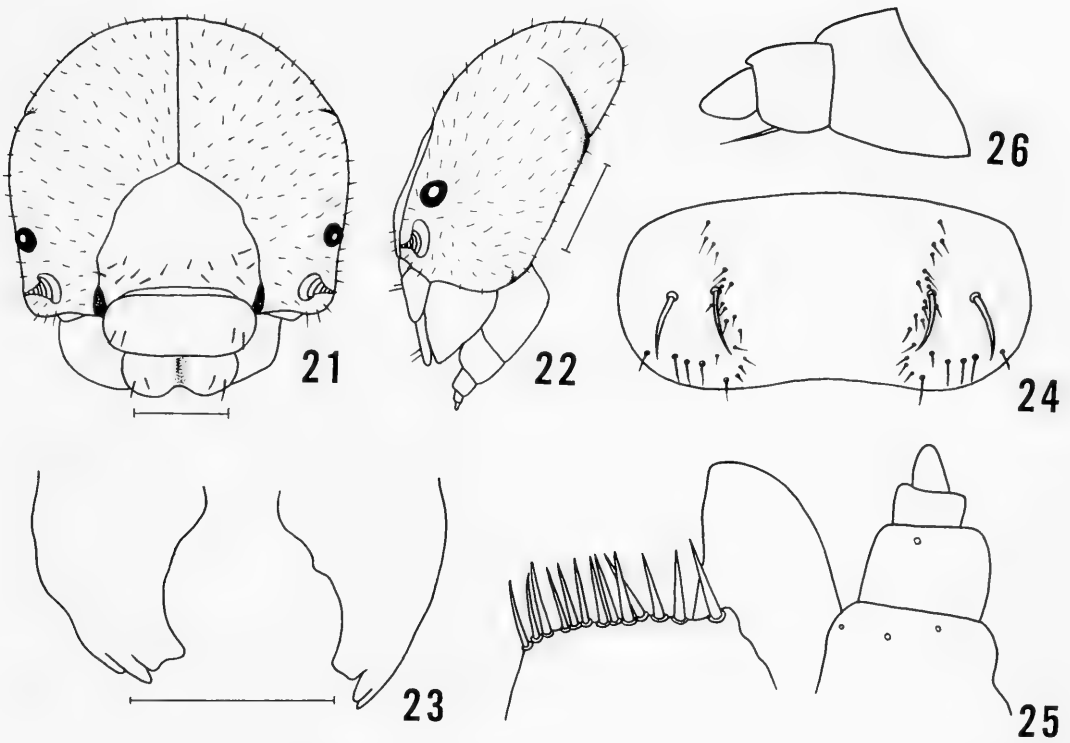


Fig. 20. Distributional map of *Neocolochelyna* spp. (Closed circles = *N. itoi*; open circles = *N. hakusana* sp. nov.)



Figs. 21–26. Larva of *N. hakusana* sp. nov. 21, head, frontal view, 22, head, lateral view, 23, mandibles, dorsal view, 24, labrum, 25, maxilla, 26, labial palpus. Scale for 21–23: 1 mm.

Arashima, Fukui Pref., 6. VI. 1982, T. Murota leg.; two females, same data as for holotype. One paratype female is deposited in the National Museum of Natural History, Washington, D.C., one paratype male is deposited in the Department of Zoology, National Science Museum (Nat. Hist.), Tokyo, and others in my collection.

Remarks.—This new species is very closely allied to *N. itoi* in coloration and structure. However, it is distinguished from the latter by the ratio between OOL and POL (in *itoi*, the ratio between OOL and POL is about 1.7:1.0), by the ratio between the eye and the head behind the eyes (in *itoi*, the eye is slightly longer than the head behind the eyes, ratio about 1.2:1.0), by the number of serrulae of the lancet (in *itoi*, the number of serrulae is 25), and by the characters of the male genitalia (see Figs. 14–19).

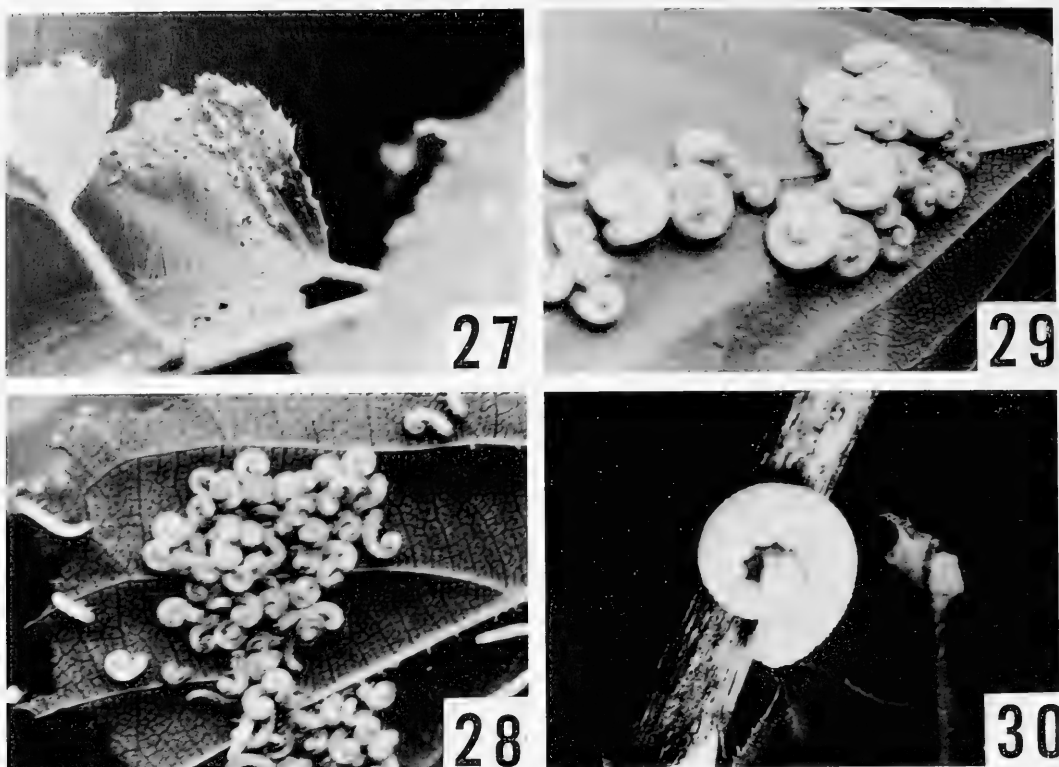
DESCRIPTION OF LARVA OF *N. hakusana*, NEW SPECIES

Figs. 21–30

Final instar.—Length 45–50 mm. Head pale yellow; eye and eye spot black; mandible black. Body uniformly milky white, covered with thin layer of white wax.

Head: vertical furrows distinct (Figs. 21 and 22); antenna 6-segmented; frons rather triangular in form, with 14 setae (Fig. 21); clypeus with 2 long setae (Fig. 21) on each side; labrum with shallow longitudinal furrow (Fig. 21) and with 2 long and 24 short setae on each side (Fig. 24); mandibles as in Fig. 23; maxillary palpus 3-segmented, relative lengths of segments about 1.0:0.7:1.8, galea digit-like (Fig. 25), lacinia with 13 strong setae (Fig. 25); labial palpus 3-segmented, relative lengths of segments about 1.0:1.4:1.7 (Fig. 26).

Prothorax 3 annulate; meso- and meta-



Figs. 27–30. Eggs and larvae of *N. hakusana* sp. nov. 27, foliage of *Actinidia arguta* with eggs in typical oviposition pattern, 28, resting colony of 1st to 2nd instar larvae, 29, resting colony of 3rd to 4th instar larvae, 30, final instar larva.

thorax each with 5-annulate; first to ninth abdominal segments each 7-annulate.

Food plant: *Actinidia arguta* Plauch.

Notes on biology.—This species is univoltine. Adults appeared in June in 1994 and the female oviposited in many rows along the edge of foliage (Fig. 27). Larvae were present from early July to early August. First to fourth instar larvae form a colony on the under side of the foliage when resting (Figs. 28 and 29). When eating, they go to the edge of the foliage. Final instar larvae are not found in a colony but feed singly. When mature, the larvae drop to the ground and penetrate into the soil where they pass the autumn and winter seasons.

Neocolochelyna itoi Takeuchi

Figs. 6–9, 11, 13, 15, 17, 19

Neocolochelyna itoi Takeuchi, 1951, p. 62;

Togashi, 1955, p. 154; Togashi, 1965, p.

246; Okutani, Tsuruta and Shinohara, 1992, p. 238.

Distribution.—Japan (Pacific coast of Honshu, Shikoku and Kyushu)(see Fig. 20).

Food plant.—*Actinidia arguta* Plauch.

Specimens examined.—Kyushu—1 ♀, Mt. Hikosan, Fukuoka, 23. V. 1950, N. Fukuohara; 2 ♀, Mt. Hikosan, Fukuoka, 3. VI. 1971, I. Togashi; 1 ♀, Mt. Kuju, Oita, 14–15. V. 1986, A. Shinohara. Shikoku—1 ♀, Mt. Ishizuchi, Ehime, 18. VI. 1978, N. Yashiro. Honshu—1 ♀ 1 ♂, Mt. Odaigahara, Nara, 28–29. V. 1977, K. Mizuno; 3 ♀ 5 ♂, Mts. Ohminesan, Nara, 7. VI. 1981, K. Mizuno; 1 ♀, Mt. Kunimiyama, Nara, 5. VI. 1988, K. Mizuno; 1 ♀, Ohara, Kyoto, 21. VI. 1984, T. Matsumoto; 1 ♀, Mt. Kurotakiyama, Gumma, 20. V. 1987, T. Matsumoto.

Supplemental description of adult.— OOL:POL:OCL = 1.7:1.0:2.1; eye in dorsal view slightly longer than head behind the eyes; sawsheath as in Figs. 6–9; lancet with 25 serrulae (Figs. 11 and 13). Male: apical portion of subgenital plate nearly rounded (Fig. 15); apical portion of harpes rather sharply rounded (Fig. 17); penis valve as in Fig. 19.

According to my observation at Mt. Hiko-san in 1971, female of this species oviposited in many rows along the edge of the foliage of *Actinidia arguta*. But I do not found the larvae.

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**LEPIDOPTERA ASSOCIATED WITH GREENLEAF MANZANITA,
ARCTOSTAPHYLOS PATULA E. GREENE (ERICACEAE), IN
SHASTA COUNTY, CALIFORNIA**

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Abstract.—Fifty lepidopteran taxa were collected in association with greenleaf manzanita. Of these, 31 were collected from manzanita foliage as larvae and 29 were reared to adulthood. A listing of taxa is presented including method of collection, life stage(s) encountered in the field, collecting locations, and parasitoids reared from collected specimens.

Key Words: Lepidoptera, *Arctostaphylos patula*, greenleaf manzanita, parasitoids

Greenleaf manzanita, *Arctostaphylos patula* E. Greene (Ericaceae), is a broadleaf evergreen shrub that commonly occurs in the Sierra Nevada mountain range of the western United States (Hickman 1993). This particular manzanita species grows in mesic habitats associated with montane forest zones generally above 303 m (1000 ft) in elevation (Ball et al. 1983). In general, information concerning insects and brushfield ecosystems (e.g. montane chaparral communities) is currently lacking in the literature (Force 1990); this is certainly the case concerning herbivorous insects associated with greenleaf manzanita (e.g. Haws et al. 1988). In response to the growing concern over a limited number of control options for greenleaf manzanita shrubs which compete with more economically important timber species, a study was conducted from 1989 to 1994 to evaluate the potential of using native insects to alter vegetative composition (Valenti 1994). More than 500 insect species were identified in association with greenleaf manzani-

ta. In this paper we present results of the Lepidoptera inventory. This list includes important host information on many species for which virtually nothing is known. In addition, records of parasitoids and other natural enemies, when available, are presented for a number of species.

