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A REVIEW OF THE GENUS *TACHYGONUS* (COLEOPTERA: CURCULIONIDAE) NORTH OF MEXICO

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Abstract.—Examination of types of North American *Tachygonus* shows that there are five valid species that occur north of Mexico: *T. lecontei* on oaks, *T. tardipes* on elm, *T. centralis* on locust (*Robinia*), *T. rhombus* on *Coursetia,* and *T. fulvipes* on *Berchemia.* Characters and placement of the genus are discussed. A key to North American species is presented as well as diagnoses and figures; five new synonymies are proposed. Variation in color patterns of *T. rhombus* and *tardipes* is documented, and that in *T. lecontei* is analyzed geographically. Arizona populations on oak, assigned here to *T. lecontei* may represent more than one distinct species, but require additional collecting and perhaps biological studies to determine species limits.

Key Words: Biogeography, host plants, intraspecific variation, leaf-miners

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The weevil genus *Tachygonus* Schoenherr is widely distributed in the New World, occurring from Canada to Argentina. Members of the genus are unusual morphologically in being dorsoventrally flattened, having enlarged hind legs which articulate primarily in the plane of the body rather than perpendicular to it, and possessing a very short first antennal segment. At least part of their unusual form is related to their larval ecology as leaf-miners. Unfortunately, little has been published on the biology of the genus other than a life history of one Brazilian species (Kogan 1963) and the adult behavior of a Panamanian species in the closely related genus *Tachygonidius* (Aiello and Vogt 1986; review in Hespenheide 1991). Similarly, the ecology of North American species is largely unknown, other than for *T. lecontei* or mention of host plants for other species (see below).

The genus *Tachygonus* was first proposed by Schoenherr for the North American species *T. lecontei* in 1833. LeConte (1868, 1876) described three additional species and Casey (1897) named three more forms in his revision; two other names have been proposed subsequently (Blatchley 1920, 1922). The existence of several apparently unique types and the discovery of extensive variation in three North American species indicated a need for a review of the genus. From the study of these types and other material, I conclude here that the fauna of America north of Mexico consists of five species and that five other names are synonyms, although further study is needed of southwestern populations assigned here to *T. lecontei.*

Tachygonus Schoenherr

As mentioned above, the genus *Tachygonus* is characterized by the short scape and non-geniculate antennae and the unusual hind legs, making its members "among the strangest insects of the family" (LeConte 1876). In most recent catalogues (O'Brien and Wibmer 1982, Klima 1936) and treatments (Blatchley & Leng 1916) the genus is given its own subfamily, together with one other small New World segregate (*Tachygonidius,* Champion 1906) and with two Old World genera that are probably not related. When the large number of undescribed Neotropical species are studied, additional genera may well be recognized. In addition to striking modifications of the hind femora (Champion 1906: 131), I have found that species of *Tachygonus* differ in the structure of the mesosternum and in the presence or absence of a visible scutellum (see below), which are characters often used to separate genera, for example in the Zygopinae.

The relationships and placement of *Tachygonus* are uncertain. Although currently treated as its own subfamily, it has also been treated as a tribe (LeConte 1876, Casey 1897) or even as a family (Pierce 1916). It seems likely that its morphology is highly derived as a consequence of its ecology. Several authors have suggested a connection with the Zygopinae: LeConte (1876) noted the large eyes and very narrow front; Casey (1897), the 7-jointed funicle and the large, curved tibial spine; and Champion (1906), the pectinate setae shared with *Philides.* Champion (1906) placed the genus immediately after *Philides* and the "Zygopina." *Tachygonus* also shares an exposed pygidium and enlarged simple pale setae along the apical margin of the elytral suture with *Philides* and *Philinna,* although placement of these genera in the Zygopinae is uncertain (Champion 1906: 129). Several genera in the Zygopinae possess enlarged, elongate posterior legs, including arcuate, flattened tibiae (*Mnemyne, Paramnemyne, Paramnemynellus,* etc.), although none of these are very similar to *Tachygonus* in specific details.

Within the genus, species have typically been separated by characters from the structure of the posterior legs (LeConte 1876, Casey 1897), especially their size and shape, the number and size and position of the teeth on the femora, and the shape of the tibiae. The overall shape and ground color and the pattern of setae have also been used, but these prove to be quite variable and difficult to interpret unless large series of specimens are available. In addition to the mesosternum and scutellum mentioned above, I have also found that species differ in the size and shape of the tarsi. North American species of *Tachygonus* can be separated by the following key. The five species are then considered in turn.

KEY TO NORTH AMERICAN *TACHYGONUS*

1\. Mesosternum excavate and laterally carinate for receiving tip of rostrum; elytra black; pectinate setae of elytral disc bicolored, white and fulvous; legs bicolored; scutellum inconspicuous; Arizona, Mexico to Panama *rhombus* Casey

– Mesosternum transverse between middle coxae; elytra black, reddish or variegated; pectinate setae of elytra usually white; legs uni- or bicolored; scutellum conspicuous or not 2

2\. Hind tibiae strongly curved, flattened, usually sharply angulate on external margin; erect tufts of dark setae on disc of pronotum on both sides of midline on basal half; erect tufts of white setae on elytral disk at apical ¾; scutellum conspicuous; length to tip of elytra usually greater than 2.5 mm; hosts: *Quercus* spp.; eastern United States to Guatemala .... *lecontei* Gyll.

– Hind tibiae straight or only slightly curved, not conspicuously flattened or angulate on external margin; small patches of semi-erect white setae at posterior angles of pronotum; semi-erect patches of white setae on elytra usually only along suture behind scutellum; scutellum conspicuous or not; length usually less than 2.5 mm 3

3\. Elytra bicolored, yellowish and black; pectinate setae on elytra usually in several conspicuous patches; hind femora long, slender, not noticeably swollen, with three long slender spines on inner margin; scutellum conspicuous; host: elm .... *tardipes* LeConte

– Elytra black; pectinate setae on elytra in conspicuous patches only along suture behind scutellum; hind femora short, swollen, with few short teeth on inner margin; scutellum inconspicuous 4

4\. Rostrum and legs all black; third tarsal joint scarcely wider than second; all elytral intervals similar; length usually greater than 2.1 mm; host: *Robinia* spp.; southwestern states .... *centralis* LeConte

– Apex of rostrum and at least fore tibiae yellow or pale; third tarsal joint conspicuously wider than second; even elytral intervals elevated, at least at base; length usually less than 2.1 mm; Gulf states .... *fulvipes* LeConte

Tachygonus rhombus Casey, 1897: 681.
Tachygonus tardipes LeConte, 1884, not LeConte, 1876.

Form rhomboid, more narrowly attenuate in front than behind. Black, except antennae, fore and middle legs, basal half of hind femora yellowish- to brownish-orange; semi-erect white pectinate setae in small tufts at posterior angles of pronotum, on scutellum, and in spot on first elytral interval behind scutellum; recumbent white pectinate setae scattered on elytra, dense on base of rostrum, sides of pronotum, on epimera and episterna, somewhat sparser on ventral surface and basal half of hind femora; yellow-orange pectinate setae in spot along suture of elytra behind scutellum, more or less scattered on elytra, especially at base; simple erect white setae on pygidium and basal half of hind femora; coarse simple erect dark setae on pronotum, elytra, distal and hind tibiae. Figure 3.

Pronotum rather sparsely punctate, shining. Elytra coarsely punctate, intervals raised, even ones somewhat more strongly so. Mesosternum declivous with well-defined longitudinal groove for receiving tip of rostrum, with smooth, narrow channel in middle and margins on outer edge. Abdomen more or less uniformly punctate, more sparsely so in middle of segment 2. Hind femora relatively short, arcuately curved at base, moderately swollen beyond middle, with two acute teeth, inner one at distal ¾ and longer, outer one shorter, between inner tooth and middle; hind tibiae more or less terete and straight, slightly twisted outward at tip; segment 3 of tarsi equal in width to segment 2.

Distribution: Arizona, Mexico (Guerrero, Morelos, Oaxaca, Quintana Roo, Tamaulipas); Honduras (Copan); Costa Rica (Guanacaste); Panama (Panama).

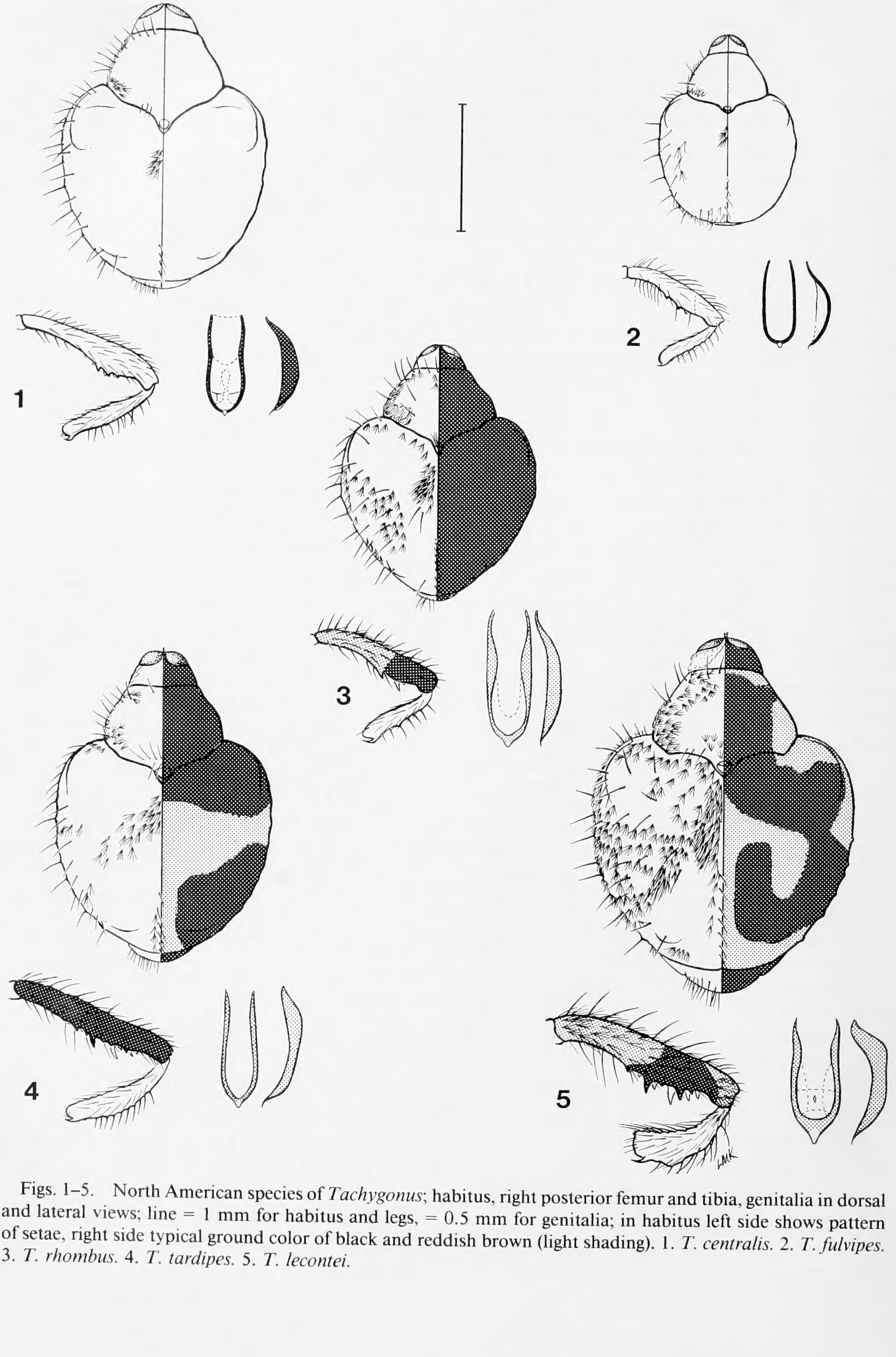
Adult host: Coursetia microphylla Gray (Fabaceae).

Discussion: As treated here, this species is rather variable, primarily in the density of pectinate setae on the disc of the elytra other than the post-scutellar tufts. The structure of the mesosternum has not been mentioned in previous publications on this or any other species of *Tachygonus.* In most members of the genus the mesosternum is transverse and essentially unmodified except for surface sculpture. It is modified in *T. rhombus* and about 11 other of about 60 species known to me from North and Central America, including the described forms *T. caseyi* Champion, *T. flavisetis* Champion, *T. semirufus* Champion, and *T. gowdeyi* Marshall. The inconspicuous scutellum is shared with *T. centralis* and *T. fulvipes* among North American species as well as with *T. caseyi, T. flavisetis* and *T. gowdeyi.*

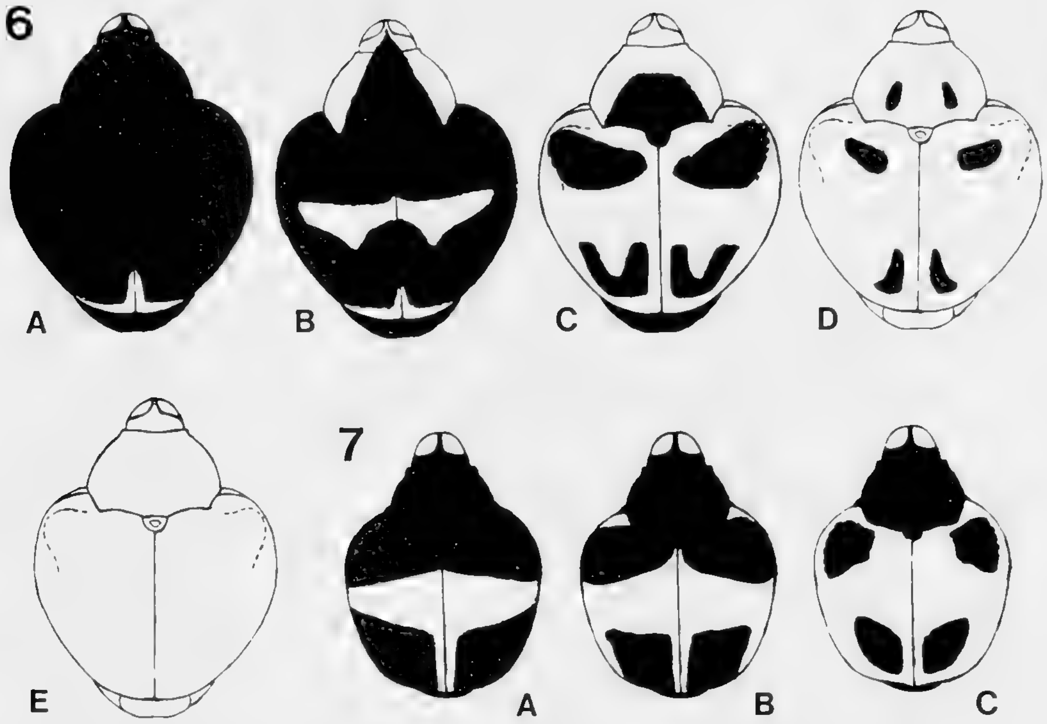
Although collected in numbers in Arizona by Morrison (Champion 1906, Casey 1897), there are only three recent collections, all from Tucson or nearby Sabino Canyon in the Santa Catalina Mountains, in one case from *Coursetia.* Two specimens in the U.S. National Museum are labelled "Cal.," but no other specimens are known from California.

Tachygonus lecontei Gyllenhal, in Schoenherr, 1833: 312.
T. horridus Chevrolat, 1835: pl. 38.
T. spinipes Casey, 1897: 680. NEW SYNONYMY.
T. bifasciculatus Champion, 1906: 135. NEW SYNONYMY.

Form ovoid-rhomboid, more narrowly attenuate in front, more rounded behind. Color very variable (Fig. 6; see discussion below), from the extreme of mostly dark reddish brown and only metasternum and abdomen black to mostly black except antennae, tip of rostrum, tips of elytra, fore and middle legs, and basal ½ of hind femora pale to dark reddish brown; coarse simple erect dark setae in tuft on pronotum on either side of midline at basal ⅓, elsewhere scattered on pronotum, elytra, distal half of



Figs. 1–5. North American species of *Tachygonus*; habitus, right posterior femur and tibia, genitalia in dorsal and lateral views; line = 1 mm for habitus and legs, = 0.5 mm for genitalia; in habitus left side shows pattern of setae, right side typical ground color of black and reddish brown (light shading). 1. *T. centralis.* 2. *T. fulvipes.* 3. *T. rhombus.* 4. *T. tardipes.* 5. *T. lecontei.*



Figs. 6–7. Variation in ground color. 6.(a–e) *Tachygonus lecontei.* 7.(a–c) *T. tardipes.*

hind femora and hind tibiae; semi-erect white pectinate setae in small dense tuft on elytra beyond middle and midway between suture and lateral margin, in larger diffuse tuft on elytra before middle and behind scutellum along interval 1, more or less dense white pectinate setae on front, sides of pronotum, epimera and episterna, lateral margins of metasternum and abdominal segments, along anterior margins and in transverse band across middle of elytra, and the basal ½ of posterior femora; simple erect white setae on pygidium and basal ½ of hind femora. Figure 5.

Pronotum densely punctate on disk, except for rectangular impunctate area along midline at middle, shining; scutellum conspicuous. Elytra coarsely punctate, intervals raised, humeri very prominent. Mesosternum vertical, transverse, glabrous. Abdomen relatively densely punctate except for transverse elliptical impunctate area along suture between segments 1 and 2. Hind femora relatively stout, somewhat swollen beyond middle, with inner and outer series of 3(–4) teeth, teeth stout, acute, slightly curved apically, outer teeth longer and series beginning at middle of femora, inner beginning at ⅔ length, first in series longest; hind tibiae somewhat flattened, shallowly arcuate on inner margin, biangulate on outer margin, with narrower angle near apex, wider angle at basal ⅓, apex obliquely truncate inward; segment 3 of tarsi nearly 2× wider than segment 2.

Distribution: Alabama, Arkansas, Arizona, District of Columbia, Florida, Georgia, Indiana, Louisiana, Maryland, Mississippi, New Jersey, New York, North Carolina, Ohio, South Carolina, Tennessee, Texas, Virginia; Mexico (Queretaro); Guatemala.

Larval hosts: Quercus spp.

Discussion: Examination of the types of all four names—those of *T. lecontei* and *horridus* from Stockholm, *spinipes* from the U.S. National Museum, and *bifasciculatus* from the British Museum—and study of the geographic variation in the color and setation pattern of the *Tachygonus* associated with oaks in North America (see below) shows both *spinipes* and *bifasciculatus* to fall within the range of variation of this widely distributed species, which argues against retaining the names. The name *spinipes* is associated with the extreme form which has a combination of black ground color and sparse elytral setae. Because this extreme form turns up in widely separated geographic areas (Long Island, N.Y.; New Jersey; Maryland: Georgia; Arkansas; Ohio; Indiana) and because it occurs (in populations other than New York) mixed with other forms, there does not seem to be any special reason to retain the name even as a subspecific epithet.

Although *T. lecontei* is the most widely distributed and frequently collected species of *Tachygonus,* there has been no published study of its life history. The leaf-mining insect faunas of oaks have been extensively studied ecologically (review in Hespenheide 1991), but have mentioned *T. lecontei* only in passing: Bultman and Faeth (1985) estimated densities on *Quercus falcata* Michx., *Q. hemisphaerica* Bartr. and *Q. nigra* L. in northern Florida to be relatively low (0.35–1.36/1000 leaves) among the 14 miners using the three oaks; Faeth and Simberloff (1981; their Table 1) estimated 2–3 generations/year and duration of the mining stages to be 30–60 d on these hosts at the same site.

Tachygonus tardipes LeConte, 1876: 266.
T. gracilipes Casey, 1897: 680. New Synonymy.

Form ovoid-rhomboid, rather irregularly attenuate in front, broadly rounded behind, elytra abruptly wider than pronotum. Color variable, mostly black or dark reddish brown, except yellow antennae, transverse band and more or less of rest of elytra (Fig. 7), fore and middle legs, and hind tarsi; tip of rostrum and hind tibiae light brown; semierect white pectinate setae on elytra in irregular patch interior to suture and behind scutellum, in small spots on disk, and on apical margins; recumbent white pectinate setae on sides of pronotum and metepisterna, sparsely on metasterna and abdominal segments 1–2, densely on posterior margin of segment 2; simple erect white setae on pygidium and basal ½ of hind femora; coarse simple erect dark or yellowish setae on pronotum, elytra, distal half of hind femora and hind tibiae. Figure 4.

Pronotum conspicuously constricted behind apex to form "collar," noticeably convex from side, moderately punctate on disk, more sparsely so along midline at middle, shining; scutellum conspicuous. Elytra finely punctate, punctures separated by more than their diameters, intervals raised, even ones more strongly so. Mesosternum vertical, transverse, finely transversely rugose. Abdomen sparsely punctate on segments 1 and 2. Hind femora long, straight, scarcely swollen, with 2 long acute spines on inner side beyond middle and a third on outer side at middle; hind tibiae long, shallowly arcuate, especially on outer margin, somewhat flattened; segment 3 of tarsi nearly 2 × wider than segment 2.

Distribution: Indiana, Ohio, New York, Pennsylvania, Texas; Canada (Ontario).

Adult hosts: Ulmus spp.

Discussion: Examination of the types of both names and study of the variation among specimens at a single locality (Cincinnati, Ohio) shows that these names should be considered to refer to the same species. Variation occurs primarily in the proportion of black and yellow on the elytra (Fig. 7) and is similar to, albeit less extensive than the range of variation shown by *T. lecontei.* Adults are associated with elm (*Ulmus americana* L.) and the species seems most common in the upper Ohio River Valley. Although the type of *T. tardipes* is from Texas without locality and therefore apparently disjunct, there is a recent collection from Burleson County (R. H. Turnbow).

Tachygonus centralis LeConte, 1868: 55.
T. fulvipes var. *nigrescens* Blatchley 1922: 98. New Synonymy.

Form rhomboid, rather narrowly attenuate in front and behind, elytra abruptly wider than pronotum. Black, except antennae, tips of tibiae, and last two tarsal segments pale yellowish brown; semi-erect white pectinate setae in small tufts at posterior angles of pronotum, and in large spot along suture behind scutellum; recumbent white pectinate setae on sides of pronotum, metepisterna and sides of metasterna, and posterior corners of abdominal segment 2; simple erect white setae on pygidium and basal half of hind femora; coarse simple erect dark setae on pronotum, elytra, distal half of hind femora and hind tibiae. Figure 1.

Pronotum moderately densely punctate, shining; scutellum inconspicuous. Elytra coarsely punctate, punctures larger than intervals, intervals slightly raised. Mesosternum vertical, transverse, smooth. Abdomen coarsely, densely punctate. Hind femora slender at base, swollen at apical ⅔, with 2–3 short, blunt teeth or tubercles; hind tibiae terete and nearly straight, slightly twisted outward at tip; segment 3 of tarsi only slightly wider than segment 2.

Distribution: Arizona, Colorado, Illinois, Nebraska, New Mexico, Texas.

Adult host: Robinia neomexicana Gray (Fabaceae).

Discussion: Of 141 specimens examined in this study, all but 12 were collected in Arizona, where it occurs widely. Specimens from Nebraska (AMNH) and Texas (USNM) were without further locality data. Blatchley (1922) in the original description of his "variety" *nigrescens* suggested that it might prove to be conspecific with *centralis.* My examination of the type of *nigrescens* in the Field Museum confirmed his suspicion. The type of *nigrescens* is from Illinois, far from the next closest specimens from Nebraska. This species is relatively common on its host plants in Arizona, shrubs of the genus *Robinia.* LeConte (1868) records the type as occurring on a species of *Rhus* in Colorado, but the specimen labelled as the type in the Museum of Comparative Zoology also has a "N.M." label; three other specimens associated with the type are unlabelled. The original description gives the length as "1.5 mm," although the smallest of the four specimens is 1.9 mm and the type is 2.3 mm. Because no other species of *Tachygonus* are known from the area, there is no confusion about the identity of *T. centralis,* but the typification deserves further study.

Tachygonus fulvipes LeConte, 1876: 266.
T. minutus Blatchley 1920: 263. NEW SYNONYMY.

Form ovoid, rather narrowly attenuate in front, broadly rounded behind, elytra abruptly wider than pronotum. Color somewhat variable, from mostly black, except antennae, apical half of rostrum, fore and middle tibiae and tarsi, bases of fore and middle femora, hind tarsi and apex of tibia pale yellowish brown to black with all of legs yellowish except distal ⅓ of femora dark brown; semi-erect white pectinate setae in small tufts at posterior angles of pronotum, and in large spot along suture behind scutellum; recumbent white pectinate setae on apical margins of elytra and very sparsely scattered on disk, on sides of pronotum, on metepisterna and sides of metasterna, and abdominal segments 2–4, and basal ⅔ of hind femora; simple erect white setae on pygidium and basal ⅔ of hind femora; coarse simple erect dark setae on pronotum, elytra, distal half of hind femora and hind tibiae. Figure 2.

Pronotum sparsely punctate on disk, with oval impunctate area along midline slightly behind middle, shining; scutellum inconspicuous. Elytra coarsely punctate, punctures slightly larger than intervals, even intervals raised. Mesosternum vertical, transverse, smooth. Abdomen sparsely punctate on segments 1 and 2. Hind femora relatively short and stout, somewhat swollen with a short acute tooth on inner side at apical ⅔; hind tibiae terete and slightly sinuate, twisted outward at tip; segment 3 of tarsi nearly 2× wider than segment 2.

Distribution: Alabama, Florida, Louisiana, Illinois, Texas.

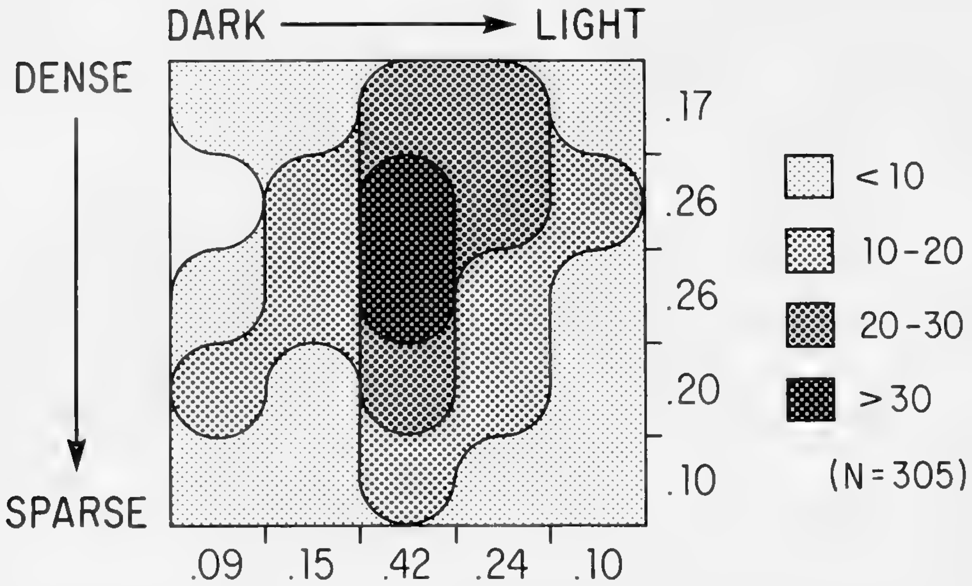


Fig. 8. Relationship between ground color and setation pattern in *Tachygonus lecontei*. Ground color varies from dark to light (Fig. 6); setae vary from dense to sparse. Number of specimens in each category is indicated by shading, and the proportions of all specimens is indicated on the right and bottom margins.

Adult host: Berchemia scandens (Hill) K. Koch (Rhamnaceae).

Discussion: Examination of the type of *T. fulvipes* in the collection of the Museum of Comparative Zoology shows it to be teneral, which has probably confused later interpretations of it. My experience in rearing species of *Tachygonus* is that they often emerge from the leaf before becoming completely colored. A specimen from Texas was compared with the types of both *T. minutus* at Purdue University and *fulvipes,* and was found to differ only in color and size. This had been the least frequently collected species of *Tachygonus* in North America until a long series was taken by Robert H. Turnbow in Alabama. These insects were collected on *Berchemia* and differ from the other collections from Louisiana and Texas in having darker legs and being somewhat larger. Because male genitalia were identical and no other consistent differences appear to exist, all are considered conspecific. The distribution of *T. fulvipes* seems primarily to be close to the coast of the Gulf of Mexico, despite the type from "Illinois." The record of Monte (1949) for this species (as *T. minutus*) from Tampico, Mexico, refers to another, undescribed species.

VARIATION IN NORTH AMERICAN *TACHYGONUS*

Because of the variation observed among specimens of *T. lecontei, T. tardipes* and *T. rhombus,* these three species were scored for patterns of variation in ground color (*T. tardipes,* Fig. 7), density and color of setae (*T. rhombus*), or both (*T. lecontei,* Figs. 6, 8, 9). Only *T. lecontei* was numerous enough in collections that patterns in variation could be analyzed quantitatively. The following discussion is based on 310 specimens of the species that were assigned to one of five categories of integument color from mostly black to mostly reddish brown (Fig. 6) and one of five categories of densities of setae on the elytra from sparse to dense. Figure 8 shows the relationship between ground color and density of setae for all specimens of *T. lecontei* examined. In general there appears to be a very weak correlation between red coloration and higher density of setae, but most specimens are intermediate in both characters.

Geographic variation in these two characters in *T. lecontei* is shown in Fig. 9. As can be seen, change in the proportions of specimens of different ground color and density of setae changes clinally throughout

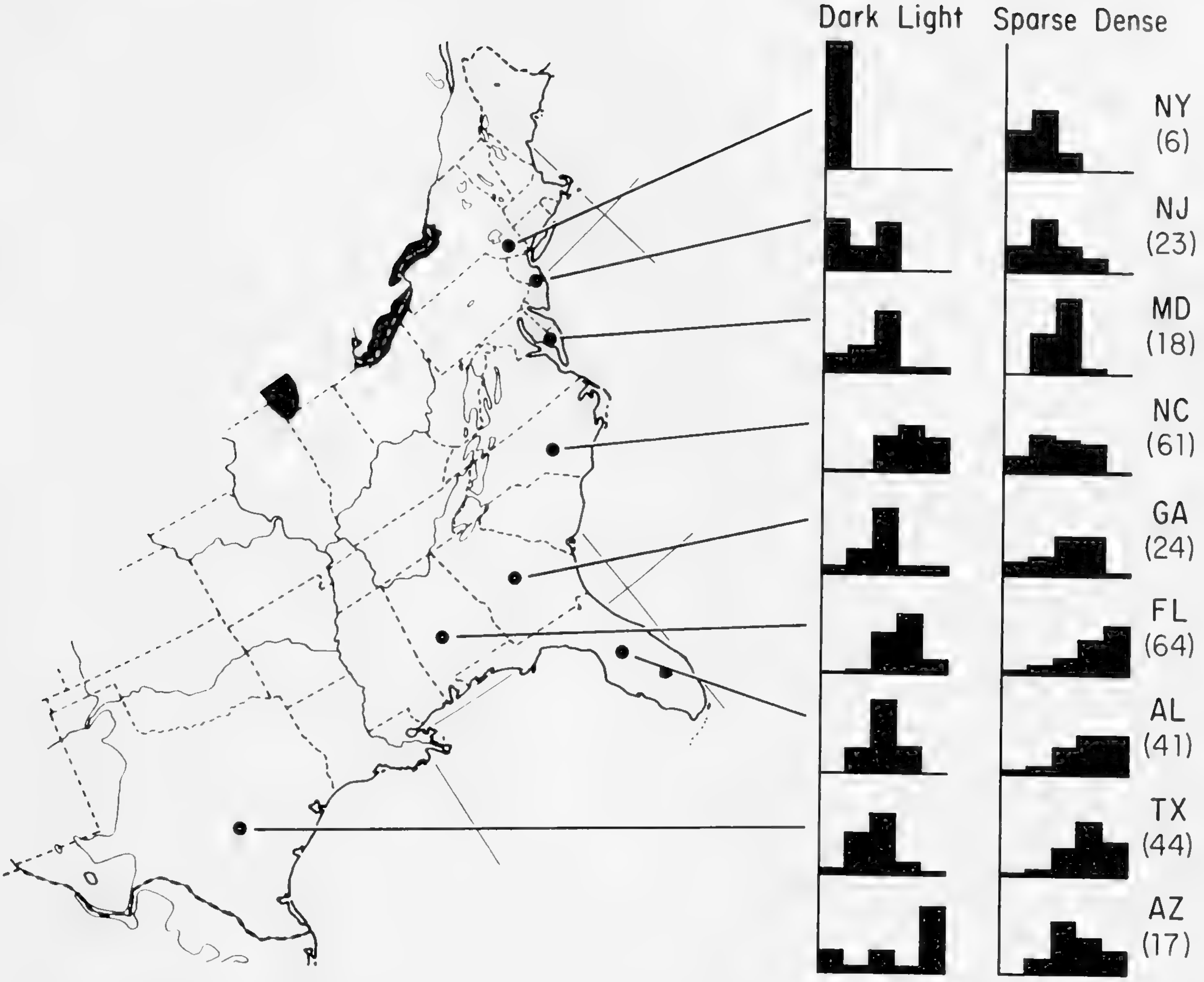


Fig. 9. Geographic variation in ground color (dark to light; Fig. 6) and setation pattern (dense to sparse) for *Tachygonus lecontei* Gyll. Sample sizes for each state given in parentheses.

the range of *T. lecontei.* At the northeastern extreme of the range, New York populations are largely black with relatively sparse setae ("spinipes" form). As one moves south along the Atlantic coastal states, the proportion of individuals that are red and more densely covered with setae increases. Populations increase in the proportions of blacker, less densely covered forms west of Florida. The patterns of variation shown in Fig. 9 must be considered a crude approximation, because specimens were unevenly collected geographically. Systematic sampling and comparison with ecological variables may allow understanding of causal factors.

The pattern of variation becomes more difficult to interpret in Arizona. Although there are only a small number of collections of *T. lecontei* from Arizona, morphs appear to be more distinct and consistent, with relatively few intermediates (Fig. 9). On the other hand, there seems to be no genitalic differentiation between morphs that might suggest separate species, although no males are known from the most distinctive all-red morph. Other characters also vary, however; for example, the hind tibiae are typically rather sharply angulate on the external margin, but are more regularly arcuate in some specimens from Arizona. This more complicated pattern of morphological variation clearly needs further study, including possible correlation with larval hosts and biology. It is also not clear how or whether the Arizona populations are connected with those in central Texas. There is a complex of forms in Mexico that are either conspecific with or closely related to *T. lecontei* (e.g. *T. nigrocristatus* Champion), some of which have been collected as adults on oak. At present, therefore, it seems most practical to consider all of the Arizona forms under the name of *lecontei* until more extensive and detailed studies are undertaken. Moreover, the large amount of variation in three of North America's five species argues for caution in recognizing new taxa within the genus in general.

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LYGUS DESERTUS KNIGHT, 1944, A NEWLY RECOGNIZED SYNONYM OF *LYGUS ELISUS* VAN DUZEE, 1914 (HETEROPTERA: MIRIDAE)

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Abstract.—*Lygus desertus* Knight, 1944, is considered a **junior synonym** of *Lygus elisus* Van Duzee, 1914, based on a review of the literature and new morphometric, morphological, and distributional analyses.

Key Words: Miridae, *Lygus,* morphometrics, morphology, distribution

The genus *Lygus* Hahn currently includes 34 North American species (Kelton 1975, Henry and Wheeler 1988). Most Nearctic species occur in the western and northwestern United States and western Canada where several, such as *L. hesperus* Knight and *L. elisus* Van Duzee, are important pests of various crops.

The taxonomy of the genus and associated taxa is complex (Henry and Lattin 1987) and further complicated by the great amount of literature treating the group. Graham et al. (1984) listed more than 2400 citations concerning the *Lygus* complex (*Lygus* sensu lato as cataloged by Carvalho 1959) from 1900–1980. Despite the many taxonomic works already treating the genus *Lygus* and near relatives (e.g., Knight 1917, 1941, 1944, Kelton 1955a, b, c, 1975), positive identification of certain species remains difficult, even with type material available for comparison. Many of the host plant associations listed by several authors (e.g., Stitt 1949, Kelton 1975, Scott 1977, Fye 1980, Domek and Scott 1985) may require verification because of the species recognition problem.

While the broader problems of *Lygus* taxonomy have been discussed elsewhere (Henry and Lattin 1987), we address here a specific one between *L. desertus* Knight and *L. elisus* Van Duzee. Because these two species have been mentioned frequently in the applied literature and have been treated in considerable depth by staff of the U.S. Department of Agriculture's Biological Control of Insects Laboratory, Tucson, Arizona, we have gone to particular effort to document our reasons for considering *L. desertus* a junior synonym of *L. elisus.*

Taxonomic History

Knight (1944) described *L. desertus* from specimens taken in eight western states, with the holotype from Ajo, Arizona. He noted that *L. desertus* was closely related to *L. elisus,* but that it could be distinguished by the more elongate form, more convex scutellum, shorter and finer vestiture, and the slightly shorter rostrum. He also commented that the genital parameres were similar to those of *L. elisus* and, although there were small differences, these structures were not useful for sorting species.

Knight (1968) also provided the replacement name, *L. desertinus,* for *L. desertus* upon discovering that it was preoccupied by *Lygus desertus* Becker, 1864 (Carvalho 1959). Muminov (1986) showed that Becker's species belonged in the genus *Deraeocoris* Kirschbaum, thus removing *L. desertus* Knight from secondary homonymy (Henry and Wheeler 1988). *Lygus desertinus* is the name that appears in all of the economic literature to the present.

Kelton (1975: 39) maintained *L. desertus* (as *L. desertinus*) as a distinct species, but cautioned that it might be "confused with *elisus* as they are similar in size and color, and are often found together" and "the life history pattern appears to be similar to that of *elisus.*" Kelton (1975) considered the color of the mesoscutum (partly pale in *L. desertus,* black in *L. elisus*) the most diagnostic character for distinguishing these two species.

OVERVIEW OF OTHER PERTINENT LITERATURE

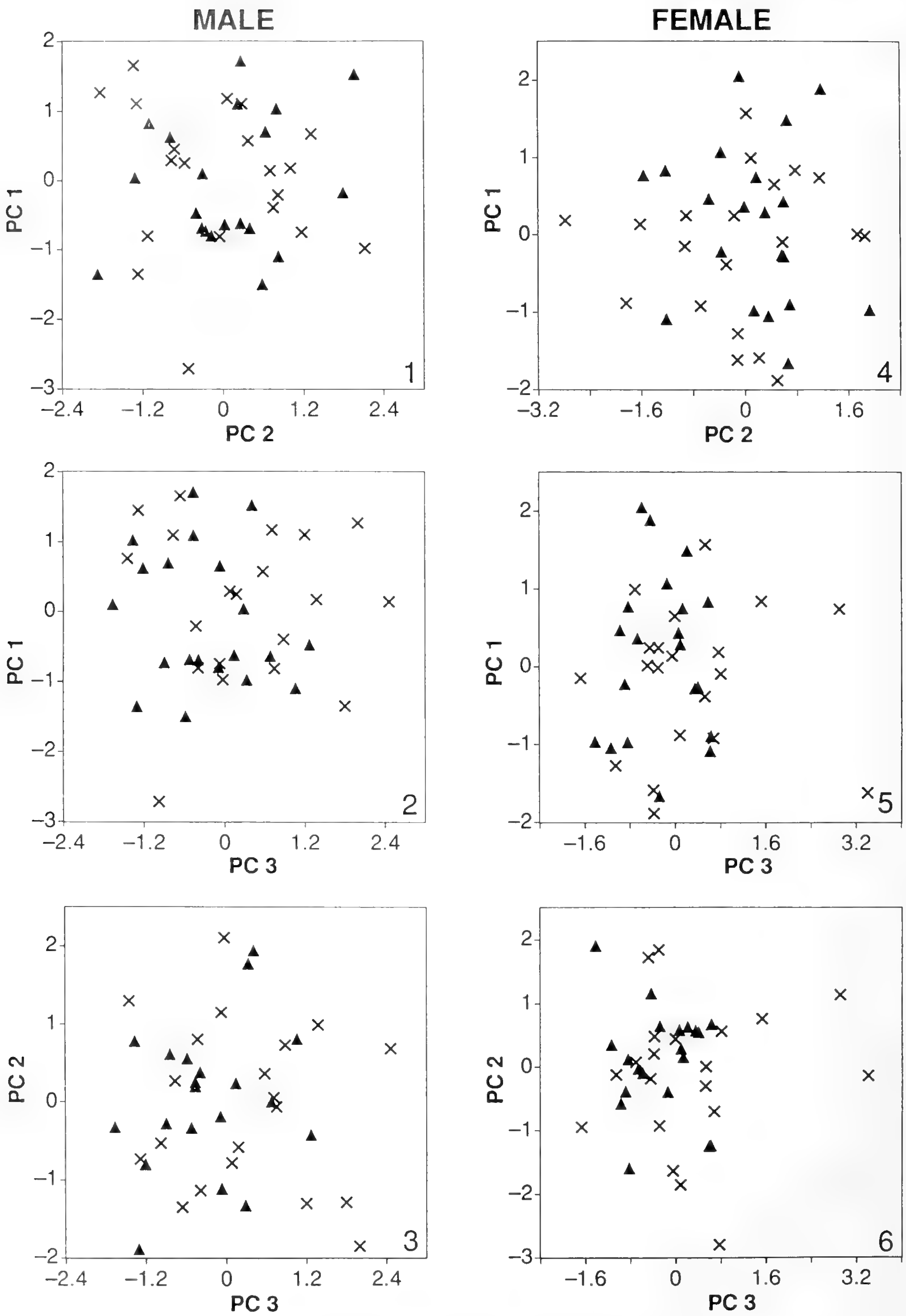
Specimens identified as *L. desertus* and *L. elisus* were documented to interbreed in three studies. Graham (1982) first questioned the distinctness of *L. desertus* (as *L. desertinus*) and *L. elisus* after showing that field-collected specimens interbreed in the laboratory. Sluss et al. (1982) considered laboratory crosses between *L. desertus* and *L. elisus* "very fertile," noting that only *L. elisus* female × *L. desertus* male crosses had a lower fertility than intraspecific ones, but that F1 progeny did not differ significantly from intraspecific crosses. Both Sluss et al. (1982) and Graham (1982) recorded variable mesoscutal color in *L. desertus* and *L. elisus* reared under similar conditions. Graham et al. (1987) provided detailed information showing that the two species readily interbreed in the laboratory, and speculated that the preference for *L. desertus* × *L. desertus* matings probably was the result of population differences or that it indicated *L. desertus* "is evolving toward a distinct species."

Preliminary data from Graham (1982) also indicated that the proportion of *L. desertus* without mesoscutal markings increased significantly when nymphs were reared at lower temperatures (at 20°C, 23% without markings versus 3% at 30°C without markings). Graham and Carranza (1983) confirmed that temperature influenced mesoscutal color, especially when late instars were exposed to cooler temperatures. They also reported, through personal communication with R. E. Fye (USDA, ARS, Yakima, WA), that the proportion of *L. elisus* individuals increased dramatically over those of *L. desertus* in late September and November in Washington.

Sluss et al. (1982) determined that *L. desertus* and *L. elisus* were morphologically "very similar" and distinct from *L. lineolaris* (Palisot) and *L. hesperus* Knight based on a morphometric study of rostral, tibial, antennal, pronotal and head lengths. Their study, which combined measurements of males and females diminished their results, but strongly suggests to us that the range of measurements for *L. desertus* and *L. elisus* was due to intraspecific variation. Their conclusion, based on morphological data, combined with somewhat inconclusive allozyme data, was the "*L. desertinus-elisus* complex . . . appears to be still in a subspecific state."

OTHER SUPPORTING EVIDENCE

Morphometric analysis: An ocular micrometer was used to measure 21 external characters of 20 male and 20 female specimens of both forms of *L. elisus* (as determined by mesoscutal coloration), from Utah, Box Elder Co., Cedar Hills, 11 August 1972. The measurements were—length from apex of tylus to: apex of membrane (1), apex of abdomen (2), cuneal fracture (3); length



Figs. 1–6. Principal component ordination of 40 male and 40 female specimens of *L. elisus* Van Duzee (Utah, Box Elder Co., Cedar Hill) based on the analysis of 21 measurements. 1–3. Males. 1. First and second principal axes. 2. First and third principal axes. 3. Second and third principal axes. 4–6. Females. 4. First and

of cuneus (4); width across widest portion of hemelytra (5); medial length of pronotum (6); posterior width of pronotum (7); width of: pronotal collar (8), head across eyes (9); interocular width at: vertex (10), frons near antennal fossa (11); length of head from apex of tylus to carina of vertex (12); length from apex of tylus to margin of eye near antennal fossa (13); width of eye in dorsal view (14); length of antennal segment: 1 (15), 2 (16), 3 (17), 4 (18); length of: rostrum (19), rostral segment 1 (20), metatibia (21). We applied principal component analysis to the measurements using SPSS PC+ (Norusis 1988). The measurements of the same sex from each form were combined and then the sexes were analyzed separately. Combining the data from each form allowed us to find relationships among measurements and among individuals in each analysis. The character scores on the first three principal components, accounted for 55.6% of total variation of males and 53.3% of total variation of females. The projection of the individual specimens onto combinations of the first three principal axes is shown in Figs. 1–6. The first principal component (PC 1, 35.2% male, 35.3% female) weakly reflected general size variation among the individuals. The second and third principal components (PC 2, 11.5% male, 9.5% female; PC 3, 8.9% male, 8.5% female) showed very weak shape variation. The results shown in Figs. 1–6 clearly do not separate the specimens of either sex into distinct species groups.

Male genitalia: The number and placement of the sensory lobe spines are the most variable features of the left paramere (Fig. 9). We were unable to detect any consistent differences among specimens of either *L. elisus* form. The right paramere (Fig. 8) is practically uniform throughout the genus. The shape of the two spinose fields of the vesica and the conformation of the single spicule of the vesica are also variable (Figs. 7, 10). The intra-population variability in the spicule is as great as the variability found in specimens at the latitudinal extremes of the distribution of *L. elisus* (Figs. 11–22). The great variability of the spiculae within this one species of *Lygus* illustrates the diminished taxonomic utility of this structure to discriminate species in the genus.

Vestiture: Although we observed some difference in the hemelytral pubescence, we feel this is individual variation, as is often found in *L. lineolaris.* Specimens in collections may be segregated into two groups, those with more sparse and shorter pubescence are *L. desertus*; those with longer setae are *L. elisus.* Individuals with shorter setae appear more shiny than those bearing heavier pubescence.

Length of rostrum: Although Knight (1944) claimed that the rostrum of *L. desertus* was shorter than in *L. elisus,* we were unable to observe this difference. Our findings corroborate those of Kelton (1975).

Distribution and host plants: We found both forms in many series that were collected at the same locality and time on the same host plant (see Appendix). Our findings agree with those of Kelton (1975): these species are sympatric on the same host.

Mesoscutal color: This character is the primary reason *L. desertus* and *L. elisus* have been maintained as separate species. We have studied many series of specimens in the Canadian and U.S. National Collections and two from reared material made available to us by H. Graham (USDA Tucson Lab.) and have found they all contain a mixture of individuals exhibiting either dark, yellow-marked, or intermediate-colored mesoscuta. The intra-population variation

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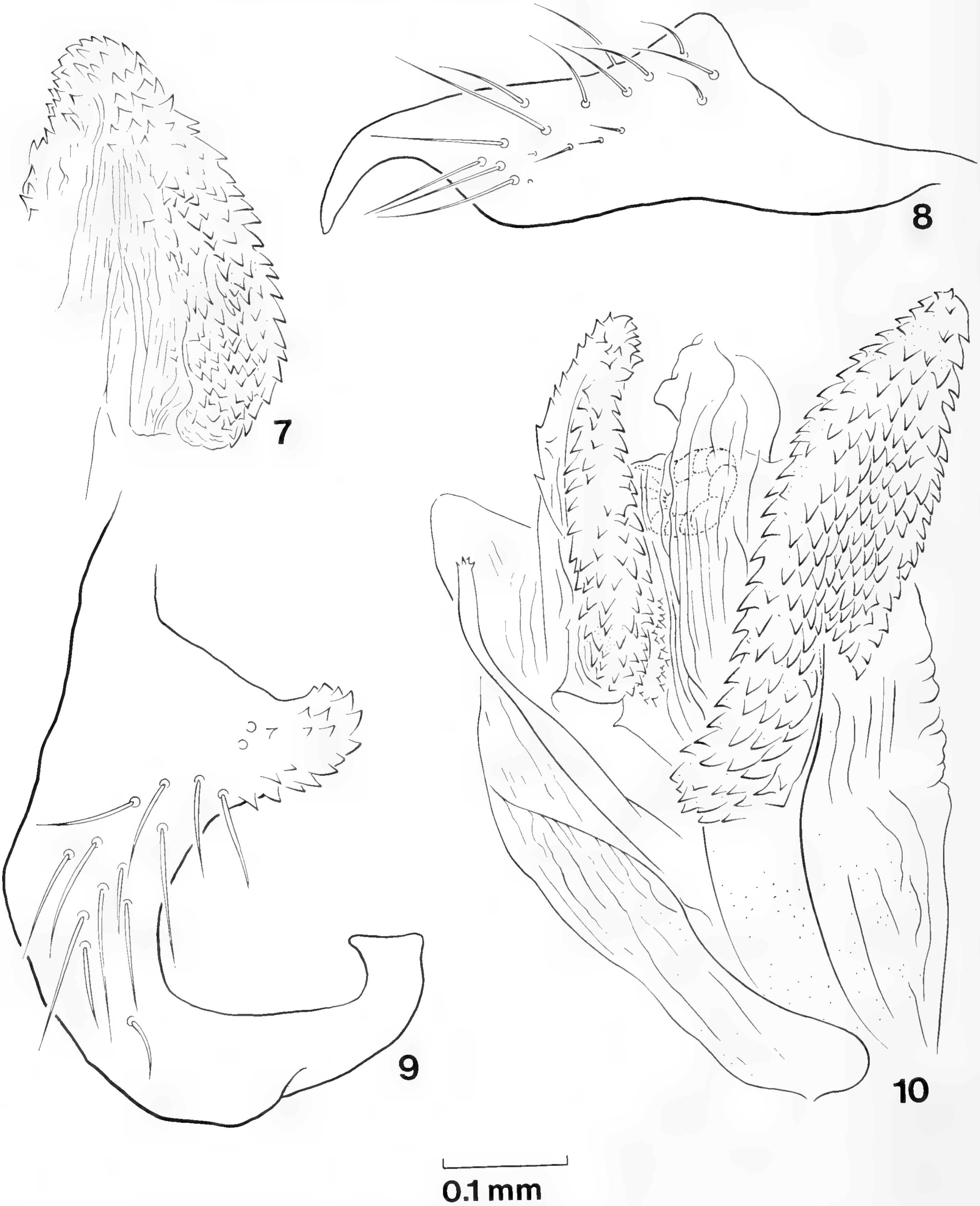
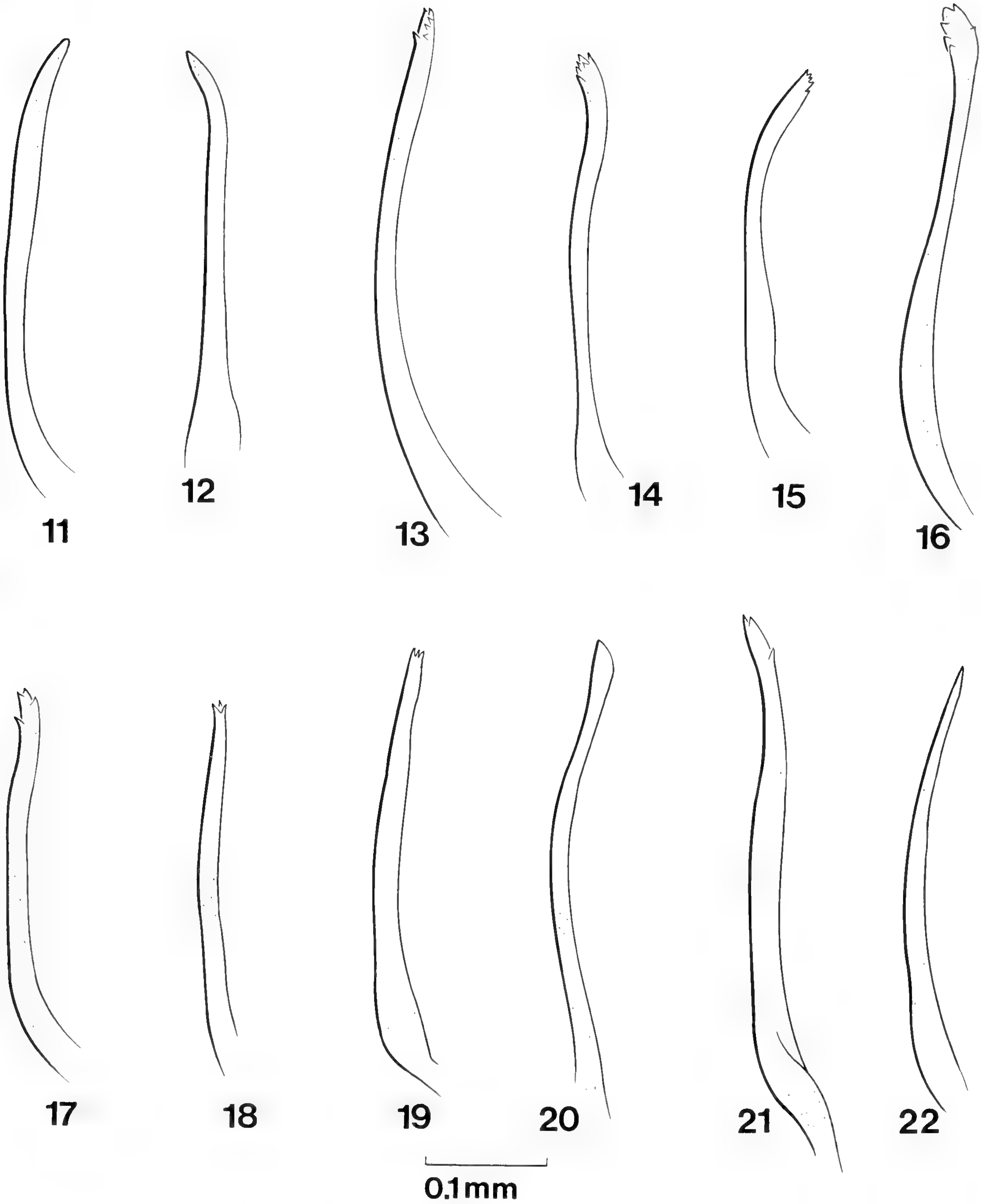
second principal axes. 5. First and third principal axes. 6. Second and third principal axes. ▲ = *L. elisus—elisus* form. × = *L. elisus—desertus* form.



Figs. 7–10. Male genitalia of *L. elisus* Van Duzee (Utah, Box Elder Co., Cedar Hill). 7, 10. Vesica. 7. Detail of left spinose field, left lateral view. 10. Vesica, anterior view. 8, 9. Parameres, lateral view. 8. Right. 9. Left.

of the mesocutal color pattern exhibited in a single collection from Utah, Box Elder Co., Cedar Hills (Figs. 23–28) spans the variation found across the entire species. The distribution of the forms of *L. elisus,* as determined by the mesoscutal pattern, varies with respect to temperature (Graham and Carranza 1983) and this variation is



Figs. 11–22. Detail of vesical spiculae of *L. elisus* Van Duzee. 11–18. Utah, Box Elder Co., Cedar Hill. 11–14. *L. elisus—elisus* form. 15–18. *L. elisus—desertus* form. 19, 20. Southern localities. 19. *L. elisus—desertus* form, Texas, Brewster Co., Big Bend Nat'l. Park, Santa Elena Cyn. 20. *L. elisus—elisus* form, Texas, Jeff Davis Co., Ft. Davis. 21, 22. Northern localities. 21. *L. elisus—desertus* form, Yukon Territory, Takini Hot Sprgs. 22. *L. elisus—elisus* form, Northwest Territories, Ft. Simpson.

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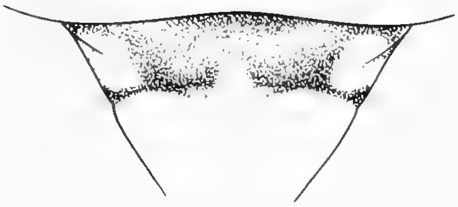

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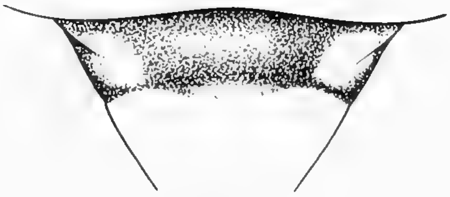

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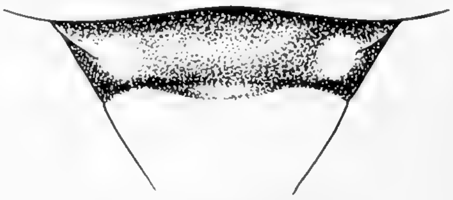

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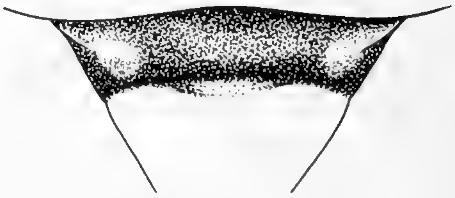

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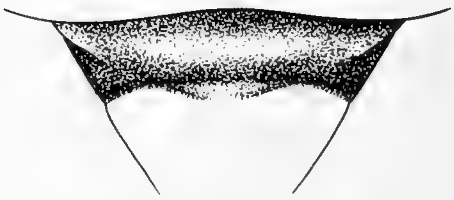

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Figs. 23–28. Mesoscuta of *L. elisus* Van Duzee, Utah, Box Elder Co., Cedar Hill.

reflected by latitude (Fig. 29). There is a predominance of the *elisus* form in the northern portion of the range and a predominance of the *desertus* form in the southern portion of the range. The graphic representation of this correlation was based on the study of more than 3500 specimens including material collected from all times of the year, and averaging the proportion of the *L. elisus* form from the same locality from early and late in the year (see Appendix collection numbers 5 and 6, 81 to 84, 86 and 87). We note that most of the laboratory-reared offspring seem to reflect the parent-type mesoscutum when reared under similar conditions, as was indicated by Graham (1982), Sluss et al. (1982), and Graham and Carranza (1983). In field-collected ma-

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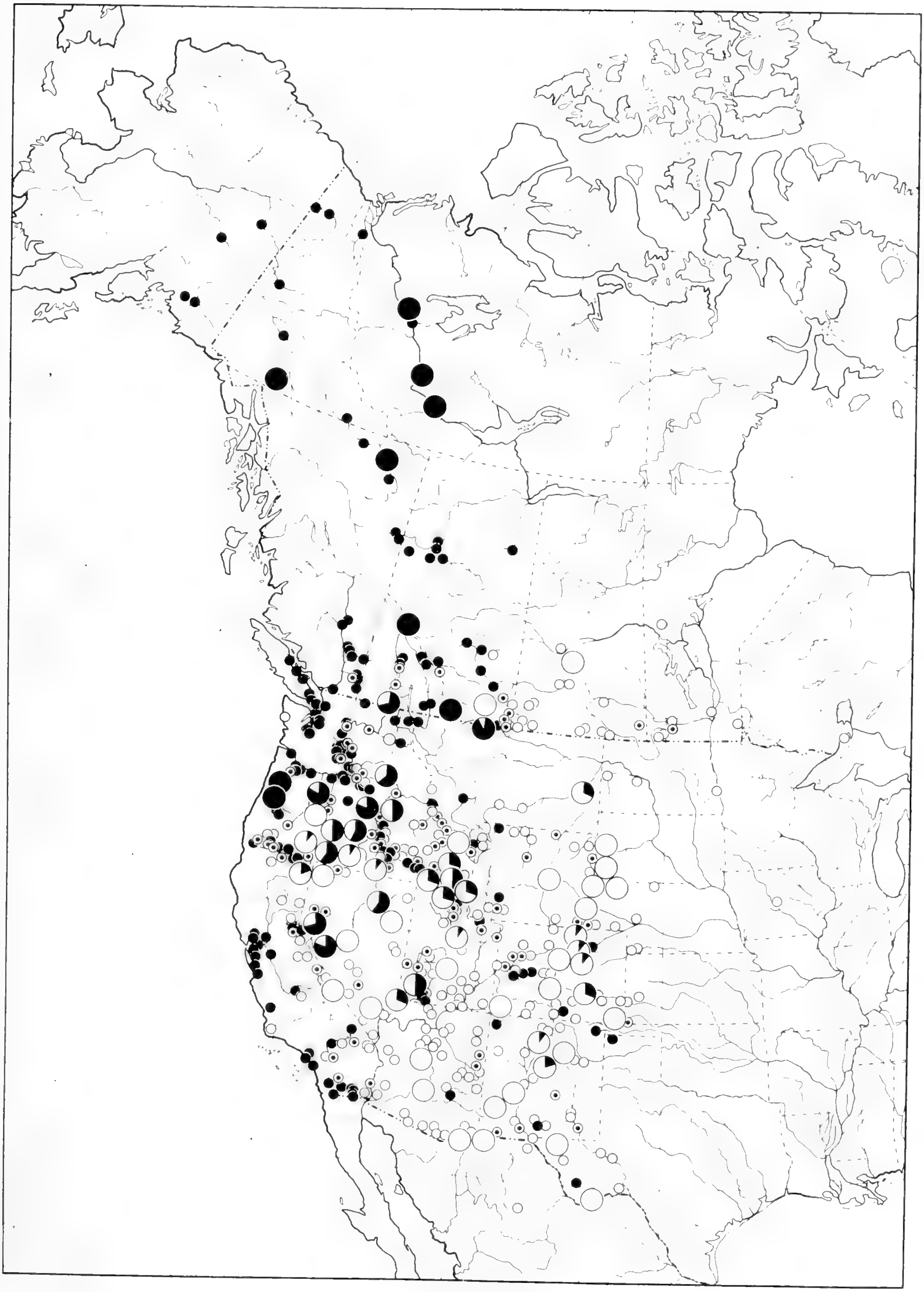
Fig. 29. Distribution of forms of *L. elisus* Van Duzee. Large circles—locality with 10 or more specimens (n = 10 to 374, $\bar{x} = 24$, see Appendix for complete locality data); black portion of pie represents proportion of *elisus* form of total number of specimens in 10% increments (rounded to nearest 10%). Small circles—locality with less than ten specimens; ● *elisus* form, ○ *desertus* form, ⊙ *elisus* and *desertus* form.



terial, however, we have observed much more variation, suggesting that seasonal and daily temperature fluctuations affect more individuals and, perhaps, more matings involve pairs with mixed mesoscutal types.

Conclusion

The color of the mesoscutum, the chief character used to separate *L. desertus* and *L. elisus,* varies both within populations reared under similar conditions and in those affected by variable temperatures. That both color types (and intermediates) are often found in the field together on the same host plants, readily interbreed in the laboratory, and produce fertile offspring eliminates arguments for sexual isolation, or even subspecies consideration. Accordingly, based on this and other information gathered from the literature, and on the analyses of museum specimens presented here, we are convinced that *L. desertus* is a color morph of *L. elisus.*

The following synonymic list, modified from Henry and Wheeler (1988), updates the names we consider conspecific with *L. elisus*:

Lygus elisus Van Duzee

Lygus pratensis var. *elisus* Van Duzee, 1914: 20.
Lygus elisus: Van Duzee, 1916: 40.
Lygus (*Lygus*) *elisus* var. *viridiscutatus* Knight, 1917: 575. Synonymized by Kelton, 1975: 36.
Lygus nigrosignatus Knight, 1941: 270. Synonymized by Kelton, 1975: 37.
Lygus desertus Knight, 1944: 471. NEW SYNONYM.
Liocoris elisus: Kelton, 1955c: 548.
Liocoris desertus: Kelton, 1955c: 548.
Liocoris nigrosignatus: Kelton, 1955c: 552.
Lygus desertinus Knight, 1968: 189. New name for *Lygus desertus* Knight, a secondary homonym preoccupied by *Lygus desertus* Becker, 1864; homonymy eliminated by Muminov, 1986: 41 (see also Henry and Wheeler 1988: 322–323).

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APPENDIX

List of localities with 10 or more specimens of either *elisus* form and *desertus* form of *Lygus elisus,* or a combination of both forms[1]

Canada:

1. ALBERTA: Coutts: 15 June 1952, A. R. Brooks (13:1); L. A. Konotopetz. (23:1). Total: 36:2 **95%** (CNC)
2. ALBERTA: Crowsnest, 19 July 1974, L. A. Kelton, ex *Artemisia.* (19:0) **100%** (CNC)
3. ALBERTA: Jasper, 29 Aug. 1970, L. A. Kelton. (19:0) **100%** (CNC)
4. ALBERTA: Lethbridge, 5 July 1956, E. E. Sterns. (0:11) **0%** (CNC)

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[1] Order of appendix data: collection number, locality(ies) contributing to percentage, n = ratio of *elisus* form to *desertus* form, percentage of *elisus* form, institution; collections numbers in parentheses are combined with other similar localities, bold percentages are used in Fig. 29.

(5.) BRITISH COLUMBIA: Oliver: 13 Apr. 1923, C. B. Garrett (1:0); 23 Apr. 1923, C. B. Garrett (1:0); 24 Apr. 1923, C. B. Garrett (1:0); 26 Apr. 1923, C. G. Garrett (1:0); 14 May 1948, ex alfalfa (2:0); 14 May 1959, L. A. Kelton (11:0); 14 May 1959, R. Madge (1:0); 20 June 1975, L. A. Kelton (1:0). Total: (19:0) 100% (CNC)

(6.) BRITISH COLUMBIA: Oliver, 19 July 1970, L. A. Kelton, ex *Artemisia* (0:3); 12 Aug. 1953, D. F. Hardwick (1:1); 1000′, 17 Aug. 1953, J. E. H. Martin (0:1). 23 Aug. 1953, J. R. McGillis (1:0); 25 Aug. 1953, J. E. H. Martin (1:1); 26 Aug. 1953, J. E. H. Martin (1:0). Total: (4:6) 40% (CNC); #5 and #6 **74%**

7. BRITISH COLUMBIA: Summit Lk., mi 392 Alaska Hwy., 8 July 1959, 4500′, R. E. Leech, ex yarrow. (15:0) **100%** (CNC)

(8.) NORTHWEST TERRITORIES: Norman Wells, 19 May 1953, J. S. Waterhouse. (13:0) 100% (CNC)

(9.) NORTHWEST TERRITORIES: Norman Wells, 21 June 1969, G. E. Shewell. (33:1) 97% (CNC); #8 and #9 **99%**

(10.) NORTHWEST TERRITORIES: Ft. Simpson, 14 June 1950, D. P. Whillans. (16:1) 94% (CNC)

(11.) NORTHWEST TERRITORIES: Ft. Simpson, 19 Aug. 1950, D. P. Whillans. (37:1) 97% (CNC); #10 and #11 **96%**

12. NORTHWEST TERRITORIES: Wrigley, 14 June 1969, G. E. Shewell. (23:0) **100%** (CNC)

13. YUKON TERRITORY: Takini Hot Sprgs., 19 Aug. 1962, R. E. Leech, ex *Artemisia.* (56:0) **100%** (CNC)

(14.) SASKATCHEWAN: Saskatoon, 28 Apr. 1949, A. R. Brooks, ex *Salix* sp. (0:16) 0% (CNC)

(15.) SASKATCHEWAN: Saskatoon, 5 July 1950, A. R. Brooks, ex *Chenopodium album.* (0:11) 0% (CNC); #14 and #15 **0%**

United States:

16. ARIZONA: *Cochise Co.:* Tombstone, 12 May 1978, B. L. Rozen & R. Goelet. (0:12) **0%** (NYC)

17. ARIZONA: *Gila Co.:* 8 mi SW of jct. of Rts. 87 & 188 (off Rt. 87), Tonto Nat'l. For., 4000′, 27–28 May 1983, R. T. Schuh & G. M. Stonedahl, ex MV lite. (0:17) **0%** (AMNH)

18. ARIZONA: *Yavapai Co.:* Prescott, 16 Aug. 1972, L. A. Kelton. (0:14) **0%** (CNC)

19. CALIFORNIA: *Modoc Co.:* 4 mi E of Cedarville, 1440 m, 2 July 1979, R. T. Schuh, B. M. Massie, ex *Sarcobatus vermiculatus* (2:6); 2 mi E of Cedarville, 1440 m, 1 July 1979, R. T. Schuh, B. M. Massie, ex *Sarcobatus vermiculatus* (Chenopodiaceae) (0:1); 24.7 mi NW of Canby, 1375 m, 1 July 1979, R. T. Schuh, B. M. Massie (0:2). Total: (2:9) **18%** (AMNH)

20. CALIFORNIA: *Mono Co.:* 20 mi N of Bishop, 7000′, 5 Aug. 1962, D. R. Smith. (0:13) **0%** (OSU)

21. COLORADO: *Baca Co.:* Regnier, 37°00′N 102°50′W, 4500′, 6–9 June 1919. (1:19) **5%** (AMNH)

22. COLORADO: *Boulder Co.:* Boulder, 5400′, 10 June 1961, B. H. Poole. (2:19) **10%** (CNC)

(23.) COLORADO: *Boulder Co.:* Nederland, 8200′, 29 June 1961, J. R. Stainer. (1:15) 6% (CNC)

(24.) COLORADO: *Boulder Co.:* Nederland, Science Lodge, 9500′, 4 July 1961, J. R. Stainer. (0:19) 0% (CNC)

(25.) COLORADO: *Boulder Co.:* Nederland, Science Lodge, 9500′, 5 July 1961, J. R. Stainer. (0:11) 0% (CNC)

(26.) COLORADO: *Chaffee Co.:* Buena Vista, 7800′, 22–23 June 1961, J. R. Stainer. (2:67) 3% (CNC)

(27.) COLORADO: *Chaffee Co.:* Buena

Vista, 9000′, 22 June 1961, J. R. Stainer. (0:15) 0% (CNC); #26 and #27 **2%**

(28.) COLORADO: *Clear Creek Co.:* Doolittle Ranch, Mt. Evans, 9800′, 8 July 1961, J. R. Stainer. (2:13) 13% (CNC)

(29.) COLORADO: *Clear Creek Co.:* Doolittle Ranch, Mt. Evans, 9800′, 9 July 1961, J. R. Stainer. (0:23) 0% (CNC)

(30.) COLORADO: *Clear Creek Co.:* Doolittle Ranch, Mt. Evans, 9800′, 17 July 1961, J. R. Stainer. (0:18) 0% (CNC)

(31.) COLORADO: *Clear Creek Co.:* Mt. Evans, 12,000′, 3 Aug. 1961, B. H. Poole. (1:16) 6% (CNC)

(32.) COLORADO: *Clear Creek Co.:* Mt. Evans, 12,000′, 3 Aug. 1961, B. H. Poole. (1:14) 7% (CNC)

(33.) COLORADO: *Clear Creek Co.:* Summit Lk., Mt. Evans, 12,800′, 10 July 1961, W. R. M. Mason. (0:18) 0% (CNC)

(34.) COLORADO: *Clear Creek Co.:* Summit Lk., Mt. Evans, 12,800′, 16 July 1961, J. R. Stainer. (3:52) 5% (CNC)

(35.) COLORADO: *Clear Creek Co.:* Summit Lk., Mt. Evans, 12,800′, 24 July 1961, J. R. Stainer. (0:21) 0% (CNC)

(36.) COLORADO: *Clear Creek Co.:* Timberline, Mt. Evans, 11,600′, 13 July 1961, J. R. Stainer. (0:21) 0% (CNC); #23–#25, #28–#36 **3%**

37. COLORADO: *Douglas Co.:* 1 mi S of Parker, along Cherry Crk., 1780 m, 20 May 1978, J. T. Polhemus & R. T. Schuh. (1:9) **10%** (AMNH)

38. COLORADO: *El Paso Co.:* Colorado Sprgs., 27 June 1966, J. A. Slater. (3:7) **30%** (AMNH)

(39.) COLORADO: *Larimer Co.:* Estes Park, 7500′, 2 July 1961, J. R. Stainer. (2:16) 11% (CNC)

(40.) COLORADO: *Larimer Co.:* Estes Park, 7500′, 20 July 1961, J. R. Stainer. (1:70) 1% (CNC)

(41.) COLORADO: *Larimer Co.:* Estes Park, 7500′, 10 Aug. 1961, J. R. Stainer. (2:9) 18% (CNC); #39–#41 **10%**

42. COLORADO: *Montezuma Co.:* Cortez, 19 July 1968, L. A. Kelton, ex *Chenopodium.* (0:10) **0%** (CNC)

43. IDAHO: *Adams Co.:* Mesa, 4 Aug. 1972, L. A. Kelton, ex *Chenopodium.* (13:12) **52%** (CNC)

44. IDAHO: *Bear Lake Co.:* Montpelier, 42°19′N, 111°18′W, 6100′, 6 July 1920. (3:8) **27%** (AMNH)

(45.) IDAHO: *Bingham Co.:* 6 mi SW of Blackfoot, 28 June 1977, J. M. Domek, ex *Medicago sativa.* (8:18) 30% (UID)

(46.) IDAHO: *Butte Co.:* 18 mi NE of Howe, 17 Aug. 1965, R. L. Westcott. (10:21) 32% (UID); #45–#46 **31%**

47. IDAHO: *Cassia Co.:* 5 mi NW of Oakley, 21 June 1965, W. F. Barr, ex *Eurotia lanata.* (7:15) **32%** (UID)

48. IDAHO: *Jefferson Co.:* 4.5 mi NW of Terreton, 14 June 1972, J. M. Domek, ex *Chaenactis* sp. (0:14) **0%** (UID)

49. IDAHO: *Oneida Co.:* Rock Crk., 29 June 1972, G. F. Knowlton. (7:6) **54%** (OSU)

50. IDAHO: *Owyhee Co.:* 13 mi SE of Murphy, 4 Sept. 1962, W. F. Barr, ex *Chyrsothamnus viscidiflorus.* (2:13) **13%** (UID)

51. MONTANA: *Prairie Co.:* Fallon, 8 Aug. 1962, J. G. & B. L. Rozen. (3:8) **27%** (AMNH)

(52.) NEBRASKA: *Sheridan Co.:* Hay Sprgs., 28 June 1973, L. A. Kelton, ex alfalfa. (0:27) 0% (CNC)

(53.) NEBRASKA: *Sheridan Co.:* Hay Sprgs., 28 June 1973, L. A. Kelton, ex *Symphoricarpos.* (0:14) 0% (CNC); #52 and #53 **0%**

54. NEBRASKA: *Sioux Co.:* 7 mi N of Harrison, 13 Aug. 1962, J. G. & B.

L. Rozen, ex *Helianthus.* (3:57) **5%** (AMNH)

55. NEVADA: *Elko Co.:* Elko, 30 Aug. 1967, L. A. Kelton, ex rabbitbrush. (14:11) **56%** (CNC)

56. NEVADA: *Elko Co.:* E side of Ruby Mts., nr. Thompson Crk., T31N R59E, 6300′, 26 June 1983, R. T. Schuh & M. D. Schwartz, ex *Lupinus* sp. (Fabaceae). (0:11) **0%** (AMNH)

57. NEVADA: *Lander Co.:* 1.5 mi S of Rt. 50 on Rt. 376, T18N R45E, 5900′, 28 June 1983, R. t. Schuh & M. D. Schwartz, ex *Grayia spinosa* (Hook.) Moq. (Chenopodiaceae). (0:10) **0%** (AMNH)

58. NEVADA: *Nye Co.:* 2.5 mi NE of Gabbs, off Rt. 844 at Gabbs Rifle Range, 4800′, 2 July 1983, R. T. Schuh & M. D. Schwartz, ex MV lite. (10:2) **83%** (AMNH)

59. NEVADA: *Nye Co.:* Nevada Atomic Test Site, S of GS500 on Jackass Flats Rd., 3300′, (A25), 6 June 1983, R. T. Schuh, M. D. Schwartz & G. M. Stonedahl, ex *Franseria dumosa* Gray (Asteraceae). (2:9) **0%** (AMNH)

60. NEVADA: *Washoe Co.:* 6 mi W of Vya toward Cedarville, 1810 m, 2 July 1979, R. T. Schuh & B. M. Massie, ex *Chrysothamnus* sp. (Asteraceae). (0:19) **0%** (AMNH)

61. NEVADA: *Washoe Co.:* Wadworth, 30 Aug. 1967, L. A. Kelton, ex *Ambrosia.* (20:7) **74%** (CNC)

62. NEW MEXICO: *Grant Co.:* Roberts' Lk. Gila Nat'l. For., 19 Aug. 1972, L. A. Kelton. (0:20) **0%** (CNC)

(63.) NEW MEXICO: *Hidalgo Co.:* 23 mi S of Animas, 28 Aug. 1975, J. G. Rozen & R. McGinley. (0:23) 0%

(64.) NEW MEXICO: *Hidalgo Co.:* 23 mi S of Animas, 30 Aug. 1975, J. G. & K. C. Rozen. (1:14) 7% (AMNH)

(65.) NEW MEXICO: *Hidalgo Co.:* 25 mi S of Animas, 30 Aug. 1975, J. G. & K. C. Rozen. (0:33) 0% (AMNH)

(66.) NEW MEXICO: *Hidalgo Co.:* 2 mi S of Rodeo, 3 May 1975, J. G. Rozen. (1:12) 8% (AMNH)

(67.) NEW MEXICO: *Hidalgo Co.:* 5 mi N of Rodeo, 1310 m, 6 May 1978, R. T. Schuh, ex *Chenopodium* sp. (Chenopodiaceae). (0:11) 0% (AMNH); #63–#67 **3%**

68. NEW MEXICO: *San Miguel Co.:* Montezuma, Gallinas Cyn., 22 Aug. 1972, L. A. Kelton. (0:14) **0%** (CNC)

69. NEW MEXICO: *Sandoval Co.:* Jemez Sprgs., 23 Aug. 1972, L. A. Kelton. (2:12) **14%** (CNC)

70. NEW MEXICO: *Santa Fe Co.:* Santa Fe, 23 Aug. 1972, L. A. Kelton. (4:21) **16%** (CNC)

71. NEW MEXICO: *Socorro Co.:* Magdalena, Cibola Nat'l. For., 21 Aug. 1972, L. A. Kelton. (2:96) **2%** (CNC)

72. OREGON: *Baker Co.:* 3 mi E of Baker, Conrad Allen Ranch, 6 Aug. 1963, C. W. Baker. (8:2) **80%** (OSU)

(73.) OREGON: *Benton Co.:* Corvallis, Willamette R., 4 May 1961, J. D. Lattin. (10:0) 100% (OSU)

(74.) OREGON: *Benton Co.:* Corvallis, Willamette R., 28 Sept., J. D. Lattin. (10:0) 100% (OSU); #73 and #74 **100%**

(75.) OREGON: *Deschutes Co.:* 8 mi SE of Brothers, 9 July 1968, J. D. Lattin, ex *Chrysothamnus vicidiflorus.* (0:14) **0%** (OSU)

(76.) OREGON: *Deschutes Co.:* 5 mi W of Redmond, 15 Aug. 1971, P. Oman. (0:18) **0%** (OSU)

(77.) OREGON: *Deschutes Co.:* Sisters, 3180′, 7 Aug. 1935, G. Ferguson, ex *Chrysothamnus* sp. (0:12) 0% (OSU)

(78.) OREGON: *Deschutes Co.:* nr, Sisters, 3300′, T14S R10E S15, 1 Oct. 1979, P. Oman. (0:17) 0% (OSU); #75–#78 **0%**

79. OREGON: *Jefferson Co.:* Madras, 13 Aug. 1949, V. Roth. (13:4) **76%** (OSU)

80. OREGON: *Harney Co.:* 6.5 mi N of Burns, 29 Apr. 1980, P. Oman. (9:6) **60%** (OSU)

(81.) OREGON: *Harney Co.:* 5 mi E of Fish Lake, Steens Mts., 8250′, 16 July 1957, J. D. Lattin, ex *Helenium hoopesii.* (0:16) 0% (OSU)

(82.) OREGON: *Harney Co.:* 8 mi E of Frenchglen, 16 July 1957, J. D. Lattin, ex *Lupinus caudatus.* (0:12) 0% (OSU)

(83.) OREGON: *Harney Co.:* 2 mi N of Jupiter Ranch, 18 July 1957, J. D. Lattin. (0:22) 0% (OSU)

(84.) OREGON: *Harney Co.:* Mann's Lake, 30 May 1957, B. Malkin. (11:11) 50% (OSU); #81–#84 **10%**

85. OREGON: *Lake Co.:* Hart Mt., 6250′, 2 Sept. 1977, J. Schuh, ex *Chrysothamnus* sp. (6:4) **60%** (AMNH)

(86.) OREGON: *Lake Co.:* Silver Lk., 11 mi N of Summer Lk. P. O., 16 May 1957, J. D. Lattin. (25:2) 93% (OSU)

(87.) OREGON: *Lake Co.:* Silver Lk., 28 June 1930, H. A. Scullen, ex *Chrysothamnus* sp. (1:31) 3% (OSU); #86–#87 **50%**

88. OREGON: *Lake Co.:* Summer Lk., 26 May 1957, B. Malkin. (1:14) **7%** (OSU)

89. OREGON: *Polk Co.:* Hwy. 99/Parker Rd., 11 May 1988, A. Asquith, ex *Lupinus* sp. (14:0) **100%** (OSU)

90. SOUTH DAKOTA: *Custer Co.:* Black Hills, 28 June 1973, L. A. Kelton. (0:15) **0%** (CNC)

91. SOUTH DAKOTA: *Lawrence Co.:* Spearfish, 23 Aug. 1957, R. F. Koontz, ex light. (0:37) **0%** (OSU)

92. TEXAS: *Brewster Co.:* Big Bend Nat'l. Park, Santa Elena Cyn., 2100′, 9 May 1959, W. R. M. Mason. (0:16) **0%** (CNC)

93. TEXAS: *Culberson Co.:* 38 mi N of Van Horn, 1220 m, 28 Apr. 1978, R. T. Schuh, ex *Atriplex* sp. (Chenopodiaceae). (0:10) **0%** (AMNH)

(94.) UTAH: *Box Elder Co.:* Cedar Hill, 11 Aug. 1972, G. F. Knowlton, ex *Echinopsilon hyssopifolia.* (90:284) 23% (CNC)

(95.) UTAH: *Box Elder Co.:* Curlew Valley, 2 mi SE of Cedar Hills, 1 Sept. 1970, G. F. Knowlton, ex *Chrysothamnus viscidiflorus.* (12:18) 40% (OSU); #94 and #95 **32%**

96. UTAH: *Iron Co.:* Parowan, 25 July 1948, M. Cazier. (10:9) 53% (AMNH)

97. UTAH: *Utah Co.:* Salem, 25 July 1961, G. F. Knowlton. (1:9) 10% (CNC)

98. UTAH: *Sevier Co.:* 20 mi E of Salina, 18 Aug. 1957, W. F. Barr. (0:18) **0%** (UID)

99. UTAH: *Washington Co.:* St. George, 1 Mar. 1966, G. F. Knowlton. (7:15) **32%** (CNC)

100. WASHINGTON: *Columbia Co.:* Dayton, 3 Aug. 1972, L. A. Kelton, ex turnip. (12:16) **67%** (CNC)

101. WYOMING: *Goshen Co.,* 7 May 1952, R. E. Pfadt. (0:15) **0%** (CNC)

102. WYOMING: *Natrona Co.:* Natrona, 12 Aug. 1962, J. G. & B. L. Rozen. (0:10) **0%** (AMNH)

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SEVEN NEW NORTH AMERICAN SPECIES OF *NEONEURUS* (HYMENOPTERA: BRACONIDAE)

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Abstract.—Pertinent literature on the holarctic genus *Neoneurus* Haliday is reviewed and summarized. Seven new North American species are described and illustrated: ***Neoneurus diabolicus, Neoneurus mantichora, Neoneurus mantis, Neoneurus masneri, Neoneurus pallidus, Neoneurus portalensis***, and ***Neoneurus spinarius***. These are the first *Neoneurus* species to be named from the Nearctic region. The genus *Neoneurus* is diagnosed, and a key to known world species is provided. Some observations on the behavior of *Neoneurus mantis*, an ant-associated species from Wyoming, are given.

Key Words: Parasitoid, ant-associated, holarctic, new species

Parasitoid species of the ant-associated holarctic genus *Neoneurus* Haliday may justifiably be considered among the rarest and most remarkable of the braconid wasps occuring in North America. Neoneurine species are thought to be koinobiont endoparasitoids of adult worker ants; however, information on their biology and behavior is very sparse. Although they are most usually found in association with ants, and oviposition has been observed, the details of larval development are not known. Most *Neoneurus* females are distinctive in having greatly modified fore legs (Figs. 3–24), which presumably are used to brace their position during oviposition. Several species have been named from the Palearctic region, and although their existence in the Nearctic region has been known for many years (Marsh 1979) and was suspected for quite some time before that (Muesebeck 1922), none of the North American species has yet been named or described. Their relative rarity is demonstrated by the fact that the largest North American collection of Braconidae, that of the U.S. National Museum of Natural History (USNM), has only accumulated a total of eleven *Neoneurus* specimens (of which only two are females). Consequently, the discovery during the summers of 1990 and 1991 in Wyoming of a reliably locatable population of *Neoneurus* and the collection of thirty-six specimens is a matter of general scientific interest. The initial purpose of this paper was to describe and name this new *Neoneurus* species, as a necessary precursor to publishing observations on its biology and behavior. As the work progressed, additional specimens of other *Neoneurus* species were discovered in several museums, consequently this study has matured into a complete synopsis of the *Neoneurus* species in the Nearctic region and a review of the Palearctic species. In view of the obscure nature of *Neoneurus* species, it seems very likely that additional species will be discovered in the near future. This work does, however, provide a complete summary of the *Neoneurus* species known at present and their distributions. It is hoped that this work will stimulate further discoveries of *Neoneurus* and inspire additional studies on the behavior of these magnificent ant-associated parasitoids.

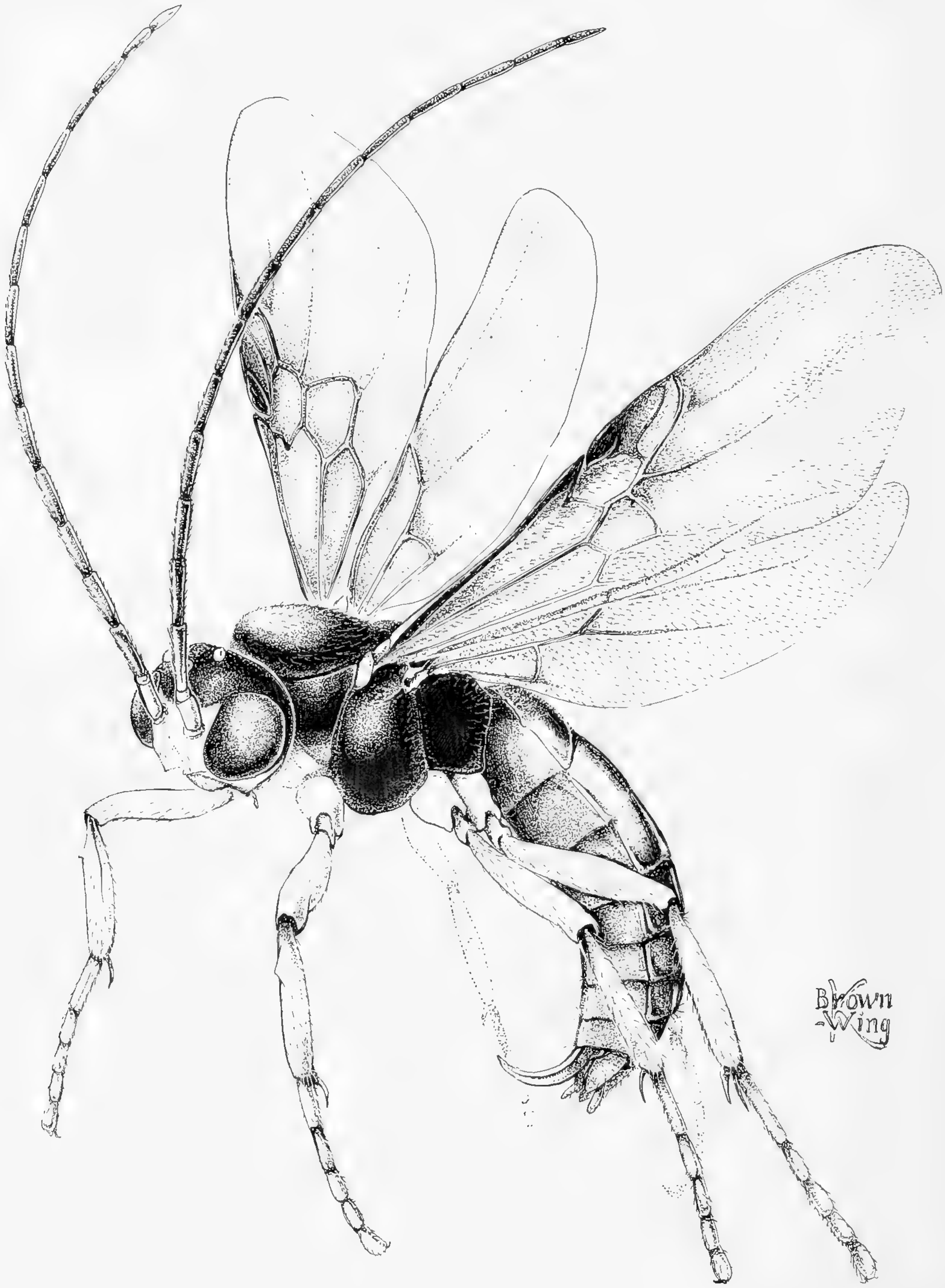
Genus *Neoneurus* Haliday
(Figs. 1–30)

Neoneurus Haliday, 1838. No species included. Type species: *Neoneurus halidaii* Marshall (by subsequent monotypy). First included species by Marshall, 1897.

Ecclites Foerster, 1862. Type species: *Ecclites clypeatus* Foerster (original designation). Synonymized with *Neoneurus* by Ashmead, 1900.

Diagnosis of female.—Body small, 2–4 mm long; lower parts of head, especially face, and legs pale colored; mesosomal and metasomal color varying from black to reddish or yellowish brown; head large, transverse, broader than mesonotum; face often with a pair of spinose protuberances; clypeus short and wide, lower margin truncate; labrum flexible and often exposed; mandible narrow, curved, and bidentate; maxillary palpi 2-segmented; labial palpi 1-segmented; compound eye large, but only slightly prominent, smooth, antero-ventrally converging; ventral facets of compound eye larger than dorsal facets; malar space narrow, distinctly less than basal width of mandible; occiput convex; occipital carina absent; antenna filiform and sparsely setose, slightly longer than fore wing, distinctly longer than the head and mesosoma together; flagellum with 14 flagellomeres; mesonotum broad, convex, abruptly declivous anteriorly; notauli absent; scutellum separated from mesonotum by a smooth transverse sulcus; fore wing with a short, complete radial cell, with a spectral spurious vein (wing fold) extending from apex of radial cell towards wing margin; costa and metacarpus abnormally thick; pterostigma broad, with a pouch-like fold at anterior edge, visible from below; second cubital cell small, subquadrate, weakly indicated by spectral intercubiti; recurrent vein spectral, five-sided discoidal cell open apically; apex of fore wing without an apparent apical fringe of setae (at 80×); prosterna enlarged, subquadrate; legs slender; femorae, especially fore femora, compressed; fore tibia robust, often with a basal longitudinal carina along inner margin and a subbasal protuberance on anterior margin; tibial spurs large and distinct, larger spur at least ½ as long as basitarsus; tarsi slender, tapering towards apex; tarsal claws minute; pulvilli, especially fore pulvillus, greatly enlarged (Figs. 13–14); hind trochantellus obsolescent; anterior subalar depression with a distinct tubercle; first metasomal tergum longer than broad, contracted behind the spiracles, and sessile basally; terga 2 and 3 flat dorsally, sharply folded laterally; metasoma narrow, with apex strongly compressed; ovipositor shorter than hind basitarsus, compressed, sickle-like, and strongly curving anterad when exserted; ovipositor emerging subapically when exserted, withdrawn into metasoma when at rest (most specimens die with the ovipositor exserted).

Male.—Moderately sexually dimorphic: body smaller than in female; head, mesosoma, metasoma, and coxae mostly black; head not as wide as in female, about as broad as mesonotum; face evenly convex, without a pair of spinose protuberances; clypeus short and wide; labrum less conspicuously exposed; compound eye smaller than in female, slightly less prominent, and not so strongly converging antero-ventrally; ventral facets of compound eye not discernibly larger than dorsal facets; malar space slightly wider than in female; flagellum densely setose and slightly shorter than in females, about as long as fore wing; fore tibia normal, more slender than in female, without a basal longitudinal carina along inner margin or a subbasal protuberance on anterior margin; tibial spurs shorter than in female; tarsi more slender and longer than in female; pulvilli not so greatly enlarged; metasoma shorter, not so narrow or strongly compressed as in female; cuspides not dissociated; cuspidal lobes broad, with six regularly arranged sen-



1. Habitus of *Neoneurus mantis* female, antero-lateral view.

sillae; digitus with abundant spinules (male genitalia of *Neoneurus viennense* Giraud illustrated by Tobias 1966); otherwise as in female.

Remarks.—Although rarely encountered, their aberrant wing venation (Figs. 1, 2) allows both male and female neoneurines to be easily diagnosed to subfamily and genus. Specimens may be identified to subfamily using the illustrated key to the subfamilies of holarctic Braconidae (van Achterberg 1990). Specimens may be identified to genus using the keys of Muesebeck (1922), Huddleston (1976), or Marsh et al. (1987). The remarkable fore legs of *Neoneurus* females (Figs. 3–24) are unique within the family Braconidae.

The only genera of the subfamily Neoneurinae known to occur in North America are *Neoneurus* and *Elasmosoma.* Species of *Elasmosoma* were revised by Huddleston (1976). Two additional genera, *Euneoneurus* and *Parelasmosoma,* were recently described to include certain remarkable Asian species (Tobias and Yuldashev 1979). Keys to neoneurine genera and *Neoneurus* species occurring in the western part of the USSR were provided by Tobias et al. (1986).

Taxonomic characters of value at the species level.—Sexual dimorphism is more extreme than in most braconids, and the differences between species are most obvious when comparing female specimens. Most apparent are the unusual modifications of the female fore leg (Figs. 3–16, 19–24), and the development of facial spinules or spines (Figs. 27–28). The modified female fore leg is formed by the compression of the fore femur (e.g. Fig. 21), shortening of the fore tibia (e.g. Fig. 6) and development of a tibial carina and an associated sharp tubercle (e.g. Fig. 5), enlargement of the tibial spur (e.g. Fig. 14), shortening of the fore tarsus (e.g. Fig. 10), and enlargement of the fore pulvillus (e.g. Fig. 13). Presumably these adaptations are raptorial in nature, allowing the female to grasp the rapidly moving host ant securely, although briefly, during oviposition. However, limited observations indicate that oviposition is extremely rapid, and an hypothesis of raptorial function for the female fore leg cannot be confirmed or rejected at the present time. Likewise, the facial spines (e.g. Fig. 28) may be developed to allow the female to better position herself on the rapidly moving host ant, by bracing the head against the posterior margin of metasomal tergum 2. However, high-speed photography of the oviposition sequence will be needed to examine these hypotheses.

Body color is moderately variable, especially between females of different species. Size of the ovipositor is not a very useful taxonomic character in *Neoneurus* species since the ovipositor is retracted into the metasoma when not in use, therefore its apparent size is actually an artifact of its position at the death of a particular specimen. Likewise, the body length of dead specimens is apparently more variable than it actually would be in live specimens, since in some dead specimens the metasoma is bent forwards or shriveled. Fore wing length is a better indicator of relative body size. Diagnosis of males is difficult. Unfortunately, some of the species described so far in the Palearctic region were based on male type specimens.

Hosts.—Associated with adult worker ants, particularly those of the *Formica fusca* and *rufa* species-groups (Shenefelt 1969). Donisthorpe (1927) reports observing *Elasmosoma* ovipositing in the metasoma of adult worker ants, and also claims to have reared them from observation nests. As clarified by Huddleston (1976), Donisthorpe's observations probably pertain to *Neoneurus,* following Morley's (1914b) misidentification of *Neoneurus halidaii* Marshall as *Elasmosoma berolinense* Ruthe, a nomenclatorial confusion that persisted until cleared up by Nixon (1934), although noted by Muesebeck (1922).

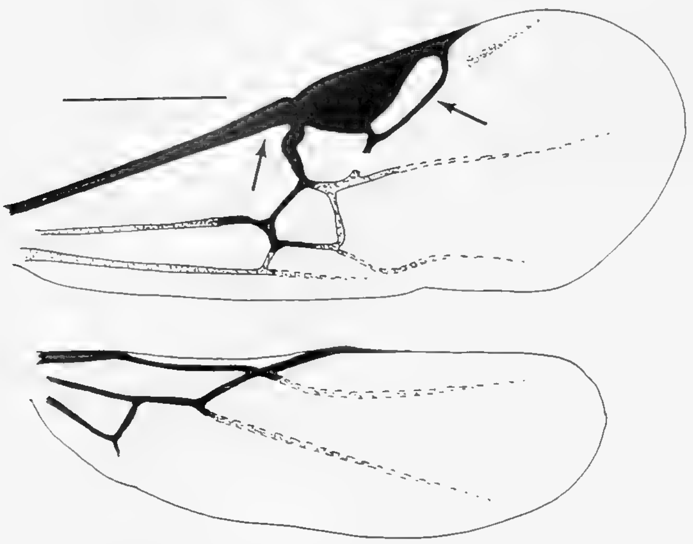
*Key to the Known Species of *Neoneurus*

1 Females: apical flagellomere narrow and only moderately setose (as in Fig. 25) . . 2
[*female unknown for *clypeatus*]

– Males: apical flagellomere ovate and densely setose (as in Fig. 26) 12
[*male unknown for *curvicalcar, mantichorus,* and *spinarius*]

2(1) Anterior longitudinal carina of fore tibia produced into two thorn-like projecting spines, one medially and one basally (as in Figs. 7–8) 3

– Anterior longitudinal carina of fore tibia not produced into two thorn-like projecting spines, although one blunt projection



2. Wings of *Neoneurus diabolicus* female.

is often present basally, no such spine is present medially (as in Fig. 5) 5

3(2) Nearctic species 4

– Palearctic species (Mongolia) .... *Neoneurus armatus* Tobias

4(3) Facial spines shorter than antennal scape; head with occiput pale yellowish white; United States (Arizona) .... *Neoneurus portalensis,* new species

– Facial spines longer than antennal scape; head with occiput black; United States (California) .... *Neoneurus spinarius,* new species

5(2) Fore tibial spur large and sometimes strongly curved (e.g. Figs. 14 and 16), as long or longer than ½ tibia length (as in Figs. 20, 22 and 24); facial spines long and distinct (as in Fig. 28), about as long, or longer than, antennal pedicel 6

– Fore tibial spur relatively smaller and only slightly curved (as in Figs. 9–10), distinctly shorter than ½ tibia length; facial spinules much smaller and less distinct (as in Figs. 1 and 27) or absent, always shorter than antennal pedicel 10

6(5) Fore tibial spur shorter than fore basitarsus (as in Fig. 16) *and* facial spines shorter than antennal scape; Palearctic species .. 7

– Fore tibial spur as long as fore basitarsus (as in Fig. 14) *or* facial spines longer than antennal scape (as in Fig. 28); North American species 8

7(6) Subbasal tibial protuberance falcate; facial spines separated by distance distinctly greater than scape width; Austria, Czechoslovakia, Denmark, Finland, Netherlands, Sweden, Yugoslavia .... *Neoneurus viennense* Giraud

– Subbasal tibial protuberance not falcate; facial spines separated by distance equal to scape width; Kazakhstan .... *Neoneurus curvicalcar* Belokobylskij

8(6) Facial spines as long as antennal scape .. 9

– Facial spines shorter than antennal scape; United States (Georgia) .... *Neoneurus mantichorus,* new species

9(8) Fore tibial spur sharply curved apically (Fig. 14); facial spines widely spaced (Fig. 28), the distance between their tips distinctly greater than width of median ocellus; United States (North Dakota) .... *Neoneurus diabolicus,* new species

– Fore tibial spur relatively straighter (Fig. 12), only gradually curved apically; facial spines close together, the distance between their tips about equal to width of median ocellus; United States (Oregon, Washington) .... *Neoneurus masneri,* new species

10(5) Facial spinules present, although small (as in Figs. 1 and 27); fore basitarsus distinctly shorter than fore tibia (as in Figs. 19–20); fore tibia with a distinct basal longitudinal carina along inner margin and a subbasal protuberance on anterior margin (as in Figs. 3–5); North American species 11

– Facial spinules absent; fore basitarsus about equal in length to fore tibia; fore tibia without a distinct basal longitudinal carina along inner margin or a subbasal protuberance on anterior margin; European species .... *Neoneurus auctus* (Thomson)

11(10) Mesosoma extensively marked with yellowish brown, especially mesonotum anteriorly, pronotum laterally, and mesopleuron ventrally (Fig. 29); Canada (Ottawa) and United States (Colorado, North Carolina, Michigan, Virginia) .... *Neoneurus pallidus,* new species

– Mesosoma mostly black (Fig. 1); Canada (Alberta, British Columbia) and United States (California, Oregon, Wyoming) .. .. *Neoneurus mantis,* new species

12(1) Nearctic species 13

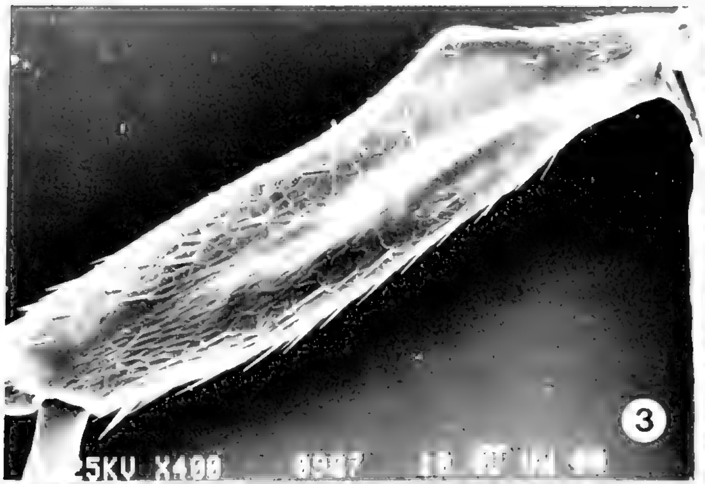
– Palearctic species 17

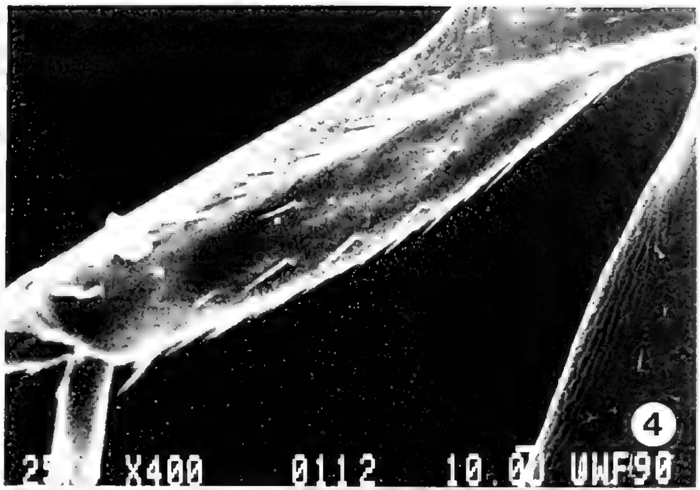
13(12) Tegula pale yellow or whitish; hind coxa mostly yellowish brown or, at most, infused with brown basally 14

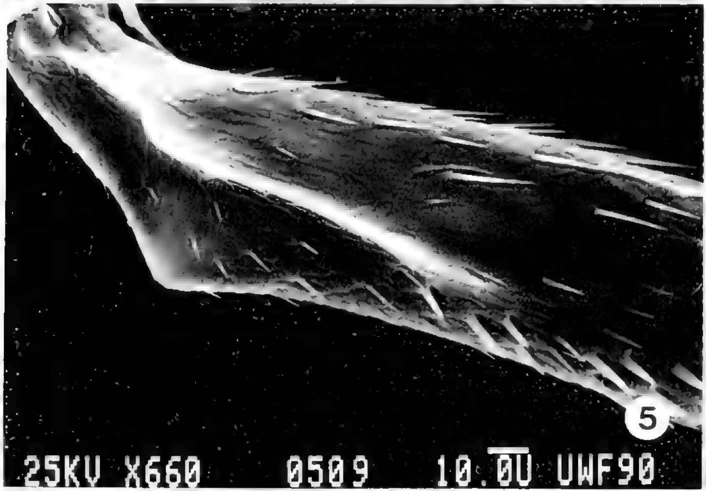
– Tegula dark brown; hind coxa mostly black 16

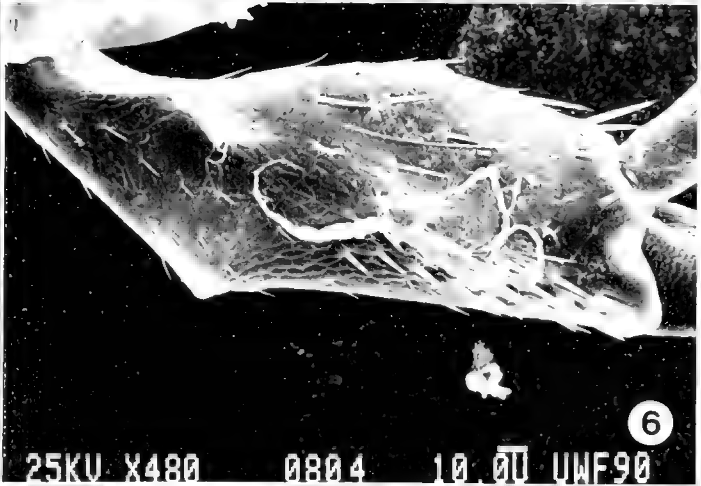
14(13) Face, scape, and sometimes pedicel marked with pale yellowish brown (Fig. 30); prosternum yellowish brown; fore tibial spur evenly curved and about ½ as long as basitarsus; Canada (Ottawa) and United States (Colorado, North Carolina, Michigan, Virginia) ... *Neoneurus pallidus,* new species

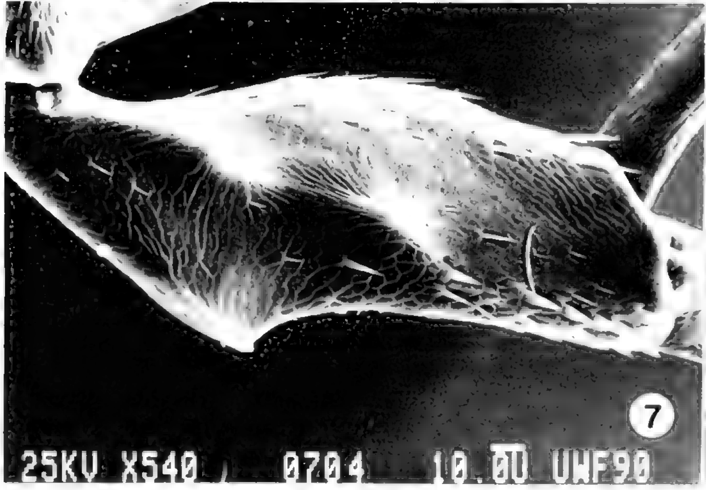
– Face black or black irregularly infused with

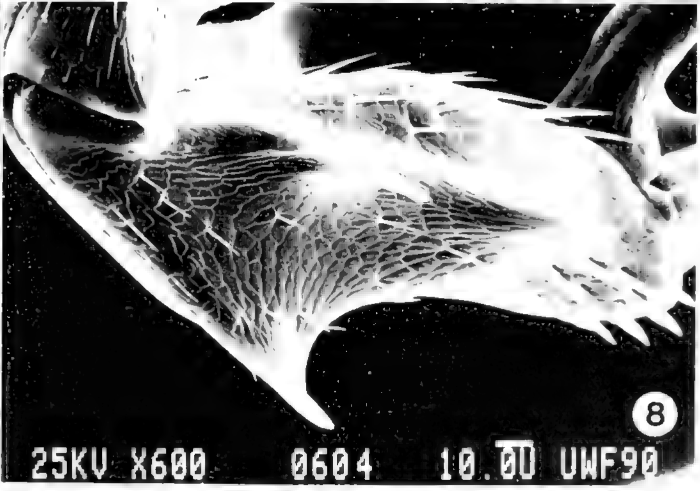












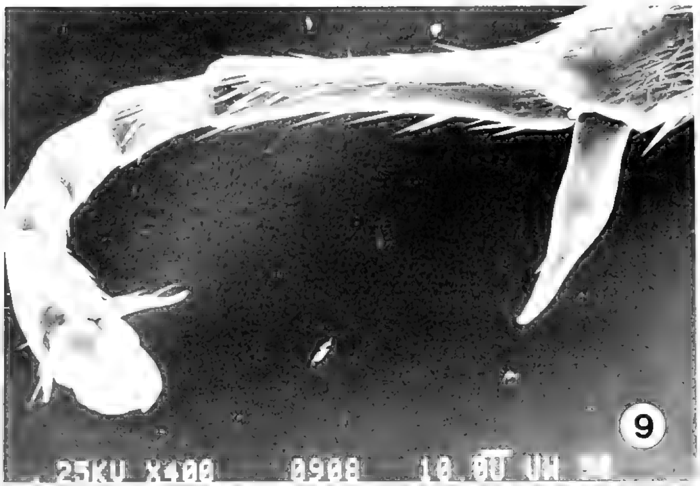
3. Fore tibia of *Neoneurus mantis* female.
4. Fore tibia of *Neoneurus pallidus* female.
5. Fore tibia of *Neoneurus masneri* female.
6. Fore tibia of *Neoneurus diabolicus* female.
7. Fore tibia of *Neoneurus portalensis* female.
8. Fore tibia of *Neoneurus spinarius* female.

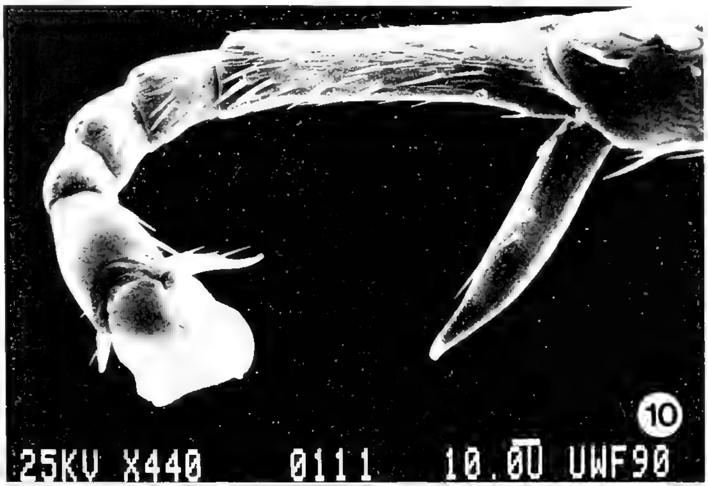
yellowish brown, scape and pedicel brown; prosternum dark brown or black; fore tibial spur curved in basal ¼ then relatively straight, definitely more than ½ as long as basitarsus 15

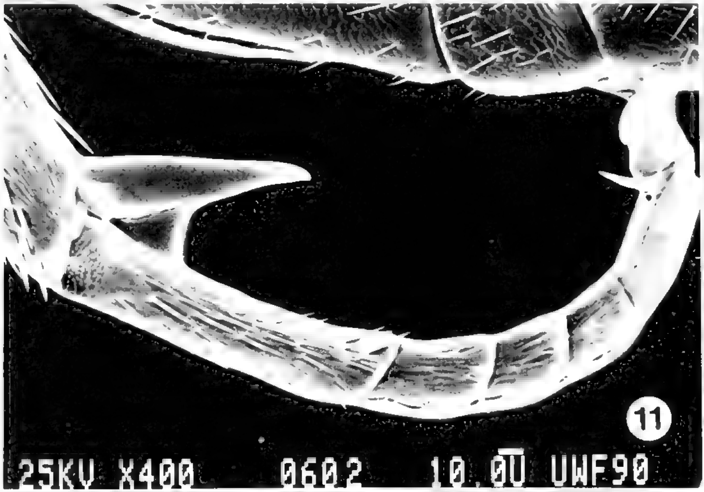
15(14) Clypeus entirely pale yellowish white; fore tibial spur nearly as long as basitarsus (Fig. 18); United States (Arizona) . . . . *Neoneurus portalensis*, new species

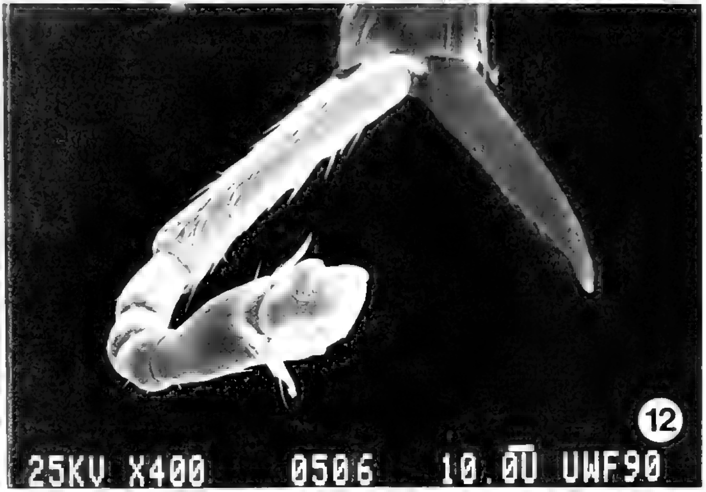
– Clypeus yellowish brown, darker dorsally; fore tibial spur about ¾ as long as basitarsus; United States (North Dakota) . . . . *Neoneurus diabolicus*, new species

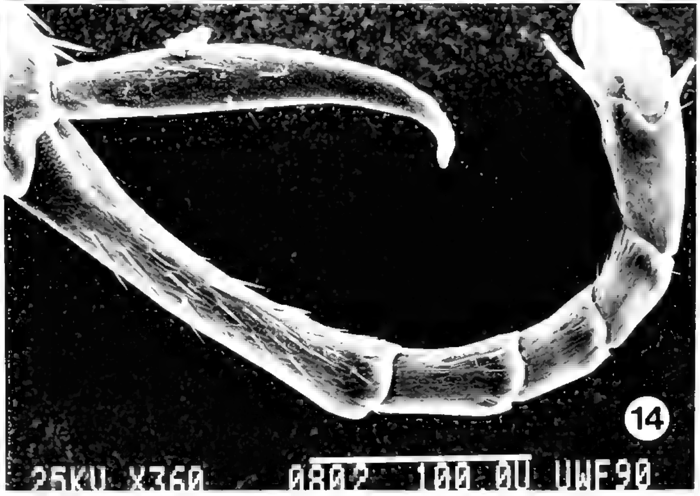
16(13) Wings distinctly infumate; nonmarginal











9. Fore tibial spur and tarsus of *Neoneurus mantis* female.
10. Fore tibial spur and tarsus of *Neoneurus pallidus* female.
11. Fore tibial spur and tarsus of *Neoneurus spinarius* female.
12. Fore tibial spur and tarsus of *Neoneurus masneri* female.
13. Fore tibial spur and tarsus of *Neoneurus portalensis* female.
14. Fore tibial spur and tarsus of *Neoneurus diabolicus* female.

venation of fore wing distinctly sclerotized and appearing yellowish brown from below [in very old specimens there may be some fading that will render this couplet difficult] ..... *Neoneurus mantis*, new species

– Wings indistinctly infumate; nonmarginal venation of fore wing weakly sclerotized and appearing white from below .... *Neoneurus masneri*, new species

17(12) Vertex finely granular 18

– Vertex finely transversely rugulose .... *Neoneurus auctus* (Thomson)

18(17) Clypeus and hind femur entirely yellow; Europe ...... *Neoneurus clypeatus* (Foerster) and *Neoneurus* viennense Giraud

– Clypeus black; hind femur yellow infused with dark brown and black; Mongolia .. .. *Neoneurus armatus* Tobias

SYNOPSIS OF *NEONEURUS* SPECIES

Neoneurus armatus Tobias, 1977

Neoneurus armatus Tobias, 1977.

Diagnosis.—Female with facial spinules distinct but short; spinules situated on thick tubercles that are nearly as long as antennal pedicel but distinctly shorter than antennal scape; fore tibial spur large and strongly curved, about as long as ⅓ tibia length, and slightly shorter than basitarsus length; anterior longitudinal carina of fore tibia produced into two thorn-like projecting spines, one medially and one basally.

Male with vertex finely granular; facial markings black; clypeus black; tegula dark brown; hind coxa dark brown; hind femur dark brown; fore tibial spur strongly curved and about as long as ¾ basitarsus length.

Material examined.—1 holotype female, Mongolia: Eastern Aimak, Derkmin-Tsagan-Obo, 60 km. ENE Bayan-Burda, 2.VIII.1976, M. Koslov [ZIL]; 1 male, Mongolia: Uvs Aimak, Sandgebiet Altan els, 35 km WNW von Somon Tes, 1400 m, Exp. Dr. Z. Kaszab, 1986, Nr. 1007, 23.VI.1968, det. *Neoneurus viennense* Papp, 1974 [TMB].

Distribution.—Mongolia.

Hosts.—Unknown.

Remarks.—The head and fore leg of the holotype were figured by Tobias (1977). *Neoneurus armatus* is quite distinctive in being the only known palearctic species with a medial spine projecting from the anterior longitudinal carina of the fore tibia. In this regard, *Neoneurus armatus* is similar only to the nearctic species *Neoneurus portalensis* and *Neoneurus spinarius,* however, these species both have the tibial spines more extremely developed than in *armatus.* Tobias (1977, Fig. 5a) shows the female facial spinules to be curved to the left in an asymmetrical fashion. This is probably an abnormal specimen in this regard, as other *Neoneurus* species typically have straight spines or spinules. Most likely, the spinules of this specimen were bent soon after emergence, while the cuticle was still soft.

The single male specimen included here is assumed to be *armatus* since this is the only species known from Mongolia. It was compared with the male holotype of *viennense* and is definitely distinct from that species. It could not be compared with *Neoneurus curvicalcar* Belokobylskij, the only other Asian species, for which the male is unknown.

Neoneurus auctus (Thomson), 1895

Elasmosoma aucta Thomson, 1895; transferred to *Neoneurus* by Bengtsson, 1918.

Neoneurus halidaii Marshall, 1897; synonymized by Bengtsson, 1918.

Neoneurus bistigmaticus Morley, 1909; synonymized with *halidaii* by Morley, 1914a.

Diagnosis (modified from Bengtsson, 1918).—Female with head finely transversely rugulose; facial spinules absent; fore tibia without a distinct basal longitudinal carina along inner margin or a subbasal protuberance on anterior margin; fore tibial spur small and only slightly curved, distinctly shorter than ½ tibia length; fore basitarsus about equal in length to fore tibia.

Males with vertex finely transversely rugulose; clypeus and antenna dark brown; tegula dark brown; wings lightly infumate; submarginal venation very pale; hind coxa mostly black; hind femur yellow; fore tibial spur about ¾ as long as basitarsus, only slightly curved.

Final instar larva (Čapek 1970) with mandibles wedge-shaped, about the same size as maxillary palpus; hypostoma much shorter than stipital sclerite; hypostomal spur lightly indicated; labial sclerite almost square; antenna disc-shaped; setae beneath labial sclerite short.

Material examined.—1 female lectotype of *Neoneurus auctus* (Thomson) (here designated), "Sm, Bhn, 1975 604, 1991 179" [pinned, hind leg and metasoma glued on separate card] [ZML]; 1 male paralectotype of *Neoneurus auctus* (Thomson) (here designated), same data as lectotype [ZML]; 1 male, Bengtsson collection [ZML]; 1 male, Norwegen Coll. Strand, Hatfjelddahl, Coll. Schmiedeknecht [ZMH]; 2 females, Wisenburg, 25.VI.16, Bischoff [ZMH]; 1 female, Mizdroy, July 28, Bischoff S.G. [ZMH]; 1 male, Finkenkrug, 2.9.28, Bischoff S.G. [ZMH]. 1 male paralectotype of *Neoneurus halidaii* Marshall, 1897 [TMB]. 1 female holotype of *Neoneurus bistigmaticus* (Morley), 1909, card-mounted, B.M. Type Hym. 3c1287, Weybridge, July 1906 [BMNH].

Distribution (according to Shenefelt 1969).—Austria, Czechoslovakia, England, Finland, Norway, Poland (Silesia), Sweden.

Seasonal occurrence.—In England, occurring from June 15 through July 21 (Donisthorpe, 1909b).

Hosts.—*Formica rufa* Linnaeus, according to Morley (1909) and Donisthorpe (1909a, b) [as *bistigmaticus*]. Donisthorpe (1909a, b, 1927) noted that females are found flying over nests of the host ant and described how they hover over the ant and dart rapidly to oviposit between the metasomal segments.

Remarks.—Wings, fore leg, and metasoma were figured by Bengtsson (1918), fore wing by Tobias (1966), and larval mouthparts by Čapek (1970). *Neoneurus auctus* is most similar to *Neoneurus mantis* and *Neoneurus pallidus* in the form or the fore tibial spur, which is relatively short; however, these species can be separated by differences in the length of the tibia relative to the basitarsus and several other characters (see key). *Neoneurus auctus* females are very distinct from all other known *Neoneurus* species in lacking facial spinules and having a relatively unspecialized fore tibia without a distinct basal longitudinal carina along inner margin or a subbasal protuberance on anterior margin. Although the fore femora is somewhat compressed and the tibial spur of moderate size, it is unclear based on morphology alone whether the fore leg of this species may have a raptorial function as is hypothesized for other *Neoneurus* species.

Neoneurus clypeatus (Foerster), 1862

Ecclites clypeatus Foerster, 1862; transferred to *Neoneurus* by Ashmead, 1900.

Diagnosis.—Female unknown.

Male with clypeus and antenna pale yellowish white; face brown; vertex granular; tegula yellowish white; wings hyaline, venation very pale; hind coxa and femur yellow.

Material examined.—1 male holotype, Germany, "Aachen, 17, 279, Frst, clypeatus Frst, Zool. Mus. Berlin, *Ecclites clypeatus* Foerster det. C. van Achterberg 1979, *Neoneurus clypeatus* (Foerster) type series checked C. van Achterberg 1979, sen. syn. of *Neoneurus viennense* (Giraud) det. C. van Achterberg 1979."

Distribution.—Aachen, Germany.

Hosts.—Unknown.

Remarks.—This species was not treated by Bengtsson (1918). Muesebeck (1931) compared the holotypes of *Ecclites clypeatus* Foerster and *Neoneurus halidaii* Marshall (= *auctus*) and concluded that Ashmead (1900) was correct in synonymizing *Ecclites* with *Neoneurus*. Since Muesebeck did not synonymize the two species, it can only be assumed that he considered *clypeatus* to be distinct from what is here treated as *auctus* (Thomson).

Neoneurus clypeatus poses a real taxonomic difficulty, since it is known only from a male holotype which is in poor condition. Both antennae are broken before the apices and both fore legs are missing. The body is discolored and faded with age and it is difficult to acertain its original condition.

Specimen labels indicate that the holotype was studied by C. van Achterberg in 1979 and determined to be conspecific with *Neoneurus viennense* (Giraud). However, direct comparison of the male holotypes of both species indicates that although they are morphologically very similar, there are some subtle differences that suggest that they may be different valid species. The basal flagellomeres of *Neoneurus clypeatus* are shorter and less densely setose than in *Neoneurus viennense,* and the hind tibial spurs and hind tarsomeres are shorter than in *Neoneurus viennense.* The antennae, body, and hind coxa of *Neoneurus clypeatus* are much more pale than in *Neoneurus viennense,* but this could be partly due to aging of the specimen. The *Neoneurus clypeatus* holotype has quite obviously faded with age, but it is difficult to attribute these differences entirely to aging, since the *Neoneurus viennense* holotype is nearly as old. It seems advisable to retain these as separate species until topotypic females of *clypeatus* are discovered for comparison.

Neoneurus curvicalcar Belokobylskij

Neoneurus curvicalcar Belokobylskij, 1986.

Diagnosis.—Female with facial spines long and distinct, about as long as antennal pedicel, but shorter than antennal scape; facial spines separated by a distance equal to scape width; subbasal tibial protuberance not falcate; fore tibial spur large and strongly curved, about as long as ½ tibia length, and slightly shorter than basitarsus length. Male unknown.

Material examined.—1 female holotype, USSR, Eastern Kazakhstan, 8 km NW Verkhubinka, Uba region, 11.VIII.1983, Belokobylskij [ZIL].

Distribution.—Eastern Kazakhstan.

Hosts.—Unknown.

Remarks.—The head, fore wing, fore leg, and first tergum were illustrated by Belokobylskij (1986). This species is very similar to *Neoneurus viennense* (Giraud), except that the subbasal tibial protuberance is not falcate and the facial spines are separated by a distance equal to scape width. In *Neoneurus viennense* the subbasal tibial protuberance is falcate and the facial spines are separated by a distance distinctly greater than the scape width.

Neoneurus diabolicus **Shaw, New Species**

Figs. 2, 6, 14, 24 & 28

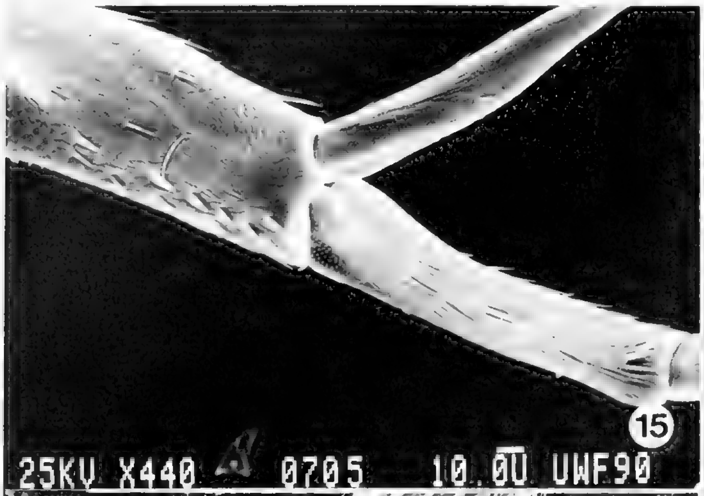
Holotype.—Female, United States: North Dakota, McHenry County, Denbigh Exp. Forest, Sec. 36, T. 156, R. 78, 20–21 August 1969, M. E. McKnight, Collector, Malaise trap, Hopk. 53988Q [USNM].

Description of holotype female.—Body length 2.67 mm; fore wing length 1.97 mm.

Color: Lower parts of head pale yellowish white, except apex of mandible dark reddish black; ocellar triangle, temple, vertex, and occiput black; scape, pedicel, and flagellomere 1 yellowish white, flagellum otherwise gradually darker brown apically; compound eye dull silvery black; mesosoma marked with yellowish brown on mesonotum anteriorly, laterally, and medially, pronotum marginally, and subalar area of mesopleuron; prosterna, tegula, wing base, and costa basally pale yellowish white; legs entirely pale yellowish brown except trochantelli and pulvilli brown; wing venation pale yellowish brown to hyaline, except remainder of costa and stigma dark brown; wing membrane very lightly infumated with brown; mesosoma otherwise black (especially mesopleuron and propodeum); metasoma pale yellowish brown, except antero-medial area of tergum 1 infused with black.

Head: Minutely granulate except short smooth furrow anterior to median ocellus; facial spines long and distinct, longer than antennal pedicel, and about as long as antennal scape; malar space/eye height = 0.11; ocell-ocular distance/lateral ocellus diameter = 1.8; ocellar triangle slightly raised.

Mesosoma: Minutely granulate except mesopleuron medially and propodeum medially and posteriorly rugulose; mesopleu-



15. Fore tibial spur and basitarsus of *Neoneurus portalensis* female.
16. Fore tibial spur and basitarsus of *Neoneurus viennense* female.
17. Fore tibial spur and basitarsus of *Neoneurus mantis* male.
18. Fore tibial spur and basitarsus of *Neoneurus portalensis* male.

ron posteriorly and metapleuron medially nitid; fore tibial spur large and strongly curved, as long as ¾ tibia length, and as long as fore basitarsus.

Metasoma: Tergum 1 and tergum 2 minutely granulate; metasoma otherwise nitid.

Paratype female.—Essentially as in holotype except right fore wing removed for study (mounted on microscope slide for study by Marsh et al. 1987); ocell-ocular distance/lateral ocellus diameter = 1.9.

Paratype males.—Face black, scape and pedicel brown; tegula pale yellow or whitish; hind coxa mostly yellowish brown or, at most, infused with brown basally; wings clear or only lightly infumate.

Paratype data.—1 female, same data as holotype except collected 11–17 July, Hopk. 53988H; one male, same data as holotype except collected 28–31 July, Hopk. 53988L; one male, same data as holotype except collected 22–25 August, Hopk. 53988P [USNM, RMSEL]. The following data are from the associated Hopkins card file: "Collections from Malaise trap installed 21 May 1969 at approximate center of NW Sec. 36, 60 feet east of windbreak and 50 feet north of its south end. Overstory largely cottonwood. Trap dismantled 15 October 1969."

Remarks.—The facial spines of the female are much larger than in any other *Neoneurus* species (Fig. 28), and the fore tibial spur is larger than in any other North American *Neoneurus* species (Fig. 14).

Etymology.—From the Latin *diabolus* meaning devil or evil spirit; in reference to the pair of long facial spines of the female that give her a decidedly devilish appearance.

Neoneurus mantichorus Shaw, New Species

Holotype.—Female, United States: Georgia, Rabun County, Satolah, 2500 feet, 4 July 1957, W.R.M. Mason [CNC].

Description of holotype female.—Body length 3.03 mm; fore wing length 2.12 mm.

Color: Lower parts of head pale yellowish white, except apex of mandible dark reddish black; ocellar triangle, temple, vertex, and occiput black; scape and pedicel yellowish white; flagellum pale brown basally, gradually darker brown apically; compound eye dull silvery black; mesosoma marked with yellowish brown on mesonotum anteriorly, laterally, and medially, pronotum marginally, subalar area of mesopleuron, and mesopleuron ventrally; prosterna, tegula, wing base, and costa basally pale yellowish white; legs entirely pale yellowish white basally to pale yellowish brown apically, except trochantelli apically and pulvilli brown to black; wing venation pale yellowish brown to hyaline, except remainder of costa and stigma dark brown; wing membrane very lightly infumated with brown; mesosoma otherwise dark reddish brown to black (especially mesopleuron medially and propodeum); metasomal tergum 1 and tergum 2 basally dark reddish brown to black; metasoma otherwise pale yellowish brown irregularly infused with black.

Head: Minutely granulate except median area of frons between antennal insertions minutely rugulose; facial spines long and distinct, longer than antennal pedicel, but shorter than antennal scape; face with a short median tubercle just above paired facial spines; malar space/eye height = 0.09; ocell-ocular distance/lateral ocellus diameter = 2.0; ocellar triangle only very slightly raised.

Mesosoma: Minutely granulate except pronotum dorsally, mesopleuron medially, metapleuron ventrally, and propodeum medially and posteriorly rugulose; mesopleuron posteriorly nitid; fore tibial spur large and strongly curved, as long as ¾ tibia length, and as long as fore basitarsus.

Metasoma: Tergum 1 basally and medially and tergum 2 basally minutely rugulose; metasoma otherwise minutely granulate.

Remarks.—Known only by the holotype female, this species is very similar to *Neoneurus diabolicus*; however, *mantichorus* has shorter facial spines and the fore tibia is longer and not so stout as in *diabolicus.*

Etymology.—From the Latin; a fabulous beast with a human face, lion's body, and a scorpion's tail.

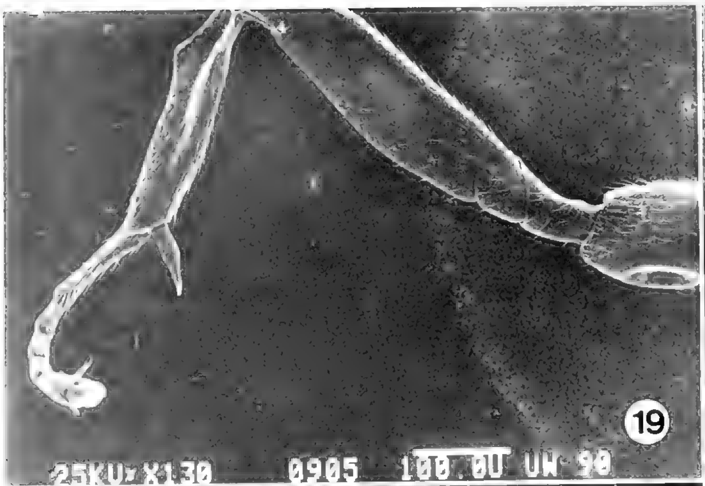
Neoneurus mantis Shaw, New Species

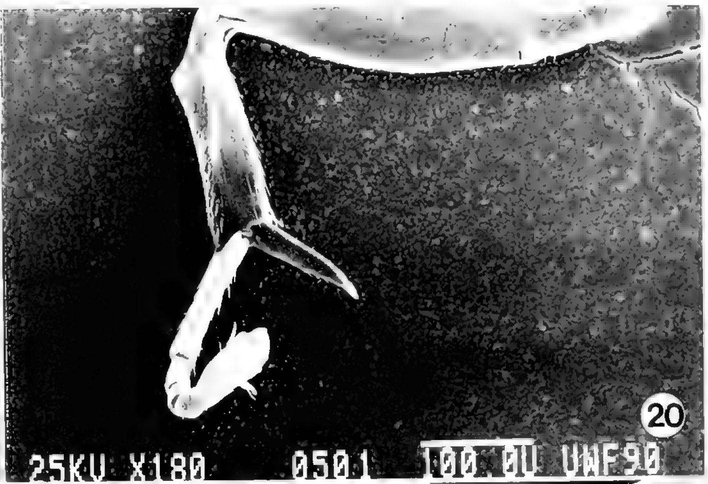
Figs. 1, 3, 9, 17, 19, 25, 26 & 27

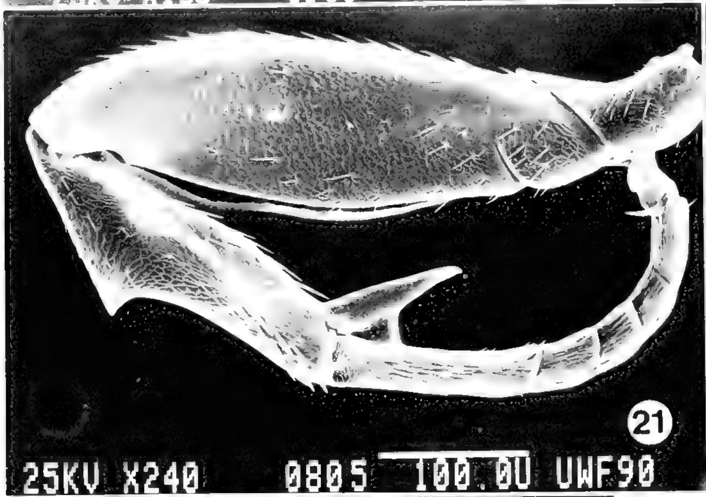
Holotype.—Female, United States: Wyoming, Albany County, Medicine Bow National Forest, 0.5 mi. SW Lincoln Monument, montane meadow near mixed conifer/aspen forest, 27 June 1990, Scott R. Shaw, aspirated from grass stems near entrance to ant mound [RMSEL].

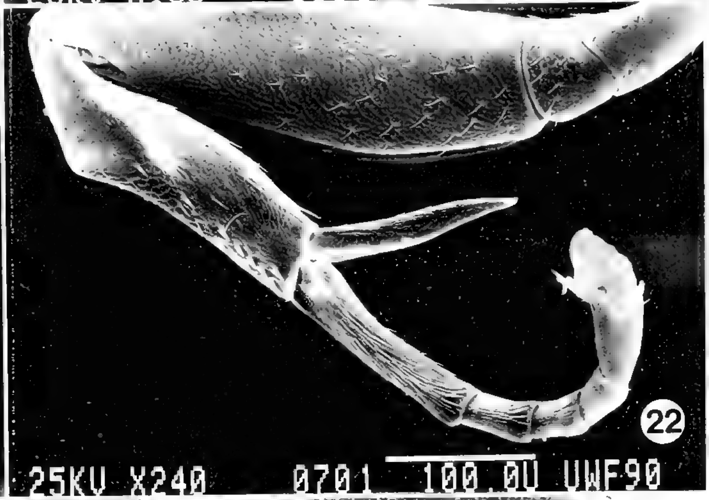
Description of holotype female.—Body length 2.58 mm; fore wing length 1.97 mm.

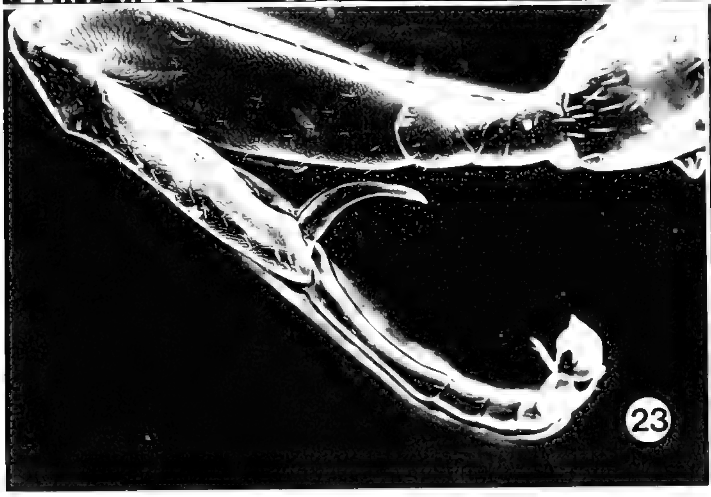
Color: Lower parts of head pale white, except apex of mandible dark reddish black; frons medially, ocellar triangle, temple, vertex, and occiput black; scape pale yellowish brown; pedicel brown; flagellum dark brown to black; compound eye dull silvery gray; mesosoma black except prosterna white; tegula, wing base, and costa basally pale yellowish brown; fore coxa and trochanter white, remainder of leg pale yellowish brown except apical tarsomere, claws, and pulvillus dark brown; middle coxa and trochanter white, remainder of leg pale yellowish brown except tarsi dark brown; hind coxa white infused with black basally, hind trochanter white, hind femora yellowish brown; hind tibia and tarsi dark brown; wing venation pale brown to hyaline, except remainder of

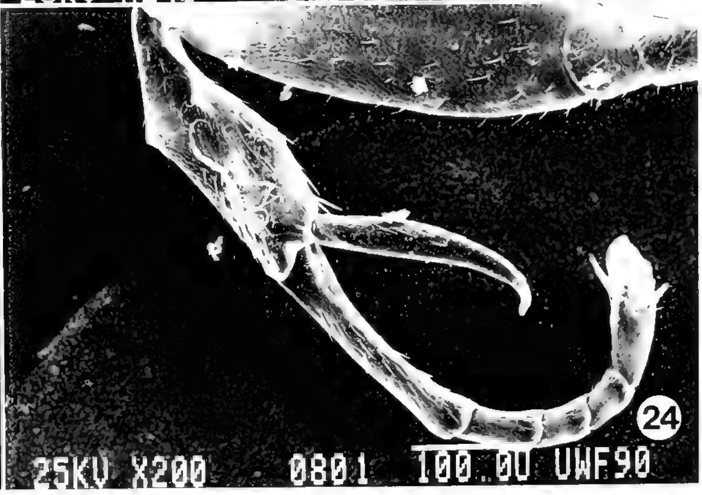












19. Fore leg of *Neoneurus mantis* female.
20. Fore leg of *Neoneurus masneri* female.
21. Fore leg of *Neoneurus spinarius* female.
22. Fore leg of *Neoneurus portalensis* female.
23. Fore leg of *Neoneurus viennense* female.
24. Fore leg of *Neoneurus diabolicus* female.

costa and stigma dark brown; wing membrane deeply infumated with brown; metasomal tergum 1 and extreme base of tergum 2 black; remainder of metasoma yellowish brown irregularly infused with black along posterior margins of terga, on laterotergites, and sterna.

Head: Minutely granulate except median area of frons between antennal insertions minutely rugulose; facial spinules minute, distinctly shorter than ½ antennal pedicel length, although spinules placed on raised tubercles; face with a short median tubercle just above paired facial spines; malar space/

eye height = 0.13; ocell-ocular distance/lateral ocellus diameter = 1.78.

Mesosoma: Minutely granulate except mesopleuron medially and posterior face of propodeum rugulose, postero-dorsal area of mesopleuron nitid; fore tibial spur small and only slightly curved, distinctly shorter than ½ tibia length.

Metasoma: Tergum 1 and antero-medial area of tergum 2 minutely rugulose; metasoma otherwise minutely granular to nitid.

Paratype females.—Wyoming specimens essentially as in holotype female except body length 2.33–3.12 mm; fore wing length 1.67–1.97 mm; malar space/eye height = 0.19–0.22; ocell-ocular distance/lateral ocellus diameter = 1.64–1.70. Oregon series essentially as in Wyoming paratypes except pronotum laterally, subalar area of mesopleuron, hind tibia, hind tarsus, and sometimes mesonotum antero-laterally yellowish brown; mesosoma more extensively infused with black along posterior margins of terga; facial spinules distinctly longer than in Wyoming population. Alberta specimen with similar mesosomal markings to Oregon series; however, metasomal color lighter, as in Wyoming specimens; facial spinules distinctly longer than in Wyoming population, about equal to those of Oregon series.

Paratype males.—Wyoming specimens with tegula dark brown; hind coxa mostly black; wings distinctly infumate. Alberta specimens with tegula lighter brown; wings less deeply infumate.

Paratype data.—1 female, 1 male, same data as holotype; 5 females, 2 males, same data as holotype except 28 June 1990; 2 females, 2 males, same data as holotype except 29 June 1990; 5 females, 2 males, same data as holotype except 2 July 1990; 2 males, same data as holotype except 5 July 1990, yellow pan trap; 2 males, same data as holotype except 9 July 1990, yellow pan trap; 1 male, same data as holotype except 12 July 1990, yellow pan trap; 2 females, same data as holotype except 2 August 1990; 3 females, same data as holotype except 8 August 1990; 4 females, same data as holotype except 26 June 1991; 1 female, same data as holotype except 27 June 1991; 1 female, same data as holotype except 19 July 1991 [RMSEL, USNM, TAMU]. 1 female, **United States, California:** Marin County, Alpine Lake, Lily Pond, 1500', 23 June 1970, D.D. Munroe, Malaise trap [CNC]. **Oregon:** 3 females, Sixes R. Valley, 1–11 August 1985, Myrtle woods, L. Masner [CNC]; 1 female, Pinehurst, 29 June 1978, H.&M. Townes [AEI]; 2 females, Ochoco Creek, 8–14 July 1978, H.&M. Townes [AEI]; 1 female, 2 males, Grant County, Aldrich Mountains, 12 August 1987, T.R. Torgersen [AEI]; 1 female, Union County, Mt. Emily, 21 August through 1 September 1987, T.R. Torgersen [AEI]; 1 female, same data except collected 14 June [AEI]; 1 male, same data except collected 6–21 August (aberrant specimen with pale tegula) [AEI]. **Canada, Alberta:** 1 female, Banff, Eisenhower Junction, 4700′, 10 July 1962, Mason [CNC]; 3 males, Kananaskis, For. Exp. Stn. Seebe, 21–23 June 1962, W.R.M. Mason [CNC]; 1 male, Onefour, 49.6, 110.24, 7 June 1955, J.R. Vockeroth [CNC]; 1 male, McMurray, 13 July 1953, W.J. Brown [CNC]. **British Columbia:** 1 male, Vancouver Island, Teanook Lake, August 1984, Malaise trap, M. Sharkey & K. Johnson [CNC]; 6 females, 1 male, Blind Bay, June 1987, C.A. Elsey [CNC].

Hosts.—In Wyoming associated with, but not reared from, *Formica podzolica* Francoeur. Host ants build large, low mounds with multiple entrances, commonly near the base of sagebrush bushes. Mounds typically have many protruding grass stems.

Remarks.—Specimens of the Wyoming population are notably homogeneous in their color patterns and morphology. The single female from California does not differ notably from the Wyoming series, nor do those from British Columbia. The Oregon populations differ slightly in color pattern by having some lighter mesosomal markings and a darker metasoma; however, in morphology they are quite close to the Wyoming specimens except that the facial spinules are slightly larger. The Ochoco Creek population, in particular, is unusual in having the facial spines somewhat lower on the face, the anterior longitudinal carina of the fore tibia is raised into a distinct lamella, and the fore tibial spur is longer than usual. These differences being rather slight, I am inclined to interpret them as intraspecific variation, although it is possible that some of the Oregon populations are actually separate sibling species. In the absence of host or behavioral data on the Oregon populations, there is little justification for separating possible sibling species at this time. Likewise, there are some minor differences in the Alberta specimens in body color and size of the facial spinules.

Behavior.—*Neoneurus mantis* was found in Wyoming consistently in close association with three mounds of *Formica podzolica* Francoeur in a montane meadow of the Medicine Bow National Forest. Females were found hovering slowly near the nest entrances, or more commonly, perching for extended periods of time on grass stems near the nest entrances at a height of about 2.5 cm. The fore legs of the female wasp were often held in an upraised, mantid-like, position while at rest. When *Neoneurus* were present, the ants were very active near the mound, and many workers appeared to be patrolling the grass stems. *Neoneurus* were not found at the mounds during periods of low ant activity, and ants were only noted to patrol stems on the days when *Neoneurus* were present. When disturbed by an approaching ant, the *Neoneurus* female quickly took to flight and hovered nearby (2.5 cm or less) paralleling the movements of the ant. In such encounters, the ant appeared to perceive the presence of the parasitoid, actively chasing it and snapping with its mandibles. Such encounters were common, usually lasting from a few seconds to 15 seconds or more, but most often oviposition did not occur. In most cases the encounter ended by the ant running rapidly away, and the female wasp slowly hovered to a new position. In some cases the female returned to the same perch. Oviposition was observed during three such encounters. Each time the female hovered close, paralleling the movements of the ant for about five to ten seconds, when the ant suddenly moved from the ground up a grass stem. At about three to five cm height the ant slowed to reverse its position, at which point the wasp rapidly darted down and alighted on the metasoma of the ant for a period of less than one second. The female wasp then quickly retreated away 5 cm or more, and hovered slowly for about one minute before taking a new perch. Following oviposition, the ants became very agitated and quickly ran away in an erratic fashion. Only one was captured, however, it died in the laboratory within 48 hours and no parasitoid ever emerged from it. Although female wasps were found to be active both in mornings and afternoons, males were found near the ant mounds only during morning hours. Males also perched on grass stems, but only for shorter periods of time and at much greater heights (7–15 cm above the ant mound). Males were also found at greater distances from the ant mound (45–60 cm away), whereas females always were within 5–10 cm of the nest entrances.

Etymology.—From the Greek for soothsayer; in reference to the fore legs of the female, which are often held in an upraised, mantid-like position while at rest.

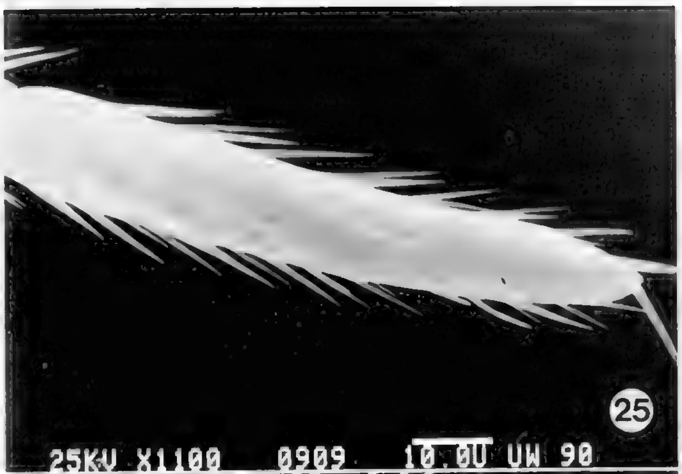
Neoneurus masneri Shaw, New Species

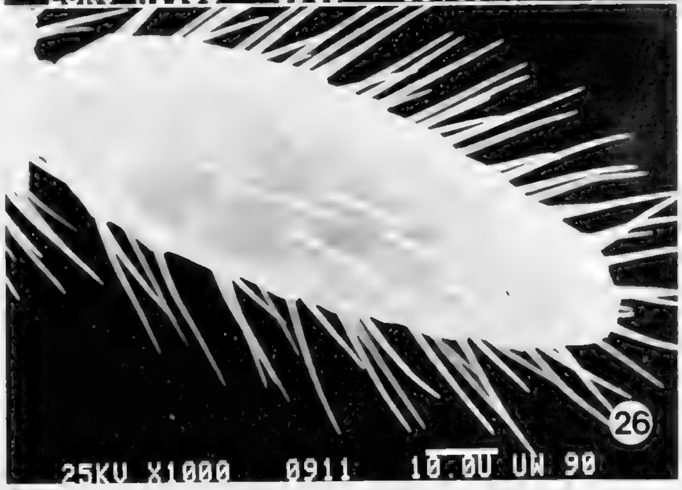
Figs. 12 & 20

Holotype.—Female, United States: Washington, Ashford, W. Mt. Rainlor [= Ranier] National Park, 1–14 August 1985, L. Masner [CNC].

Description of holotype female.—Body length 2.15 mm; fore wing length 1.67 mm.

Color: Lower parts of head pale yellowish white, except apex of mandible dark reddish black; frons medially, ocellar triangle, tem-





25. Apical flagellomere of *Neoneurus mantis* female antenna.

26. Apical flagellomere of *Neoneurus mantis* male antenna.

ple, vertex, and occiput black; scape, pedicel, and extreme base of flagellomere 1 yellowish white; flagellum otherwise dark brown; compound eye silver; mesosoma black except pronotum marginally, mesonotum laterally, and subalar area of mesopleuron yellowish brown; prosterna yellowish brown; tegula, wing base, and costa basally pale yellowish white; legs entirely pale yellowish white basally to pale yellowish brown apically, except pulvilli dark brown; wing venation pale yellowish brown to hyaline, except remainder of costa and stigma dark brown; wing membrane very lightly infumated with brown; metasomal tergum 1 and tergum 2 basally black; metasoma otherwise pale yellowish brown banded with dark brown along basal and apical margins of terga.

Head: Minutely granulate; facial spines long and distinct, longer than antennal pedicel and as long as antennal scape; spines close together, the distance between their tips about equal to width of median ocellus; face with a short median tubercle just above paired facial spines; malar space/eye height = 0.16; ocell-ocular distance/lateral ocellus diameter = 2.11.

Mesosoma: Minutely granulate except pronotum laterally, mesopleuron anteromedially, metapleuron ventrally, and posterior face of propodeum rugulose; posterodorsal area of mesopleuron nitid; fore tibial spur large, longer than ½ tibia length and as long as fore basitarsus; spur relatively straight, curved only in its apical ¼.

Metasoma: Tergum 1 and antero-medial area of tergum 2 granular; metasoma otherwise minutely granular to nitid.

Paratype female.—Essentially as in holotype female except body length 2.12 mm; fore wing length 1.79 mm; malar space/eye height = 0.18; lateral aspects of metasoma less rugulose and more granular; metasoma less distinctly banded and more deeply infused with brown (probably due to postmortem discoloration).

Paratype males.—Head except labrum and mandible, metasoma, and metasomal tergum 1 black; labrum and mandible yellowish white; remainder of metasoma and all coxae dark brown; legs otherwise yellowish brown; wings lightly infumate; submarginal venation very pale.

Paratype data.—2 males, same data as holotype female [CNC]. 1 male, **Washington:** Grant Co., Potholes Research Station, S. Mores Lake, 27 August 1985, Finnamore & Thormin [CNC]. 1 female, **Oregon:** Corvallis, 3 October 1980, H.K. Townes [AEI].

Remarks.—*Neoneurus masneri* is closest to *Neoneurus diabolicus* in having very large facial spines and fore tibial spur; however, the facial spines are much closer together than in *diabolicus* and the fore tibial spur is much straighter (Figs. 12, 20). Except for their paler wings, males of this species are very similar to those of *Neoneurus mantis,* and males are best identified by association with females.

Etymology.—Named for Lubomir Masner, renowned hymenopterist and collector of the holotype.

Neoneurus pallidus Shaw, New Species

Figs. 4, 10, 29 & 30

Holotype.—Female, United States: Colorado, Baca County, Springfield, 20–25 July 1988, R. Wharton, Malaise trap, high plains [TAMU].

Description of holotype female.—Body length 2.16 mm; fore wing length 1.85 mm.

Color: Lower parts of head pale white, except apex of mandible dark reddish black; frons medially, ocellar triangle, temple, vertex, and occiput black; areas of head bordering black markings grading from black through yellowish brown to white; scape, pedicel, and extreme base of flagellomere 1 white, flagellum otherwise dark brown; compound eye silver; mesosoma extensively marked with yellowish brown (paler laterally and ventrally), especially mesonotum anteriorly, scutellar disc, pronotum laterally, subalar area of mesopleuron, and mesopleuron ventrally; prosterna, tegula, wing base, and costa basally pale yellowish white; fore and middle legs white; hind leg white basally, grading to pale yellowish brown apically; wing venation pale brown to hyaline, except remainder of costa and stigma dark brown; wing membrane very lightly infumated with brown; mesosoma otherwise black (especially mesopleuron medially and propodeum); metasoma pale yellowish brown, except tergum 1 and extreme base of tergum 2 darker yellowish brown; tergum 1 irregularly infused with black medially.

Head: Minutely granulate, especially on vertex; facial spinules small but distinct, slightly shorter than ½ antennal pedicel length; malar space/eye height = 0.10; ocell-ocular distance/lateral ocellus diameter = 1.89.

Mesosoma: Minutely granulate except pronotal furrow and posterior face of propodeum rugulose, postero-dorsal area of mesopleuron nitid; fore tibial spur small and only slightly curved, distinctly shorter than ½ tibia length.

Metasoma: Tergum 1 and antero-medial area of tergum 2 minutely rugulose; metasoma otherwise nitid.

Paratype females.—Colorado specimens essentially as in holotype except body length 2.88–2.89 mm; fore wing length 1.91–1.97 mm; malar space/eye height = 0.12–0.14; ocell-ocular distance/lateral ocellus diameter = 1.80–2.0; tergum 1 lighter in color, not distinctly marked with black; postero-lateral corners of propodeum infused with reddish brown. Virginia specimen essentially as in holotype except body length 2.94 mm; fore wing length 2.12 mm; malar space/eye height = 0.16; ocell-ocular distance/lateral ocellus diameter = 2.10; mesosternum black; mesopleuron rugulose medially; tibial carina raised submedially; spiracles of metasomal tergum 1 slightly more prominent.

Paratype males.—Face, scape, and sometimes pedicel marked with pale yellowish brown; tegula pale yellow or whitish; hind coxa mostly yellowish brown or, at most, infused with brown basally; wings clear or only lightly infumate.

Paratype data.—1 female, 5 males, same data as holotype; 1 female, same data as holotype except collected 14–20 July, H. Mann [TAMU, RMSEL]. **Canada, Ontario:** Bergland, 3 August 1960, S.M. Clark [CNC]. **United States, Maryland:** 1 male, Plummer's Island, 26 June 1915, R.C. Shannon collector [USNM]; 1 male, Cabin John, September 1915 [USNM]. **Michigan:** 1 male, Midland County, 16 August 1941, R.R. Driesbach [AEI]; 1 male, Midland county, 24 June 1959, R.R. Dreisbach [USNM]. **North Carolina:** 1 male, Highlands, Whiteside Mountain, 20 July 1957, W.R. Richards [CNC]; 1 male, Mt. Mitchell, 6800′, 12 August 1957, J.G. Chillcott [CNC]; 1 female, Pink Beds, 21 July 1952, G. & L.

Townes [AEI]; 2 males, Wagon Road Gap, 21 July 1952, G. & L. Townes [AEI]. **Virginia:** 1 male, Fairfax, Dead Run, 8 May 1915, R.C. Shannon collector, at light [USNM]; 1 female, 1 male, Hawksbill, Shenandoah National Park, 3600–4050′, 7 June 1962, J.R. Vockeroth [CNC].

Remarks.—Most similar to *Neoneurus mantis* but differing most obviously by much more extensive light yellowish brown markings on the mesosoma and metasoma of *Neoneurus pallidus* females (Fig. 29). Males are unusual in having pale facial markings (Fig. 30), which may be a slight expression of an otherwise female trait (all known *Neoneurus* females have a pale face). Morphologically *Neoneurus pallidus* is very similar to *Neoneurus mantis* but there are subtle differences in the form of the female fore legs (Figs. 9, 10). The basitarsus is somewhat shorter and thicker in *pallidus,* and the tibial spur is less tapered at the apex. *Neoneurus mantis* has a depression in the female fore coxa that articulates with the prosternum (Fig. 19) and this depression does not appear to be present in *pallidus,* but this is a cryptic character requiring further study.

Etymology.—From the Latin for ashen or pale.

Neoneurus portalensis **Shaw,**
NEW SPECIES

Figs. 7, 13, 15, 18 & 22

Holotype.—Female, United States: Arizona, Portal, 18 September 1987, H.& M. Townes [AEI].

Description of holotype female.—Body length 2.79 mm; fore wing length 1.88 mm.

Color: Head entirely pale yellowish white, except apex of mandible dark reddish black and ocellar triangle black; scape, pedicel, and flagellomeres 1–3 yellowish white, flagellum otherwise gradually darker brown apically; compound eye mottled silvery gray with black patches; mesosoma mostly pale orangish yellow anteriorly, except pronotum anteriorly, mesonotum posteriorly, mesopleuron and mesosternum anteriorly irregularly infused with black; metanotum, metapleuron, and propodeum black; legs entirely pale yellowish white except pulvilli, hind tibia and tarsus brown; wing venation brown; wing membrane very lightly infumated with brown; metasoma pale orangish brown, irregularly infused with black.

Head: Minutely granulate; facial spinules distinct but short; spinules situated on thick tubercles that are nearly as long as antennal pedicel but distinctly shorter than antennal scape; malar space/eye height = 0.08; ocell-ocular distance/lateral ocellus diameter = 1.82.

Mesosoma: Minutely granulate except mesopleuron medially and propodeum medially and posteriorly rugulose; mesopleuron posteriorly nitid; apex of fore femora produced in a short but distinct spine; fore tibial spur large and only gradually curved, nearly as long as ¾ tibia length, and nearly as long as fore basitarsus; anterior longitudinal carina of fore tibia produced into two thorn-like projecting spines, one medially and one basally.

Metasoma: Terga 1–3 distinctly granulate; metasoma otherwise minutely granulate to nitid.

Paratype males.—Body dark reddish brown to black except clypeus and tegula entirely pale yellowish white; legs pale yellowish brown except hind coxa infused with dark brown basally; wings very lightly infused with brown; fore tibial spur nearly as long as basitarsus.

Paratype data.—16 males, same data as holotype except collected 19 August to 13 September; 2 males, same data as holotype except collected 10–16 August 1974; 2 males, same data as holotype except collected 2–12 September 1976, J. van der Vecht [AEI, RMSEL].

Remarks.—*Neoneurus portalensis* is distinctive in having the anterior longitudinal carina of fore tibia produced into two thorn-like projecting spines, one medially and one basally (Figs. 7, 22). The only other known *Neoneurus* species with such an elaborately

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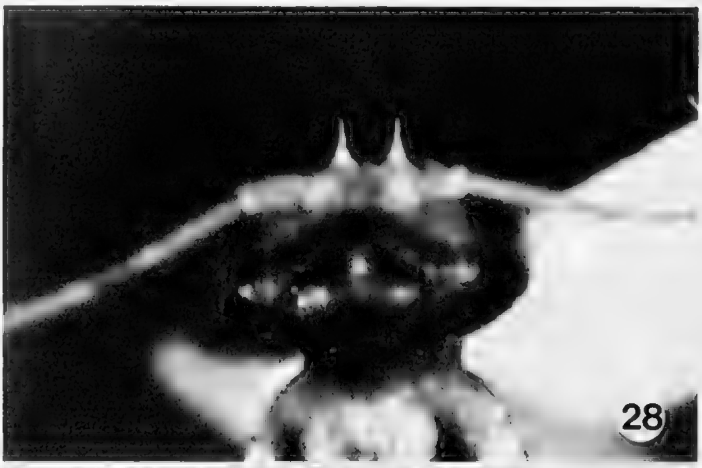

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27. Dorsal view of *Neoneurus mantis* female head showing profile of frontal spinules.
28. Dorsal view of *Neoneurus diabolicus* female head showing profile of frontal spinules.
29. Lateral view of *Neoneurus pallidus* female head and mesosoma showing pale coloration.
30. Anterior view of *Neoneurus pallidus* male head showing pale coloration.

formed fore tibia is *Neoneurus spinarius*; however, these two species are easily separated by differences in the form of the facial spines (see key). Males of *Neoneurus portalensis* have the fore tibial spur substantially longer than in other known *Neoneurus* species (Fig. 18).

Etymology.—Named for the type-locality.

Neoneurus spinarius Shaw, NEW SPECIES

Figs. 8 & 11.

Holotype.—Female, United States: California, Lake Wohlford, 21 April 1974, H.& M. Townes [AEI].

Description of holotype female.—Body length 2.97 mm; fore wing length 1.97 mm.

Color: Lower parts of head pale yellowish white, except apex of mandible dark reddish black; frons medially, ocellar triangle, temple, vertex, and occiput black; frontal orbit of eye pale yellowish brown; scape and pedicel pale yellowish brown; flagellum dark brown; compound eye silver; mesosoma extensively marked with yellowish brown, especially mesonotum antero-laterally and postero-medially, scutellar disc, pronotum laterally, subalar area of mesopleuron, and mesopleuron postero-medially; prosterna, tegula, wing base, and costa basally pale yellowish white; legs pale yellowish white except hind tibia and tarsus brown; wing venation pale brown to hyaline, except remainder of costa and stigma dark brown; wing membrane very lightly infumated with brown; mesosoma otherwise dark reddish brown to black; metasomal tergum 1 and tergum 2 basally black; metasoma otherwise pale yellowish brown banded with dark brown along apical margins of terga 2–5.

Head: Minutely granulate except short

smooth medial furrow anteriad of median ocellus; facial spines very large and distinct, longer than antennal scape; malar space/eye height = 0.24; ocell-ocular distance/lateral ocellus diameter = 1.91.

Mesosoma: Minutely granulate except pronotum laterally, metapleuron ventrally, and propodeum medially and posteriorly rugulose; mesopleuron postero-dorsally nitid; apex of fore femora produced in a short but distinct spine; anterior longitudinal carina of fore tibia produced into two very large thorn-like projecting spines, one medially and one basally.

Metasoma: Tergum 1 and antero-medial area of tergum 2 minutely rugulose; metasoma otherwise minutely granular to nitid.

Remarks.—Known only by the holotype female, the fore tibia of *Neoneurus spinarius* is more extremely spinose and more elaborately developed than in any other *Neoneurus* species (Fig. 8). *Neoneurus spinarius* is similar to *Neoneurus portalensis* since these are the only two Nearctic species known to have a medial thorn-like spine on the fore tibia (a putative synapomorphy); however, the two species are easily separated as *spinarius* has both the facial and tibial spines more extremely developed.

Etymology.—Named for the remarkable spines on the fore tibia of this species.

Neoneurus viennense Giraud
Figs. 16 & 23

Elasmosoma viennense Giraud, 1871; transferred to *Neoneurus* by Bengtsson, 1918.

Diagnosis.—Female with facial spines long and distinct, about as long as antennal pedicel, but shorter than antennal scape; facial spines separated by distance distinctly greater than scape width; subbasal tibial protuberance falcate; fore tibial spur large and strongly curved, about as long as ½ tibia length, and slightly shorter than basitarsus length.

Male with vertex finely granular, clypeus yellowish brown, darker dorsally; tegula dark brown; wings lightly infumate; submarginal venation very pale; hind coxa mostly black; hind femur yellow; fore tibial spur about ¾ as long as basitarsus, only slightly curved.

Material examined.—1 male, holotype of *Elasmosoma viennense* Giraud, "vien." Museum Paris, coll. Giraud 1877 [MNHN]; 1 male, Bengtsson collection [ZML]; 1 female, Netherlands: Meyendel nr. The Hague, Bierlap, inner dunes, 25–31.VII.1974, A.P.M. van der Zon, det. van Achterberg, 1976 [RMSEL].

Distribution (according to Shenefelt, 1969).—Austria, Czechoslovakia, Denmark, Finland, Netherlands, Norway, Sweden, Yugoslavia.

Hosts.—*Formica rufa* Linnaeus, according to Fahringer (1935).

Remarks.—Originally described from a male specimen, the female of this species was first associated, described, and figured by Bengtsson (1918). The modified female fore leg and both male and female genitalia were figured by Tobias (1966). It is the only known European species with a large falcate fore tibial spur, and in this regard it is most similar to the new North American species, *Neoneurus diabolicus* and the Asian species, *Neoneurus curvicalcar*. *Neoneurus viennense* and *Neoneurus diabolicus* differ in a number of characters, most notably the size of the fore tibial spur and facial spines (see key). *Neoneurus viennense* and *Neoneurus curvicalcar* are more similar, but can be separated by differences in the position of the facial spines and the form of the subbasal tibial protuberance (see Remarks for *curvicalcar*).

Neoneurus spp. unassociated males

Material examined.—Specimens near *diabolicus* with pale tegula and dark facial markings: **CALIFORNIA:** 1 male, El Dorado county, Echo Lake, 17 July 1956, W.W. Middlekauff collector [USNM]; 1 male (possibly the male of *spinarius*), Julian, 26 May 1974; H.&M. Townes, "*Neoneurus* 1" det. Townes 1981 [AEI]. **COLORADO:** 1 male, "1547," collection C.F. Baker [USNM]. **IDAHO:** 1 male, nr. Stanley, 2 August 1978, H.&M. Townes [AEI]. **MINNESOTA:** 1 male, Itasca State Park, 18 September 1927, S. Garthside, *Neoneurus* n.sp. det. Cushman [USNM].

Specimen near *mantis* with dark tegula, infumate wings, and dark facial markings: **WASHINGTON:** 1 male, San Juan Island (west side), 23 July 1944, R.D. Shenefelt, sweeping American vetch, *Neoneurus* sp. det. Muesebeck [AEI].

Specimen near *masneri* with dark tegula, pale wings, and dark facial markings: **WASHINGTON:** 1 male, Port Angeles, Mt. Pleasant District, 18 July 1945, R.D. Shenefelt, sweeping *Lathyrus torreyi* [AEI].

Remarks.—These specimens could not be assigned with certainty to any of the species recognized in this paper; however, they are interesting for their distributional data. They may represent variation and range extensions of the above species, or additional new species; it is difficult to assess their significance based on males alone.

Acknowledgments

Specimens for this study were provided by the following collections:

AEI	American Entomological Institute, Gainesville [D. Wahl]
BMNH	The Natural History Museum (British Museum), London [T. Huddleston]
CNC	Canadian National Collection of Insects, Arachnids, and Nematodes, Ottawa [M. Sharkey]
MNHN	Museum National d'Histoire Naturelle, Paris [J. Casevitz-Weulersse]
RNHL	Rijksmuseum van Natuurlijke Historie, Leiden [C. van Achterberg]
RMSEL	Rocky Mountain Systematic Entomology Laboratory, Laramie
TAMU	Texas A&M University, College Station [R. Wharton]
TMB	Természettudományi Múzeum Állatára, Budapest [J. Papp]
USNM	United States National Museum of Natural History, Washington, D.C. [P. Marsh]
ZIL	Zoological Institute, Academy of Sciences, Leningrad, USSR [S. Belokobylskij]
ZMH	Zoologisches Museum, Humboldt-Universität zu Berlin [F. Koch]
ZML	Zoological Museum, Lund [R. Danielsson]

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Figure 1, the habitus of *Neoneurus mantis,* was done by Ms. Katherine Brown-Wing of the Museum of Comparative Zoology, Harvard University and is reproduced here by permission of the artist.

Figure 2, the forewing of *Neoneurus diabolicus,* is modified from Marsh et al. (1987), and was reproduced with the permission of the senior author.

Specimens of the ant *Formica podzolica* Francoeur were identified by Mr. Stefan Cover of the Museum of Comparative Zoology, Harvard University, James P. O'Connor, of the National Museum of Ireland, kindly provided a photocopy of Haliday's 1838 essay. Prof. Lew Bagby, of the University of Wyoming, provided critical Russian translations.

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THE EGGS OF *AEDES VIGILAX* AND *AEDES VITTIGER* (DIPTERA: CULICIDAE)

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Abstract.—Descriptions based on scanning electron micrographs are given for the eggs of *Aedes* (*Ochlerotatus*) *vigilax* and *Ae.* (*Och.*) *vittiger.* There is pronounced lateral asymmetry in the egg of both species, with the dorsal surface flatter and the ventral surface more arched, especially in *Ae. vittiger.* In both cases the outer chorionic cells differ in size on the ventral, lateral and dorsal surfaces, but in *Ae. vittiger,* which exhibits a remarkable and distinctive overall surface uniformity, the structure of the tubercles within the cells is extremely constant. There are minor structural differences between cells on the different surfaces of *Ae. vigilax* eggs.

Key Words: Insecta, mosquito, eggs, fine structure, chorionic sculpturing

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Aedes (*Ochlerotatus*) *vigilax* (Skuse) is an important coastal mosquito associated with low-lying estuarine land and mangrove swamps in the Australasian and Oriental regions. Typically, it breeds in very temporary bodies of brackish water formed by exceptionally high tides or rainfall accumulations in saline habitats. Although the larvae usually are found in water with some salt content, they have been found occasionally breeding in fresh water (Dobrotworsky 1965). The adults are vicious biters of man. This, as well as importance as a vector of disease organisms (see Lee et al. 1984), has made *Ae. vigilax* the subject of considerable research. Various studies of the egg stage have been made and the ecology of the egg has been investigated with respect to the natural distribution of eggs in the field as affected by soil wetness and the presence or absence of plants and shade (Reynolds 1961, Sinclair 1976, Kay and Jorgensen 1986). Pillai (1962) experimented with factors that affect survival of the egg and provided the first information on the egg's morphology by means of celloidin impressions of the chorion. Kay and Jorgensen (1986) partially described the fine structure of the egg with the aid of three electron micrographs, but did not give an account of variations in structure on the different surfaces as well as other details. We provide here a more complete description, enhanced by considerably more illustration.

Like *Ae. vigilax, Ae. vittiger* is a floodwater species, but in fresh rather than saline accumulations (Lee et al. 1984), where it prefers sunlight and bordering emergent grass (Marks 1967). The females actively attack man both by day and night and will feed also on a variety of animals (Lee et al. 1984). Multiplication of Murray Valley encephalitis virus takes place in females fed virus suspension (McLean 1953), and the species is considered a possible temporary or local vector of myxomatosis (Fenner and

Ratcliffe 1965). The biology of *Ae. vittiger* is less well known than *Ae. vigilax* and, apart from a celloidin impression of the mid-ventral chorion (Pillai 1962), the egg has not been described.