MATERIALS AND METHODS

Site descriptions.—Bear Wallow. This 20+ ha, old-growth greenleaf manzanita brushfield (elevation 1524 m [5000 ft]) is located 3 km (by dirt road) from CA Route 89 in Old Station (approximately 6.6 km south southwest of the Logan Lake site) (T32N R4E S10). Greenleaf manzanita, which averaged 1.5–2.0 m in height, accounted for approximately 85% of the total vegetation.

Hat Creek. Located adjacent to the USDA Forest Service Work Center, Hat Creek, CA (T34N R4E S16) (elevation 1018 m [3340 ft]), this site consists of a variety of woody plant species. Greenleaf manzanita is fairly common but accounted for less than 30% of the total vegetation. Other plant species present at this site included: sagebrush (*Artemisia tridentata*

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Nuttall) (Asteraceae); curl-leaf mountain-mahogany (*Cercocarpus ledifolius* Nuttall), birch-leaf mountain-mahogany (*C. betuloides* Torrey & A. Gray), and antelope bitterbrush (*Purshia tridentata* [Pursh] de Candolle) (Rosaceae); California black oak (*Quercus kelloggii* Newberry) (Fagaceae); and a mixture of conifers including ponderosa pine (*Pinus ponderosa* Lawson), sugar pine (*P. lambertiana* Douglas), white fir (*Abies concolor* [Gordon & Glendinning] Lindley), Douglas-fir (*Pseudotsuga menziesii* [Mirbel] Franco), incense cedar (*Calocedrus decurrens* [Torrey] Florin), and western juniper (*Juniperus occidentalis* Hooker) (Pinaceae).

Logan Lake. This site (elevation 1512 m [4960 ft]) is located 3.2 km (by dirt road) northwest of CA Route 89 in Old Station, approximately 24 km south of Hat Creek, CA (T32N R4E S2&3). Dominant vegetation consisted of greenleaf manzanita (74%), tobacco brush (*Ceanothus velutinus* Hooker) (Rhamnaceae) (11%), and ponderosa pine (9%). The 50+ ha site is located 1.6 km west of Logan Lake on an east-facing slope and was mechanically cleared of all standing vegetation in 1976 and planted to ponderosa pine the following year. Greenleaf manzanita shrubs averaged 1.5–2.0 m in height.

Tamarack Swale. In 1974, this 25+ ha site was mechanically cleared and ponderosa pine seedlings were planted in 1975. The site is located in a valley 6.4 km (by dirt road) southwest of CA Route 89 approximately 5 km south of Hat Creek (T33N R4E S4&9) (elevation 1646 m [5400 ft]). Tobacco brush (16%) and ponderosa pine (8%) were interspread with the dominant species, greenleaf manzanita (61%). Greenleaf manzanita shrubs were removed again in 1984 during a second mechanical clearing treatment, however, shrubs subsequently became reestablished and averaged 0.75 m in height.

Other location. In May 1991, a localized outbreak of a tussock moth (Lymantriidae) was discovered in Redding, California, at

the junction of Hilltop Drive and California Route 44. Larvae were actively feeding on an ornamental manzanita, *Arctostaphylos densiflora* Baker, and several dozen were subsequently transferred to caged *A. patula* plants at the Hat Creek Forest Insect Laboratory.

Arthropod survey.—Lepidoptera were sampled by visually searching and hand picking individuals from plants, sweeping foliage with a canvas net, and Malaise trapping (at the Logan lake site only). Generally, collecting began in May and ended in August for the years 1989 to 1994. Adult specimens collected in the field were transported to the USDA Forest Service, Forest Insect Laboratory, Hat Creek, CA, for preparation. All adult specimens were pinned and labelled with complete collecting information. Voucher specimens are deposited in the Maurice T. James Entomological Collection, Department of Entomology, Washington State University, Pullman.

Attempts were made to rear all encountered immatures to adults. Individual larvae were placed in small plastic containers or screen cages with host material and allowed to develop and pupate. Many pupae required a cold treatment (e.g., 90 d at 4°C) before adults emerged. Parasitic flies (Diptera) and wasps (Hymenoptera) were collected from these larval rearings.

RESULTS

Following the scientific name of each species is the method of collection (Hp—hand picking, Sw—sweeping foliage, or Mt—Malaise trap), stage(s) encountered (E—egg, L—larva, P—pupa, A—adult, and rA—reared adult), and collection location (BW—Bear Wallow, HC—Hat Creek, LL—Logan Lake, TS—Tamarack and Swale, and OL—other location). Greenleaf manzanita is the host for 31 of the species collected and, unless otherwise noted, apparently represent new host records. None of the hymenopteran parasitoids encountered in this study are listed in the comprehensive catalog by Krombein et

1979) and just two tachinid (Diptera) parasitoid records (as noted) have previously been reported (Arnaud 1978). Accounts of spider (Araneae) predation on larvae of a geometrid are also new. Distributional records are included for an additional 19 species of Lepidoptera collected in association with greenleaf manzanita brushfield communities (18 as adults and one as a chrysalis and reared to adulthood).

GREENLEAF MANZANITA HOST RECORDS

Psychidae

Hyaloscotes fumosa Butler: Hp; L, rA; HC

Gracillariidae

undet. genus and species (serpentine mine): Hp; L; BW, HC, LL, TS

undet. genus and species (blotch mine): Hp; L; BW, HC, LL, TS

Coleophoridae

Coleophora glaucella Walsingham: Hp; L, rA; BW, HC, LL, TS

Related host record: *Arctostaphylos glaucella* Lindley (Walsingham 1882)

This casebearer is also known to feed on other manzanita species including *A. insularis* E. Greene, *A. viscida* C. Parry, and *A. patula* (J.-F. Landry, pers. comm.).

Parasitoids reared from larvae:

Agathis sp. (Hymenoptera: Braconidae): HC

Chelonus sp. (Hymenoptera: Braconidae): HC

Gelechiidae

Gelechia panella Busck: Hp; L, rA; HC, LL

Pseudochelaria manzanitae (Keifer): Hp; L, rA; HC, LL, TS

Related host record: *Arctostaphylos* sp. (Duckworth 1964)

Parasitoid reared from larvae:

Erynnia tortricis (Coquillett) (Diptera: Tachinidae): HC

Tortricidae

Amorbia cuneana (Walsingham): Hp; L, rA; HC

Choristoneura sp. (*rosaceana* [Harris] species complex): Hp; L, rA; HC

Parasitoids reared from larvae (†also listed in Arnaud [1978]):

Erynnia tortricis (Coquillett) (Diptera: Tachinidae): † HC

Eumea caesar (Aldrich) (Diptera: Tachinidae): † HC

Nilea or *Lespesia* sp. (Diptera: Tachinidae): HC

Epinotia arctostaphylana (Kearfott): Hp; L, rA; LL

Related host record: *Arctostaphylos uva-ursi* L. (Dyar 1904)

E. miscana (Kearfott): Hp; L, rA; LL, TS

E. subplicana (Walsingham): Hp; L, rA; LL

Related host record: *Arctostaphylos manzanita* C. Parry (Heinrich 1923)

E. terracoctana (Walsingham): Hp; L, rA; LL

Lycaenidae

Incisalia augustus iroides (Boisduval): Hp; L, rA; HC, LL

Related host record: *Arctostaphylos uva-ursi* L. (Scott 1986)

Geometridae

Aethaloida packardaria (Hulst): Hp; E, L, rA; HC, LL

Several generations of this species were also reared through on kinnikinnick, *Arctostaphylos uva-ursi* L.

Anacamptodes clivinaria clivinaria (Guenée): Hp; L, rA; LL

Eupithecia sp.: Hp; L, rA; HC

Hesperumia fumosaria impensa Rindge: Hp; L, rA; BW, HC, LL, TS

Larval habits were previously unknown. Late larval instars occur in three distinct color morphs which mimic host stems. A yellow-green morph with a dorsal crimson stripe and a uniformly crimson morph occur on greenleaf manzanita. The third morph is mottled gray and occurs on antelope bitterbrush.

Parasitoids reared from larvae:

Deopalpus sp. nr *contiguus* (Reinhard) (Diptera: Tachinidae): HC

Madremyia saundersii (Williston) (Diptera: Tachinidae): HC

Phryxe pecosensis (Townsend) (Diptera: Tachinidae): HC

Aleiodes nolophanae (Ashmead) (Hymenoptera: Braconidae): HC

Nemoria glaucomarginaria (Barnes & McDunnough): Hp; L, rA; LL

Porter (1986) reported that wild collected larvae are unknown. He collected ova from wild female moths and reared larvae on California live oak, *Quercus agrifolia* Née, California white oak, *Q. lobata* Née, and cork oak, *Q. suber* L. (Fagaceae). Larvae we collected from greenleaf manzanita plants have dorsolateral projections, and late instars mimic greenleaf manzanita inflorescence stems both in coloration (yellow, green, and red) and physical appearance.

Synaxis cervinaria (Packard): Hp; E, L, rA; BW, HC, LL, TS

Larval habits were previously unknown. Mature larval coloration varies from dark gray to crimson (often mottled). Larvae mimic stems and twigs of greenleaf manzanita shrubs (see Valenti [1994] for complete descriptions of all life stages and life history).

Parasitoids reared from eggs:

Trichogramma sp. (Hymenoptera: Trichogrammatidae): HC, LL

Telenomus alsophilae Viereck (Hymenoptera: Scelionidae): HC, LL

Parasitoids reared from larvae:

Campylochaeta sp. (Diptera: Tachinidae): LL

Aleiodes n. sp. (Hymenoptera: Braconidae): LL

Meteorus rubens (Nees) (Hymenoptera: Braconidae): LL

Dusona nigrifibialis (Viereck) (Hymenoptera: Ichneumonidae): LL

Euplectrus sp. (Hymenoptera: Eulophidae): LL

Parasitoid observed in the field attacking larval instar III:

Goniozus gracilicornis (Kieffer) (Hymenoptera: Bethyliidae): HC

Predators observed in the field attacking larvae:

Misumenops celer (Hentz) (Araneae: Thomisidae): LL

Xysticus sp. (Araneae: Thomisidae): LL

Metaphidippus sp. (Araneae: Salticidae): LL

Lasiocampidae

Malacosoma californicum (Packard): Hp; L, rA; HC, LL

M. constrictum (Henry Edwards): Hp; L, rA; HC

M. disstria Hübner: Hp; L, rA; HC

Phyllodesma americana (Harris): Hp; L, rA; LL

Lymantriidae

Orgyia cana Henry Edwards: Hp; L, rA; OL

Larvae were collected from Vine Hill manzanita, *Arctostaphylos densiflora*, in Redding, California, and reared to adulthood on greenleaf manzanita at Hat Creek; a subsequent generation was also reared through to adulthood with greenleaf manzanita as host.

Saturniidae

Hemileuca eglanterina shastaensis (Grote): Hp; L, rA; HC, LL

Related host record: *Arctostaphylos* sp. (Packard 1914)

Hyalophora euryalus (Boisduval): Hp; E, L, rA; HC, LL

Related host record: *Arctostaphylos* sp. (Collins and West 1961)

aturnia mendocino Behrens: Hp; E, L, rA; LL, TS

Related host record: *Arctostaphylos tomentosa* (Pursh) Lindley (Edwards 1880)

Parasitoid reared from larvae:
Lespesia sp. (Diptera: Tachinidae): LL

Sphingidae

Sphinx vashiti Strecker: Hp; L, rA; HC

Noctuidae

Acronicta ? perdita Grote: Hp; L, rA; LL

Apharetra californiae McDunnough: Hp; L, rA; LL

Parasitoid reared from larvae:
Periscepsia helymus (Walker) (Diptera: Tachinidae): LL

Aseptis ethnica Smith: Hp; L, rA; HC, LL

Parasitoid reared from larvae:
Periscepsia helymus (Walker) (Diptera: Tachinidae): LL

DISTRIBUTIONAL RECORDS

Hepialidae

Hepialis hectoides Boisduval: Hp; A; HC

Pyrilidae

Tulsa ? oregonella (Barnes & McDunnough): Mt; A; LL

Hesperiidae

Hesperia sp.: Mt; A; LL

Nymphalidae

Nymphalis californica (Boisduval): Hp; P, rA, A; BW, HC, LL, TS

This species is known to feed on *Ceanothus* spp. and has been recorded on other shrubs including *Arctostaphylos* (Furniss and Barr 1975). Adults were fairly commonly encountered and a single chrysalis was found attached to a leaf in a clump of isolated greenleaf manzanita shrubs growing in a gravel pit at the Hat Creek site.

Geometridae

Apodrepanulatrix litaria (Hulst): Sw; A; LL

Chlorosea nevadaria Packard: Sw; A; HC

Cyclophora dataria (Hulst): Sw; A; LL
Drepanulatrix rectifascia (Hulst): Sw; A; LL

D. unicalcararia (Guenée): Sw; A; LL
Itame guenearia (Packard): Sw; A; HC

I. quadrilinearia (Packard): Mt; A; LL
Nemoria darwiniata (Dyar): Sw; A; HC, LL

Sabulodes edwardsata (Hulst): Mt; A; LL

Semiothisa signaria dispuncta (Walker): Mt; A; LL

Sericosema juturnaria (Guenée): Sw; A; HC

S. wilsonensis (Cassino & Swett): Mt; A; LL

Sphingidae

Hyles lineata (F.): Mt; A; LL

Paonias myops (J.E. Smith): Hp; A; HC

Several adults were collected on the inside of an 8 × 8 m bird enclosure (with 1.5 × 1.5 cm openings) containing only greenleaf manzanita. It is doubtful these adults came from outside the enclosure because they were larger than the net openings. It is quite conceivable that larvae fed on greenleaf manzanita and pupated inside the enclosure. Adults that subsequently emerged became trapped inside the enclosure netting.

Arctiidae

Spilosoma vestalis Packard: Sw; A; HC, LL

DISCUSSION

The information presented here represents the first in-depth study of the lepidopterous fauna associated with a manzanita species. In two general treatments of insects affecting important western trees and shrubs (Furniss and Barr 1975, Furniss and Carolin 1977), only four species of Lepidoptera are recorded feeding on *Arctostaphylos* spp.; *Nymphalis californica*, *Hemileuca eglanterina*, *Hyalophora euryalus*, and a species not encountered in our

study, *Orgyia vetusta gulosa* (Henry Edwards) (Lymantriidae). The collection and rearing of 29 species substantiates that a significant number of Lepidoptera utilize greenleaf manzanita as a host. Some of these species are certainly generalists (e.g., *Nymphalis californica*, *Malacosoma californicum*, *M. disstria*, and *Phyllodesma americana*) and manzanita may not necessarily be the primary host. For most cases, we have presented new records of larval rearings and host associations. Additionally, a number of new larval/parasitoid relationships were discovered through the rearings.

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**XANTHAPANTELES, A NEW GENUS OF MICROGASTRINAE
(HYMENOPTERA: BRACONIDAE) FROM SOUTH AMERICA**

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Abstract.—*Xanthapanteles*, a new genus of Microgastrinae, is described and illustrated, with *X. cameronae*, n. sp., from Argentina, as type species. A brief discussion and tabular comparison of the features of *Xanthapanteles* and several somewhat similar microgastrine genera is presented.

Key Words: Parasitoids, Neotropical, Apanteline, *Xanthapanteles cameronae* new genus and species

In the process of examining a large bulk of unplaced material of Microgastrinae to prepare a key to the genera for an upcoming manual of New World Braconidae, specimens of an extremely unusual undescribed species were encountered that could not be placed, even with some difficulty, into any known genus. The new species is described below and a new genus is erected for it. A comparison of critical features of the new genus with those of related genera is presented along with the generic description. The biological habits of the new genus are unknown.

As the new genus is at this time based on only a single species, only a brief discussion of characters distinguishing the genus from other known and presumably related genera will be presented. Accompanying this discussion is a tabular comparison of the states a number of characters of *Xanthapanteles* and those of a number of the most obviously similar genera (Table 1). Because the phylogeny of microgastrine genera has been a subject of much (and still unresolved) controversy (Mason 1981, Williams 1985, Walker et al. 1990, Austin 1990, Austin and Dangerfield 1992), it would be premature at this time to attempt

a phylogenetic placement of the genus within the subfamily. Nevertheless it is hoped that the character comparisons presented will ultimately contribute to the resolution of some of the remaining phylogenetic questions.

Terms for wing venation features follow Mason (1986) and a new venational nomenclature (modified slightly from that discussed by Sharkey, 1994) being developed for the upcoming identification manual to the New World genera of Braconidae. Microsculpture terms follow the usage of Harris (1979), except that some intermediates between the states discussed by Harris are indicated by compound designations.

***Xanthapanteles*, NEW GENUS**

Figs. 1-3

Type species: *Xanthapanteles cameronae* n. sp. (described below). Monobasic.

Xanthapanteles possesses a unique combination of features that will easily distinguish it from any known genus of Braconidae. Many features of this genus such as the wing venation (the configuration of forewing veins 1Rs and 1M and the absence or reduction to spectral traces of veins 2r-m, 4Rs and 4M, as well as the well-defined

Table 1. Comparison of several selected morphological characters across a range of microgastrine genera. One might, on the basis of one or more of the characters, be confused with *Xanthapanteles*. Characters and states are presented in a simplified fashion; see text and description for further detail.

Genus	Antennal Placodes	Forewing Areolet	Propodeal Pattern*
<i>Alphomelon</i>	two ranks	open, 2r-m absent	areola, 2 anterior carinae
<i>Apanteles</i>	two ranks	open, 2r-m absent	areola (variable)
<i>Austrocotesia</i>	two ranks	closed, 2r-m present	areola, 1 ant. carina
<i>Choeras</i>	two ranks	variable	medial carina
<i>Dasylagon</i>	two ranks	closed, 2r-m present	areola, 1 or 2 ant. carinae
<i>Dolichogenidea</i>	two ranks	open, 2r-m absent	areola (variable)
<i>Exoryza</i>	two ranks	open, 2r-m absent	areola (poorly defined)
<i>Hygroplitis</i>	irregular or three ranks	closed, 2r-m present	medial carina
<i>Microgaster</i>	two ranks	closed 2r-m present	medial carina
<i>Miropotes</i>	two ranks	closed, 2r-m present	areola, 1 anterior carina
<i>Papanteles</i>	two ranks	closed, 2r-m present	areola, usu. 1 ant. carina
<i>Parapanteles</i>	two ranks	open, 2r-m absent	areola (variable)
<i>Pholetesor</i> (some)**	two ranks	open, 2r-m absent	areola, 1 anterior carina
<i>Promicrogaster</i>	two ranks	usually closed by 2r-m	medial carina or groove
<i>Rhygoplitis</i>	two ranks	open, 2r-m absent	medial carina
<i>Xanthapanteles</i>	irregular	open, 2r-m absent	areola, 2 ant. carinae
<i>Xanthomicrogaster</i>	two ranks	closed, 2r-m present	medial carina

* The propodeal pattern is, in several genera, poorly defined or obscured in some species; the predominant clear pattern is presented.

** Several species groups of *Pholetesor* would never be confused with *Xanthapanteles* due to structure of the metasoma and to absence of a propodeal areola.

vannal lobe of the hindwing—see Fig. 3), the 18-segmented antennae and the separation of the spiracle of the first metasomal tergum from its central tergite, all clearly indicate that the new genus belongs to the Microgastrinae as currently defined (Austin and Dangerfield 1992, Whitfield and Mason 1994). *Xanthapanteles* possesses perhaps the most complete (although perhaps somewhat exaggerated) pattern of propodeal areolation of any microgastrine (Fig. 2), suggesting at least that it does not belong to one of the lineages possessing derived or reduced propodeal carination patterns such as a medial longitudinal carina or completely rugose surface. The hypopygium is medially desclerotized, membranous and expandible through a series of submedial pleats, as in genera such as *Apanteles*, *Dolichogenidea*, *Choeras* and *Promicrogaster*. Austin (1990), in contrast to Mason (1981), considers this to be a possible synapomorphy for the above group of genera plus perhaps several others. The distribution of solid (evenly sclerotized) hypopygia, not only

among outgroup taxa but also among putatively basal lineages of Microgastrinae, would tend to support Austin's view. In addition, the structure of the pleated hypopygium in the Microgastrinae listed above and in *Xanthapanteles* is different from superficially similar hypopygia in Cardiochilinae and other related groups in lacking an apical sclerotized bridge. The ovipositor sheaths are moderately long, fairly hairy throughout, and attached about halfway or more up the second valvifers—again as in those genera (as also in many others—see discussions by Austin 1990, Williams 1985). Unlike any of those genera, however, the first metasomal tergite is strongly enlarged, entirely covering the dorsum of the first tergum and it, along with the second and third tergite, has a finely pebble-grained surface unlike that of any other known microgastrine (this appearance is only approximated in figure 2; it perhaps most resembles the sculpturing in some weakly sclerotized hormiines). Lastly, the antennae are unique: the first flagellomere is shorter than the second or third, and sub-

Table 1. Continued.

Metasomal Tergite 1	Tergite Sculpture	Hypopygium
moderately broad	smooth to punctate	evenly sclerotized
usu. posteriorly narrowing	smooth to aciculatorugose	medially pleated
usu. posteriorly narrowing	smooth to aciculatorugose	evenly sclerotized
moderately broad	smooth to aciculatorugose	medially pleated
very broad	smooth to punctate	medially pleated
moderately broad	smooth to aciculatorugose	medially pleated
very broad	aciculatorugose to rugose	medially pleated
very broad	aciculatorugose to rugose	evenly sclerotized
very broad	aciculatorugose to rugose	usually pleated
usually narrow	smooth to aciculatorugose	medially pleated
moderately broad	aciculatorugose	medially pleated
moderate to narrow	aciculatorugose	evenly sclerotized
moderate to broad	aciculatorugose to rugose	evenly sclerotized
moderately broad	smooth to aciculatorugose	medially pleated
moderate to broad	aciculate to rugose	medially pleated
extremely broad	smooth to finely colliculate	medially pleated
very broad	punctate to aciculatorugose	evenly sclerotized

equal with the length of the fourth, and the longitudinal placodes on all longer flagellomeres are arranged irregularly rather than in even single or double ranks. This irregular placement of the placodes is known from several other micrigastrine genera, but not from any others with a propodeal areola. The general appearance of the wasp is also slightly unusual, as the mesosoma is somewhat more slender and straight-backed than is typical for microgastrines, the color is primarily orangish yellow, and the wings are brownish and unusually slender (Fig. 1). In several of these body shape features *Xanthapanteles* somewhat resembles the presumably distantly related *Rhygoplitis* and *Hygropplitis*.