MATERIALS AND METHODS

Eggs of both species were obtained from blood-fed females collected in New South Wales, Australia. Oviposition on filter paper was induced in the laboratory and several papers supporting eggs from a number of females were folded (while very damp) inside small petri dishes and mailed to Vero Beach. Groups of eggs for microscopy were prepared either by cutting out small pieces of paper bearing numbers of eggs and sticking these to stubs with silver paint, or by transferring single eggs with a fine artist's brush to stubs covered with double-sided sticky tape. Eggs from individual females could not be identified, but to increase the probability that eggs from several females were represented, specimens from widely separated areas of each egg paper were selected. Eight stubs were prepared for each species.

Once attached to stubs, eggs were dried over calcium chloride (0.5 h), coated with gold and examined in a Hitachi S-510 scanning electron microscope.

Where means (±SE) of dimensions and structures are given in the text, they were derived from 5 separate eggs selected so as to optimize the probability of each being from a separate female. The measurements were made from micrographs using a digitizing tablet and SigmaScan software (Jandel Scientific, Corte Madera, California). Cell dimensions were taken to the middle of the outer chorionic reticulum, lengths between the two points of the cell most widely separated approximately in the egg's longitudinal axis, widths between similar points circumferentially. Cell areas were obtained by digitizing the perimeter in each case. Tubercles were measured across the widest point. Analysis of variance and the Student-Newman-Keuls procedure (Sokal and Rohlf 1969) were used to test for significant differences between means. However, analysis of cell length and width data was omitted as superfluous because differences in cell size could be demonstrated adequately from area data. In the terminology we have followed Harbach and Knight (1980). Additionally, we have used the terms "outer chorionic cell field" (Linley 1989), and "micropylar dome" (Linley et al. 1991).

RESULTS

Aedes (*Ochlerotatus*) *vigilax*
(Figs. 1–3)

Size: as in Table 1. Color: matte black. Overall appearance: asymmetrical in lateral view, ventral side more curved, dorsal side flatter (Fig. 1), widest at about anterior 0.3. In lateral view each outer chorionic cell distinguished by presence, usually, of a single large tubercle, but boundaries of individual cells indistinct. Small tubercles aligned predominantly in circumferential direction (Fig. 1). Micropylar collar not conspicuous.

Chorion, ventral, lateral and dorsal surfaces: all surfaces basically similar, outer chorionic cells irregularly shaped, elongated circumferentially, thus width greater than length (Table 2). Cell dimensions greatest on lateral surface, slightly less on ventral surface, least on dorsal, so cell areas significantly different as indicated (Table 2), but length/width ratio more or less constant.

Cells on ventral surface almost always with single large tubercle, more or less round but sometimes irregularly shaped or compound (Fig. 2a, b). Base of tubercle joined some distance from bottom by bridges from surrounding small tubercles (Fig. 2a, b), cap of tubercle with small, often poorly defined nodules (Fig. 2b, c). Large tubercles in lateral and dorsal cells usually single, but sometimes smaller, or divided (particularly on dorsal surface) into two or three separate, smooth-surfaced tubercles with bridges to neighboring small ones (Fig. 2d, e, f). Mean

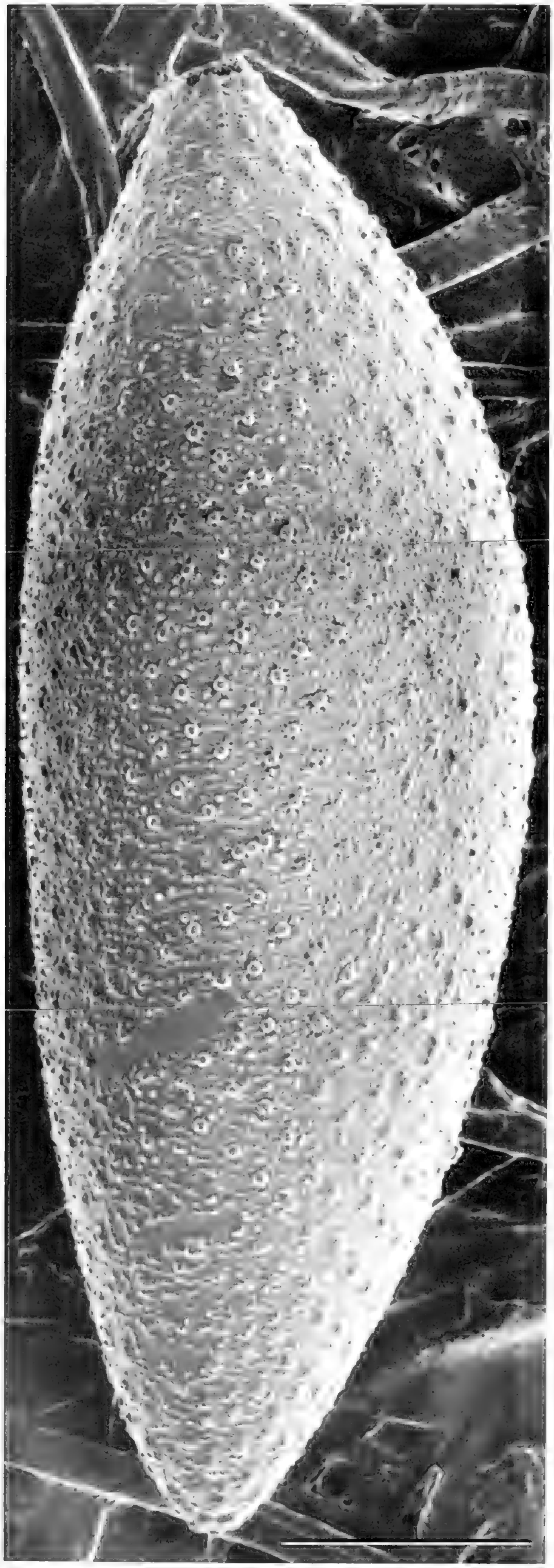

Fig. 1. *Aedes vigilax*. Entire egg, lateral view, ventral side at right, anterior end at top. Scale = 100 μm.

diameter of large tubercles on dorsal surface significantly less than elsewhere (Table 3).

Small tubercles on all surfaces irregular in shape, often difficult to identify individually (therefore not counted or measured), surfaces rough, almost always inclined towards and often forming a bridge to large tubercle (Fig. 2a, b). Small tubercles in cell circumferential extensions usually joined by bridges to one another (Fig. 2a, b). Outer chorionic reticulum on all surfaces usually a fine meshwork, moderately distinct (Fig. 2b, c, f), diameter 3.0–3.3 μm, with central row of small protuberances, diameter 0.2–0.6 μm. Reticulum in some areas on ventral surface sometimes narrower, striations of meshwork less distinct and perforated by small pores (Fig. 2b).

Anterior end, micropyle: chorionic cells smaller towards anterior end, width reduced relative to length (Fig. 3a, b), cell field increasingly obliterated by progressively fused small tubercles, especially just posterior to micropylar collar (Fig. 3b). Cells immediately posterior to collar elongated longitudinally, large tubercles and reticulum less distinct (Fig. 3b). Collar not prominent, anterior edge rounded, continuous or with small gaps (Fig. 3c, d), height 9–12 μm, outer diameter 24–38 μm and highly variable, surface rough (Fig. 3d). Wall width 1.2–9 μm, sometimes very narrow (Fig. 3c), but in some eggs much thicker, with gaps (Fig. 3d). Internal diameter of collar 20–23 μm, inner wall with very shallow excavations (Fig. 3c, d), micropylar disk wide, diameter 13–16 μm, boundary distinct and raised, with more or less round or slightly irregular margin (Fig. 3c, d). Micropylar dome present, not easily distinguished in some eggs, diameter 9.5–12 μm, micropylar orifice unusually small, very slightly trilobed (Fig. 3c), diameter 1.7 μm.

Posterior end: chorionic cells smaller approaching posterior end, widths reduced relative to lengths, small tubercles progressively more fused and united to large tubercles (Fig. 3e, f), reticulum clearly visible

Table 1. Dimensions of eggs of *Ae. vigilax* (n = 7) and *Ae. vittiger* (n = 10).

Species	Length (μm)		Width (μm)		L/W Ratio	
	$\bar{x} \pm$ SE	Range	$\bar{x} \pm$ SE	Range	$\bar{x} \pm$ SE	Range
Ae. vigilax	627.7 ± 4.7	605.7–640.0	201.94 ± 4.2	188.6–217.1	3.11 ± 0.07	2.88–3.36
Ae. vittiger	742.9 ± 3.8	732.3–770.2	352.0 ± 1.1	346.0–356.1	2.11 ± 0.01	2.07–2.15

but its meshwork much less distinct (Fig. 3f).

Aedes (*Ochlerotatus*) *vittiger*
(Figs. 4–6)

Size: as in Table 1. Color: satiny black. Overall appearance: shape rhomboidal in ventral (Fig. 4) and dorsal views, asymmetrical in lateral view, ventral surface much more arched, dorsal surface flatter (Fig. 5a), widest just anterior to middle of egg (Fig. 4). All surfaces appear extremely uniform, outer chorionic cells pentagonal or hexagonal, each with a single prominent, round large tubercle (Figs. 4, 5a). Micropylar collar fairly conspicuous (Fig. 4).

Chorion, ventral, lateral and dorsal surfaces: all surfaces very similar (Fig. 5b, c, d), outer chorionic cells somewhat wider than long and L/W ratio decreasing significantly from ventral to dorsal surfaces (Table 2), indicating progressive relative increase in width. Cells in lateral region significantly greatest in area, however, followed by ventral and then dorsal cells (Table 2).

Each cell on all surfaces invariably with a single round, centrally positioned large tubercle (Fig. 5a, b, c), which appears very round at relatively low magnifications (Figs. 4, 5b). Perimeter of tubercle base slightly irregular, vertical walls rough, supporting a more or less round cap ornamented with very clearly defined nodules separated by clear, narrow fissures (Fig. 5e, f, g). Diameter of large tubercles very uniform on each surface, greatest on ventral, least on dorsal, not differing markedly between surfaces, but significant differences present as indicated (Table 3).

Small tubercles quite evenly spaced around margins of cell fields (Fig. 5b, c, d), some cells also with a halo of radially oriented ridges or tiny, nodular tubercles surrounding central large one (Fig. 5d, e, f, g). Numbers of small tubercles (counting only those in outer ring) in each cell as shown (Table 3), significantly different between all three surfaces, but very uniform and not significantly different in diameter (Table 3). Shape of small tubercles variable, tending to be triangular or diamond shaped in cell corners, rectangular along cell margins (Fig. 5d, e, f). Base of each tubercle slightly greater in diameter than cap, walls smooth (Fig. 5e, f, g), cap covered with small nodules,

Table 2. Attributes of outer chorionic cells in eggs of *Ae. vigilax* and *Ae. vittiger* (n = 15). Means followed by same letter do not differ significantly ($P < 0.05$).

Species	Surface	Mean (±SE) Outer Chorionic Cell			
		Length (μm)	Width (μm)	Ratio L/W	Area (μm^2)
Ae. vigilax	Ventral	14.6 ± 0.5	33.2 ± 0.7	0.44 ± 0.01a	287.3 ± 9.2a
	Lateral	16.7 ± 0.5	34.7 ± 0.9	0.49 ± 0.02a	300.0 ± 11.6a
	Dorsal	12.7 ± 0.3	28.3 ± 0.8	0.45 ± 0.01a	210.9 ± 8.2b
Ae. vittiger	Ventral	25.4 ± 0.6	26.3 ± 0.8	0.98 ± 0.04a	436.3 ± 14.3a
	Lateral	24.6 ± 0.8	34.6 ± 0.7	0.72 ± 0.03b	537.9 ± 21.1b
	Dorsal	20.8 ± 0.6	30.7 ± 0.6	0.68 ± 0.02c	386.4 ± 9.8c

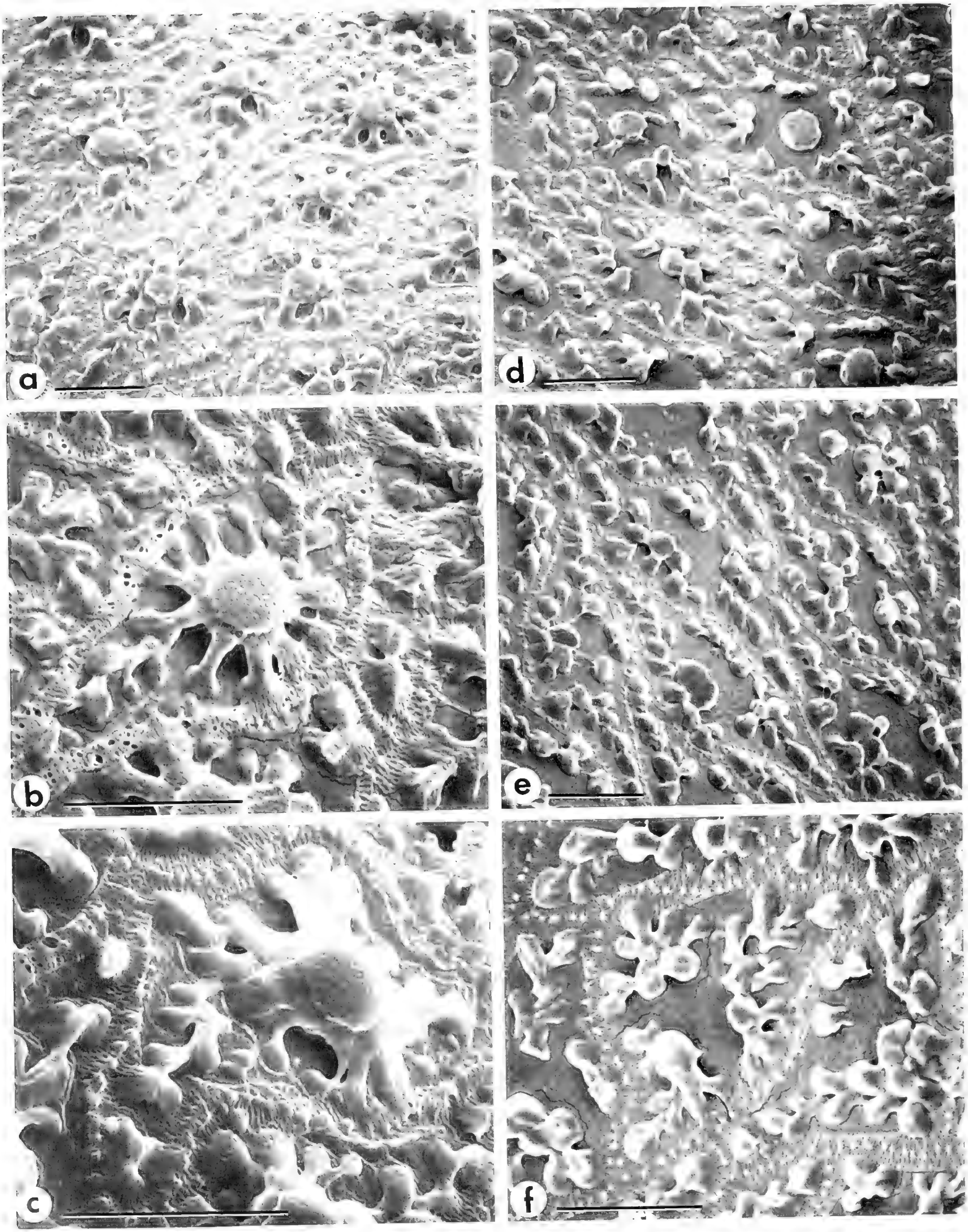

Fig. 2. *Aedes vigilax.* (a) Chorionic cells, ventral surface, middle of egg; (b) chorionic cell detail, ventral surface; (c) detail of chorionic reticulum, ventral surface; (d) chorionic cells, lateral surface, middle of egg; (e) chorionic cells, dorsal surface, middle of egg; (f) chorionic cell detail, dorsal surface. Scale = 10 μm.

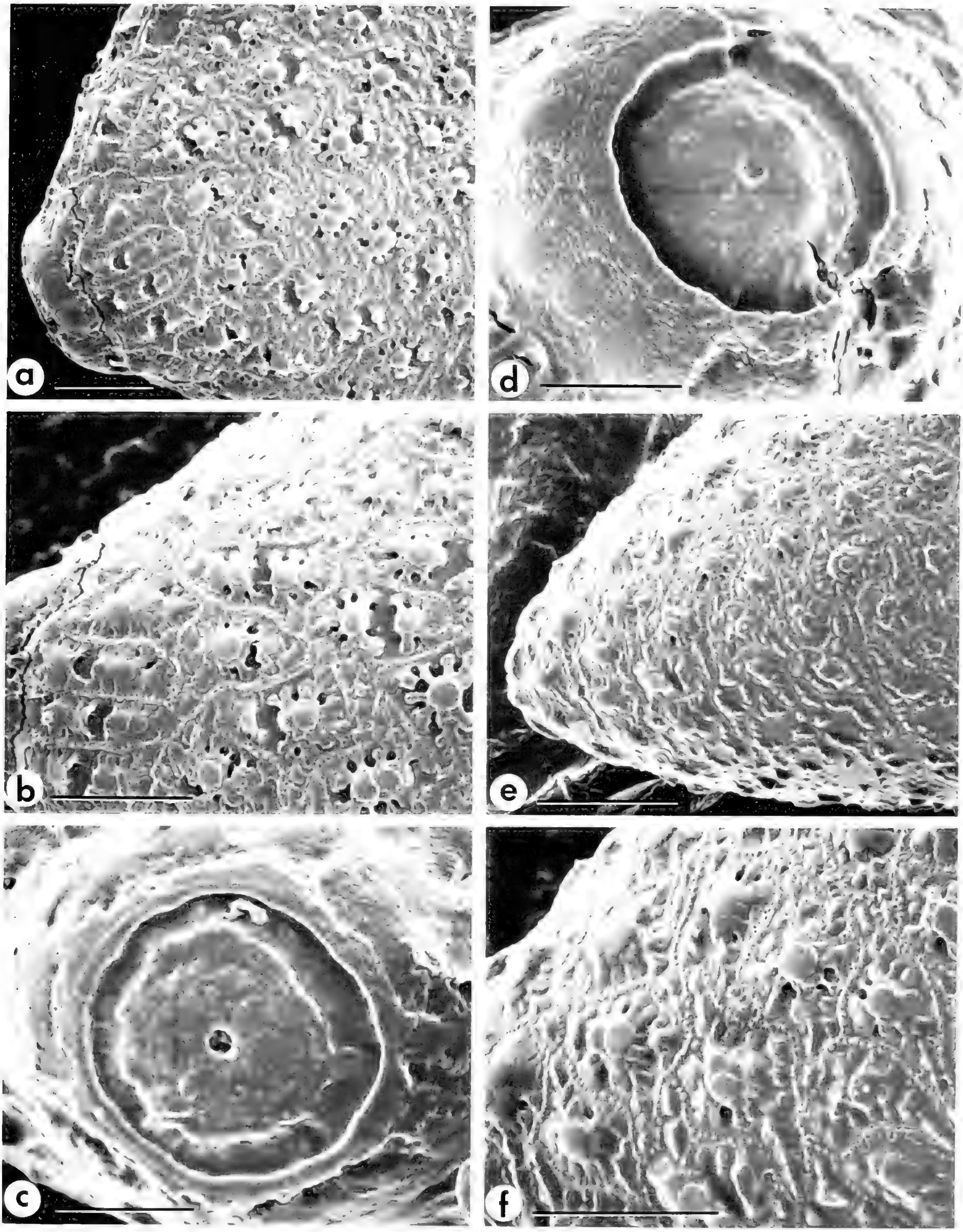

Fig. 3. *Aedes vigilax*. (a) Anterior end, lateral view; (b) anterior end, chorionic cell detail; (c) micropylar apparatus, showing continuous collar; (d) micropylar apparatus with discontinuous collar and showing micropylar dome; (e) posterior end, lateral view; (f) posterior end, chorionic cell detail. Scale = 20 μm (a, b, e, f), = 10 μm (c, d).

which are smaller and more round than those on large tubercles (Fig. 5g), dividing fissures well defined and uniform in width. Cell fields partly smooth, especially bordering peripheral small tubercles, but much of area covered with a more or less continuous fine reticulation (Fig. 5g), similar to that in outer chorionic reticulum. Reticulum structured as just indicated, diameter 2–3.2 μm, surface usually with very shallow indentations (Fig. 5e, f), and a central line of tiny papillae, diameter 0.2–0.6 μm.

Anterior end, micropyle: chorionic cells diminish in size immediately posterior to micropylar collar, cell fields generally smoother and central papillae in reticulum less distinct or absent (Fig. 6a, b). Large tubercles immediately posterior to collar somewhat longitudinally elongated, becoming continuous with collar (Fig. 6a, b). Collar fairly prominent, lateral and anterior faces lumpy (Fig. 6a, d, e), surface slightly rough (Fig. 6e). Collar often a complete ring (Fig. 6d, e), but occasionally with one to three gaps (Fig. 6c), height 8–11.5 μm, outer diameter 51–55 μm, wall width fairly uniform (gaps excepted), 7–13 μm. Collar internal diameter 32–37 μm, inner wall with shallow excavations, walls with vertical striations (Fig. 6d, e), micropylar disk fairly distinct, slightly raised, outline irregular, surface rough (Fig. 6d, e), diameter 16–19 μm. Micropylar dome also visible, diameter 11–12 μm, orifice distinctly tri-lobed (Fig. 6e), diameter 2.1 μm.

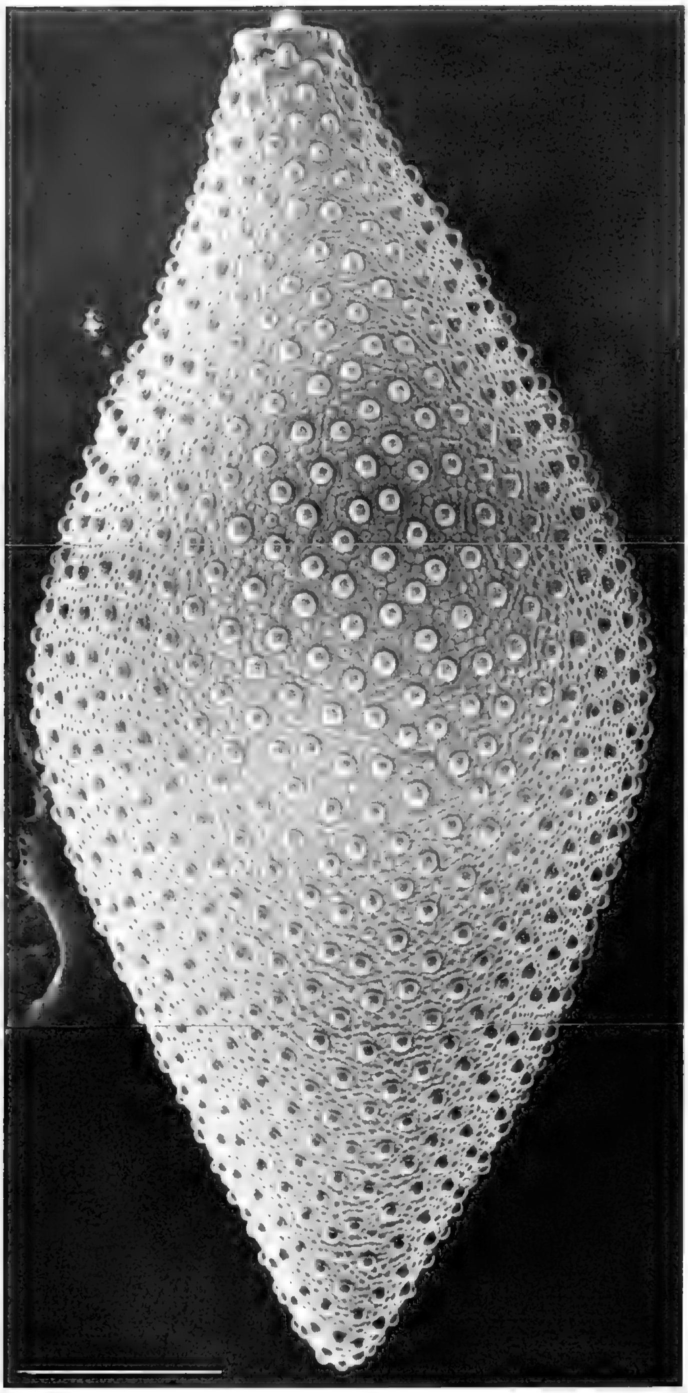

Fig. 4. *Aedes vittiger.* Entire egg, ventral view, anterior end at top. Scale = 100 μm.

Table 3. Attributes of the large (n = 15) and small (n = 30) outer chorionic tubercles in eggs of *Ae. vigilax* and *Ae. vittiger.* Means followed by same letter do not differ significantly ($P < 0.05$).

Species	Surface	Mean (±SE)		
		Large Tubercles Diameter (μm)	Small Tubercles No.	Small Tubercles Diameter (μm)
Ae. vigilax	Ventral	4.7 ± 0.1a		
	Lateral	4.4 ± 0.1a	not determined	
	Dorsal	2.4 ± 0.1b		
Ae. vittiger	Ventral	9.6 ± 0.1a	13.5 ± 0.3a	2.7 ± 0.2a
	Lateral	9.4 ± 0.2ab	15.1 ± 0.5b	2.6 ± 0.2a
	Dorsal	9.0 ± 0.1b	10.7 ± 0.3c	2.9 ± 0.2a

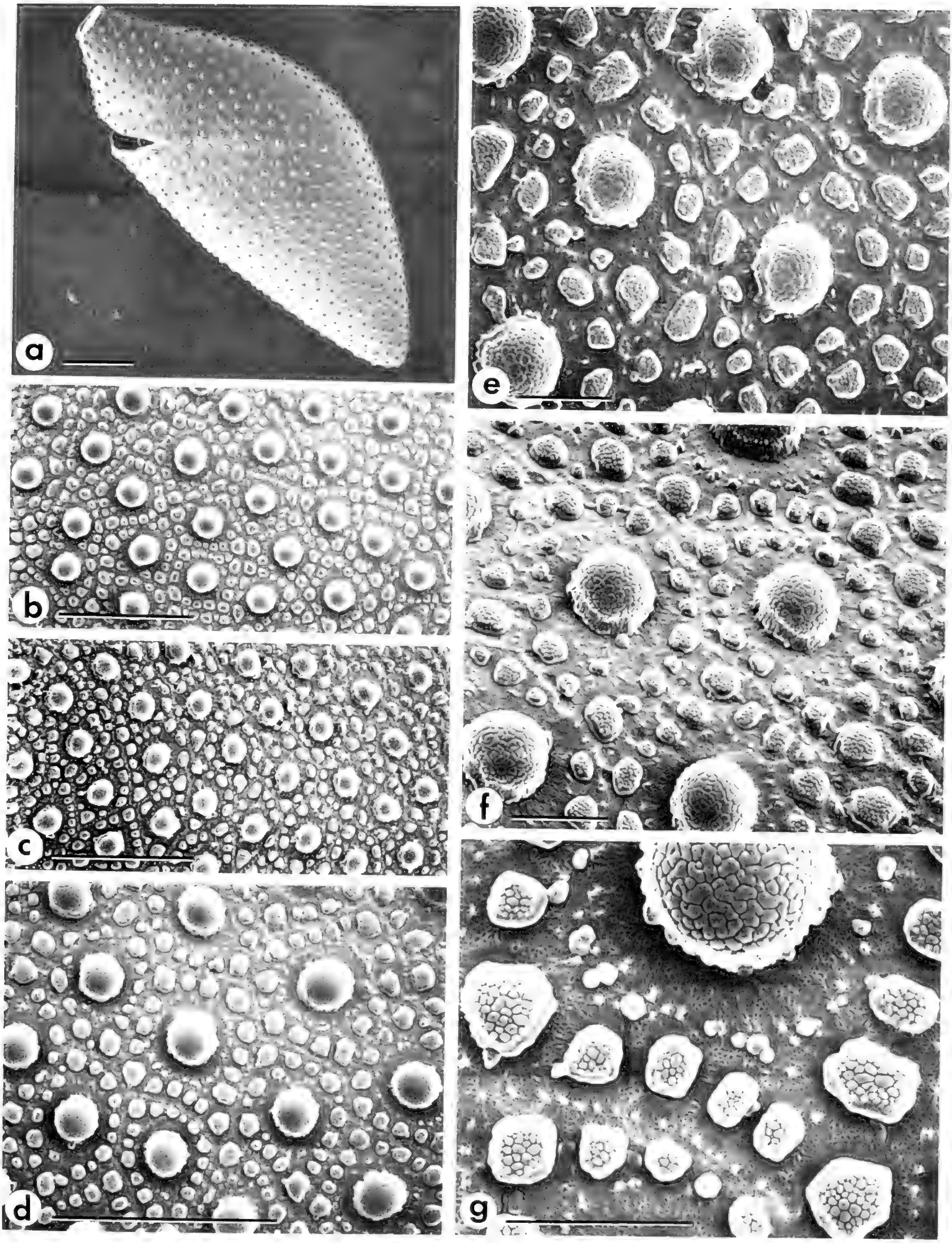

Fig. 5. *Aedes vittiger.* (a) Entire egg, lateral view, anterior end at left; (b) chorionic cells, ventral surface, middle of egg; (c) chorionic cells, dorsal surface, middle of egg; (d) chorionic cells, lateral surface, middle of egg; (e) chorionic cell detail, dorsal surface; (f) chorionic cell detail, lateral surface; (g) detail of tubercles and chorionic reticulum, ventral surface. Scale = 100 μm (a), = 50 μm (b, c, d), = 10 μm (e, f, g).

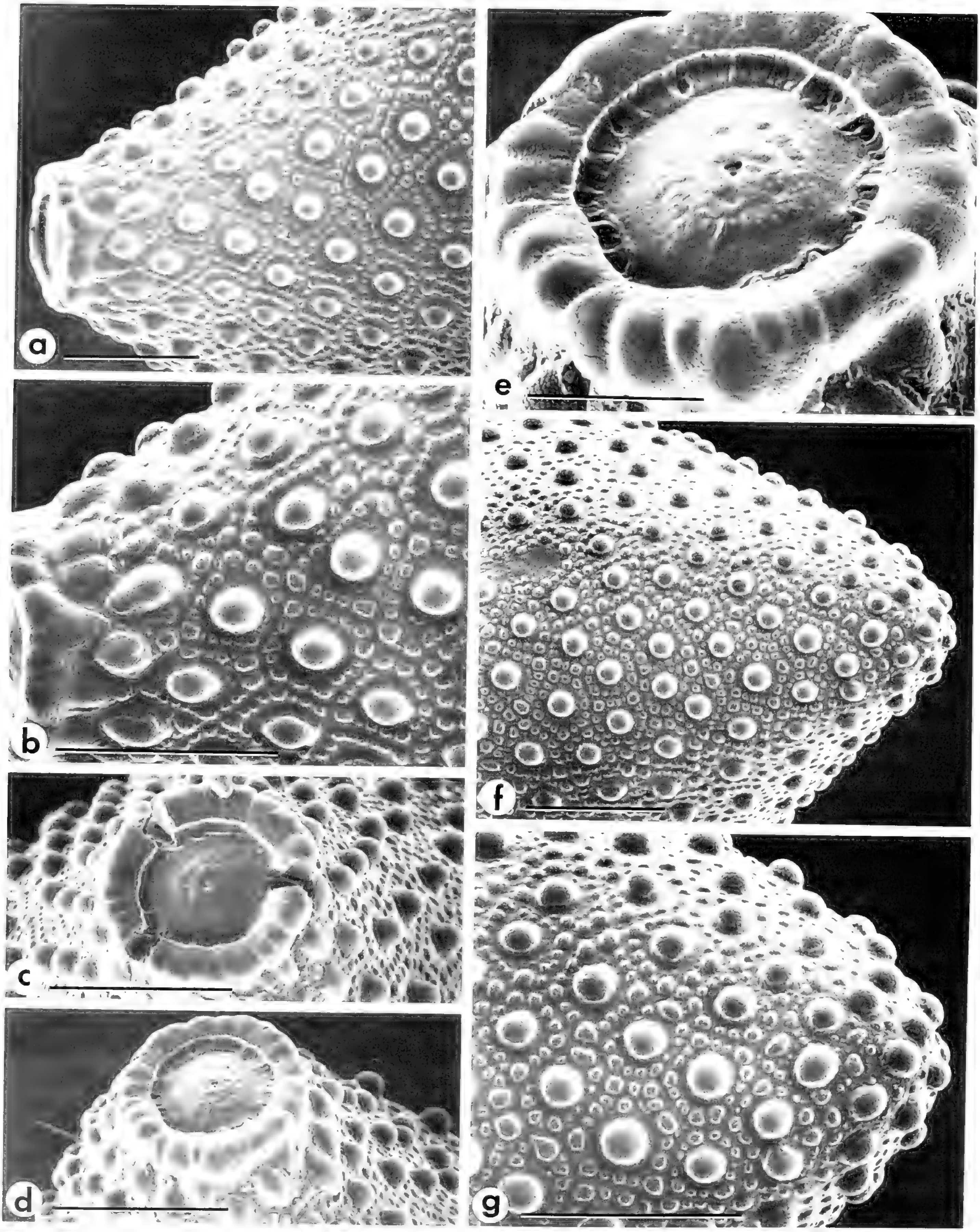

Fig. 6. *Aedes vittiger.* (a) Anterior end, lateral view; (b) anterior end, chorionic cell detail; (c) anterior end and micropylar apparatus with discontinuous collar; (d) anterior end and micropylar apparatus, continuous collar; (e) detail of micropylar apparatus, showing micropylar disk and dome; (f) posterior end, lateral view; (g) posterior end, chorionic cell detail. Scale = 50 μm (a, b, c, d, f, g), = 20 μm (e).

Posterior end: chorionic cells progressively smaller towards posterior end, numbers of small tubercles fewer, cell fields smoother, reticulum less distinct with central papillae not easily visible (Fig. 6f, g). Identity of individual chorionic cells with single large tubercle distinct even at very end of egg (Fig. 6g).

DISCUSSION

The relative uniformity of structure over all surfaces of *Ae. vigilax* eggs is in keeping with observations suggesting that females of this species do not cement their eggs to the oviposition surface. Hamlyn-Harris (1933) reported that *Ae. vigilax* deposits eggs both on salt water and on damp surfaces subject to flooding, while Sinclair (1976) described the preferred site as damp soil with low covering vegetation, but not bare mud. Kay and Jorgensen (1986) recovered eggs from mangrove pneumatophores and from the bases of marine couch plants, which might suggest attachment of the eggs, but they also remarked that eggs were easily dislodged by agitation or a fine jet of water. Freedom from attachment may be important for these eggs as they may be carried some distance on incoming tidal flow and left in isolated pools as waters recede (Hamlyn-Harris 1933). The exact oviposition sites preferred by female *Ae. vittiger* are unknown, but certainly the extreme surface uniformity of its eggs and absence of cement from eggs laid in the laboratory indicate no attachment to the substrate.

A seemingly unusual feature of *Ae. vigilax* eggs is the rather complex shape of the outer chorionic cells, in which there are tongue-like circumferential extensions on each side of the cell. Olson and Meola (1976) described such cells on the egg of *Ae.* (*Och.*) *sollicitans* (Walker) and recent observations of eggs of several other species indicate that this may be a fairly common configuration within the subgenus *Ochlerotatus.* In eggs of *Ae.* (*Och.*) *procax* (Skuse), for example, the tongue-shaped extensions are highly developed (J. R. Linley, M. J. Geary and R. C. Russell, unpublished observations). Cells similarly shaped are present over the entire surface of *Ae.* (*Och.*) *scapularis* (Rondani) eggs (J. R. Linley and F. J. Burton, unpublished) and on the lateral and dorsal surfaces in *Ae.* (*Och.*) *infirmatus* Dyar and Knab (Linley 1990). There is apparently some advantage associated with this shape, either during egg development in the ovary, where the follicular epithelial cells must also be so formed, or after the egg is laid. Under the stereomicroscope, the complex outline of the cells can be distinguished by reflected light at high (≥80×) magnification and this might be quite useful for rapid and easy identification without resort to electron microscopy or hatching to obtain larvae. According to Hamlyn-Harris (1933), *Ae.* (*Mucidus*) *alternans* (Westwood) may share breeding habits with *Ae. vigilax,* but the substantially more rhomboidal shape of its egg and distinctly different chorionic cell structure (Linley et al. 1991) render it easily distinguishable stereomicroscopically from *Ae. vigilax.*

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LIFE HISTORY AND DESCRIPTIONS OF IMMATURE STAGES OF *NEASPILOTA VIRIDESCENS* QUISENBERRY (DIPTERA: TEPHRITIDAE) ON NATIVE ASTERACEAE IN SOUTHERN CALIFORNIA

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Abstract.—*Neaspilota viridescens* Quisenberry is a multivoltine, oligophagous tephritid reproducing in flower heads of species of *Aster, Chrysopsis, Chrysothamnus, Erigeron, Gutierrezia, Haplopappus,* and *Machaeranthera* in the tribe Astereae and *Lepidospartum* in the tribe Senecioneae of the Asteraceae in California. The larvae feed mainly on the ovules and immature achenes as first and second instars; however, as third instars, they usually extend their feeding chambers into the receptacle and additionally feed on sap. The chamber walls of plant fragments become impregnated with excess sap and liquid feces that harden when dry to protect the overwintering larvae. *Neaspilota viridescens* mainly overwinters as a diapausing "prepuparium," a non-feeding, mostly quiescent, fully grown third instar with its gnathocephalon retracted. The egg, first, second and third instar larvae, prepuparium, and puparium are described and figured. Premating and mating behavior is described, including the use of the asymmetrical foretarsi of the male. Nuptial gift formation and presentation by the male also is described as part of courtship behavior.

Key Words: Insecta, *Neaspilota viridescens,* nonfrugivorous Tephritidae, courtship behavior, mating behavior, immature stages, nuptial gift, host plants, Asteraceae

Revision of the genus *Neaspilota* (Diptera: Tephritidae) by Freidberg and Mathis (1986) facilitated determination of specimens reared from capitula of native California Asteraceae (= Compositae), and allowed Goeden (1989) to report on the host plants of this taxon in California. It also stimulated several life-history studies, among which this report on *N. viridescens* Quisenberry is the first completed for the genus from the western United States.

Materials and Methods

This paper was based on study of selected subsamples of mature flower heads of Asteraceae infested by *N. viridescens* from among many samples collected annually throughout California in the manner described by Goeden (1985, 1989). Adults studied were reared in glass-topped sleeve cages in the insectary of the Department of Entomology from bulk flower-head samples at 14-h photoperiod and 27 ± 1°C. Additional adults and parasitoids were reared from larvae and puparia of *N. viridescens* 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.

Adult longevity and oviposition were studied in 850-ml, clear-plastic cages fitted with screened lids for ventilation and basal water reservoirs in which absorbant cotton wicks and cut ends of bouquets of flower-

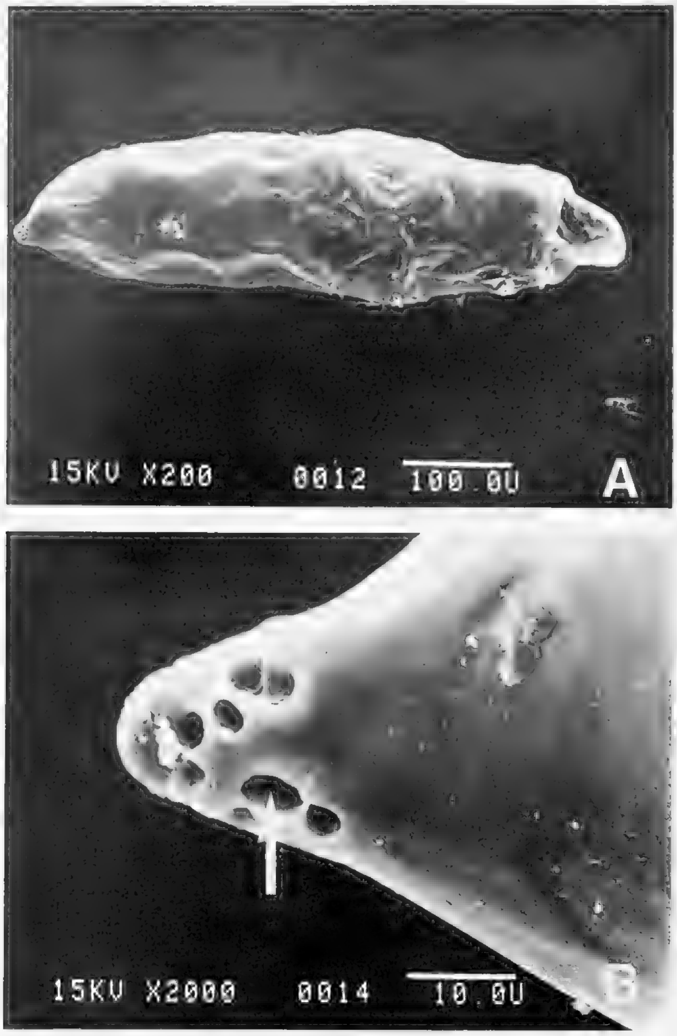

Fig. 1. Egg of *Neaspilota viridescens*. A. Habitus, aeropyle at left. B. Detail of aeropyle, arrow denotes aeropyle pore.

head bearing peduncles were emersed through a hole in each cage bottom. Honey striped on the underside of the lids provided food for the flies (Headrick and Goeden 1990b, Goeden and Headrick 1990, 1991a, b). Mating behavior was observed and photographed in 9-cm diam., clear-plastic Petri dishes used only once per pairing. Unlike Jenkins (1990), we provisioned these arenas with honey and water renewed daily and applied to a pad of absorbant cotton pressed flat onto the arena floor. Arenas were carried between home and laboratory for extended viewing at room temperatures under natural and artificial lighting during waking hours for 2 or 3 days.

Plant names used in this paper follow Munz (1974). The materials, methods, format, and nomenclature used to describe the immature stages follow Headrick and Goeden (1990a, 1991) and Goeden and Headrick (1990, 1991a, b). Means ± SE are used throughout this paper. Voucher specimens of reared adults of *N. viridescens* and its parasitoids reside in the research collections of RDG; preserved specimens of eggs, larvae, and puparia in the research collection of immature Tephritidae of DHH.

Results and Discussion

Taxonomy

Quisenberry (1949) first described *N. viridescens.* Freidberg and Mathis (1986) redescribed this species and illustrated important adult characters, including its dark-veined unpatterned wings, dark pterostigma, and asymmetrical male foretarsi. The useful key for *Neaspilota* that they also provided was based in large part on such wing characters, male foretarsi, setal color, and chaetotaxy. The immature stages of *N. viridescens* heretofore have been neither illustrated nor described.

Egg.—The egg (Figs. 1A, 8A) is smooth, shiny, white, elongate-ellipsoidal, sometimes flattened along one side, and rounded at the end opposite the peg-like, 0.02-mm pedicel. Fifteen eggs recovered from flower heads of *Aster spinosus* L. (Asteraceae) measured 0.57 ± 0.12 (range, 0.46–0.64) mm in length and 0.17 ± 0.12 (range, 0.14–0.18) mm in greatest width. These measurements were shorter and narrower on average than (and the ranges did not include) the length and width of the egg of *N. alba* (Loew) reported by Schwitzgebel and Wilbur (1943), who also described this egg as slightly curved and pointed at one end.

Scanning electron microscopy revealed an egg virtually free from distinguishing surface features (Fig. 1B). Even the pedicellar end, usually bearing symmetrical and well-defined aeroscopic pores in other non-frugivorous tephritids, e.g. *Tephritis baccharis* (Coquillett) (Goeden and Headrick 1991b, DHH unpublished data), was highly reduced and irregular (Fig. 1B). The egg body lacked polygonal reticulations, which are present even on the typically featureless eggs of frugivorous species, i.e. *Ceratitis capitata* (Wiedemann) (DHH unpublished data). Why this flower head-infesting species should have an egg with such highly reduced features is unclear. After processing for SEM, eggs of *N. viridescens* were observed to collapse more at the basal end opposite the pedicel (Fig. 1A), which suggested more structural strength to the chorion nearer the pedicel. This explanation would be consistent with other more structurally complex tephritid eggs, e.g. *Tephritis baccharis,* that have highly developed reticulation of the chorion near the pedicel, where these reticulations provide strength and protection to the end of the egg which is exposed after oviposition (Goeden and Headrick 1991b).

Larva.—The third instar larva provides the basis for our general description, and descriptions of the first and second instars are limited to observed differences. The third instar larva (Fig. 2A, B) is elongate and dorso-ventrally flattened with well-defined segmentation. The anterior end is bluntly rounded and the posterior end has a unique and characteristic shape (Fig. 2A). The caudal segment is upturned ca. 60° and distinctly flattened, such that the posterior spiracular plate is borne dorsally and the ventral portion of the segment juts posteriorad. In the fully grown larva, the integument of the last two or three posterior segments is hardened and often darkly discolored. This is a reliable character for distinguishing this species from species in other genera, e.g. *Trupanea,* that may sometimes share the same flower head.

The gnathocephalon is smooth anteriorly, though rugose pads surround the anterior sensory lobes and the perimeter of the mouth lumen (Fig. 2C). These lateral pads are rectangular, with their posterior margin dentate (Fig. 2D—1). The mouth hooks are tridentate and the median oral lobe is smooth ventrally (Fig. 2D—3). The ventral margin of the median oral lobe in *N. viridescens* is attached to the floor of the mouth lumen, as illustrated in Belcari (1987) for the Italian species, *Acanthiophilus helianthi* (Rossi). The independent mobility, morphology, and use of this fleshy lobe located between the mouth hooks was first described by Headrick and Goeden (1990) for *Paracantha gentilis* Hering. No feeding larva of *N. viridescens* was examined to determine the comparative degree of movement of its attached median oral lobe. All non-frugivorous tephritid larvae described thus far have median oral lobes (Headrick and Goeden 1990a, 1991, Goeden and Headrick 1990a, 1991b, DHH, unpublished data). However, only the larva of *N. viridescens* among North American species of non-frugivorous tephritids is known to have the median oral lobe attached basally to its mouth lumen.

The dorsal sensory organ is not well defined in *N. viridescens.* There is a distinct flattened area that lies medial of the anterior sensory organs (Fig. 2E—1). This area had small pores associated with it that were irregular in number and placement among the six larvae examined. The dorsal sensory organ is typically very distinct and not a part of the anterior sensory lobe. This species also has two sensilla not observed before, a pair of small depressions with a small central papilla dorsad of the anterior sensory lobes (Fig. 2E—2); these sensilla are bilaterally symmetrical and were consistent in placement on both second instars and all six third instar larvae examined.

The anterior sensory lobe bears the terminal sensory organ, the lateral sensory organ, the pit sensory organ and a sensillum that lies dorsal to the lateral sensory organ (Fig. 2F—2). The last, uncommon sensillum was previously described in *Tomoplagia cressoni* Aczél (Goeden and Headrick 1991a), but it is not a constant feature of the anterior sensory lobe among other tephritid species from southern California examined to date (DHH, unpublished data). This sensillum and the lateral sensory organ

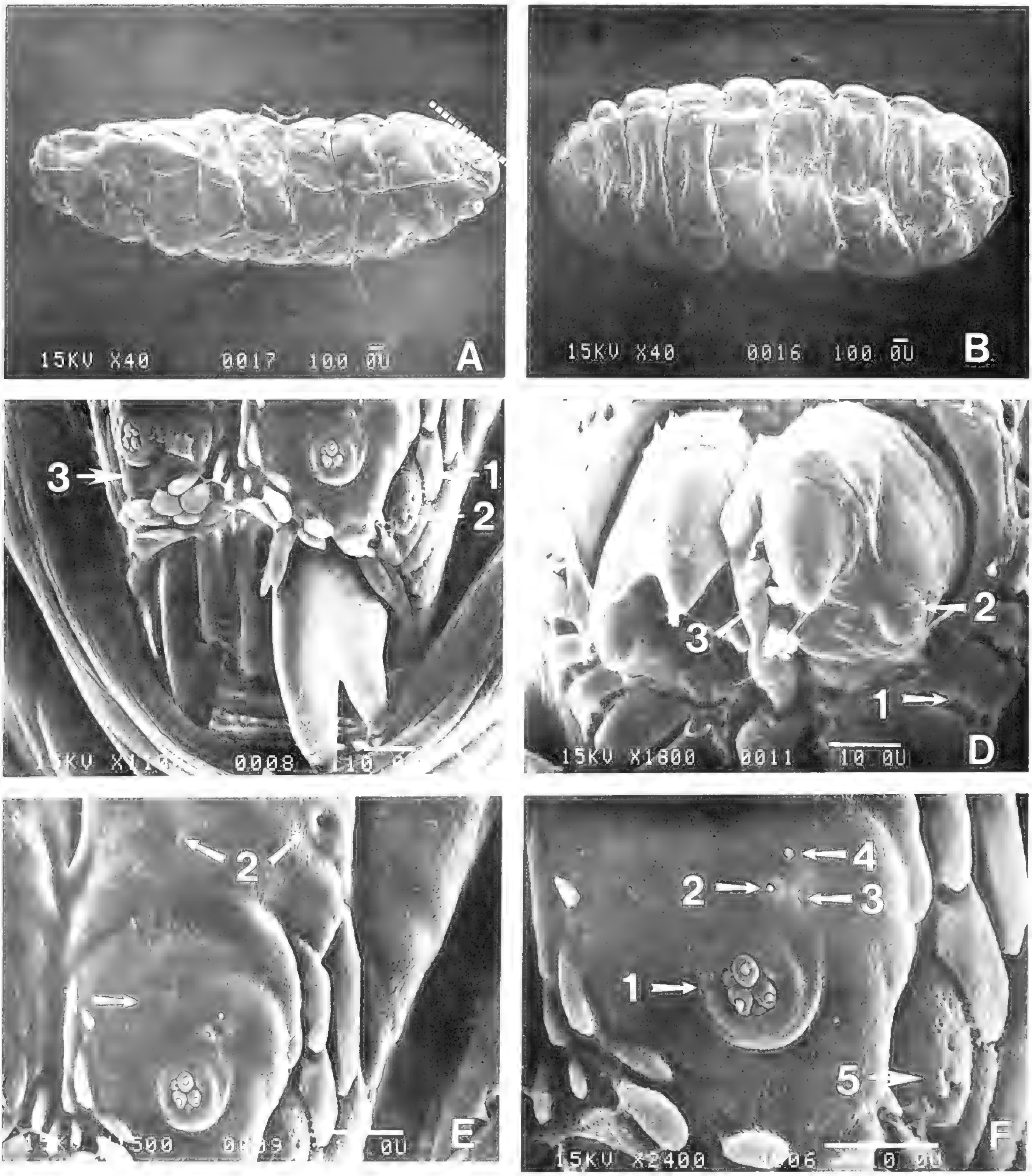

Fig. 2. Third instar larva. A. Habitus, lateral view. Dashed line marks the upturned caudal segment. B. Habitus, ventral view. C. Anterior view; 1—rugose pads, 2—lateral sensory lobe, 3—anterior sensory lobe. D. Anterior view; 1—rugose pads, 2—mouth hooks, 3—median oral lobe. E. Anterior sensory lobe; 1—probably dorsal sensory organ, 2—paired sensory depressions. F. Anterior sensory lobe, detail; 1—terminal sensory organ, 2—lateral sensory organ, 3—pit sensory organ, 4—dorsal sensillum, 5—stomal sense organ.

in *N. viridescens* are composed of a single papilla in a raised cuticular ring (Fig. 2F—2, 4). The terminal sensory organ is composed of three ringed structures and two single papillae all surrounded by a raised cuticular ring (Fig. 2F—1). The lack of a well-defined dorsal sensory organ and the presence of supernumerary anterior sensilla are noteworthy in *N. viridescens,* as the anterior sensory complex is usually highly conserved among tephritid species (Carroll and Wharton 1989, Headrick and Goeden 1990a, DHH, unpublished data). The stomal sense organs lie ventral of the anterior sensory lobes on the lateral aspect of the mouth lumen and are composed of several cone-shaped sensilla on a flattened lobe (Fig. 2F).

The prothorax is smooth, circumscribed by several flattened sensilla (Fig. 3A), and bears the anterior thoracic spiracles on its posterior margin (Fig. 3B). In the third instar larvae and puparia we examined (n = 12), the number of papillae varied from two to three among individuals and between sides of individuals. This supports the suggestion of Freidberg and Mathis (1986) that this character is useful to diagnose the larvae of the subgenera of *Neaspilota,* although the range in the number of papillae in *Neorellia* is slightly greater, two to four rather than three to four. Later instars of *Neaspilota* (s. str.) generally have six to eight papillae.

The surface features of the body segments of *N. viridescens* larvae also are unique compared with other tephritid larvae examined to date. The segments are demarcated by shallow longitudinal depressions which circumscribe the body. The rows of acanthae that are usually restricted to this intersegmental area in other species form a band around the middle of each segment in *N. viridescens,* and the intersegmental area is smooth (Fig. 3C). The acanthae of *N. viridescens* are mostly rounded and dome-shaped (Fig. 3D), with only a few of the more typical, posteriorly directed spines as described for *P. gentilis* (Headrick and Goeden 1990a).

On the lateral midline of each body segment between the prothorax and caudal segment is the lateral spiracular complex (Fig. 3E). In *N. viridescens* this complex is composed of a lateral spiracle, which is round and sometimes open, as first reported in *Trupanea californica* Malloch by Headrick and Goeden (1991), and a single dome-shaped sensillum with a central pore. Each lateral spiracular complex lies near the anterior margin of the segment within the band of acanthae.

The caudal segment is dorsally flattened and in the fully grown larva is hardened and dark. It bears the posterior spiracular plates. The associated sensilla that are usually very pronounced and often quite complex in other tephritid species are only small and dome-shaped in *N. viridescens,* but they lie in positions typical for tephritid larvae (Phillips 1946, Headrick and Goeden 1990a). The posterior spiracular plates bear three, nearly contiguous, elongate-oval rimae, the interspiracular processes, and the ecdysial scar (Fig. 3F). The interspiracular processes are small and reduced to four or fewer branches. They are also inserted between the rimae closer to the midline of the body than has been described for other tephritid species (Phillips 1946, Carroll and Wharton 1989, Headrick and Goeden 1990a).

Second instar larva: The second instar larva is barrel-shaped, white, and about one-third the size of the fully grown third instar larva (Fig. 4A). The gnathocephalon is smooth, with rugose pads around the anterior sensory lobes and mouth lumen, whose posterior margins are dentate (Fig. 4B). The mouth hooks are tridentate, and the median oral lobe has no ventral papillae; it is also ventrally attached to the floor of the mouth lumen (Fig. 4C).

The anterior sensory lobes bear four sensory structures with the same placement as observed in the third instar larva (Fig. 4D). As reported for *P. gentilis* (Headrick and Goeden 1990a), there is considerable morphogenesis of structures between instars thus, the sensory organs on the anterior sensory lobe are not as well developed as in the third instar larva. Again, a distinct, flattened area that is not clearly separated from the anterior sensory lobe in the second instar may serve as the dorsal sensory organ (cf. *P. gentilis,* Headrick and Goeden 1990a).

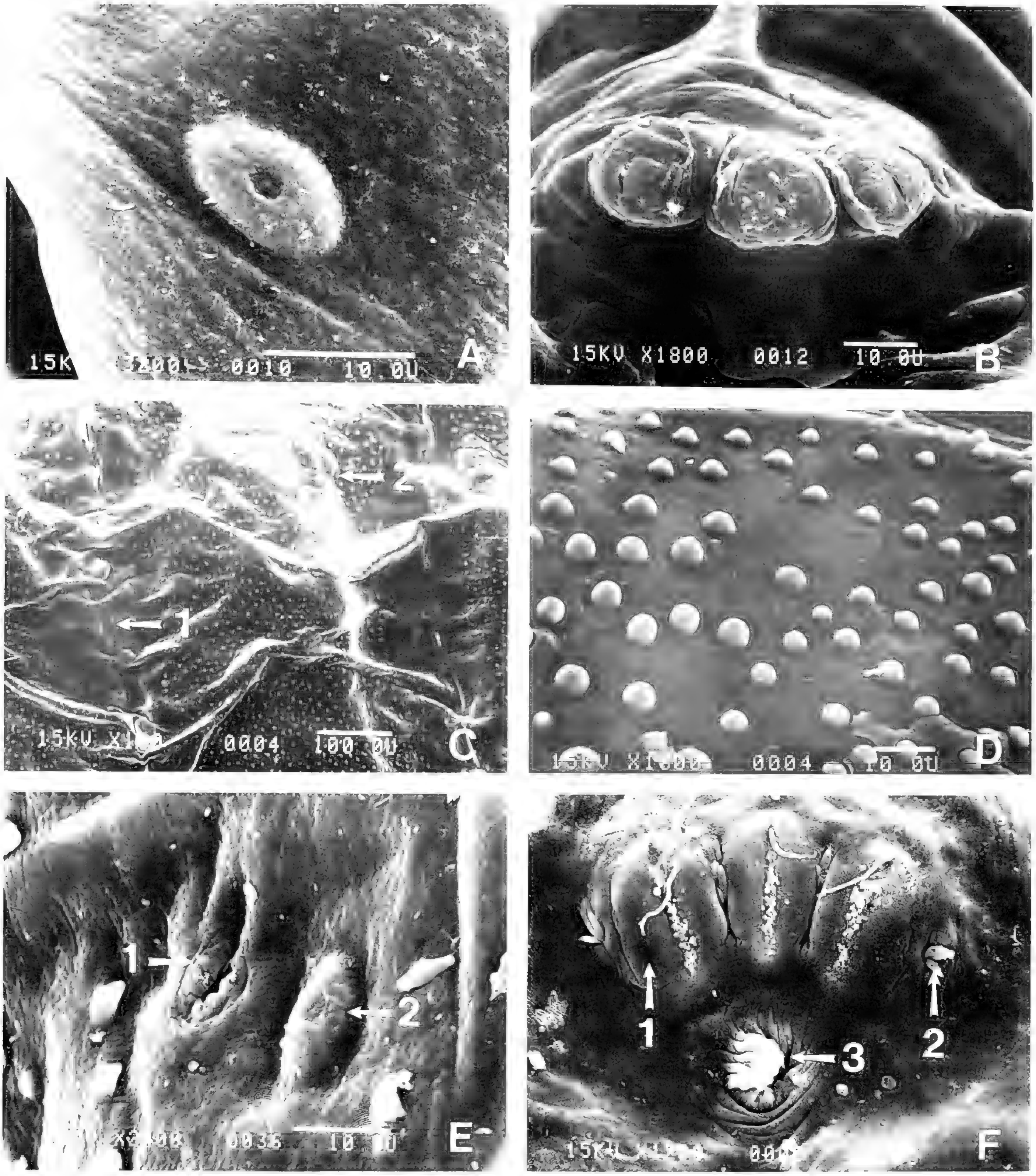

Fig. 3. Third instar larva. A. Prothoracic sensillum. B. Anterior thoracic spiracle. C. Intersegmental area; 1—intersegmental depressions, 2—acanthae. D. Acanthae, detail. E. Lateral spiracular complex, 1—lateral spiracle, 2—lateral sensillum. F. Posterior spiracular plate, 1—rima, 2—interspiracular process, 3—ecdysial scar.

The stomal sense organs are located ventral of the anterior sensory lobes and bear three cone-shaped sensory structures (Fig. 4E).

The posterior spiracular plate bears three elongate oval rimae, four interspiracular processes, and an ecdysial scar (Fig. 4F). The interspiracular processes are two-branched at most, and again are short and located more toward the midline of the body.

First instar larva: The body of the first instar larva is translucent, parallel-sided, cylindrical, and bluntly rounded at both ends

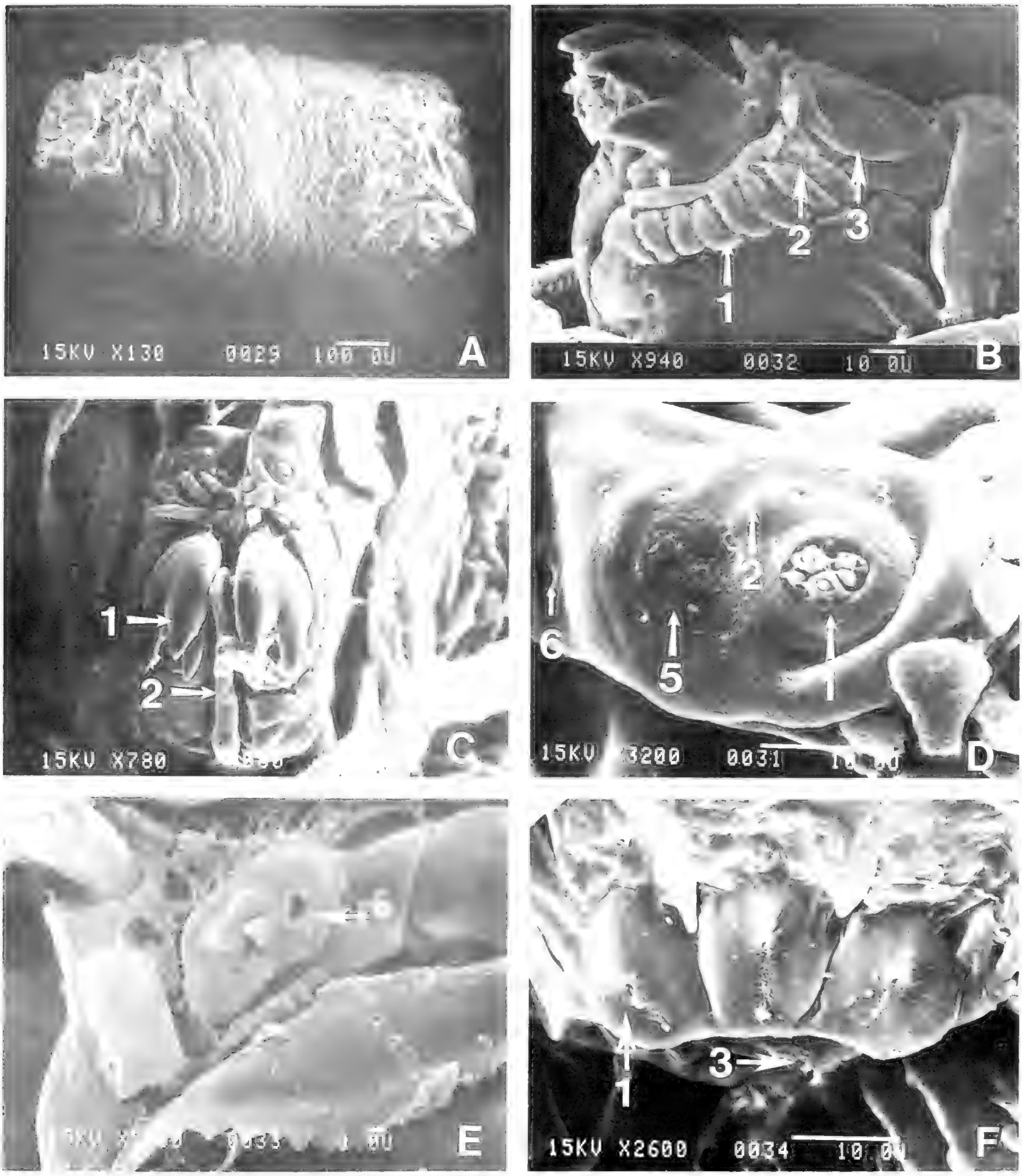

Fig. 4. Second instar larva. A. Habitus. B. Anterior end, left lateral view; 1—rugose pads, 2—lateral sensory lobe, 3—anterior sensory lobe. C. Anterior view; 1—mouth hooks, 2—median oral lobe. D. Anterior sensory lobe; 1—terminal sensory organ, 2—lateral sensory organ, 3—pit sensory organ, 4—dorsal sensillum, 5—probably dorsal sensory organ, 6—paired sensory depression. E. Stomal sense organ. F. Posterior spiracular plate; 1—rima, 2—interspiracular process, 3—ecdysial scar.

(Fig. 5A). The gnathocephalon has extremely reduced features composed of three lobes on either side of the midline. Dorsally to ventrally, they are a large lobe that may bear the dorsal sensory organ, the anterior sensory lobe, and a lobe that develops in later instars into the integumental petals surrounding the mouth lumen. The anterior

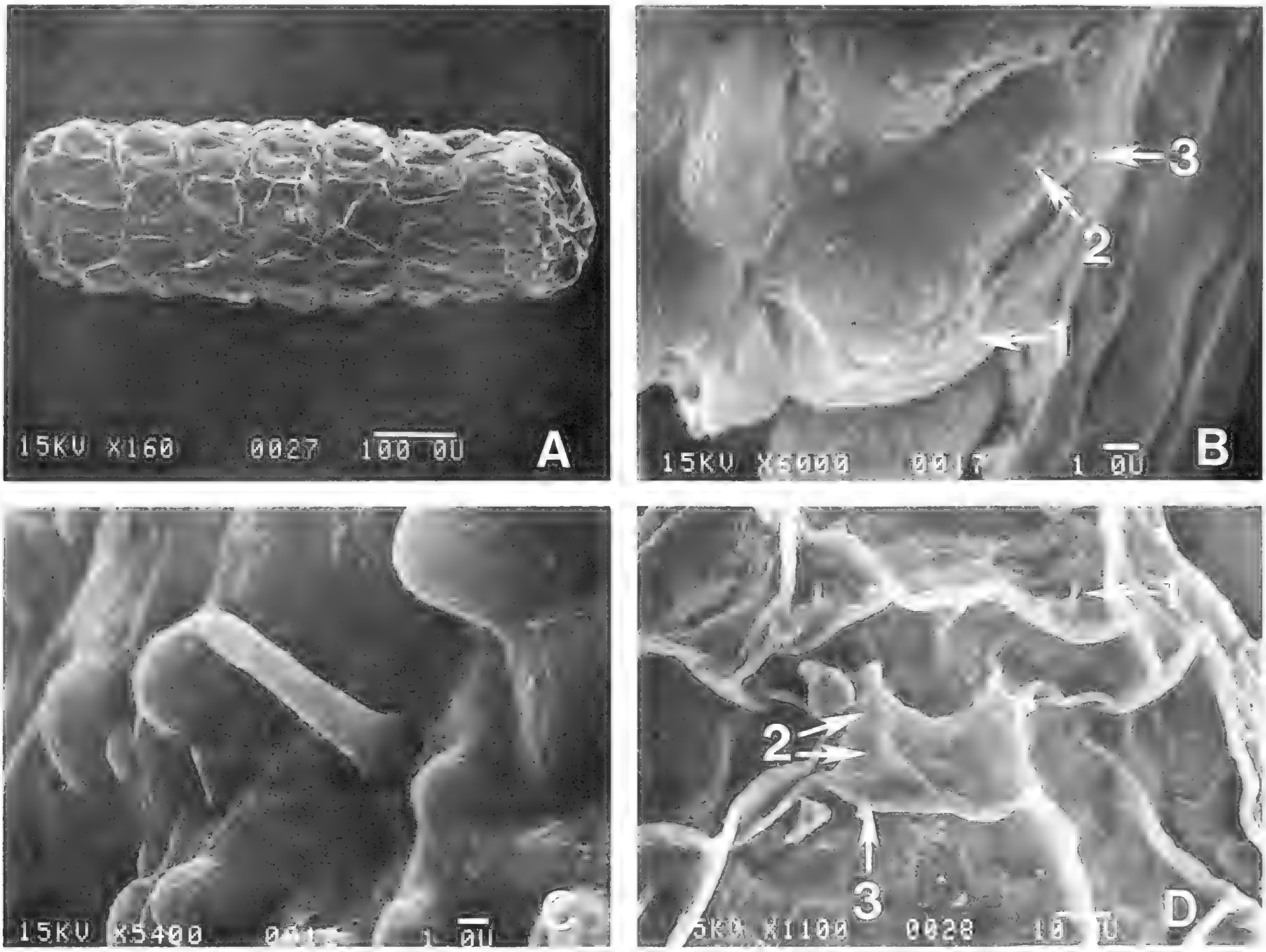

Fig. 5. First instar larva. A. Habitus. B. Anterior sensory lobe; 1—terminal sensory organ, 2—lateral sensory organ, 3—dorsal sensillum. C. Typical sensillum on lateral aspect of abdominal segment. D. Posterior spiracular plates; 1—caudal sensillum, 2—rima, 3—interspiracular process.

sensory lobe bears three distinguishable sensilla, but the pit sensory organ was not visible (Fig. 5B). The terminal sensory organ is composed of three ringed papillae and at least one of the two single papillae observed in later instars (Fig. 5B). Again, these structures are indistinct in the early instars and only reach full development in the third instar larva. The segments posterior to the gnathocephalon of the first instar bear several finger-like sensilla (Fig. 5C). These sensilla often change form in later instars to a more flattened dome-shaped sensillum, but retain their relative placement. The first instar larvae of *Paracantha gentilis* also have these same finger-like sensilla, which take on different forms in later instars (Headrick and Goeden 1990a). The caudal segment bears ten finger-like sensilla on its margins (Fig. 5D). The posterior spiracular plate bears two small, barely perceptible spiracular slits, and four interspiracular processes, with up to four branches (Fig. 5D). The median ecdysial scar does not form until the first instar larva molts. The spiracular slits are easier to observe under a dissecting microscope as they are scelotized and show up against the translucent white of the integument.

Prepuparium.—This "stage" in the phenology of *N. viridescens* will be described separately from the third instar larva and the puparium from which it differs morphologically and behaviorally, and occupies a significant amount of time in the life history. However, no molt separates it from the other stages; instead, this is a transitory step towards pupariation. The third instar,

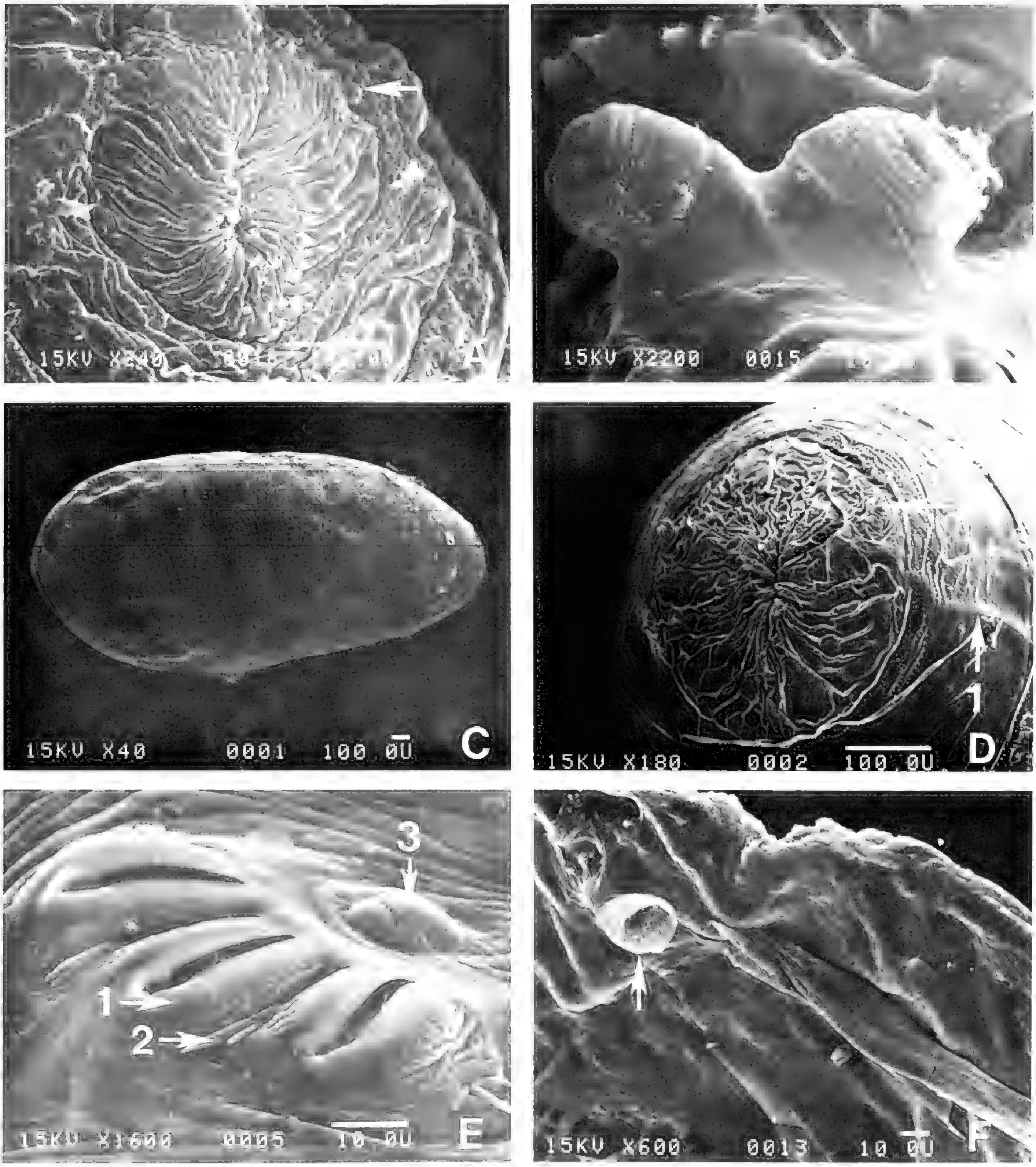

Fig. 6. A, B.—Prepuparium, C, F.—Puparium. A. Anterior view; arrow denotes anterior thoracic spiracles. B. Anterior thoracic spiracles, detail. C. Habitus. D. Anterior view; 1—fracture line, 2—anterior thoracic spiracles. E. Posterior spiracular plate; 1—rima, 2—interspiracular process, 3—ecdysial scar. F. Interior view of cephalic cap; arrow denotes open tracheal attachment to the anterior thoracic spiracle.

while feeding head down in a flower head, withdraws its gnathocephalon into the body almost to the margin of the prothorax, forming a heavily ridged cephalic cap (Fig. 6A). The larva does not go through the process of tanning and hardening as it would to form a puparium, but remains soft, pliable, and "waxy" appearing. The integument is very wrinkled, and does not become smooth until pupariation, at which time muscle contractions form the body into the typical barrel-shaped puparium. The anterior spiracles remain exposed (Fig. 6B), but their role in gas exchange is questionable. The posterior spiracles are possibly more important for gas exchange as they are held up and directed away from the receptacle in the air space at the top of the feeding chamber. Pupariation takes place only after the pre-puparium reverses itself in the flower head.

Puparium.—The puparium of *N. viridescens* (Fig. 6C) is elongate-oval, superficially smooth, rounded and dark brown to black at both ends, and off-white or unpigmented centrally. Thirty-seven puparia averaged 2.7 ± 0.3 (range, 2.4–3.2) mm in length and 1.2 ± 0.2 (range, 1.0–1.5) mm in width. The cephalic cap is heavily ridged with distinct fracture lines (Fig. 6D). The anterior spiracles lie nearer to the midline than in other tephritid species examined to date (Fig. 6D). The posterior end is superficially smooth. The spiracular slits are distinct and open (Fig. 6E); however, just before pupariation the prepuparium turns head upward, which makes the anterior spiracles the primary sites of air entering the puparium for the developing pupa. The taenidia maintain an open tracheal attachment to the anterior spiracles to permit gas exchange (Fig. 6F).

This is the first description of the immature stages of *N. viridescens.* Thus, it is worth noting several features of taxonomic interest that separate *N. viridescens* from species in other genera. The ventrally attached median oral lobe is the first reported for any of the 16 species in eight other genera examined thus far by DHH (unpublished data). The poorly defined dorsal sensory organ may be the most easily determined feature for this species, as the anterior sensory structures are visible under a dissecting microscope. Another difference is the band of acanthae that occurs only around the middle of each body segment, and not on the intersegmental lines. Lastly, there are the much reduced interspiracular processes, which species of *Procecidochares* also possess (DHH and Teerink, unpublished data).

Adult: The asymmetrical foretarsi of the male are currently one of the main characters used to separate the genus *Neaspilota* from other genera in the Terelliinae (Freidberg and Mathis 1986). However, this rather unusual morphological feature has only been documented with SEM in *N. alba* (Freidberg and Mathis 1986). We provide here a detailed description of the male foretarsus of *N. viridescens,* and later provide behavioral evidence of its use.

The fifth tarsomere of the male is more elongate, but not wider than preceding tarsomeres (Fig. 7A). Each tarsomere is cylindrical, longitudinally wrinkled, and invested with several types of spines. One type is a straight, thin, acantha drawn into a fluted spiral (Fig. 7A—1, B). These acanthae are arranged in somewhat regular longitudinal rows in which each is directed distally. There are also larger setae which are much stouter, especially at their base. These setae are drawn out into a long, parallel-fluted sharply pointed structure (Fig. 7A—2).

The fifth tarsomere has a cluster of setae on its anterodistal margin that are short, stout, bluntly tapered, and fluted (Fig. 7A, B). The sockets are drawn out from the parallel ridges of the integument to form a pad of 11 sockets in three parallel rows. The anterior-most row has three setae, the middle row has four setae, and the posterior row has four setae. In comparison, the SEM micrographs published in Fig. 2 for *N. alba* in Freidberg and Mathis (1986: 13) show that the anterior row has six setae and the posterior row has four for a total of ten setae. The smaller, thin acanthae occur up to and project beyond the pad of stout setae in *N. viridescens,* and several of the long setae surround the pad. The setae on the pad project distad except for the two most proximal setae which project proximad.

On the ventral aspect of the fifth tarsomere is a subapical empodium (Fig. 7C—1, D). The empodium is a ventral projection

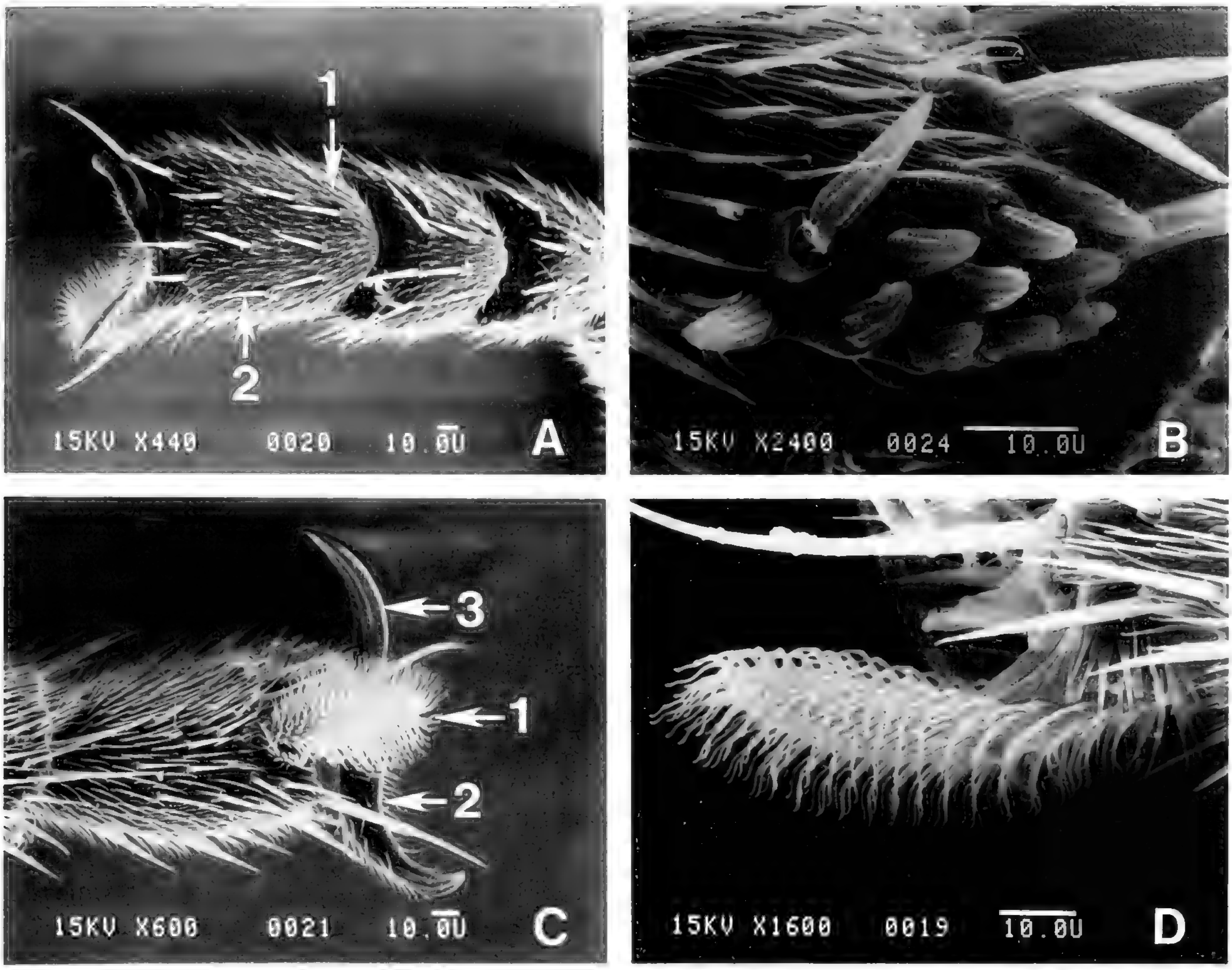

Fig. 7. Male foretarsus. A. Fifth tarsal segment, lateral view; 1—Socketless acantha, 2—Socketed spine. B. Anteriodistal pad. C. Fifth tarsomere, medial view; 1—empodium, 2—anterior claw, 3—posterior claw. D. Empodium, lateral view.

of the integument, the base of which is fluted, and surrounded by a brush of sharply pointed, flattened projections. The empodium extends from the fifth tarsomere foramen to form a foot-like pad invested with 20 rows of thinly tapered ventrally projecting spines. Each spine is bent ventrally once at about half its length, and again laterally near its apex.

The claws are asymmetrical both in size and orientation (Fig. 7A, C). Each claw is a fluted spiral. The anterior claw is the larger of the two; it is curved such that the apex of the claw is proximally projected. Each claw bears several small, sharp acanthae near its base, and is smooth distally. The posterior claw is somewhat flattened and tapers to a ventrally projecting fluted point. The acanthae are the same size and shape as the smaller ones found on the tarsomeres.

DISTRIBUTION AND HOSTS

Freidberg and Mathis (1986) mapped collection records for *N. viridescens* and described its geographic distribution as "... Western North America from Alaska and the Yukon Territory southward through Washington and Montana to California and Colorado." Their collection records and sole rearing record for *Aster spinosus* L. represented 11 counties in California. Goeden (1989) reported rearing records from six additional California counties, from two additional species of *Aster,* and from 13 other host species in the genera *Chrysothamnus, Erigeron, Gutierrezia, Haplopappus, Lepidospartum,* and *Machaeranthera.* All reported host genera belong to the tribe Astereae of the Asteraceae, except *Lepidospartum* in the tribe Senecioneae (Goeden 1989). We add the following new rearing records recently acquired by RDG: *Aster foliaceus* Lindley, 1 ♂, Indian Creek, E. side of White Mountain, Inyo National Forest, Esmeralda Co., Nevada, 26.vii.1989 (apparently the first published record for this fly from Nevada); *A. intricatus* (Gray) Blake, 1 ♂, 5-bridges Road N of Bishop and bridge over Owens River at 1207 m, Inyo Co., 9.x.1990; *Chrysopsis villosa* (Pursh) Nuttall, 1 ♂ and 1 ♀, Frenchman Lake, Plumas National Forest, Plumas Co., California, 22.viii.1989 (new host-genus, and -species records). *Chrysopsis* also belongs to the Astereae; thus, there is a predictable pattern to the host range of *N. viridescens.* As currently defined, *N. viridescens* is the most commonly encountered species with the widest host range in this genus in California (Freidberg and Mathis 1986, Goeden 1989).

BIOLOGY

Egg.—The eggs are laid in the immature flower heads (so-called flower "buds"), usually singly under natural conditions (Fig. 8A). As many as four eggs were recovered from single heads of *Aster spinosus* in insectary cagings. Schwitzgebel and Wilbur (1943) reported that *N. alba* oviposited a single egg "against the inside of the involucre" (i.e. on the periphery of the receptacle) inside the flower heads of *Vernonia interior* Small. In *A. spinosus,* a few eggs of *N. viridescens* were inserted in the center of a head, but most were located to one side, not touching the involucre bracts, and with their long axes parallel to the florets. The eggs were laid alongside and sometimes touching the floret perianths, usually above and not touching the ovules or young achenes, but always located among the pappus hairs (Fig. 8A). The pedicels projected upward away from the receptacle. The eggs were loose or only lightly glued to the pappus hairs or perianths. The incubation period under insectary conditions was 5–6 days.

Larva.—The newly hatched larva immediately tunnels into an immature ovule (Fig. 8B). The first and second instars then mined through a series of ovules and soft achenes (fertilized ovules), usually around the periphery and parallel to the receptacle surface in flower heads of *Chrysopsis villosa* and *Erigeron foliosus* Nuttall (Fig. 8C). In smaller flower heads, e.g. *Aster spinosus, Chrysothamnus teretifolius* (Durand and Hilgard) Hall, and *Haplopappus cooperi* (Gray) Hall (Fig. 8D, E, G), the ovules and soft achenes are almost entirely consumed, then feeding is extended into the basal parts of the tubular perianths and pappus. In larger heads of *E. foliosus,* the larva began feeding on the rest of the florets only after all or most of the soft achenes were mined (Fig. 8C).