Xanthapanteles cameronae, NEW SPECIES

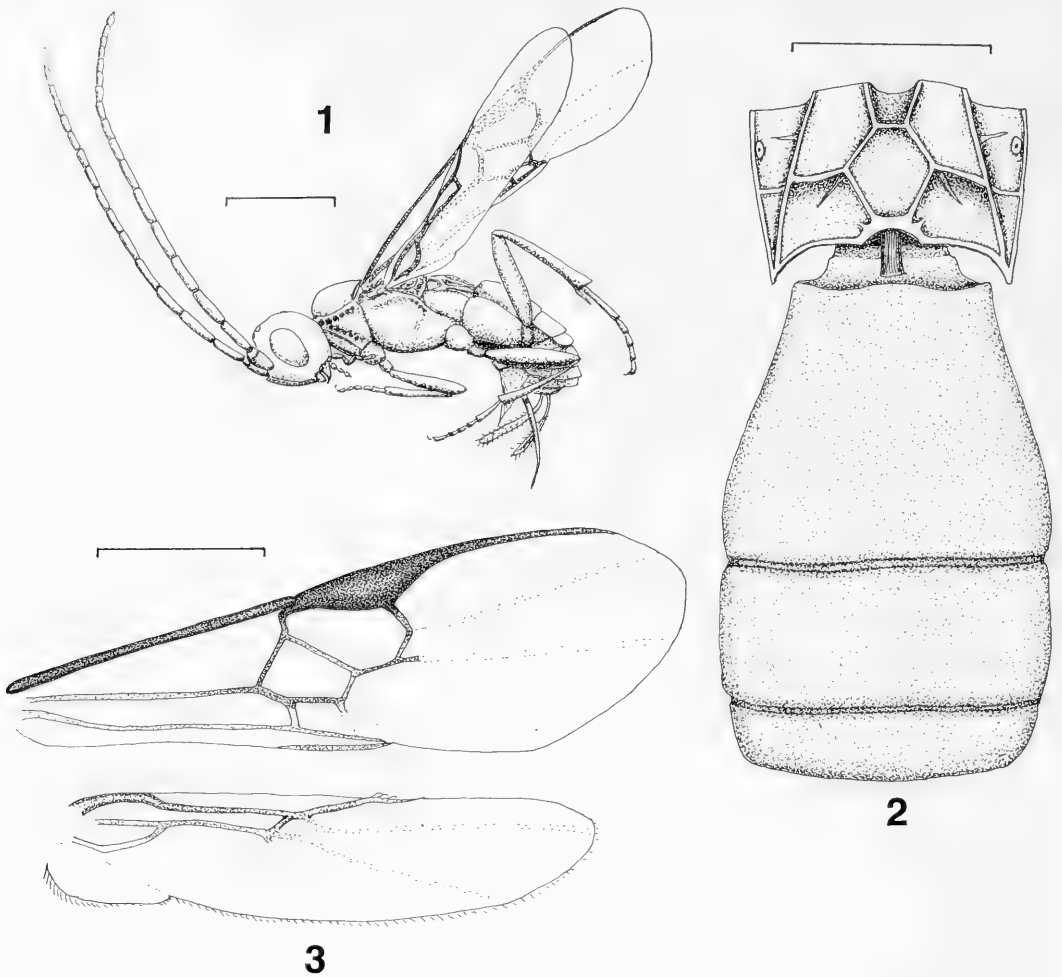
Figs. 1–3

Holotype female.—Body length 3.8 mm; forewing length 4.3 mm. Lateral habitus—Fig. 1.

Head: Pale honey-orange throughout except darker antennae and area between ocelli. Frons 2.0× as broad at midheight as long medially, weakly punctate; inner margins of eyes converging towards clypeus,

and slightly indented just above antennal bases. Antennae medium brown throughout, 1.2× as long as forewing; all but distal flagellomeres with scattered placodes, occasionally forming 3 indistinct ranks on placodes; flagellomere 2 3.75× as long as broad; flagellomere 14 2.3× as long as broad. Palpi light yellow-golden throughout visible portions. Head in dorsal view 1.7× as broad as medially long. Vertex relatively smooth and extremely finely granular, nearly appearing polished.

Mesosoma: Entire mesosoma pale orange-brown except darker dorsal portion of pronotum, lateral portions of metanotum and posteromedial section of propodeum. Pronotum with strong, broad, crenulate upper and lower grooves. Mesoscutum evenly, finely granular but appearing superficially smooth and polished; width just anterior to tegulae slightly less than that of head. Scutoscutellar scrobe composed of approximately 5–6 partly confluent crenulations, nearly straight medially. Scutellar disc slightly longer than anteriorly broad, similarly sculptured to mesoscutum. Mesopleuron finely granular, convex, without obvious longitudinal depression. Metanotum an-



Figs. 1-3. *Xanthapanteles cameronae* n. sp. 1, Lateral habitus. 2, Propodeum and anterior metasomal tergites. 3, Wings. Scale lines: 1—1 mm; 2—0.5 mm; 3—1 mm.

teriorly appressed to scutellum; sublateral setiferous lobes not clearly distinct. Propodeum (Fig. 2) with strongly raised areolate pattern of carinae, the areola being hexagonal and bearing 2 anterior carinae leading to anterior margin of propodeum; background sculpturing not obvious.

Legs: Coloration entirely honey-orange except darker terminal tarsomeres (fore- and mid-legs), apices of hind femora and tibiae, and most of hind tarsi. Spines on outer faces of hind tibiae tiny, inconspicuous, irregularly scattered. Apical spurs of hind tibiae subequal in length, the inner spur about 0.4 length of hind basitarsus.

Wings: More slender (Fig. 3) than in most microgastrines. Tegulae pale honey-yellow. Forewing venation moderate yellow-brown; wings tinged slightly brownish. Vein 2r weakly arched, somewhat longer than 2 + 3RS, meeting it at about 100° angle. Vein 2r-m absent. Vein R1 (metacarp) much longer than stigma, approximately 4× as long as distance from its distal end to end of 4RSb fold along wing edge. Stigma 4× as long as broad. Hindwing with vannal lobe subapically flattened, sparsely fringed with hairs.

Metasoma: Entirely honey-orange except darker ovipositor sheaths. Anterior ter-

gites—Fig. 2. Tergite I fused to tergite II posteriorly, although not clearly so laterally; broadening posteriorly, slightly longer than posteriorly broad, with extremely precipitous and short anterior excavation; anterolateral portions strongly raised over edges of tergite; entire surface finely granular. Tergite II sculptured similarly to I, fused posteriorly to II, subquadrate and just over twice as broad as long. Tergite III sculptured similarly to I and II, much shorter than II and with weakly rounded posterolateral corners. Succeeding terga of normal, unsculptured, overlapping form. Hypopygium moderately long, acute apically, desclerotized medially into a series of expandable pleats. Ovipositor sheaths about 0.75 as long as hind tibiae, deep brown, slender-fusiform, hairy over most of length. Ovipositor weakly decurved, bladeliike.

Males: Unknown.

Variation: Only two virtually identical females known.

Cocoons: Unknown.

Material examined.—Holotype female: ARGENTINA: Buenos Aires, La Plata (Fac. Agronomia), X-XI-1968, C. Porter (MCZ). Paratype: 1 female, same data. Holotype and paratype in Museum of Comparative Zoology, Harvard University.

Hosts.—Unknown.

Comments.—The species is named for Dr. Sydney Cameron, for her unfailing support for my own efforts, for her many collections of braconid wasps over the years, and for her keen interest in the South American fauna.

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son helped support Mason's initial studies of these specimens. This and other studies of New World braconid genera have been supported by a grant from the National Science Foundation (DEB-9300517). Chris Carlton, Sydney Cameron and Scott Shaw provided useful comments on the manuscript; Scott Shaw also provided useful information on the curatorial history of these specimens.

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NOTES ON *PARABLASTOTHRIX NEARCTICA*
(HYMENOPTERA: ENCYRTIDAE)

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Abstract.—New host records and a range extension are reported for *Parablastothrix nearctica*, as well as inaccuracies in the original description. Only one adult emerges from each host, suggesting the species is monoembryonic. *Parablastothrix* has been placed in the Copidosomatini, but its mode of reproduction contrasts with the other genera of the tribe, all of which appear to consist of polyembryonic species.

Key Words: *Parablastothrix nearctica*, *Paradelius rubra*, *Stigmella variella*, Copidosomatini, polyembryony

Parablastothrix nearctica Miller (Hymenoptera: Encyrtidae) was described from specimens collected in the eastern United States and reared from two leafminers, a *Coptodisca* sp. (Lepidoptera: Heliozelidae) and an *Obrussa* sp. (Lepidoptera: Nepticulidae) (Miller 1965). In parts of this and some subsequent papers, this species was also referred to as *P. nearcticus*: this suffix is incorrect because the generic name is based on the Greek feminine *thrix*.

In March 1994, I collected five cocoons from the underside of leaves of a coast live oak (*Quercus agrifolia* Nee) at our experiment station in Albany, California. Three of these were formed by *Stigmella variella* (Braun) (Lepidoptera: Nepticulidae), from each of which emerged a single *Parablastothrix* adult (two females and one male). A male *Paradelius rubra* Whitfield (Hymenoptera: Braconidae) emerged from the fourth cocoon.

The *Parablastothrix* adults exhibited a frenetic activity, typical of many hyperparasitoids. But when I dissected the four empty cocoons, I found no more than one meconial pellet in each cocoon, indicating both

species were solitary, primary parasitoids. The fifth cocoon held a dead, well-formed *P. rubra* male pupa. In October 1994, I collected 10 more *Parablastothrix* adults (nine females and one male) from the foliage of the same trees.

The *Parablastothrix* specimens were identical to those reported in a study on parasitoids of leafmining lepidopterans on oaks in northern California, dating back to 1961 (Green 1979). All specimens had yellow legs with darkened metatibiae, and a green body with a bronze hue, but which otherwise matched the description of *P. nearctica*. Green (1979) reported this encyrtid emerged individually from cocoons of *S. variella*, and from undetermined stages of *Coptodisca powellella* Opler, *Bucculatrix albertiella* Busck (Lepidoptera: Lyonetiidae) and *Phyllonorycter sandraella* (Opler) (Lepidoptera: Gracillariidae), while still in their leaf mines.

Miller (1965) reported that *P. nearctica* had white legs, and the overall body color was black with bluish and greenish reflections. Reexamination of the holotype and two paratypes of *P. nearctica* revealed that

the original description was in error. All three type specimens have dark metatibiae and a green body, identical to the California specimens. Thus the latter represent a range extension of *P. nearctica*. I have seen additional specimens of *P. nearctica* collected from Arizona and central and southern California.

Hosts have been recorded for only 8 of the 17 described *Parablastothrix* species—all are leaf-mining Lepidoptera from the families Gracillariidae, Lyonetiidae, and Nepticulidae (Hedqvist 1976, Logvinovskaya 1981, Khan 1983, Trjapitzin 1989). An undescribed *Parablastothrix* sp. was reported as a solitary, primary parasitoid on a nepticulid, a heliozelid, and a gracillariid on pecan in Georgia (Dutcher and Heyerdahl 1988).