Third instar larvae usually feed within elongate-saccoidal chambers with smooth-surfaced inner walls constructed of uneaten fragments of achenes, pappus hairs, and perianths. The third instar larva also usually taps into the conductive tissues that ramify the receptacle (Romstöck 1987). It chews a smoothly rounded, cuplike feeding depression within which the sap collects, upon which it also feeds (Fig. 8D). This type of feeding behavior has been reported for the third instar larvae of other flower head-infesting Tephritidae, e.g. *Paracantha gentilis* Hering (Headrick and Goeden 1990c) and *Tomoplagia cressoni* (Goeden and Headrick 1991a). In *P. gentilis,* receptacle scoring is a density moderated behavior among third instars, but in *N. viridescens,* it was the usual feeding behavior in most host species studied. For example, only one (0.2%) of 367 larvae in separate heads of *A. spinosus* did not score a receptacle; 17 (12%) of 142 larvae in separate heads of *H. cooperi;* and one (10%) of 10 larvae in separate heads of

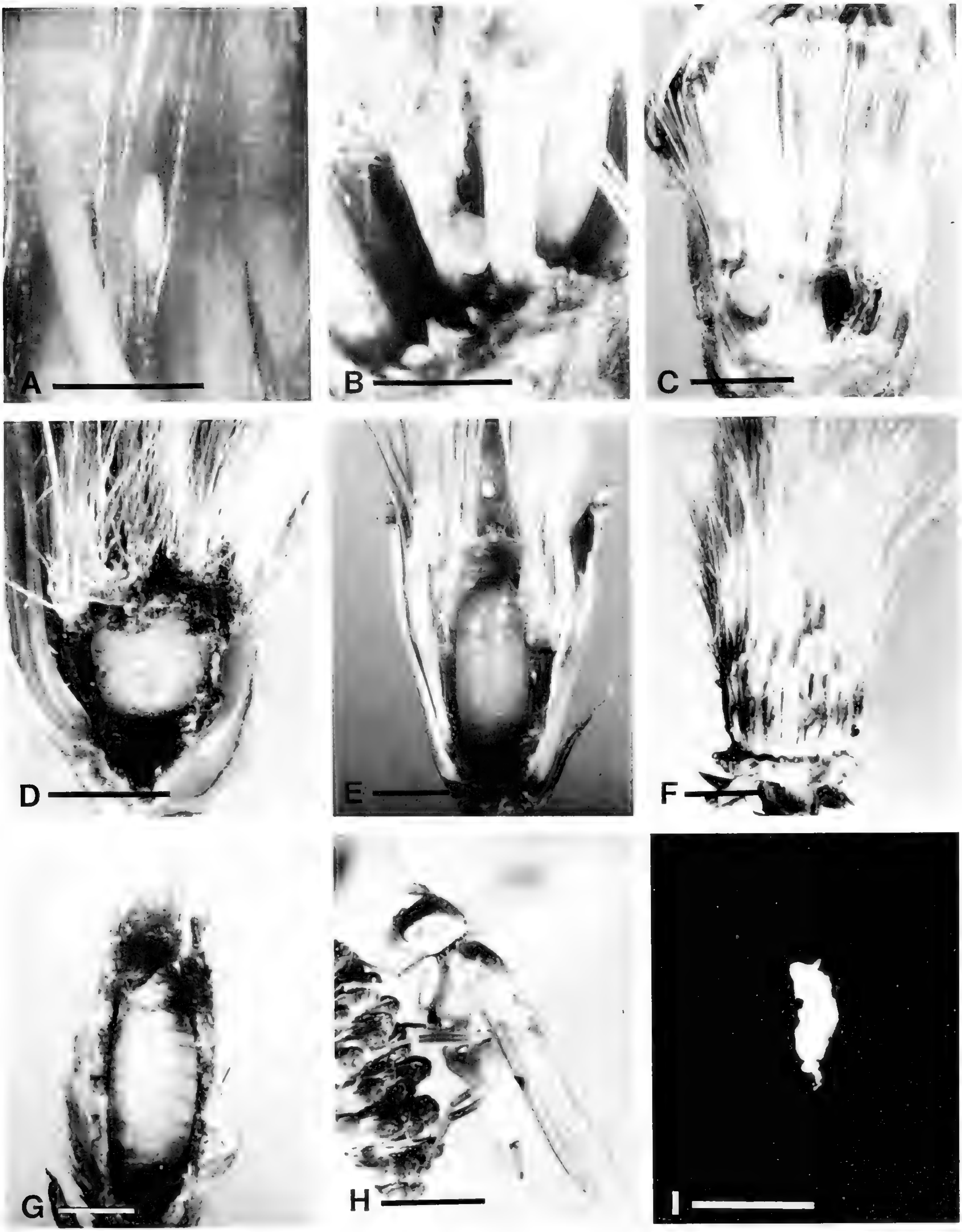

Fig. 8. Life stages of *N. viridescens*. A. Egg in flower head of *Aster spinosus*. B. First instar larva feeding on ovule of *A. spinosus*. C. Second instar larva feeding in head of *Erigeron foliosus*. D. Third instar larva and feeding depression in receptacle in head of *A. spinosus*. E. "Prepuparium" in flower head of *Haplopappus cooperi*. F. Flower head of *A. spinosus* containing overwinter larva (prepuparium). G. Empty puparium in head of *Chrysothamnus teretifolius*. H. Adult female at rest on head of *A. spinosus*. I. Nuptial gift. Lines = 1 mm.

Chrysopsis villosa. However, 23 (68%) of 34 larvae in separate heads of *Chrysothamnus nauseosus* did not score the receptacles and fed within and just above the achenes. The basal stumps of the achenes connected to the receptacles apparently also served as conduits for sap upon which the larvae fed. This latter mode of feeding is similar to that employed by at least one species each of *Neaspilota, Procecidochares,* and *Trupanea* (RDG, unpublished data), and by *Paracantha gentilis* at low densities (≤three) in heads of *Cirsium* thistles (Headrick and Goeden 1990c).

Excess sap and liquid feces impregnate the walls of the feeding chambers of *N. viridescens.* These liquid wastes eventually dry to a yellow-brown (ochrous) solid after larval feeding ceases; this drying causes the wall to assume a brittle, protective hardness (Fig. 8E, G). Excised pappus hairs and other floret fragments were oriented transversely to the long axis of the flower head in the upper ends of the chamber walls, possibly reflecting the turning of the larva on its long axis as it fed. Chamber walls in heads of *Chrysothamnus teretifolius* appeared more fibrous than walls in heads of *H. cooperi,* reflecting the larger pappus of the achene of the former host (Fig. 8E, G).

The chambers were formed off-center in heads of *E. foliosus,* and occupied most of the interiors in smaller heads of *A. spinosus, Chrysothamnus teretifolius,* and *H. cooperi* (Fig. 8D, E, G). However, six of eight chambers were located centrally in separate heads of *Chrysopsis villosa;* the remaining two chambers were located towards one side of different heads.

Feeding chamber length was measured from the bottom of the feeding depression in the receptacle (Fig. 8D) outward to the circular, 0.6 ± 0.2-mm diam. ($n = 31$) mouth of the chamber, where the sap- and feces-impregnated walls end (Fig. 8E, G). A ring of florets and pappus hairs forms the unimpregnated extension of the chamber walls out through which the emerging adult passes (Fig. 8E, G). A loose plug of unimpregnated, excised floret apices and pappus hairs closes the chamber distally. In infested heads of *A. spinosus,* 22 feeding chambers averaged 4.3 ± 0.1 mm long by 1.2 ± 0.1 mm wide at their centers. The walls averaged 0.5 ± 0.1 mm wide at their thickest in the center of the chamber. This compared with mean chamber lengths of 4.7 ± 0.2 mm in 25 heads of *Chrysothamnus teretifolius* (Fig. 8G); of 3.4 ± 0.1 mm in seven heads of *Chrysopsis villosa;* and of 3.6 ± 0.5 mm in 58 heads of *H. cooperi* (Fig. 8E). Four larvae destroyed an average of 19.8 ± 2.8 achenes in heads of *A. spinosus,* whereas each of nine larvae destroyed 9.8 ± 0.3 achenes in heads of *Chrysothamnus teretifolius.* As reported by Benjamin (1934) for *N. achilleae* Johnson, *N. dolosa* Benjamin, and *N. punctistigma* Benjamin, larvae of *N. viridescens* usually feed singly in flower heads (Fig. 8C, D, E, G). However, one head of *Chrysopsis villosa* was infested by a third instar larva of *N. viridescens* and an intact puparium of *Procecidochares minuta* (Snow); another head was infested by a third instar larva of *N. viridescens* and two empty puparia of *P. minuta.* [This is a new host record for *P. minuta* (Wasbauer 1972).]

After the larva stops feeding in heads of *H. cooperi* and *Chrysopsis villosa,* it becomes quiescent and withdraws its gnathocephalon nearly up to its anterior spiracles (Fig. 6A). While still in this "prepuparial stage," it reverses itself 180° such that its posterior segments lie closely cupped within the feeding depression, its anterior end facing outward (Fig. 8E). The duration of this prepuparial stage was not determined, mainly because the larvae and puparia are hidden in flower heads; moreover, this period varies with the time of year and host plant involved. For example, in heads of spring-blooming hosts, cf. *H. cooperi* (Fig. 8E), and summer-blooming hosts, cf. *E. foliosus* and *Chrysopsis villosa,* it apparently is of relatively short duration, i.e. pupariation ensues once the prepuparial larva has rotated in its feeding chamber. However, in areas with temperate climates, i.e. mountains in southern California, and more northern latitudes in California and elsewhere, *N. viridescens* (and other species of *Neaspilota*; Goeden, Headrick, and Teerink, unpublished data) overwinters primarily as diapausing prepuparia in hard-walled chambers in heads of fall-blooming hosts, i.e. *A. spinosus, Lepidospartum squamatum,* and *Chrysothamnus teretifolius* (Fig. 8F). Nondiapausing individuals also emerge as adults from excised heads of fall-blooming hosts (see below).

Puparium.—The puparium is formed with its anterior end facing outward, away from the receptacle to facilitate emergence of the adult (Fig. 8E, G). The puparium snugly fits the feeding chamber, reaching to within 1–3 mm of the loosely plugged chamber mouth. The emerging adult pushes the plug outward with its ptilinum through the chamber mouth and exits the head via the 2–5-mm long, encirling band of florets, pappus hairs, and involucre bracts (Fig. 8E, G).

Puparia were dissected intact only with difficulty from hardened chambers in dried, overwintered heads of *A. spinosus.* Overwintering prepuparia-bearing heads also are distinguished by the whitish tufts of pappus and uneaten florets and achenes that surround the cell and remain attached to and project from the receptacle (Fig. 8F). This was in stark contrast to the bare receptacles from which the achenes of uninfested heads had long been shed.

Adult.—Females of *N. viridescens* newly emerged from flower heads of spring-, summer-, and fall-blooming hosts (n = 3 per season) all bore small, undeveloped ovaries and little fat body tissue. A preoviposition period during which the adults feed and gain sexual maturity is requisite, as with other flower head-infesting Tephritidae, e.g. *Neotephritis finalis* (Loew) (Goeden et al. 1987), *P. gentilis* (Headrick and Goeden 1990b), *Tomoplagia cressoni* (Goeden and Headrick 1991a), and several *Trupanea* spp. (Cavender and Goeden 1982, Goeden 1987b, 1988, Headrick and Goeden 1991).

Males and females emerged together throughout the entire emergence period in a male-biased sex ratio based on analysis of the following samples of insectary-reared *Neaspilota viridescens* ($\chi^2 = 28.03, P < .005$, 4 df): 76 males and 71 females reared between 27.xi.1989 and 15.ii.1990 from mature flower heads of *Haplopappus palmeri* collected in N. San Jacinto Valley, Riverside Co., on 7 and 18.xi.1989. By 15.xii.1989, nine males and seven females had emerged; by 15.i.1990, 59 males and 51 females had emerged. Similarly, a total of 70 males and 89 females were reared from heads of *Aster spinosus* collected near Calipatria, Imperial Co., on 6.xii.1988, 11.i.1990, and 16.ii.1990. Again, seven males and five females emerged by 22.iii.1989; 46 males and 38 females by 7.iv.1989.

Other large samples of insectary-reared adults included: 17 males and 13 females from *Aster occidentalis* (Nuttall) Torrey and Gray, from Round Valley Reservoir, Plumas Nat. Forest, Plumas Co., 10.ix.1986; 58 males and 53 females from *Chrysothamnus teretifolius,* Mountain Springs, Imperial Co., 6.xi.1986; and 193 males and 138 females from *Haplopappus cooperi,* Walker Pass, Kern Co., 16.v.1989. Slightly male-biased sex ratios also were reported for *Trupanea conjuncta* (Adams) (Goeden 1987b) and *Procecidochares* sp. (Silverman and Goeden 1980).

Resting adults in isolated cagings exhibited no unique behavior. They held their wings over their dorsa, parallel to the substrate, and slightly parted ($\leq 30°$). Their mouthparts pumped rhythmically, as they otherwise remained motionless in this resting posture for a few to many minutes, or even hours (Fig. 8H).

Interspersed among these varying periods of inactivity were spontaneous wing displays, sideways rocking movements, grooming, and droplet formation. Spontaneous wing displays involved episodes of rapid wing hamation at rates of two to three passes over the abdomen per s, in bursts of four to seven passes. Hamation consisted of holding the wings over the dorsum parallel to the substrate and moving them together from one side to the other through about 45°, as described for *T. californica* (Headrick and Goeden 1991). Sideways rocking, also noted with *T. californica,* and grooming behaviors were similar to that described for *Neotephritis finalis* by Goeden et al. (1987). Droplet formation was an activity of resting, replete adults of both sexes of *Neaspilota viridescens,* as noted with other nonfrugivorous species (Headrick and Goeden 1990b, 1991). Clear droplets suspended from the labellum were formed over periods of about 2 or 3 min. They grew in size to two-thirds that of the adult's head, only to be rapidly ingested in about 10 s, and another droplet started to form in about 20 s (n = 6). This behavior occurred with adults resting on both horizontal and vertical surfaces, so that the process appeared independent of gravity.

Freidberg and Mathis (1986) speculated that the modified male foretarsi (Fig. 7) of several species of *Neaspilota* were used to clasp the females during courtship or copulation. We describe here, for the first time for this genus, how *N. viridescens* males use their foretarsi during premating behavior based on nine pairings of virgin males and females lasting 1 to 3 days each.

After 30 h of acclimation, during the midafternoon of the second day of a pairing of a 15-day-old male and a 19-day-old female, premating behavior was observed for the first time. This activity initially involved, as noted by Headrick and Goeden (1991) for *T. californica,* an exaggeration of resting behaviors, i.e. frequent wing hamation and sideways rocking by both sexes as they faced each other at 3 to 5 mm distance within the confines of the arena. The male then proceeded to climb up and over the female, to turn and assume the typical mating posture briefly, and then to dismount without copulating. This procedure was repeated during the next 10 h, with the male atop the female for 2 to 20 min before again dismounting after no copulation occurred. The female signaled her receptivity by bending her oviscape upward, rapidly hamating her wings, and even by approaching the male to reinitiate contact.

Gift presentation also was first noted with this pair of flies. The male deposited a clear oral droplet on the substrate which dried or jelled to form a low mound that was transparent and shiny along its margin, where it was thinnest, but translucent white and smoothly pustulate centrally. With other pairs of flies, this deposition sometimes was augmented between repeated dismountings and mountings to appear as a linear deposit (Fig. 8I). The male stood in front of or astride of this gift awaiting the female. Anal droplet formation by *N. viridescens* males also was observed during courtship; the droplets were dabbed onto the substrate and may have represented the contribution of an anal secretion to female attraction.

The receptive female attempted to feed on the gift by approaching the male with outstretched proboscis, lowered head, upraised oviscape, and rapid hamation of her wings. The male in turn also exhibited rapid wing hamation, but more indicative of his excitation, also displayed inflated abdominal pleura, like that reported for other nonfrugivorous Tephritidae, e.g. *Trupanea bisetosa* (Coquillett) (Cavender and Goeden 1982), *Paracantha gentilis* (Headrick and Goeden 1990b), *Aciurina mexicana* (Aczél) (Jenkins 1990), *Tomoplagia cressoni* (Goeden and Headrick 1991a), and *Trupanea californica* (Headrick and Goeden 1991). It was while she stood still and fed on the offering that the male mounted her rapidly from the front, or occasionally, from the side.

Mating first was observed with a pair composed of a 34-day-old male and a 29-day-old female, and subsequently with three pairs of similar ages. Premating behavior was as described above; however, the asymmetrical foretarsi of the male (Fig. 7) were used to grasp the wings of the female on the costal margin at the base of the costal vein, securing a hold that was difficult for the female to break. The hind legs were used to twist and hold the wings of the female down along her sides. The claws of the hind legs were hooked onto the costal vein distally and the legs pressed together such that the costal margins were brought together below her abdomen. The male then used his middle legs to further stimulate the female for copulation. The claws of his middle legs grasped the costal vein near the middle of her wings and his legs were synchronously and rapidly rubbed along her wings from anterior to posterior three to five times. The ovipositor apex was held upward against the epandrium by the lateral appression of his hind legs against her wings. The wing rubbing activity was maintained until the female exerted her ovipositor into the epandrium and coitus could be initiated. If after several minutes the female was unreceptive, the male would dismount and add to the nuptial gift. After allowing the female to feed, he would mount her again, twisting and rubbing the wings as before.

Once coitus began, the male loosened his grip on the wing bases of the female and assumed the posture common to many other mating Tephritidae, i.e. foretarsi grasping the female at the juncture of her thorax and abdomen, midtarsi grasping the base of the oviscape, and hindtarsi on the substrate. The wings of both sexes are flattened, parallel to the substrate, and parted at about 20° in the male and 45° in the female (cf. Headrick and Goeden 1990b). Three matings by separate pairs occurred near dusk (n = 3) roughly between 6:30 to 7:30 PDT, and each was of longer duration, i.e. >4 h, >9 h, >3 h, than viewing opportunities permitted.

Three of 13 (23%) females began oviposition at ages 8 to 10 days when individually caged with one male each and an excised branch of *Aster spinosus*. Each cage bore a fully open flower head, a preblossom immature head about 4 mm diam. on which the florets were as long as the phyllaries (apparently the preferred stage), and a smaller, immature, closed head ("bud"). The ovaries in these three females respectively contained 10 and 13, 13 and 15, and 15 and 23 full-size ova after each had laid a single, apparently unfertilized egg. Subsequently, fully open and postblossom, mature flower heads as well as those <4 mm in diam. received few or no eggs from the remaining 10 females. Females laid less than one egg per day on average. The oldest female to oviposit was at least 43 days old.

Adults of *N. viridescens* were long-lived in laboratory cagings. Eighteen females lived an average of 87 ± 10 (range, 42–163) days; 22 males averaged 86 ± 9 (range, 30–171) days.

Seasonal history.—*Neaspilota viridescens* is multivoltine, like some other oligophagous, nongallicolous Tephritidae in southern California, e.g. *Neotephritis finalis* (Goeden et al. 1987), *Trupanea bisetosa* (Cavender and Goeden 1982), and *T. californica* (Headrick and Goeden 1991). It reproduces in a succession of spring-, summer-, and fall-blooming Asteraceae, and primarily in the high- and low-elevation deserts and interior valleys. Unlike many other species of flower head-infesting Tephritidae in southern California, it overwinters as diapausing larvae (prepuparia), as noted above. The emergence of a few adults from samples of mature flower heads collected in late fall suggests that some individuals may overwinter as adults. These latter adults may even reproduce on yet undetected, winter-blooming, desert hosts, though 11 years of field surveys by RDG render this fairly unlikely (Goeden 1989). Some other species of *Neaspilota* currently under study also overwinter in dead flower heads as prepuparial larvae in southern California; other species apparently overwinter as long-lived adults (Goeden and Teerink, unpublished data). The same apparently holds true for southern California species of *Urophora* currently under study (Goeden 1987a, Goeden and Teerink, unpublished data).

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THE FIRST SHORE FLY OF THE GENUS *GLENANTHE* HALIDAY FROM THE AUSTRALASIAN REGION (DIPTERA: EPHYDRIDAE)

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Abstract.—The first species of *Glenanthe* from the Australasian Region is described (***G. ismayi*** type locality: Papua New Guinea. Central Province: Lea Lea). The genus is diagnosed, including characterization of the male terminalia.

Key Words: *Glenanthe,* Australasian Region

The shore-fly genus *Glenanthe* Haliday presently includes only seven species on a world basis, and nearly all of these are from temperate climates of the Northern Hemisphere (Wirth 1965, 1968, Cogan 1984). Many more are known, however, especially in the Western Hemisphere, and a revision of these species is now being prepared for publication (Mathis, in preparation). No described species has been reported from the Oriental or Australasian regions, although previously I noted that specimens of a species of *Glenanthe* from Australia and Papua New Guinea were known (Mathis 1989). The purpose of this paper is to formally describe this species for inclusion of its name in a forthcoming world catalog of the shore flies (Mathis and Zatwarnicki, in preparation) and to present a revised generic diagnosis, including characters of the male terminalia.

Among the described species of *Glenanthe,* only *G. litorea* Cresson is reported to occur in the New World tropics (Bahamas, El Salvador, and Panama) as well as North America (Wirth 1965, 1968). Description of the new species from Papua New Guinea and Australia thus establishes that the genus includes species that occur exclusively in the tropics. Other tropical species will be described in the forthcoming revision of New-World species.

The methods and terminology used in this paper follows Mathis (1986). Two venational ratios are used commonly in the descriptions and are defined here for the convenience of the user (ratios are averages of three specimens).

1. Costal vein ratio: the straight line distance between the apices of R_{2+3} and R_{4+5}/distance between the apices of R_1 and R_{2+3}.
2. M vein ratio: the straight line distance along M between crossveins (r-m and dm-cu)/distance apicad of crossvein dm-cu.

Specimens of the new species will be deposited in the Australian Museum, Sydney (AM); Australian National Insect Collection, Canberra (ANIC); and National Museum of Natural History, Smithsonian Institution, Washington, D.C. (USNM).

Genus *Glenanthe* Haliday

Glenanthe Haliday, 1839: 404 (as a subgenus of *Hydrellia* Robineau-Desvoidy). Type species: *Glenanthe ripicola* Haliday, by monotypy.

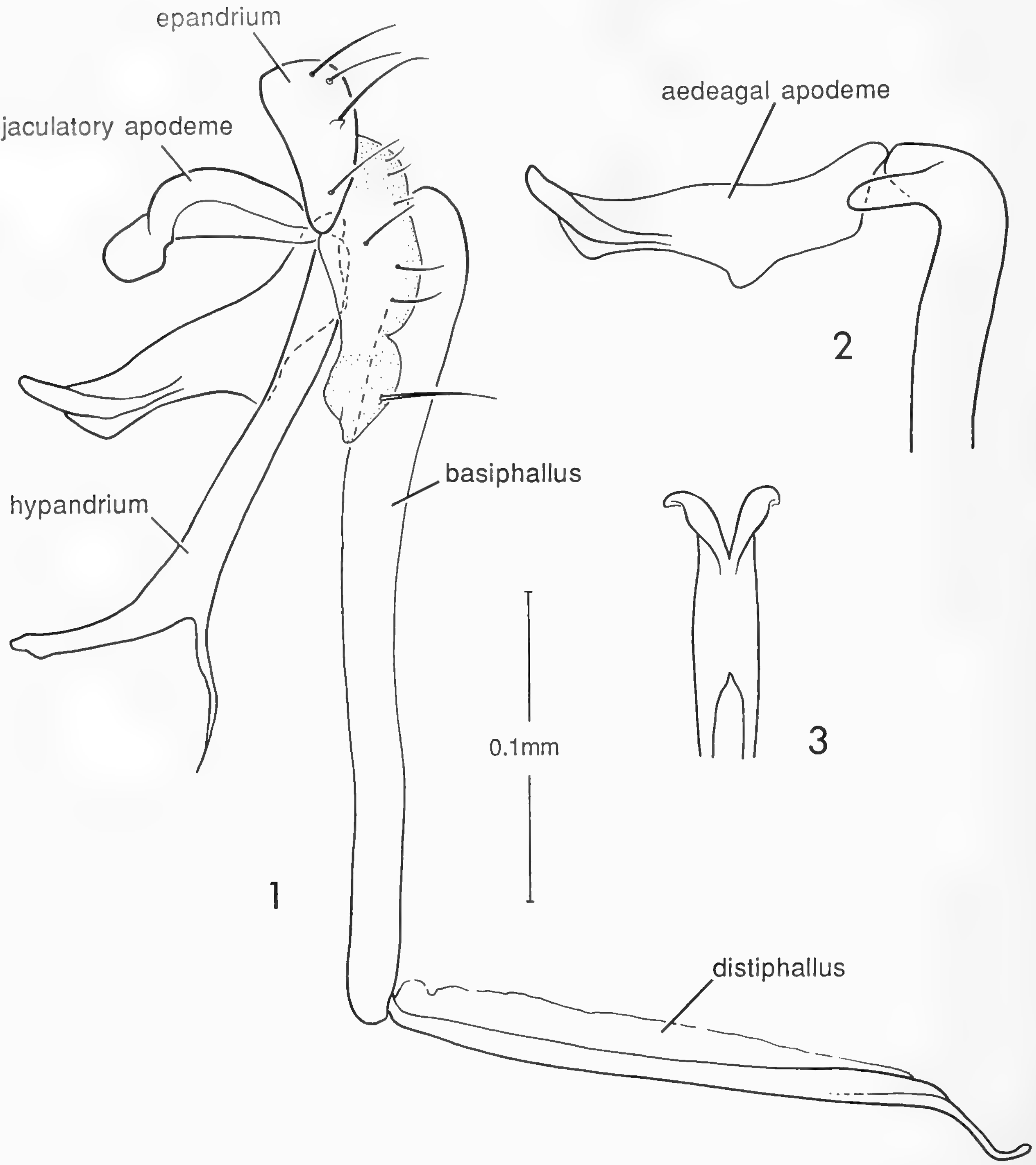
Description.—Minute to moderately small shore flies, length 0.80 to 2.00 mm.

Head: Wider than high; frons densely microtomentose, with mesofrons undifferentiated; ocellar seta lacking, only setulae present; intrafrontal setae and setulae inserted front of anterior ocellus; pseudopostocellar setae usually about ⅓ length of ocellar setae; 1 reclinate fronto-orbital and 2 proclinate setae present; both inner and outer vertical setae present; ocelli arranged to form equilateral triangle. Antennae generally within shallow facial grooves; arista slightly longer than first 3 antennal segments, bearing numerous short hairs above and below, appearing brush-like; pedicel bearing short proclinate dorsal seta. Eye pyriform (the principal distinguishing character for the genus), densely setulose. Face with dorsal half between antennal grooves carinate, but not with tuberculate prominence below level of antennal grooves, with anterior margin in profile more or less vertical and flat; oral margin from anterior view only slightly wider than narrowest distance between eyes, ventral margin shallowly emarginate; facial setae in 2 vertical series, with median row larger and mesoclinate, and with lateral row lateroclinate and inserted next to parafacial; gena short, at most ¼ eye height; labella narrow, shorter than mediproboscis; palpus pale, mostly yellowish.

Thorax: Chaetotaxy moderately well developed, arranged in setal tracks as follows: acrostichal setulae in 2 to several rows, variable depending on species; prescutellar acrostichal setae usually well developed, inserted wide apart, distance more than between either seta and posterior dorsocentral seta, length subequal to that of posterior dorsocentral seta; dorsocentral track terminated posteriorly with larger seta, otherwise lacking large setae; intra-alar setulae irregularly seriated; 1 postpronotal seta; presutural seta reduced or lacking; 1 postalar seta; 2 scutellar setae and with sparse, scattered setulae on scutellar disc; 2 notopleural setae, insertion of posterior one elevated above anterior one; 2 anepisternal setae along posterior margin and with several setulae along dorsal and posterior margins; katepisternal seta well developed, conspicuous; katepisternum also bearing 3 to 6 smaller setae, sometimes with setae in a vertical row anteriad of larger seta. Wing: membrane very lightly milky white to light tan; veins behind costa dark, yellowish brown to brown; vein R_{2+3} extended well beyond level of crossvein dm-cu, 3rd costal section at least 3 times longer than 2nd section; alular marginal setulae short, length less than ½ alular height. Legs: usually lacking distinctive setae or ornamentation.

Abdomen: Fifth tergum of male visible dorsally, as long as combined length of 3rd and 4th terga; 5th sternum U-shaped, with arms elongate, forming pocket into which the long aedeagus and surstyli lie. Male terminalia as follows: epandrium short in lateral view, not extended beyond posterior margin of cerci, notched posterodorsally; surstylus usually distinct from epandrium, much longer than wide, sparsely setulose, with setae long in some species and weakly developed in others; aedeagus long and very narrow; basiphallus tubular; distiphallus a flap or more complicated process that folds back on the basiphallus; gonites apparently vestigial or lacking; aedeagal apodeme more or less triangular in lateral view; hypandrium well developed, a pocket into which the rest of the genitalia are folded, variously shaped.

Discussion.—*Glenanthe* is a genus of the tribe Lipochaetini Townsend and thus far is the only known representative of this tribe from the Australasian Region. Indeed, aside from *Homalometopus* Becker (Mathis 1984), *Glenanthe* is the only other genus-group taxon of Lipochaetini known from the Old World. *Glenanthe* is distinguished from all other members of the tribe and its monophyly is established by the unusual shape of the eye, which is pyriform or like an upside down pear and is unique among shore flies. The eye is also moderately to densely setulose. Another unusual character is the brush-like arista, with numerous short hairs above



Figs. 1–3. *Glenanthe ismayi.* 1, Male terminalia, lateral view. 2, Aedeagal apodeme and base of basiphallus, lateral view. 3, Base of basiphallus, posterior view.

and below. The latter is common to taxa of Lipochaetini, and this character and the vestigial or absent gonites establish the monophyly of the tribe.

***Glenanthe ismayi* Mathis,**
New Species

Figs. 1–3

Description.—Minute to small shore flies, length 0.80 to 1.10 mm; generally grayish brown, lightly to moderately invested with microtomentum, appearing dull.

Head: Frons grayish brown to grayish tan; mesofrons with 3–4 pairs of weakly developed setulae (including ocellar setulae); pseudopostocellar setae lacking; 1 large reclinate fronto-orbital seta and 2 proclinate setae, the latter about ½ length of reclinate seta and inserted anterolaterad of this seta. Antenna mostly yellowish orange; 1st flagellomere with some brown coloration dorsobasally near insertion of arista. Face whitish gray; antennal grooves moderately well developed; 2 series of facial setulae, with inner series numbering 3, upper 2 inclinate, posterior seta ventroinclinate; outer series numbering 3–4, oriented outward and slightly upward; no genal seta. Palpus yellowish brown to brown.

Thorax: Mesonotum faintly golden tan to brown; acrostichal setulae in 2 rows; prescutellar pair of acrostichal setae not well developed; only posteriormost, dorsocentral seta well developed. Pleural areas brownish gray to gray; anepisternal setae limited to 2–3 along posterior margin; 1 large, slightly upcurved, katepisternal seta. Legs yellow, generally lacking distinguishing setae; femora with apical ½ with faint brown apically; tarsi yellowish brown to brown. Wing lightly and uniformly infuscate, vein brown; costal vein ratio averaging 0.25; M vein ratio averaging 0.45.

Abdomen: Tergum blackish brown, with light gray investment of microtomentum. Male terminalia (Figs. 1–3) as follows: generally weakly sclerotized; epandrium in lateral view narrow, gradually tapered ventrally; surstylus much reduced, short, not too much longer than height of epandrium, mostly membranous, with sclerotized portion limited to ventral apex, almost as an extension of the cerci; cerci likewise weakly sclerotized, with only posterior margin sclerotized, otherwise membranous; aedeagus (Fig. 1) with basiphallus long, narrow, parallel sided, base of basiphallus bifurcate (Fig. 3); distiphallus also long (Fig. 1), over ⅔ length of basiphallus, with posterior surface (unfolded) membranous, anterior portion sclerotized, apex recurved; aedeagal apodeme roughly narrowly triangular in lateral view (Figs. 1, 2); hypandrium narrowly Y shaped in posterior view, with thin, anteroventral extension that attaches to 5th sternum, which is deeply and narrowly U shaped.

Type material.—The holotype male is labeled "PAPUA NEW GUINEA Central Prov. LeaLea 6 Oct 1985, J.W.Ismay (saltpan margin)." The allotype female and 22 paratypes (6 ♂, 16 ♀; USNM) bear the same label data as the holotype. The holotype is double mounted (minuten in a block of plastic), is in excellent condition, and is deposited in the USNM. Other paratypes are as follows: AUSTRALIA. Queensland: Cairns, 19–25 Apr 1957, W. W. Wirth (5 ♂, 10 ♀; AM, ANIC, USNM).

Distribution.—Australasian: Australia (QLD), Papua New Guinea.

Etymology.—The specific epithet, *ismayi,* is a genitive patronym to recognize the efforts of Dr. John W. Ismay, who collected hundreds of specimens of shore flies while he was stationed in Papua New Guinea.

Remarks.—This species is easily distinguished from congeners by the yellowish orange antennae; lack of well-developed pseudopostocellar setae; whitish gray face; acrostichal setulae arranged in only two rows; prescutellar pair of acrostichal setulae indistinct or lacking; and shape of the male terminalia, especially the lack of well-developed surstyli, very long distiphallus, and shape of the hypandrium (see description and figures).

Elsewhere in the Old World, *Glenanthe* is represented by three species, all from the Palearctic Region, as listed in Cogan (1984) with the addition of the following species that was omitted from the catalog:

bimaculata Hendel. Palearctic: Mongolia.
G. bimaculata Hendel, 1934: 16
[Mongolia. Hutjertu-gol.]

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LIFE HISTORY AND LARVAL DESCRIPTION OF *EXEMA ELLIPTICA* KARREN (COLEOPTERA: CHRYSOMELIDAE) ON *BACCHARIS HALIMIFOLIA* L. (ASTERACEAE) IN TEXAS[1]

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Abstract.—Adults and larvae of the chrysomelid *Exema elliptica* Karren feed on leaves of *Baccharis halimifolia* L. along the southern and eastern coasts of the southern United States. In Texas, there were three generations per year. Adults fed for two to three weeks before mating and ovipositing. Females mated often, laid an average of 178 eggs, and lived 139 days. Eggs were covered by the female with a case composed of partially digested leaf particles. The egg case became the protective case of the larva. In the laboratory, eclosion occurred in about 11 days if moisture was available. Larvae without a case did not survive. There were four larval instars. A taxonomic description and diagnostic characters are given of the fourth-instar larva and pupa.

Key Words: Chrysomelidae, Chalamisinae, *Exema,* biology, taxonomy, *Baccharis,* Asteraceae

The woody shrub sea myrtle or consumption weed, *Baccharis halimifolia* L. (Asteraceae), is a native perennial shrub that grows in pastures, brackish swamps, and coastal areas from Texas to Florida and north to Massachusetts (Tarver et al. 1979, Boldt 1989). It is considered a weed because it is unpalatable as forage and its leaves contain a cardiotoxic glucoside that may be toxic to livestock and wildlife (Manley et al. 1982). In Florida, *B. halimifolia* blooms in September and October and produces pollen that causes hayfever (Wodehouse 1971). Shrubs of *B. halimifolia* are unisexual, 1–4 m in height, and grow in thick stands.

The genus *Exema* Lacordaire of America, north of Mexico, has nine species, most of which feed on plants in the Asteraceae (Karren 1966). Larvae of *Exema* are casebearers. Adult appendages fit into body grooves and their distinctive form and dark color give them the appearance of caterpillar frass or other debris (Brown 1943). Four species of *Exema* occur on *B. halimifolia*: *E. deserti* Pierce, *E. gibber* (Fabricius), *E. neglecta* Blatchley, and *E. elliptica* Karren (Karren 1966, Palmer and Bennett 1988). *Exema elliptica* probably feeds only on *Baccharis.* In Texas, Palmer (1987) observed heavy infestations of larvae and adults on leaves and stems of small shrubs of *B. halimifolia.* He did not find *E. elliptica* on a reported host, *Iva frutescens* (Asteraceae) (Karren 1966), and considers this to be a misidentification because it is similar in appearance to *B. halimifolia.*

Materials and Methods

Field studies.—This study was part of a general survey of the phytophagous insect

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[1] Contribution from the U.S. Department of Agriculture, Agricultural Research Service.

fauna of *B. halimifolia.* Observations were made at three sites, one to two ha. each, in abandoned pastures near Waller, Waller Co.; Port Lavaca, Calhoun Co.; and along a roadside ditch at Indianola, Calhoun Co., Texas. Each site contained 50 to 150 plants of *B. halimifolia.* The number of larvae, pupae, and adults was assessed monthly by sweeping 10 plants at each site, selected without bias, from August 1986 to December 1988.

Laboratory studies.—Laboratory experiments were conducted in September 1986 or from June to August 1989 and 1990. Experiments were conducted at room temperature of 25 ± 1°C, relative humidity of 40 to 60% and 14:10 h L:D photoperiod under artificial light. Leaf consumption, egg and larval head capsule measurements were made with a calibrated ocular grid or micrometer in a stereomicroscope.

Egg size was determined by measuring live eggs, 0 to 48 h old, with and without cases. The effect of moisture on egg eclosion was determined by holding groups of 0- to 24-hour-old eggs, selected without bias, on filter paper in separate petri dishes. Each group was moistened with distilled water beginning 0, 2, 4, 6, 8, 10, 16, or 30 days after oviposition. Once moisture was introduced, it was supplied every two days. There were 3 to 5 replications of 5 to 15 eggs each. Treatment means were analyzed with the Kruskal-Wallis one-way analysis of variance by ranks test (MSTAT 1985).

The number of larval instars was determined by collecting larvae, 0 to 24 hours old, as they emerged from eggs and rearing them through successive instars. About 15 larvae in each instar were preserved in 70% ethanol and their head capsule widths were measured. Larval leaf consumption and longevity were determined by placing each of 10 larvae, 0 to 24 hours old, in separate 25 ml plastic vials with freshly excised leaves of *B. halimifolia.* Leaves were replaced three times weekly and the amount of feeding was measured with a 1 mm^2 plastic grid. Two drops of water were added to a 3 cm^2 piece of absorbent paper placed in the bottom of each vial to maintain humidity.

Pupae and adults were collected for oviposition studies. Pairs of one-week-old copulating adults were placed in separate petri dishes with leaves of *B. halimifolia* and held until death. Leaf consumption, number of eggs laid, number of copulations per female, and male and female longevity were recorded.

Morphology.—The larvae and pupae of *E. elliptica* on which the descriptions are based were collected at Indianola, Calhoun County, Texas, on August 23, 1990, from *B. halimifolia.* Larvae of *E. deserti* were collected at Frijole Ranch, Guadalupe Mountains National Park, Culberson County, Texas, on September 20, 1990, from *Baccharis pteronioides* DC. Terminology follows that of LeSage (1982). Insect voucher specimens of larvae, pupae, and adults have been deposited in the National Museum of Natural History, Washington, D.C.

RESULTS

Field studies.—Three generations of *E. elliptica* per year fed on *B. halimifolia* in 1987 and 1988 at Indianola and Waller, Texas (Fig. 1). The first generation of adults was observed in January and February and coincided with the advent of new leaves. The second generation of adults emerged in July and August and overlapped the third generation that appeared in September or October and November. Our sampling initially detected only the summer and fall generations of adults at Waller. However, we collected many young larvae in April 1988 that confirmed the presence of a spring generation. At Indianola, adult population decreased from a high of 14.8 adults per plant in 1987 to 2.3 adults in 1988. This decrease was probably due to a severe drought that lasted from September 1987 through the end of the sampling period in 1989 (NCDC 1988). Many shrubs of *B. halimifolia* were

Table 1. Effect of moisture on development of eggs of *Exema elliptica*.

No. of Days Without Moisture[1]	No. of Eggs	Percent Eclosion[2]	Number of Days to Hatch[2]	Standard Deviation
0	34	73.5^{a}	10.8^{a}	±0.9
2	36	73.5^{a}	9.8^{a}	±1.1
4	35	74.3^{a}	11.2^{a}	±0.9
6	37	78.4^{a}	11.3^{a}	±0.8
8	46	60.9^{a}	11.0^{a}	±1.0
10	49	76.6^{a}	11.2^{a}	±0.7
12	44	81.8^{a}	13.4^{b}	±0.9
14	49	10.8^{b}	15.0^{b}	±0.8
16	26	0	—	—

[1] From day of oviposition.

[2] Means in a column followed by the same letter are not significantly different ($P = 0.05$) based on the Kruskal-Wallis test.

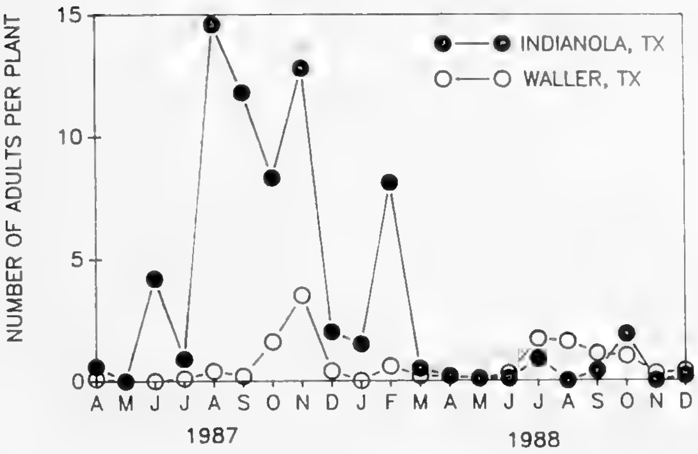


Fig. 1. Seasonal distribution of adults of *Exema elliptica* on *Baccharis halimifolia* in Texas.

severely defoliated, damaged, or killed due to a reduction of 55% in rainfall.

Larvae and adults fed on both sides of the leaf, leaf petioles, and occasionally on green stems. Adults were present on all parts of the plant through the year except mid-summer when they sometimes clustered on new leaf growth near the ground. When disturbed, adults hid on the underside of the leaf near the axil or dropped to the ground. This response of falling when disturbed probably caused us to underestimate the actual population of *E. elliptica*.

Eggs were laid on both sides of the leaf in bell-shaped cases, each attached to the leaf surface with a short, twisted stalk. Larvae were continuously present in the field from April to November, usually feeding on the upper surface of the leaf. Pupation occurred on small stems or occasionally on the leaf.

Laboratory studies.—Eggs of *E. elliptica* were oblong, smooth, and light yellow in color. Most of them were covered with a 0.2 to 0.3 mm thick case apparently composed of partially digested leaf particles held together with a sticky secretion. Females who were interrupted while covering an egg, usually by another adult, abandoned uncovered or partially covered eggs. Encased eggs measured 1.0 ± 0.1 mm length × 0.6 ± 0.1 mm dia. ($n = 25$, $\bar{x} \pm$ SD) while the uncovered eggs measured 0.7 ± 0.03 mm length × 0.4 ± 0.02 mm dia. ($n = 15$).

Eggs of *E. elliptica* did not diapause, but water absorption was required for egg eclosion. Eggs moistened before they were 10 days old hatched in 9.8 to 11.2 days after wetting ($n = 200$ eggs, Table 1). Eggs moistened when they were 12 to 14 days old hatched 1.0 to 1.4 days later. Mortality was greatest in the 14-day-old eggs ($n = 93$ eggs). Eggs that did not receive water within 14 days did not hatch. At the end of the experiment, unhatched eggs were found to contain normal-appearing larvae. This indicated that water was not required for embryo development. In the field, eggs may hatch after a rain to assure the larvae of new leaf growth (Tauber et al. 1986).

At eclosion, neonate larvae chewed away the top of the egg case and broke the stalk that attached it to the plant. They remained in the case but carried it over them with only head and legs exposed. Thus, the original egg case became a protective case. In our ovipositional study, one percent (13 of 1221 eggs) of the eggs laid were not covered or only partially covered. In our rearing colony, where the density of adults was higher, the number of uncovered eggs was much greater, probably because the female was disturbed more often by other adults. Neonate larvae initially wandered about their

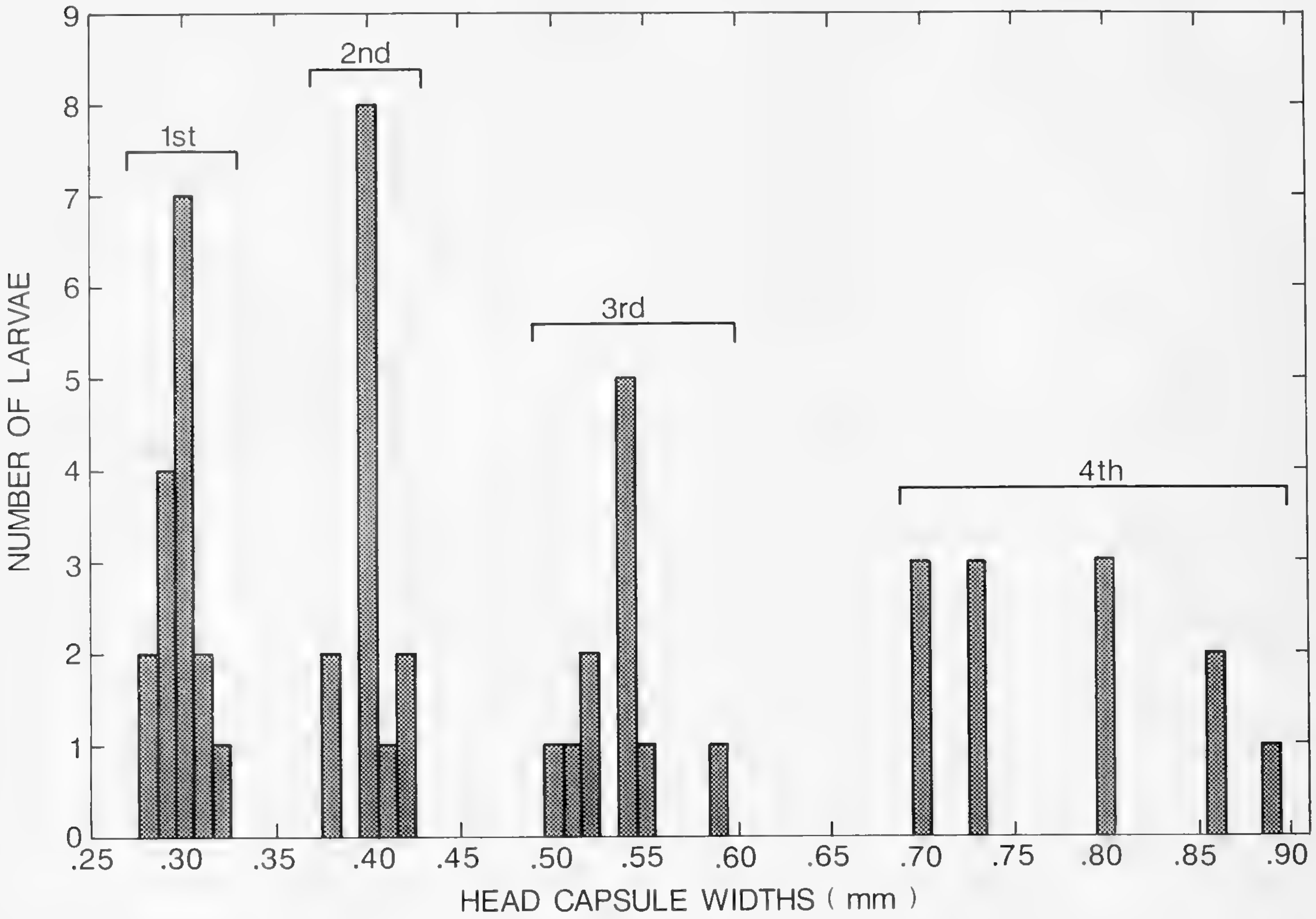


Fig. 2. Frequency distribution of head capsule widths (mm) of larvae of *Exema elliptica*.

container for up to two days without feeding. Only when they found free water did they stop, appear to drink, and then began to feed. Larvae from eggs without a case or that left their case always died.

There were four larval instars (Fig. 2). Head capsule widths were 0.29 ± 0.01, 0.39 ± 0.01, 0.52 ± 0.01, and 0.78 ± 0.09 mm for the first, second, third, and fourth instar, respectively. During each molt the case was attached firmly to the leaf by several white threads for two to three days. Second and third instar larvae placed their cast exuviae at the top of the case but fourth instar larvae left the exuviae on the floor of the case. As larvae grew, they enlarged their case by adding chewed leaf particles to the edge. The cases of third and fourth instar larvae have a nipple at the top that is the remainder of the original egg case. Brown (1943) regards this nipple to be an identifying characteristic of the genus.

The larval parasites *Anastatus* sp. (Hymenoptera: Eupelmidae) and *Aprostocetus* sp. (Hymenoptera: Eulophidae) were infrequently reared from field collected larvae.

After emergence, adults fed for about 2 weeks before mating. Feeding occurred on the leaf petiole or on either side of the leaf. Usually only the surface of the leaf was eaten but holes occasionally were eaten in small or thin leaves. During courtship, copulating males faced the posterior of the female and sat in an upright perpendicular position on the flattened fifth abdominal pygidium. The pygidium did not necessarily touch the substrate and the female, when disturbed, would move with the male still attached. All females mated frequently throughout their life. Copulation in this study occurred an average of 16 times per female.

Females laid 178.9 ± 99.2 (n = 9) eggs. The greatest number of eggs laid by one female was 329. During oviposition the female attached one end of the egg to the substrate with a stretchable (ca. 1 mm long) stalk and, holding the egg under her abdomen, twisted the stalk by slowly rotating the egg with her rear legs. At the same time, a viscous, particulate fluid was secreted from the tip of the extended abdomen. The particles were probably bits of digested plant material. An inverted, bell-shaped case gradually formed around the egg from its base to its top. Finally, the exposed tip of the case was packed with particulate material by the tip of the abdomen to form a concave cap. The case soon hardened and turned brown. Females lived 139.4 ± 21.9 days (n = 9) and males lived 122.0 ± 39.4 days (n = 9).

MORPHOLOGY
Figs. 3–8

Fourth instar larva.—Body strongly bent ventrally with apex of abdomen directed downward or forward; body widest at 5–7th abdominal segments; legs elongated, directed forward. Head pale brown to dark brown. Body white. Legs: coxae pale brown to brown; femur and tibiae pale brown to nearly white. Length—3.8 to 4.5 mm.

Head: Hypognathous, ovoid, evenly rounded, from anterior view length slightly greater than width; distinctly pigmented, varying in color from pale brown to dark brown, lightest at sides. Epicranial suture distinct, Y-shaped, upper arm impressed and darkly pigmented at about basal half, remainder of suture shallow and marked by a light furrow, each lateral arm angled downward at about its midlength.

Ocelli well-developed, each side of head with 6 ocelli, four located above antenna, two below antenna.

Epicranium (Fig. 7) with 5 pairs of dorsal epicranial setae (des) each side, des 1 on disk below sensillum (deml), des 2 lateral to des 1, des 3 above and des 4 below paired sensillae desm 2 and desm 3, des 5 above superior ocelli.

Frons with 4 pairs of frontal setae forming three transverse rows, fsl above front sensillum (fsm), fs2 below fsm, fs3 and fs4 in lower third of frons, with no fs5. Frons partially fused with clypeus, no suture evident in median area.

Clypeus fused with labrum. Two pairs of clypeal setae (csl–2) located medially in fused area of frons and clypeus.

Labrum transverse, apex sinuated, behind apex with a median, sinuated, chitinized area. Three pairs of labral setae (lbs) present, labral sensilla (lbesm) above lbsl.

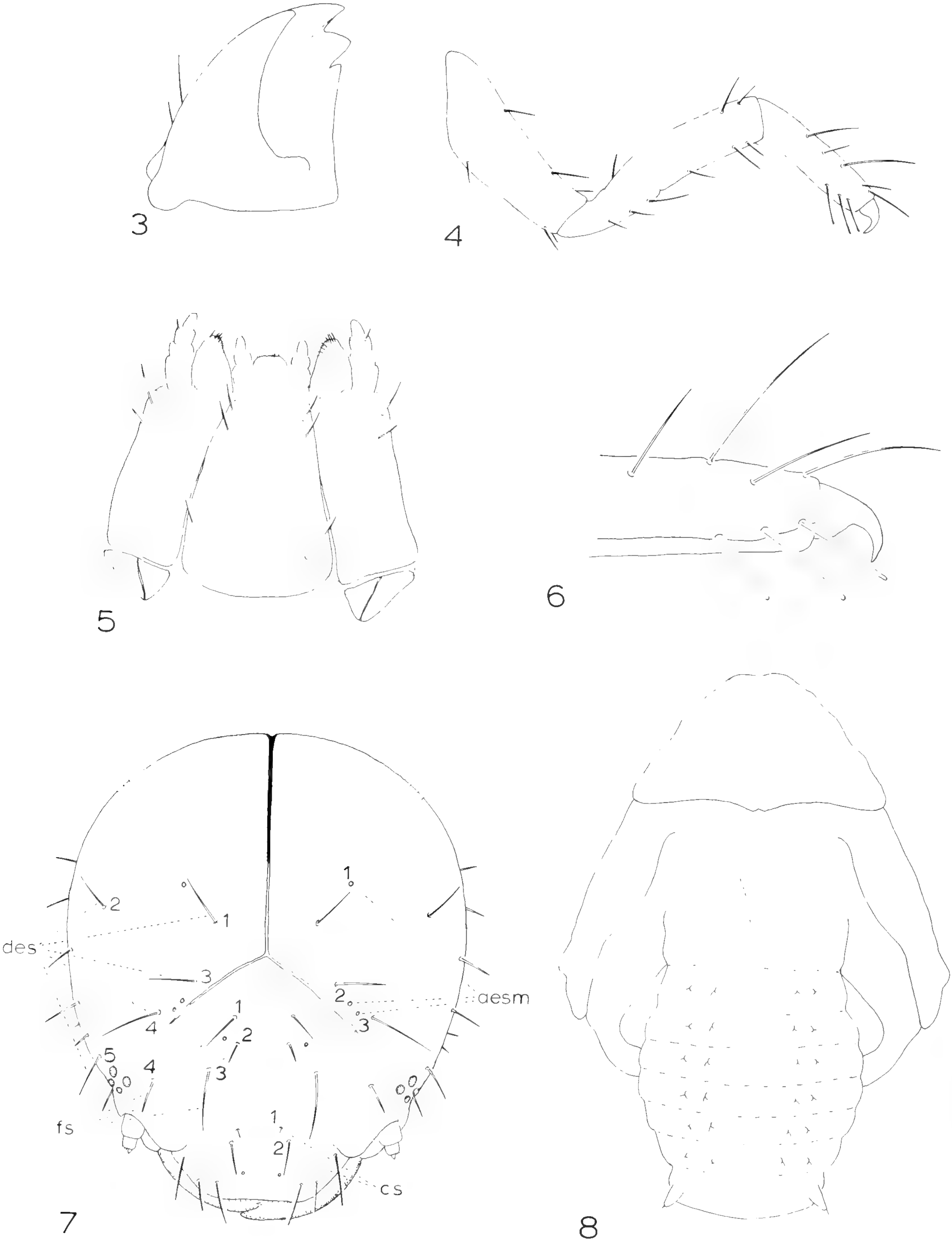
Epipharynx with 5 pairs of spiniform submarginal ephipharyngeal setae, inner and outer pairs largest; epipharyngeal sensillae in three groups, two groups of 6 sensillae each side basally, one median group of 10 sensillae apically; apex of epipharynx ending in a dense bunch of spinules.

Antenna small, two-segmented; first segment a little wider than long and bearing two sensillae; second segment about as long as wide, apically bearing a number of spinules, one longer than others; at apex with a conical papilla.

Mandible (Fig. 3) stout, four-toothed, without mola and retinaculum; mesal surface evenly concave, inner dorsal edge nearly straight; one large mandibular seta located on outer edge, toward base with a smaller seta.

Labium (Fig. 5) prementum and postmentum not fused. Postmentum bearing 3 pairs of setae, of which one pair is large, located basally, the other two located apically, with the small pair anterior to the larger pair, and a sensilla located between them. Prementum with a large seta near base of each palp, with tiny setae apically between palps; labial palp two-segmented, each segment with a sensillum, last segment with a number of spine-like processes.

Maxillary cardo of 2 fused sclerites. Stipes large, elongated, bearing 2 large, outer setae and one small, inner seta. Mala bearing eight or ten stout setae of varying sizes. Maxillary palpus four-segmented, segment 1 with 2 large basal setae and 1 sensillum; segment



Figs. 3–8. *Exema elliptica*, larva and pupa. 3, mandible. 4, prothoracic leg. 5, labium. 6, tibiotarsus. 7, head capsule. 8, pupa.

2 without setae but with 2 sensillae, segment 3 with 1 outer seta, a small inner seta and a sensillum, segment 4 with a sensillum and minute apical spicules.

Thorax: Cuticle largely colliculate, pronotum weakly sclerotized; setae of varying sizes, mostly along anterior margin, a few along posterior margin, nearly absent on disk, with 3 or 4 sensillae along anterior margin each side of midline. Meso- and metanotum not sclerotized, bearing a few, small setae. Prothoracic spiracle large, bean-shaped, with one opening.

Pro-, meso-, and metathoracic legs (Fig. 4) nearly identical in size, shape, and chaetotaxy. Each leg long, slender, primarily white, but basal segment of each light to medium brown and with base and apex narrowly white; with claw-like tarsungulus. Setae as shown in figure. Tibiotarsus (Fig. 6) of each leg with three pairs of ventral setae forming two rows, apices of setae more or less clubbed. Claw arcuate, basal thickening bearing a single seta.

Abdomen: Bent downward or forward, not sclerotized, broadest at 5th–7th segments. Cuticle largely colliculate. Segments with sparse, long and short setae. Spiracles annular, on Segments I–VIII.

Pupa.—White throughout, bare, with no chitinized features and few setae; length 3.6 mm, width 1.7 mm. Head directed downward and concealed from above. Pronotum broad, nearly two times as wide as long, disk protuberant, basal margin at middle as a widely spread W. Wing pads bare and extending to fourth abdominal segment. Pedothecae bare, may be partly visible from above. Mesonotum strongly transverse, bare, somewhat protuberant posteriorly at middle. Metanotum transverse, bare, about 1.5 times as long as mesonotum. Abdomen mostly bare, segments 1–6 with setae (moderate in length) set on small mounds, number of paired setae per segment as follows: segment 1 with 2; segments 2–3–4– with 3; segments 5 and 6 with 2. Abdominal segment seven with a long fleshy mound each side bearing a seta; segment eight bent downwards, non-setate, not visible from above.

Diagnostic characters.—In addition to *E. elliptica,* specimens of *E. deserti* and *E. canadensis* were inspected. For a drawing of the larva of the closely related *E. canadensis,* see LeSage (1982). The following notes result from examination of the specimens.

Larvae of *elliptica, canadensis,* and *deserti* may be distinguished by leg and head characters: *elliptica* has the tibiotarsus of each leg with 3 pairs of ventral setae forming 2 rows and each side of head with epicranial setae 1–2–3– non-equidistant, des1 and des3 are clearly closer to one another than they are to des2; *canadensis* has the tibiotarsus of each leg with 4 pairs of ventral setae forming 2 rows and each side of head with dorsal epicranial setae 1–2–3 about equidistant from one another; *deserti* has the tibiotarsus of each leg with 3 pair of ventral setae forming 2 rows and each side of head with dorsal epicranial setae 1–2–3 about equidistant from one another.

The pupae of *elliptica* and *canadensis* can be distinguished by abdominal setae. The pupa of *elliptica* has abdominal segments 1–6 each with 2 pairs of setae. *E. canadensis* pupa has abdominal segments 1–5 each with 1 pair of setae and segment 6 with 2 pairs.

Pupae of *E. deserti* were not examined. For a presentation of the characters which will distinguish the adults of the species of *Exema,* see Karren (1966).

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Service, Salt Flat, Texas, for permission to collect.

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HOST RELATIONSHIPS, ETHOLOGY AND SYSTEMATICS OF PSEUDOMETHOCA ASHMEAD (HYMENOPTERA: MUTILLIDAE, ANDRENIDAE, HALICTIDAE AND ANTHOPHORIDAE)

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Abstract.—Two new species of *Pseudomethoca* are described and figured, ***perditrix*** from Arizona and New Mexico, and ***bethae*** from Arizona, New Mexico, and the states of Jalisco and Puebla in Mexico; behavioral notes are included for each. Brief taxonomic notes and figures, and/or behavioral notes are given for eight other taxa of *Pseudomethoca.*

Ps. perditrix parasitizes larvae of the communal andrenid bee, *Perdita portalis* Timberlake, in New Mexico. *Ps. toumeyi* (Fox) is a putative parasitoid of *Pe. portalis* in New Mexico. The Floridian *Pe. graenicheri* Timberlake may be a host of *Ps. torrida* Krombein. The eumenid wasp, *Ancistrocerus lutonidus* Bohart, is considered to be an improbable host of *Ps. frigida. Ps. bethae* was found in Arizona in a nest of the communal anthophorid bee, *Exomalopsis solani* Cockerell. *Ps. mulaiki* Mickel from Texas may have species of the anthophorid, *Exomalopsis,* and/or the halictid, *Agapostemon,* as hosts. *Ps. propinqua* (Cresson) may have as hosts the halictid, *Nomia melanderi* Cockerell, and the anthophorid, *Melissodes pallidisignata* Cockerell in Wyoming. *Ps. sanbornii aeetis* (Fox) has the halictid, *Nomia nevadensis bakeri* Cockerell, as a putative host in coastal South Carolina. *Ps. donaeanae* (Cockerell and Fox) has an unknown bee host in Arizona, based on collection of a female bearing numerous pollen grains around the mouthparts.

A table is included of known or putative hosts of *Pseudomethoca* in America north of Mexico and the authorities for each association.

Key Words:—*Pseudomethoca,* parasitoid, communal and solitary bees, Andrenidae, Halictidae, Anthophoridae

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There is very little published information on host relationships within *Pseudomethoca* Ashmead. Krombein (1979) listed bee hosts for only 5 of the 44 species-level taxa in America north of Mexico. Manley and Neff (1989) and Riddick (1991) added putative or positive bee associations respectively for two additional species from this area.

There are many additional species of *Pseudomethoca,* mostly undescribed, in Mexico, Central and northern South America. Mickel (1969) and Brooks and Roubik (1983) reported positive bee hosts respectively for one species in Costa Rica, and two more species in Panama.

During the past several years, B. B. Norden and I, working in southeastern Arizona and peninsular Florida, obtained probable or putative bee hosts respectively for one new species and for a previously described taxon. B. N. Danforth, working in southwestern New Mexico, obtained a positive bee association for another new species, and a putative host association for a previously described taxon. Unpublished putative or probable bee host associations were obtained by A. Hook in southernmost Texas, W. L. Jellison in Wyoming, K. V. Krombein in southeastern Arizona, and D. G. Manley in coastal South Carolina.

Detailed natural history observations and descriptions of the two new taxa, and behavioral and taxonomic notes on previously described *Pseudomethoca* are presented below. A concluding section on host relationships includes a tabulation of 14 species-level taxa, their positive or putative bee hosts, and the authorities for each association.

Depositories for specimens listed are as follows:

AMNH	American Museum of Natural History
DGM	Donald G. Manley, personal collection
DJB	Denis J. Brothers, personal collection
ESB	Eric S. Brewster, personal collection
KU	Snow Entomological Museum, University of Kansas
USNM	National Museum of Natural History, Smithsonian Institution

Pseudomethoca perditrix Krombein, NEW SPECIES

Figs. 1, 3–5, 7, 8

This small species runs to couplet 17 in Mickel's revised key to species (1935). It differs from the two taxa keying out there, *Ps. oculissima* Mickel and *Ps. scaevolella* (Cockerell and Casad), in the edentate inner margin of the mandible (cf. Figs. 1, 2), and the more sparsely punctate and hirsute second tergum (cf. Figs. 6, 7) which lacks the paired spots of recumbent silvery vestiture.

Holotype female.—Length: 4.2 mm. Ferruginous, apex of mandible black, thoracic dorsum anteriorly slightly darker; legs darker brown except tarsi; head above (Fig. 4) with dense, recumbent, silver pubescence and longer, scattered, erect silvery setae; dorsum of thorax with somewhat coarser and sparser appressed pubescence, black anteriorly, silvery posteriorly, and with longer, erect, scattered, silvery setae; legs with sparse, silvery setae, calcaria whitish; abdominal terga 1–2 with scattered, erect, moderately long, silvery setae, 2 also with moderately dense, long recumbent setae, black except a narrow silver band apically; tergum 3 with scattered, erect, moderately long, scattered, silvery setae, and a narrow apical band of recumbent silvery setae; terga 4–5 with scattered, erect, black setae, 4 with a narrower fringe of recumbent silvery setae than 3; tergum 6 with erect black setae anterolaterally.

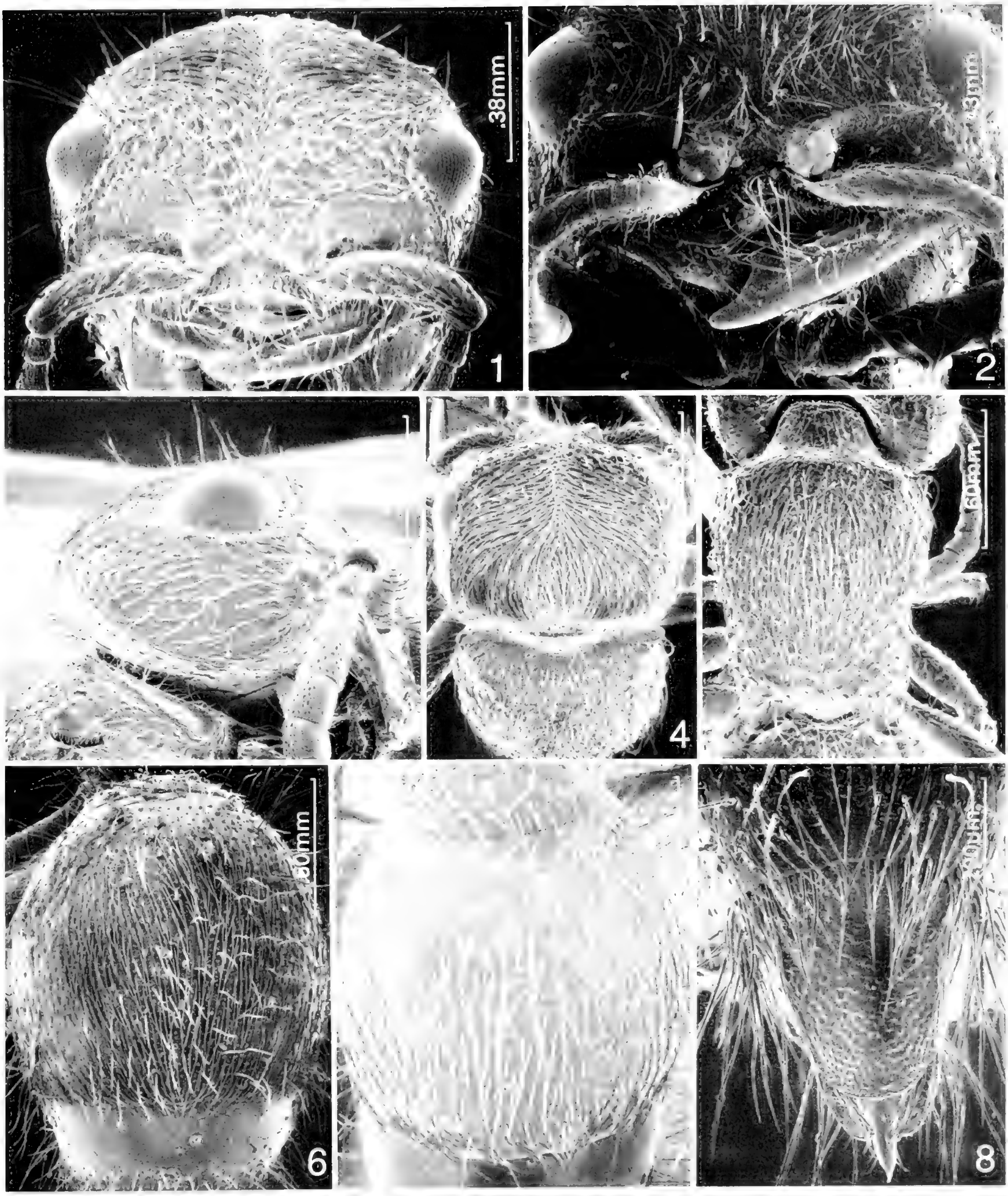
Head (Fig. 4) including eyes 1.2× as wide as thorax; mandible without small, subapical tooth on inner margin (Fig. 1); antennal scrobe with a weak carina; antennal tubercles separated by a distance about the diameter of a tubercle; distance between posterior margin of eye and posterolateral angle of head equal to greatest eye diameter; gena carinate posteriorly (Fig. 3); hypostomal carina not dentate; front and vertex densely punctate, gena moderately so.

Thorax (Fig. 5) dorsally as wide as long, rather densely punctate on anterior three-fourths, coarsely reticulate posteriorly; humeral angle with small, blunt tooth; side of thorax smooth and polished, mesopleuron anteriorly with vertical carina extending from dorsum to mid coxa; posterior surface of propodeum above with a row of weak, large reticulations, smooth elsewhere, lateral margin carinate but not denticulate.

Second tergum with small separated punctures; pygidium (Fig. 8) carinate laterally on basal half, surface smooth, weakly alutaceous.

Male.—Unknown; possibly similar to *Ps. toumeyi* (Fox) in being 3–5 mm long and having predominantly erect, silvery setae.

Holotype.—ARIZONA: ♀, Cochise Co.,



Figs. 1–8. *Pseudomethoca* species. 1, *perditrix*, head, frontal view. 2, *scaevolella*, head, frontal view. 3, *perditrix*, head, lateral view. 4, *perditrix*, head, dorsal view. 5, *perditrix*, thorax, dorsal view. 6, *scaevolella*, abdominal tergum 2. 7, *perditrix*, abdominal tergum 2. 8, *perditrix*, pygidium.

AZ 82, 0.5 mi W of AZ 90, [4415 ft, on a narrow red dirt road a hundred feet from AZ 82], 4 September 1990, K. V. Krombein (USNM).

Paratypes.—NEW MEXICO: ♀, Hidalgo Co., Animas, [4405 ft], 3 Sep 1990, K.V. Krombein, [on bare earth along NM Route 338] (USNM). ♀, Hidalgo Co., 2 mi N of

Rodeo, [4360 ft], 3 Sep 1989, B. N. Danforth, in nest PPO#11 of *Perdita portalis* Timberlake (KU); ♀, same locality as preceding but 21 Aug 1989, possibly from nest of *Pe. portalis,* B. N. Danforth, (ESB). ARIZONA: ♀, Cochise Co., 17.5 mi SW of Apache, [4120 ft], 25 Jul 1969, K. C. Rozen (AMNH); ♀, Cochise Co., Geronimo Trail, 5.5 mi E of Douglas, [4360 ft], 28–29 Aug 1986, K. V. Krombein (USNM).

Variation.—Paratype females are 3.7–4.5 mm long. The ferruginous is lighter in some specimens, the second abdominal tergum may be slightly darker posterolaterally, and occasionally the femora and tibiae may be red.

Etymology.—From the Latin *perditrix,* destroyer.

Behavior.—Danforth (1991) had a below-ground observation nest of *Perdita portalis* Timberlake, a ground-nesting communal bee, 2 km north of Rodeo. He noted that a cell had been provisioned on 29 August 1989, and saw a female *portalis* in the nest on the 30th. He observed a female *perditrix* on the 31st resting in a filled lateral burrow about 9 cm from the junction with the main tunnel, but saw no bees in the nest that day. The mutillid remained in the nest for four days,[1] and was captured when it left the nest. During those four days the mutillid entered four cells with bee larvae and parasitized three of them. Two post defecating mutillid larvae had spun cocoons by 14 September, and were kept for rearing when the entire observation nest was brought to the laboratory and disassembled. These diapausing larvae were kept at room temperature, and were still viable in November 1991.

Danforth excavated another *portalis* nest on 21 August 1989. He found a female *perditrix* crawling on the excavated soil, but was not certain whether it came from the nest or was in the immediate vicinity and crawled onto the spoil heap.

The holotype has rather numerous pollen grains over most of the body, particularly around the mouthparts and legs, and some mud adhering to the posterior terga, conditions that suggested she had recently been in the nest of a bee.

Pseudomethoca toumeyi (Fox)
Figs. 9, 10

This small species, 3–5 mm long, appears to be the most common taxon of *Pseudomethoca* in southeastern Arizona. A combination of the prominent, acute genal tooth, genal carina extending upward onto the vertex and rounded hypostomal prominence (Fig. 10), the small, acute subapical tooth (occasionally eroded by wear) on the inner margin of the mandible (Fig. 9), and the dense, appressed silvery vestiture on the head and on paired spots on the second abdominal tergum readily separate *toumeyi* from other known species of the genus.

NEW MEXICO: Hidalgo Co., 2 km N of Rodeo, 26 Aug 1989, B. N. Danforth (ESB).

Behavior.—Danforth collected this female crawling on soil excavated from a nest of *Perdita portalis* Timberlake. The *Ps. toumeyi* may have been in the bee's burrow or on the soil surface adjacent to the nest. There were no pollen grains on the mutillid's body.

B. B. Norden collected six female *Ps. toumeyi* (USNM) on the ground at Willcox, Cochise Co., AZ, 24–25 Aug 1990. Some of the mutillids explored nest burrows of the nyssonid wasp, *Hapalomellinus albitomentosus* (Bradley), a species that was preying upon immature cicadellids. The *toumeyi* left the burrows a few seconds after entering them, too short a time for them to have parasitized the wasp larvae. No small bees were nesting in the restricted area where the *toumeyi* were crawling. The mutillids ap-

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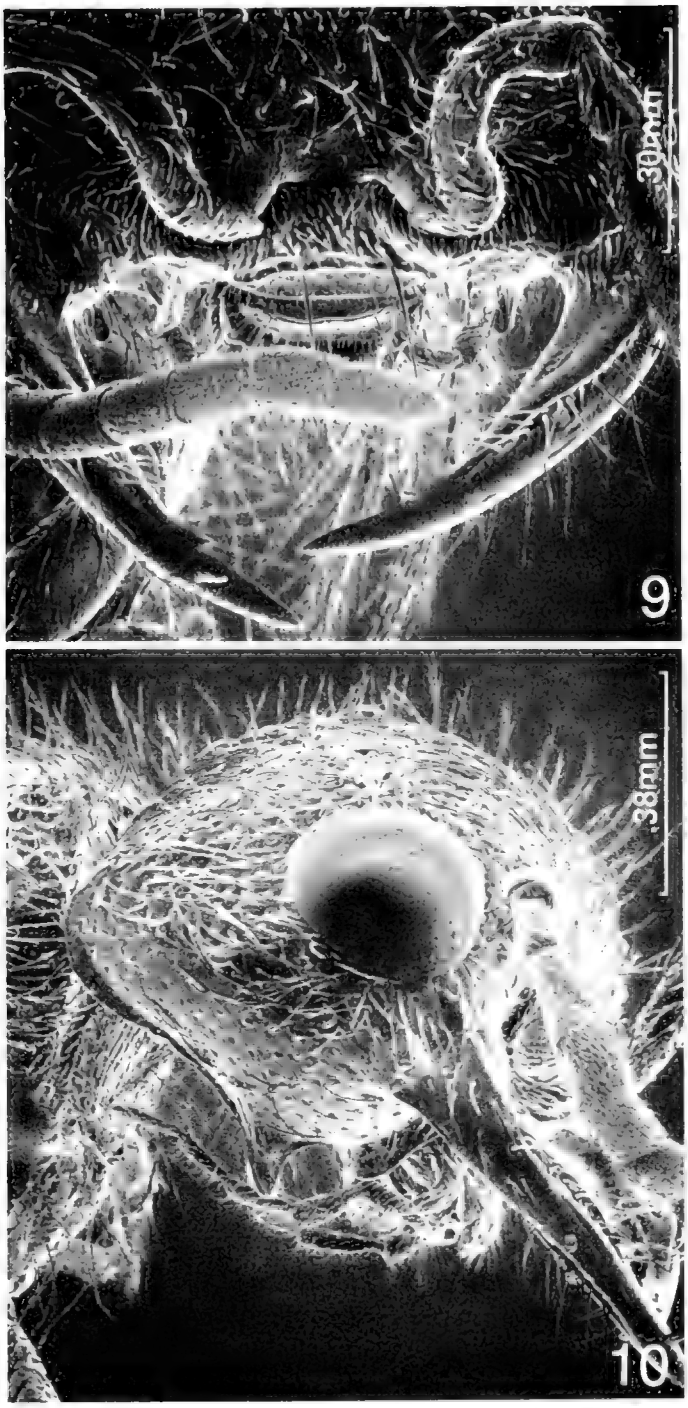
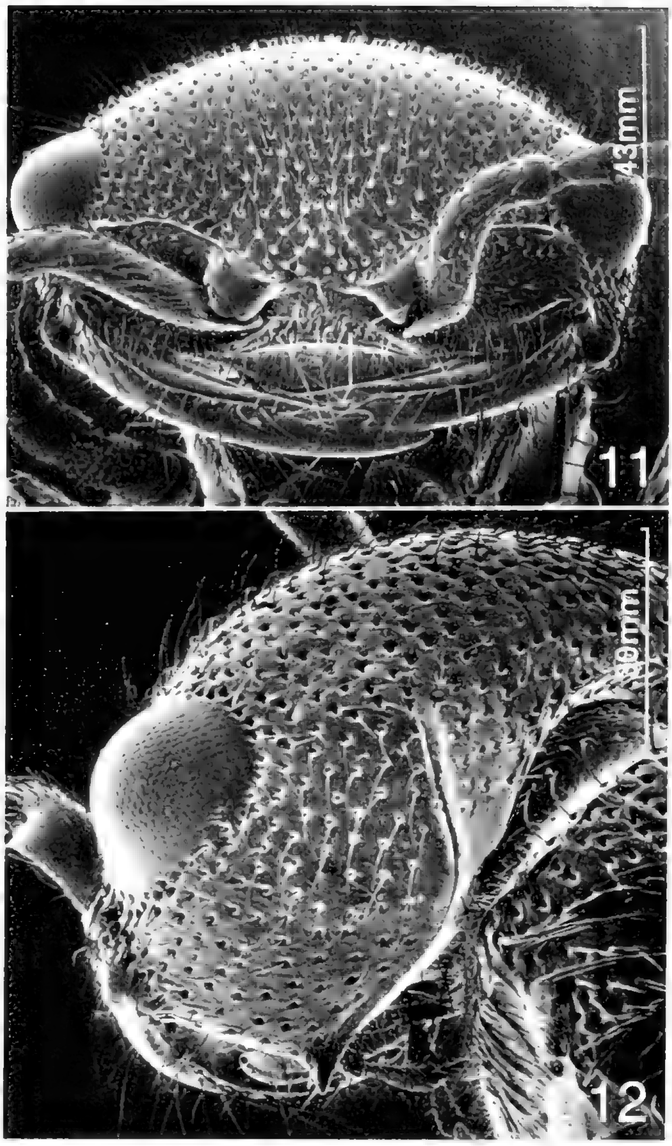
[1] This observation confirms Brothers' (1972) supposition that females of *Ps. frigida* (Smith) probably remain for some time in the nest of the host bee. This behavior is perhaps normal when a female *Pseudomethoca* finds a multicellular host nest with brood in various developmental stages, as evidenced also by Norden's finding of two *Ps. bethae* females remaining overnight in a nest of *Exomalopsis solani* Cockerell.



Figs. 9, 10. *Pseudomethoca toumeyi.* 9, mandibles and clypeus. 10, head, lateral view.



Figs. 11, 12. *Pseudomethoca torrida.* 11, head, frontal view. 12, head, lateroposterior view.

peared to be newly emerged, and none bore pollen grains.

Pseudomethoca torrida Krombein
Figs. 11, 12

This is another small species in the 3–5 mm range, and the only small *Pseudomethoca* occurring in peninsular Florida. It is separated from the other species discussed in this paper by a combination of the small, acute genal tooth and genal carina extending onto the vertex (Fig. 12), and the blunt subapical tooth on the inner margin of the mandible (Fig. 11).

Behavior.—Beth Norden and I were at the Archbold Biological Station, Lake Placid, Florida, 8–15 Aug 1989. We studied the mating behavior and nesting of a solitary andrenid bee, *Perdita graenicheri* Timberlake, a species that constructs a multicellular nest. A number of nest entrances of this gregarious bee were in close proximity in sandy soil near the shore of Lake Annie. No other bees nested nearby. While excavating several nests, Norden collected a female *torrida* crawling on the sand only a few cm distant from *Perdita* nest entrances. I presume that *graenicheri* may be a host of *tor-*

rida, a supposition strengthened by the fact that *perditrix,* and perhaps *toumeyi,* are also associated with a species of *Perdita.*

Pseudomethoca frigida (Smith)

Behavior.—This species has been reported by many observers (Table 1) as having various small species of halictine bees as positive or putative hosts. *Dialictus zephyrus* (Smith) was noted as a positive or putative host by five observers. In addition, J. C. Bridwell has a double mount of a ♀ *frigida* and ♀ *zephyrus* (USNM), with a note that they were fighting at dusk at a nest entrance at Clifton, VA, 1 July 1933.

There is an anomalous record of a female *frigida* and 5 ♀, 6 ♂ of the eumenid wasp, *Ancistrocerus lutonidus* Bohart emerging from a mud nest (Fattig 1943). Fattig observed a female *lutonidus* bringing mud to her nest "during early May 1929." The nest was "on a wire lying loosely through the branches of a trailing rose." He captured the wasp after it made several trips to gather mud, sent it subsequently to G. A. Sandhouse, who identified it as *A. birenimaculatus* (Saussure), a name applied erroneously to the taxon now known as *lutonidus.* Fattig returned "a few weeks later" and found the wire and nest lying on the ground. He removed the nest, placed it in a wire mesh cage, and obtained the series of *lutonidus* and the *frigida.*

I queried Fattig about this host record in 1953. He stated that not all of the mud cells were completed when he recovered the nest, and that C. E. Mickel had identified the *frigida.* Fattig gave his collection to H. O. Lund, University of Georgia, but the nest cannot now be found in the material at the university.

I believe that the association of *frigida* with this eumenid wasp is so unlikely, that a host relationship must be considered improbable. The wasps must have emerged soon after Fattig placed the nest in the cage, because adult emergence of the eumenid would have been expected about a month after the egg was laid; Fattig picked up the nest "a few weeks" after collecting the mother. Considering the number of confirmed host associations of *frigida* with various halictine bees, I suspect that this particular female had no relationship with the eumenid wasp other than that of just sheltering in an uncompleted cell after the wasp's nest came into contact with the ground.

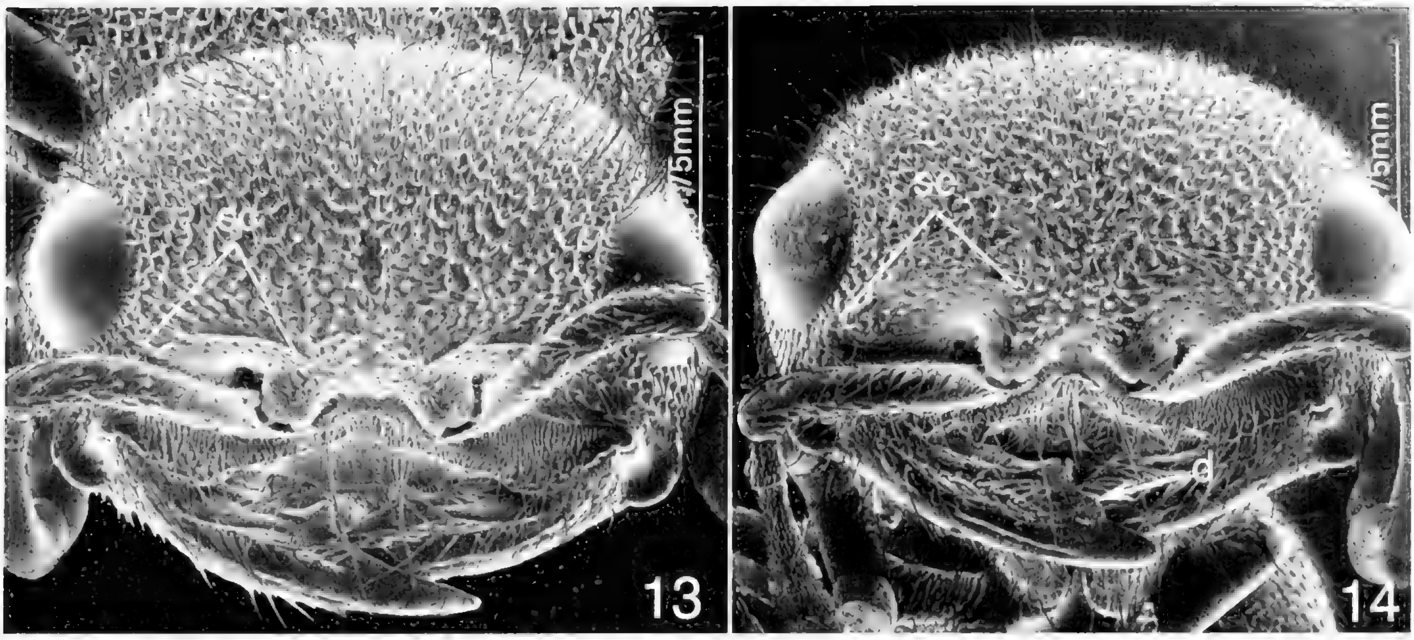
I noted (1951) that females of *frigida* and a few males fed on honeydew droppings of the tulip-tree scale on the ground beneath the trees, and that other males visited the secretions on the leaves. Brothers (1972) noted that *frigida* females in sealed observation nests sometimes lapped up liquid from moist pollen-nectar masses in host cells, and that one female punctured a bee pupa with her mandibles and fed on the exuding liquid.

***Pseudomethoca bethae* Krombein, NEW SPECIES**

Figs. 13–17, 19, 21, 23, 25

In describing *Ps. mulaiki,* Mickel (1938) mentioned that it was distinguished from other species of the genus in America north of Mexico by the pair of pale integumental spots posteriorly on abdominal tergum 2. The present species also has such pale integumental spots, is closely related to *mulaiki,* but differs in a number of details. The two species occupy discontinuous ranges, *mulaiki* being known only from Cameron and Hidalgo counties in extreme southern Texas at low elevations, and *bethae* from the high desert of southeastern Arizona and southwestern New Mexico at 4360–4380 ft elevation, and the Sierra Madre Occidentale of Mexico at elevations of 3600–6000 ft.

The morphological differences are: the carina of the antennal scrobe is weaker and of the same width in *mulaiki,* stronger and noticeably widened proximad in *bethae* (cf. Figs. 13, 14, 19, 20); the antennal tubercles in *mulaiki* are separated from each other by about the diameter of a tubercle, but in *bethae* they are separated by 1.25× their di-



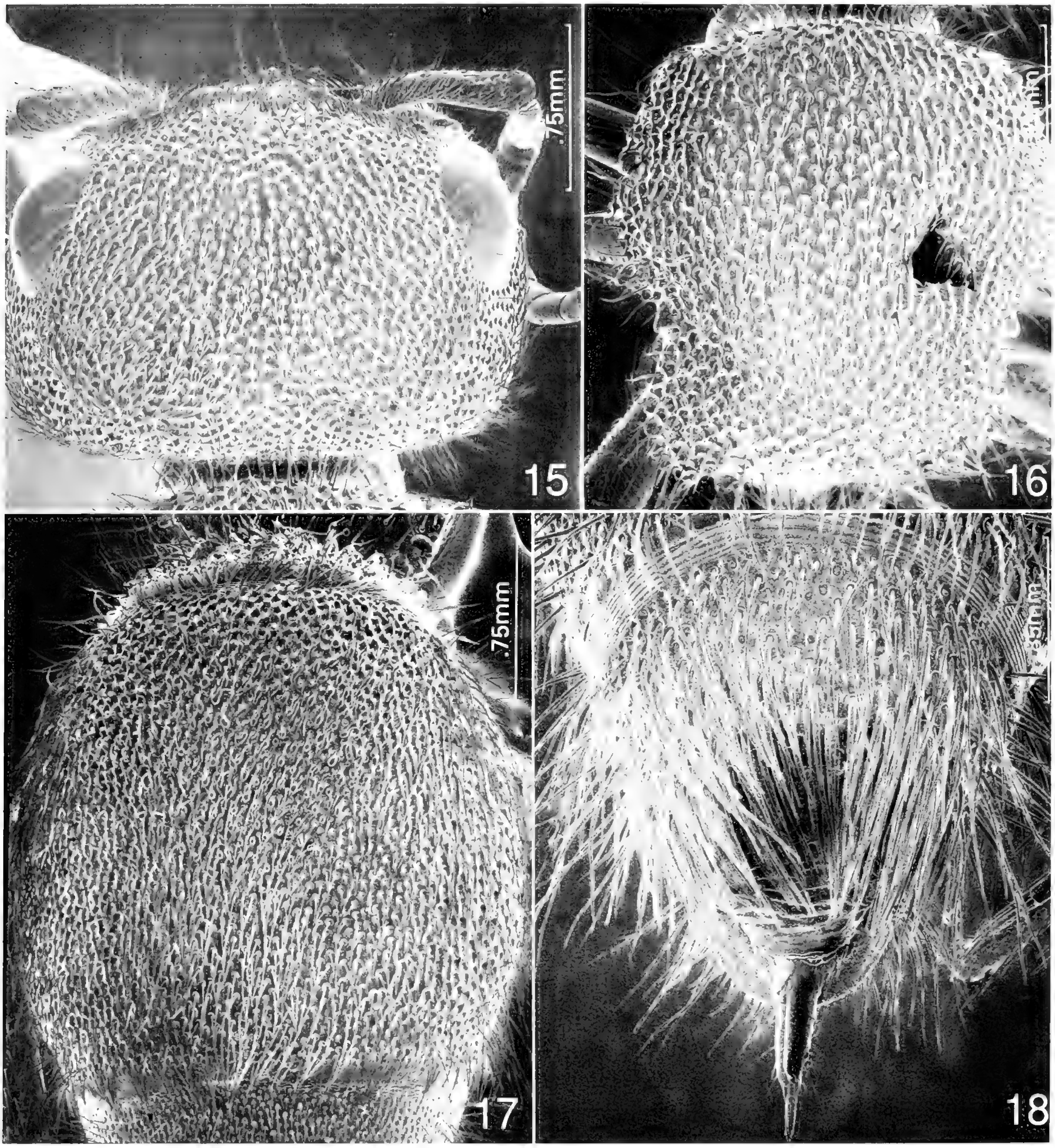
Figs. 13, 14. *Pseudomethoca* species. 13, *bethae,* head, frontal view (sc, scrobal carina). 14, *mulaiki,* head, frontal view (sc, scrobal carina; d, dirt on mandible, not a tooth).

ameter; the hypostomal carina is well developed in both, but it is noticeably higher in *bethae* where it diverges toward the mandible and is not so raised in *mulaiki* (cf. Figs. 21, 22); the vertical mesopleural carina in *mulaiki* extends from the anterior mesonotal tubercle downward to the anterior angle of the midcoxa, but is absent on the lower half or two-thirds in *bethae* (cf. Figs. 23, 24). The pale integumental spots on tergum 2 are ovate and oblique in *mulaiki,* subcircular in *bethae.* There are also differences in the vestiture: the apical fringe of setae on tergum 1 is completely silvery in *bethae,* but black on the middle third in *mulaiki*; and the silvery appressed setae on the pale yellow spots of tergum 2 are connected above by a narrow band of silvery setae in *mulaiki,* but this area in *bethae* has only appressed black setae.

Holotype female.—Length 8.3 mm. Ferruginous, apical half of mandible and antennal flagellum black, the following brown—side of head and large triangular area posterolaterally on top of head; most of abdominal tergum 2 except central spot at base, sides and apex narrowly red, and a pair of moderately large, subcircular, creamy spots toward apex separated from each other by about their transverse diameter; most of terga 3–6 and apices of sterna; legs mostly darker red than thorax, tarsi paler.

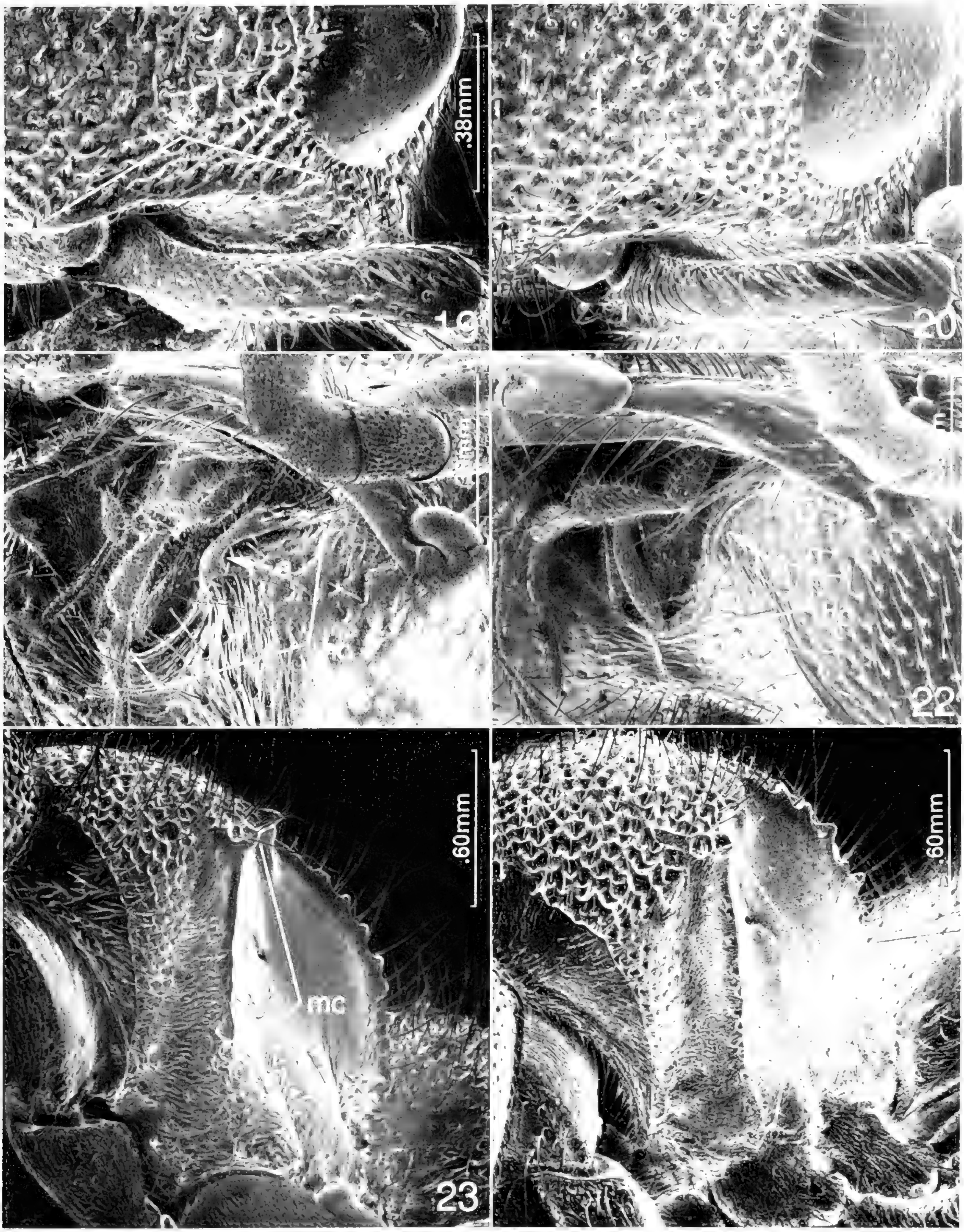
Vestiture: Front and vertex with short, rather sparse, subappressed, dark red setae and scattered, longer, erect setae; gena with short, sparser, appressed silvery setae; thoracic dorsum with moderately dense, subappressed reddish setae and scattered, longer, erect silvery setae; terga 1–5 with a band of appressed silvery setae, that on 1 wider except narrowly in middle, 2–5 quite narrow, rather inconspicuous on 4–5; tergum 1 with small subapical patch of black setae; tergum 2 with dense appressed setae, silvery on pale yellow spots and on a narrow, vaguely defined strip extending anteriorly from each pale spot and becoming slightly broader toward base of tergum, black on darker areas, and with scattered, longer, erect silvery setae; 3–5 with scattered, erect silvery setae anteriorly; 6 with coarse, dense, subappressed pale setae on basal half (Fig. 18); sterna 2–5 with scattered, longer, suberect silvery setae anteriorly and a narrow apical band of subappressed silvery setae; sternum 6 with erect silvery setae; legs with sparse, silvery pubescence, calcaria pale.

Head (Fig. 15) including eyes 1.1 × as wide



Figs. 15–18. *Pseudomethoca bethae.* 15, head, dorsal view. 16, thorax, dorsal view. 17, abdominal tergum 2. 18, pygidium.

as thorax; mandible as in *mulaiki,* with a large tooth at midpoint of inner margin, and a tiny tooth halfway between tip and large tooth, teeth sometimes obscured by long setae curving downward from base of clypeus and inward from mandible (Fig. 13); antennal scrobe with a strong carina noticeably higher proximad (Fig. 19); antennal tubercles separated by about 1.25 × the diameter of a tubercle; distance between posterior margin of eye and posterolateral angle of head equal to greatest diameter of eye; gena carinate posteriorly; hypostomal carina well developed, not dentate but noticeably high-



Figs. 19–24. *Pseudomethoca* species. 19, *bethae*, left side of head, dorsal (sc, scrobal carina). 20, *mulaiki*, left side of head, dorsal (sc, scrobal carina). 21, *bethae*, underside of head, oblique (hc, hypostomal carina; a, angle). 22, *mulaiki*, underside of head, oblique (hc, hypostomal carina; a, angle). 23, *bethae*, side of thorax, oblique from anteriorly (mc, mesopleural carina). 24, *mulaiki*, side of thorax, oblique from anteriorly (mc, mesopleural carina).

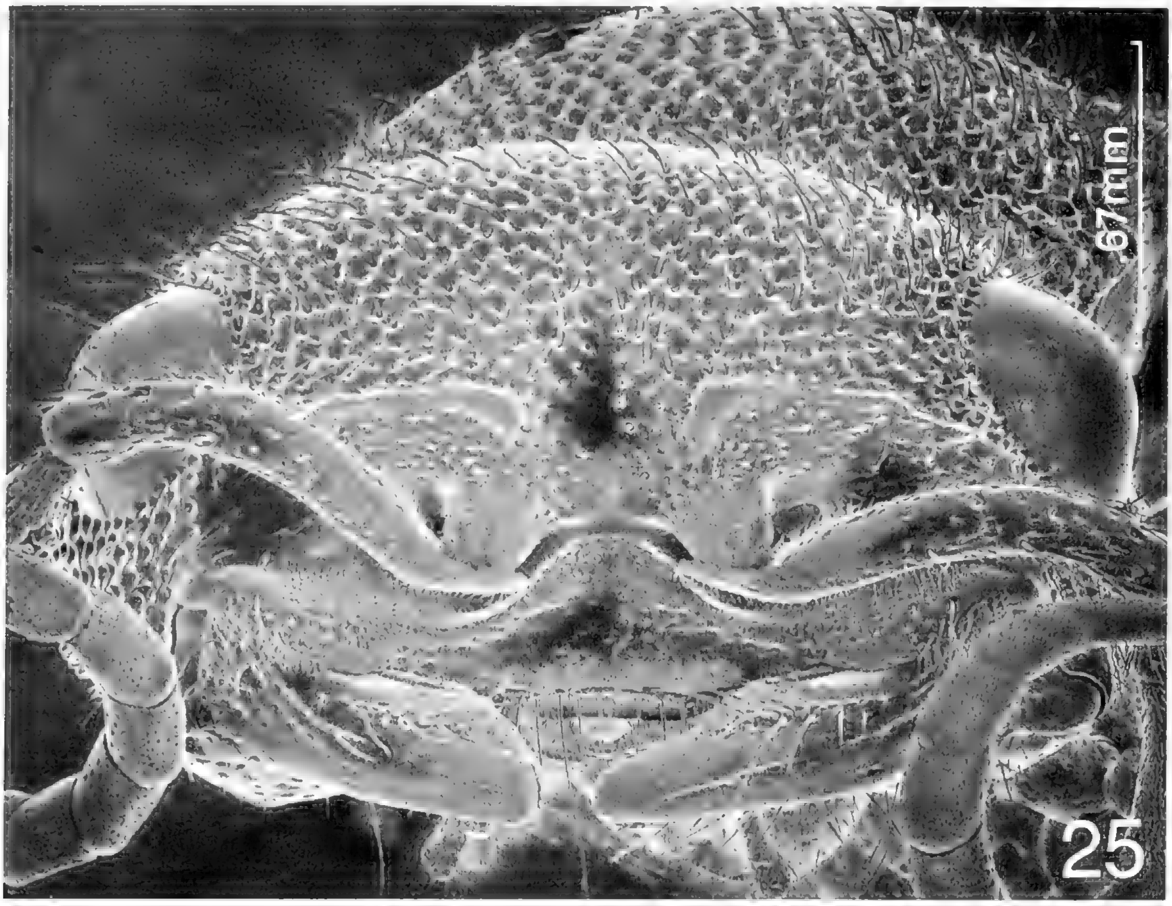


Fig. 25. *Pseudomethoca bethae,* head, frontal view showing extreme mandibular erosion.

er where it diverges toward mandible than in *mulaiki* (cf. Figs. 21, 22); front and vertex with dense punctures, those on gena more separated.

Thorax dorsally (Fig. 16) as wide as long, widest at anterior mesonotal tooth, densely punctate becoming reticulate apically; humeral angles carinate but not produced; side of mesonotal area with a pair of teeth, anterior one above vertical mesopleural carina; lateral surface of pronotum carinate anteriorly; vertical mesopleural carina (Fig. 23) extending from dorsum only halfway toward anterior angle of midcoxa, a more delicate oblique carina extending from posterior angle of midcoxa to lower end of vertical carina; posterior surface of propodeum narrowly reticulate above and laterally, finely scattered punctures below, lateral margin denticulate.

Tergum 2 (Fig. 17) closely punctate, more deeply and densely anteriorly than laterally and apically; tergum 6 (Fig. 18), pygidial area with transverse, somewhat irregular rugulae, not carinate laterally.

Male.—Unknown.

Holotype.—NEW MEXICO: ♀, Hidalgo Co., 3 km N of Rodeo, [4360 ft], 24 Aug 1991, B. B. Norden (USNM).

Paratypes.—NEW MEXICO: ♀, same label data as holotype except 25 Aug 1991; ♀, same label data as holotype except 2 km N of Rodeo, 21 Aug 1991, K. V. Krombein; ♀, Rodeo, 31 Aug 1970, D. J. Brothers (DJB); ARIZONA: 2 ♀, Cochise Co., Apache, [4380 ft], 30 Aug–1 Sep 1986, K. V. Krombein (USNM). 3 ♀, same locality but 27–31 Aug 1988, K. V. Krombein, B. Norden (USNM); 2 ♀, same locality but 31 Aug 1988, B. Norden, one in nest gallery and one in cell of *Exomalopsis solani* Cockerell; ♀ MEXICO, Jalisco, south edge of Guadalajara, 6000 ft, 11 Jul 1973, R. R. & M. E. Murray (DGM); ♀, MEXICO, Puebla, 11 km NW Tehuitzingo, 1100 m, 1–2 Jul 1975, E. M. & J. L. Fisher (DGM).

The holotype and 21 Aug 1991 paratype are newly emerged females in pristine condition.

Variation.—The tiny tooth on the inner margin of the mandible halfway between the tip and the large tooth may be lacking, possibly having been eroded by use. One paratype from the nest at Apache has such badly eroded mandibles (Fig. 25), apparently from digging into the cement-like bee cells, that the tips do not meet on the midline and the large tooth on the inner margin is entirely worn off. The paratypes from New Mexico and Arizona are rather uniform in size, 7.3–8.2 mm long. They agree well with the holotype except the gena and first flagellar segment are red in one specimen, and the flagellum and apex of the mandible are brown in another. The Mexican specimens are 5.5 (Puebla) and 9.5 mm long (Guadalajara) and differ in a few details of coloration and vestiture as follows: head and legs uniformly red; vertex with either a median area or entirely with appressed black setae; appressed setae of thoracic dorsum entirely black or only in the middle; darker areas of tergum 2 lighter in hue; and apical fringe of tergum 2 black except extreme side in Puebla specimen.

Discussion.—*Ps. bethae* and *mulaiki* belong to a complex of species occurring in Mexico and Central America that is characterized by the pair of pale integumental spots posterolaterally on tergum 2, and the thorax noticeably narrowed posteriorly with a pair of prominent teeth laterally on the mesonotum. Several of the species also share with *bethae* the similarly developed antennal scrobe and hypostomal carina but are otherwise distinct. Cameron (1894–1900) described two species from Mexico in *Sphaerophthalma* (sic) that may belong to the complex but they are not *bethae.*

Etymology.—The species is named for Beth B. Norden, a cherished companion in the field, discoverer of the species' host, and, most recently, collector of the holotype.

Behavior.—Norden began to excavate a nest of the communal anthophorid bee, *Exomalopsis solani* Cockerell, at noon on 30 August. She found a female *bethae* under a rock near the nest entrance, and also collected several *solani* bearing pollen as they returned to the nest. By the end of the day Norden had exposed the perpendicular main tunnel and reached a depth of about 40 cm. She stuffed grass tightly into a section of the main burrow to prevent egress or ingress. We then placed a large rubberized poncho in the bottom of the pit and against the vertical, exposed burrow profile, folded the top of the poncho over the level ground surface, and placed rocks and loose soil on the edge of the poncho. We then filled the excavation with the loose soil that had been removed earlier.

After removing the loose soil and poncho, and finding the plug of grass still intact in the main tunnel Norden continued the excavation at noon on the 31st. She found a female *bethae* at the 37 cm level on the pollen-nectar mass in an uncompleted bee cell apparently feeding on the moist mass. This substantiates Brothers' (1972) observation of *Ps. frigida* feeding on a pollen-nectar mass in the host nest.

She found a second female *bethae* with badly eroded mandibles at the 39 cm level in an empty gallery. The mandibles of the female from the 37 cm level also were eroded, but not so badly as in the second specimen. There is no doubt that both females had been in the nest when Norden began the excavation on the 30th because we had thoroughly sealed access to the burrow at the end of that day.

She recovered a number of sealed cells, several of which were parasitized by larvae of other aculeate Hymenoptera. Subsequently she reared several adult *Nomada (Micronomada) gutierreziae* Cockerell from some of the parasitized cells.

I collected two of the 27–31 August female of *bethae* and two females of *gutierreziae* in an area of about one hectare surrounding the nest location. The variation in size of the type series of *bethae* indicates strongly that other bees also serve as hosts of this mutillid. I also collected in the same area several specimens of the nomadine bee, *Paranomada nitida* Linsley. It is known to parasitize species of *Exomalopsis,* but was not reared from this nest of *solani.* I have included *gutierreziae* as a questionable host of *bethae* in Table 1 inasmuch as its larva may also serve as a host for the mutillid.

Several *bethae* from Apache and the Jalisco specimen, all captured while crawling on the ground, have grains of pollen around the mouthparts, indicating that they had recently been within a bee nest.

Females may be found on sunny days crawling on the ground, once the surface has warmed sufficiently, from about 0900 h until 1030. Diurnal activity above ground resumes in the late afternoon from about 1600 until at least 1730. Hours of above ground activity may be lengthened during overcast conditions. The three specimens of *bethae* collected on 21, 24 and 25 August 1991 were taken respectively at 0930, 1715 and 1730. We noted similar periods of activity above ground for females of other *Pseudomethoca,* e.g. *perditrix, scaevolella,* and *toumeyi.*

Pseudomethoca mulaiki Mickel

Figs. 18, 20, 22, 24

Three females (2 in USNM, 1 in DGM) from Bentsen, Rio Grande Park, Hidalgo Co., Texas, agree in all details with Mickel's unique type from N.E. Cameron Co., Texas, off Bird Island, except that the integument of the type is a lighter red.

Behavior.—Two of the Bentsen specimens each bear an additional label, "A. Hook/Bio.Note No./1.42-81/" or "1.43-81." Hook (unpublished notes) was working at Bentsen during 1981 on the nesting and behavior of the philanthid wasp, *Trachypus mexicanus* Saussure, which preys upon other aculeate Hymenoptera, chiefly Apoidea. The prey, taken either in nests or from wasps in flight, included: Halictidae—*Agapostemon* (10 of one species, 2 each of two others), 1 specimen of *Sphecodes,* 5 specimens of *Dialictus,* and 34 specimens of *Augochlorella*; and Anthophoridae—10 specimens of *Exomalopsis,* and one specimen of *Melissodes.* He noted four species of mutillids, three of *Dasymutilla* and one of *Pseudomethoca,* searching the nesting areas of *T. mexicanus.* He saw five episodes of mutillids halting and retreating from nest entrances of *mexicanus* due to the presence of guards, and eight episodes of mutillids entering inactive nests and remaining inside 10 seconds to 16 minutes. He reared no mutillids from 83 viable cocoons of *mexicanus.*

Hook's two *mulaiki* show only slight wear of the apical mandibular tooth, but no erosion of the large tooth on the inner margin of the mandible. The wear of the apical tooth may have been incurred during the mutillid's exit from the cocoon to the ground surface. Hook thought that nests of many of the bees listed as wasp prey were interspersed among the wasp nests.

Pseudomethoca propinqua (Cresson)

Behavior.—I reported *Nomia melanderi* Cockerell as a host of *propinqua* (1958). This was based on two females from Riverton, Wyoming, 14 August 1957, sent for identification by G. F. Knowlton with a note that they parasitized this bee. Knowlton never validated this record by publication of the details, so I consider that it is only a putative association.

Later, I received from W. L. Jellison a copy of a letter that he had written to C. E. Mickel concerning enormous populations of female bees, and of a mutillid which Mickel identified subsequently as *propinqua.* Jellison stated that he had observed both species early in August 1971, shortly after their appearance on a bare, level, rather sandy lot of about 6500 sq ft in Ravalli Co., Montana. Thousands of the bees were burrowing in the soil. He estimated 6000–

7000 *propinqua* males in sight at one time, and that females outnumbered males by 10:1. He noted that *propinqua* males were swarming when it was cool, but scarce when it got hot, and that they flew swiftly just above the ground surface. He also saw 4–5 males clustered around a single female, but did not mention seeing mating. He stated that "other bees (possibly parasites), wasps and tiger beetle larvae" were in the area. Although he visited the site on three successive dates, he did not mention seeing *propinqua* females entering bee burrows. There is a tray of material from Jellison with the above locality and date labels in the USNM *Pseudomethoca* collection. It contains 5 ♀ and 11 ♂ *propinqua,* and the following anthophorid bees identified by P. D. Hurd, Jr.: 4 ♀ *Melissodes (Eumelissodes) pallidisignata* Cockerell and 4 ♀ *Triepeolus wyomingensis* Cockerell.

Knowlton's *propinqua* are somewhat smaller than Jellison's specimens, a size difference that is also evident in the three putative bee hosts. None of the *propinqua* bear pollen grains around the mouthparts, indicating that they had not been feeding on the pollen-nectar masses within bee nests, at least recently. Knowlton's specimens do not have worn mandibles nor is there mud on the tibiae. One of Jellison's specimens has the mandibles quite worn, and three evidence some mandibular wear; three have some mud on the mid and hind tibiae, an indication that they had been exploring burrows. All of the *pallidisignata* had been gathering pollen, so provisioning of nests was in progress. It seems probable that *pallidisignata* was the host of *propinqua* considering the very large populations of each, the absence of large numbers of any other bee species, and the relative sizes of the individuals.

There is a possibility that *wyomingensis* also may have *pallidisignata* as a host, in which case a mature larva of the *Triepeolus* in a *pallidisignata* cell could also conceivably serve as a host of *propinqua.*

Pseudomethoca sanbornii sanbornii (Blake)

Mickel (1924) reported that both sexes of this taxon were reared by E. A. Schwarz from cells of the halictid bee, *Nomia pattoni* Cockerell, from Selma, Albama.

Pseudomethoca sanbornii aeetis (Fox)

Behavior.—D. G. Manley advised me that he found a number of females of this mutillid crawling on the ground among a large aggregation of nests of the solitary halictid, *Nomia nevadensis bakeri* Cockerell. The nests were in a fallow, cultivated field in coastal South Carolina. He did not observe female mutillids entering the nests, but the large numbers of both populations suggest a probable host-parasite association. This probable host association is strengthened by the fact that nominotypical *Ps. sanbornii* (Blake) was reared from cells of *Nomia pattoni* Cockerell.

Beth Norden (Krombein and Norden, in preparation) collected one female visiting exudate from a fruiting stalk of a scrub palmetto in Florida. The fluid was obtained from a wound made by a *Dasymutilla* female at the base of the fruit bearing stem.

Pseudomethoca donaeanae (Cockerell and Fox)

The species has a wide distribution in the desert from western Texas to southern California. Mickel (1924, 1935) did not describe it other than to give key characters, and he did not mention the size. The single female in USNM is 8.0 mm long, has an untoothed genal carina, mandible with two teeth along the inner margin, a strongly developed scrobal carina, and a well developed median tubercle at the apex of the thoracic dorsum.

ARIZONA: Cochise Co., Apache, [4380 ft], 30 Aug–1 Sept 1986, K. V. Krombein.

Behavior.—This female was crawling on the ground where various aculeate Hymenoptera were nesting. The mandibles were quite unworn, suggesting that it had emerged recently. There were numerous pollen grains on the venter of the head and mandibles, and fewer scattered grains elsewhere on the head, thorax and abdomen, evidence that it had fed recently on a pollen-nectar mass in a bee nest.

HOST ASSOCIATIONS OF *PSEUDOMETHOCA*

A review of the positive and putative host associations of *Pseudomethoca* from America north of Mexico as listed in Krombein (1979), from subsequent literature and in the present contribution, suggests that solitary and communal bees may be the only hosts within the genus. Forty-five species-level taxa are now known from this area, 17 from both sexes, 20 from females only, and 8 from males only. Fourteen species-level taxa (31%) have bees as positive or putative hosts as listed in Table 1. If we assume, as is probable, that the eight species known from males only are the opposite sexes of taxa presently known only from females, the taxa with possible bee hosts increases to 38%.

There are a number of *Pseudomethoca* species, mostly undescribed, in Central and South America. There are positive host records for three species from Costa Rica and Panama. Mickel (1969) described *Ps. willei* from specimens reared from cells of the halictid, *Dialictus umbripennis* (Ellis), in Costa Rica. Brooks and Roubik (1983) reported *Ps. hesperus* Brothers and *Ps. transversa* Brothers as parasitoids of the halictid bee, *Halictus (Seladonia) hesperus* Smith. Specimens of both *Pseudomethoca,* but mostly *hesperus,* were noted trying to enter, or actually entering nests of the bees, but being repelled by guard bees.

I consider positive host associations in *Pseudomethoca* to be actual rearing of the parasitoid from a cell of the host bee, finding a female mutillid ovipositing on a paralyzed host larva, or observing the female mutillid fighting with a guard bee at or near the nest entrance.

A probable host association could be finding a female mutillid in a bee nest, sometimes feeding on the pollen-nectar mass, but no evidence otherwise that there might be a host association.

Another possible host association might be with a parasitic anthophorine bee, such as *Nomada* or *Triepeolus.* Mature or diapausing larvae of these bees could serve as possible hosts of *Pseudomethoca.* Eggs of the parasitic bees are placed in a host bee cell containing a pollen-nectar mass and host bee egg. They usually hatch before the host egg, seek out the latter and destroy it or a newly hatched host larva, before feeding on the pollen-nectar mass. They might be as subject as host bee larvae to parasitism by a mutillid.

Finally, the finding of numerous pollen grains especially on the venter of the head and mandibles, and also sometimes scattered more sparsely on the head, thorax and abdomen of a female *Pseudomethoca* is persuasive, presumptive evidence that the specimen had been feeding at a pollen-nectar mass in a cell of a bee. A lack of pollen around the mouthparts would not eliminate the possibility that the mutillid fed at a pollen-nectar mass, because thorough grooming might remove the pollen. I have noted finding numerous pollen grains on the mouthparts of some specimens in some of the individual accounts that precede this section.

Pseudomethoca females have not been reported to visit flowers for nectar. Females of *frigida* and *simillima* were found visiting honey-dew secretions of the tulip-tree scale on the ground (Krombein 1951); probably females may also visit secretions of aphids in similar sites. A female of *sanbornii aeetis* was noted on sweet exudate from a scrub palmetto fruit (Krombein and Norden, in preparation).

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Table 1. Host associations in *Pseudomethoca*: an asterisk denotes a positive host association; lack of an asterisk denotes a possible or probable host association; the abbreviations And., Ant., and Hal. are of the host bee families Andrenidae, Anthophoridae, and Halictidae; and question mark, ?, before a name denotes a possible host.

Pseudomethoca	Host Bee	Source
bethae, n. sp.	Ant.: *Exomalopsis solani* Cockerell, ? *Nomada* (*Micronomada*) *gutierreziae* Cockerell	Krombein, supra
donaeanae (Cockerell & Fox)	Unknown bee	Krombein, supra
frigida (Smith)	Hal.: **Dialictus zephyrus* (Smith) (recorded as *pruinosus* (Robertson)	Melander & Brues, 1903
	Hal.: **Dialictus zephyrus* (Smith)	Krombein, 1938
	Hal.: *Augochlorella striata* (Provancher)	Michener & Wille, 1961
	Hal.: **Dialictus zephyrus* (Smith)	Lin, 1964
	Hal.: **Dialictus zephyrus* (Smith)	Batra, 1965, 1966
	Hal.: **Dialictus versatus* (Robertson)	Michener, 1966
	Hal.: **Evylaeus cinctipes* (Provancher)	Knerer & Atwood, 1967
	Hal.: **Dialictus zephyrus* (Smith), **D. coeruleus* (Robertson), *D. imitatus* (Smith), *D. laevissimus* (Smith), *D. rohweri* (Ellis)	Brothers, 1972
gila (Blake)	Andrenidae: *Pseudopanurgus rugosus* (Robertson)	Manley and Neff, 1989
mulaiki Mickel	Hal.: *Agapostemon angelicus* Cockerell, *A. melliventris* Cresson, *A. texanus* Cresson Ant.: *Exomalopsis* sp.	Krombein, supra
nudula Mickel	And.: ?*Calliopsis* sp.	Mickel, 1924
perditrix, n. sp.	And.: **Perdita portalis* Timberlake	Krombein, supra
propinqua (Cresson)	Hal.: *Nomia melanderi* Cockerell	Krombein, 1958
	Ant.: *Melissodes* (*Eumelissodes*) *pallidisignata* Cockerell, ? *Triepeolus wyomingensis* Cockerell	Krombein, supra
sanbornii sanbornii (Blake)	Hal.: *Nomia pattoni* Cockerell	Mickel, 1924
sanbornii aeetis (Fox)	Hal.: *Nomia nevadensis bakeri* Cockerell	Krombein, supra
simillima (Smith)	And.: **Andrena macra* Mitchell Ant.: **Nomada* sp.	Riddick, 1991
torrida Krombein	And.: *Perdita graenicheri* Timberlake	Krombein, supra
toumeyi (Fox)	And.: *Perdita portalis* Timberlake	Krombein, supra
vanduzei Bradley	Hal.: **Nomia maneei* Cockerell	Fattig, 1943

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G. Manley, and E. S. Brewster, New York, N.Y., for specimens from their personal collections. R. W. Matthews, University of Georgia, was kind enough to check that collection for Fattig's nest of *Ancistrocerus lutonidus.* I thank D. J. Brothers, and K. W. Cooper, University of California, Riverside, for their painstaking reviews of the manuscript. I thank also the directors of the Southwestern Research Station, AMNH, and Archbold Biological Station for making available housing and technical facilities for Beth Norden and myself. Finally, I am grateful to Beth Norden for discussing various aspects of the host-parasite relationships, and for constructive criticism.

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ANALYSIS OF KNOWN AND NEW HOST RECORDS FOR *TRUPANEA* FROM CALIFORNIA (DIPTERA: TEPHRITIDAE)

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Abstract.—One hundred twenty-four, new rearing records are reported for eight of the 16 known species of *Trupanea* occurring in California. The host relations of all 16 species are assessed, including *T. texana* Malloch newly reported from California, for which hosts are unknown; one species for which only the host genus is known; four other monophagous species; three oligophagous species (one host tribe); one nearly oligophagous species; and six generalist species, all restricted to Asteraceae. *Trupanea signata* Foote is reported for the first time as a monophagous, obligate stem-gall former on *Gnaphalium luteo-album* L. One other monophagous species, as known to date, probably also is an obligate gall former; whereas, another is a facultative gall former. All other 11 species are ovule and soft achene feeders in flower heads, including *Trupanea arizonensis* Malloch, newly reported as monophagous on *Trixis californica* Kellogg. The host tribes are tabulated and the number of host genera and species within them are enumerated for each fly species. The six generalist species have been reared from at least five tribes each. This dispersed pattern of hosts among tribes is discussed in terms of procedures for determining the host specificities of Tephritidae as candidate agents for biological control of weeds. Two plant species, *Brickellia oblongifolia* Nuttall in the tribe Eupatorieae and *Haplopappus squarrosus* Hooker and Arnott in the tribe Astereae, are attacked by all six generalists. The Astereae, Cichorieae, Helenieae, Heliantheae, and Senecioneae contain the most host-plant genera and species recorded, and also are the largest of the 12 tribes of Asteraceae in southern California.

Key Words: Insecta, *Trupanea,* Tephritidae, Asteraceae, flower head-feeders, host specificities, monophagy, oligophagy, gall-formers, biological control, evolution, resource utilization, speciation

Six years ago I reported many new records for *Trupanea* (Diptera: Tephritidae) reared from flower heads of Asteraceae in southern California (Goeden 1985). This paper reports additional rearing records acquired since mid-1984 from both northern and southern California for this common and widespread genus of nonfrugivorous fruit flies (Foote and Blanc 1963).

MATERIALS AND METHODS

Materials and methods used were described by Goeden (1985). My earlier emphasis on sampling in southern California was changed during 1985–1990 to include collecting trips of 3- to 5-days duration to northern California, as floristically and geographically defined by Munz (1974). This expanded collecting effort in northern California allowed sampling of plant species and Tephritidae not present, or only of limited occurrence, in southern California (Munz and Keck 1959, Foote and Blanc 1963, Munz 1974). Voucher specimens of tephritids reside in my research collection; pressed voucher specimens of uncommon or otherwise poorly represented host-plant species were deposited in the Herbarium of the University of California, Riverside. A sixteenth species in California, *Trupanea texana* Malloch, was identified in 1982 by F. L. Blanc (in litt. 1991) from one male collected by W. R. M. Mason at W. Palm Springs, Riverside Co., on 3.v.1955. This specimen was deposited in the Canadian National Collection at Ottawa, Canada.

RESULTS

New rearing records are listed below for eight of 15 species of *Trupanea* reported from California by Foote and Blanc (1963). Host records unreported by Wasbauer (1972), Cavender and Goeden (1982, 1983), Goeden (1985, 1986, 1987, 1988), and Headrick and Goeden (1991) are listed by genera and species in a slightly different, more readible manner from Goeden (1985). Unless otherwise noted, all flies were reared from ca. 1-liter samples of mature flower heads. Among multiple samples of a particular new host-plant species, only the sample from which the most individuals of each fly species was recovered is reported. The plant nomenclature used largely follows Munz and Keck (1959) and Munz (1968, 1974); the insect nomenclature follows Foote (1960) and Foote and Blanc (1963). Rearing records for the flies and their host plants are listed alphabetically.

Trupanea actinobola (Loew)

New host genera: Amphipappus, Brickellia, Haplopappus, Trichoptilium.

New host records: Amphipappus fremontii Torrey and Gray; 1 ♂ and 1 ♀; Wheeler Canyon at 1204 m, Inyo Nat. Forest, Inyo Co.; 21.v.1988. *Aster spinosus* Bentham; 5 ♂ and 3 ♀; NW of Blythe at 85 m, Riverside Co., 2.xii.1987. *Bailyea pleniradiata* Harvey and Gray; 3 ♂ and 6 ♀; sand dunes NW of Indio at Hidden Springs, Riverside Co.; 14.iv.1986. *Brickellia oblongifolia* Nuttall; 3 ♂; Santa Rosa Mountain at about 1400 m, San Bernardino Nat. Forest (S section), Riverside Co.; 14.vi.1988. *Gutierrezia bracteata* Abrams; 2 ♂ and 4 ♀; Bratton Valley at 387 m, San Diego Co.; 31.v.1989. *Gutierrezia sarothrae* (Pursh) Britton and Rusby; 18 ♂ and 9 ♀; Mountain Springs, SW Imperial Co; 6.xi.1986. *Haplopappus bloomeri* Gray; 1 ♂; Beasore Meadow at 1972 m, Sierra Nat. Forest, Sierra Co.; 16.viii.1988. *Haplopappus cooperi* (Gray) Hall; 4 ♂ and 2 ♀; Mojave River Forks, San Bernardino Nat. Forest, SW San Bernardino Co.; 12.v.1987. *Haplopappus squarrosus* Hooker and Arnott; 3 ♂ and 1 ♀; Kitchen Creek Road above Cibbetts Flat Campground at 1341 m, Cleveland Nat. Forest, San Diego Co.; 6.x.1988. *Trichoptilium incisum* (Gray) Gray; 3 ♀; Indian Well, Imperial Co.; 12.iii.1986.

Trupanea femoralis (Thomson)

New host genera: Baccharis, Brickellia, Eriophyllum, Holocarpa, Lessingia, Machaeranthera, Monolopia, Perezia, Viguiera.

New host records: Baccharis salicifolia (Ruiz and Pavon) Persoon (= *glutinosa* Persoon); 1 ♂ and 1 ♀; bottom of Parkfield-Coalinga Grade near San Andreas Fault at 393 m, Fresno Co.; 18.iv.1989. *Brickellia oblongifolia*; 5 ♂ and 2 ♀; base of Santa Rosa Mountain, San Bernardino Nat. Forest (S section), Riverside Co.; 14.vi.1988. *Chrysothamnus paniculatus* (Gray) Hall; 1 ♂; N of Pioneertown atop N rim of Chaparossa Wash at 1356 m, SW San Bernardino Co.; 31.x.1990. *Chrysothamnus teretifolius* (Durand and Hilgard) Hall; 2 ♂; along Death Valley Road as it leaves Owens Valley at 1378 m, Inyo Co.; 11.x.1990. *Eriophyllum lanatum* (Pursh) Forbes; 1 ♂ and 1 ♀; Cedar Slope along State Highway 190 at 1646 m, Sequoia Nat. Forest, Tulare Co.; 12.vi.1990. *Haplopappus cuneatus* Gray; 2 ♂ and 1 ♀; Alder Saddle, S of Pacifica Mountain at 1737 m, Angeles Nat. Forest, Los Angeles Co.; 20.ix.1990. *Haplopappus lanceolatus* (Hooker) Torrey and Gray; 1 ♂; open meadow on N shore of Frenchman Lake at 1703 m, Plumas Nat. Forest, Plumas Co.;

22.viii.1989. *Haplopappus propinquus* Blake; 1 ♂; Mountain Springs Pass, SE San Diego Co.; 7.x.1987. *Haplopappus racemosus* (Nuttall) Torrey; 1 ♀; saline, grassy meadow in Fish Slough, 10 km N of Bishop at 1225 m, Inyo Co.; 9.x.1990. *Hemizonia kelloggii* Greene; 1 ♂; Valle Vista at 546 m, Riverside Co.; 1.vii.1988. *Holocarpa heermannii* (deCandolle) Greene; 10 ♂ and 5 ♀; Tule River Indian Reservation above S Fork of Tule River at 438 m, Tulare Co.; 17.v.1989. *Holocarpa virgata* (Gray) Keck; 4 ♂ and 7 ♀; E of Sacramento off State Highway 50 at 128 m, Sacramento Co.; 7.ix.1987. *Lessingia glandulifera* Gray; 1 ♂ and 1 ♀; dry bed of Hamilton Creek, E of Anza at 1222 m, Riverside Co.; 28.ix.1989. *Lessingia lemmonii* Gray; 1 ♂; Big Meadow, S of Tom's Place above Round Valley at 1966 m, Mono Co.; 10.x.1990. *Lessingia nemaclada* Greene; 1 ♂ and 1 ♀; Big Sandy Bluff along State Highway 168 at 1280 m, Sierra Nat. Forest, Fresno Co.; 17.viii.1988. *Machaeranthera tephrodes* (Gray) Greene; 1 ♂ and 1 ♀; W end of Jacumba at 866 m, San Diego Co.; 6.xi.1986. *Monolopia lanceolata* Nuttall; 35 ♂ and 39 ♀; Tremlor Range, along State Highway 58, E of California Valley, San Luis Obispo Co.; 10.iv.1987. *Perezia microcephala* (deCandolle) Gray; 2 ♀; mouth of Mill Creek Canyon at 1200 m, San Bernardino Nat. Forest (N section), SW San Bernardino Co.; 6.vii.1989. *Viguiera laciniata* Gray; 2 ♀; 5 km S of Alpine at 460 m, San Diego Co.; 18.iv.1989.

Trupanea jonesi Curran

New host genera: Achrachaena, Antennaria, Aster, Blepharipappus, Brickellia, Chrysopsis, Hulsea, Lasthenia, Madia, Monolopia.

New host records: Achrachaena mollis Schauer; 10 ♂ and 12 ♀; S of Camp Roberts Military Reservation, near Chimney Rock, San Luis Obispo Co.; 19.iv.1988. *Antennaria rosea* Greene; 1 ♂ and 1 ♀; along Deadman Creek at 2408 m, Inyo Nat. Forest, Mono Co.; 21.vii.1987. *Arnica longifolia* deCandolle; 34 ♂ and 27 ♀; Deadman Creek, W of Sonora Pass at 2790 m, Stanilaus Nat. Forest, Tuolumne Co.; 8.ix.1988. *Arnica sororia* Greene; 16 ♂ and 26 ♀; along Deadman Creek at 2499 m, Inyo Nat. Forest, Mono Co; 9.ix.1986. *Artemisia cana* Pursh; 1 ♀; Campito Meadow on White Mountain at 3246 m, Inyo Nat. Forest, Mono Co.; 19.viii.1987. *Artemisia michauxiana* Besser; 1 ♂; below Patriarch Grove on White Mountain at 3414 m, Inyo Nat. Forest, Mono Co.; 19.viii.1987. *Aster alpigenus* (Torrey and Gray) Gray; 7 ♂ and 13 ♀; Kaiser Pass Meadow at 2720 m, Sierra Nat. Forest, Fresno Co.; 17.viii.1988. *Aster campestris* Nuttall; 3 ♂ and 1 ♀; E side of Frenchman Lake at 1728 m, Plumas Nat. Forest, Plumas Co.; 22.viii.1989. *Aster eatonii* (Gray) Howell; 15 ♂ and 18 ♀, above Perazo Meadow, Tahoe Nat. Forest, Sierra Co.; 10.ix.1986. *Aster integrifolius* Nuttall; 36 ♂ and 34 ♀; Jackass Meadow at 2256 m, Sequoia Nat. Forest, Tulare Co.; 24.vii.1984. *Aster occidentalis* (Nuttall) Torrey and Gray; 21 ♂ and 23 ♀; W of Sonora Pass at 2850 m, Stanilaus Nat. Forest, Tuolumne Co.; 8.ix.1988. *Blepharipappus scaber* Hooker; 1 ♂; W of Fandango Pass at 1615 m, Modoc Nat. Forest, Modoc Co.; 23.viii.1989. *Brickellia oblongifolia*; 2 ♀; Waucoba Canyon, Inyo Nat. Forest, Inyo Co.; 10.vi.1987. *Chaenactis glabriuscula* deCandolle; 9 ♂ and 9 ♀; junction of La Panza Road and State Highway 58 at 433 m, San Luis Obispo Co.; 18.iv.1990. *Chaenactis parishii* Gray; 1 ♂ and 2 ♀; Santa Rosa Mountain at 1554 m, San Bernardino Nat. Forest (S section), Riverside Co.; 3.vi.1987. *Chaenactis santolinoides* Greene; 1 ♂ and 1 ♀; Burnt Peak, Angeles Nat. Forest, Los Angeles Co.; 28.v.1988. *Chaenactis steviodes* Hooker and Arnott; 7 ♂ and 9 ♀; Walker Well, N side of Freeman Canyon, E of Walker Pass, Kern Co.; 8.v.1990. *Chaenactis xantiana* Gray; 40 ♂ and 29 ♀; Shell Creek Road, Avenales Wildlife Area at 390 m, San Luis Obispo Co.; 18.iv.1990. *Chrysopsis breweri* Gray; 1 ♂ and 2 ♀; NE of Shaver Lake at 2170 m, Sierra Nat. Forest, Fresno Co.; 17.viii.1988. *Coreopsis bigelovii* (Gray) Hall; 1 ♂ and 3 ♀; N side of Yucca Valley at 1173 m, SW San Bernardino Co.; 16.iii.1988. *Eriophyllum ambiguum* (Gray) Gray; 4 ♂ and 4 ♀; Spanish Needle Creek, S of Lamont Peak at 1250 m, Kern Co.; 11.iv.1989. *Eriophyllum lanatum*; 4 ♂ and 5 ♀; Deadman Creek, along Deadman Creek at 2499 m, Inyo Nat. Forest, Mono Co.; 21.vii.1987. *Haplopappus acaulis* (Nuttall) Gray; 7 ♂ and 5 ♀; N of Crooked Creek, White Mountain at 3173 m, Inyo Nat. Forest, Mono Co.; 26.vii.1989. *Haplopappus apargioides* Gray; 2 ♂; Poison Creek on White Mountain at 3155 m, Inyo Nat. Forest, Mono Co.; 19.viii.1987. *Haplopappus bloomeri*; 8 ♂ and 4 ♀; Niagra Creek Campground at 1900 m, Stanilaus Nat. Forest, Tuolumne Co.; 8.ix.1988. *Haplopappus cooperi* (Gray) Hall; 1 ♂ and 1 ♀; Walker Well, N side Freeman Canyon, E of Walker Pass, Kern Co.; 8.v.1990. *Haplopappus lanceolatus* (Hooker) Torrey and Gray; 5 ♂ and 6 ♀; meadow on shore of Frenchman Lake at 1704 m, Plumas Nat. Forest, Plumas Co.; 22.viii.1989. *Haplopappus macronema* Gray; 1 ♂ and 4 ♀; Deadman Creek, W of Sonora Pass at 2790 m, Stanilaus Nat. Forest, Tuolumne Co.; 8.viii.1988. *Haplopappus suffruticosus* (Nuttall) Gray; 2 ♂ and 6 ♀; County Line Hill on White Mountain at 3170 m, Inyo Nat. Forest, Mono Co.; 19.viii.1987. *Hulsea vestita* Gray; 2 ♂; rocky scree near Big Meadow at 2286 m, Sequoia Nat. Forest, Tulare Co.; 12.vi.1985. *Lasthenia californica* deCandolle ex Lindley; 2 ♂; Figueroa Mountain at 792 m, Los Padres Nat. Forest, Santa Barbara Co.; 17.iv.1985. *Lasthenia glabrata* Lindley; 1 ♂; San Jacinto Valley, Riverside Co.; 3.vi.1987. *Layia ziegleri* Munz; 1 ♂ and 3 ♀; Junction of State Highways 74 and 371, Burnt Valley at 1372 m, San Bernardino Nat. Forest (S section), Riverside Co.; 12.v.1988. *Madia gracilis* (Smith) Keck; 3 ♀; Silver Lake at 2195 m, Inyo Nat. Forest, Mono Co.; 21.vii.1987. *Monolopia lanceolata*; 1 ♂; Tremlor Range, along State Highway 58, E of California Valley, San Luis Obispo Co.; 10.iv.1987. *Senecio breweri* Davy; 4 ♂ and 2 ♀; Doney, S of Woody at 1006 m, Kern Co.; 18.v.1989. *Senecio integerrimus* Nuttall; 6 ♂ and 5 ♀; S of Patriarch Grove, White Mountain at 3149 m, Inyo Nat. Forest, Mono Co.; 26.vii.1989. *Senecio multilobatus* Torrey and Gray; 4 ♂ and 9 ♀; White Mountain at 3048 m, Inyo Nat. Forest, Inyo Co.; 18.vi.1986. *Senecio serra* Hooker; 1 ♂; June Lake at 2316 m, Inyo Nat. Forest, Mono Co.; 21.vi.1987. *Senecio triangularis* Hooker; 10 ♂ and 6 ♀; Dana Plateau on White Mountain at 3353 m, Inyo Nat. Forest, Mono Co.; 8.viii.1986. *Solidago californica* Nuttall; 1 ♂ and 1 ♀; 4.8 km W of Hat Creek, Lassen Nat. Forest, Shasta Co.; 24.viii.1989. *Solidago canadensis* L.; 2 ♂ and 5 ♀; along Deadman Creek at 2499 m, Inyo Nat. Forest, Mono Co.; 9.ix.1986. *Solidago multiradiata* Aiton; 3 ♂; Horseshoe Meadow at 2926 m, Inyo Nat. Forest, Inyo Co.; 22.vii.1987.

Trupanea nigricornis (Coquillett)

New host genera: Amphipappus, Dicoria, Geraea, Madia, Monolopia.

New host records: Amphipappus freemontii Torrey and Gray; 1 ♂; Wheeler Canyon at 1204 m, Inyo Nat. Forest, Inyo Co.; 21.v.1988. *Baccharis sarathroides* Gray; 1 ♂; Proctor Valley at 168 m, SW San Diego Co.; 8.x.1987. *Chrysothamnus albidus* (Jones) Greene; 1 ♂ and 1 ♀; Fish Slough, N of Bishop at 1286 m, Inyo Co.; 21.viii.1989. *Chrysothamnus parryi* (Gray); 2 ♂; above Jackass Meadow, Sequoia Nat. Forest, Tulare Co.; 24.vii.1984. *Dicoria canescens* Torrey and Gray; 2 ♂ and 1 ♀; sand dunes at Glamis, Imperial Co.; 5.xi.1986. *Eriophyllum lanatum*; 1 ♂; Crowder Flat at 1542 m, Modoc Nat. Forest, Modoc Co.; 23.viii.1989. *Geraea viscida* (Gray) Blake; 4 ♂ and 7 ♀; Kitchen Creek Canyon, Cleveland Nat. Forest, San Diego Co.; 27.iv.1985. *Haplopappus bloomeri* Gray; 6 ♂ and 4 ♀; Beasore Meadow at 1970 m, Sierra Nat. Forest, Madera Co.; 16.viii.1988. *Haplopappus linearifolius* deCandolle; 1 ♂; along

Sherman Pass Road above N Meadow Creek at 1585 m, Sequoia Nat. Forest, Tulare Co.; 21.v.1986. *Haplopappus propinquus* Blake; 1 ♀; Mountain Springs Pass, Inyo Co.; 7.x.1987. *Haplopappus squarrosus*; 1 ♂; Kitchen Creek Canyon, Cleveland Nat. Forest, San Diego Co.; 23.x.1985. *Haplopappus suffruticosus* (Nuttall) Gray; 1 ♂; County Line Hill, White Mountain at 3170 m, Inyo Nat. Forest, Mono Co.; 19.viii.1987. *Iva axillaris* Pursh; 1 ♀; NW of Chimney Peak, Sequoia Nat. Forest, Tulare Co.; 30.vii.1986. *Machaeranthera tortifolia* (Gray) Cronquist and Keck; 6 ♂ and 6 ♀; Death Valley Road, Last Chance Mountain Range at 975 m, Inyo Co.; 9.vi.1987. *Perezia microcephala*; 7 ♂ and 4 ♀; Mill Creek Canyon at 1250 m, San Bernardino Nat. Forest (N section), SW San Bernardino Co.; 28.vii.1990. *Psathyrotes annua* (Nuttall) Gray; 1 ♂ and 1 ♀; Fish Slough, N of Bishop at 1314 m, Mono Co.; 25.vii.1990. *Psathyrotes ramosissima* (Torrey) Gray; 1 ♂ and 5 ♀; Painted Canyon, Riverside Co.; 28.xi.1984. *Tetradymia glabrata* Gray; 71 ♂ and 62 ♀; Payson Canyon at 1707 m, Inyo Co.; 18.vi.1986. *Viguiera lacinata*; 2 ♀; W of Barrett Junction, N of Tecate Peak at 335 m, San Diego Co.; 4.iii.1988. *Viguiera reticulata* Watson; 12 ♂ and 11 ♀; Death Valley Road, base of Last Chance Mountain at 1128 m, Inyo Co.; 17.vi.1986.

Trupanea radifera (Coquillett)

New host genera: Atrichoseris, Brickellia, Calycoseris, Dyssodia, Erigeron, Haplopappus, Lasthenia.

New host records: Atrichoseris platyphylla Gray; 4 ♂ and 7 ♀; Death Valley Road at 835 m, N of Death Valley Nat. Monument, Inyo Co.; 18.v.1988. *Brickellia oblongifolia*; 2 ♀; Santa Rosa Mountain at 1402 m, San Bernardino Nat. Forest (S section), Riverside Co.; 3.vi.1987. *Calycoseris wrightii* Gray; 1 ♂ and 1 ♀; Death Valley Road, Last Chance Range at 178 m, Inyo Co.; 9.vi.1987. *Dyssodia cooperi* Gray; 1 ♂ and 2 ♀; Kane Springs, NE of Barstow near Rodman Mountains, W San Bernardino Co.; 4.v.1988. *Erigeron aphanactis* (Gray) Greene; 1 ♂; Hanging Rock Canyon, Last Chance Range at 1554 m, Inyo Co.; 17.vi.1986. *Eriophyllum lanosum* (Gray) Gray; 12 ♂ and 13 ♀; Lobeck's Pass, E San Bernardino Co.; 24.iii.1988. *Haplopappus apargioides*; 2 ♂ and 4 ♀; Poison Creek on White Mountain at 3155 m, Inyo Nat. Forest, Mono Co.; 19.viii.1987. *Haplopappus squarrosus*; 1 ♀; Poison Creek on White Mountain at 3246 m, Inyo Nat. Forest, Mono Co.; 19.viii.1987. *Lasthenia californica* deCandolle; 2 ♂ and 4 ♀; Warner Springs, San Diego Co.; 30.iv.1986. *Malacothrix saxatilis* (Nuttall) Torrey and Gray; 10 ♂ and 10 ♀; Mill Creek Canyon at 1230 m, San Bernardino Nat. Forest, SW San Bernardino Co.; 5.vi.1987. *Malacothrix sonchoides* (Nuttall) Torrey and Gray; 18 ♂ and 16 ♀; Death Valley Road at 853 m, N of Death Valley Nat. Monument, Inyo Co.; 18.v.1988. *Microseris campestris* Greene; 8 ♂ and 3 ♀; E of Pozo in Frazer Canyon at 500 m, Los Padres Nat. Forest, San Luis Obispo Co.; 17.iv.1990. *Microseris douglasii* (deCandolle) Schultz; 2 ♀; N of Parkfield, S of summit at 686 m, Monterey Co.; 18.iv. 1989. *Senecio breweri*; 1 ♂; E of Lake San Antonio at 344 m, Monterey Co.; 20.iv.1989. *Senecio multilobatus*; 4 ♂ and 4 ♀; White Mountain at 3048 m, Inyo Nat. Forest, Inyo Co.; 29.vii.1986.

Trupanea signata Foote

New host record: Gnaphalium luteo-album L.; 4 ♂ and 2 ♀ (reared from puparia dissected from galls on branches and stems of); N of Lake Hemet, Riverside Co.; 29.ix.1989.

Trupanea vicina (van der Wulp)

New host genus: Pectis.

New host record: Pectis papposa Harvey and Gray ex Gray; 1 ♂; just N of Signal Mountain, Imperial Co.; 29.xi.1984.

Trupanea wheeleri Curran

New host genera: Baccharis, Brickellia, Helianthus, Perezia.

New host records: Baccharis plummerae Gray Canada de Media; 2 ♂ and 1 ♀; Santa Cruz Island, Santa Barbara Co.; 7.x.1985. *Baccharis sarathroides*; 1 ♀; Proctor Valley at 168 m, SW San Diego Co.; 8.x.1987. *Brickellia oblongifolia*; 2 ♂ and 4 ♀; Santa Rosa Mountain at about 1400 m, San Bernardino Nat. Forest (S section), Riverside Co.; 14.vi.1988. *Chaenactis artemisiaefolia* (Harvey and Gray) Gray; 14 ♂ and 14 ♀; Aguanga Mountain at 1128 m, Cleveland Nat. Forest, San Diego Co.; 5.vi.1985. *Chrysothamnus teretifolius*; 15 ♂ and 19 ♀; Mountain Springs at 700 m, SW Imperial Co.; 6.xi.1986. *Haplopappus acradenius* (Greene) Blake; 2 ♂ and 2 ♀; Mountain Springs at 699 m, SW Imperial Co.; 6.xi.1986. *Haplopappus detonsus* (Greene) Raven; 1 ♀; Prisoners' Harbor, Santa Cruz Island, Santa Barbara Co.; 13.ix.1984. *Haplopappus linearifolius*; 1 ♀; Mill Creek Canyon at 1219 m, San Bernardino Nat. Forest (N section), SW San Bernardino Co.; 8.v.1987. *Haplopappus palmeri* Gray; 34 ♂ and 27 ♀; N of Barrett Junction at 305 m, San Diego Co.; 20.x.1987. *Helianthus gracilentus* Gray; 5 ♂ and 5 ♀; San Ysidro, SW San Diego Co.; 10.iv.1987. *Hemizonia fasciculata* (deCandolle) Torrey and Gray; 8 ♀; Otay Mesa at 168 m, above San Ysidro, SW San Diego Co.; 31.v.1989. *Perezia microcephala*; 146 ♂ and 143 ♀; mouth of Mill Creek Canyon at 1200 m, San Bernardino Nat. Forest (N section), SW San Bernardino Co.; 28.vi.1989. *Solidago occidentalis* (Nuttall) Torrey and Gray; 1 ♂ and 2 ♀; Carpenteria, Santa Barbara Co.; 4.x.1987.

DISCUSSION

The host-plant specificities of *Trupanea* species reported from California after 11 years of field study remain largely as I initially assessed them (Goeden 1985), with a few noteworthy exceptions. *Trupanea pseudovicina* Hering continues to be assessed as a strictly monophagous species (Goeden 1985). *Trupanea arizonensis* Malloch reared from flower heads of *Trixis californicus* Kellogg was misidentified by me as *Trupanea actinobola* in Goeden (1985); although, the latter species also has been identified by F. L. Blanc (in litt. 1991) among other specimens that I reared from heads of this same host plant from the same location. I still have not reared *T. maculigera* Foote or *T. texana*; although, another rare species for which no host was known, *T. signata,* has since been reared, as reported above. *Trupanea signata* is now known to be a monophagous or nearly monophagous, obligate gall former, and its biology and ecology currently are under study in southern California (Goeden, Headrick, and Teerink, unpublished data). This discovery lent credence to the rearing record for *T. maculigera* from "galls in *Gnaphalium* sp." in Foote (1960), a reported mode of development on which neither he nor Wasbauer (1972) commented, perhaps because it may have been suspect at that time for any *Trupanea.* However, since then, Goeden (1987) reported facultative gall formation by *T. conjuncta* (Adams), and in the present paper, obligate gall formation by *T. signata.* Thus, it is quite probable that *T. maculigera* is indeed an obligate gall former on a still to be determined species of *Gnaphalium* (Foote 1960). Unfortunately, the rearing record from 1950 in Foote (1960) is from San Ysidro, California, just north of the border at Tijuana, Mexico, and presently this is a highly disturbed and otherwise problematic area in which to collect. Nevertheless, I am now in active pursuit of this tephritid in less disturbed, undeveloped areas along the border to the east in southcentral San Diego County.

The following species remain classed as oligophagous species (known from one host tribe, Goeden 1985): *T. bisetosa* (Coquillett), now known from four genera and six species of hosts, all in the tribe Heliantheae

Table 1. Numbers of host genera and species (tabulated as genera/species) for 16 species of *Trupanea* reported from nine tribes of Asteraceae in California.

	Tribes									
Trupanea sp.	Anthemideae	Astereae	Cichorieae	Eupatorieae	Helenieae	Heliantheae	Inuleae	Murtiseae	Senecioneae	Totals
actinobola	1/1	8/14	—	1/1	4/5	1/1	—	1/1	1/1	17/24
arizonensis	—	—	—	—	—	—	—	1/1	—	1/1
bisetosa	—	—	—	—	—	4/6	—	—	—	4/6
californica	—	—	—	—	—	—	2/9	—	—	2/9
conjuncta	—	—	—	—	—	—	—	1/1	—	1/1
femoralis	—	9/22	—	1/1	2/2	3/6	—	1/1	2/2	18/34
imperfecta	—	—	—	—	—	3/3	—	—	—	3/3
jonesi	1/5	9/31	2/2	1/1	8/19	9/13	2/2	—	5/13	37/86
maculigera	—	—	—	—	—	—	1/1	—	—	1/1
nigricornis	—	10/28	—	2/6	3/3	6/12	—	1/1	5/9	27/59
pseudovicina	—	—	—	—	1/1	1/1[a]	—	—	—	2/2
radifera	—	8/10	5/11	2/2	7/8	1/1	—	—	1/3	24/35
signata	—	—	—	—	—	—	2/2	—	—	2/2
texana	—	—	—	—	—	—	—	—	—	—
vicina	—	—	—	—	4/4	1/1	—	—	—	5/5
wheeleri	—	6/19	—	1/2	3/3	3/5	—	1/1	—	14/30

[a] The host record represented here for *Bebbia juncea* (Bentham) Greene in Wasbauer (1972) is probably erroneous (Goeden 1985, 1988, Goeden and Ricker 1989).

(Cavender and Goeden 1983, Table 1); *T. californica* Malloch, now known from two genera and nine species of hosts, all in the tribe Inuleae (Headrick and Goeden 1991, Table 1); and *T. imperfecta* (Coquillett), still known from three genera and three species, all in the tribe Astereae (Goeden 1988, Table 1).

Trupanea vicina (van der Wulp) is now assessed as nearly oligophagous (Goeden 1985). It is now known from five host species in five genera, four of which are in the tribe Helenieae, with a fifth host in the tribe Heliantheae (Table 1). This occasional pest of ornamental marigolds, *Tagetes* sp., recently also was selected for field and laboratory study in southern California.

The diversity of host plants attacked by each of the six species designated as generalists by Goeden (1985) was made even more apparent by the many new records presented in the present paper. Each of the following generalists is now known to infest hosts from at least five tribes of Asteraceae (Table 1), but only from this plant family, which thus serves to distinguish them from polyphages by my definition (Goeden 1985).

Trupanea actinobola is now known from nine tribes, 22 genera, and 38 species of Asteraceae in North America (Wasbauer 1972, Goeden 1985, and the present study). Twenty-four (63%) of its known hosts are from California (Table 1), and all but two of these represent my rearing records. One host species was reported by Wasbauer (1972) from each of the tribes Cichorieae and Inuleae, although I have not reared this fly from either tribe (Table 1). The majority of its hosts are in the tribes Astereae and Helenieae in California (Table 1).

Trupanea femoralis is now known from six tribes, 18 genera, and 34 species of Asteraceae in North America (Wasbauer 1972, Goeden 1985, 1986, and the present study). All 34 of its known hosts occur in California, and all but seven of these represent my rearing records. The majority of its hosts in California also are Asteraceae (Table 1).

Trupanea jonesi now has the broadest host range in terms of known genera and species attacked of any native tephritid from California, indeed, probably from North America (Wasbauer 1972, Goeden 1985). As reported to date, its host range comprises eight tribes, 37 genera, and 86 species of Astereae in North America (Wasbauer 1972, Goeden 1985, and the present study). Only *T. actinobola* is known from more tribes, though fewer genera and species (see above). All 86 of the known hosts of *T. jonesi* are from California, and all but 13 of these represent my rearing records, including two from Wasbauer (1972) which I have confirmed. Again, most hosts of *T. jonesi* in California belong to the Astereae, with good representation also in the tribes Helenieae, Heliantheae, and Senecioneae (Table 1).

Trupanea nigricornis was one of the first generalists in this genus to have its biology studied in some detail (Cavender and Goeden 1983). It is currently under even more detailed study in southern California (Knio and Goeden, unpublished data), in comparison with its cryptic, sympatric, oligophagous congener, *T. bisetosa,* previously studied by Cavender and Goeden (1982). The known host range of *T. nigricornis* comprises seven tribes, 28 genera, and 60 species of Asteraceae (Wasbauer 1972, Cavender and Goeden 1983, Goeden 1985, and the present paper). All 60 hosts are from California, 55 of which represent my host records (Table 1). I have not confirmed five records in Wasbauer (1972), one of which, for *Carthamus tinctorius* L. in the tribe Cynareae is highly suspect in my opinion, and therefore, was not listed in Table 1. *Trupanea nigricornis* is otherwise unknown from thistles in the tribe Cynareae, the insect fauna and ecology of several native and introduced species of which have been studied in southern California for many years by my co-workers and me (c.f. Goeden and Ricker 1986, 1987). Moreover, no *Trupanea* species otherwise has been reared from Cynareae in California (Goeden and Ricker 1986, 1987; Table 1) or elsewhere in North America (Wasbauer 1972).

Trupanea radifera is now known from five tribes, 24 genera, and 35 species of Asteraceae in North America (Wasbauer 1972, Goeden 1985, and the present study). All but one host species occur in California (Table 1), and all but two hosts represent my rearing records. Most hosts of this tephritid belong to the tribes Cichorieae, Eupatorieae, and Helenieae (Table 1).

Trupanea wheeleri is now known from five tribes, 14 genera, and 29 species of host plants in North America (Wasbauer 1972, Goeden 1985, and the present study). All of its known hosts are from California and represent my rearing records. The majority of its hosts belong to the Astereae (Table 1).

I have stressed the contribution of California Asteraceae to knowledge of the hosts of these species of *Trupanea* in order to demonstrate how little is known about the host plants of these species elsewhere in North America. Only *T. maculigera* among them is known solely from California (Foote and Blanc 1963, F. L. Blanc in litt. 1991). Most other species of *Trupanea* occur in several western states; some, like *T. actinobola,* are distributed across North America (Foote 1960). Thus, this lack of knowledge of hosts, let alone biologies, involves one of the largest, most common, and widespread genera of nonfrugivorous Tephritidae native to the western United States (Foote 1960, Foote and Blanc 1963, Blanc and Foote 1987). The amount of fundamental data still to be obtained on the hosts of these and other nonfrugivorous Tephritidae is truely awesome.

The data in Table 1 for the six oligophagous species also demonstrate that their hosts are not limited to one or two favored tribes of Asteraceae, but rather may also involve scattering of only one or two hosts in each of several other tribes. Whether the flies on these few taxonomically isolated hosts in less well exploited tribes represent evolutionarily younger relationships resulting from host-plant transfers from one of the better utilized host tribes is an intriguing question. Or are these relationships the vestiges of formerly, more heavily utilized tribes? The low numbers of flies reared from some host species indicate that those hosts were less suitable than others for reproduction (Goeden 1985). Thus, the question arises as to what drives these host transfers? Is it tephritid competition for natural enemy-free space (Price et al. 1980, Zwölfer 1982, Strong et al. 1984)? Or positive behavioral responses to similar flower head morphology (Zwölfer 1982, 1988)? Or, to similar host-plant architecture (Strong et al. 1984)? Or, perhaps, some or all of these factors, and more? And, from which taxa did their ancestors transfer? Presumably each transfer would involve biochemically closely related host taxa (Erlich and Raven 1964, Zwölfer 1987, 1988, Futuyma and McCafferty 1990).

The hosts of the generalist species represented in Table 1 are not clustered in one or two tribes, as one might expect from intra-tribal host shifts among closely related hosts. Nor are they clustered in only a few genera within the more heavily exploited tribes (Table 1). It would appear that the life strategies of these generalists is to "spread the risk" by reproducing on a wide range of hosts (Zwölfer 1983), or to specialize in not specializing (Moran and Southwood 1982).

Trupanea californica, T. maculigera, or *T. signata* may represent the products of a past, intertribal host-transfer by a facultative gall-forming, flower-head infesting ancestor like *T. conjuncta* (Goeden 1987) to the Inuleae, and the subsequent separation and speciation of its descendants as an obligate flower head-infesting species like *T. californica* (Headrick and Goeden 1991), and obligate gall-formers like *T. signata* and *T. maculigera* on the same or congeneric host plants. Perhaps, *T. vicina* also provides evidence of a former host transfer from the Helenieae to the Heliantheae (Table 1), or vice-versa.

Resource sharing is practiced by *Trupanea* species at both the host species as well as at the host deme and individual flower head levels in southern California, as noted by Goeden (1985). Zwölfer (1987, 1988) has studied resource sharing among Tephritidae in flower heads of European Cynareae. All species of *Trupanea* for which hosts are known, except probably *T. imperfecta* (Goeden 1988), share some of their hosts with other species of *Trupanea* (Table 2). The number of congeneric species with which hosts are shared varies from a low of one each for *T. californica* and *T. signata*; to two congeners for *T. arizonensis, T. bisetosa, T. conjuncta, T. pseudovicina,* and *T. vicina*; to five congeners for *T. nigricornis* and *T. wheeleri*; to six congeners for *T. femoralis* and *T. radifera*; to seven congeners for *T. jonesi*; to a high of eight congeners for *T. actinobola.* Generally, the stenophagous species share their hosts with the least number of congeners in California (Tables 1 and 2).

Each generalist species of *Trupanea* also shares many of its host species in California, and mainly with one to five other congeneric generalists. *Trupanea actinobola* shares 12 (50%) of its 24 reported host species with congeners; *T. femoralis* similarly shares 24 (71%) of its 34 reported hosts; *T. jonesi* shares 34 (40%) of its 86 reported hosts; *T. nigricornis* shares 38 (63%) of its 60 reported hosts; *T. radifera* shares 15 (43%) of its 35 reported hosts; and *T. wheeleri* shares 22 (73%) of its 30 reported hosts. At least two host species are now known to be shared by all six generalist species in southern California: *Brickellia oblongifolia* Nuttall, an occasional, spring-blooming subshrub in dry, stony places below 2700 m in the tribe Eupatorieae; and *Haplopappus squarrosus* Hooker and Arnott, a common, many stemmed, low, fall-blooming shrub on dry slopes below 1400 m in the tribe Astereae (Munz 1974).

The tribes Astereae, Cichorieae, Helenieae, Heliantheae, and Senecioniae contain the most host-plant genera and species recorded for *Trupanea* flies (Table 1). These tribes

Table 2. Number of host-plant species shared by each of 14 *Trupanea* species with its congeners in California as known to date (see text).

	actinobola	*arizonensis*	*bisetosa*	*californica*	*conjuncta*	*femoralis*	*imperfecta*	*jonesi*	*nigricornis*	*pseudovicina*	*radifera*	*signata*	*vicina*	*wheeleri*
actinobola	—	1	—	—	1	6	—	6	8	1	3	—	—	3
arizonensis	1	—	—	—	1	—	—	—	—	—	—	—	—	—
bisetosa	—	—	—	—	—	1	—	1	—	—	—	—	—	—
californica	—	—	—	—	—	—	—	—	—	—	—	2	—	—
conjuncta	1	1	—	—	—	—	—	—	—	—	—	—	—	—
femoralis	6	—	1	—	—	—	—	11	16	—	4	—	—	12
imperfecta	—	—	—	—	—	—	—	—	—	1[a]	—	—	—	—
jonesi	6	—	1	—	—	11	—	—	19	—	10	—	1	9
nigricornis	8	—	—	—	—	16	—	19	—	—	7	—	—	16
pseudovicina	1	—	—	—	—	—	1[a]	—	—	—	—	—	—	—
redifera	3	—	—	—	—	4	—	10	7	—	—	—	1	3
signata	—	—	—	2	—	—	—	—	—	—	—	—	—	—
vicina	—	—	—	—	—		—	1	—	—	1	—	—	—
wheeleri	3	—	—	—	—	12	—	9	16	—	3	—	—	—

[a] See footnote to Table 1.

also are the largest of the total of 12 tribes found in southern California, comprising 22, 23, 25, 30, and seven genera and 117, 61, 65, 89, and 32 species, respectively (Munz and Keck 1959, Munz 1968, 1974).

Several stenophagous species of gall-forming or flower head-infesting Tephritidae have found use in the biological control of weeds (Harris 1989). The dispersed pattern of host-plant incidence depicted in Table 1 also has implications for host-specificity determination of Tephritidae under consideration as candidate agents for biological control. This is because current methods of testing and defining host-plant specificity and safety of use of agents rely principally on a centrifugally arranged array of test plants clustered about the target weed and its most closely taxonomically-allied, cultivated relative, termed a "critical test plant" (Zwölfer and Harris 1971, Wapshere 1974). Away from this central cluster of closely related plants are species representative of other tribes of Asteraceae selected for further definition of the outer limits of the host range of the tephritid. The data in Table 1 suggest that these tribal representatives, often also selected on the basis of availability or ease of culture, probably would not be one of the few host species in those tribes to be attacked by that oligophagous tephritid in nature. These data also demonstrate that hosts of nearly oligophagous, nonfrugivorous tephritids are not necessarily clustered within single tribes of Asteraceae, e.g. *T. vicina.* This is not to denigrate the enviable record that biological control workers have achieved to date in predicting the safety of introduction of phytopagous arthropods (Zwölfer and Harris 1971, Wapshere 1974, Schroeder and Goeden 1986). Rather, these data should simply serve to remind biological control of weed workers that continued caution should be employed, and that overreliance on conventional wisdom that hosts are clustered within taxonomically defined aggregations may be problematic.

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BALDCYPRESS, *TAXODIUM DISTICHUM* (CONIFERALES: TAXODIACEAE), A PRIMARY FOOD SOURCE OF GYPSY MOTH, *LYMANTRIA DISPAR,* IN MARYLAND (LEPIDOPTERA: LYMANTRIIDAE)

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Abstract.—We observed gypsy moths, *Lymantria dispar,* feeding on baldcypress, *Taxodium distichum* during 1987 on the Maryland portion of the Del-Mar-Va peninsula. This is the first record of baldcypress as a natural food source of gypsy moths. Three sites dominated by baldcypress (>50%) in Worcester County, Maryland were sampled during 1989 to determine whether gypsy moths could utilize this species as a primary food source and for oviposition sites. Gypsy moth larvae fed readily on baldcypress needles in the laboratory, and underwent metamorphosis, mated and oviposited on an exclusive diet of this deciduous conifer. The average number of egg masses per tree (at two sites) increased from 5.5 to 10.5 (a 95% increase) between March and September 1989. Seventy-seven percent of laboratory reared larvae fed exclusively on baldcypress needles, completed larval development and emerged as adults.

Key Words: Lepidoptera, Lymantriidae, *Lymantria dispar,* gypsy moth, *Taxodium distichum,* baldcypress, Maryland

The gypsy moth, *Lymantria dispar,* was first reported in Maryland (Cecil County) in 1969 and has subsequently spread statewide. Although gypsy moth larvae prefer oaks (*Quercus* spp.) as their primary host, they are polyphagous and will feed on a variety of different plant species if oaks are not available (Johnson and Lyon 1988). For example, Forbush and Fernald (1896) found 458 different plant species acceptable as hosts, whereas Mosher (1915) tested 152 different hosts and concluded that most conifers were unsatisfactory food sources, including baldcypress. Rossiter (1987) studied the utilization of pitch pine, *Pinus rigida* Miller, as food source for the gypsy moth and found that later instars were able to feed successfully on this evergreen conifer. Doskotch et al. (1977) and Jermy et al. (1968) found several other conifers that served as a primary food source for gypsy moth larvae. Based on gypsy moth feeding responses to plant extracts, Doskotch et al. (1977) categorized 29 plant species as either "stimulant" hosts (>50% feeding rate), or "neutral" hosts (<50% feeding rate). They considered baldcypress a "neutral" host. There are several recent records of gypsy moth larvae feeding on conifers in the northwestern United States (Miller and Hanson 1989, Joseph 1990, Miller et al. 1991). Miller and Hanson (1989) tested three native North American species of Taxodiaceae as suitable hosts for gypsy moth. They found that Redwood (*Sequoia sempervirens*) and Giant sequoia (*Sequoiadendron* *gigantea*) were suitable hosts, whereas Dawn redwood (Metasequoia glyptostroboides) was not suitable.

Baldcypress is injured by several insects but damage is usually minor (Goyer and Lenhard 1988), and this species is considered to be relatively free of severe insect pests (Elias 1980). Bagworm (*Thyridopteryx ephemeraeformis*) is a common defoliator of baldcypress in Maryland and Delaware during late summer and early fall, but defoliation by this species is apparently never complete and damage is usually minimal (personal observation). The cypress looper (*Anacamptodes pergacilis*) is known to cause significant damage to needles of baldcypress periodically in Arkansas, Georgia, Florida and Maryland (Baker 1972, Johnson and Lyon 1988). The fruit tree leafroller, (*Archips argyrospila*), previously unknown as a pest of baldcypress, became epidemic on this species in southern Louisiana in 1983 (Goyer and Lenhard 1988). Goyer and Lenhard (1988) reported severe defoliation of baldcypress by this leafroller with some dieback, but no mortality in mature trees. All other known pests of baldcypress either damage cones or other plant parts but do not cause defoliation (Wilhite and Toliver 1990).

During 1987 we discovered gypsy moth larvae feeding extensively on baldcypress within the floodplain of the Pocomoke River in Worcester County, Maryland. This paper documents the first record of gypsy moth utilizing baldcypress as a natural primary host and reports observations on natural populations and laboratory reared larvae feeding on this plant species.

MATERIALS AND METHODS

We studied natural populations of gypsy moth on baldcypress at three sites selected during March 1989 in Worcester County, Maryland. These sites are: (1) Furnace Town, on Furnace Town Road, 6.4 km NW of Snow Hill; (2) Millville Road off Furnace Town Road, 7.7 km NW of Snow Hill and 1.3 km N of Furnace Town Road; and (3) Liberty Town Road, 12.5 km N of Berlin. Criteria for site selection were >50% baldcypress per stand and >200 egg masses per site based on a 1/40 acre survey. A 1/40 acre survey was conducted during the initial March 1989 visit to determine egg mass density. Sites were visited weekly from mid-April (hatching) to late June (pupation) to further monitor larval development and extent of defoliation.

In early April 1989, we collected ten egg masses from site 1 and cleaned them with air drawn through a 20 mesh screen by electric vacuum to remove setae and other debris (Tardif and Secrest 1970). Eggs were examined with a dissecting microscope for viability, parasites, and physical damage. Ten eggs were placed in each of ten rearing containers (10 cm covered glass petri dishes). Eggs and rearing containers were sterilized in a 0.25% sodium hypochlorite solution to retard viral, bacterial and fungal growth.

Baldcypress needles were collected from site 1 and sterilized in a 0.25% sodium hypochlorite solution, and introduced to newly hatched larvae. Every third day the chambers were cleaned and new baldcypress needles added. Larvae were examined daily for mortality, and their development monitored. Emerging third instars were transferred to 750 ml glass jars, the amount of baldcypress needles increased to offset increased consumption, and the jars cleaned every two days thereafter. Immediately after pupation, pupae were individually placed in covered plastic cups until adults emerged.

RESULTS

Field study.—Pre-season egg mass surveys from March 1989 were compared to post-season surveys from September 1989. Comparisons between the pre- and post-season total egg mass counts per acre, based on the 1/40 acre survey, for the three sites indicated a significant increase in egg mass density over the 1989 season (Table 1).

Hatching of gypsy moth eggs at all 3 sites was completed by 30 April 1989. All larval

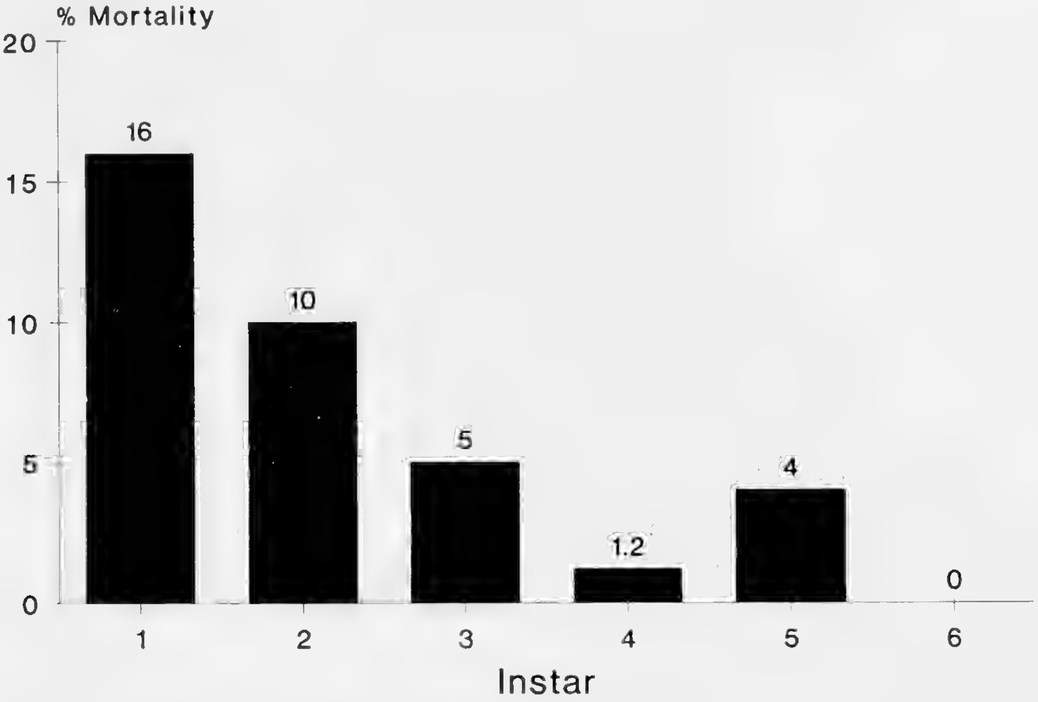

Fig. 1. Mortality rates of gypsy moth larvae reared on baldcypress.

stages were observed feeding on baldcypress and oaks (*Quercus* spp.). Observations of larval development on baldcypress and oak trees at all three study sites indicated that pupation began as early as 8 June on both hosts.

During June 1989, defoliation of immature baldcypress was estimated to be approximately 40%, 30% and 60% at sites 1–3 respectively. Leaf litter and frass was observed at this time at all three sites on the ground surrounding baldcypress trees. Oviposition began in early August at sites 1 & 2, with a combined average of new egg mass numbers of 97 on oak and 84 on baldcypress. During early August 1989, site 3 was severely flooded and unaccessible. Of note was an observation of egg masses deposited on perennially flooded baldcypress trees. This can be explained by the fact that we occasionally observed larvae actively swimming on the surface of the water in flooded areas. Laboratory observations of swimming gypsy moth larvae indicated that they would drown within several hours in glass beakers containing water without branches as purchase sites.

Laboratory study.—Eighty-one of the 100 incubating eggs hatched in the laboratory. Barbosa and Capinera (1977) observed greatest mortality in laboratory reared gypsy moth larvae during the first two instars. Our study produced similar results, with highest mortalities occurring during the first (16%) and second (10%) instars (Fig. 1). Miller and Hanson (1989) established four criteria for distinguishing most suitable hosts for gypsy moths among 39 species of gymnosperms. Their criteria were: 1) >80% survival of 1st instar larvae, 2) development to pupation in <41 days, 3) female pupal weights 1100 mg or greater, 4) production of >350 ova. Since 84% of 1st instar larvae survived in the present study, this indicates

Table 1. Comparison of the total number of gypsy moth egg masses at Worcester County, Maryland, survey sites during March and September 1989.

	March 1989		September 1989	
Site	Total Egg Masses	Average No. Masses per Tree	Total Egg Masses	Average No. Egg Masses per Tree
1. Furnace Town	1160	3	2880	6
2. Millville Rd.	240	8	6480	15
3. Liberty Town Rd.	13,580	30+	*	*

* Site unavailable due to severe flooding of Pocomoke River during late August.

that baldcypress is a potential most suitable host for this criterion as defined by Miller and Hanson (1989). Of the 64 surviving larvae in our present study, all pupated, and 49 emerged as adults (77%). Development to pupation in this study ranged from 46 to 55 days with an average of 47 days, which is longer than the 41 day maximum as defined by Miller and Hanson (1989) for most suitable hosts. Two laboratory reared females mated and oviposited viable fertilized egg masses containing 373 and 291 eggs (avg. 332), which is somewhat lower than the >350 eggs as defined by Miller and Hanson (1989) for most suitable hosts.