Hoffer (1955) placed *Parablastothrix* in the tribe Microteriyini (subtribe Pentacnemii), with *Calometopia* Mercet and *Pentacnemus* Howard. Noyes and Hayat (1984) synonymized *Pentacnemus* with *Copidosoma* Ratzeburg, and Trjapitzin (1989) synonymized *Calometopia* with *Parablastothrix*. Trjapitzin and Gordh (1978) placed *Parablastothrix* in the subtribe Parablastothrichina within the Copidosomatini, but remarked on the absence of proven polyembryony. Noyes and Hayat (1984) considered the genera in this subtribe to be morphologically closer to the Aphycina (tribe Aphycini); however they did not formally place these genera in their scheme of systematic relationships. Recent work by G. Zolnerowich (pers. comm.) retains *Parablastothrix* as a more basal lineage within the Copidosomatini.

Within the Copidosomatini, polyembryony appears to be the rule, having been reported in all species whose biologies have been investigated, including species of *Ap-silophrys* De Santis, *Copidosoma* (= *Litomastix* Thomson), *Copidosomopsis* Girault, *Paralitomastix* Mercet, *Ageniaspis* Dahlbom, *Holcothorax* Mayr and *Paraleurocerus* Girault (Noyes 1980, Noyes and Hayat 1984). Polyembryony may also occur in

Coelopencyrtus Timberlake (Timberlake 1919, Trjapitzin 1960, Taylor 1961, Annecke 1968), but this mode of reproduction has never been conclusively demonstrated.

Solitary parasitism presupposes monoembryony. However, such evidence is not conclusive, because the polyembryonic species *Macrocentrus ancyliivorus* Rohwer (Hymenoptera: Braconidae) is known to develop as a solitary parasitoid (Daniel 1932). Embryological studies have not been conducted on any *Parablastothrix* species. Nevertheless, the solitary habit of *P. nearctica* and the absence of any mention of multiple emergences from all other *Parablastothrix* rearing records, suggests that polyembryony is absent in the entire genus. Such a lifestyle would then biologically separate this genus from the remainder of the Copidosomatini.

Material examined.—ARIZONA. COCHISE Co.: 10 mi. W. Portal, on *Juniperus*. CALIFORNIA. ALAMEDA Co.: Albany, *Stigmella variella* on *Quercus agrifolia*; Berkeley Hills, *S. variella* on *Q. agrifolia* and *Phyllonorycter sandraella*; Patterson Reserve, Del Valle Lake, *Stigmella* sp.; CONTRA COSTA Co.: Antioch, *S. variella* on *Q. agrifolia*; 3 km E of Antioch, *S. variella* on *Q. agrifolia*; Cowell, *S. variella* on *Q. agrifolia*; Oakley, *S. variella* on *Q. agrifolia*; Russellmann Park; Russell Tree Farm, 6 km NE of Orinda, *S. variella*; MARIN Co.: Novato, *Coptodisca powellella* on *Q. agrifolia*; Sausalito, on *Q. agrifolia*; MONTEREY Co.: 10 km SE of Big Sur; SAN MATEO Co.: Woodside, *Bucculatrix albertiella* on *Q. agrifolia*; SANTA BARBARA Co.: Santa Cruz Island, Canada de la Cuesta, *Stigmella* sp. on *Q. dumosa*; SONOMA Co.: Sonoma, *Stigmella* sp. on *Q. agrifolia*. MICHIGAN. MIDLANDS Co.: VIRGINIA. Falls Church. MISSISSIPPI. HINDS Co.: Jackson, *Coptodisca* sp. on *Vaccinium arboreum* Marsh, holotype (no. 8800, deposited in Canadian National Collection, Ottawa, Ontario) and paratype (deposited in United States National Museum, Washington, D.C.). WEST VIRGINIA, MONON-

ALIA Co.: Morgantown, *Obrussa* sp.,
 paratype (deposited in U.S.N.M.).

ACKNOWLEDGMENTS

I thank Jerry Powell, University of California, Berkeley, for identifying the *S. variella* cocoons, and Michael Schauff (U.S.N.M.), Vince Lee (California Academy of Sciences) and Steven Heydon (U.C., Davis) for providing access to material. Gary Gibson of the Biosystematics Research Centre (Agriculture Canada) kindly reexamined the holotype of *P. nearctica*. Ken Hagen and Leo Caltagirone (U.C., Berkeley) and Gregory Zolnerowich (Texas A&M University) provided valuable discussions and advice.

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NOTE

A New Name For A Homonym In *Jembrana*
(Homoptera: Cercopoidea, Aphrophoridae)

In 1992 Chou, Yuan, and Liang published an article in which the name *Jembrana forcipenis* Chou and Liang was used for two different new species. This error was made by the printer and was not corrected by the authors because they did not see proofs of the article before publication. To correct this unfortunate mistake I propose the following replacement name for the second species.

***Jembrana wangi* Liang, NEW NAME**

Jembrana forcipenis Chou and Liang, *In* Chou, I., Yuan, F. and Liang, A.-P., 1992: 235, 236 (Chinese), 242 (English), fig. 2 *In* Chen, S. X., ed., *Insects of the Hengduan Mountains Region*, Science Press, Beijing, pp. 234–242. [preoccupied by *Jembrana forcipenis* Chou and Liang, *In* Chou, I., Yuan, F. and Liang, A.-P., 1992: 235 (Chinese), 241, 242 (English), fig. 1 *In* Chen, S. X., ed., *Insects of the Hengduan Mountains Region*, Science Press, Beijing, pp. 234–242.]

Jembrana wangi (as *J. forcipenis* Chou and Liang, *In* Chou, I., Yuan, F. and Liang, A.-P., 1992: 235, 236, 242, fig. 2) was described from three males from Sichuan (Nanping: Jiuzhaigou) and Shaanxi (Wugong) in China. The replacement name is a patronym to honor the collector of the holotype of this spittlebug, Mr. Suiyong Wang. The holotype is housed in the Insect Collection of the Institute of Zoology, Academia Sinica, Beijing, China.

Acknowledgments.—I thank Dr. Lee Herman of the Department of Entomology, American Museum of Natural History, New York, for his kind help during the preparation of this report.

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NOTE

Range Extensions for the Ant *Leptothorax pergandei* (Hymenoptera: Formicidae):
A Mesic Forest Species Discovered in the Chihuahuan Desert

Leptothorax pergandei Emery was recently evaluated, and determined to be a single, highly variable species (MacKay, W. 1993, *Sociobiology* 21: 287–297). This species normally occurs in shaded deciduous forests or shaded prairie sites of eastern United States, as far west as Nebraska, Kansas, Oklahoma and Texas, and as far north as Iowa (MacKay 1993, loc. cit.). We were thus very surprised to find this species in the Chihuahuan Desert in Arizona and in New Mexico, the first records of this species from both states and from such arid habitats.

This species was collected at two localities in Arizona. The first site is the Chiricahua Mountains, Cochise Co., 6.4 km WNW Jct. National Forest road 42 with National Forest road 42B, elevation 1580 m, 11-vii-1992 (Silver Creek Valley near Paradise). The area consists of a grazed, grassy meadow surrounding a wash with scattered oaks (*Quercus gambelii*) and junipers (*Juniperus monosperma*) up to 5 m tall. Other shrubs include rabbitbush (*Chrysothamnus* sp.) and Hopi tea (*Thelesperma megapotamicum*). The soil is fine textured with moderate to heavy clay. The *L. pergandei* nests are cryptic and fully exposed to the sun [vouchers in Museum of Comparative Zoology]. It is common in this area; 45 nests were collected and far more nests were seen. The second Arizona site is Graham Co., 14 mi. S Safford, ix-13-1976, leg. D. S. Chandler, from sweeping low vegetation [1 specimen in Univ. of Ariz., Tucson, collection].

The first site of two New Mexico collections is Hidalgo Co., San Simon Valley, 1 km W Jct. Rt. 80 on Rt. 533 (Portal Rd.), elevation 1250 m, 2-viii-1988 and 15-vii-

1992. The area consists of open, grazed Chihuahuan Desert scrub with scattered mesquite, *Ephedra* sp., patches of *Hilaria mutica*, creosotebush (*Larrea tridentata*) and mesquite (*Prosopis glandulosa*). The soil has a moderate to heavy clay component and parts of the area tend to accumulate water temporarily during summer rain events. *Leptothorax pergandei* nests are cryptic, consisting of tiny, bare holes in bare soil or in grass clumps, in areas fully exposed to the sun [vouchers in MCZ]. The second site in southern New Mexico is Doña Ana Co., 45 km NE Las Cruces. It is a typical creosotebush (*Larrea tridentata*) scrub community. A single worker was collected in a pitfall trap, 24-vi-1984 [voucher in Laboratory for Environmental Biology, UTEP].

This species is apparently not common in the Chihuahuan Desert. We have done extensive collecting in Arizona and New Mexico for over 17 years and these are the only Chihuahuan Desert collections we have for this species. In two of the localities (first and third listed), this species is abundant, nesting in open, sun-baked desert sites as if it were the "normal" habitat for this species. We have not collected it in more mesic sites in the two states, despite extensive collecting in such habitats.

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NOTE

Seasonal Flight Activity of *Vanhornia eucnemidarum* Crawford
(Hymenoptera: Vahnornidae) in the Mid-Atlantic States

I have been collecting with Malaise traps at various sites in Maryland, Virginia, and West Virginia from the coastal plain to the West Virginian and western Maryland Appalachians for more than ten years. The traps were in operation for the full season, from March or April to October or mid-November, depending on the site, and I have been able to accumulate seasonal flight data on an array of groups. I have always kept specimens and records of *Vanhornia eucnemidarum*, the only described North American species of the family. It has been considered rather rare and is scarce in collections. Most collection records of *V. eucnemidarum* are in spring, and the data presented here, based on collections of 398 specimens, verify it as a univoltine, spring-flying species. Deyrup (1985. *Great Lakes Entomologist* 18: 65–68) gave a comprehensive account of the biology and taxonomy of this species from his work in Indiana.

Specimens of *V. eucnemidarum* are not common, but I have found them at seven collecting sites where I have trapped. Specimens have been taken from mid-May to to late July, with the peak flight during the last third of May to the end of June (Fig. 1). The earliest record was V-8-14-1985 from Fairfax Co., Virginia, and the latest record was VII-19-28-1992 from Tucker Co., West Virginia.

Vanhornia eucnemidarum is known from Quebec west to Michigan, south to Georgia and Kentucky (Deyrup 1985). Localities for specimens I have examined are as follows, with the earliest and latest dates of collection, years of trapping, (number of specimens trapped, and number of traps used per year): MARYLAND: Prince Georges Co.,

Beltsville Agricultural Research Center, -- 16-23 to VII-11-24, 1991–1993 (32; 3 to 4 traps). VIRGINIA: Clarke Co., University of Virginia Blandy Experimental Farm, 2 mi. S. Boyce, VI-1-11 to VII-6-19, 1990–1994 (25; 5 to 11 traps); Fairfax Co., near Annandale, V-8-14 to VII-17-23, 1982–1994 (247; 1 trap); Essex Co., 1 mi. SE Dunnsville, V-13-29 to VII-10-27, 1991–1994 (75; 10 to 16 traps); Louisa Co., 4 mi. S. Cuckoo, V-28-VI-5 to VI-16-25, 1987–1989 (13; 4 to 12 traps). WEST VIRGINIA: Tucker Co., Fernow Experimental Forest, ca. 3 mi. S. Parsons, VI-10-19 to VII-19-28, 1991–1993 (5; 20 traps); Hardy Co., 3 mi. NE Mathias, VII-5-18, 1994 (1; 2 traps).