Discussion

Comparisons of natural and laboratory reared populations indicate that all larval instars readily feed on baldcypress and are able to utilize this plant as a primary food source. Although weights were not recorded for laboratory reared specimens, no noticeable differences in instar size or development times between natural and laboratory reared larvae were observed. Similarly, adult moths that emerged in the laboratory were comparable to field captured adults morphologically.

Most broadleaf trees can withstand defoliation for several years before decline or death occurs, whereas some conifers can die after one complete defoliation by gypsy moth larvae (Johnson and Lyon 1988, Corliss 1952). Therefore, the potential for extensive damage to the great cypress swamps of the southeastern United States is possible as the gypsy moth continues to extend its range farther south.

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ETHOLOGY OF *CYRTOPOGON MONTANUS WILCOXI* JAMES (DIPTERA: ASILIDAE) IN WYOMING[1]

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Abstract.—In southeast Wyoming *Cyrtopogon montanus wilcoxi* James hunted primarily from surfaces of large boulders. Prey, captured in flight, represented six insect orders with Diptera and Hymenoptera predominating. Courtship consisted of male approaching female from the rear, placing his foretarsi on her wings, and then simultaneously elevating his body and vibrating his wings. The flies positioned themselves linearly for mating.

Key Words: Behavior, feeding, cleaning, courtship, mating

In over 115 years since the discovery of *Cyrtopogon montanus* (Diptera: Asilidae), entomologists have taken specimens from an exceptionally wide area in western North America. Loew originally described the species in 1874 from several females H. Edwards collected in the Sierra Nevada mountains of California. Osten Sacken described the male in 1877 based on three specimens he collected on July 22 from Weber Lake, also in California. Various authors (James 1938, Melander 1923, Curran 1923, Wilcox and Martin 1936) later extended known distribution to include mountainous areas from British Columbia and Alberta south to California and New Mexico. James (1942) designated specimens from Colorado as the new subspecies, *C. montanus wilcoxi.*

We located four populations of *C. montanus* in Wyoming. Three were in the mountains, namely, on Elk Mountain (2520 m), on Casper Mountain (2205 m), and in Ryan Park, in the Snowy Range Mts. (2440 m). These flies frequented open areas in or near forest. The fourth population lived in a series of gullies next to the Sybille Game and Fish Experimental Unit (Wyoming Game and Fish Commission), off State Route 34, 18 miles north and 22 miles east of Laramie (1830 m).

We at first doubted if these flies were *C. montanus wilcoxi.* Dr. Joseph Wilcox, who died in 1983, had identified them only as *C. montanus* Loew. However, our specimens resemble *C. montanus wilcoxi* James more closely than they resemble the nominate subspecies. We have deposited voucher specimens as Lot #51 in the Smithsonian Institution, Washington, D.C.

Observations stretched over several years, and involved two of the four populations. Most data came from the Sybille Canyon site (Fig. 1); we began observing the flies' daily activities there in 1978 (May 24 to June 13) and continued in 1981 (May 28 to June 12). Dr. R. J. Lavigne also observed

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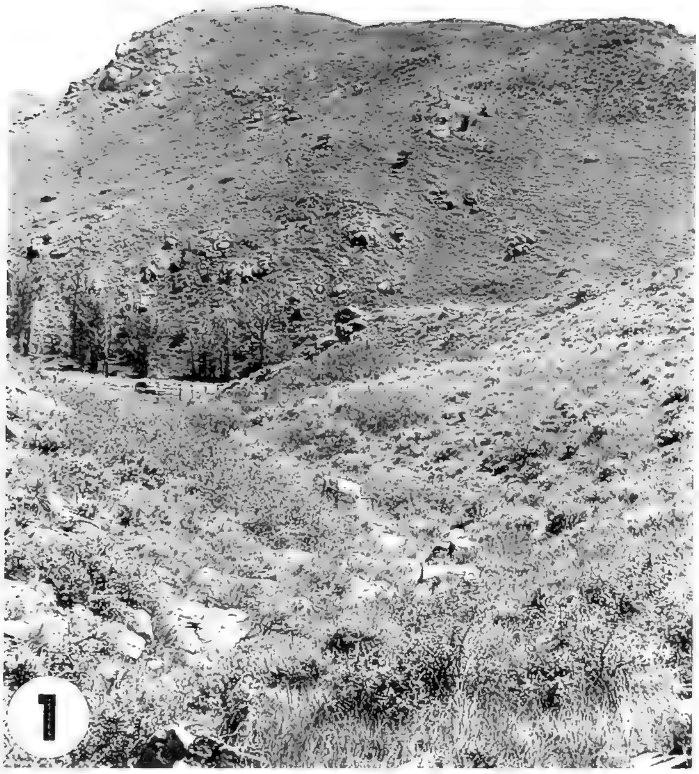

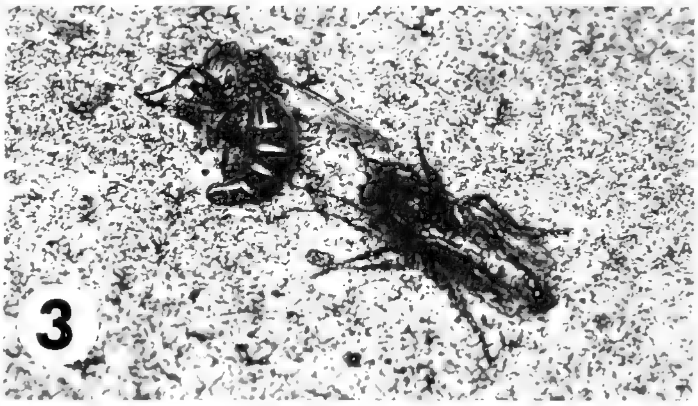

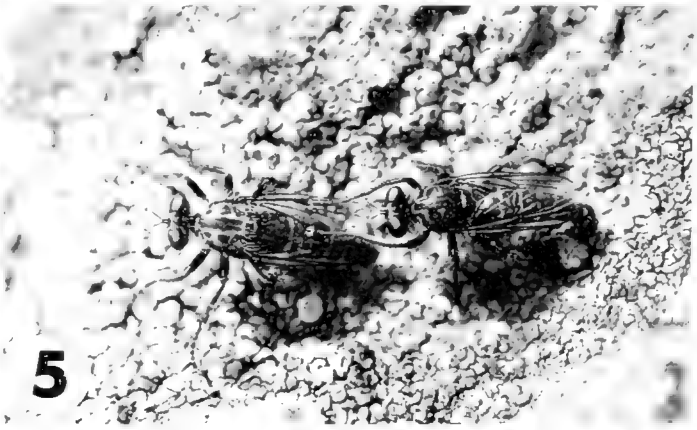

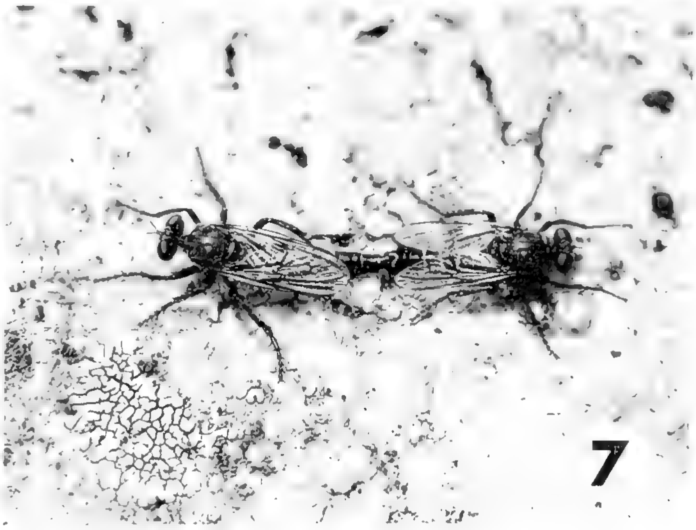

Fig. 1. Water eroded gully habitat of *Cyrtopogon montanus* wilcoxi ca. 20 miles NE of Laramie, WY.

Fig. 2. *Cyrtopogon m. wilcoxi* female with cicadellid impaled on her proboscis.

Fig. 3. *Cyrtopogon m. wilcoxi* female manipulating prey with mid- and hind-tarsi while attending to a courting male.

Fig. 4. Male *Cyrtopogon m. wilcoxi* approaching female from the rear in first phase of courtship sequence.

Fig. 5. Male *Cyrtopogon m. wilcoxi* with foretarsi on female's wings in first phase of courtship sequence.

the flies on Casper Mountain June 1-27, 1975.

Habitat may have influenced the flies' behavior. Plants and their general aspect varied little from year to year and site to site. At Sybille Canyon, a community of plants, typified by short grass, grew on the rocky slopes of the gullies. Common plants included *Artemisia cana* Pursh. (dominant), *A. tridentata* Nutt., *A. frigida* Willd., *Bouteloua gracilis* (H.B.K.) Lag ex Steud., *Rhus trilobata* Nutt., *Opuntia polyacantha* Haw, *Astragalus drummondi* Douglas, *Zygadenus* sp., and *Leucocrinum montanum* Nutt.

MATERIALS AND METHODS

We used our normal methods of gathering and analyzing information on robber flies to learn more about the ethology of *C. montanus wilcoxi.* Lavigne described these methods in his 1982 paper on *Neoitamus vittipes* Macquart. We also analyzed some data using chi-square tests.

RESULTS AND DISCUSSION

Hunting and feeding behavior.—Individuals of *Cyrtopogon m. wilcoxi* hunted from sun-lit surfaces of boulders, rarely perching for brief periods on other substrates. The flies often perched on rock lichens instead of bare rock, making it difficult to discern their presence. Individual flies flew frequently, and only occasionally returned to the same spot more than two or three times.

In Sybille Canyon, boulders from which the flies hunted lay in a treeless ravine. This ravine formed a natural causeway for air currents. During times of gusting winds, the flies perched on the lee sides of boulders.

The flies varied the stance they took on the boulders, mainly in relation to time of day. In the morning, they pressed their bodies to the rock surface and aligned themselves at right angles to the incoming sunlight. In the afternoon they stood head-on to the sun, with legs outstretched nearly vertically underneath their bodies. Variation in stance probably mollified temperature extremes. Presumably the flies' stance in the morning would increase absorption of solar radiation, by increasing body area exposed. This stance also would increase heat conduction from rock surface to venter of the fly. The stance taken in the afternoon would have opposite effects.

The flies also varied their stance in relation to potential prey, all of which was air borne. As insects flew by, watching robber flies initially pulled their legs under their body. They then turned their heads, and, sometimes perhaps their bodies, as much as 30°. Some extended their legs underneath their bodies while turning, or stretched their heads as far as possible in the direction of the prey. Most often the flies mingled these several motions into one simultaneous action. In the middle of the day they often became very animated as various insects flew by.

Lastly, the flies varied their stance for reasons we can only guess. In the morning, often males would lift their bodies and briefly vibrate their wings just after landing. This behavior may have generated heat, as a by product of contracting the wing muscles. Vibrating the wings also could have stretched these muscles, in preparation for more active flight later in the day.

The flies rarely moved far using their legs. Occasionally, and inexplicably, they ran for distances up to three or four times their body length.

The flies apparently could detect potential prey only by the light they reflected.

←

Fig. 6. Male *Cyrtopogon m. wilcoxi* elevating its body and vibrating its wings in second phase of courtship sequence.

Fig. 7. Mated pair of *Cyrtopogon m. wilcoxi* in typical "chain" position.

Because the flies landed more horizontally than vertically on the rock surfaces, and because their eyes face as much forward as upward, they mostly hunted insects that flew in front of instead of directly over them. They seemed to scan the sky near the horizon for low-flying insects, rather than the upper air for high-flying ones. Early in the morning and late in the afternoon, when the sun rested low in the sky, they turned toward it. This last behavior suggests that they may have been spotting prey by a second method, i.e. back-lighting.

But they probably were not back-lighting, in the sense that they detected prey as a dark spot against a bright sky. They probably noticed flying insects by sunlight reflecting off their wings. The flies might see flying insects easily in the mornings and evenings this way. At these times the incoming sunlight forms less of an angle with the wing surfaces of a typically horizontally-flying insect. This light has more of a chance of being reflected than during the middle of the day. In the mornings and afternoons, we could see flying insects at four or fives times the normal distance by light reflected off their wings.

During several days in 1981, when we observed individual flies continuously, recording their behavior, we were able to measure the mean length of a hunting flight. "Hunting flights," as used here, did not include flights initiated in relation to a conspecific, or as a reaction to being disturbed, as for example by a landing insect, or by the approach of a rock-bound ant or spider. Of 184 such flights, we could only keep the fly in constant view for 169. These flights measured from 3 to 120 cm in length (males, $\bar{x} = 68.5$ cm, N = 71, sd = 66; females, $\bar{x} = 56$ cm, N = 98, sd = 43.2).

For these 169 flies, "flight distance" equaled half of the total distance flown. Estimating flight length this way was intuitively obvious when the fly returned to its perch using the same path by which it flew outward. It was not obvious when the fly flew along the surface of a rock for some distance and then landed, or when it took a more contorted path. In these instances, we estimated as best we could total distance flown, and then divided by two.

The robber flies did not chase everything that flew by. Nor did they apprehend everything they chased. They would not chase sphecid wasps, chrysidid wasps, large bees, and butterflies. They sometimes pursued sarcophagids, calliphorids, and small day-flying moths for 2–3 m, but never caught them. Once, a female followed and circled a bombyliid without attacking it. Even one tipulid, a clumsily flying and often-taken prey item, got away.

While measuring flight distances, we counted flights resulting in capture. We thus could calculate capture efficiency. In 13 of the 184 "hunting" flights the fly returned with an insect, giving a capture efficiency of 7.1%. Females captured 7.3% of the prey they chased in 110 flights, just slightly more than the 6.8% taken by males in 74 flights.

Several times a fly apprehended an insect, and then released it before landing (chrysomelid, 1; coccinellid, 3). We did not consider these instances to be captures.

The flies did not always kill the insects they landed with (Fig. 2), giving a hunting efficiency, or number of kills/total number of pursuit flights, lower than capture efficiency. Of the 13 flies mentioned above as returning with potential prey, only 6 killed it. Males ended 2.7% of their flights by killing prey (2 kills for 74 flights); females ended 3.6% of their flights the same way.

In 19 instances, including the seven mentioned in the preceding paragraph, the flies apparently lost their grip on the insects they captured. In four of these instances we identified the insect that escaped (coreid, 1; elaterid, 1; small hymenopterans, 2).

Our estimates of capture and hunting efficiency are probably short of the real values. Including flights flies may have initiated for thermoregulatory or other reasons would inflate the denominator in our equation. Often we could not see the insects the flies pursued, probably because of their minute size. The flies could have initiated many shorter "hunting" flights to reposition themselves. They also may have taken some long flights, especially those in which they landed some distance away from their starting point, for the same reason. The average flight probably had a number of overlapping functions; for example, a fly might chase an insect, miss it, then briefly engage in aerial maneuvers with a conspecific, and finally land at a new location.

During the three day period in 1981 spent recording the activities of one fly at a time, we observed 195 flights in 682 minutes, allowing us to calculate both number of flights/minute and average time between feeding. Because we could not always distinguish between males and females from several feet away, we had to settle for an average number of flights/minute, namely 0.286, for the sexes taken together. We then calculated approximate inter-feeding times separately for the sexes. The inter-feeding time is the reciprocal of the product of 0.286 flights/minute times hunting efficiency. These calculations gave 130 minutes between kills for males and 98 minutes between kills for females.

The flies killed or stunned 33.5% of the prey before landing. Many of these were smaller prey. Difficulty encountered in holding prey may have determined when a fly attempted to immobilize it.

Feeding flies repositioned their proboscis multiple times during a single feeding, presumably to help their external digestion. They apparently injected digestive enzymes separately into almost non-communicating regions of the prey's haemocoel, as for example the head, thorax, and abdomen of acutelate Hymenoptera. Forty flies repositioned prey after initially handling it (N = 76). Twenty-seven flies manipulated it once, 9 flies twice, 2 flies three times, and single flies 4 and 6 times each.

Repositioning an insect required that the fly manipulate it precisely using its tarsi. The flies used 4, 5, or 6 tarsi, using more tarsi for larger prey. Flies did not handle minute prey, probably because they found them difficult to hold; once the fly released such a small insect from the comparatively firm hold of its hypopharynx, it could be blown away, before being grasped by the tarsi.

When handling small prey, the flies grasped the rock face with the foretarsi, bracing themselves with the tip of their abdomen. Foretarsi and abdomen formed a tripod, freeing the mid- and hind-tarsi (N = 30) to hold the prey (Fig. 3). For slightly larger prey the flies hung by one fore tarsus, either left (N = 13) or right (N = 7), and grasped the prey with the other five legs. With very large prey, e.g. a tipulid, level support, and no wind, the flies rolled on their side, and held the item with all six tarsi (N = 3). In 15 instances the flies handled prey just before discarding it.

We saw 11 flies capture an insect, feed upon it, and then discard it. These "complete" feedings required from 1.5 to 34 minutes ($\bar{x} = 11.36$).

We observed a total of 41 flies discard prey after feeding on it. Before taking flight, 25 flies, or 61%, pushed the prey off their proboscis with their foretarsi. The remaining flies discarded prey during flight.

Prey Selection.—We collected 326 prey from *C. m. wilcoxi.* These prey came from Sybille Game and Fish Reserve and Casper Mt., and include six orders of insects (Table 1). The 23 prey from Casper Mountain represent five orders. At both locations, the flies captured primarily Diptera and Homoptera. Certain families predominated. In the following list of these families, numbers for males are listed before numbers for females: HOMOPTERA: Cicadellidae (24, 69); DIPTERA: Bibionidae (10, 17), Chironomidae (9, 14), Empididae (4, 22), Tipulidae (4, 10); COLEOPTERA: Scarabaeidae (5, 14); HYMENOPTERA: Formicidae (5, 10 winged reproductives).

Size of examined *C. m. wilcoxi* varied

Table 1. Dietary composition of prey *by sex* taken by *Cyrtopogon montanus* (and measured) in Wyoming. Predator lengths (mm); ♂ 10.3 ± 0.80, N = 15; ♀ 11.3 ± 0.74, N = 15.

Prey	Males			Females		
	No.	%	$\bar{x} \pm$ SD	No.	%	$\bar{x} \pm$ SD
Coleoptera	9	10.8	4.74 ± 1.6455	25	12.6	4.69 ± 1.8599
Diptera	38	45.9	5.82 ± 3.4733	77	38.7	5.67 ± 3.8997
Hemiptera	2	2.4	5.35 ± 0.4950	9	4.5	5.39 ± 1.4633
Homoptera	27	32.5	3.29 ± 1.2508	72	36.2	2.96 ± 0.8108
Hymenoptera	6	7.2	7.33 ± 3.3874	16	8.0	5.89 ± 3.4361
Isoptera	1	1.2		0		
	83	100.0	4.95 ± 2.94	199	100.0	4.72 ± 3.82

little; size of the prey varied greatly. Male flies averaged 10.3 mm in length, female flies 11.3 mm. Prey killed by males ranged from 1.0 to 17.5 mm in length. That killed by females ranged from 1.3 to 21.0 mm (Table 2). Both males and females killed prey of about the same mean length (4.95 mm for males vs. 4.72 mm for females). Predator to prey ratio was 2.2:1.

Cleaning movements.—The flies regularly engaged in motions that we took to be cleaning activities. First, and most often, while extending and elevating their forelegs in front of their face, they rubbed their foretarsi together along their long axis. Second, they brushed the lateral margins of their compound eyes with their foretarsi. They invariably brushed both eyes simultaneously, and on one occasion a fly turned its head from side to side while doing so. Third, they rubbed their folded wings synchronously with their metathoracic tarsi, most commonly combing along the coastal margins, and rarely, in separate operations, scraping both upper and under surfaces as well. Fourth, they brushed the dorsolateral margins of the abdomen with their hind tarsi, while extending the wings laterally. Fifth, they lifted the hind tarsi and rubbed them together beneath the elevated abdomen. Again, they rubbed the tarsi together along their long axes.

Courtship.—Courtship commonly precedes mating in some species of *Cyrtopogon,* i.e. *C. auratus* Cole, *C. glarealis* Melander (Lavigne 1970), *C. marginalis* Loew (Lavallee 1970), *C. vanduzeii* Wilcox and Martin (Powell 1969), and *C. willistoni* Curran (Lavigne & Holland 1969).

Wilcox and Martin (1936) and Powell (1969) reported courtship by males of *C. montanus.* Probably these observations refer to two different species of flies. Wilcox and Martin (1936) stated that "The males of *C. montanus* Loew also stand in front of the female during courtship. Wing movement seems to be the major part of the courtship, at times a low buzz being produced by the wings." Conversely, Powell (1969) reported that, as opposed to several other species of *Cyrtopogon* that "carry out courtship in a face-to-face position," *Cyrtopogon montanus* males, like those of *C. vanduzeii,* approach the female from behind and rest their foretarsi on the female's wings. If differences in courtship behavior signify different species, either Wilcox and Martin (1936) or Powell (1969) erred in their taxonomic determination.

Based on Wilcox's 1978 identification of the specimens from Sybille Canyon and Casper Mt., Wyoming as *C. montanus,* and on these males approaching the female from the rear to court, we think the original comment by Wilcox and Martin referred to courtship by some yet unidentified species or subspecies.

As illustrated in Figs. 4–6, the sequence of events in courtship of *C. m. wilcoxi* splits into two discrete phases. The behavior of

Table 2. Dietary composition of prey taken by *Cyrtopogon montanus* in Wyoming.

Taxon	Number of prey			Length (mm)	
	Observed	Percent	Taken and Measured	Mean ± SD	Range
Coleoptera	39	12.0	34	4.70 ± 1.78	1.7–10.3
Diptera	143	43.9	116	5.74 ± 3.736	1.5–21.0
Hemiptera	11	3.3	11	5.38 ± 1.318	2.7–7.6
Homoptera	105	32.2	101	3.03 ± 0.950	1.5–5.6
Hymenoptera	26	8.0	22	6.28 ± 3.405	1.9–11.3
Isoptera	2	0.6	1	—	3.3
Total	326	100.0	285	4.69 ± 2.987	1.5–21.0

the male drives the first phase. The second phase occurs only if the female remains stationary and/or responds properly.

First, the male sights and approaches a conspecific. He lands on the substrate ca. 1 cm behind it and remains still for several seconds (Fig. 4). If the other robber fly does not fly away, he crawls forward and places his foretarsi near the apices of its wings (Fig. 5).

He then attempts to contact the genitalia of the fly in front of him. He begins by elevating the fore portion of his body to an angle of ca. 45°. He lifts his foretarsi from the wings, and sometimes crosses them as well. He then rapidly vibrates his wings, and curls his abdomen forward between his legs (Fig. 6) to make contact.

A female may respond in several ways. When the male first moves forward, she may fly. She may move her head or raise and lower her body. Often, she will open her wings to a ca. 45° angle.

The female's response determines how the male reacts, and his reaction, in turn, determines the female's next move. If the female flips open her wings, the male will place his foretarsi on the apical segments of her abdomen rather than on the wings themselves. This action usually results in the female closing her wings, and the male repositioning his foretarsi on them. Or a female may move sideways over the rock surface. The male usually follows, never letting his tarsi lose contact with her wings. The female may then attempt to brush off the male's foretarsi using her hind tarsi.

In either case, once the male elevates his body and vibrates his wings, the female commonly flies away, with the male chasing her. If the female remains, she may spread her wings, vibrate them rapidly, or flip her abdomen up and down several times. If she rises on her legs and vibrates her wings the male will desist and fly.

Occasionally courtship begins differently. Several times males elevated their bodies and then vibrated their wings immediately after landing behind a female. Probably these males continued behavior begun on another rock. In the instances where we tracked interacting pairs from rock to rock, courtship recommenced with the male taking this peculiar stance.

Males land ca. 3–37 mm to the side or rear of a female. If the male lands to one side of the female, he quickly orients to her rear. In the single instance when a male landed facing a female, she spread her wings to a 45° angle and backed up rapidly.

Rarely, courting males engaged in what may be an optional step in the sequence. In 9 instances, after placing their foretarsi on the female's wings, they elevated the tip of the abdomen and swirled it in a circle. Once, at least, the fly extended the sclerites of the hypopygium. Males of *C. glarealis* regularly engage in a similar display, lashing their elevated abdomens from side to side (Lavigne 1970). Twice, the flies swirled their abdo-

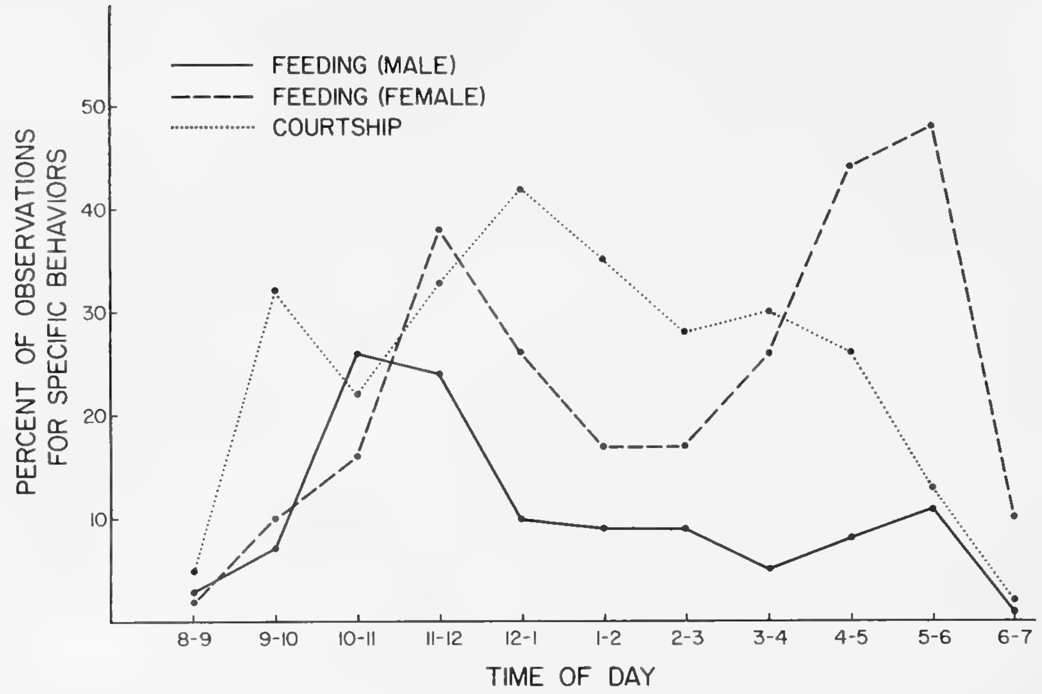

Fig. 8. The diurnal rhythm of activity of *Cyrtopogon m. wilcoxi.* (The percentage of asilids engaged in specific behaviors was calculated from the total number of observations of each behavior—268, 102, 222—for courtship, feeding males, and feeding females respectively.)

mens when a second male begin courting. Perhaps the flies displayed their hypopygia to intimidate the intruders.

Courting males apparently cannot distinguish females unless they note specific behaviors. Sometimes they court flies of other species, or insects in other orders. One male briefly courted a piece of lichen.

If courted, males do not exhibit appropriate behavior. They either fly away or turn to face their suitor. In the latter case, courting males invariably fly away.

Courting males probably first cue in on the size of the target object, e.g. the size of the average female fly. This hypothesis would explain why they occasionally court other insects, also why they rarely court females engaged in feeding. Feeding females might seem larger because of added bulk of the prey. But in 11.2% of the cases (30 out of 268), females did have prey. Once, a male with prey initiated courtship.

Mating.—We observed everything but initiation of mating. We saw five copulating pairs in eight days in 1978; all pairs had already interlocked genitalia. All pairs rested on rocks, and had aligned themselves linearly, with heads facing in opposite directions (Fig. 7). When disturbed they flew in tandem, usually to another rock. Two of the pairs landed on branches of small bushes. Copulated pairs were observed only in the afternoon (1618, 1707, 1735, 1812, and 1822 h). Rock temperatures measured 39, 31.7, 30.6, 33.3, and 27.8°C, respectively. Measured portions of three copulations ran for 7, 8, and 13 min.: These matings ended with the males opening their claspers, walking away from the female, and then flying.

Oviposition.—We did not observe oviposition. Dennis and Lavigne (1976) observed a female laying eggs at another site, on Elk Mountain. They thought this female was *C. inversus* Curran. Later, Lavigne asked J. Wilcox to confirm the identification. He identified it as *C. montanus.* This female deposited her eggs in soil.

Daily rhythm of activity.—Patterns of behavior varied with time of day (Fig. 8). Males began courting as early as 0845 h and continued to as late as 1802 h, with a peak at midday. Males fed most during the middle hours of the morning. Females fed mostly in the late afternoon.

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THE SPECIES OF THE *ARGE MALI*-GROUP (HYMENOPTERA: ARGIDAE) IN JAPAN

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Abstract.—One new species, **Arge shinanensis** sp. nov. is described and illustrated, and a key is provided for the species of the *mali*-group occurring in Japan.

Key Words: Argidae, *Arge, mali*-group

The species of the *Arge mali*-group are characterized as follows: 1, Third and fourth abdominal segments fulvous (Fig. 1); 2, forewing with dark spot below stigma which is limited by cubitus (Figs. 1, 11–13); and 3, hind tibia dirty white, but apical portion dark brown to black (Figs. 14–16).

To date, two species belonging to the *mali*-group, *Arge mali* (Takahashi) and *A. rufocincta* Gussakovskij, have been recorded in Japan (Takeuchi 1939). An additional species is described and illustrated in this paper.

KEY TO THE SPECIES OF THE *ARGE MALI*-GROUP IN JAPAN

1. Antenna brown to fulvous; all tibiae dirty white but apical ⅓ of hind tibia black (Fig. 14) (sawsheath as in Figs. 21 and 24; lancet with 22 serrulae (Fig. 27); second cubital cell of forewing as long as the third: see Fig. 11) .... *mali* (Takahashi)
– Antenna dark brown to black; all tibiae black but apical half of hind tibia black and basal half dirty white (Figs. 15 and 16) 2
2. Frons with a weak median longitudinal keel (Fig. 3); 4th segment of maxillary palpus only slightly shorter than 5th (Fig. 9); 2nd cubital cell of forewing as long as 3rd (Fig. 12); hind basitarsus pulvillus slightly longer than half length of following segment (Figs. 17 and 19); sawsheath as in Figs. 22 and 25; lancet with 19 serrulae (Fig. 28) .... *shinanensis* sp. nov.
– Frons without a median longitudinal keel (Fig. 4); 4th segment of maxillary palpus ½ as long as 5th (Fig. 10); 2nd cubital cell of forewing longer than 3rd (Fig. 13); hind basitarsus pulvillus shorter than a half length of following segment (Figs. 18 and 20); sawsheath as in Figs. 23 and 26; lancet with 20 serrulae (Fig. 29) . ... *rufocincta* Gussakovskij

Arge shinanensis **Togashi, NEW SPECIES**

(Figs. 1, 3, 6, 9, 12, 15, 17, 19, 22, 25, 28)

Female.—Length 9 mm. Body bluish black but 3rd and 4th abdominal segments fulvous (in paratype, basal half of 5th abdominal segment fulvous); antenna black; legs black but basal half of hind tibia dirty white (Fig. 15); wings slightly yellowish hyaline, venation and stigma dark brown to black but analis dirty white (Fig. 12).

Head (Figs. 3 and 6): postocellar, interocellar, and lateral furrows nearly absent; OOL:POL:OCL = 0.8:1.0:0.75; frons with a weak median longitudinal keel; maxillary palpus 6-segmented, 4th segment shorter than 5th (ratio of length of apical three segments about 1.0:1.2:1.8) (Fig. 9).

Thorax normal. Second cubital cell of forewing about as long as third (Fig. 12); hind basitarsus slightly longer than following three segments combined (ratio about 1.0:0.9); hind barsitarsus pulvillus slightly longer than half length of second tarsal segment, in lateral view (ratio about 1.0:1.8) (Fig. 19).

Abdomen normal. Sawsheath as in Figs. 22 and 25; lancet with 19 serrulae (Fig. 28).

Punctation.—Head covered with very fine setigerous punctures but area between antennal sockets covered with shallow and scattered punctures; thorax except for mesopleuron covered with very fine setigerous punctures; mesopleuron covered with rather long greyish-white hairs.

Male.—Unknown.

Holotype: female, 18. VIII. 1979, Shinano-oiwake, Nagano Pref., Honshu, Nishida leg.

Paratype: 1 female, 29. VII. 1959, Happo-one, Nagano Pref., Honshu, collector unknown. All types are deposited in the National Science Museum (Nat. Hist.), Tokyo.

Distribution.—Japan (Honshu).

Remarks.—This new species very closely resembles *A. rufocincta* Gussakovskij from Japan, but it is distinguished from the latter by the length of the second cubital cell of the forewing (in *rufocincta,* the second cubital cell is longer than the third one); by the length of the hind basitarsus pulvillus (in *rufocincta,* the length of the hind basitarsus pulvillus is shorter than half length of the second segment, in lateral view); and by the form of the frons (in *rufocincta,* the frons has no median longitudinal keel).

Arge rufocincta Gussakovskij
(Figs. 4, 7, 10, 13, 16, 18, 20, 23, 26, 29)

Arge rufocincta Gussakovskij, 1935: 262.

Specimens examined: 1 female, 25. VII. 1978, Nakasuda, Hiyama, Hokkaido, Y. Sugawara leg.; 1 female, 1. VIII. 1986, Oohirayama, Shihamaki, Hokkaido, Y. Nishijima leg.

Distribution.—Japan (Hokkaido).

Food plant.—Unknown.

These specimens agree with the original description by Gussakovskij (1935).

Supplementary notes.—The third and fourth abdominal segments are fulvous; OOL:POL:OCL = 0.8:1.0:0.75; postocellar and interocellar furrows rather distinct (Fig. 7); 4th segment of maxillary palpus ½ as long as 5th (Fig. 10); 2nd cubital cell of forewing longer than 3rd (Fig. 13); hind basitarsus pulvillus shorter than half length of following segment, in lateral view (Fig. 20); lancet with 20 serrulae (Fig. 29).

Arge mali (Takahashi)
(Figs. 2, 5, 8, 11, 14, 21, 24, 27, 30, 31, 32)

Hylotoma mali Takahashi, 1906: 53.

Specimens examined: (Hokkaido) 2 females, 20. VII. 1985, Utonai, Tomakomai, Y. Nishida leg.; 1 female, 25. VIII. 1987, Nijibetsu, Shibecha, Y. Nishijima leg. (Honshu) 2 females, date unknown, Koiwai, Iwate Pref., K. Sato leg.; 1 male, 10. VII. 1937, Hirakubo, Fukushima Pref., K. Sato leg.; 1 female, 31. VII. 1960, Uraminotaki, Nikko, Tochigi Pref., N. Fukuda leg.; 1 female, 20. VIII. 1971, Sekirozan, Kanagawa Pref., Y. Kurosawa leg.; 1 female, 30. VII. 1932, Sugadaira, Nagano Pref., K. Sato leg.; 1 female, 28. VI. 1934, Karuizawa, Nagano Pref., K. Sato leg.

Distribution.—Japan (Hokkaido and Honshu), Korea, and Siberia.

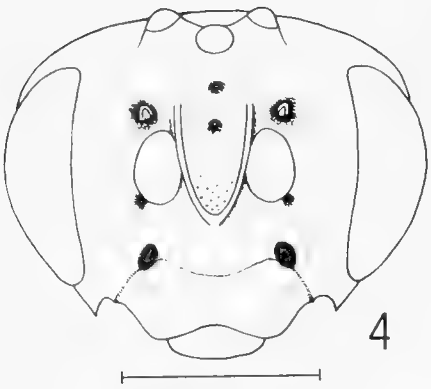
Food plant.—Apple and pear trees.

These specimens agree with a specimen identified by Takeuchi.

Supplementary notes.—OOL:POL:OCL = 0.8:1.0:1.0; 4th segment of maxillary palpus about as long as half of 5th (Fig. 8); lancet with 22 serrulae (Fig. 27). Male genitalia as in Fig. 30; volsella and sagitta as in Fig. 31; penis valve as in Fig. 32.

ACKNOWLEDGMENTS

I express my cordial thanks to Dr. David R. Smith, U.S. Department of Agriculture, Washington, D.C., for his kind advice and reading through the manuscript and to Dr. A. Shinohara, the National Science Museum (Nat. Hist.), Tokyo, for lending the specimens which are deposited in that Museum. I am indebted to Dr. Y. Nishijima, Chitose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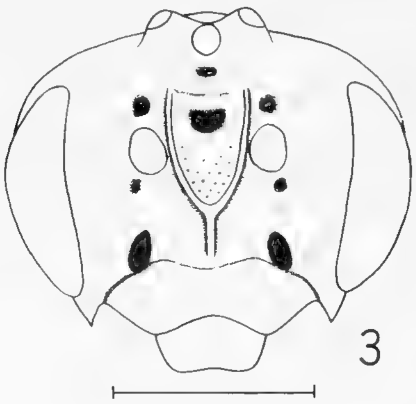
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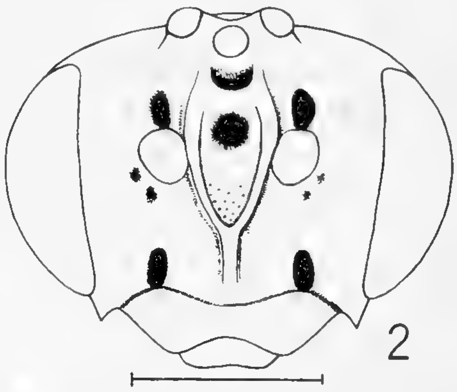
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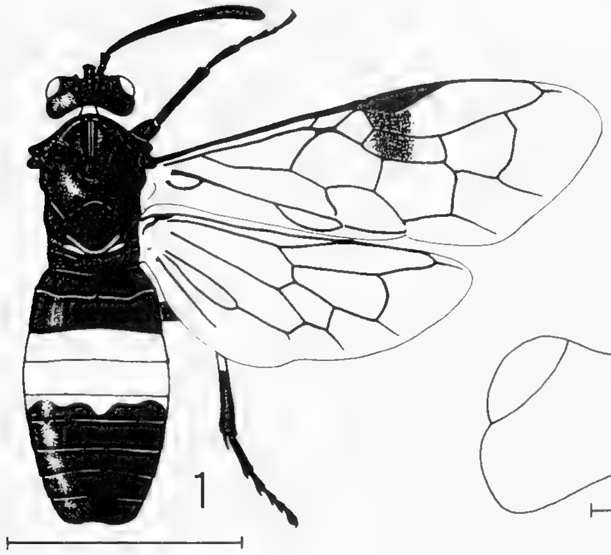
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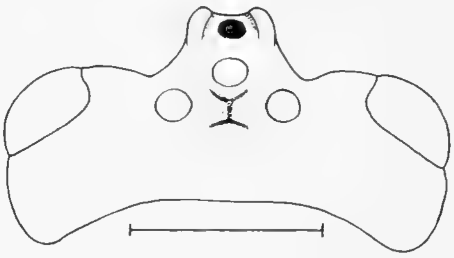
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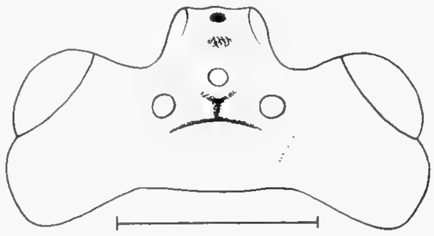
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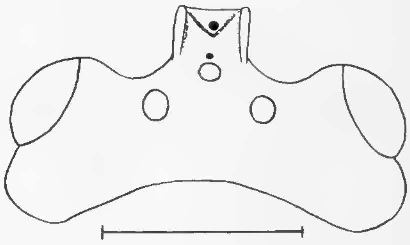
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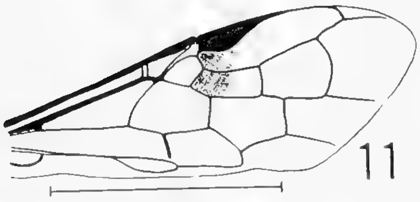
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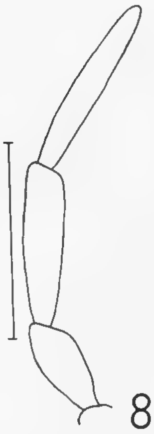
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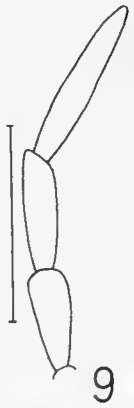
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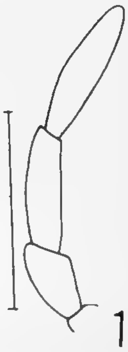
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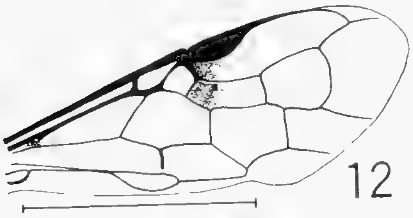
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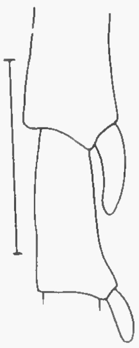
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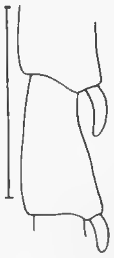
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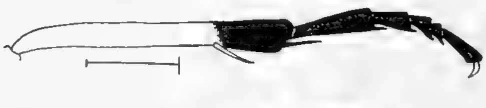
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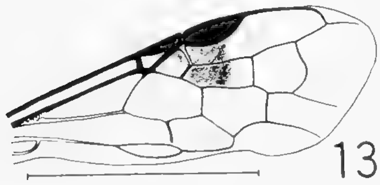
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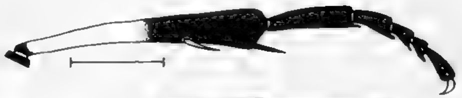
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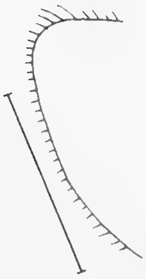
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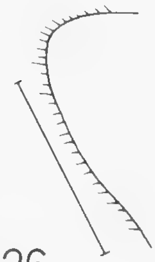
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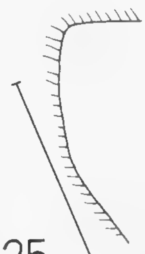
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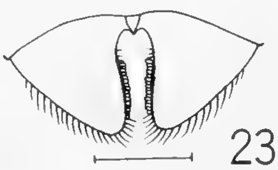
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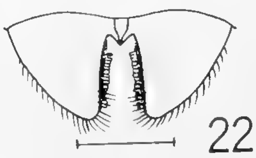
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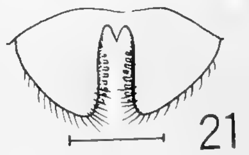
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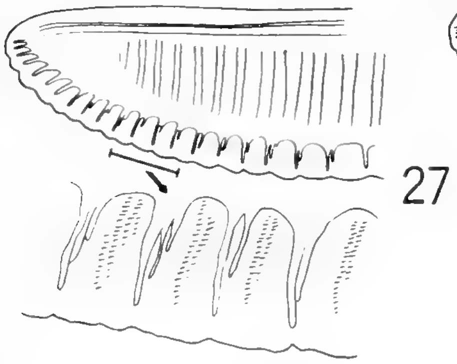
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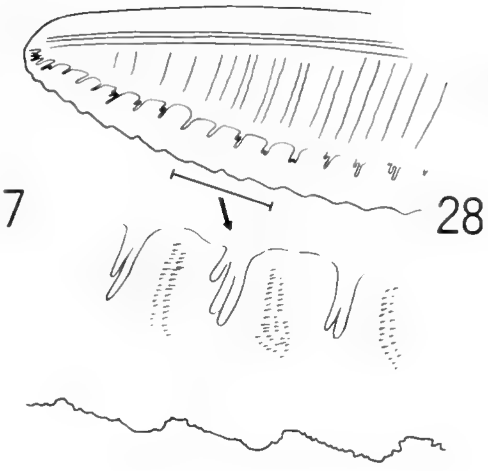
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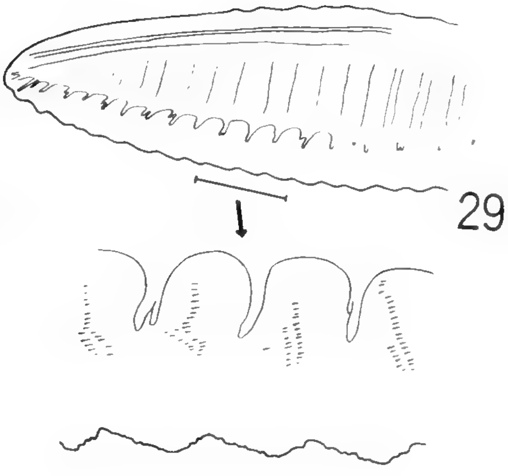
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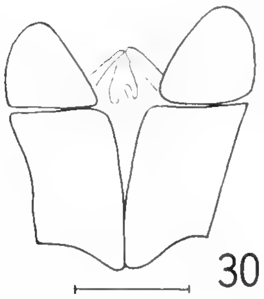
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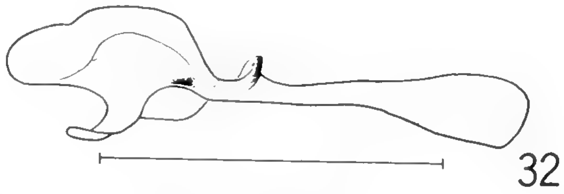
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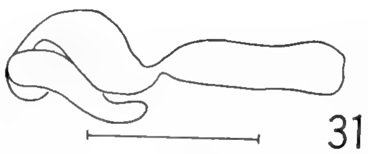
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Figs. 27–29. Lancet: 27, *A. mali*; 28, *A. shinanensis* sp. nov.; 29, *A. rufocincta*.

Figs. 30–32. Male genitalia of *A. mali*. 30, genitalia; 31, volsella and sagitta; 32, penis valve. (Scale of 30 and 31—0.5 mm; scale of 32—1 mm.)

City, Hokkaido, for lending me valuable material.

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Fig. 1. Dorsal view of *Arge shinanensis* sp. nov. (Paratype).

Figs. 2–4. Head front view: 2, *A. mali* (Takahashi); 3, *A. shinanensis* sp. nov.; 4, *A. rufocincta* Gussakovskij.

Figs. 5–7. Head, dorsal view: 5, *A. mali*; 6, *A. shinanensis* sp. nov.; 7, *A. rufocincta*.

Figs. 8–10. Apical three segments of maxillary palpus, lateral view: 8, *A. mali*; 9, *A. shinanensis* sp. nov.; 10, *A. rufocincta*.

Figs. 11–13. Wing venation of forewing: 11, *A. mali*; 12, *A. shinanensis* sp. nov.; 13, *A. rufocincta*.

Figs. 14–16. Hind tibia and tarsus, lateral view: 14, *A. mali*; 15, *A. shinanensis* sp. nov.; 16, *A. rufocincta*.

Figs. 17, 18. Hind basitarsus pulvillus, ventral view: 17, *A. shinanensis* sp. nov.; 18, *A. rufocincta*.

Figs. 19, 20. Hind basitarsus pulvillus, lateral view: 19, *A. shinanensis* sp. nov.; 20, *A. rufocincta*.

Figs. 21–23. Sawsheath, dorsal view: 21, *A. mali*; 22, *A. shinanensis* sp. nov.; 23, *A. rufocincta*.

Figs. 24–26. Sawsheath, lateral view: 24, *A. mali*; 25, *A. shinanensis* sp. nov.; 26, *A. rufocincta*. (Scale of 1, 11, 12, and 13—5 mm; scale of 2–7 and 14–16—1 mm; scale of 8–10, 17–20, and 21–26—0.5 mm.)

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94(1), 1992, pp. 136–150

BREEDING PATTERNS IN SOUTHERN KOREAN CARABINA (COLEOPTERA, CARABIDAE)

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Abstract.—Breeding patterns of the subtribe Carabina were investigated on Mt. Sobaek and Mt. P'algong in Korea. Two different breeding patterns were distinguished by the developmental conditions of the female gonads: *Carabus sternbergi, Lipaster venustus, Eurycarabus fraterculus* and *Damaster leechi* were spring breeding types, and *Leptocarabus koreanus, L. semiopacus, L. seishinensis, Damaster jankowskii* and *D. smaragdinus* were autumn breeding types.

Key Words: Breeding patterns, Carabina

Annual breeding types of carabid beetles have frequently been classified into two major groups according to their reproductive season (spring or autumn) and hibernation stage (adults or larvae) in the temperate zone (Lindroth 1949, Thiele 1977, Paarmann 1979): Spring breeders hibernate as adults and reproduce from spring to early summer, and autumn breeders reproduce in autumn or even from midsummer and hibernate as larvae.

Sota (1985) concluded that the life history patterns of the ten species of the subtribe Carabina in Japan, eight species were categorized as spring breeders without larval hibernation and two species were autumn breeders with larval hibernation.

In the fauna of Korean Carabina, many geographical variations in the subspecific levels were reported (Ishikawa and Kim 1983, Kwon and Lee 1984). However, they were restricted to morphological viewpoints and for the further comprehension of their adaptive strategies and species diversification, detailed surveys of carabid life cycles are therefore needed.

In the present paper, for providing information on the future studies of the Korean carabid species, the authors investigated the breeding patterns of the Carabina on Mt. Sobaek and Mt. P'algong, both located in southern Korea.

MATERIALS AND METHODS

Areas surveyed

This study was conducted on Mt. Sobaek (1439 m, 37°57′N, 128°29′E) and Mt. P'algong (1192 m, 36°1′N, 128°42′E) in southern Korea. On Mt. Sobaek, from April to October in 1989, five sampling sites were chosen in deciduous forests at the following altitudes: ca. 600 m, 800 m, 1000 m, 1200 m and 1400 m above sea level. On Mt. P'algong, from August to October in 1989 and from April to July in 1990, three sampling sites were chosen in deciduous forests at the following altitudes: ca. 400 m, 600 m, and 800 m above sea level.

Methods

The materials were collected by pitfall traps at fortnightly intervals and the traps were exposed for two days. The trap was a

Table 1. Carabids collected and investigated from Mt. Sobaek (1989) and Mt. P'algong (1989–1990).

Mt. Sobaek	Mt. P'algong
Carabus (*Eucarabus*) *sternbergi* Roe. (=*C.* (*Parhomopterus*) *sternbergi sobaeksanensis* K. et L.)	*Carabus* (*Eucarabus*) *sternbergi* Roe. (=*C.* (*Parhomopterus*) *sternbergi palgongsanensis* K. et L.)
Lipaster (*Morphocarabus*) *venustus taebeagsanus* Ishi.	*Leptocarabus* (*Weolseocarabus*) *koreanus coreanicus* (Breu.)
Leptocarabus (*Weolseocarabus*) *koreanus* Roe. (=*L.* (*W.*) *koreanus minor* K. et L.)	*Leptocarabus* (*Adelocarabus*) *semipacus* (Reitter)
Leptocarabus (*Adelocarabus*) *semiopacus* (Reitter)	*Leptocarabus* (*Adelocarabus*) *seishinensis seishinensis* Lap.
Leptocarabus (*Adelocarabus*) *seishinensis seishinensis* Lap.	*Eurycarabus* (*Tomocarabus*) *fraterculus assimilis* K. et L.
Eurycarabus (*Tomocarabus*) *fraterculus assimilis* K. et L.	*Damaster* (*Coptolabrus*) *jankowskii jankowskii* (Ober.)
Damaster (*Acoptolabrus*) *leechi* (Bat.)	*Damaster* (*Coptolabrus*) *smaragdinus branickii* (Tac.)
Damaster (*Coptolabrus*) *jankowskii jankowskii* (Ober.)	
Damaster (*Coptolabrus*) *smaragdinus fulminifer* (Roe.)	

plastic cup of 6.5 cm in top diameter and 7.2 cm in height. Fifty traps were buried at about 3 m intervals at each site. They were classified according to the degree of gonadal development of the females into three categories: 1) New or virgin female, without mature eggs and corpora lutea; 2) Reproductive female, with mature eggs; 3) Spent or post reproductive female, without mature eggs but with corpora lutea. Those of two or more years as adults were distinguished from new adults during the nonreproductive period by the presence of corpora lutea.

RESULTS

On Mt. Sobaek nine species under five genera and on Mt. P'algong seven species under four genera were collected during investigation periods (Table 1).

Seasonal trends and female reproductive conditions of *Carabus sternbergi* on Mt. Sobaek and Mt. P'algong are shown in Fig. 1 and Fig. 2. On Mt. Sobaek, this species was trapped from May and it reached its peak of activity late May to early July, and on Mt. P'algong it occurred from April at lower sites, and reached its seasonal peak in June to August. The reproductive females oc-

Table 2. Breeding patterns of the subtribe Carabina by female reproductive conditions on Mt. Sobaek and Mt. P'algong, Korea.

Species	Breeding type	Stage of hibernation
C. sternbergi	Spring breeder	Adult
Li. venustus		
E. fraterculus		
D. leechi		
Le. koreanus	Autumn breeder	Larva and adult
Le. semiopacus		
Le. seishinensis		
D. jankowskii		
D. smaragdinus		

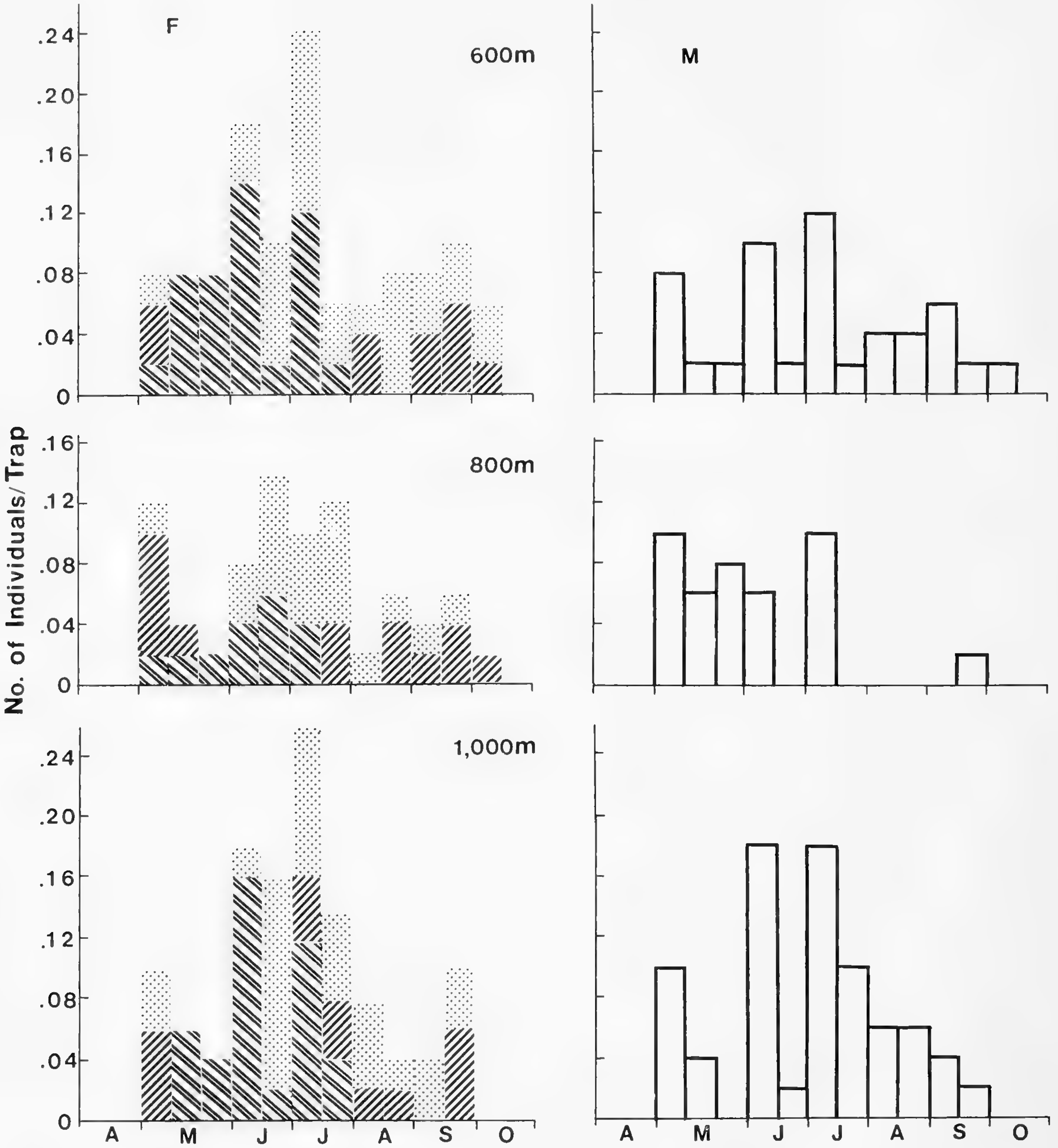


Fig. 1. The seasonal activity patterns of *Carabus sternbergi* on Mt. Sobaek (F, female; M, male; □, post reproductive adults; ▧, new adults; □, reproductive adults).

curred from spring to midsummer. The length of the reproductive period was three to three and a half months. Beginning in June, the increasing number of post reproductive females seemed to be a result of ovulation in May and the emergence of those in early spring was thought to be overwintered spent females of the last year(s). Therefore, it suggests that the life span of this species is two years or more. New adults which occurred from early spring may have been overwintered adults newly emerged during the last year. Those occurring in midsummer seemed to be mostly newly emerged adults during the year. Therefore, this species is obviously a spring breeder.

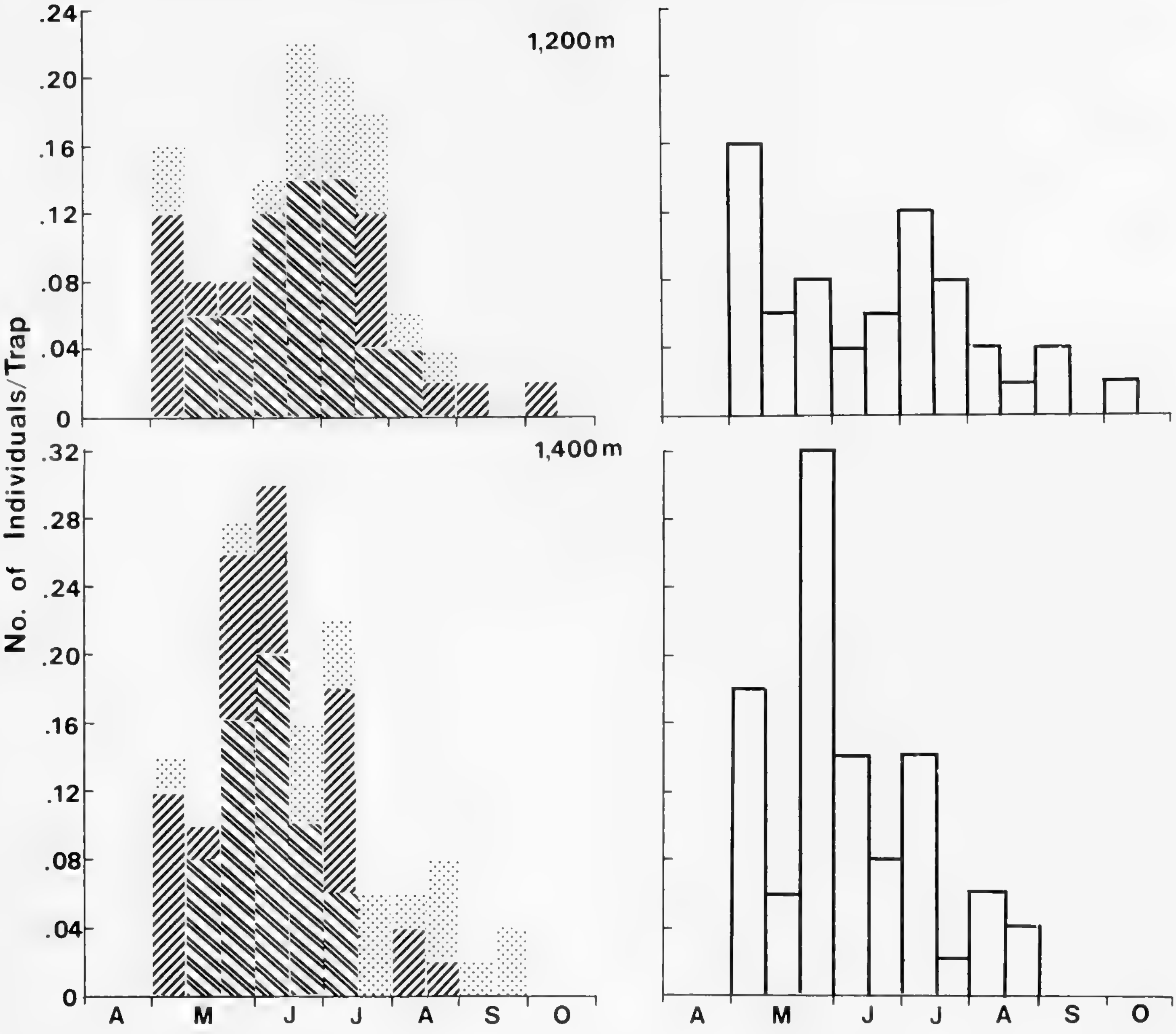
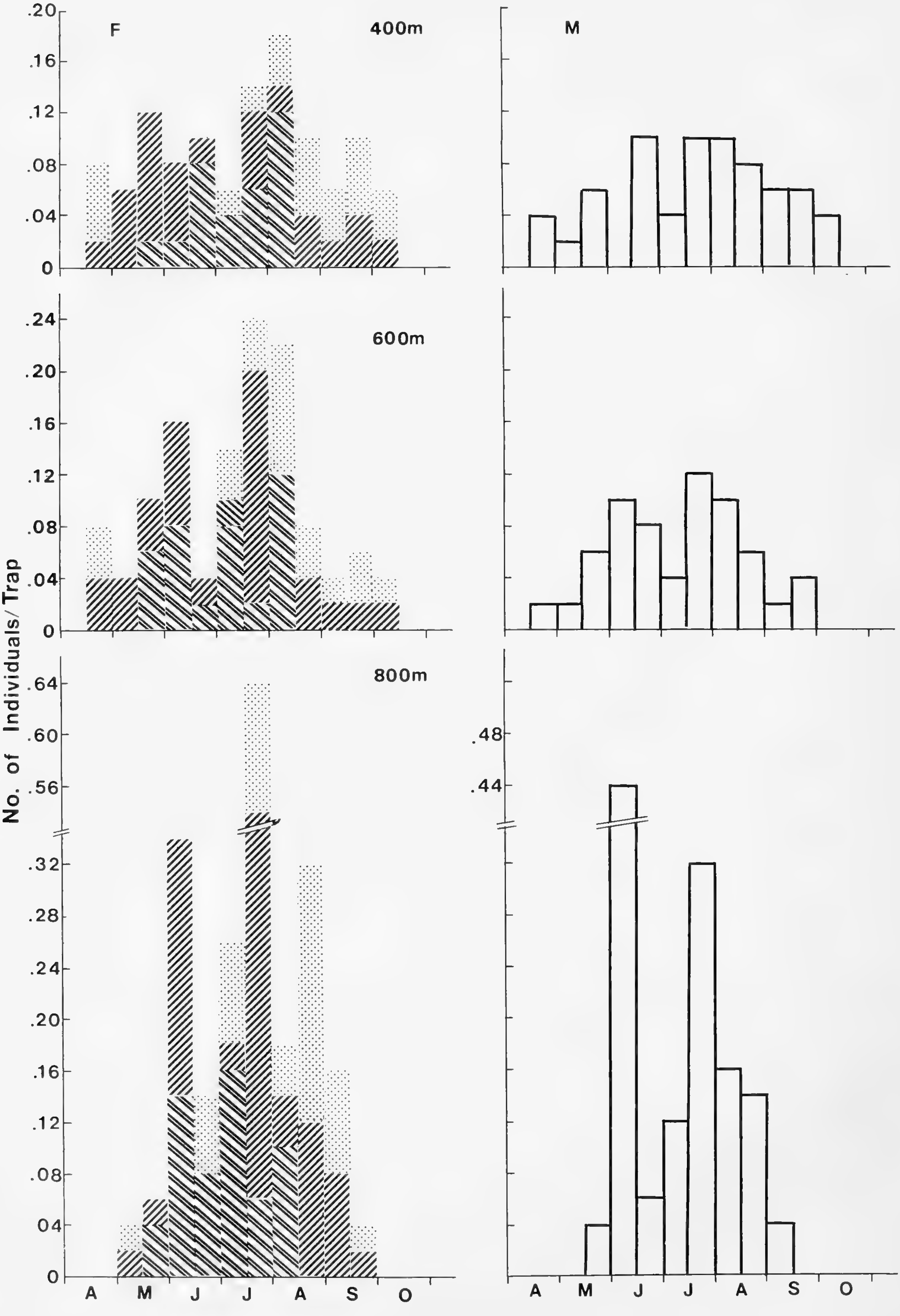


Fig. 1. Continued.

Leptocarabus semiopacus on Mt. Sobaek (Fig. 3) was collected from June or July and the time of occurrence at higher sites (above 1000 m) was slightly later than at lower sites. But on Mt. P'algong (Fig. 4), no difference was found along altitude in seasonal emergence as seen in July collections. They reached their seasonal peak during August in the two localities. On Mt. Sobaek, the reproductive females occurred from July to October, but reproduction began earlier at the higher altitudes (above 1000 m) which started in July while in the lower sites it started in August. The end of the reproductive season was from September to early October, but was also slightly earlier at the higher habitats. The length of the reproductive period indicated by the above results was about two to three months. On Mt. P'algong, that period was from August to September, but no distinct altitudinal differences were observed. In the two localities, during September and October no new adults were collected. This suggests that the hatched larvae do not develop to adults during the first year, hence, they hibernate as larvae. The collection of the spent females in June suggests that the life span of this species is also two years or more. From the above results, *L. semiopacus* is evidently an autumn breeder.

On Mt. Sobaek, *Leptocarabus seishinen-*


F
400m
M
.20
.16
.12
.08
.04
0
600m
.24
.20
.16
.12
.08
.04
0
800m
.64
.60
.56
.32
.28
.24
.20
.16
.12
.08
04
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.48
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No. of Individuals/Trap
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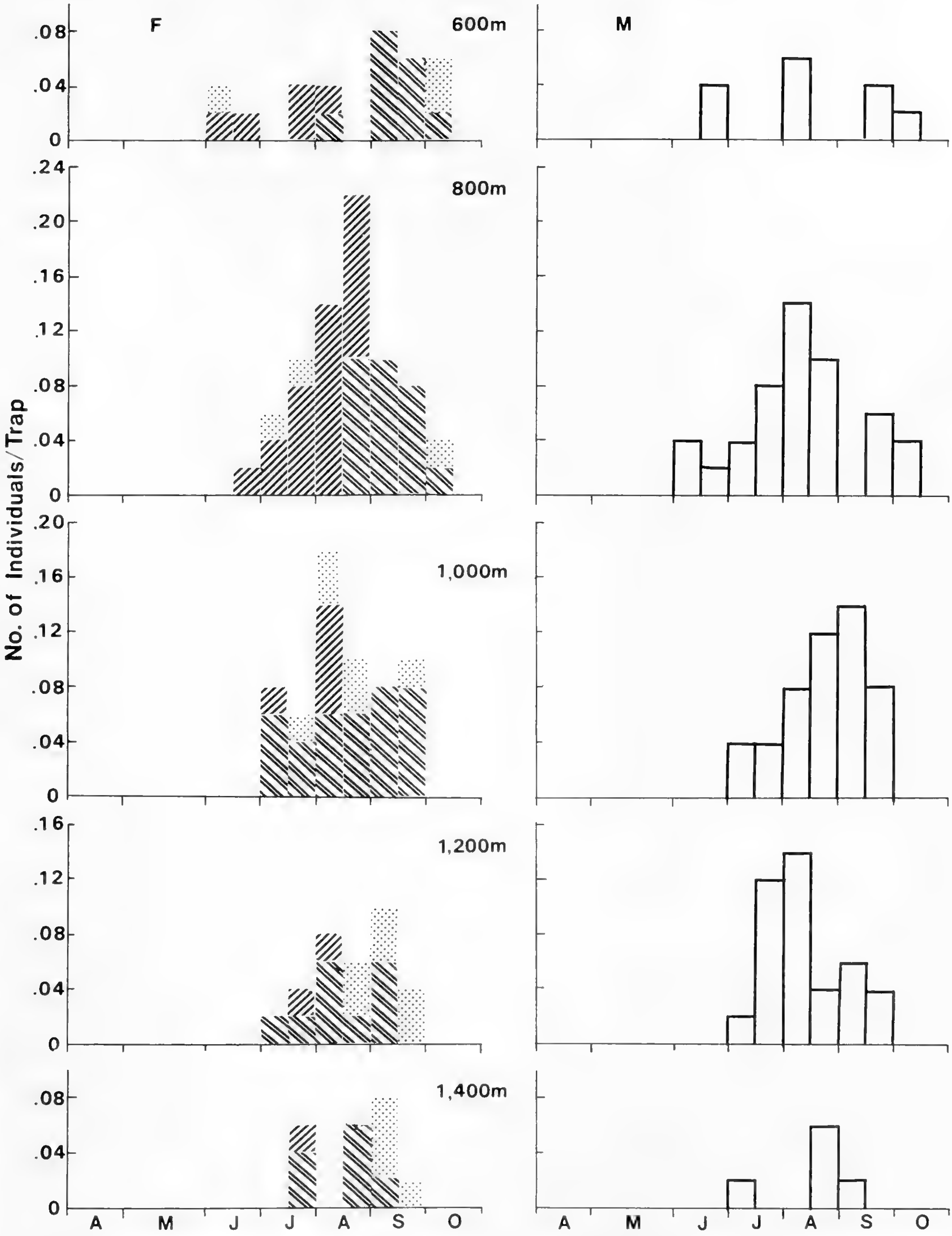

Fig. 3. The seasonal activity patterns of *Leptocarabus semiopacus* on Mt. Sobaek. For further explanations, see Fig. 1.

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Fig. 2. The seasonal activity patterns of *C. sternbergi* on Mt. P'algong. For further explanations, see Fig. 1.

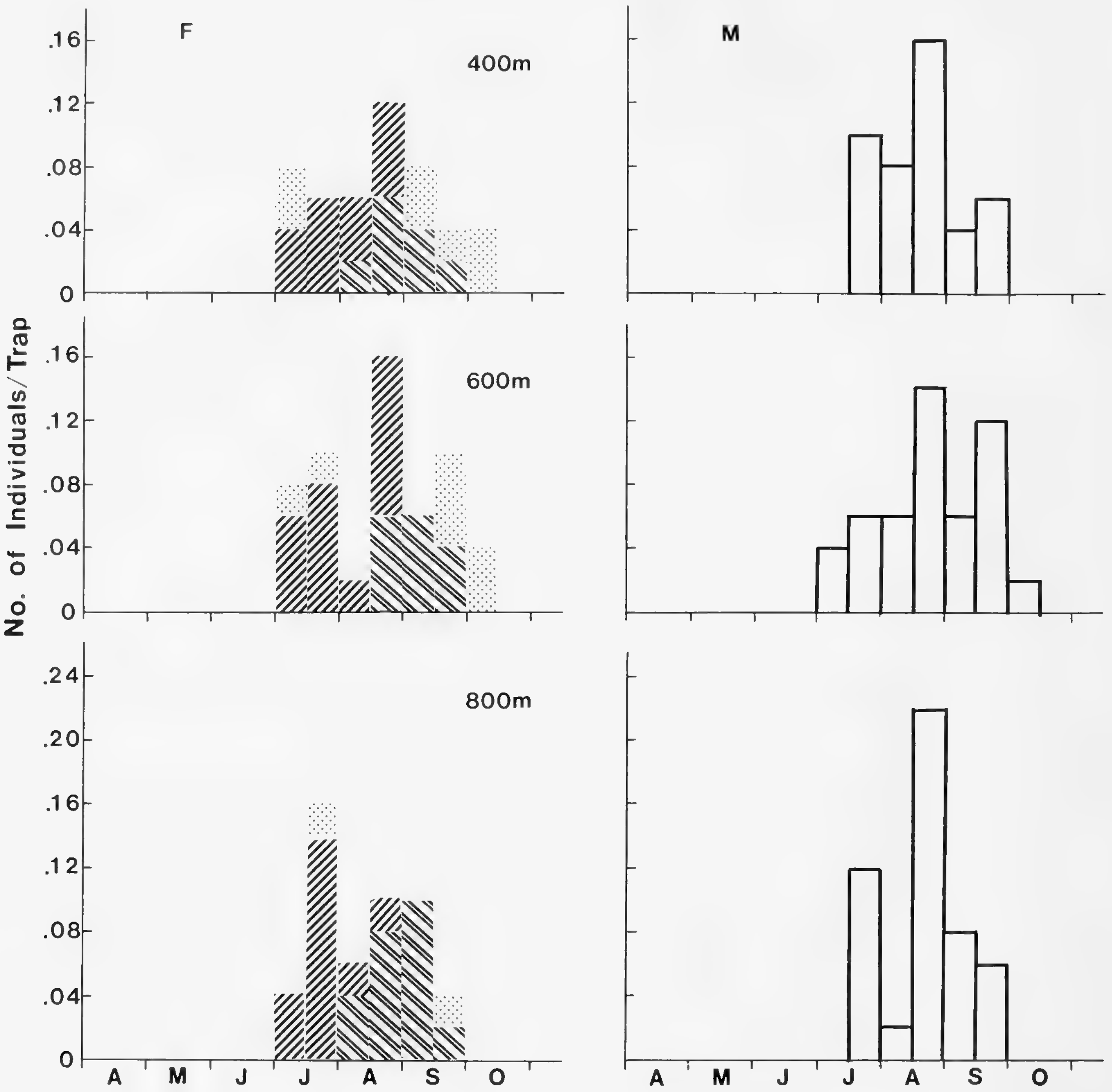

Fig. 4. The seasonal activity patterns of *L. semiopacus* on Mt. P'algong. For further explanations, see Fig. 1.

sis seishinensis was collected from June to early in October at the lower sites and from July to September at the higher sites (Fig. 5). Its reproductive females occurred in August at lower habitats and in July at the higher habitats. This continued to early in September at all habitats. At the higher sites, its reproductive period was longer than at the lower sites. And on Mt. P'algong (Fig. 6), this species was collected from June at 400 m and 600 m. It was collected during July at 800 m. Its reproductive females occurred from July to September. They reached their seasonal peak in midsummer in the two localities. Seasonal occurrences of the new and spent females of this species were similar to *L. semiopacus,* the autumn breeder. So from the results stated above, *L. seishinensis seishinensis* is an autumn breeder like the preceding species.

Damaster jankowskii jankowskii on Mt. Sobaek was trapped from early June to October at 600 m and in September at the other altitudes (Fig. 7). Its reproductive fe-

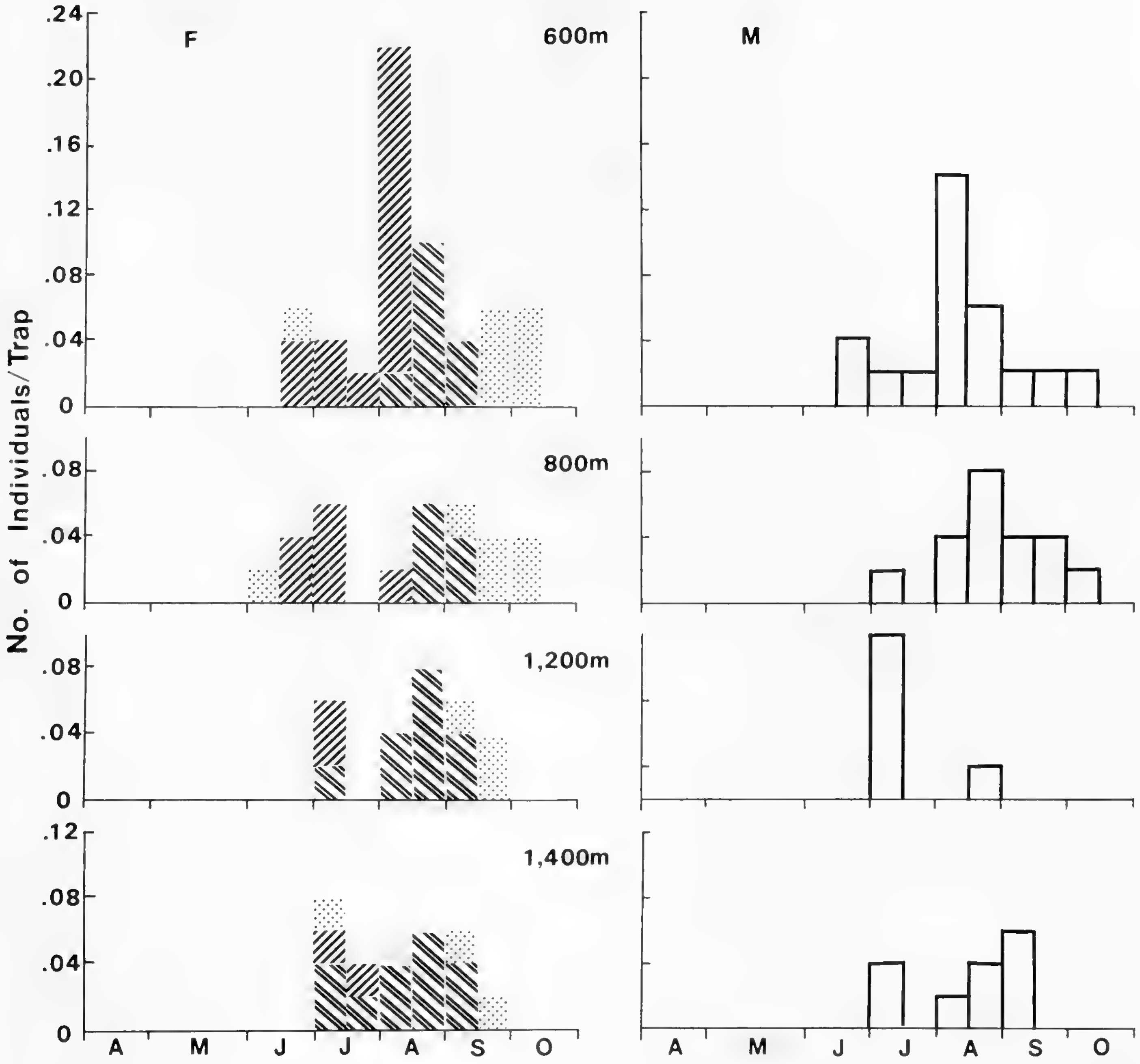

Fig. 5. The seasonal activity patterns of *Leptocarabus seishinensis seishinensis* on Mt. Sobaek. For further explanations, see Fig. 1.

males occurred from early July at lower sites and from late June at higher sites. On Mt. P'algong this species was collected from early June to September or early October and its reproductive females occurred from late June or early July (Fig. 8). In the two localities, this species reached its peak of activity in midsummer. Seasonalities of the new and spent females were very similar to the preceding autumn breeding types. Therefore this species is evidently an autumn breeder.

Eurycarabus fraterculus assimilis on Mt. Sobaek was collected in small numbers compared to the above species except at the highest site, 1400 m (Fig. 9). It appeared from May to September or October. At the highest site, it reached its peak of seasonal activity in spring. The reproductive females occurred from spring to midsummer. This species on Mt. P'algong was trapped in very small numbers. It is exhibited with the results from all sites in Fig. 9. The tendency of seasonality in this species was similar to that of *C. sternbergi,* the spring breeder. Therefore, it was concluded that this species is also a spring breeder.

Leptocarabus koreanus, Damaster leechi

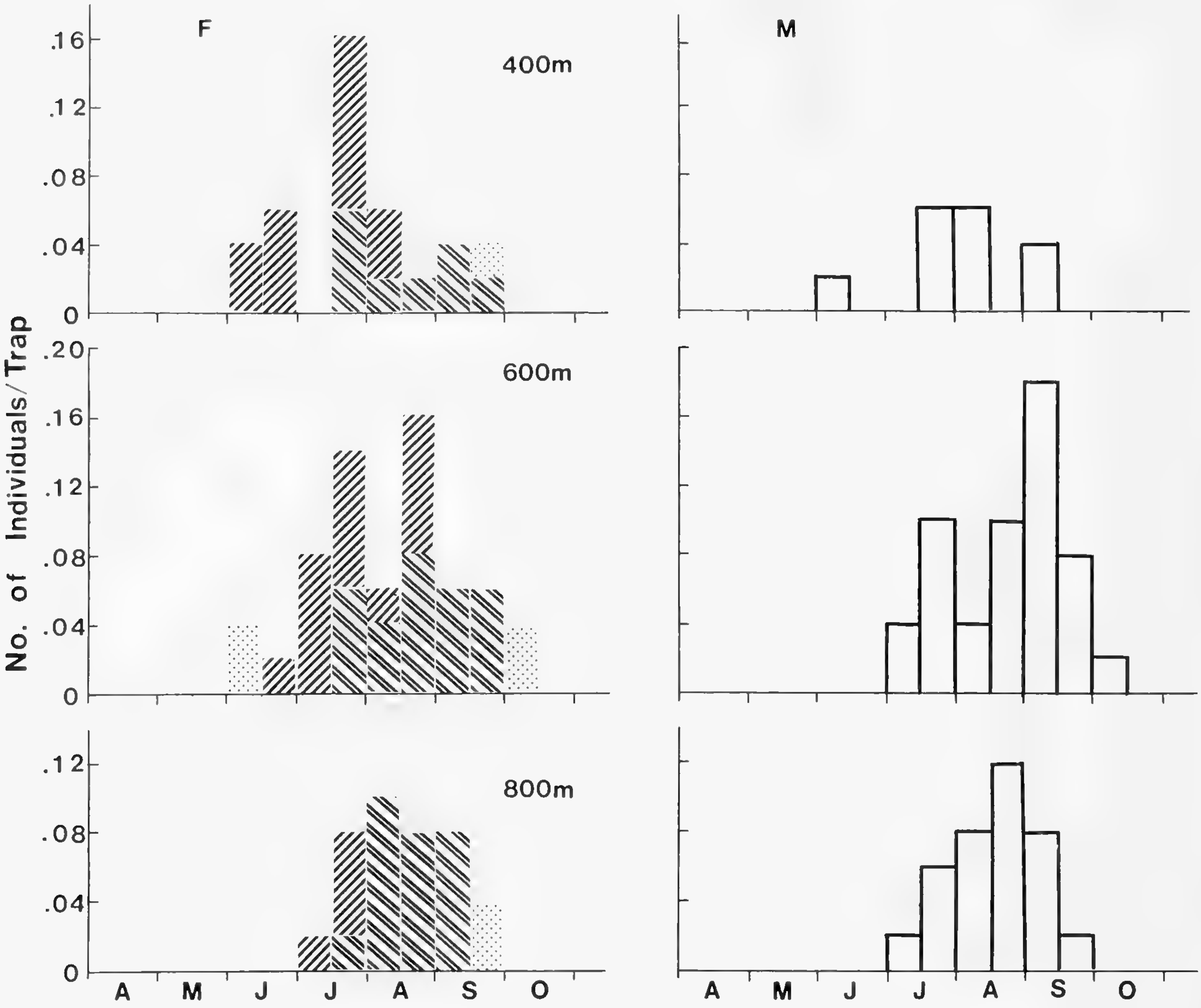

Fig. 6. The seasonal activity patterns of *L. seishinensis seishinensis* on Mt. P'algong. For further explanations, see Fig. 1.

and *Lipaster venustus taebeagsanus* rarely occurred on Mt. Sobaek (Fig. 10) only three females of *L. koreanus coreanicus* were trapped on Mt. P'algong during the entire sampling period. But judging from the appearance of the reproductive adults, *L. koreanus* is an autumn breeder and the other two species appear to be spring breeders. Although *Damaster smaragdinus branickii* on Mt. P'algong was also trapped in small numbers (Fig. 11) and only one female *D. smaragdinus fulminifer* on Mt. Sobaek was collected during the sampling period; this species appears to be an autumn breeder.

The results mentioned above are summarized in Table 2. Of total nine species from Mt. Sobaek and Mt. P'algong, four species, *C. sternbergi, L. venustus, E. fraterculus* and *D. leechi* were spring breeders hibernating as only adults, and five species, *L. koreanus, L. semiopacus, L. seishinensis, D. jankowskii* and *D. smaragdinus* were autumn breeders hibernating as larvae and older adults.

Discussion

The life history patterns of carabids are affected by geographical variations. Some differences of seasonalities were shown on Mt. Sobaek. It had more investigative sites and also a higher altitude than Mt. P'algong. Reproductive females of *Carabus sternber-*

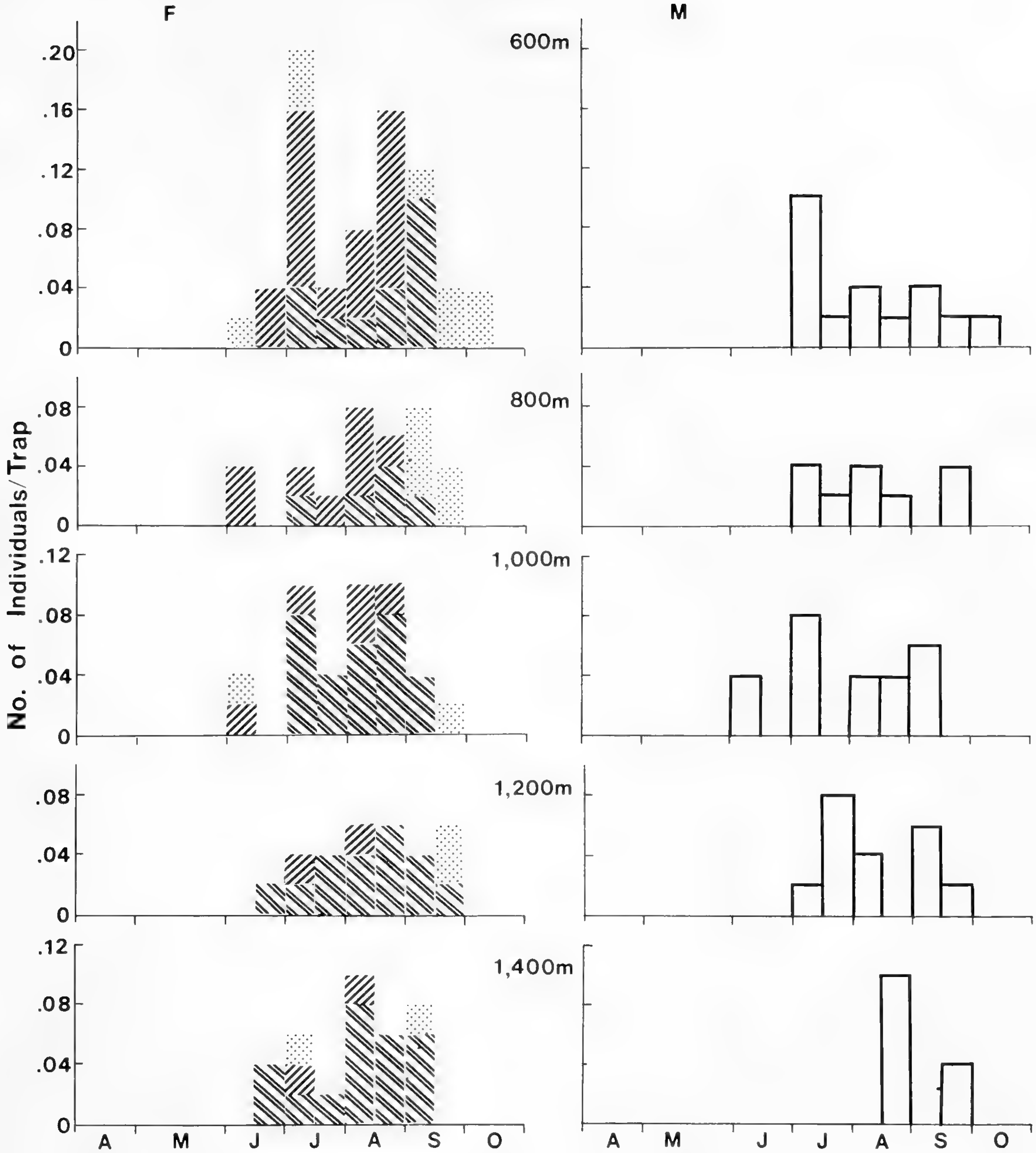

Fig. 7. The seasonal activity patterns of *Damaster jankowskii jankowskii* on Mt. Sobaek. For further explanations, see Fig. 1.

gi, the spring breeder, occurred slightly later at the higher altitudes (above 1000 m). Nonreproductive adults of *Leptocarabus semiopacus, L. seishinensis* and *Damaster jankowskii,* the autumn breeders, emerged earlier and reproductive forms occurred later at the lower sites. Through the study of the autumn breeder *Leptocarabus kumagaii,* Sota (1986a) explained this phenomenon as follows: The delay of new adult emergence at the higher altitudes is probably due to extended larval and pupal period under low temperatures at the higher altitudes. However, the absence of a hot sum-

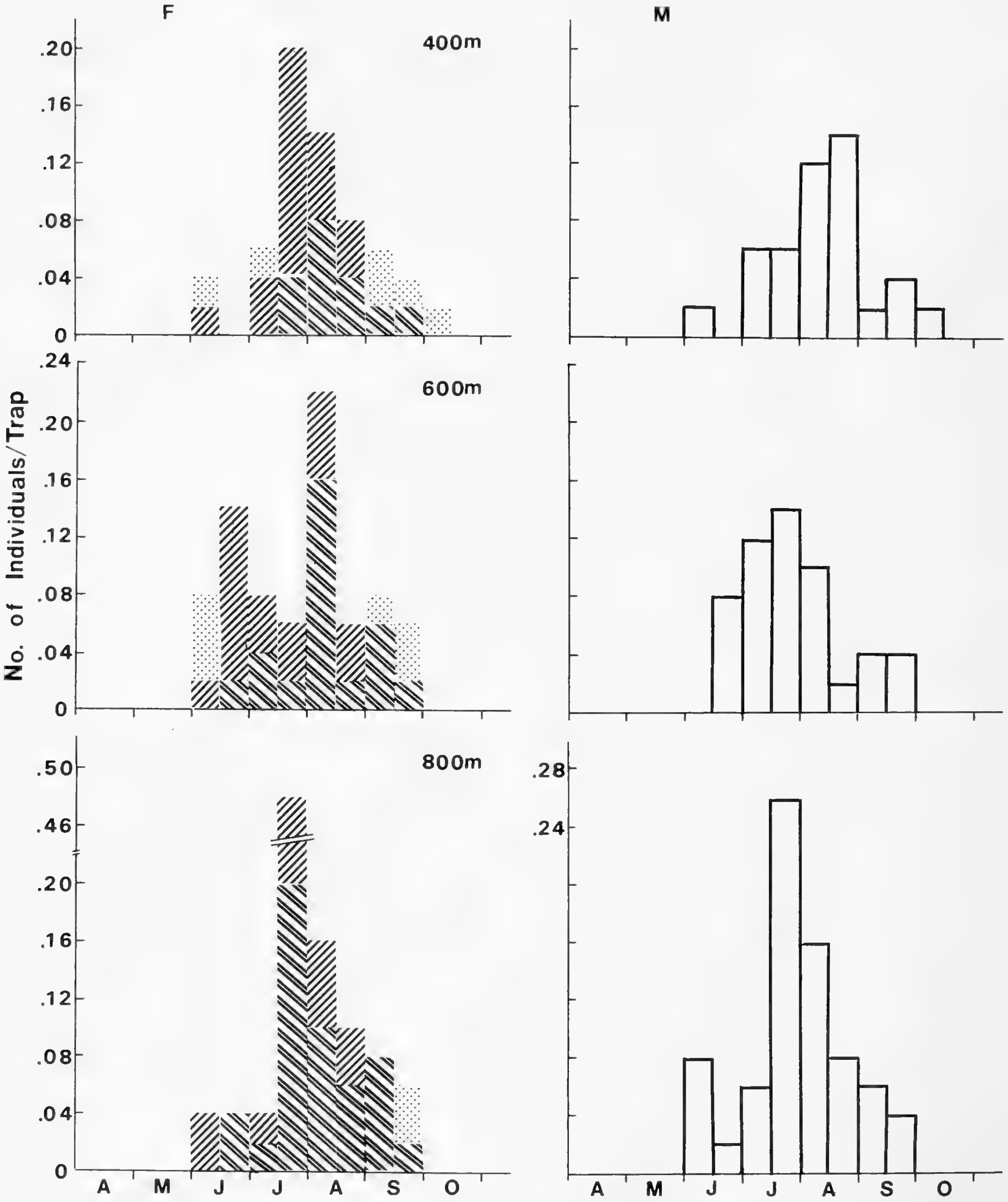

Fig. 8. The seasonal activity patterns of *D. jankowskii jankowskii* on Mt. P'algong. For further explanations, see Fig. 1.

mer at the higher altitudes seems to enable the beetles to start reproduction earlier. Using this point of view, we can conclude that the seasonal patterns of the above mentioned autumn breeders were similar to his results, and the delayed occurrence of reproductive adults of *C. sternbergi* at the higher sites can be explained by the climatic conditions. That is, at the higher altitudes under lower temperature, the vitellogenesis

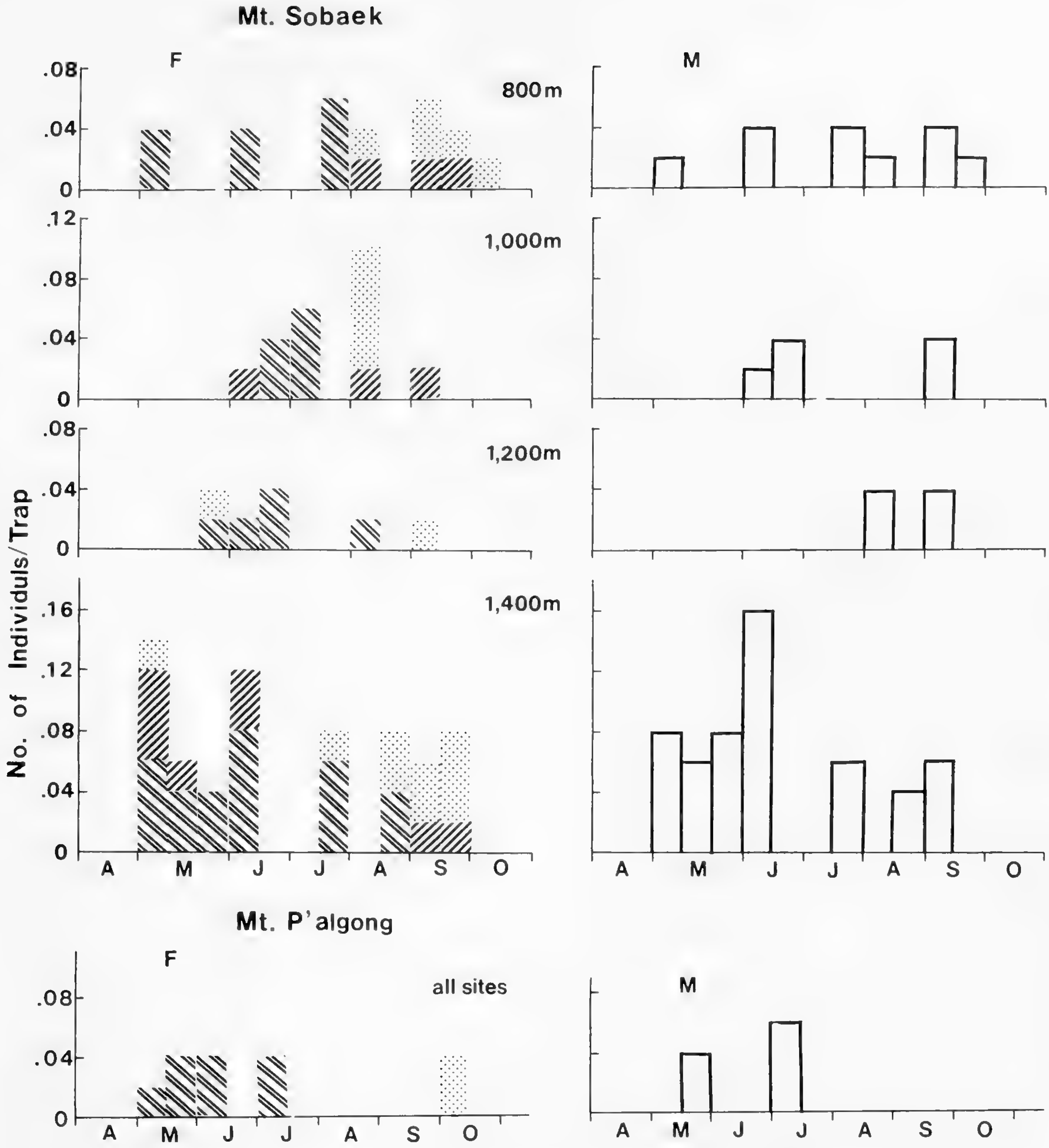

Fig. 9. The seasonal activity patterns of *Eurycarabus fraterculus assimilis* on Mt. Sobaek and Mt. P'algong. For further explanations, see Fig. 1.

of females will be delayed by the climatic condition. It is likely that other climatic factors such as the photoperiod and their surrounding environments also affect the insect life cycle patterns. There are many background interpretations (e.g. Brandmayr and Brandmayr 1986, Butterfield 1986, Danilevsky et al. 1970, Hemmer et al. 1986, Paarmann 1976, 1977, 1979, Refseth 1984, 1986, 1988, Sota 1986b, 1987, Tauber and Tauber 1973, 1976, Tauber et al. 1986, Thiele 1971, 1975, 1977, 1979a, b, Zaslavsky 1988). Hence a high degree of adaptations in response to these factors will be necessary if a species is to become widely distributed.

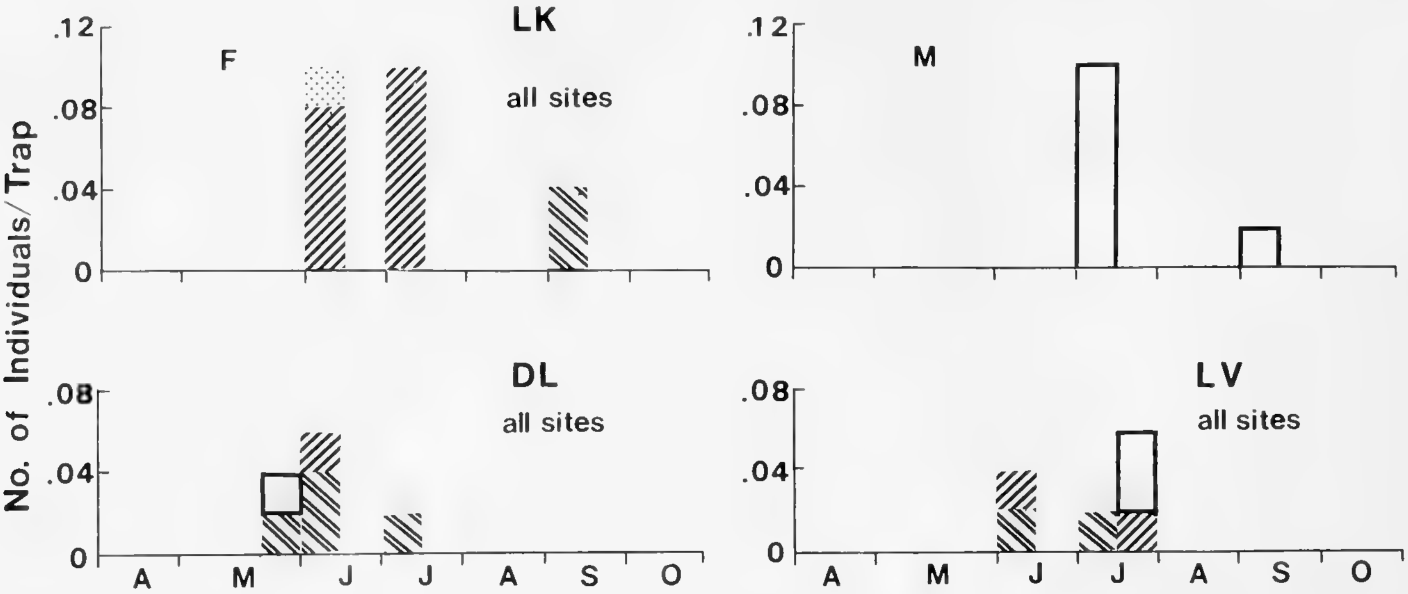

Fig. 10. The seasonal activity patterns of *Leptocarabus koreanus* (LK), *Damaster leechi* (DL) and *Lipaster venustus taebeagsanus* (LV) on Mt. Sobaek. For further explanations, see Fig. 1.

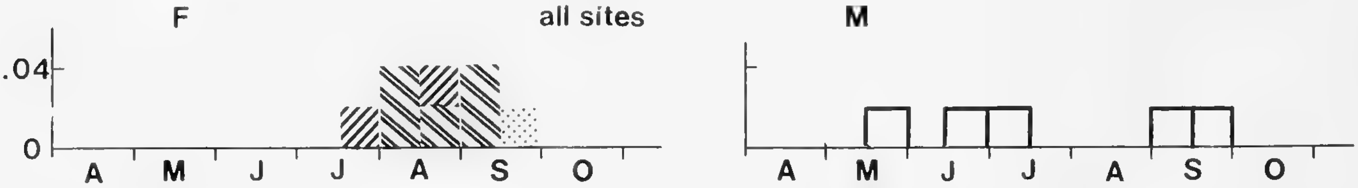

Fig. 11. The seasonal activity patterns of *Damaster smaragdinus branickii* on Mt. P'algong. For further explanations, see Fig. 1.

When reviewing the evolutionary considerations of the life cycles of the spring and autumn types, Paarmann (1979) stated the spring breeders seem to be the more advanced type because of their more complicated control of the gonad dormancy in females. Erwin (1979) suggested that evolution of Carabidae probably proceeded from wet (especially riparian) habitats to mesic ones like forests. According to his suggestion, Bousquet (1986) proposed it is more likely that autumn breeding is the derived condition while spring breeding is the ancestral condition because of their differences of habitats from his results that mainly spring breeders inhabited wet condition and autumn breeders inhabited forests. But in this study, differences of habitat conditions were not a factor. All of the investigated sites were forests and their composition percentages of both breeding types were also similar. To clarify the evolution of these carabids and their phylogenetic relationships, more detailed investigations are therefore required.

Den Boer (1980) reviewed that taxonomically closely related (carabid) insects, i.e. species in the same genus, can indeed be considered to be also ecologically closely related. From his results, he noted in many genera most species do show the same type of annual reproduction rhythm, and as a whole this phenomenon is highly significant. When compared with the results of the present study and Sota (1985), genera *Carabus* as spring breeder and *Leptocarabus* as autumn breeder had the same life cycle types. But in the case of genus *Damaster,* it appeared to be dissimilar, that is, in this paper *D.* (*Coptolabrus*) *jankowskii* and *D.* (*C.*) *smaragdinus* were autumn breeders while *D.* (*Acoptolabrus*) *leechi* was a spring breeder. In his result, *D. blaptoides* was a spring breeder. This species belongs to subgenus

Damaster. From these results, it is concluded that in the genus *Damaster*, their breeding types are separated by subgeneric levels. The differences among subgenera in this genus need further research in viewpoint of phylogeny (see Ishikawa 1986).

ACKNOWLEDGMENTS

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COMPARISON OF MID-INSTAR NYMPHS OF *PERIPLANETA FULIGINOSA* (SERVILLE) AND *PERIPLANETA AMERICANA* (L.) (BLATTODEA: BLATTIDAE)

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Abstract.—Mid-instar nymphs of two *Periplaneta* species are described and compared. Although middle to late stage nymphs of *Periplaneta fuliginosa* (Serville) and *Periplaneta americana* (L.) are difficult to distinguish from each other, two key characters (spines on the prothoracic femur and teeth on the left mandible) are described and drawn which allow for separation of the species.

Key Words: Prothoracic legs, mandibles, diagnosis

Two *Periplaneta* species, the smoky-brown cockroach, *P. fuliginosa* (Serville), and the American cockroach *P. americana* (L.), are considered to be major pest species in the southeastern United States (Appel and Rust 1987). Since there are differences in behavior and habitat preference between the two species (Schal et al. 1984), correct identification of the two species is important. The adults are easily distinguished by color patterns (see adult description in this paper). However, the middle and late instar nymphs are very similar and there are no existing accurate keys for discrimination of these developmental stages.

Because of morphological differences between early and late instar nymphs of the two species, keys should specify which stage of development is being identified. However, stage of development has not been provided consistently in the existing literature. Hebard (1917) described briefly the nymphs of *P. americana, P. fuliginosa* and *P. australasiae* (F.) but did not differentiate between early and late instars. Sweetman (1965) also provided key characters for early instar nymphs of *P. americana, P. australasiae, P. fuliginosa* and *P. brunnea.* Powell and Robinson (1980) presented one of the first thorough descriptions and keys to identify first instar nymphs of five *Periplaneta* species. They also reported that when Burmeister (1838) established the genus *Periplaneta,* he misidentified a nymph of *P. americana* as *P. brunnea.*

The following comparison between these two species includes an adult diagnosis, a diagnosis of the mid-instar nymphs, a detailed description of the mid-instar nymphs, the known distribution of the species, and biological notes on each species. Figures are included where differences need to be elucidated.

MATERIALS AND METHODS

Specimens for this study were obtained from laboratory colonies maintained at the Clemson University Urban Entomology Laboratory. Six unhatched oothecae of *P. americana* and *P. fuliginosa* (three of each) were removed from laboratory rearing containers and placed individually in petri dishes and checked daily. Once the oothecae hatched, the nymphs from each ootheca were placed in a quart Ball® jar containing a screen, a water vial with a sponge plug and dog food. When the nymphs reached a length of approximately 120–130 μ (=15–18 mm) they were identified as middle instar nymphs after a classification by Appel and Rust (1986) and were placed in a freezer and held for examination.

Ten specimens each of *P. fuliginosa* and *P. americana* were examined at 40× under a dissecting microscope fitted with an ocular micrometer. The conversion factor for the micrometer is eight microns in one millimeter. For consistency, measurements will be reported in this paper in microns. Observations were made first on the whole insect body, then exploratory dissections were conducted on legs, abdominal segments, thoracic segments, head and mouthparts. Drawings were made of anatomical parts where a difference between the two species was conspicuous. Voucher specimens are deposited in the Clemson University Arthropod Collection.

Discussion

Periplaneta americana (Linnaeus)

Adult.—Color above chestnut brown; tegmina unicolorous; last segment of male and female cercus twice as long as wide; male abdominal segment I unmodified; male supraanal plate translucent, apically rounded and deeply notched, produced considerably beyond the subgenital plate (Powell and Robinson 1980).

Mid-instar nymph (N = 10).—Head dark brown to black on vertex and frons fading to reddish brown on clypeus. Antennae as long as body, dark brown basally to light red brown apically. Mandibles darker in color on dents (mesal margins), left mandible with seven dents (Fig. 1), right mandible with five. Palps light brown and white on each segment, labial palps white apaxially, maxillary palps reddish brown apically.

Pronotum: Length 38 μ (±8 μ), width 52 μ (±8 μ), ratio 0.73, sparsely setose with very short setae. Mesonotum: length 22 μ (±5 μ), width 58 μ (±5 μ), ratio 0.37. Metanotum: length 18 μ (±3 μ), width 58 μ (±3 μ), ratio 0.31. Thoracic nota variable in color, usually with pronotum reddish brown with pale brownish white markings on lateral margins and dark anterior and posterior margins. Mesonotum and metanotum uniformly reddish brown.

Abdominal terga reddish brown anteriorly, changing to dark brown posteriorly, sparsely setose with very short setae. Segments I–III white ventrally, segments IV–VIII reddish brown ventrally with dark brown on lateral margins. Segments IV–VIII each 10 μ (±6 μ) long, and, IV to VIII, respectively, 52 μ (±4 μ), 55 μ (±3 μ), 55 μ (±3 μ), 55 μ (±3 μ), 50 μ (±2 μ), wide.

Legs light reddish brown ventrally. Coxa dark brown anteriorly and white posteriorly with small scattered setae. Femur 40 μ (±5 μ) long, one long and three short spines on anteroventral margin. Fifteen long spines on posteroventral margin. Tibia 20 μ (±5 μ) long, with 15 large (9 μ long) spines radially, tibia and tarsus covered with setae. Tarsal segments = 5,5,5, spurs at apex of each tarsomere 1–4, no spurs on tarsomere 5, two tarsal claws present with arolium (5 μ long) (Fig. 3). Cerci reddish brown, densely setose ventrally.

Known distribution.—Africa, Europe, India, Japan, Australia, North America, South America (Bell and Adiyodi 1982).

Biological notes.—*Periplaneta ameri-*

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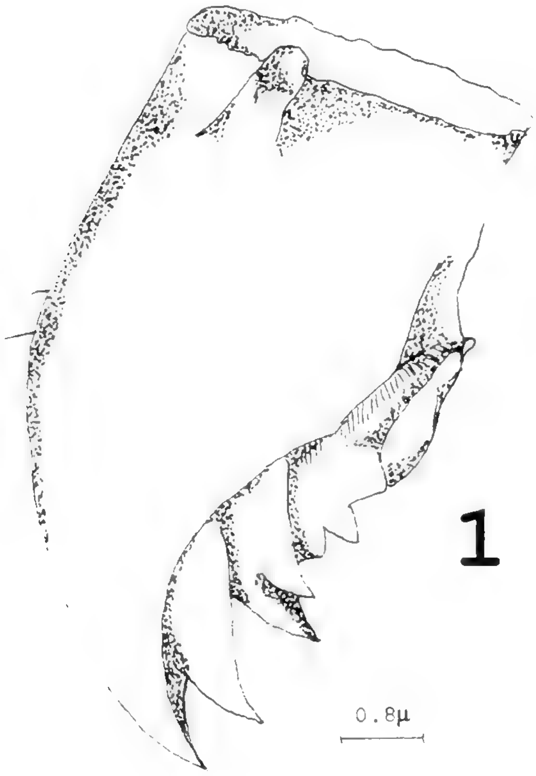
Figs. 1–4. *Periplaneta* spp. 1, *Periplaneta americana* left mandible (ventral view). 2, *Periplaneta fuliginosa* left mandible (ventral view). Scale bar = 0.8 μ. 3, *P. americana* left prothoracic leg (anterior view). 4, *P. fuliginosa* left prothoracic leg (anterior view). Scale bar = 8.8 μ.



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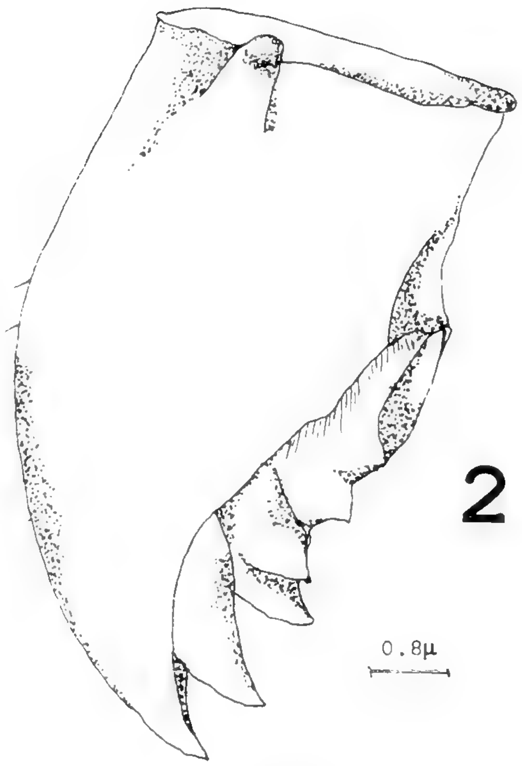

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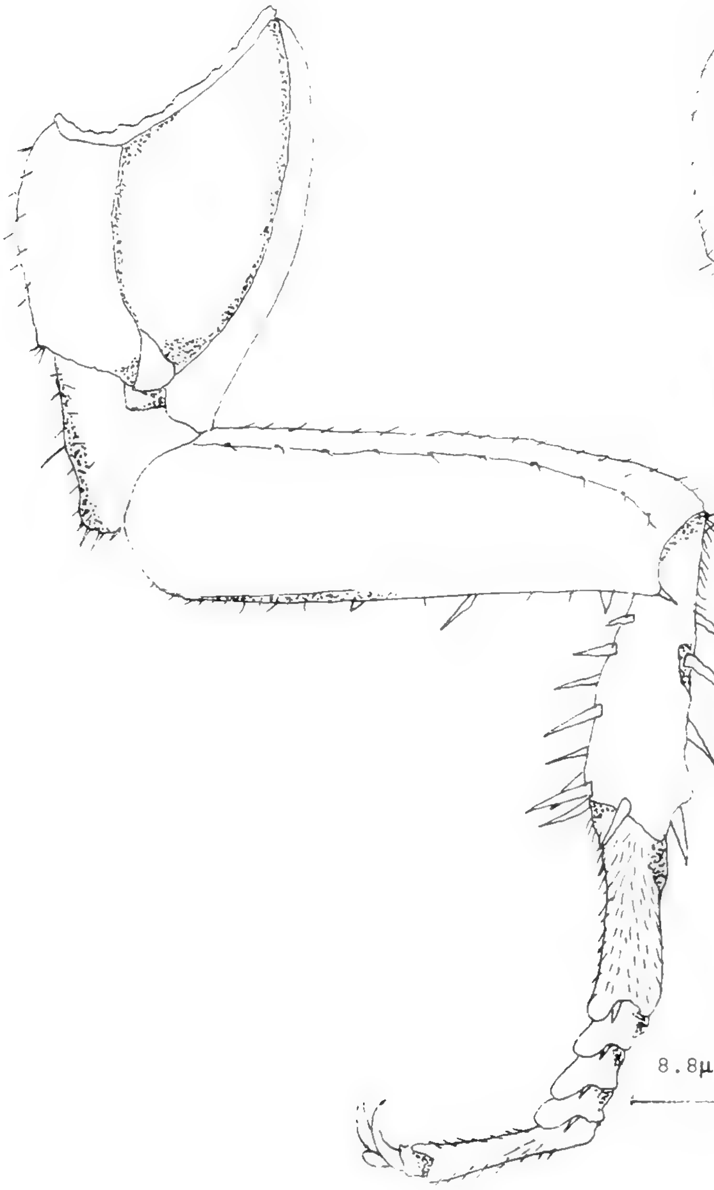

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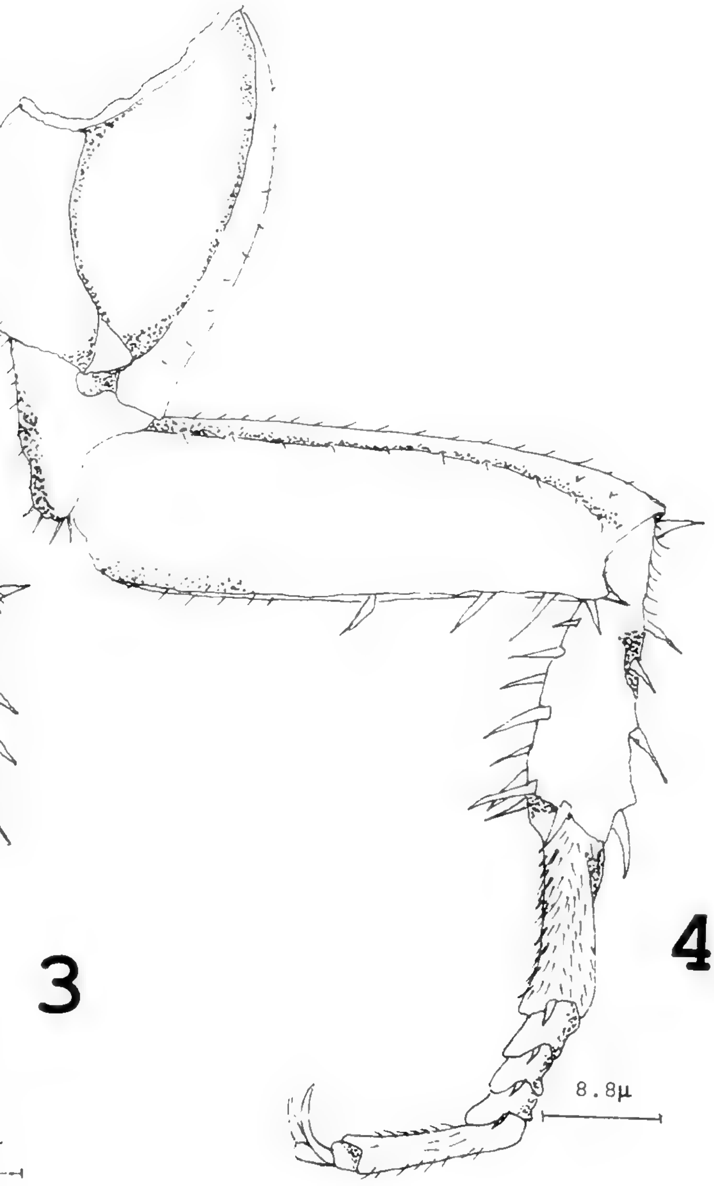

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cana prefers a warm, moist environment. The upper limit of preferred temperatures is 33°C. In tropical and subtropical America, this cockroach is common outdoors and seen most frequently in the summer months, however they do remain active at 21°C. Evidence points to their origin being tropical Africa (Cornwell 1968). The American cockroach is an indoor/outdoor pest of human structures, feeding on decaying organic matter, debris and almost any available substrate. They are found in leaf litter, shrubbery, and in most lower levels of structures which provide adequate moisture. There are 9–12 nymphal molts and a lifespan of two years (Cornwell 1968).

Periplaneta fuliginosa (Serville)

Adult.—Color above entirely blackish brown; both sexes fully winged; male abdominal segment I with broad shallow depression bearing tuft of setae; male supraanal plate sclerotized, opaque, apically truncate and not deeply notched, not or scarcely produced beyond the subgenital plate; ventral surface of male supraanal plate specialized bearing two large callosities, the surfaces of which are covered with microscopic denticulations (Powell and Robinson 1980).

Mid-instar nymph (N = 10).—Head reddish brown dorsally and ventrally. Palps brown and white alternatively; maxillary palps reddish brown apically, 24 μ (±6 μ) long, labial palps white apically, 10 μ (±4 μ) long. Left mandible with six teeth on mesal surface (Fig. 2), right mandible with five teeth on mesal surface. Antennae as long as body; uniformly reddish brown, each segment showing band of pale brown apically.

Thoracic nota reddish brown with dark brown on posterior edges. Pronotum: length 40 μ (±8 μ), width 55 μ (±8 μ), ratio 0.72 covering ⅔ of head. Mesonotum: length 11 μ (±5 μ), width 70 μ (±5 μ), ratio 0.31. Metanotum: length 22 μ (±5 μ), width 70 μ (±5 μ), ratio 0.31. All thoracic nota sparsely setose with short setae.

Abdominal terga reddish brown with dark brown on posterior edges, sparsely setose, segments IV–VIII 10 μ (±4 μ) long and segments IV to VIII, respectively, 62 μ (±4 μ), 65 μ (±2 μ), 68 μ (±2 μ), 68 μ (±2 μ), and 55 μ (±4 μ) wide. Segments I–III white ventrally, segments IV–VIII reddish brown ventrally.

Legs reddish brown. Coxa with small scattered setae. Femur 40 μ (±5 μ) long, five spines of even length on anteroventral margin, 15 long spines on posteroventral margin. Tibia 20 μ (± 5 μ) long, with 15 large (9 μ long) spines radially, tibia and tarsus covered with setae. Tarsal segments = 5,5,5, spurs at apex of each tarsomere 1–4, no spurs on tarsomere 5, two tarsal claws present with arolium (5 μ long) (Fig. 4). Cerci reddish brown, densely setose ventrally.

Known distribution.—Japan, China, North America, South America (Schal et al. 1984).

Biological notes.—*Periplaneta fuliginosa* also prefers warm moist habitats and has a biology which is similar in some respects to *P. americana. P. fuliginosa* is a domiciliary pest found most commonly in the southern United States. It infests structures as well as harboring in leaf litter, shrubbery, mulch and especially in the upper branches of large hardwoods. For this reason it is commonly found in attics and upper levels of structures which it enters through the roof or attic windows (Cornwell 1968). Unlike *P. americana,* the nymphal development of *P. fuliginosa* is not affected as much by temperature as by the proximity of other nymphs. *P. fuliginosa* has approximately 9–12 nymphal molts and a life span of two years (Guthrie and Tindall 1968).

For a comparison of diagnostic characteristics between the mid-instar nymphs of the two *Periplaneta* species, see Table 1.

SUMMARY

Ten mid-instar nymphs of *P. americana* and *P. fuliginosa* were dissected and examined under the microscope. In a textbook

Table 1. Diagnosis of mid-instar nymphs of *Periplaneta* spp.

P. americana (L.)	*P. fuliginosa* (Serville)
Left mandible with seven dents (Fig. 1)	Left mandible with six dents (Fig. 2)
Prothoracic femur with four small spines of varying length on anteroventral margin (Fig. 3)	Prothoracic femur with five subequal spine (c. 5) on anteroventral margin (Fig. 4)
Antennae dark brown basally, pale red apically	Antennae unicolorous reddish brown
Head dark brown to black on vertex and frons, reddish rown on clypeus	Head unicolorous reddish brown
Pronotum variable, often reddish brown with pale lateral margins and dark brown anterior and posterior margins; otherwise, thoracic nota pale reddish brown, white ventrally	Thorax reddish brown dorsally, white ventrally
Abdominal terga light brown anteriorly, shading to dark reddish brown posteriorly; sterna pale reddish brown	Abdominal terga reddish brown with darker margins posteriorly; sterna pale reddish brown

by Stehr (1987), these two species are separated by the presence (*P. fuliginosa*) or absence (*P. americana*) of an arolium. Of the 20 specimens examined in both species the arolia were always present. Many other characteristics used to separate the two species are highly variable, such as color and size. Two consistent diagnostic characters were identified which are easily seen using a common dissecting microscope at 40×. These characters were also found in some of the smaller instars (although they become difficult to see with smaller sizes) and larger instars through adults. Seven distinct teeth are present in the left mandible of *P. americana* and only six teeth in the left mandible of *P. fuliginosa* (FIgs. 1, 2). The prothoracic legs of *P. americana* have only one long and three short spines along the lateral posterior margin of the femur while the same area of *P. fuliginosa* has five long spines (Figs. 3, 4).

The characters described above would be useful in the field identification of the two *Periplaneta* species if a good hand lens were used. In the laboratory, these characters could be used for separating nymphs of the two *Periplaneta* species with the aid of a dissecting microscope. Continued research on differences between the more frequently confused *Periplaneta* cockroach species should provide more information for differentiating both nymphs and adults of these species in the future.

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TWO NEW DIXIDAE (DIPTERA) FROM NORTH KOREA

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Abstract.—Two new species, ***Dixa orientalae*** and ***Dixella corensis,*** are described and their distinguishing morphological characteristics illustrated. A brief history of the unusual "unearthing" of these specimens (after 50+ years) is included.

Key Words: Insecta, Diptera, Dixidae, *Dixa, Dixella*

The species of Dixidae described below are the first to be reported from North Korea, a country in which little recent work in insect taxonomy is currently being published. The dixids are not particularly odd, but the story behind my acquisition of them is of interest. It all started with my coming to Massachusetts and meeting Dr. Charles P. Alexander.

"Doc Alex" at the time was a professor emeritus and distinguished taxonomist (see Byers 1982, Wheeler 1985) dedicated to the description of nematocerous Diptera, primarily in the family Tipulidae, but with interest in Tanyderidae, Trichoceridae, and Ptychopteridae, among others. He and his wife, Mabel, seemed to have organized most aspects of their lives as thoroughly as their work in the taxonomy of Diptera. For example, I knew that they maintained and added to an immense photographic file of biologists they met, and of wild flowers encountered in their collecting trips. I should also have suspected that their correspondence files were as well organized as all else I encountered with Doc and Mabel Alexander. It was only after Doc Alex's death that I came to appreciate and benefit from their years of unceasing dedication to the details of life.

The executor of Dr. Alexander's will, William B. Nutting, called me to go through whatever entomological materials were still in the Alexander home after Doc Alex's death. Of course the entire collection and pertinent literature previously had been removed by personnel of the Smithsonian Institution, the purchaser of Doc Alex's collection. Among the materials I found in the back of a closet were: about ½ of the Alexander photo slide collection, an original typed index to the entire photographic slide collection (over 10,000 slides), a couple of vials containing body parts of tipulid holotypes and a variety of old entomological supplies. Among the latter were two tin mailing boxes, still partially wrapped, that caught my attention. The boxes were addressed to Doc Alex from Alexander Yankovsky and contained glassine triangles of specimens Yankovsky had collected during 1937 in North Korea.

As I sorted through the triangles of Crane flies to discard those destroyed by dermestids I recalled that Doc Alex had described several dixids, scattered among his thousands of tipulid descriptions. I suspected that these dixids were inadvertently included in collections bought by Alexander from professional collectors who couldn't distinguish between dixids and the small types of tipulids. My idea was confirmed when I found two triangles with dixids and mycetophilids among the tipulids. The dixids described below are from one of the triangles, marked "Ompo-600 ft."

Yankovsky, a nobleman, had escaped from Russia with his family and a large retinue of retainers at the time of the Bolshevik revolution and had set up an essentially feudal estate in the wilderness of northern Korea. He earned hard currency from a variety of activities, including the collection and sale of animals, ranging from tigers for zoos to spectacular Lepidoptera, reared and wholesaled to biological supply houses (Price 1936). Thus, it was through one of his advertisements that he came to the attention of Charles P. Alexander in the mid 1930s. Dr. Alexander, at the peak of his life's work on tipulid taxonomy, wrote Mr. Yankovsky, who agreed to collect tipulids in the mountains of Northern Korea for 5 cents/specimen.

Yankovsky sent three shipments to Alexander containing his tipulid collections from 1937. Alexander apparently perused the specimens, picking out the undescribed species, labelling those he already knew, and writing Yankovsky a long letter of encouragement to continue and intensify his collecting efforts, all on the day the shipment arrived. The rest of the shipment was put aside and lay untouched for over forty years.

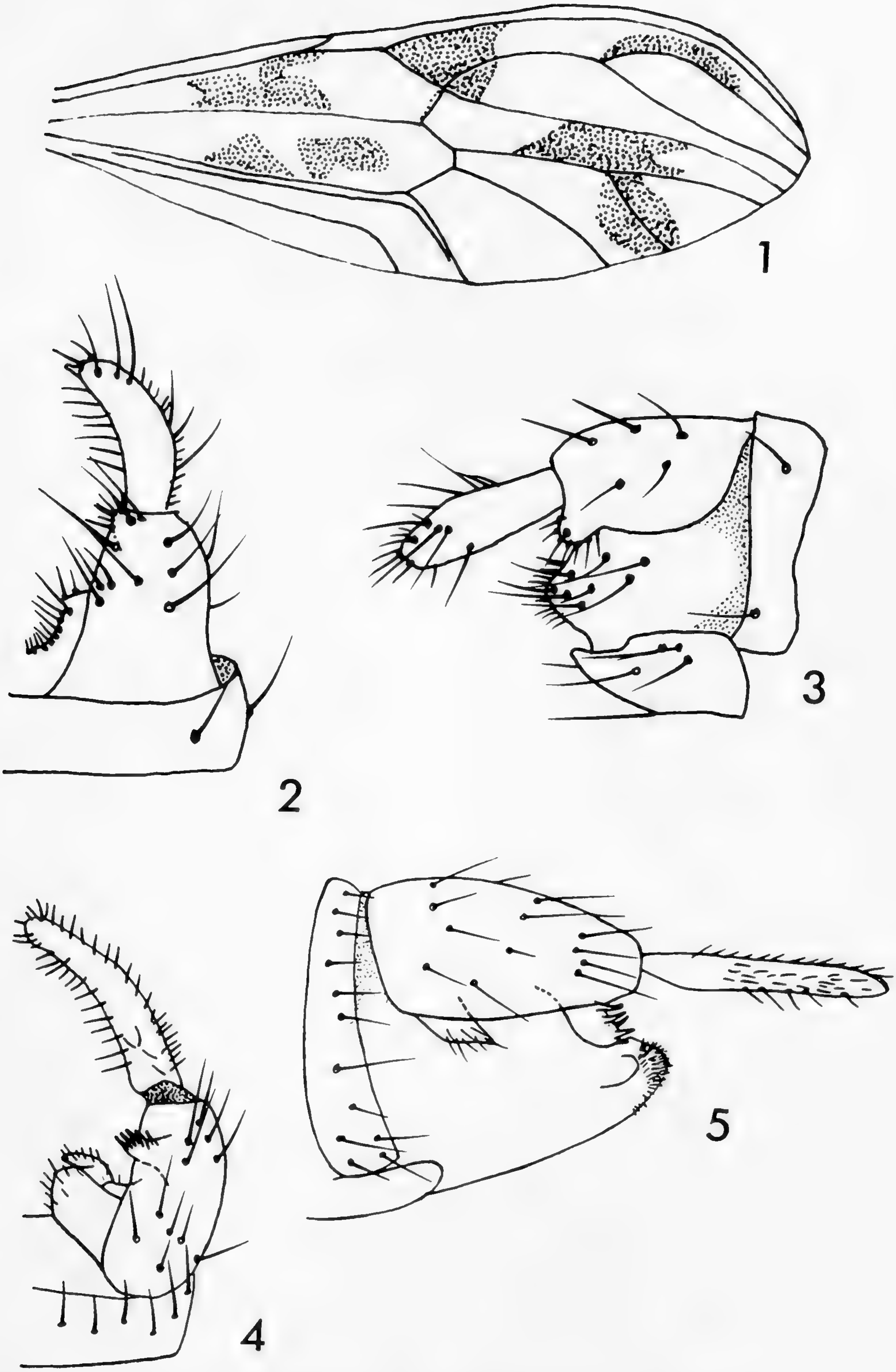
A visiting Korean scientist in our department, Dr. Hy Phong Lee, gave me the coordinates for the only "Ompo" he could find on modern-day maps of the Korean peninsula. These were for a small island off the extreme southern tip and didn't include the prefix, "Shuotsu," present on the mailing labels. Lawrence Feldman, the head librarian in our biological sciences library found a "Shuotsu" entry in a gazetteer for Korea. It identified a hot springs resort in North Korea, but without an "Ompo" associated with it. Paul Shepard, librarian in the University map library retrieved sets of modern maps of Korea, but none revealed a Shuotsu-Ompo.

After some deliberation about approaches to discovering the whereabouts of "Shuotsu-Ompo" I decided to see if any information was available in the Alexander files that had been included in the Smithsonian archives. William Cox, the assistant archivist, to whom I had previously mailed the index and photographic slides, had sent me a guide to the Alexander holdings (Cox 1985). A file on Korea-Manchuria and a file on A. M. Yankovsky were listed. I called the Archives and within 10 minutes Susan W. Glenn, another assistant archivist, had pulled the files and agreed to copy and send the material. Included was a map with both "Ompo" and "Shuotsu" marked. Reexamination of modern maps showed that "Shuotsu" was the name in Japanese-dominated Korea of a town now known as Chuuronjang. The nearby town of Ompo is now called Wadok. Wadok is located at the coordinates listed in the species descriptions.

***Dixa orientalae* Peters, New Species**

Figs. 2, 3

Adult.—*Head:* Dark brown, microtrichose, with a row of setae along periphery of compound eye, a seta mesad of this row on vertex; frontoclypeus dark brown, with 2 setae much shorter than setal row on vertex; antenna dark brown, subequal in length to head and thorax; flagellar segments fusiform, first flagellomere width: length as 1:4.7. *Thorax:* Scutum with 3 dark brown vittae, yellow-brown and pruinose between, mesal vitta with a longitudinal row of 8 setae, and a row of 4 setae on lateral side of scutum from ventral edge extending dorsally just anterior to posterior limits of mesal vitta, all setae slightly shorter than peripheral row on vertex; scutellum with a transverse row of 13 setae, most lateral setae in row longest, progressively shorter mesally, with tips forming a straight line, another seta behind center of row. *Wing:* Clear, with small, diffuse cloud around r–m, length 4.4–4.9 mm; M3+4:M1+2 as 1:1.7,M3+4:Mst



Figs. 1–5. *Dixella corensis* Fig. 1, wing; Fig. 4, ♂ terminalia, dorsal view; Fig. 5, lateral view; *Dix orientalae*; Fig. 2, ♂ terminalia, dorsal view; Fig. 3, lateral view.

as 1:2.0–2.6, R2+3:R3 as 1:1.0–1.4. Crossvein r–m complete. *Halter:* Hyaline at base; club medium brown. *Legs:* Distal spiniform seta on tarsomere 3 of each leg; basal spiniform seta on tarsomere 3 of middle leg; 1–2 weak basal recurved spiniform setae on tarsomere 5 of foreleg; claws of all legs with 3–4 moderately long teeth on venter, 5 on claws of foreleg of 1 male; femur:tibia:tarsus length ratios of foreleg as 1:1.07–1.09:1.18–1.36; of middle leg as 1:0.96:1.33; of hind leg as 1:1.02–1.13:1.43–1.54. *Abdomen:* Medium brown; gonocoxite as in Figs. 2 and 3, lacking basal lobe, apical lobe projecting mesally without elaborations; gonostylus cylindrical, slightly swollen in middle (in lateral view), in dorsal view, curving mesally, subequal in length to gonocoxite; ejaculatory duct lacking; phallus membranous, pappillose.

Specimens examined.—Holotype male, from Yondu mountain, within the Chuuron River drainage system, near the town of Wadok, 41°37′30″N, 129°32′30″E. Collected by Alexander M. Yankovsky on Nov. 8, 1937, at an altitude of about 600 feet, deposited in Alexander Collection, Smithsonian Institution, Washington. One male paratype also included in a glassine triangle labelled “Ompo-600 Ft.”; deposited in the T. Michael Peters dixid collection, Department of Entomology, University of Massachusetts, Amherst, Massachusetts.

Dixella corensis **Peters,**
NEW SPECIES

Figs. 1, 4, 5

Adults.—*Head:* Dark brown; microtrichose; two long along dorsal periphery of eye; frontoclypeus with 12 setae (length 1½ times width of first flagellomere arranged in a circle; antenna concolorous with head; first flagellomere about 7.5 times as long as wide, slightly fusiform so that individual flagellomeres are distinct; antennal length over almost twice length of thorax. *Thorax:* Scutum uniformly dark brown, pruinose, without discernable vittae; scutellum with 11 setae (0.8 × length of first flagellomere), central one with another posterior to it; anterior pronotum with 2 setae (0.8 × width of pedicel); posterior pronotum without setae. Pleuron without setae. *Wing:* Lightly patterned as in Fig. 1, length 2.96 mm; M3+4:m1+2 as 1:1.6, M3+4:Mst as 1:1.6, R2+3:R3 as 1:1.39. Crossvein m–cu complete; r–m contacts radius at its furcation; *Halter:* hyaline, capitum scarcely broader than pedicel. *Legs:* Distal spiniform seta on tarsomeres 1–4; basal recurved spiniform seta on tarsomere 5 of foreleg, but less stout than on any other species ever examined; hind tibia distinctly swollen distally; claws of foreleg with 5 long ventral teeth, also 3 slender dorsal teeth; hind claws with 2 thin teeth on venter. *Abdomen:* Color medium brown. Male terminalia as in Figs. 4 and 5; without sclerotized ejaculatory duct; claspettes and penis valves were not discernable in cleared glycerin mount, even under interference microscopy.

Specimens examined.—Holotype male, from Yondu mountain, within the Chuuron River drainage system, near the town of Wadok, 41°37′30″N, 129°32′30″E.

DISCUSSION

The two new species described above are easily distinguished from the sole species reported in northeastern Asia, *Dixa guttipennis* Thomson. *Dixa orientalae* has only a single diffuse spot around r–m on the wing, whereas *Dixa guttipennis* Thompson has a series of 4 wing spots in a row from near the wing base to the fork of the Rs. The spots are unequal in size and spacing. In *Dixella corensis* the most distal wing spot starts at the fork of R_2 and R_3.

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KEY TO THE GROUP OF NEOTROPICAL WASP-MIMETIC HARPACTORINE GENERA AND THE DESCRIPTION OF A NEW SPECIES (HEMIPTERA: REDUVIIDAE)

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Abstract.—**Neotropiconyttus heminigra** is described from Peru and a key to the neotropical wasp-mimetic harpactorine genera is given.

Key Words: *Neotropiconyttus heminigra,* Reduviidae, Harpactorinae, wasp-mimetic genera, key, Peru

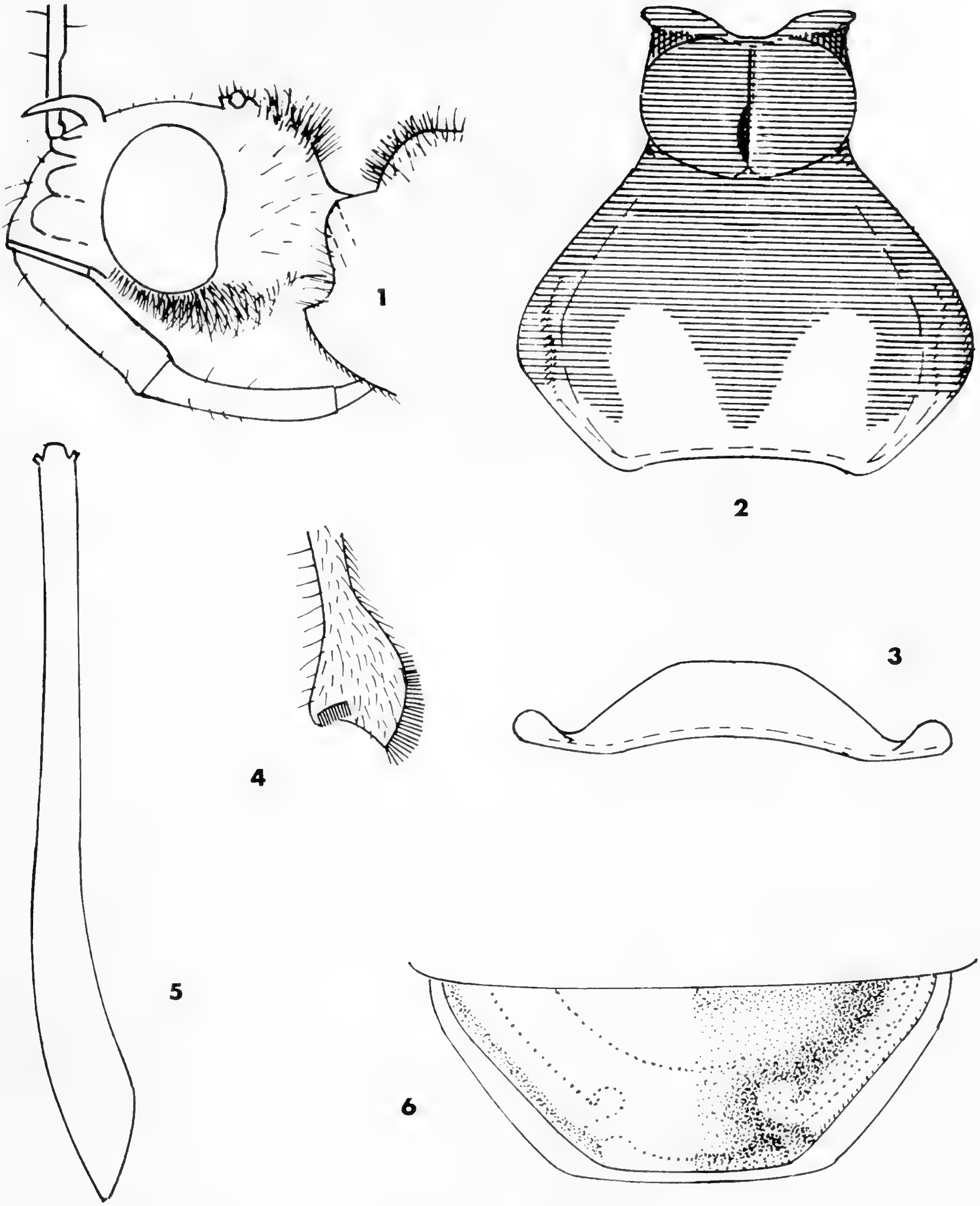
A few genera of Harpactorinae resemble bees (*Notocyrtus* Burmeister, 1837 and *Coilopus* Elkins, 1969) or wasps, especially ichneumonids. Although this is somewhat an artificial way of grouping genera, it helps to sort out specimens quickly from unidentified material. The wasp-mimetic genera keyed below have elongate, delicate bodies, the hemelytra exceed the tip of the abdomen by ¼ or ⅓ their total length and are wider posteriorly than width of pronotum; the cubital cell is narrow, at least 4 times as long as wide, with sides subparallel, and the third antennal segment is much more than twice as long as second. *Neotropiconyttus* species differ from the other wasp-mimetic genera by having short, relatively stout bodies and the abdomen narrowed basally. They closely resemble braconids. The other genera of this group somewhat resemble ichneumonid wasps, even though their abdomens are not flattened laterally. The Ethiopian wasp-mimetic *Harpagocoris* is closely related to the New World genera. Members of this genus lack a postantennal spine, the hind tibiae are not thickened or pilose, the third antennal segment is less than twice as long as the second and several are brightly colored.

The new species described below was found among a small lot of Reduviidae from Peru collected by the junior author. The holotype is deposited in the National Museum of Natural History in Washington, D.C. All measurements are in mm.

Description

Neotropiconyttus heminigra Maldonado and Lozada
Figs. 1–6

Female.—*Coloration:* black: head, antennae, rostrum, anterior lobe of pronotum, pronotum laterally, anterior half of posterior lobe of pronotum, thoracic sterna, middle and posterior coxae, upper half of penultimate and antepenultimate abdominal segments, genital segment, round spot on disc of scutellum, last two abdominal terga. Reddish black: basal portions of femora, apical annulus on middle and hind femora, hind trochanter, tarsi. Brown: anterior coxa, costal margin to pterostigma, first and second trochanters, apical external angle of co-



Figs. 1–6. *Neotropiconyttus heminigra* n. sp., female 1. head, lateral; 2. pronotum, dorsal; 3. base of pronotum, caudal view; 4. apex of protibia; 5. profemur, dorsal; 6. eighth tergum, caudal view.

rium. Very pale brown: fore tibiae above, below with irregular darker brownish areas. Ivory white: middle section of middle and hind femora, caudal half of posterior lobe of pronotum (Fig. 2). Reddish yellow: basal half of pterostigma. Reddish orange: abdominal sterna and lower half of penultimate and antepenultimate abdominal sterna. Pilosity—slightly pilose: first and second antennal segments, tibiae above, hemelytra except membrane, abdomen ventrally, rostrum, setae fine and vertical; moderately pilose: fore and middle tibiae externally (actually dorsally); densely pilose: head, thorax especially in front, fore and middle femora, tibiae ventrally, posterior femur on basal ventral half, posterior tibia, coxae and trochanters ventrally; legs with scarcer long fine setae and more abundant thicker and shorter sensory hairs, the fine setae as long or longer than thickness of corresponding segments; mesosternum with a longitudinal median patch of white scale-like setae.

Head.—Shiny, smooth; length 1.80, width across eyes 1.50; interocular space narrowing toward base, narrowest in front of ocelli, width at midlength 0.80; ocellar elevation short, transverse, immediately behind interocular suture, 0.85 wide to outside margin of ocelli, ocelli 0.60 apart, postantennal spine set basad of projected anterior margin of eye, curved cephalad, surpassing antennal base, 0.40 long. First antennal segment 3.75 long, straight, others missing; rostral segments: I, 1.10; II, 0.85; III, 0.40; I the thickest; neck shiny, about 0.30 long. Pronotum: collar very short medially, well developed laterally (Fig. 2), sharply produced laterad, about 0.35 below surface of anterior lobe; surface of anterior and posterior lobes at same level; anterior lobe—length 0.70, greatest width 1.20, slightly bigibbous, median sulcus deeper posteriorly; posterior lobe—length 1.40, greatest width 2.25, lateral margins slightly convex, posterior margin straight above scutellum then angularly bent to humeral angles; humeral angles rounded, slightly humped, well above level of posterior margin (Fig. 3). Scutellum wider than long (0.9:0.5), with a V-shaped carina. Legs: coxae slightly elongate, lengths 0.50, 0.50, 0.70; femora thickened basally, thickest part 1.5 times as thick as apex, apex with short lateral truncate projections (Fig. 5); base of fore and last femora incurved as seen from above; fore and middle tibiae slightly thickened apically, with a small lateral projection, a "comb," and a dense pad of sensory hairs ending in a short *fossula spongiosa* (Fig. 4) that surpasses apex of segment; hind tibia of equal thickness throughout, the dense pilosity of the middle third gives the impression that it is thicker; tarsi slightly thickening towards apex, apparently two-segmented because the first is very short; claws notched basally. Dimensions of legs—trochanters (measured laterally to both ends): 0.50, 0.50, 0.60; femora: 3.30, 2.60, 3.70, postbasal thickness of femora: 0.40, 0.36, 0.35, apical thickness of femora: 0.25, 0.20, 0.20; tibiae: 3.1, 3.00, 4.40; tarsi: 0.50, 0.40, 0.50. Abdomen slightly compressed laterally thus deeper than wide, greatest depth at fourth and fifth segments (2.10), notably thinner basally (1.20) and apically; connexivum narrow, 0.20–0.30 wide at fourth and fifth segments, each apical angle slightly produced apicad. Genital segment as in Fig. 6. Overall length 12.20.

Holotype female, PERU, PA, Prov. Oxapampa, Iscozacin, 13 VIII 1987, at 250 m. P. Lozada collector; in the National Museum of Natural History, Washington, D.C. The trivial name refers to the coloration that is part dark or black (*heminigra*) and part of some other color.

DISCUSSION

The genus also includes *Neotropiconyttus dama* (Burmeister) 1837:105, from Brasil and *N. alboannulatus* (Stål) 1855:189, from Colombia. All species have a whitish-yellow annulus on middle of the meso- and metafemora. They can be separated by their coloration as follows:

	N. dama	*N. alboannulatus*	*N. heminigra*
overall pronotum	black	black	black
hind lobe pronotum	black	black	black & ivory white
mesosternum	black*	black	black, with row of scalelike setae
mesopleura	red	black	black
protrochanter	red	black	black
hemelytra	black	black	half & half very pale & dark brown
abdomen	yellow	half & half deep red & black	mostly red, apex black

* row, if present, not mentioned in original description.

KEY TO THE NEOTROPICAL WASP-MIMETIC HARPACTORINE GENERA

1. Posterior lobe of pronotum elevated on disc, elevation spined posteriorly; anterior trochanter usually with a conspicuous spine .... *Acanthischium* Amyot & Serville
– Posterior lobe of pronotum without such a discal elevation; trochanter never spined 2
2. Head twice as long as wide across eyes, glabrous; basal half of profemora moderately thickened and curved ...... *Myocoris* Burmeister
– Head at most 1.3 times as long as wide, usually no longer than wide, pilose; profemora thickened basally or not 3
3. Fore femur clearly thicker basally than apically 4
– Fore femur of uniform thickness 5
4. Postantennal spine short, curved forward; lobes of anterior disk of pronotum slightly elevated; hind tibia basally thickened and thickly pilose .... *Neotropiconyttus* Kirkaldy
– Postantennal spine absent; lobes of anterior disk not elevated; hind tibiae slender, glabrous .. .. *Hiranetis* Spinola
5. Postantennal spine straight, semivertical; head 1.3 times as long as wide across eyes, sparsely pilose, height behind eyes 1.2 times height of eye; fore tibia straight .... *Graptocleptes* Stål
– Postantennal spine curved; head as long as wide across eyes, densely pilose, height behind eyes 1.5 times height of eye; fore tibia curved apically .... *Xystonyttus* Kirkaldy

All species of the above genera lack a plica on the mesopleura. Those of *Acanthischium* lack a postantennal spine. The head is glabrous in the species of *Acanthischium* and *Myocoris* and densely pilose in those of *Neotropiconyttus* and *Hiranetis.* Species of *Xystonyttus* and *Myocoris* have the fore trochanters tumescent and covered with short pile.

Elkins (1961:21) keyed the species in *Acanthischium. Hiranetis braconiformis* (Burmeister) and a few other species have yellowish or straw-colored hemelytra with a median, transverse, black band and an apical black area. This pattern also occurs in a few species of *Repipta,* South American *Zelus,* and the Ethiopian *Harpagocoris. Repipta* species have postantennal spines and in *Zelus* the profemora are as long or longer than the metafemora and without postantennal spine.

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NAME CHANGES IN THE GENUS *TACHINA* OF THE NEARCTIC REGION (DIPTERA: TACHINIDAE)

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Abstract.—Name changes are needed for six Nearctic *Tachina.* Three valid names are proposed: *T. ampliforceps* (Rowe, 1931) for *T. hispida* (Tothill, 1924), nec *T. hispida* Robineau-Desvoidy (1830); *T. dakotensis* Townsend (1892) for *T. florum* Walker (1849), nec *T. florum* Robineau-Desvoidy (1830); and *T. robinsoni* (Townsend, 1915) for *T. nitida* (van der Wulp, 1882), nec *T. nitida* Zetterstedt (1838). Three **new names** are proposed: *T.* ***californimyia*** Arnaud for *T. intermedia* (Reinhard, 1942), non *T. intermedia* Zetterstedt (1844); *T.* ***nearctica*** Arnaud for *T. spinosa* (Tothill, 1924), non *T. spinosa* Zetterstedt (1838); and *T.* ***oligoria*** Arnaud for *T. latifrons* (Tothill, 1924), non *T. latifrons* Meigen (1824).

Key Words: Insecta, Diptera, Tachinidae, *Tachina,* new names, valid names

In his treatment of the Tachinidae in the *Manual of Nearctic Diptera,* Wood (1987) proposed many generic synonymies and new combinations in footnotes in his key to genera. He reported that 39 species of *Tachina* Meigen occur in the Nearctic Region with the footnote, "Included here are all species formerly placed in *Metopotachina* Townsend and *Nowickia* Wachtl." (This total agrees with the number of taxa included in *Metopotachina* and *Nowickia* as cataloged by Sabrosky and Arnaud (1965: 993–996)). I interpret Wood's action as having transferred all Nearctic species of *Metopotachina* and *Nowickia* and their junior synonyms to *Tachina.* In cataloging these taxa I found the following nomenclatural changes necessary.

Tachina ampliforceps (Rowe), Valid Name

Fabriciella hispida Tothill, 1924: 265.—As *Tachina hispida* (Tothill): Wood, 1987: 1244 (new combination; preoccupied by *Tachina hispida* Robineau-Desvoidy (1830: 189)).

Fabriciella ampliforceps Rowe, 1931: 673–674.

Fabriciella hispida Tothill was transferred to *Nowickia* (*Fabriciella*) by Sabrosky and Arnaud (1965: 995) and to *Tachina* by Wood (1987). Since *Tachina hispida* (Tothill) is a secondary junior homonym of *Tachina hispida* Robineau-Desvoidy (1830), *Tachina ampliforceps* (Rowe) is removed from synonymy and becomes the valid name of this taxon.

Tachina dakotensis (Townsend), Valid Name

Tachina florum Walker, 1849: 722. Preoccupied by *Tachina florum* Robineau-Desvoidy (1830:192).

Echinomyia dakotensis Townsend, 1892: 94. Transferred to *Tachina* by Wood (1987: 1244).

The primary homonymy of *Tachina florum* Walker (1849) with *Tachina florum*

Robineau-Desvoidy (1830) was overlooked until now. *Tachina florum* Walker was transferred to *Nowickia* (*Fabriciella*) by Sabrosky and Arnaud (1965: 944) and returned to *Tachina* by Wood (1987). This species has two synonyms—*Echinomyia dakotensis* Townsend (1892) and *Larvaevoropsis orientalis* Townsend (1916). Since *Tachina florum* Walker should be replaced by the oldest available name, *Tachina dakotensis* (Townsend) becomes the valid name for this taxon.

***Tachina robinsoni* (Townsend),**
VALID NAME

Jurinia nitida van der Wulp, 1882: 82.—As *Tachina nitida* (van der Wulp): Wood, 1987: 1244 (new combination; preoccupied by *Tachina nitida* Zetterstedt (1838: 646)).

Upodemocera robinsoni Townsend, 1915: 229.

Jurinia nitida van der Wulp was transferred to *Nowickia* (*Rhachogaster*) by Sabrosky and Arnaud (1965: 996) and to *Tachina* by Wood (1987). Since *Tachina nitida* (van der Wulp) is a secondary junior homonym of *Tachina nitida* Zetterstedt, *Tachina robinsoni* (Townsend) is removed from synonymy and becomes the valid name for this taxon.

***Tachina californimyia* Arnaud,**
NEW NAME

Fabriciella intermedia Reinhard, 1942: 27–28.—As *Tachina intermedia* (Reinhard): Wood, 1987: 1244 (new combination; preoccupied by *Tachina intermedia* Zetterstedt (1844: 1114)).

Fabriciella intermedia Reinhard was transferred to *Metopotachina* by Sabrosky and Arnaud (1965: 993) and to *Tachina* by Wood (1987). With its inclusion in *Tachina,* it is a secondary junior homonym of *Tachina intermedia* Zetterstedt. *Tachina californimyia* Arnaud, new name, is proposed for *Tachina intermedia* (Reinhard), non *Tachina intermedia* Zetterstedt.

***Tachina nearctica* Arnaud,**
NEW NAME

Fabriciella spinosa Tothill, 1924: 263.—As *Tachina spinosa* (Tothill): Wood, 1987: 1244 (new combination; preoccupied by *Tachina spinosa* Zetterstedt (1838: 648)).

Fabriciella spinosa Tothill was transferred to *Nowickia* (*Echinomyodes*) by Sabrosky and Arnaud (1965: 994) and to *Tachina* by Wood (1987). It is a secondary junior homonym of *Tachina spinosa* Zetterstedt (1838). *Tachina nearctica* Arnaud, new name, is proposed for *Tachina spinosa* (Tothill), non *Tachina spinosa* Zetterstedt.

***Tachina oligoria* Arnaud,**
NEW NAME

Fabriciella latifrons Tothill, 1924: 260, 269.—As *Tachina latifrons* (Tothill); Wood, 1987: 1244 (new combination; preoccupied by *Tachina latifrons* Meigen (1824: 365)).

Even though Tothill did not provide an original description of his new species, *Fabriciella latifrons,* the name was validated on the basis of characters included in his key and with the distribution "Man., N.W.T., S.D., Colo." Walley (1933: 168) cited the number of specimens deposited in collections and gave specific localities. *Fabriciella latifrons* was transferred to *Nowickia* (*Rhachogaster*) by Sabrosky and Arnaud (1965: 996) and to *Tachina* by Wood (1987), where it has become a secondary junior homonym of *Tachina latifrons* Meigen (1824). *Tachina oligoria* Arnaud, new name, is proposed for *Tachina latifrons* (Tothill), non *Tachina latifrons* Meigen. The name is derived from the Greek *oligoria*—"slighting, negligence"—in reference to Tothill's omission of an original description in the proposal of his new taxon *Fabriciella latifrons.*

ACKNOWLEDGMENTS

I thank Dr. Wojciech J. Pulawski and Mr. Vincent F. Lee, California Academy of Sciences, San Francisco, for nomenclatural and editorial assistance.

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PROC. ENTOMOL. SOC. WASH.
94(1), 1992, pp. 169–171

NOTE

Taxonomic Status of Historically Confused Species of Potamanthidae and Heptageniidae (Ephemeroptera)

The mayfly genus *Anthopotamus* McCafferty and Bae (1990. Entomological News 101: 201) was established for Nearctic species of the mayfly family Potamanthidae, which had all previously been placed in the Palearctic genus *Potamanthus* Pictet. *Anthopotamus verticis* (Say), originally described as *Baetis verticis* Say (1839. Journal of the Academy of Natural Sciences of Philadelphia 8: 42), was designated the type species of the genus. However, Say's original description is very incomplete and there are no Say specimens for reference; thus, the concept of *Anthopotamus verticis* was based on the more complete description and remaining original material of *Ephemera flaveola* Walsh (1862. Proceedings of the Academy of Natural Sciences of Philadelphia 1862: 377), which was regarded as a junior synonym of the former (McDunnough, J. 1926. Canadian Entomologist 58: 184–196). The status of this species and any nomenclature correctly or incorrectly associated with it, as well as applicable type specimens require clarification.

Needham (1920. Bulletin of the Bureau of Fisheries 36: 287) recombined Walsh's *flaveola* with *Potamanthus,* and McDunnough (1926) recombined Say's *verticis* with *Potamanthus* and at the same time synonymized the two. All Ephemeroptera workers, with the exception of Ide (1935. Canadian Entomologist 67: 113–125), have recognized that synonymy [see McCafferty (1975. Transactions of the American Entomological Society 101: 447–504)].

As a result of the great Chicago fire of 1871 [see Burks (1953. Illinois Natural History Survey Division Bulletin 26: 1–216)], the only existing original material of Walsh's *flaveola* consists of one male adult and one female adult preserved on pins at the Museum of Comparative Zoology, Harvard University. We have examined this material. The male specimen (MCZ Type No. 11210) was designated by hand but not published as the lectotype of *Ephemera flaveola* by Nathan Banks. A technicality remaining therefore is to publish this lectotype designation. We therefore designate the above numbered specimen (also labeled "*E. flaveola* Rock Island Walsh 688, BAE-91") as the LECTOTYPE of *Ephemera flaveola* Walsh.

Available data support McDunnough's (1926) synonymy of Walsh's *flaveola* with Say's *verticis* and thus validate the present nomenclatural usage. Assuming Say's description was based on females, then Say's (1839) comparative measurements regarding the body and cerci length, "Length over one-fourth of an inch, of the setae [cerci] over three-tenths," are in approximate agreement with Walsh's (1862) measurements of 9–10.5 mm for the female body and 12 mm for the female cerci. Unfortunately, this cannot be confirmed by the Walsh specimens because cerci are now broken and missing from the remaining original material. Nevertheless, cerci that are only slightly longer than the body are relatively uncommon among Ephemeroptera, considerably strengthening the case for the synonymy. Described color patterns are also in general agreement, and the absolute measurements given by both Say and Walsh fall within the range we have determined for the species. Walsh (1863. Proceedings of the Entomological Society of Philadelphia 2: 204) suggested that Say's *verticis* would eventually prove to belong in the genus *Cloe* [= *Baetisca,* family Baetiscidae] because of the short cerci; however, the cerci of *Baetisca* are slightly to considerably shorter than the body in both sexes, particularly on those species that are found in Indiana, where Say's material had been collected.

It is important that a neotype be designated for *Baetis verticis* because it is the type of *Anthopotamus.* We therefore do this as follows: NEOTYPE of *Baetis verticis* Say [= *Anthopotamus verticis* (Say)]—Male adult (in alcohol), Indiana, Tippecanoe Co., West Lafayette, VI-25-1974, A. V. Provonsha, at light; deposited in the Purdue Entomological Research Collections (PERC). This species agrees in all available morphological detail with the MCZ lectotype of Walsh's *Ephemera flaveola* and thus solidifies the species synonymy and generic concept. Numerous additional male and female adults and larvae of *A. verticis* associated with the neotype and from the neotype locality are housed in the PERC. Notably, Say's collections came from the Wabash River near New Harmony, Indiana; the neotype also comes from the Wabash River, but farther north, where the species is now common in the river. It is doubtful that the species inhabits the Wabash River near New Harmony at the present, since the river substrate has become considerably silted in that region due to extended local agricultural erosion during the 20th Century.

Unfortunately, all descriptions and treatments of *Baetis verticis* and its synonyms appearing after Say's original description and up to and including Eaton's monograph (1883–88. Transactions of the Linnaean Society of London. Second Series—Zoology 3) [see especially that of Hagen (1861. Smithsonian Miscellaneous Collections 1861: 46)], are based on a misidentification (McDunnough 1926). We have determined that those misidentifications are evidently referable to the North American heptageniid species *Stenonema terminatum* (Walsh), as will be discussed below.

Eaton (1885), recognizing that what he believed to be Say's *verticis* was not a true *Baetis* (Baetidae), recombined it with the heptageniid genus *Ecdyurus* Eaton [= *Ecdyonurus* Eaton]. In addition, Eaton (1885) regarded *Heptagenia flaveola* (Pictet) as a junior synonym of *Ecdyurus verticis* (based on his misidentification of the latter). Pictet's *flaveola* had originally been described as *Baetis flaveola* Pictet (1843–45. Histoire Naturelle des Insectes Néuroptères. Famille des Éphémérines 1843–45: 186) and it was recombined with *Heptagenia* Walsh by Eaton (1871. Transactions of the Entomological Society of London 19: 1–164). (The names *Baetis flaveola* Pictet and *Ephemera flaveola* Walsh, treated above, refer to different species and should not be confused.)

Georg Ulmer examined two specimens housed at the Vienna Museum that were presumably the material on which Pictet based his description of *Baetis flaveola.* (There evidently had been a female and male before Pictet since he gave measurements for a female, but figured a male.) Ulmer (1921. Archiv für Naturgeschichte 87: 242–244) concluded that one of these specimens was *Heptagenia interpunctatum* (Say) [= *Stenacron interpunctatum* (Say)] and one was *Heptagenia pulchellum* (Walsh) [= *Stenonema pulchellum* (Walsh)]; the former name has chronological priority over Pictet's name, but the latter does not. Regardless of rules of priority, however, this synonymy has gone unrecognized [it was overlooked in the revision of *Stenonema* by Bednarik and McCafferty (1979. Canadian Bulletin of Fisheries and Aquatic Sciences 201: 1–73)] and appears invalid on scientific bases. We have also studied these specimens from the Kollar collection at the Vienna Museum, and, since they are subimagos and are poorly preserved, it is impossible to identify them to species with any confidence. The female cannot even be identified to genus; the male (bearing the label "*Baetis flaveola*" in Herman Hagen's handwriting), however, is definitely a *Stenonema.* Other than this, however, these probable cotypes are of little value in establishing a species concept.

We have also examined materials from

the McLachlan collection at the British Museum of Natural History (BM) which Eaton (1871, 1885) had evidently used for his descriptions of *Heptagenia flaveola* and *Ecdyurus verticis,* respectively. This material is identifiable as *Stenonema terminatum* (Walsh) [originally described as *Palingenia terminata* Walsh (1862: 376)]. Interestingly, Hagen, in Walsh (1863: 177), had suggested that males from Washington, D.C., that were treated by him (Hagen, 1861) under the name *Baetis verticis* were in actuality Walsh's *Palingenia terminata.*

From all the above, we conclude that Pictet's *Baetis flaveola* belongs to the genus *Stenonema* and therefore it can be regarded as *Stenonema flaveolum* (Pictet) NEW COMBINATION, but because of its incomplete description and subimaginal type specimens there is no way to establish whether it represents a distinct species or is equivalent to another named species. We therefore designate *Stenonema flaveolum* a NOMEN DUBIUM, for eventual suppression, and regard the suggested synonymy of Ulmer (1921) as invalid.

Finally, we have also studied three pinned adults in the BM, identified by Francis Walker as "*Baetis flaveola* (type) Walker," but we agree with Herman Spieth's subsequent identification of them as *Stenonema luteum* (Clemens), *Stenonema rubromaculatum* (Clemens) [= *Stenonema modestum* (Banks)], and *Heptagenia hebe* McDunnough [= *Leucrocuta hebe* (McDunnough)]. The "type" labels were evidently Walker's way of indicating a tentative identification. This is corroborated by the fact that in his treatment of the Neuropterous insects in the BM (Walker, 1853. Catalogue of the Neuropterous Insects in the Collection of the British Museum 3: 533–585) he listed these specimens as "? *Baetis flaveola.*"

In summary, Hagen's (1861) and Eaton's (1871 and 1885) treatments of *Baetis flaveola* Pictet, *Heptagenia flaveola* (Pictet), *Baetis verticis* Say, and *Ecdyurus verticis* (Say) are referable to *Stenonema terminatum* (Walsh) (Heptageniidae). Furthermore, while the applicability of Pictet's *flaveola* remains unknown and it is therefore regarded a nomen dubium, Say's *verticis* is now known as *Anthopotamus verticis* (Say) (Potamanthidae), and because it is the type of the genus *Anthopotamus,* it is reestablished herein by the designation of a neotype. Walsh's *flaveola* (nec Pictet) is confirmed as a junior synonym of *Anthopotamus verticis.*

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NOTE

Biting Midges (Diptera: Ceratopogonidae) Captured by Sundews

Sundew plants (*Drosera* spp., Droseraceae) supplement their nutritional needs by capturing prey with the sticky mucilagenous secretions of their leaves. Prior studies of sundews have not reported Ceratopogonidae among the prey items (Dixon et al. 1980, Aust. J. Bot. 28: 283–297; Thum 1986, Oecologia 70: 601–605; van Achterberg 1973, Entomol. Berich. 33: 137–140; Watson et al. 1982, Aust. J. Ecol. 7: 13–22). Ceratopogonid midges were collected from sundews at three sites on the Gulf Coastal Plain of Alabama and Florida: from *D. capillaris* Poiret, *D. intermedia* Hayne, and *D. tracyi* Macfarlane in Baldwin County, Alabama, along the flood plain of the Perdido/Styx river system; from *D. capillaris* and *D. intermedia* in Santa Rosa County, Florida, in a stream terrace bog along Pittman Creek; and from *D. capillaris* and *D. tracyi* in Walton County, Florida, in a hillside bog along U.S. Highway 331. Plants were sampled biweekly from April–November 1986 and from April–October 1987. Most ceratopogonids were captured by *D. tracyi,* although all three species of sundews captured some biting midges. Many of the recovered specimens were understandably in poor condition; however, we were able to obtain positive identifications of 10 species of ceratopogonids, and 8 to genus in the following list of Ceratopogonidae captured by sundews. Voucher specimens of all taxa are in the Auburn University Entomology Collection, or in the collection of the second author. We thank Willis W. Wirth for identifying the specimens of *Atrichopogon* and *Forcipomyia.*

Atrichopogon sp.—ALABAMA (Baldwin Co.) 18 Oct 1986, 1 ♀. *Atrichopogon* (*Atrichopogon*) *minutus* (Meigen)—FLORIDA (Walton Co.) 20 May 1986, 1 ♂, 1 ♀; 12 Apr 1987, 1 ♀; 18 May 1987, 1 ♀; 17 Jun 1987, 1 ♀; (Santa Rosa Co.) 19 Oct 1986, 1 ♀. *Forcipomyia* (*Forcipomyia*) sp.—FLORIDA (Walton Co.) 19 Oct 1986, 1 ♀. *Forcipomyia* (*Lasiohelea*) *fairfaxensis* Wirth—FLORIDA (Santa Rosa Co.) 19 Oct 1986, 1 ♀. *Forcipomyia* (*Saliohelea*) *leei* Wirth and Ratanaworabhan—FLORIDA (Walton Co.) 19 Oct 1986, 1 ♂, 2 ♀; 18 May 1987, 1 ♀. *Forcipomyia* (*Euprojoannisia*) *blantoni* Soria and Bystrak—FLORIDA (Walton Co.) 24 Sep 1986, 1 ♂. *Forcipomyia* (*E.*) *calcarata* (Coquillett)—ALABAMA (Baldwin Co.) 18 Oct 1986, 1 ♂. *Forcipomyia* (*E.*) sp.—FLORIDA (Walton Co.) 19 Oct 1986, 1 ♀. *Dasyhelea* sp.—ALABAMA (Baldwin Co.) 11 Apr 1987, 1 ♂. FLORIDA (Walton Co.) 20 May 1986, 2 ♀; 19 May 1987, 1 ♀. *Dasyhelea scutellata* (Meigen)—ALABAMA (Baldwin Co.) 11 Apr 1987, 1 ♀. FLORIDA (Santa Rosa Co.) 19 Oct 1986, 1 ♀; (Walton Co.) 20 May 1986, 2 ♀; 13 Aug 1986, 1 ♀; 4 Sep 1986, 1 ♀; 19 Oct 1986, 1 ♀; 12 Apr 1987, 2 ♀; 19 May 1987, 3 ♀; 17 Jun 1987, 2 ♀. *Dasyhelea traverae* Thomsen—FLORIDA (Santa Rosa Co.) 19 Oct 1987, 1 ♀; (Walton Co.) 13 Aug 1986, 1 ♂. *Dasyhelea* sp. nr. *mutabilis* (Coquillett)—ALABAMA (Baldwin Co.) 18 May 1987, 2 ♀. FLORIDA (Walton Co.) 20 May 1986, 1 ♀; 14 Aug 1986, 1 ♀; 24 Sep 1986, 1 ♂. *Culicoides venustus* Hoffman—FLORIDA (Walton Co.) 19 Oct 1986, 1 ♀. *Brachypogon* sp. nr. *canadensis* Downes—ALABAMA (Baldwin Co.) 11 Aug 1986, 1 ♀; 14 Aug 1986, 1 ♀; 11 Apr 1987, 1 ♂, 1 ♀. FLORIDA (Walton Co.) 18 May 1987, 1 ♀. *Stilobezzia* (*Stilobezzia*) *bulla* Thomsen—FLORIDA (Walton Co.) 19 May 1987, 1 ♀. *Clinohelea bimaculata* (Loew)—FLORIDA (Santa Rosa Co.) 17 June 1987, 1 ♀. *Bezzia* sp. nr. *expolita* (Coquillett)—FLORIDA (Walton Co.) 4 Sep 1986, 1 ♂. *Bezzia* sp. nr. *albidorsata* Malloch—ALABAMA (Baldwin Co.) 11 Apr

1987, 2 ♂. LAES publication number 91-17-5106.

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Note

Trichoptera do exist on Curaçao!

Recent efforts to identify and curate various collections of Neotropical caddisflies (Trichoptera) uncovered a small lot of micro-caddisflies (Hydroptilidae) collected on Curaçao by W. E. Steiner and J. M. Swearingen. The specimens were identified and put aside for incorporation in the collection; as I was unaware of any species being known from the island, I thought the record interesting. Most remarkably, within two weeks I received a reprint of a paper by Botosaneanu (1990, Bulletin de l'Institut Royal des Sciences Naturelles de Belgique, Entomologie 60: 39–48) in which the statement is made "After making sure that Curaçao supports no Trichoptera even in the (very rare) more promising habitats . . . ." This brought to mind the aforementioned collection, which was soon retrieved, its identity verified and the collector contacted. It also recalled the old adage—never say never!

Mr. Steiner, an avid collector and employee of the Department of Entomology, Smithsonian Institution, did clearly remember both the site of the collection and having taken caddisflies that night as he, too, thought their presence unusual. He very generously made his field notes available to me, from which the following data are extracted. They visited Playa Santa Cruz on the evening of February 14, 1987, and found a mangrove inlet nearby that looked undisturbed. A desertic hill with scrubby *Acacia* and tree cacti came right down to the water's edge next to the mangroves. Cut off from the mangroves by the elevated road bed were mud flats that might have been flooded by heavy rains or very high tides (and from which were swept series of several species of salt-loving Ephydridae, W. N. Mathis, pers. com.). The black light that evening attracted more insects than at other sites on the island, perhaps because of the diverse habitat and protection from the usually steady winds. It is unknown where the caddisflies might have been breeding: on the mud flats or on the mangrove roots (both saline or at least brackish), or from some other area on the island from which they were blown to the protected site.