Vanhornia eucnemidarum is a parasitoid of beetles of the family Eucnemidae (see Deyrup 1985). Eucnemidae are found in wood that has just begun to decay, mainly in beech and maple. Most of the collections were in traps in woods or wood edges, a habitat where the hosts would be expected. All of the Tucker Co. traps were set within a broadleaf forest. The largest collections, however, were from a trap adjacent to a woodpile in my backyard (Fairfax Co.). I found specimens in this trap each of the 13 years of operation. We have a number of large silver maples (*Acer saccharum* Marsh.) around the house, and we frequently cut limbs and branches and add them to the woodpile, thus there is wood in various states of decay. Little did I know that I was creating a habitat suitable for the host beetle and its parasitoid as well.

I thank the following for allowing field work on their properties: M. Bowers, C. Sacchi, and E. Connor, University of Virginia Blandy Experimental Farm; J. and B.

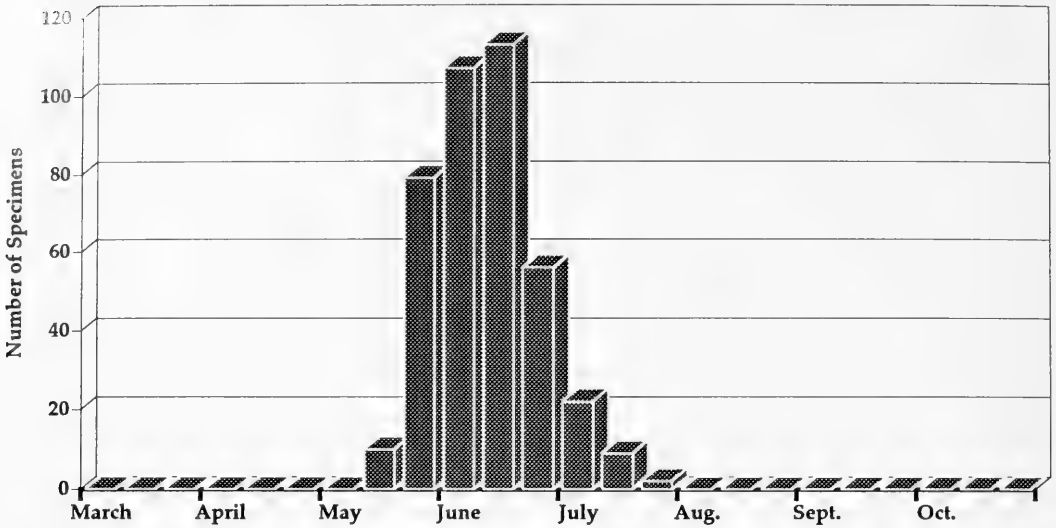


Fig. 1. Seasonal flight activity of *Vanhornia eucnemidarum* in the mid-Atlantic states. Includes records from all sites from 1982-1994.

Kloke, Louisa and Essex counties, Virginia; and T. J. Henry and D. R. Miller, Hardy Co., West Virginia. E.M. Barrows, Georgetown University, Washington, D.C., provided specimens from the Fernow Experimental Forest, Tucker Co., West Virginia.

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NOTE

Polistes dominulus (Christ) (Hymenoptera: Vespidae)
New to Maryland

Polistes dominulus (Christ) is a common and widespread paperwasp in the palearctic region. The species is common in Europe and often goes under the name *P. gallicus* (L.) (Menke, Spheces 12: 21, 1986). In the Palearctic *P. dominulus* is known from North Africa, the warmer parts of France, Belgium, and Germany, and eastward to the Pacific Coast of China. Generally, the species is found in warmer and drier localities within its range.

Polistes dominulus was first collected in the United States in 1980 at Cambridge, Massachusetts (Hathaway, Psyche 88: 169–173, 1981). Since 1980, *P. dominulus* has been collected in Connecticut, New Jersey, New York, Ohio, and Pennsylvania (R. S. Jacobson, per. comm.).

On 3 October 1994, I. B. Smith, Maryland Department of Agriculture, and R. Ruschell, University of Maryland, examined two colonies of *P. dominulus* on the

College Park campus. One colony was at the top of a door jamb of a seldom used doorway and the second was on the housing of an exhaust fan at approximately ground level in an exterior stairwell. Over 100 adult *P. dominulus* were collected. This is a new state record.

Polistes dominulus is a distinctive species, looking more like a yellowjacket (*Vespula* spp.) than any of the *Polistes* native to North America. It forms a typical paper wasp single comb in the open or in enclosed areas such as the open ends of pipes.

Voucher specimens have been deposited in the Maryland Department of Agriculture and the U.S. National Museum of Natural History. Maryland Department of Agriculture Contribution Number CN86-94.

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NOTE

Transferral of *Polycentropus timesis* (Denning) Comb. Nov. from the
Genus *Neureclipsis* (Trichoptera: Polycentropodidae)

Polycentropus timesis (Denning)
comb. nov.

Neureclipsis timesis Denning 1948, Bull.
Brooklyn Ent. Soc. 43: 119, fig. 1 ♂.

Polycentropus picicornis.—Blickle &
Morse 1955, Bull. Brooklyn Ent. Soc. 50:
96–98 [New Hampshire specimens are *P.*
timesis].

Recent collections of caddisfly material collected at Spruce Hole, Durham, New Hampshire, via Malaise traps, May–June 1990, by Donald S. Chandler, yielded specimens of *Neureclipsis timesis* Denning (1948), a species that previously was only known from the holotype collected in Amherst, Massachusetts. Examination of the type and other specimens of *N. timesis* shows that the hindwing of this species has M with only two branches, revealing that this species does not agree with diagnostic characteristics of the genus *Neureclipsis* McLachlan, and on this basis it is transferred to the genus *Polycentropus* Curtis. Further examination of specimens from New Hampshire previously identified as *P. picicornis* by Blickle & Morse (1955), in the insect collection at the University of

New Hampshire, shows that these specimens are actually *P. timesis*.

This species is rather closely related to *P. picicornis* Stephens 1836, and differs in the male genitalia having preanal appendage with a long slender ventroposterior apical lobe and a short basodorsal lobe in lateral view, see figures of *P. timesis* in (Denning 1948) and *P. picicornis* in (H. Malicky, 1983, *Atlas of European Trichoptera*, The Hague). It is also noted that specimens of *P. picicornis* from Europe and western Canada exhibit slight differences in the male genitalia; the form from Canada was described by A. P. Nimmo (1986: 240–241, *The adult Polycentropodidae of Canada and the adjacent United States*, Qaest. Ent. 22).

I am grateful to Oliver S. Flint, Jr., Smithsonian Institution, for his helpful suggestions, Donald S. Chandler, University of New Hampshire, for providing specimens examined, W. Pulawski, California Academy of Sciences, for the loan of the type, and P. Perkins, Museum of Comparative Zoology, and A. P. Nimmo for providing additional material.

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NOTE

Replacement of a Homonymic Species Name in Anobiidae (Coleoptera)

Up to 1977 the wood-boring beetles of the genus *Xyletinus* of this hemisphere consisted of 13 species from North America north of Mexico, and a single species from Mexico. In 1977 (White, Proceedings of the Entomological Society of Washington 79: 533) described as new ten species of *Xyletinus*, bringing the total of species known from North America north of Mexico to 19, and five from Mexico.

The species of *Xyletinus* that occur in America north of Mexico are readily separated into two groups: the elongated, large eyed species (body 2.3–2.7 times as long as wide, eyes separated by 1.0–3.7 times frontal width of an eye), and the less-elongated, small eyed species (body 1.6–2.0 times as long as wide, eyes separated by 4–7 times

frontal width of an eye). All six of the new species from America north of Mexico belong to the less-elongated, small-eyed species.

It has been called to my attention by Mr. Petr Zahradník (Jiloviste-Strnady, Praha, Czechoslovakia) that the Mexican species *Xyletinus cylindricus* White (1977: 533) is a junior, primary homonym preoccupied by *Xyletinus cylindricus* Kofler (1970. Zeitschrift der Arbeitsgemeinschaft Österreichischer Entomologen. 22: 143–145). I hereby propose *Xyletinus subcylindricus* NEW NAME, as a replacement.

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NOTE

Sassafras albidum: A New Host Plant Record for Larval
Melanolophia signataria (Lepidoptera: Geometridae) from
Central Virginia

Larvae of *Melanolophia signataria* (Walker) have been reported to feed on a wide variety of woody plants in eastern North America. Recorded host plants include: *Abies* spp. (firs), *Abies balsamea* (L.) Mill. (balsam fir), *Acer* spp. (maples) *Alnus* spp. (alders), *Betula* spp. (birches), *Betula alleghaniensis* Britton (yellow birch), *Larix laricina* (DuRoi) K. Koch (tamarack), *Picea* spp. (spruces), *Picea glauca* (Moench) Voss (white spruce), *Populus* spp. (poplars), *Quercus* spp. (oaks) and *Ulmus americana* L. (American elm) (McGuffin, 1944. Canadian Entomologist 76: 124; Forbes 1948. Lepidoptera of New York and neighboring states. Part II. Memoir 274. Cornell University Agricultural Experiment Station; Tietz 1952. The Lepidoptera of Pennsylvania. Pennsylvania Agricultural Experiment Station, Pennsylvania State College, State College, PA; Covell, 1984. A field guide to the moths of eastern North America. Houghton Mifflin Co. Boston, MA). Forbes (op cit) noted past confusion between larval host plants of *M. signataria* and the closely related *M. canadaria* (Guenee) and questioned the validity of some host plant records for both species. In this note I report a new, verified host plant record for larval *M. signataria* from central Virginia.

During early June 1991, I collected larval *M. signataria* from leaves of sassafras, *Sassafras albidum* (Nutt.) Nees, growing in a forest edge near Lovingson, Nelson County, Virginia, as part of a survey of the insect herbivore complex of *S. albidum*. Field-collected *M. signataria* larvae were confined to separate recloseable plastic sandwich bags containing fresh leaves of *S. albidum*

to determine: 1) if larvae actually feed and develop on *S. albidum*: or 2) if captures were incidental on a non-food host. Captive larvae of *M. signataria* fed readily on leaves of *S. albidum*, pupated, and emerged as adults within one month of collection, indicating that *S. albidum* is an acceptable host plant for larval feeding and development. cursory field surveys conducted in the same area during 1992 again noted the occurrence of larvae of *M. signataria* feeding on leaves of *S. albidum*, confirming the trophic association between insect and plant at this site.

Melanolophia signataria was by far the least numerous member of the larval lepidopteran fauna on *S. albidum* at the Virginia site (only three larvae could be collected for rearing in 1991), which was dominated by *Caloptilia sassafrasella* (Chambers) (Lepidoptera: Gracillariidae), *Epimecis hortaria* (F) (Lepidoptera: Geometridae) and *Papilio troilus* L. (Lepidoptera: Papilionidae). It is uncertain if the relative rarity of larval *M. signataria* on *S. albidum* at the Virginia study site is due to the infrequency of the species in the area in general, to the presence of more desirable primary host plants on which adults preferentially oviposit, or because larvae feed on such a broad array of host plants that they are widely dispersed across numerous hosts.

I thank Dr. D. C. Ferguson and M. A. Solis, of the Systematic Entomology Laboratory, Agricultural Research Service, United States Department of Agriculture, Washington, D.C., for identifying reared adults of *M. signataria*. Dr. M. A. Solis (Systematic Entomology Laboratory) and

one anonymous referee made constructive comments on the manuscript. Voucher specimens are deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C.

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SOCIETY MEETINGS

999th Regular Meeting—January 5, 1995

The 999th Regular Meeting of the Entomological Society of Washington was called to order by President John W. Neal, Jr. in the Naturalists' Center of the National Museum of Natural History at 8:04 pm on January 5, 1995. The meeting was attended by 20 members and two guests. Minutes for the 998th meeting were read for outgoing Recording Secretary Dr. M. Alma Solis by incoming Recording Secretary Ms Darlene D. Judd. Minutes were accepted as read.

President Neal called for officer reports. Reporting for Membership Chair M. Alma Solis, Dr. Nathan M. Schiff announced that no new membership applications had been submitted for December 1994.

President Neal called for reports of old business. Committee member, Dr. John M. Heraty reported the 1000th meeting would be held at the Log Lodge in Beltsville on Ground Hog Day and wine and cheese would be served. Dr. Heraty elaborated on the recent trials and tribulations in the search for a guest speaker and announced that the Committee expected a firm commitment from a potential individual in the following week. President Neal announced that the 1000th meeting would have two speakers. A visiting speaker, as yet unconfirmed and a speaker from the membership, Theodore J. Spillman. In the 1984 Proceedings of the Entomological Society of Washington 86: 1-10, Mr. Spillman published an account of the first 100 years of Society activities and his presentation for the 1000th meeting will convey the meaning "of Society." This concluded the reports of old business.

President Neal called for new business, but there was none.

President Neal called for the presentation of notes, exhibitions, and accessories. President Neal noted for the first time in many meetings that Dr. Nathan M. Schiff had

nothing to present to the membership. An ensuing discussion suggested Dr. Schiff's memory lapse was due to a "seasonal-affected disorder." Ms Jill Swearingen brought a copy of the "Identification Guide to Ant Genera of the World" by Barry Bolton (1994, \$65.00), published by Harvard University Press, Cambridge, Massachusetts. President Neal then queried the membership on the possibility of an amended format for 1000th meeting. Dr. Raymond J. Gayné suggested maintaining the format of the Regular meeting for the benefit of visitors and guests. President Neal subsequently instructed Program Chair Nathan Schiff to request the membership to bring unusual notes and specimens to this particular meeting and questioned whether a special announcement should be sent to members. Dr. Schiff reported that a flyer announcing the speakers and other information would be sent to members, but those present should remind their colleagues to bring notes and exhibitions to the 1000th meeting. It was resolved that the format for the Regular meeting would be maintained for the 1000th meeting.

Dr. Nathan M. Schiff, Program Chair, introduced the speaker for the evening, Dr. Paul J. Spangler, Department of Entomology, Smithsonian Institution, whose talk was entitled "An Expedition to the Mountain of the Mist, Venezuela." The presentation focused on a biotic survey conducted in 1985 of the Cerro de la Neblina in southern Venezuela. One hundred forty-four research scientists spent 45 days collecting, illustrating, preserving, and preparing specimens from variety of habitats. The slide presentation captured the varied landscape, dramatic views, unusual flora and fauna, various collection methods, and the day to day activities of field biologists. Investigators collected 54,926 specimens and wrote 125 publications from this one expedition.

Among the Insecta, 89 species were new to science, with the orders Coleoptera, Odonata, and Trichoptera producing the most new species. In addition to the presentation, Dr. Spangler displayed a drawer of insects, botanicals, and maps of the area.

President Neal called for the introduction of new members and visitors. Mrs. Mignon Davis announced that a retirement party had been given by the Department of Entomology for Dr. Oliver S. Flint at the Natural History Building on 5 January 1995. Dr. Flint specializes on the order Trichoptera and had been a Research Scientist with the Smithsonian Institution for 37 years. The meeting was adjourned at 9:28 pm.

Refreshments were provided by Dr. Harold Harlan.

Darlene D. Judd, *Recording Secretary*

1000th Regular Meeting—February 2,
1995

The 1000th Regular Meeting of the Entomological Society of Washington was called to order by President John W. Neal, Jr. in the USDA Auditorium, Building 003 in Beltsville, Maryland, at just after 8:00 pm on February 2, 1995. The meeting was attended by 60 members and 55 guests.

President Neal gave a short welcoming address to the audience. His presentation focused on the organizational meeting of the Entomological Society of Washington held on February 29, 1884, making our Society the 4th oldest entomological society in America. President Neal brought with him a copy of the announcement for that meeting held at the home of C. V. Riley.

The first order of business by President Neal was to postpone the reading of the minutes from the 999th Meeting of the Entomological Society of Washington to the regular March Meeting. There were no objections to the amended by-laws and it was tabled without a motion. President Neal called for reports from officers. Membership Chair Dr. M. Alma Solis announced that no new membership applications had been submitted for January 1995.

President Neal called for reports of old business. In behalf of the Society, President Neal acknowledged Drs. W. Steven Shephard, Nathan Schiff, and John Heraty for their skillful organization and planning of activities encompassing the 1000th meeting.

President Neal then called for presentation of notes and the exhibition of specimens. The President brought for exhibit two books: the "Fourth Annual Report to the State of Missouri," by C. V. Riley and "A History of Economic Entomology," by L. O. Howard (1930). As a personal recommendation of the latter, Dr. Neal stated "it will absolutely make you forget about what is going on in the real world."

Dr. Nathan M. Schiff, Program Chair, introduced the first speaker for the evening. Theodore J. Spilman, a member of our Society spoke on "Vignettes of a Thousand Meetings." Mr. Spilman acted as the audience's tour guide for a historic stroll through previously published reports in the Society minutes. Highly entertaining and craftily delivered, the personalities of the founders and flavor of the meetings left one with impression that a good time was had by all in attendance at those early meetings. Mr. Spilman closed his presentation by announcing that the 2000th meeting of the Entomological Society of Washington would be held on March 4, 2106.

Dr. Pam Henson, Smithsonian Archives, introduced the second speaker for the evening, Dr. David L. Hull from Northwestern University. He spoke on "Why Scientists Behave Scientifically." The talk focused on aspects of science which he perceives are done well by scientists.

President Neal normally would have requested at this time that visitors stand and introduce themselves; however, he broke with tradition and requested that the following individuals stand and be acknowledged: Honorary Members, followed by Past Presidents and finally Past and Present Officers and Chairpersons. (By the secretary's account, only the visitors remained seated.)

To the Society he made the following salute: You have served science and society for over a century and now you have met through a thousand meetings in ways never dreamed by your founders. May you continue to be a servant of society and be a shared experience and opportunity for those who find insects and their kin to be so compelling. To the Entomological Society of Washington, may you always find your members as curious and excitable, and as a Scientific society, be as strong and as vibrant at your 2000th meeting as you are today.

Finding no other business the meeting was adjourned at 9:46 pm.

A lavish assortment of wines and cheeses were provided courtesy of the Entomological Society of Washington.

Darlene D. Judd, *Recording Secretary*

1001st Regular Meeting—March 2, 1995

The 1001st Regular Meeting of the Entomological Society of Washington was called to order by President John W. Neal, Jr. in the Naturalists' Center of the National Museum of Natural History at 8:10 pm on March 2, 1995. The meeting was attended by 16 members and seven guests. Minutes for the 999th and 1000th meetings were read by Darlene D. Judd. Minor corrections were suggested for the 999th minutes and both sets of minutes were subsequently accepted.

Reports of officers and committees were read. Reporting for Membership Chair M. Alma Solis, Dr. Nathan Schiff announced there were three new members William A. Bruce, Lodewyk Kuenen, and J.R. Vockeroth. New member, Lodewyk (Bas) Kuenen, was present and was introduced to the membership.

President-elect Dr. Ralph P. Eckerlin reported the Entomological Society of Washington's Spring Banquet will be held Wednesday, 31 May 1995 at the Associates' Court in the National Museum of Natural History. The Banquet will be attended this year by members of Maryland Entomolog-

ical Society and an attempt was made also to invite the Chesapeake Association of Professional Entomologists. Individuals with suggestions for a possible speaker for the Spring Banquet should contact either Dr. Nathan M. Schiff or Dr. Ralph P. Eckerlin.

President Neal called for reports of old business. He thanked Drs. W. Steven Shepard, Nathan M. Schiff, and John M. Heraty for their assistance in organizing the 1000th Meeting of the Entomological Society of Washington.

A call was made for new business. President Neal suggested that the by-laws for the Society be reprinted in the Proceedings of the Entomological Society of Washington. The by-laws were last published in 1987 and appear in need of revision. Volunteers were sought to review the current by-laws prior to the April Regular Meeting. Two issues to be discussed at the Executive Meeting are the cost of a life-time membership and inclusion of the June meeting in the list of Regular Meetings of the Society. An Executive Committee meeting will be held 6 April 1995.

President Neal received a letter from a member of the Society who suggested that the site of Regular Meetings should be alternated between Washington and Maryland. This prompted a membership discussion on possible sites for future meetings. It was decided Dr. Nathan M. Schiff would mail a questionnaire on the subject to area members (approximately 200) between now and next fall.

Notes, exhibitions, and specimens were called for. Dr. Paul Spangler brought a book entitled "The Lucanid Beetles of the World," edited by Hiroshi Fujita (1994), published by Mushi-Sha, Japan. Dr. William E. Bickley reported the death of Dr. J. Franklin Yeager, a noted insect physiologist in January of 1995. Dr. David Furth announced a retirement party would be held for Mr. Bill Rowe of the Department of Entomology, National Museum of Natural History on 29 March 1995.

Dr. Nathan M. Schiff, Program Chair, introduced the speaker for the evening, Dr. Martha Weiss, Department of Botany, University of Maryland, whose talk was entitled "Color Learning in Butterflies."

Two guests were present, Roxanne Algart, Department of Entomology, University of Massachusetts, and Rick Turcotte, Bee Research Laboratory, USDA, Beltsville.

Refreshments were provided by Dr. William E. Bickley.

The Meeting was adjourned at 9:24 pm.

Darlene D. Judd, *Recording Secretary*

1002nd Regular Meeting—April 6, 1995

The 1002nd Regular Meeting of the Entomological Society of Washington was called to order by President John W. Neal, Jr. in the Naturalists' Center of the National Museum of Natural History at 8:04 pm on April 6, 1995. The meeting was attended by 21 members and five guests. Minutes for the 1001st meeting were read by Darlene D. Judd, and subsequently accepted.

Reports of officers and committees were read. Membership chair M. Alma Solis announced that there were no new members.

President-elect Ralph P. Eckerlin announced that the Chesapeake Association of Professional Entomologists were interested in attending the Spring Banquet. It was reaffirmed that the Spring Banquet will be held Wednesday, 31 May 1995, at the Associates Court in the National Museum of Natural History. The speaker will be Dr. Gary Umphrey, University of Western Ontario, who will speak on "Analyzing the Literature of Insect Fiction: Themes, Dreams, Schemes and Screams." The Master/Mistress of ceremonies will be Dr. Manya B. Stoetzel.

President Neal announced that the executive committee decided unanimously to elect Drs. J. Richard Gorham and Frank W. Meade as emeritus members. It was also decided that a committee would be set up to examine the Society's by-laws dealing with such items as life membership fees.

A call was made for new business. Dr. Manya B. Stoetzel announced that Dr. Robert D. Gordon of the Systematic Entomology Laboratory would be retiring at the end of April.

Notes, exhibitions, and specimens were called for. Warren E. Steiner exhibited some live specimens of the iron clad beetles, *Zopherus holdemani* (Zopheridae), that were recently collected in Texas.

Dr. Nathan Schiff introduced the speaker for the evening, Dr. Gary Miller, USDA-ARS Systematic Entomology Laboratory, Beltsville, who gave us an enlightening presentation on "Historical Natural History: A Study of Insects in the Civil War." Dr. Miller has researched various aspects of the involvement of insects in the war ranging from the number of deaths attributed to insect-borne disease, well-known entomologists who were enlisted on either side of the conflict (although there did appear to be a preponderance of northerners), games played by the infantry using insects, and the plagues of flies, lice, and fleas that caused more than one member of the audience to scratch in sympathy. Roughly 380,000 soldiers died from disease during the war; far more than the 200,000 that actually died in battle. Over 25% of the union soldiers contracted "simple intermittent fever" or malaria. At least one anti-malarial remedy offered to southern troops included 30 parts dogwood bark, 30 parts poplar bark, and 40 parts willow bark, which was served with whiskey at 45 degree strength. The willow bark that contains salicylic acid may have offered some relief, but it was probably the whiskey that helped to raise the spirits of the soldiers.

Four guests were presented to the members: Mellissa and Brian Miller, Denise Whitman of the Department of Invertebrates, Smithsonian Institution; Kim Nesci, Department of Entomology, University of Maryland; and Ian Lowe, Fredrickburg and Sotsylvania National Military Park.

Refreshments were provided by Dr. John W. Neal, Jr.

The meeting adjourned at 9:16 pm.

John M. Heraty for Darlene D. Judd,
Recording Secretary

1003rd Regular Meeting—May 4, 1995

The 1003rd Regular Meeting of the Entomological Society of Washington was called to order by President John W. Neal, Jr. at the National Visitor Center (Beltsville) at 8:05 pm on May 4, 1995. The meeting was attended by 22 members and 19 guests. Minutes for the 1002nd meeting were read by Dr. John M. Heraty for Recording Secretary Darlene D. Judd, and subsequently accepted.

Reports of officers and committees were called for. Membership chair M. Alma Solis announced that there were two new members: Stephen Gamari (University of Illinois, Urbana, IL) and Eric L. Johnson (Aphis-PPQ, Seattle, WA).

President-elect Ralph P. Eckerlin announced the menu of the Spring Banquet was finalized. The banquet date and speaker were reaffirmed.

President Neal announced that it was decided that Dr. Norman E. Woodley and Dr. David Smith would review the Society's by-laws and present their report to the Society in October.

No new business was reported.

Notes, exhibitions, and specimens were called for. Dr. Manya B. Stoetzel made a presentation of some "dark black things" that she identified as conifer-infesting aphids, possibly of the genus *Sinara*. Dr. Nathan M. Schiff commented on the attraction of yellowjackets to aphids on conifers in the fall near the bee research laboratories. Dr. Schiff raised the question about where the meetings would be held next fall. Dr.

Neal commented that they would probably be in the Waldo Schmitt room at the National Museum of Natural History.

Dr. Schiff introduced the speaker for the evening, Dr. James Marden of Pennsylvania State University, who gave a fascinating talk on "Surface Skimming Stoneflies: Testing the Evolutionary Hypotheses of Insect Flight." Dr. Marden has been focusing on the functional morphology of Taeniopterygidae (winter stoneflies). Taeniopterygids are essentially flightless but use their wings to propel them across the water by wing flapping or by raising the wings into a vertical position and using them as sails. Dr. Marden proposed that skimming is a more plausible intermediate step toward developing functional wings for flight than the use of gill flaps for gliding. His work was supported by various experiments on observing skimming behavior, changing parameters of the wings such as length, and characterizing the morphology of wing venation within a phylogenetic perspective to explain the ancestral origin of this behavior. Dr. Marden proposed that the ability to fly may have developed more than once, but the capability for flight may have developed in a surface-skimming ancestor.

Seven guests were presented to the members. Dr. Stoetzel introduced Dr. Curtis Saborosky and Ms Louise Russell. Ms Russell noted that at age 90 she had been a member of the Society for more than 60 years, many more years than the age of most attending members.

Refreshments were provided by Dr. Manya Stoetzel.

The meeting was adjourned at 9:21 pm.

Dr. John M. Heraty for Darlene D. Judd,
Recording Secretary

PROCEEDINGS
of the
ENTOMOLOGICAL SOCIETY
of
WASHINGTON

Volume 97

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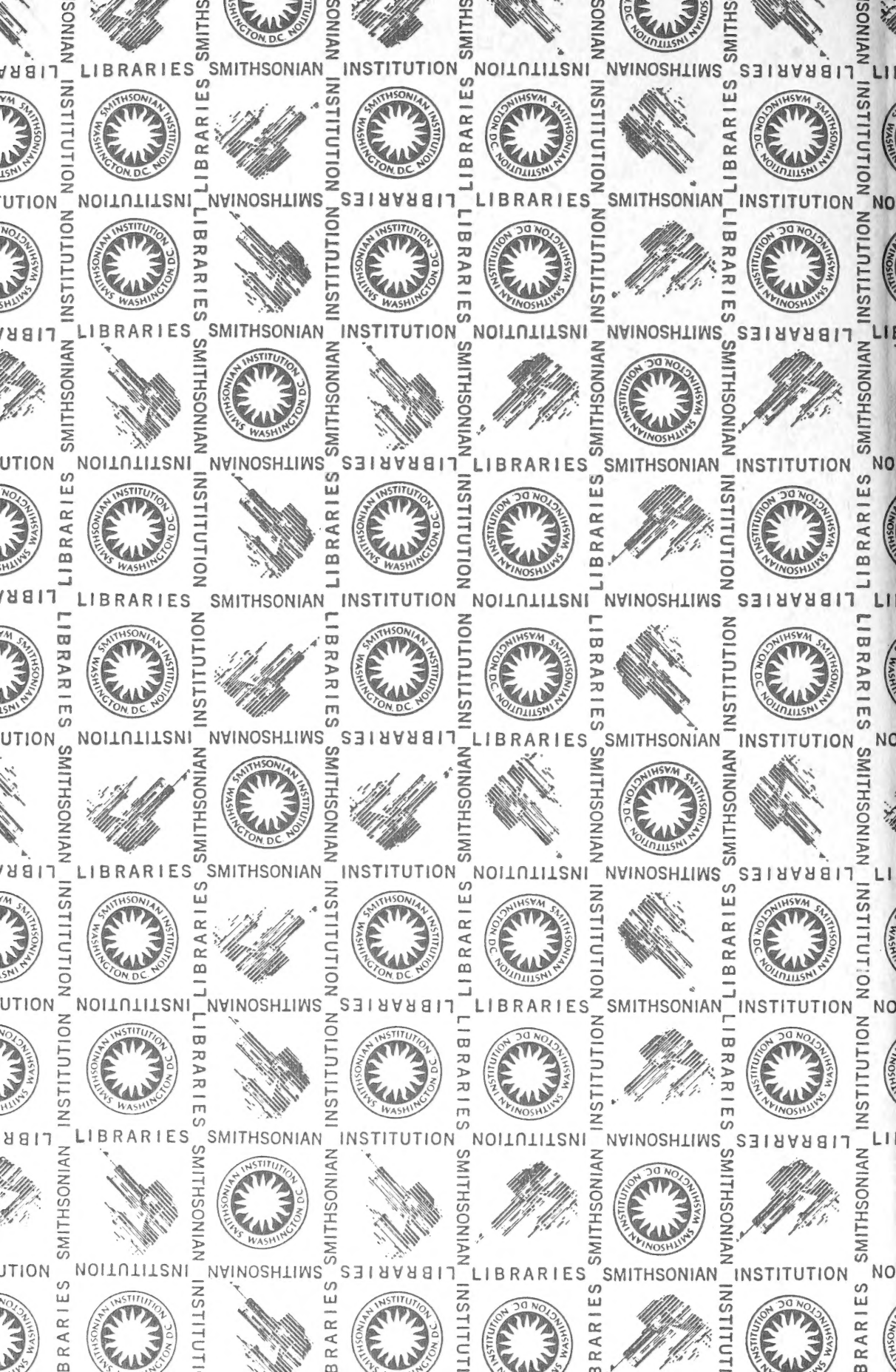
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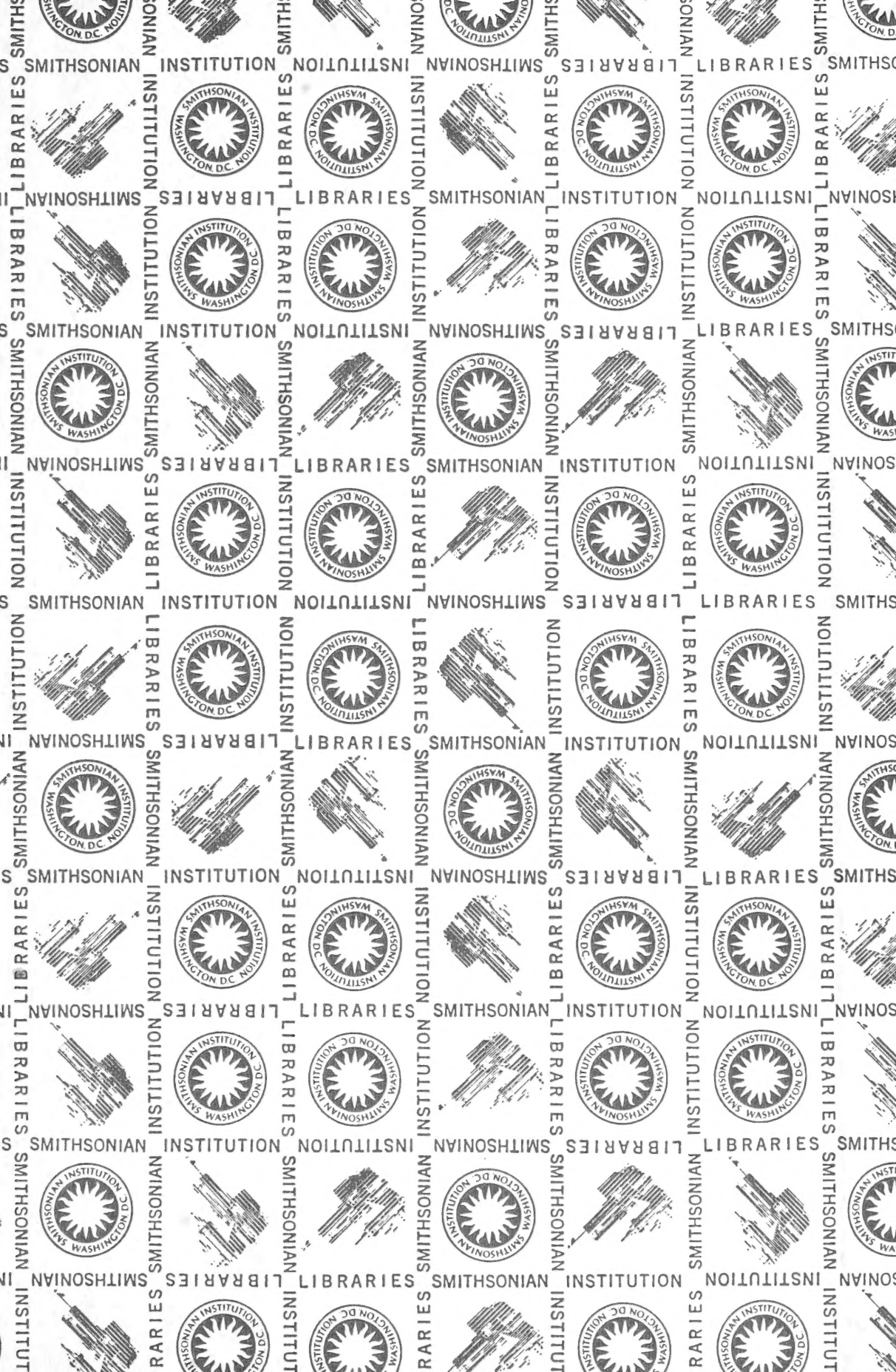
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