The collection consists of 1 male and 7 females of *Oxyethira circaverna* Kelley. The male was compared directly to the holotype, with complete agreement of the genital parts in the two examples. The associated data are: "Curaçao[,] Boca Sta. Cruz[,] 14 February 1987[,] W. E. Steiner & J. M. Swearingen," "At black light in mangrove inlet and desert scrub" and the material is deposited in the National Museum of Natural History. The species was described from the Canal Zone of Panama and the Amazonian area of Ecuador.

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BOOK REVIEWS

Pest Management in Cotton. M. B. Green and D. J. de B. Lyon. Ellis Horwood Ltd., Chichester, England. 1989. 259 pp. $112.50 (hardcover).

Integrated Pest Management Systems and Cotton Production. Raymond E. Frisbie, Kamel El-Zik, and L. Ted Wilson. John Wiley & Sons, New York. 1989. 437 pp. $54.95 (hardcover).

Pest Management in Cotton by M. B. Green and D. J. de B. Lyon, and *Integrated Pest Management Systems and Cotton Production* by R. E. Frisbie, Kamel El-Zik, and L. T. Wilson, are both recommended reading for individuals involved in cotton production, research, or protection. *Pest Management in Cotton* is the proceedings of a symposium and gives a broad view of pest problems in cotton on a worldwide basis. *Integrated Pest Management Systems and Cotton Production* deals primarily with cotton production in the U.S. with many examples taken from practices used in California and Texas. There is some overlap in the material covered, but these books are sufficiently different to make both worthwhile reading.

Pest Management in Cotton covers resistance, especially of lepidopterous pests, to pyrethroids along with control measures taken by researchers, chemical companies, and Cooperative Extension Service personnel. Chapters on pest control using host plant resistance and biological control do a good job in presenting what is available and how it can be used. Chemical control strategies for pests include chapters on seedling diseases, biological insecticides, pheromones, esfenvalerate, amitraz, and acylureas. Application problems addressed include a chapter on aerial application of endosulfan to cotton in the Sudan Gezira, and problems encountered by small farmers in tropical regions with hand-operated sprayers. An overview of a major effort by the U.S. Department of Agriculture, Agricultural Research Service, to control *Heliothis* in cotton is presented, along with a history of the development and present status of GOSSYM, a cotton crop simulation model, and COMAX, a cotton crop management expert system. *Pest Management in Cotton* should be of interest to any reader involved in pest management, especially in the area of chemical control, as it is practiced in different countries.

The material presented in *Integrated Pest Management Systems and Cotton Production* is unified by the theme that integrated pest management is part of a total cotton production system. To study this production system and the biological and economic interactions in it, the authors advocate the use of system analysis methods and computer modeling. Chapters on plant growth and culture and the development of pest and crop models are included to support this approach. A well-written history of cotton production in the U.S. and how integrated pest management has evolved are included, along with details on integrated management systems for arthropods, plant pathogens, weeds, and nematodes. Information on the biology, ecology, and population dynamics for many of the major cotton pests is also presented. The importance of sampling, economic injury levels and thresholds, biological control, and host plant resistance to integrated pest management is discussed in four excellent chapters. Presented are limitations of present control methods, future needs and methods for implementing integrated pest management in cotton, and methods for economic analysis of different management systems. *Integrated Pest Management Systems and Cotton Production* would be an excellent text for students, and a very good reference book for anyone interested in cotton pest management.

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MIMICRY AMONG APOSEMATIC APPALACHIAN XYSTODESMID MILLIPEDS (POLYDESMIDA: CHELODESMIDEA)

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Abstract.—The Appalachian Mountains of eastern North America harbor a xystodesmid milliped fauna of more than 100 aposematically colored species-group taxa. They form interactive mimetic communities that share the same dorsal color pattern, if individuals are typically surface active, or the same lateral pattern including leg color, if they are cryptic and exposed by foraging predators. Lack of coloration in the non-aposematic genus *Nannaria* may constitute mimicry with unpigmented juveniles of aposematic genera. Boundaries of mimetic communities appear to be set by distribution limits of mid-size predator complexes; adjacent communities mimic, but distant ones are free to differentiate.

Key Words: Mimicry, aposematic, Xystodesmidae, banded, bimaculate, trimaculate

More than 100 aposematic species-group taxa of several xystodesmid milliped genera inhabit eastern North America. Unlike other eastern polydesmoids they produce benzaldehyde, which imparts an almond or cherry scent to their defensive secretions, so the bold colors may warn of this compound. A striking characteristic of this fauna is the frequent occurrence of sympatry among species of different genera, and many sympatric forms exhibit similar if not identical dorsal pigmentation patterns, suggesting mimetic convergence. In northwestern North Carolina, for example, *Sigmoria* (*Sigmoria*) *latior latior* (Brolemann), with black metaterga and red to yellow paranota, occurs sympatrically with forms of *Pleuroloma flavipes* Rafinesque with the same markings, and the various banded patterns of *Sigmoria* s. lat. in southwestern North Carolina and adjacent parts of South Carolina and Georgia overlap areas where such patterns are exhibited also by species of *Dynoria, Furcillaria,* and *Brachoria* (Shelley and Whitehead 1986). To the west in the Cumberland Plateau of Tennessee, sympatric representatives of *Brachoria* and *Sigmoria* (*Falloria*) display identical patterns of red paranota and blue metatergal bands, such that the genera can be distinguished only through details of the male genitalia. As these features are imperceptible to the unaided eye, one must undertake microscopic examination to determine the genus of field-collected specimens.

In addition to rather obvious instances of mimicry like the above are others in which the colors and patterns vary, both within polymorphic populations of individual species and among the entire mimetic complex. A few polydesmoids in other chelodesmoid families, for example *Euryurus* (Platyrhacidae) and *Eurymerodesmus* (Eurymerodesmidae), also display bold colors in parts or all of their ranges and may be components of the mimetic community when they occur

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[1] Deceased, May 1990.

sympatrically with aposematic xystodesmids.

Despite the fact that mimicry has been suspected in this fauna for 30 or so years and alluded to generally in publications like that by Shelley and Whitehead (1986), the only specific reference to the phenomenon is by Hoffman (1971). He remarked that little "mimicry" appeared to be involved between *Brachoria hoffmani* Keeton and *Apheloria virginiensis corrugata* (Wood) near Haysi, Dickenson County, Virginia, whereas at Wytheville, Wythe County, the latter species and *B. separanda versicolor* Hoffman resembled each other closely. However, mimicry can occur in the lateral as well as the dorsal perspectives, so dissimilar dorsal pigmentation patterns do not necessarily indicate that the phenomenon is inoperative.

To document mimicry among these arthropods and ascertain its causes, Whitehead conducted field studies in the Appalachian Mountains during the period 1985–1989, primarily in Virginia and West Virginia. The objective at each productive collecting site was to gather a sample sufficient to gain an impression of the whole mimetic fauna and the variation of its members; population differences were assessed by sampling at nearby localities. All specimens were preserved in 70% isopropanol and deposited in the collection at the National Museum of Natural History, Smithsonian Institution, Washington, DC. Whitehead's investigations ended prematurely because of illness and subsequent death, and a draft manuscript of his findings that he had prepared was edited and developed into the present contribution by the second author upon request of colleagues in his institution, the Systematic Entomology Laboratory, U.S. Department of Agriculture. Whitehead's observations at seven principal sites—Mt. Rogers and High Knob, Virginia; Pinch, Centralia, and Alta, West Virginia; Wayah Bald, North Carolina; and Brasstown Bald, Georgia—are detailed herein along with his observations and conclusions about mimicry, an unexamined aspect of these arthropods. He died before he could test most of his ideas, and they are thus presented here as hypotheses for investigation by future students of Appalachian biology.

COLOR AND COLOR PATTERNS

Figs. 1–3

Shelley and Whitehead (1986) distinguished three color patterns in *Sigmoria*—bimaculate, for paranotal spots only; trimaculate, for paranotal plus middorsal spots; and banded, for crossbands along the caudal metatergal margins (Figs. 1–3)—and developed a notation for representing the pattern and its colors. That for *S.* (*Falloria*) *nantahalae* Hoffman, with its unique combination of red paranotal spots and white metatergal crossbands, was "banded red/white." The present study shows that leg color is important also because coiled xystodesmids often roll on their sides revealing these appendages when disturbed, so the notations should include also leg pigmentation as the last item. Thus, for samples of *S.* (*F.*) *nantahalae* with red legs from Wayah and Brasstown Balds, the description becomes "banded red/white/red."[2] "Trimaculate yellow/yellow/yellow" describes *Cherokia georgiana* (Bollman) at these localities. Pigments must be noted in the field, at the time of collection, because they fade rapidly in preservative. The pattern is visible in alcohol months or years after collection, but the colors of the spots or bands typically fade after only a few days. Consequently pigmentation notes made on preserved specimens a week or more after collection are probably unreliable.

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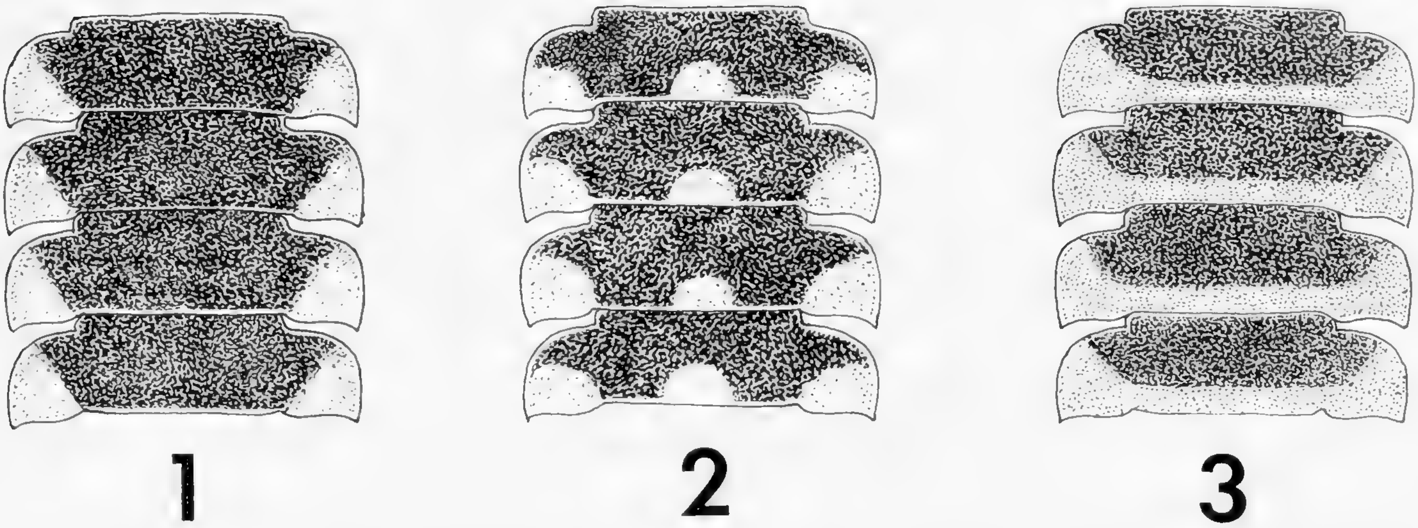
[2] The sequence of descriptors in these notations is the type of pattern (banded, trimaculate, or bimaculate) followed by the colors of the paranota, metaterga, and legs. The metatergal pigmentation is placed second in deference to the bimaculate pattern, in which the metaterga lack bright colors and exhibit the background color, usually black. "Bimaculate red/black/red" is preferable to "bimaculate black/red/red."



Figs. 1–3. Representations of the three principal xystodesmid color patterns. 1, bimaculate. 2, trimaculate. 3, banded. The size and shape of the middorsal spots varies in the trimaculate pattern from small, discrete circles to large, semilunar splotches.

Other descriptors, like subfasciate, for irregular crossbands formed of obvious middorsal and paranotal spots, and subvittate, if the middorsal spots are not confined to the metaterga, are unnecessary to describe visual impact. If the animal looked banded it was recorded so whether the band was irregular or entire; likewise, if the legs looked red they were described so even if ringed with white. If color is conspicuous, minor differences are irrelevant for the purposes of mimicry, although they help to evaluate variation and polymorphism. A population of sharply banded and sharply trimaculate individuals is probably polymorphic, with variation in the widths of the bands and the shapes and diameters of the spots. More commonly, the trimaculate condition involves variably transverse middorsal spots that expand laterad and often connect with the paranotal markings to form irregular crossbands.

TAXONOMIC NOTES

The genus *Apheloria* is under study by R. L. Hoffman, so names are not assigned to the phena labeled as species A and B. They have similar gonopods and may be consubspecific with *A. virginiensis corrugata,* but they do not exhibit the banded pattern characteristic of this race. Also awaiting description are phena A and B of *Sigmoria* (*Rudiloria*), tentatively considered as new species.

Tribal compositions of the principal Appalachian xystodesmids are as follows: Chonaphini—aposematic, one genus (*Semionellus*); Rhysodesmini—aposematic, three genera (*Boraria, Pleuroloma,* and *Cherokia*), not aposematic, one genus (*Gyalostethus*); Nannariini—not aposematic, one genus (*Nannaria*); and Apheloriini—aposematic, three genera (*Apheloria, Brachoria,* and *Sigmoria*). Of these genera, *Gyalostethus* was not encountered in this study and is not considered. In the southern Appalachian periphery there are four other aposematic genera that probably demonstrate mimicry—*Erdelyia* (Rhysodesmini) and *Deltotaria, Dynoria,* and *Furcillaria* (Apheloriini) (Shelley 1981, 1984a; Shelley and Whitehead 1986). The last three genera extend into southeastern lowland physiographic provinces and are known to resemble sympatric species of *Sigmoria* in the Piedmont Plateau and Coastal Plain. Three apparently non-aposematic rhysodesmine genera also occur in coastal Georgia, Alabama, and Florida—*Caralinda, Gonoessa,* and *Lourdesia* (Hoffman 1978, Shelley 1979, 1984b, c, 1991), as does a fifth tribe, Pachydesmini, which ranges northward into the southern fringe of the Appalachians. Thus, the mimetic Appalachian fauna intermingles with primarily lowland genera in the fringes of the southern Blue Ridge Mountains and the Piedmont Plateau Provinces, and the picture is further complicated by sympatric genera in both regions whose members do not exhibit aposematic patterns. A complete understanding of mimicry would thus involve assessing the selective advantage of dull colors on the non-aposematic genera. The overall problem is therefore enormously complex and a fitting subject for an extended research program, Whitehead's intention before he contracted a terminal illness. This contribution outlining his observations and conclusions is intended to stimulate investigation on this topic.

Color Patterns and Mimetic Communities of Appalachian Xystodesmids

Fig. 4

A complete listing of species collected during this study is presented in Table 1, and the xystodesmids encountered in and near West Virginia are listed in Table 2. Figure 4 shows Whitehead's collecting localities in both the Appalachians and neighboring regions, and collections and observations at major sampling sites are described in the ensuing paragraphs.

Mt. Rogers, Washington Co., Virginia. One syntopic community included *Apheloria tigana* Chamberlin, *Boraria stricta* (Brolemann), and *Sigmoria* (*Dixioria*) *coronata* (Hoffman). Four other aposematic xystodesmids—*Brachoria ethotela* Chamberlin, *Pleuroloma flavipes, Sigmoria* (*Sigmoria*) *latior latior,* and perhaps even *Sigmoria* (*Rudiloria*) *trimaculata kleinpeteri* (Hoffman)—also occur in this general area and are likely components of the mimetic community (Keeton 1959, Hoffman 1971, Shelley 1980, Shelley & Whitehead 1986). All are bimaculate, known or predicted yellow/black/yellow. Northward, bimaculate taxa extend only to the southernmost counties of West Virginia, so this color pattern has pronounced geographical limits.

All aposematic taxa were surface-active during daylight at least occasionally and thus are visible in dorsal aspect often enough to be remembered by potential predators like birds. Members of this surface-active complex are also behaviorally mimetic; the whole fauna is more prone to surface display than are those at other localities.

Apheloria tigana and *Apheloria* sp. A, from Wayne County, West Virginia, both bimaculate, appear to represent geographic variants that are markedly divergent in body size but similar in chromatic variation. In three specimens of *A. tigana,* the paranotal spots are small and triangular, and in one they are connected by a narrow, inconspicuous metatergal band. In the three specimens of sp. A, the paranotal spots are proportionately much larger, and in two they are connected also by a fine transverse band.

Pinch, Kanawha Co., West Virginia. Mimetic forms of *Apheloria virginiensis corrugata* and *Sigmoria* (*Rudiloria*) *rigida* Shelley occur here, both displaying yellow crossbands and bright red legs. Only one specimen of the former was encountered, distinguished in the field as a larger, stouter animal, and the red paranotal markings were much more developed than in specimens of *A. v. corrugata* found elsewhere. In dorsal aspect the red spots blend with the legs to reduce apparent body size and form to that of the narrower-bodied *S.* (*R.*) *rigida.*

These xystodesmids seemed less surface-active than those at Mt. Rogers, raising the questions as to which predators the mimicry is directed and at what range. Collectors more often find these millipeds under leaves than on the surface, and certain predators hunt for prey by "scratching" in leaves. Thus, if millipeds are exposed in this manner, they are seen in dorsal aspect at short range and benefit from immediate recognition.

Centralia, Braxton Co., West Virginia. Upstream from Pinch on the Elk River, yellow banded *A. v. corrugata* and *S.* (*R.*) *rigida* were less precisely mimetic and were syntopic with trimaculate, yellow/yellow-red/

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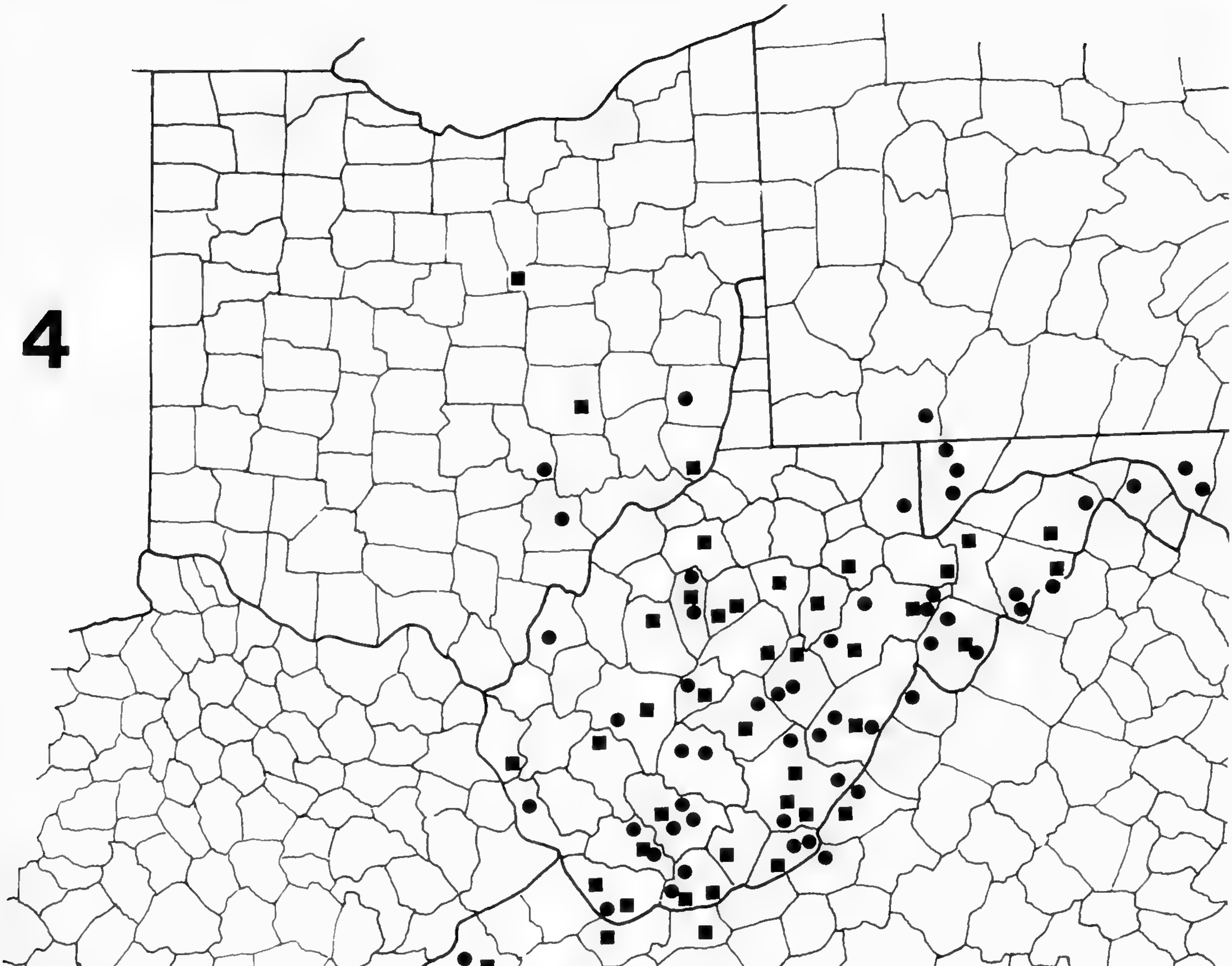

Fig. 4. Sampling sites in and near the southern Appalachians by D. R. Whitehead, 1985–1989. The squares denote localities where xystodesmids were encountered.

Table 1. Localities of aposematic Xystodesmidae collected during the study, with records of sympatric *Nannaria* and *Euryurus* (Platyrhacidae).

Locality	ST	CO	GENSUBGEN	SPSUBSP	SYNTOPGEN*	OTHGEN SUBGEN*	Pattern
Alta	WV	Gre	*Apheloria*	*v. corrugata*		Ple	banded
Alta	WV	Gre	*Pleuroloma*	*flavipes*		Aph	feebly trimac
Audra SP	WV	Bar	*Apheloria*	*v. corrugata*			banded
Bear Heaven	WV	Ran	*Brachoria*	*separanda*			trimaculate
Blue Rock SP	OH	Mus	*Apheloria*	*v. corrugata*			banded
Brasstown Bald	GA	Uni	*Cherokia*	*georgiana*	Fal		trimaculate
Brasstown Bald	GA	Uni	*S. (Falloria)*	*nantahalae*	Che		banded
Buck Creek	NC	Cla	*Cherokia*	*georgiana*			trimaculate
Cabwaylingo SF	WV	Way	*Apheloria*	sp. A			bimaculate
Camden	WV	Lew	*Apheloria*	*v. corrugata*			banded
Cedar Creek SP	WV	Gil	*S. (Rudiloria)*	sp. B			trimaculate
Centralia	WV	Bra	*Apheloria*	*v. corrugata*	Bra, Rud		banded
Centralia	WV	Bra	*Brachoria*	*separanda*	Aph, Rud		trimaculate
Centralia	WV	Bra	*S. (Rudiloria)*	*rigida*	Bra, Aph		banded
Clay	WV	Cla	*Apheloria*	*corrugata*			banded
Dolly Sods	WV	Tuc	*Semionellus*	*placidus*			banded
Dry Fork Road	WV	Ran	*S. (Rudiloria)*	*t. trimaculata*	Nan, Sem		banded
Dry Fork Road	WV	Ran	*Semionellus*	*placidus*	Nan, Rud		banded
Edray	WV	Poc	*Brachoria*	*separanda*			subfasciate
Fork Creek PHA	WV	Boo	*Apheloria*	*v. corrugata*		Nan, Rud	banded
Fork Creek PHA	WV	Boo	*S. (Rudiloria)*	*guyandotta*		Aph, Nan	trimaculate
Franklin	WV	Pen	S. (*Rudiloria*)	*t. trimaculata*		Nan	banded
French Creek	WV	Ups	S. (*Rudiloria*)	sp. B			trimaculate
Grantsville	WV	Cal	S. (*Rudiloria*)	sp. B			trimaculate
High Knob	VA	Wis	*Apheloria*	*v. corrugata*	Bra		banded
High Knob	VA	Wis	*Apheloria*	sp. B	Bra, Ple		trimaculate
High Knob	VA	Wis	*Brachoria*	*insolita*	Aph	Ple	trimaculate
High Knob	VA	Wis	*Brachoria*	nr. *dentata*	Aph		trimaculate
High Knob	VA	Wis	*Pleuroloma*	*flavipes*	Aph	Bra	trimaculate
Holly River SP	WV	Web	*Brachoria*	*separanda*	Rud		trimaculate
Holly River SP	WV	Web	*S. (Rudiloria)*	sp. A	Bra		banded
Hungry Mother SP	VA	Smy	*S. (Rudiloria)*	*t. kleinpeteri*			bimaculate
Huttonsville	WV	Ran	*Apheloria*	*v. corrugata*			banded
Mohican SP	OH	Ash	*S. (Rudiloria)*	*mohicana*	Eur	Nan	trimaculate

Table 1. Continued.

Locality	ST	CO	GENSUBGEN	SPSUBSP	SYNTOPGEN*	OTHGEN SUBGEN*	Pattern
Mount Nebo	WV	Nic	*Apheloria*	*v. corrugata*			banded
Mount Rogers	VA	Gra	*Apheloria*	*tigana*	Bor, Dix		bimaculate
Mount Rogers	VA	Gra	*Boraria*	*stricta*	Dix	Aph	bimaculate
Mount Rogers	VA	Gra	*Boraria*	*stricta*	Aph, Dix		bimaculate
Mount Rogers	VA	Gra	*S. (Dixioria)*	*coronata*	Aph, Bor		bimaculate
North Bend SP	WV	Rit	*Apheloria*	*v. corrugata*	Rud		banded
Panther SF	WV	McD	*Brachoria*	nr. *laminata*	Rud	Nan	banded
Panther SF	WV	McD	*S. (Rudiloria)*	*t. kleinpeteri*	Bra	Nan	bimaculate
Pinch	WV	Kan	*Apheloria*	*v. corrugata*	Rud		banded
Pinch	WV	Kan	*S. (Rudiloria)*	*rigida*	Aph		banded
Rinard Mills	OH	Mon	*Semionellus*	*placidus*			banded
Short Mountain	WV	Ham	*S. (Rudiloria)*	*t. trimaculata*			trimaculate
Spencer	WV	Roa	*Apheloria*	*v. corrugata*			banded
Stumptown	WV	Gil	*Apheloria*	*v. corrugata*	Rud, Nan		banded
Stumptown	WV	Gil	*S. (Rudiloria)*	sp. B	Aph, Nan		trimaculate
Twin Falls SP	WV	Wyo	*Apheloria*	*v. corrugata*			banded
Wardensville	WV	Har	*S. (Rudiloria)*	*t. trimaculata*			trimaculate
Wayah Bald	NC	Mac	*Cherokia*	*g. georgiana*	Eur, Fal		trimaculate
Wayah Bald	NC	Mac	*S. (Falloria)*	*nantahalae*	Che, Eur		banded
Williamsburg	WV	Gre	*Apheloria*	*v. corrugata*			banded

* Abbreviations: Aph, *Apheloria*; Bor, *Boraria*; Bra, *Brachoria*; Che, *Cherokia*; Dix, *Dixioria*; Eur, *Euryurus*; Fal, *Falloria*; Nan, *Nannaria*; Ple, *Pleuroloma*; Rud, *Rudiloria*; Sem, *Semionellus*.

Table 2. Aposematic Xystodesmidae in and near West Virginia; abbreviations as in Table 1.

GEN-SUBGEN	SPSUBSP	Locality	CO	ST	SYNTOPGEN	OTHGEN SUBGEN	Pattern
Apheloria	*v. corrugata*	Alta	Gre	WV		Ple	banded
Apheloria	*v. corrugata*	Audra SP	Bar	WV			banded
Apheloria	*v. corrugata*	Blue Rock SP	Mus	OH			banded
Apheloria	*v. corrugata*	Camden	Lew	WV			banded
Apheloria	*v. corrugata*	Centralia	Bra	WV	Bra, Rud		banded
Apheloria	*v. corrugata*	Clay	Cla	WV			banded
Apheloria	*v. corrugata*	Fork Creek PHA	Boo	WV		Nan, Rud	banded
Apheloria	*v. corrugata*	High Knob	Wis	VA	Bra		banded
Apheloria	*v. corrugata*	Huttonsville	Ran	WV			banded
Apheloria	*v. corrugata*	Mount Nebo	Nic	WV			banded
Apheloria	*v. corrugata*	North Bend SP	Rit	WV	Rud		banded
Apheloria	*v. corrugata*	Pinch	Kan	WV	Rud		banded
Apheloria	*v. corrugata*	Spencer	Roa	WV			banded
Apheloria	*v. corrugata*	Stumptown	Gil	WV	Rud, Nan		banded
Apheloria	*v. corrugata*	Twin Falls SP	Wyo	WV			banded
Apheloria	*v. corrugata*	Williamsburg	Gre	WV			banded
Apheloria	*tigana*	Mount Rogers	Gra	VA	Bor, Dix		bimaculate
Apheloria	sp. A	Cabwaylingo SF	Way	WV			bimaculate
Apheloria	sp. B	High Knob	Wis	VA	Bra, Ple		trimaculate
Boraria	*stricta*	Mount Rogers	Gra	VA	Aph, Dix		bimaculate
Boraria	*stricta*	Mount Rogers	Gra	VA	Dix	Aph	bimaculate
Brachoria	*insolita*	High Knob	Wis	VA	Aph	Ple	trimaculate
Brachoria	nr. *dentata*	High Knob	Wis	VA	Aph		trimaculate
Brachoria	nr. *laminata*	Panther SF	McD	WV	Rud	Nan	banded
Brachoria	*separanda*	Bear Heaven	Ran	WV			trimaculate
Brachoria	*separanda*	Centralia	Bra	WV	Aph, Rud		trimaculate
Brachoria	*separanda*	Edray	Poc	WV			subfasciate
Brachoria	*separanda*	Holly River SP	Web	WV	Rud		trimaculate
Pleuroloma	*flavipes*	Alta	Gre	WV		Aph	feebly trimac
Pleuroloma	*flavipes*	High Knob	Wis	VA	Aph	Bra	trimaculate
S. (*Dixioria*)	*coronata*	Mount Rogers	Gra	VA	Aph, Bor		bimaculate
S. (*Rudiloria*)	*guyandotta*	Fork Creek PHA	Boo	WV		Aph, Nan	trimaculate
S. (*Rudiloria*)	*t. kleinpeteri*	Hungry Mother SP	Smy	VA			bimaculate
S. (*Rudiloria*)	*t. kleinpeteri*	Panther SF	McD	WV	Bra	Nan	bimaculate
S. (*Rudiloria*)	*mohicana*	Mohican SP	Ash	OH	Eur	Nan	trimaculate

Table 2. Continued.

GEN-SUBGEN	SPSUBSP	Locality	CO	ST	SYNTOPGEN	OTHGEN SUBGEN	Pattern
S. (*Rudiloria*)	*rigida*	Centralia	Bra	WV	Bra, Aph		banded
S. (*Rudiloria*)	*rigida*	Pinch	Kan	WV	Aph		banded
S. (*Rudiloria*)	sp. A	Holly River SP	Web	WV	Bra		banded
S. (*Rudiloria*)	sp. B	Cedar Creek SP	Gil	WV			trimaculate
S. (*Rudiloria*)	sp. B	French Creek	Ups	WV			trimaculate
S. (*Rudiloria*)	sp. B	Grantsville	Cal	WV			trimaculate
S. (*Rudiloria*)	sp. B	Stumptown	Gil	WV	Aph, Nan		trimaculate
S. (*Rudiloria*)	*t. trimaculata*	Dry Fork Road	Ran	WV	Nan, Sem		banded
S. (*Rudiloria*)	*t. trimaculata*	Franklin	Pen	WV		Nan	banded
S. (*Rudiloria*)	*t. trimaculata*	Short Mountain	Ham	WV			trimaculate
S. (*Rudiloria*)	*t. trimaculata*	Wardensville	Har	WV			trimaculate
Semionellus	*placidus*	Dolly Sods	Tuc	WV			banded
Semionellus	*placidus*	Dry Fork Road	Ran	WV	Nan, Rud		banded
Semionellus	*placidus*	Rinard Mills	Mon	OH			banded

yellow-red *Brachoria separanda* Chamberlin. Legs of all 3 species varied from yellow to red. In dorsal aspect, *B. separanda* does not seem a member of the mimetic community, but membership becomes evident in side view. Increased variation in leg color in *S.* (*R.*) *rigida* at Centralia, compared with that found at Pinch, appears to reflect the presence of *B. separanda,* decreased reliance on precise dorsal mimicry, and increased reliance on mimicry in the lateral perspective.

High Knob, Wise Co., Virginia. Five phena, possibly in two parapatric communities, were discovered at four brief collecting stops within five miles of the summit. Site A, 2.9 miles north of the entrance to High Knob Lake Recreation Area, was occupied by boldly banded *A. v. corrugata* and trimaculate *Brachoria* sp. nr. *dentata* Keeton. The other three sites were 1–4 miles south of the entrance and harbored syntopic, trimaculate animals that are virtually indistinguishable in the field. Site B contained *B. insolita* Keeton, polychromic (yellow/yellow/yellow, yellow/orange/pink, pink/pink/pink). Sites C and D, where all specimens had yellow legs, contained the following: site C, *Apheloria* sp. B. and *Pleuroloma flavipes*; site D, *Apheloria* sp. B. and *B. insolita.*

Two of the three specimens of *Apheloria* sp. B displayed yellow middorsal spots on the proterga as well as the metaterga; the other had the middorsal and paranotal spots connected by a fine transverse band. As with the finely banded variants of the bimaculate *A. tigana* from Mt. Rogers and *Apheloria* sp. A from Wayne County, West Virginia, no color intergradation with the strongly banded *A. v. corrugata* was evident. These variations are unlike those found in *B. separanda* and *P. flavipes,* in which middorsal spots of some species are enlarged to connect with paranotal spots in an irregular band as a continuous series of intergrades.

Additional taxa may occur at High Knob, for example *Brachoria hoffmani* Keeton, which Hoffman (1971) recorded from another Wise County locality. His comment about lack of mimicry between this banded, polychromic species and *A. v. corrugata* was solely from the dorsal perspective and overlooked the possibility of lateral mimicry as seen by a litter-scratching predator.

Wayah Bald, Macon Co., North Carolina, and *Brasstown Bald, Union Co., Georgia.* Coiled specimens of trimaculate yellow/yellow/yellow *Cherokia georgiana* and banded red/white/red *Sigmoria* (*Falloria*) *nantahalae* presented similar outer spirals of alternating pale and dark. They thus appear to be functionally mimetic though differing in actual color and pattern.

Alta, Greenbrier Co., West Virginia. Body size of two species affects aposematism because if they are too different, mimicry will not work. Small size will correlate with reduced aposematism if mimicry develops primarily for side viewing. Because a 15–20 mm coil should be perceived much more readily by a potential predator than a 10 mm coil, the selective advantage of lateral mimicry will be reduced for small millipeds, and the metabolic cost of maintaining an aposematic color pattern will become too high. With reduction in selective advantage, aposematy for side viewing may be lost. However, if the millipeds are commonly surface-active, dorsal aposematy and mimicry provide useful visual impacts for much smaller animals. At Alta *P. flavipes* is not syntopic with either *A. v. corrugata* or with other species exhibiting a similar dorsal pattern; its smaller size prevents useful mimicry in side view as well.

A Preliminary Synthesis

Observations of geographically correlated color patterns and behavioral attributes of Appalachian xystodesmid species are explained readily and reasonably in terms of Mullerian mimicry, i.e. simplification of recognition of sympatric, specifically different groups of unpalatable organisms by potential predators. However, patterns among millipeds are varied, and as stated previously, a detailed understanding of the entire complex will require much additional research. At present, we offer the generalized thoughts that are summarized below.

Color pattern.—Because banded patterns are displayed by representatives of other diplopod orders and are more widespread in the class than spotted patterns, we postulate the banded pattern to be ancestral and that the interrupted patterns evolved in the sequence banded → trimaculate → bimaculate.

In *Apheloria,* selection for Mullerian mimicry apparently causes shifts from strongly banded to bimaculate and trimaculate patterns via loss of yellow pigment rather than through reduced intensity or dull color. In contrast, the bimaculate pattern of *S.* (*R.*) *trimaculata kleinpeteri* seems an extreme negative expression of the dull orange or red middorsal spots found in southernmost populations of *S.* (*R.*) *t. trimaculata* (Hoffman 1951) and *S.* (*R.*) *guyandotta* (Shelley and Whitehead 1986).

For taxa or populations whose principal mimetic aspect is lateral (see below), consistency of middorsal spots seems unnecessary to maintain the crucial expression of pattern. Maximum benefit in the territory of yellow banded *Apheloria* would be for a trimaculate species to have a large yellow spot, but this benefit may not justify the cost when mimicry occurs in a different perspective. Except for *Apheloria,* the middorsal spots in trimaculate taxa tend to vary from bright yellow to dull red, the latter perhaps representing drift away from mimetic control.

Aspect and mimicry.—Mimicry is expressed either in dorsal or lateral aspects of these xystodesmids. Dorsal mimicry appears to warn hunters like birds and possibly box turtles that normally do not search under leaves and logs; occasionally it may warn larger predators that might expose millipeds without disturbing them. However, foragers like grouse, turkey, raccoon, fox, and possibly shrews scratch in the litter and disturb the millipeds, which immediately coil and fall on their sides, where they are mimetic. They present a 15–25 mm spiral of legs, venter, and dorsal colors, with a notable periphery of alternating light and dark colors. Visual impact is sufficient to generate instant recognition and therefore avoidance at a distance of 6–12″ or more.

Loss of bright color.—Xystodesmid juveniles tend to lack bright colors, possibly because they are not surface active, too varied in size, and too transient in life stage to justify metabolic investment in aposematy. However, they are exposed by the same litter scratching hunters that find adults, are seen only at close range, and are recognizable immediately because the absence of bright colors and similarity in body form make them look alike.

Members of the small-bodied, non-aposematic genus *Nannaria* were notably pale and resembled juveniles of larger xystodesmids with which they were found. This appears to be a minor form of mimicry probably brought about by selection for reduction in pigment.

Body size and aposematy.—Body size appears to affect aposematy. Small size will correlate with reduced aposematy if mimicry develops primarily for side viewing. Because a 15–20 mm coil should be perceived more readily by a potential predator than a 10 mm coil, the selective advantage of lateral mimicry for small millipeds will be reduced, and the metabolic cost of maintaining an aposematic color pattern may become too high. With reduction in selective advantage, aposematy for side viewing may be lost. However, if these smaller millipeds are surface-active, dorsal aposematy and mimicry with larger species provide useful visual impacts to deter potential predators.

Community differentiation of Mullerian mimics.—Mimicry is a shared response of sympatric, specifically different prey populations to predator pressure, dependent upon range limits of pertinent predators, because it is the individual predator or its family group that is capable of learning to recognize and avoid distasteful prey. Some prey individuals will be sacrificed for this learning to occur, but the entire mimetic complex benefits. Pressures that drive sympatric mimetic populations toward a shared color pattern will decrease genetic continuity between such populations and their relatives in adjacent areas, which may be under the influence of different selective pressures caused by a different predator complex. Decreased genetic continuity among allopatric conspecific populations leads to their speciation. Thus, predator pressure may lead to evolution of the distinctive milliped communities reported here.

As indicated by their different color patterns, the faunas at High Knob and Mt. Rogers, Virginia, must be stressed by somewhat isolated sets of predator units. The sites are sufficiently remote to preclude frequent exchange of predator individuals, so the milliped fauna of each area is free to form a separate mimetic community. As the banded → trimaculate → bimaculate evolutionary sequence takes place, predatory selection at one site favors one color pattern while that at another favors another. In contrast, if xystodesmid communities are parapatric, as possibly at the three High Knob sites, they would benefit from shared mimicry patterns if they occur within the range of the same predator complexes.

Aposematy and diversity.—The number of aposematic taxa in an area correlates well with the amount of mimicry and localized gonopod differentiation, which is constrained by requirements unrelated to membership in the mimetic community. Bimaculate, trimaculate, and banded color patterns coexist among five genus-group taxa in central West Virginia, but east of Allegany Mountain, on the border between Allegany County, Virginia, and Greenbrier County, West Virginia, *Brachoria* and *Semionellus* disappear except for an isolated population of *S. placidus* in the northern and central Blue Ridge of Virginia. Otherwise, only two xystodesmid species occur in this region (*A. v. corrugata* and *S.* (*R.*) *t. trimaculata*), which vary less and typically are not mimetic. In contrast, Mount Rogers has seven taxa that share a single color pattern and differ phenotypically from taxa to the north.

CONCLUDING REMARKS

The search for understanding of phenomena that involve complex community interactions has led many biologists to tropical areas, where such interactions abound. Working in the tropics carries with it a variety of hardships ranging from risk of disease to struggles with bureaucratic regulations. The xystodesmid mimetic complex reported here offers a system for investigation that holds as much promise as a researcher could hope to find in the tropics, but one that can be investigated with comparative ease and little personal risk.

Understanding how speciation works among the aposematic Appalachian xystodesmids requires a comprehensive analysis of the entire aposematic fauna, which extends hundreds of miles in all directions to the Mississippi River, the Gulf of Mexico, the Atlantic Ocean, and nearly to Tampa Bay, Florida (Shelley and Whitehead 1986). Acquiring such knowledge could be a daunting task, for the eastern Xystodesmidae includes five tribes, numerous genera, and innumerable species. However, the fauna at each locality typically is uncomplicated taxonomically, having only one member of a given genus-group, and species-group taxa need not be syntopic nor share similar population structures to benefit from mimicry. Thus, analyses can proceed area by area in a sequence determined by the requirements and wishes of an investigator.

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NEW GENERA AND SPECIES OF SOUTHERN SOUTH AMERICAN PHYCITINAE (LEPIDOPTERA: PYRALIDAE)

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Abstract.—Six new genera of phycitine moths from southern South America are described. They are ***Cabimoides*** n. gen. with ***C. patagoniensis*** n. sp., ***Apocabimoides*** n. gen. with ***A. neuquenensis*** n. sp., ***Inverina*** n. gen. with ***I. suizensis*** n. sp., ***Ohigginsia*** n. gen. with ***O. diversa*** n. sp., ***Pseudopassadena*** n. gen. with ***P. gentilii*** n. sp., ***Eupassadena*** n. gen. with ***E. karsholti*** n. sp. Also described from this region are the following new species: *Ectomyelois* ***austrella*** n. sp., *Pseudocabima* ***australis*** n. sp., *Ephestiodes* ***argentinus*** n. sp., *Erelieva* ***steppeiana*** n. sp., *Homoeosoma* ***strongylognathosum*** n. sp., *Homoeosoma* ***eurygnathosum*** n. sp., *Homoeosoma* ***pauroaichmetes*** n. sp., *Ragonotia* ***confluenciana*** n. sp., *Passadena* ***argentina*** n. sp., *Honora* ***nirihuauensis*** n. sp., *Honora* ***palliolella*** n. sp., *Ocala* ***megajuxta*** n. sp.

Key Words: Moths, phycitines, southern Argentina, southern Chile, Patagonia

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The phycitine fauna of southern South America, particularly that part of Argentina and Chile known as Patagonia, is not well known. Heinrich (1956) brought together existing information and listed 33 species from Argentina and Chile in his checklist. Pastrana (1961a, b) provided information on two additional species which appear to be restricted to the northern part of Argentina and to Uruguay.

Our paper is based on phycitine moths in the Zoological Museum of the University of Copenhagen (ZMUC) collected in 1950, 1952, 1960, 1961, 1966, 1978–79, and 1981 in southern South America in the provinces of Chubut, Neuquén, Rio Negro, and Santa Cruz in Argentina, and Orsono in Chile. Chubut, Rio Negro and Santa Cruz are Patagonian provinces; Neuquén and Orsono are adjacent to northern Patagonia. Entomologists participating in the 1978–79 Mision Cientifica Danesa light trapped the majority of the study material. Nielsen (1980) provided information on this expedition, including notes on the dominant vegetation at the various collecting sites. Where possible, we have included this ecological information under each species.

Ectomyelois austrella Neunzig and Goodson, New Species
Figs. 1, 32, 33, 68

Type locality.—San Carlos de Bariloche, Colonia Suiza, 810 m, Rio Negro Province, Argentina.

Diagnosis.—The male genitalia (Figs. 32, 33) of *E. austrella* are easily recognized by the unusually broad bases of the gnathos, the peculiar inner, basal protuberance on the valva, and the enlarged anterior part of the aedoeagus. In the female genitalia (Fig. 68) the broadly V-shaped, irregularly margined, sclerotized plate near the genital opening, and the narrowly and deeply invaginated signum in the corpus bursae are diagnostic.

Description.—*Length of forewing:* 9.5–10.5 mm. *Head* with front and vertex fuscous, or black, and white; antenna simple in both sexes; labial palpus white and fuscous, or white and black, basal segment mostly white, distal segments mostly fuscous, or black, upturned in both sexes; maxillary palpus fuscous, or black, and white, simple in both sexes. *Thorax* with dorsum white, ochre, fuscous, black, brown and reddish brown; collar similar to dorsum. *Forewing* with ground color fuscous; white patch at base; ochre to reddish brown patch along subbasal posterior margin; antemedial line well developed, white, distinctively bordered on distal margin with black; postmedial line white, well developed, bordered proximally with black, and bordered distally, over most of its length, with brownish red; a few brownish red scales mixed with black scales of patch distad of antemedial line, and brownish red and ochre scales in posterior medial area; white dusting subbasally, medially (particularly in costal half), and in terminal area; discal spots black, well developed, fused; underside, of male, without costal fold or sex-scaling. *Hindwing* pale fuscous, darker along veins and near costal and outer margins. *Male abdominal segment 8* with pair of ventrolateral scale tufts; each tuft composed of slender, approximately straight, scales. *Male genitalia* (Figs. 32, 33) with uncus broadly triangular, apex rounded; gnathos with apical process slightly notched, and lateral, basal arms robust; transtilla complete, well sclerotized, and produced mesially into flat, broadly and bluntly pointed projection; juxta U-shaped with moderately robust, setiferous lateral arms; valva with costa broadly sclerotized, and with inner basal, setiferous protuberance; vinculum longer than greatest width; aedoeagus apically enlarged and with small cluster of scobinations. *Female genitalia* (Fig. 68) with ductus bursae short and with broadly V-shaped, irregularly margined sclerotized plate near genital opening and dense patch of scobinations where it joins corpus bursae; corpus bursae elongate, membranous, with narrowly and deeply invaginate scobinate signum, and additional scobinations near signum; ductus seminalis attached to corpus bursae near junction of ductus bursae and corpus bursae.

Distribution.—Southwestern Rio Negro Province, Argentina. *Ectomyelois austrella* occurs in forests dominated by *Nothofagus dombeyi* Blume.

Holotype.—♂—San Carlos de Bariloche, Colonia Suiza, 810 m. Rio Negro Province, Argentina, 15 Jan 1979, Mision Cientifica Danesa, genitalia slide 2996 HHN (ZMUC).

Paratypes.—Argentina. Rio Negro Prov.: Lago Nahuel Huapí, Puerto Blest, 770 m, 1 ♂, 5 Jan 1979, Mision Cientifica Danesa, genitalia slide 2986 HHN. Bariloche and environs, 1 ♀, 1 Mar 1966, Axel M. Hemingsen, genitalia slide 2997 HHN. El Bolsón, Arroyo Negro, 1 Mar 1961, Gy. Topál, genitalia slide 3071 HHN. Paratypes in ZMUC.

Pseudocabima australis **Neunzig and Goodson,**
NEW SPECIES
Figs. 2, 34, 35, 71

Type locality.—Rio Limay, Arroyito, Neuquén Province, Argentina.

Diagnosis.—Similar to *Pseudocabima perrensiella* (Ragonot) which also occurs in Argentina, but *P. australis* has the forewing with the antemedial and postmedial lines equally distinct, and the postmedial line strongly dentate; in *P. perrensiella* the antemedial line is very weak (appears to be absent in Ragonot's 1893 fig. 11, Plate V) and the postmedial line is weakly dentate. Also, *P. australis* has the ductus bursae of the female genitalia (Fig. 71) membranous and only slightly bent in its anterior half, whereas *P. perrensiella* has a partially sclerotized, strong bend in the ductus bursae in its anterior half.

Description.—*Length of forewing:* 11.0–14.0 mm. *Head* with front and vertex with white-tipped fuscous scales; antenna of male simple with sensilla trichodea about as long as diameter of shaft near base; antenna of female with sensilla trichodea about ¼ as long as diameter of shaft near base and each segment of shaft with slightly longer, slender, spinelike sensilla; labial palpus white at base, with white-tipped fuscous scales distally, upturned in male, somewhat porrect in female; maxillary palpus with white-tipped fuscous scales, simple in both sexes. *Thorax* with dorsum mostly white or brownish white with some white-tipped fuscous scales; collar with white-tipped fuscous scales; prothoracic scale tuft present, extending dorsally to partially cover eye in both sexes. *Forewing* with ground color fuscous, most of wing dusted with white, particularly along subbasal costal margin and in terminal area; antemedial line moderately distinct, bordered distally by black; postmedial line moderately distinct, strongly dentate, bordered proximally by black (black borders in medial area, in conjunction with less white dusting in this area, give wing a somewhat banded appearance); some obscure, pale brown, or pale reddish brown scales, particularly in posterior half; discal spots black, fused, relatively distinct in male, obscure in female; underside, of male, with small narrow costal fold. *Hindwing* smoky white, slightly darker near costal and outer margins. *Male abdominal segment 8* with pair of ventrolateral scale tufts; each tuft a cluster of simple, approximately straight scales. *Male genitalia* (Figs. 34, 35) with uncus spoon-shaped; gnathos with apical element strongly bifurcate; transtilla weakly developed; juxta a short plate with setiferous lateral lobes; valva simple; vinculum slightly longer than greatest width, strongly constricted towards anterior margin; aedoeagus simple, robust basally. *Female genitalia* (Fig. 71) with ductus bursae membranous, wrinkled and scobinate near junction with corpus bursae; corpus bursae membranous with many, generally distributed scobinations; signum an elongate, fused cluster of weakly sclerotized, mostly blunt, flattened, toothlike platelets; ductus seminalis attached to corpus bursae near junction of ductus bursae and corpus bursae.

Distribution.—Southeastern Neuquén Province, Argentina. Collected at sites having vegetation transitional between bush steppe and Patagonian steppe.

Holotype.—♂—Rio Limay, Arroyito, Neuquén Province, Argentina, 16 Dec 1978, genitalia slide 2894 HHN (ZMUC).

Paratypes.—Argentina. Neuquén Prov.: Piedra del Aquila, 1 ♂, 23 Dec 1978, Mision Cientifica Danesa, genitalia slide 2934 HHN. Rio Limay, Arroyito, 1 ♂, 16 Nov 1978; 1 ♂, 1 ♀, 17 Nov 1978; 2 ♂, 16 Dec 1978, Mision Cientifica Danesa, 1 ♂, 1 ♀ genitalia slides 2957, 2935 HHN. Paratypes in ZMUC.

Discussion.—An additional reason for believing *P. australis* is distinct from *P. perrensiella* is that *P. perrensiella* was collected at Goya, Corrientes Province, in northern Argentina (Ragonot 1888, 1893), near the Paraná River. According to Weber (1969), vegetation in this region consists of subtropical forest, an environment quite different from the bush and Patagonian steppe where *P. australis* occurs.

Cabimoides Neunzig and Goodson, NEW GENUS

Gender.—Masculine.

Type species.—*Cabimoides patagoniensis* Neunzig and Goodson.

Antenna (Fig. 30) simple in both sexes; sensilla trichodea of shaft of male moderately abundant and about ⅔ as long as basal diameter of shaft. Front convex, smoothly scaled. Labial palpus of both sexes upturned. Maxillary palpus simple in both sexes. Haustellum very weakly developed. Ocellus absent. Prothoracic scale tuft extending dorsally to partially cover eye in both sexes. Basal ½ of costa of forewing of male (Fig. 19) slightly convex to straight;

underside of male without costal fold or sex-scaling. Forewing without raised scales; with 11 veins; R_2 separated from R_{3+4} and R_5 at base; R_{3+4} and R_5 stalked for slightly over ½ their lengths; M_1 straight; M_2 and M_3 stalked for about ¼ their lengths; CuA_1 from lower angle of cell; CuA_2 from before lower angle of cell. Hindwing (Fig. 19) with 8 veins (1A, 2A, and 3A considered to be 1 vein); $Sc + R_1$ and R_S fused for about ½ their lengths beyond cell; M_1 from upper angle of cell; M_2 and M_3 fused for about ½ their lengths; CuA_1 shortly fused with $M_2 + M_3$ at base; CuA_2 from well before lower angle of cell; cell slightly over ½ length of wing. Eighth abdominal segment of male with pair of ventral scale tufts; tufts rather short and narrow, composed of thin, approximately straight, scales. Male genitalia (Figs. 38, 39) with uncus rather broad, terminal margin concave; gnathos with apex strongly bifurcate; transtilla very weak, incomplete mesially; juxta with robust setiferous lateral lobes; valva simple; aedoeagus robust, simple; vinculum shorter than greatest width, with small lateral protuberance. Female genitalia (Fig. 70) with ductus bursae membranous and shorter than corpus bursae; corpus bursae membranous, weakly scobinate; signum a comblike plate; ductus seminalis attached to corpus bursae about halfway between signum and junction of ductus bursae and corpus bursae.

Cabimoides is closely related to *Apocabimoides* based on similar, simple antennae and palpi, a reduced haustellum, absence of ocelli, and similar genitalia. The genera are easily separated from each other on the basis of wing venation. *Cabimoides* has 8 veins in the hindwing (Fig. 19) whereas *Apocabimoides* has 7 veins in the hindwing (Fig. 20). The appearance of the genitalia of both *Cabimoides* and *Apocabimoides* suggests an affinity to *Diatomocera* Ragonot and *Pseudocabima* Heinrich, but, most noticeably, *Cabimoides* and *Apocabimoides* lack the spoon-shaped uncus of the male genitalia so characteristic of the Ragonot and Heinrich genera.

***Cabimoides patagoniensis* Neunzig and Goodson, New Species**

Figs. 3, 19, 30, 38, 39, 70

Type locality.—Ñorquincó, Rio Negro Province, Argentina.

Diagnosis.—The male and female genitalia as shown in Figs. 38, 39, 70, and outlined in the description of the genus are diagnostic for *C. patagoniensis.*

Description.—*Length of forewing:* 9.0–11.5 mm. *Head* with front brown, dusted with white; vertex similar to front, but whiter; labial palpus white at base, becoming brown to fuscous distally; maxillary palpus mostly white with few brown scales. *Thorax* with dorsum and collar a mixture of brown, or fuscous, and white; tegulae brownish white distally. *Forewing* with ground color fuscous, rather heavily dusted with white; antemedial line angular, pale yellowish or brownish white, bordered proximally and distally by fuscous; postmedial line also, at least in part, pale yellowish or brownish white, bordered proximally by fuscous; discal spots fuscous, moderately distinct, separate. *Hindwing* smoky fuscous, darker along veins and near costal and outer margins. *Male and female genitalia* (Figs. 38, 39, 70) as in description of genus.

Distribution.—Southwestern Rio Negro Province and northeastern Santa Cruz Province, Argentina.

Holotype.—♂—Ñorquincó, Rio Negro Province, Argentina, 21 Jan 1961, Gy. Topál, genitalia slide 2993 HHN (ZMUC).

Paratypes.—Argentina. Rio Negro Prov.: Ñorquincó, 1 ♂, 21 Jan 1961; 3 ♂, 18 Feb 1961; 1 ♀, 19 Feb 1961, Gy. Topál, 2 ♂, 1 ♀, genitalia slides 2971, 2972, 3000 HHN. Santa Cruz Prov.: Fitz Roy, Tres Cerros, 1 ♂, 10 Feb 1979, Mision Cientifica Danesa, genitalia slide 3048 HHN. Paratypes in ZMUC.

Apocabimoides Neunzig and Goodson, New Genus

Gender.—Masculine.

Type species.—*Apocabimoides neuquenensis* Neunzig and Goodson.

Antenna (Fig. 27) simple in both sexes; sensilla trichodea about ½ as long as basal diameter of shaft. Front convex, smoothly scaled. Labial palpus of both sexes upturned. Maxillary palpus simple in both sexes. Haustellum much reduced. Ocellus absent. Prothoracic scale tuft extending dorsally to partially cover eye in both sexes. Basal ½ of costa of forewing of male (Fig. 20) slightly convex to straight; underside, of male, without costal fold or sex-scaling. Forewing without raised scales; with 11 veins; R_2 separated from R_{3+4} and R_5 at base; R_{3+4} and R_5 stalked for slightly over ½ their lengths; M_1 straight; M_2 and M_3 stalked for about ¼ their lengths; CuA_1 from lower angle of cell; CuA_2 from well before lower angle of cell. Hindwing (Fig. 20) with 7 veins; $Sc + R_1$ and R_S fused for about ½ their lengths beyond cell; M_1 from upper angle of cell; M_2 and M_3 completely fused; CuA_1 slightly fused with $M_2 + M_3$ at base; CuA_2 from well before lower angle of cell; cell slightly over ½ length of wing. Eighth abdominal segment of male with pair of ventral scale tufts; tufts rather short and narrow, composed of thin, more or less straight, scales. Male genitalia (Figs. 36, 37) with uncus broadly rounded at apex; gnathos with apex bifurcate; transtilla weakly formed, incomplete mesially; juxta with robust, setiferous lateral lobes; valva simple; aedoeagus robust, simple; vinculum shorter than greatest width, with small lateral protuberances. Female genitalia (Fig. 72) with ductus bursae membranous and about as long as corpus bursae; corpus bursae membranous, scobinate; signum an elongate, slightly arched, sclerotized band of fused spines; ductus seminalis attached to corpus bursae near signum.

Apocabimoides appears to be derived from *Cabimoides,* or an ancestor similar to *Cabimoides.* As mentioned under *Cabimoides,* the two genera have many similar morphological features, however, *Apocabimoides* has fewer veins in the hindwing.

Apocabimoides neuquenensis Neunzig and Goodson, New Species

Figs. 4, 20, 27, 36, 37, 72

Type locality.—Piedra del Aguila, Neuquén Province, Argentina.

Diagnosis.—The male and female genitalia as shown in Figs. 36, 37, 72, and outlined in the description of the genus are diagnostic for *A. neuquenensis. A. neuquenensis* differs from the related *Cabimoides patagoniensis* in being smaller, having fewer veins in the hindwing, and having the antemedial line evenly curved (angular in *C. patagoniensis*).

Description.—*Length of forewing:* 6.0–8.0 mm. *Head* with front with white-tipped brown or fuscous scales; vertex similar to front but with some completely white scales; labial palpus white at base, becoming brown to fuscous distally; maxillary palpus white and fuscous, or white and brown. *Thorax* with dorsum grayish brown near collar, mostly white elsewhere; collar mostly white with few brown or fuscous scales. *Forewing* mostly white, irrorated with brown or fuscous; obscure subbasal patch of pale brown in posterior half; antemedial line moderately distinct, curved, pale brown to brown, bordered distally by fuscous or black line of scales; postmedial line rather indistinct, pale brown, delineated on its proximal margin near costa by fuscous or black; obscure patch of pale brown scales between transverse lines in posterior half; discal spots fuscous or black, obscure to moderately distinct. *Hindwing* whitish brown, darker along veins and near costal and outer margins. *Male and female genitalia* (Figs. 36, 37, 72) as in description of genus.

Distribution.—Southern Neuquén Province. Occurs in areas having steppe vegetation.

Holotype.—♂—Piedra del Aguila, Neuquén Province, Argentina, 18 Nov 1978, Mision Cientifica Danesa, genitalia slide 2891 HHN (ZMUC).

Paratypes.—Argentina. Neuquén Prov.: Piedra del Aguila, 1 ♂, 18 Dec 1978; 2 ♂, 1 ♀, 19 Dec 1978, 1 ♂, 23 Dec 1978, Mision Cientifica Danesa, ♀ genitalia slide 2893 HHN. Rio Limay, Arroyito, 1 ♂, 16 Nov 1978; 1 ♂, 17 Nov 1978, 3 ♂, 22 Dec 1978, Mision Cientifica Danesa. San Martín de Los Andes, Cerro Chapelco, 1400–1600 m, 1 ♂, 12–23 Nov 1981, Nielsen & Karsholt. Zapala, El Marucho, 870 m, 4 ♂, 26 Oct 1981, M. O. Gentili, genitalia slide 2892 HHN. Paratypes in ZMUC.

Inverina **Neunzig and Goodson, New Genus**

Gender.—Feminine.

Type species.—*Inverina suizensis* Neunzig and Goodson.

Antenna (Fig. 25) simple in both sexes; sensilla trichodea of shaft of male moderately abundant and about ⅔ as long as basal diameter of shaft. Front convex with anteriorly projecting scales. Labial palpus of both sexes oblique. Maxillary palpus simple in both sexes. Haustellum well developed. Ocellus present. Basal ½ of costa of forewing of male (Fig. 21) straight to slightly convex; underside, of male, with costal fold bearing distal tuft of elongate scales. Forewing without raised scales; with 10 veins; R_2 well separated from R_{3+4} and R_5 at base; R_{3+4} and R_5 completely united; M_1 with weak base; M_2 and M_3 stalked for about ½ their lengths; CuA_1 from lower angle of cell; CuA_2 from well before lower angle of cell. Hindwing (Fig. 21) with 7 veins; $Sc + R_1 + R_S$ fused for slightly over ⅗ of their lengths beyond cell; M_1 separated from $Sc + R_1 + R_S$ at base; M_{1+2} and CuA_1 stalked for about ½ their lengths; CuA_2 from well before lower angle of cell; cell slightly less than ½ length of wing. Eighth abdominal segment of male without scale tuft. Male genitalia (Figs. 44, 45) with uncus triangular, terminal margin broadly rounded; gnathos with apex broadly U-shaped, the arms well separated; transtilla weak, incomplete mesially; juxta with lateral lobes rather short, wrinkled; valva with triangularly shaped, dorsally projecting, costal process at basal third; aedoeagus with thin, sclerotized plates; vinculum about as long as greatest width, distinctly attenuated in distal half. Female genitalia (Fig. 69) with ductus bursae about as long as corpus bursae and sclerotized and granular for most of its length; corpus bursae membranous; signum a multitoothed, elongate sclerotized plate; weak scobinations in corpus bursae, mostly near signum; ductus seminalis attached to corpus bursae just anterior to signum.

Inverina is established for the new species *suizensis.* The genus is similar to *Verina* Heinrich, particularly with regard to genitalia, but differs in some important features, such as the venation of the wings. The forewing of *Inverina* (Fig. 21) has R_2 well separated from R_{3+4} and R_5 at base and M_2 and M_3 stalked for about ½ their lengths; the forewing of *Verina* has R_2 approximate to R_{3+4} and R_5 at base and M_2 and M_3 stalked for over ⅔ their lengths. The hindwing of *Inverina* (Fig. 21) has M_{2+3} and CuA_1 stalked for about ½ their lengths and the cell slightly less than ½ the length of the wing; in the hindwing of *Verina* M_{2+3} and CuA_1 are approximate at base and the cell is only ⅓ the length of the wing. Also, *Verina* has a shallow, but distinct, sinus at the base of the male antenna that is lacking in *Inverina.*

Inverina suizensis **Neunzig and Goodson, New Species**

Figs. 5, 21, 25, 44, 45, 69

Type locality.—San Carlos de Bariloche, Colonia Suiza, 810 m, Rio Negro Province, Argentina.

Diagnosis.—The male and female genitalia as outlined in the description of the genus are diagnostic for *I. suizensis.*

Description.—*Length of forewing:* 6.0–9.0

mm. *Head* with front and vertex pale brown or brown, vertex usually slightly paler than front; labial palpus white at base, becoming brown distally; maxillary palpus brown. *Thorax* with dorsum pale brown; collar similar to dorsum. *Forewing* with ground color fuscous; lightly dusted with white (white most noticeable in basal costal half); overlay of pale brownish red scales, with most forming an inconspicuous longitudinal streak just below cell basally and extending distally to just above tornus; antemedial line somewhat weakly developed, its position mostly defined by a black distal border; postmedial line indistinct, immediately preceded by a black border; discal spots black, separate or fused. *Hindwing* smoky fuscous, darker along veins and near costal and outer margins. *Male and female genitalia* (Figs. 44, 45, 69) as in description of genus.

Distribution.—Southwestern Neuquén Province south to southwestern Santa Cruz Province in Argentina. *Inverina suizensis* is usually associated with forest ecosystems dominated by *Nothofagus* Blume.

Holotype.—♂—San Carlos de Bariloche, Colonia Suiza, 810 m, Rio Negro Province, Argentina, 29 Dec 1978, Mision Cientifica Danesa, genitalia slide 2989 HHN (ZMUC).

Paratypes.—Argentina. Chubut Prov.: Esquel, SE shore of Lago Futalaufquen, 600 m, 1 ♂, 18 Feb 1979, Mision Cientifica Danesa, genitalia slide 3029 HHN. Esquel, 550 m, 1 ♂, 1 Jan 1982, Nielsen & Karsholt, genitalia slide 3027 HHN. Esquel, Lago Menéndez, El Sagrario Puerto, 600 m, 1 ♂, 2–4 Jan 1982, Nielsen & Karsholt, genitalia slide 3026 HHN. Neuquén Prov.: Lago Lacar, Pucará, 650 m, 2 ♂, 26–27 Dec 1981, Nielsen & Karsholt, genitalia slides 2955, 2961 HHN. Rio Negro Prov.: Lago Nahuel Huapí, Puerto Blest, 770 m, 2 ♂, 22 Dec 1978, 5 Jan 1979, Mision Cientifica Danesa. San Carlos de Bariloche, Colonia Suiza, 810 m, 3 ♀, 10 Jan 1978; 1 ♂, 9 Dec 1978; 2 ♂, 1 ♀, 11 Dec 1978; 1 ♂, 12 Dec 1978; 2 ♂, 24 Dec 1978; 1 ♂, 28 Dec 1978, 5 ♂, 29 Dec 1978; 1 ♂, 31 Dec 1978; 2 ♂, 1 Jan 1979; 5 ♂, 3 ♀, 9 Jan 1979; 1 ♂, 4 ♀, 13 Jan 1979; 2 ♀, 16 Jan 1979, Mision Cientifica Danesa, 1 ♂, 1 ♀ genitalia slides 2998, 2990 HHN. San Carlos de Bariloche, Colonia Suiza, 800 m, 1 ♂, 23 Dec 1981; 1 ♂, 24 Dec 1981; 1 ♂, 1 ♀, 5–7 Jan 1982, Nielsen & Karsholt, 1 ♂, 1 ♀, genitalia slides 2991, 2992 HHN. San Carlos de Bariloche, Lago Steffen, 550 m, 1 ♀, 27 Feb 1979, Mision Cientifica Danesa. San Carlos de Bariloche, Nirihuau, 1 ♀, 30 Dec 1978; 1 ♂, 2 Jan 1979, Mision Cientifica Danesa. Santa Cruz Prov.: Lago Argentino, El Calafate, 200 m, 1 ♂, 12 Jan 1979, Mision Cientifica Danesa, genitalia slide 3042 HHN. Lago Argentinos, Península Magallanes, 250 m, 3 ♂, 2 ♀, 11 Jan 1979, Mision Cientifica Danesa, 1 ♂, 1 ♀, genitalia slides 3035, 3040 HHN. Lago Argentino, Península Magallanes, 2 ♂, 2 ♀, 11 Jan 1979; 2 ♂, 12 Jan 1979, Mision Cientifica Danesa, 2 ♂, 2 ♀, genitalia slides 3036, 3037, 3038, 3039 HHN. Paratypes in ZMUC.

Ephestiodes argentinus Neunzig and Goodson, NEW SPECIES

Figs. 6, 40, 41, 73

Type locality.—Rio Limay, Arroyito, Neuquén Province, Argentina.

Diagnosis.—*E. argentinus* is similar to *Ephestiodes lucidibasella* Ragonot. The latter species, however, has the terminal area of the forewing darker than the basal ⅓ of the wing, whereas in the former species the terminal area and the basal ⅓ of the wing are both pale. The male genitalia of *E. argentinus* have the apical processes of the gnathos shorter and broader than in *E. lucidibasella,* and the sclerotized and granulate part of the ductus bursae of the female genitalia in *E. argentinus* is longer than in *E. lucidibasella.*

Description.—*Length of forewing:* 5.5–7.0 mm. *Head* with front and vertex mostly brown or fuscous, lightly dusted with white; antenna simple in both sexes; labial palpus fuscous dusted with white (basal segment sometimes with all white or brownish white scales), upturned in both sexes; maxillary palpus brown, lightly dusted with white, simple in both sexes. *Thorax* with dorsum and collar mostly pale brown. *Forewing* with ground color fuscous; basal patch of pale brown or pale reddish brown; most of remaining area preceding antemedial line also pale brown or pale reddish brown; antemedial line relatively indistinct, brownish white or white, blending with pale area preceding line; postmedial line usually rather indistinct, brownish white or white; medial area darker than rest of wing, sometimes with longitudinal streak of pale brown, reddish brown or brown in posterior half of wing; terminal area pale, similar to basal and subbasal area of wing; discal spots black, usually indistinct; underside, of male, with costal fold. *Hindwing* smoky fuscous, darker along veins and near costal and outer margins. *Male abdominal segment 8* with paired dorsal scale tufts, each tuft consisting of four clusters of scales; second cluster of each tuft slender, sinuous and longer than others. *Male genitalia* (Figs. 40, 41) with uncus broadly rounded; gnathos with apex forked, the apical processes rather short and stout and directed slightly inwards; transtilla with distal elements divergently flared and wrinkled; juxta a semicircular band; valva with very weakly developed, angled transverse ridge across edge of cucullus; aedoeagus relatively narrow, with weak, thin cornutus; vinculum slightly longer than greatest width. *Female genitalia* (Fig. 73) with ductus bursae longer than corpus bursae and sclerotized and granulate for $\frac{9}{10}$ of its length; ductus bursae not strongly constricted in posterior half; corpus bursae membranous, oval, with signum a small cluster of flattened thornlike spines; ductus seminalis attached to corpus bursae near signum.

Distribution.—Eastern Neuquén Province, Argentina. Associated with steppe vegetation.

Holotype.—♂—Rio Limay, Arroyito, Neuquén Province, Argentina, 19 Dec 1978, Mision Cientifica Danesa, genitalia slide 2916 HHN (ZMUC).

Paratypes.—Argentina. Neuquén Prov.: Piedra del Aguila, 1 ♂, 19 Dec 1978, Mision Cientifica Danesa. Rio Limay, Arroyito, 2 ♂, 1 ♀, 17 Dec 1978; 1 ♂, 1 ♀, 22 Dec 1978, Mision Cientifica Danesa, ♂ and ♀ genitalia slides 2917, 3072, 3073 HHN. Paratypes in ZMUC.

***Erelieva steppeiana* Neunzig and Goodson, NEW SPECIES**

Figs. 7, 42, 43

Type locality.—Rio Limay, Arroyito, Neuquén Province, Argentina.

Diagnosis.—Only males of *E. steppeiana* have been collected. It is necessary to examine the genitalia (Figs. 42, 43), and the eighth abdominal segment to identify the species. The uncus is more elongate, the subanal plate of the gnathos more narrow, and the apical part of the transtilla more narrowly forked in *E. steppeiana* than in other species in the genus. Also, the valva of *E. steppeiana* bears a distinctly pointed costal process, whereas other congeneric species have only a low, elongate costal lobe. In addition, *E. steppeiana* lacks the scale tuft on the eighth abdominal segment found in other *Erelieva.*

Description.—*Length of forewing:* 6.5–7.5 mm. *Head* with front and vertex with white-tipped fuscous to black scales; antenna of male with very shallow sinus near base of shaft; labial palpus white basally, fuscous to black distally, upturned in male; maxillary palpus fuscous at base, white distally, simple. *Thorax* with dorsum with white-tipped brown or fuscous scales; collar similar to dorsum. *Forewing* with ground color fuscous, dusted with white; antemedial line white, distinct, bordered distally by broad patch of black; postmedial line white, moderately distinct; discal spots black, usually separate; underside of male with basal costal fold. *Hindwing* smoky fuscous, darker along veins and near costal and outer margins. *Male abdominal segment 8* without scale tufts. *Male genitalia* (Figs. 42, 43) with uncus subtriangular, truncate; gnathos without usual apical process, arms fused distally to form subanal plate; transtilla with forked, wrinkled distal process; juxta with small, setiferous lateral lobes; valva with distinctly pointed costal process located at about ⅔ distance to apex of valva; aedoeagus with enlarged, slightly hooked apex; vinculum about as long as greatest width.

Distribution.—Eastern and southeastern Neuquén Province, Argentina. This species was collected in vegetation transitional between bush steppe and Patagonian steppe.

Holotype.—♂—Rio Limay, Arroyito, Neuquén Province, Argentina, 17 Nov 1978, Mision Cientifica Danesa, genitalia slide 2931 HHN (ZMUC).

Paratypes.—Argentina. Neuquén Prov.: same data as for holotype, 1 ♂. Piedra del Aguila, 5 ♂, 18–19 Dec 1978, Mision Cientifica Danesa, genitalia slides 2887, 2933 HHN. Paratypes in ZMUC.

Homoeosoma strongylognathosum Neunzig and Goodson, New Species

Figs. 8, 46, 47, 75, 76

Type locality.—Piedra del Aguila, Neuquén Province, Argentina.

Diagnosis.—There have been three species of *Homoeosoma* (sensu Roesler (1973); i.e. excluding *Patagonia* Ragonot species) described from southern South America. They are *H. longiventrellum* Ragonot, *H. discrebile* Heinrich and *H. heinrichi* Pastrana. The male of *H. longiventrellum* has exceptionally long arms projecting from the vinculum of the male genitalia, and the males of *H. discrebile* and *H. heinrichi* both have an eighth abdominal segment scale tuft. *Homoeosoma strongylognathosum* and the other species of *Homoeosoma* described in this paper (*H. eurygnathosum* and *H. pauroaichmetes*) have neither long projecting vinculum arms nor an eighth abdominal scale tuft. *Homoesoma strongylognathosum* is best distinguished from *H. eurygnathosum* and *H. pauroaichmetes* by reference to the genitalia (Figs. 46, 48, 50, 75). In *H. strongylognathosum* the male gnathos has the anterior margin of its apical process broadly rounded, and the female apophysis posterioris long (over 4× as long as the length of the sclerotized collar); the other two species have the gnathos with the anterior margin of the apical process either straight or concave (sometimes with a small mesial protuberance) or straight to shallowly convex, and the apophysis posterioris less than 4× as long as the length of the sclerotized collar.

Description.—*Length of forewing:* 9.0–11.5 mm. *Head* with front pale brown to fuscous and white; vertex pale brown to fuscous and white (white usually most apparent near eyes and at base of antenna); antenna of male with shaft notched at base, of female simple; labial palpus white basally, becoming pale brown to fuscous distally, porrect (second segment slightly oblique, third segment directed forward) in both sexes; maxillary palpus pale brown to fuscous, sometimes dusted with white, simple in both sexes. *Thorax* with dorsum and collar mostly white or brownish white suffused with fuscous, sometimes with a few pale reddish brown scales. *Forewing* with ground color fuscous, well mixed with white scales; solid white streak extending along top of cell and reaching more or less to apex; costa black, narrowly so in basal half, but black streak broadening in distal half to form distinct, relatively broad, dark costal patch; a few veins overlaid, in part, with black; antemedial and postmedial lines, or patches or spots of dark scales frequently associated with these transverse lines, not evident; some specimens with a very few pale reddish brown scales in posterior half; discal spots indistinct; underside of male with narrow costal fold. *Hindwing* rather dark smoky fuscous, darker along veins and near costal and outer margins. *Male abdominal segment 8* with thornlike ventral process, and without scale tuft. *Male genitalia* (Figs. 46,

47) with uncus triangular, apex rounded; gnathos with apical process triangular, anterior margin broadly rounded; lateral arms of gnathos strongly arched posteriorly at apical process; transtilla incomplete mesially; juxta U-shaped with rather long, relatively straight, lateral arms; valva simple; vinculum about as long as greatest width; aedoeagus approximately straight with elongate internal ridged element. *Female genitalia* (Figs. 75, 76) with papilla analis lightly sclerotized; apophysis posterioris long, 4.2× as long as length of sclerotized collar; ductus bursae membranous; corpus bursae membranous with signum a dense cluster of robust spines located near middle of bursae, and patch of weakly formed microspines near junction of ductus bursae and corpus bursae; ductus seminalis attached to corpus bursae near junction with ductus bursae.

Distribution.—Southeastern Neuquén Province. Collected in a transitional zone between bush steppe and Patagonian steppe along the Limay River.

Holotype.—♂—Piedra de Aguila, Neuquén Province, Argentina, 19 Dec 1978, Mision Cientifica Danesa, genitalia slide 811 RLG (ZMUC).

Paratypes.—Argentina. Neuquén Prov.: same data as for holotype, 3 ♀, genitalia slide 816 RLG. Piedra del Aguila, 3 ♂, 4 ♀, 18 Dec 1978; 1 ♂, 23 Dec 1978, Mision Cientifica Danesa, genitalia slides 813, 814, 894, 895, 896, 900 RLG. Arroyito, Rio Limay, 1 ♂, 1 ♀, 16 Nov 1978; 2 ♀, 17 Nov 1978; 2 ♂, 22 Dec 1978, Mision Cientifica Danesa, genitalia slides 812, 815, 892, 893, 898, 899 RLG. Paratypes in ZMUC.

Homoeosoma eurygnathosum Neunzig and Goodson,

NEW SPECIES

Figs. 9, 50, 51, 77

Type locality.—Piedra del Aguila, Neuquén Province, Argentina.

Diagnosis.—Similar in general appearance to *H. strongylognathosum,* but forewings with white more extensive, and hindwings somewhat less dark. Genitalic differences between *H. eurygnathosum* and *H. strongylognathosum* also exist, as mentioned under the diagnosis of *H. strongylognathosum.* Although the genitalia of *H. eurygnathosum* and a third species of *Homoeosoma* (*pauroaichmetes*), described as new in this paper, are somewhat alike, the forewing of *H. eurygnathosum* is more uniformly white and lacks the black longitudinal lines characteristic of *H. pauroaichmetes.*

Description.—*Length of forewing:* 8.5–10.5 mm. *Head* with front pale brown to fuscous and white; vertex pale brown, pale reddish brown or ochreous and white (white concentrated near eye and at base of antenna); antenna of male with shaft notched at base, of female simple; labial palpus with basal half, or most of basal half, white, sometimes with a few pale reddish brown or ochreous scales, distal half pale brown or mostly pale brown, porrect (second segment slightly oblique, third segment directed forward) in both sexes; maxillary palpus brown to pale brown, white distally, simple in both sexes. *Thorax* with dorsum and collar white suffused with pale brown, brown, pale reddish brown or ochre, and sometimes with a few fuscous scales. *Forewing* usually almost entirely white with a few scattered fuscous or black scales (a few moths mostly white, but with more dark scales); costa black, narrowly so in basal half, but black streak broadening in distal half to form distinct, relatively broad, dark costal patch; antemedial line not evident (in some specimens, a dark spot in posterior half near where antemedial line usually occurs); postmedial line absent; most specimens with an indistinct longitudinal patch of pale reddish brown to ochre in posterior half; a single discal spot weakly to rather well developed; underside of male with narrow costal fold. *Hindwing* smoky fuscous, darker along veins and near costal and outer margins. *Male abdominal segment 8* with thornlike ventral process, and without scale tuft. *Male genitalia* (Figs. 50, 51) with uncus triangular, apex rounded; gnathos with apical process a squat triangle, distinctly broad anteriorly and with anterior margin, except for sometimes a small mesial protuberance, rather straight or concave; lateral arms of gnathos moderately arched posteriorly at apical process; transtilla incomplete mesially; juxta U-shaped with somewhat sinuate lateral arms; valva simple; vinculum shorter than greatest width; aedoeagus slightly sinuate, with elongate internal ridged element. *Female genitalia* (Fig. 77) with papilla analis lightly sclerotized; apophysis posterioris 3.8 × as long as length of sclerotized collar; apophysis anterioris 2.3 × as long as length of sclerotized collar; ductus bursae membranous; corpus bursae membranous with dense cluster of robust spines (signum) near middle of bursae, and patch of very weakly formed microspines near junction of ductus bursae and corpus bursae; ductus seminalis attached to corpus bursae near junction with ductus bursae.

Distribution.—Southern Neuquén Province, and southwestern Rio Negro Province. Most specimens collected in bush and Patagonian steppe at the Limay River.

Holotype.—♂—Piedra del Aguila, Neuquén Province, Argentina, 19 Dec 1978, Mision Cientifica Danesa, genitalia slide 819 RLG (ZMUC).

Paratypes.—Argentina. Neuquén Prov.: same data as for holotype, 2 ♂, 3 ♀, genitalia slides 820, 881 RLG. Aluminé, 1200 m, 3 ♀, 14 March 1979, Mision Cientifica Danesa, genitalia slide 821 RLG. San Martín de los Andes, 1 ♂, 11 Dec 1950, S. Shachovskoj, genitalia slide 825 RLG. Rio Negro Prov.: Ñorquincó. 1 ♂, 1 ♀, 25 Jan 1961, Gy Topál, genitalia slides 826, 827 RLG. Paratypes in ZMUC.

Homoeosoma pauroaichmetes
Neunzig and Goodson,
NEW SPECIES

Figs. 10, 48, 49, 74

Type locality.—El Marucho, Zapala, 870 m, Neuquén Province, Argentina.

Diagnosis.—A dark antemedial spot or band that is absent in *H. strongylognathosum* and sometimes weakly developed in *H. eurygnathosum* is usually rather well defined in *H. pauroaichmetes*. Also, features separating *H. pauroaichmetes* from other *Homoeosoma* occurring in southern South America have been discussed under the previous two species, *H. strongylognathosum* and *H. eurygnathosum*.

Description.—*Length of forewing:* 8.5–9.0 mm. *Head* with front pale brown to brown and white; vertex pale brown to brown and white (white concentrated near eye and at base of antenna); antenna of male with shaft notched at base, of female simple; labial palpus with basal half, or most of basal half, white, distal half pale brown or fuscous or mostly pale brown or fuscous, porrect (second segment slightly oblique, third segment directed forward) in both sexes; maxillary palpus pale brown to fuscous, usually white distally, simple in both sexes. *Thorax* with dorsum a mixture of pale brown, brown, fuscous and white; collar mostly white with some pale brown to fuscous suffusions. *Forewing* white, fuscous and black; solid white streak extending along top of cell and reaching more or less undiminished to apex; costa black in basal half, becoming mixed with white in distal half; several veins overlaid with black; relatively well developed antemedial dark band (band curved and extending from posterior margin to white longitudinal streak near costa); antemedial and postmedial lines not evident; some specimens with a very few pale reddish brown scales in posterior half; discal spots indistinct; underside of male with narrow costal fold. *Hindwing* pale smoky fuscous, slightly darker along veins and near costal outer margins. *Male abdominal segment 8* with thornlike ventral process and without scale tuft. *Male genitalia* (Figs. 48, 49) with uncus triangular, apex rounded; gnathos with apical process triangular, with anterior margin straight to shallowly convex; lateral arms of gnathos moderately arched posteriorly at apical process; transtilla incomplete mesially; juxta U-shaped with relatively straight lateral arms; valva simple; vinculum about as long as greatest width; aedoeagus rather straight with elongate internal ridged element. *Female genitalia* (Fig. 74) with papilla analis lightly sclerotized; apophysis posterioris 3.3× as long as length of sclerotized collar; apophysis anterioris 1.8× as long as length of sclerotized collar; ductus bursae membranous; corpus bursae membranous with dense cluster of robust spines (signum) located near middle of bursae, and with patch of rather distinct microspines near junction of ductus bursae and corpus bursae; ductus seminalis attached to corpus bursae near junction with ductus bursae.

Distribution.—Central Neuquén Province.

Holotype.—♂—El Marucho, Zapala, 870 m, Neuquén Province, Argentina, 26 Oct 1981, M. O. Gentili, genitalia slide 835 RLG (ZMUC).

Paratypes.—Argentina. Neuquén Prov.: same data as for holotype, 3 ♀, genitalia slide 836 RLG, 3103 HHN. Paratypes in ZMUC.

***Ohigginsia* Neunzig and Goodson, New Genus**

Gender.—Feminine.

Type species.—*Ohigginsia diversa* Neunzig and Goodson.

Antenna, of male (Fig. 28), with short, robust sensillum in shallow sinus of shaft and with sensilla trichodea of shaft moderately abundant and about ⅔ as long as basal diameter of shaft; simple in female. Front convex, roughly scaled. Labial palpus of both sexes oblique. Maxillary palpus simple. Haustellum well developed. Ocellus present. Basal ½ of costa of forewing of male (Fig. 22) slightly convex; underside, of male, simple, without costal fold or sex-scaling. Forewing without raised scales; with 11 veins, R_2 from cell, approximate to stalk of R_{3+4} and R_5 for short distance; R_{3+4} and R_5 stalked for about ⅔ their length; M_1 with weak base; M_2 and M_3 approximate for short distance beyond base; CuA_1, from lower angle of cell; CuA_2 from before lower angle of cell. Hindwing (Fig. 22) with 8 veins; $Sc + R_1$ and R_S fused for about ½ their lengths beyond cell; M_1 approximate to $Sc + R_1$ and R_S at base; M_2 and M_3 stalked for slightly over ½ their lengths; CuA_1 fused for short distance at base with $M_2 + M_3$; CuA_2 from slightly before lower angle of cell; cell about ⅓ length of wing; eighth abdominal segment of male with pair of ventral scale tufts; scales forming tufts numerous, filamentous and arising from basal and outer margins of broadly U-shaped, sclerotized plate. Male genitalia (Figs. 52, 53) with uncus reduced mesially, with pair of lateral, curved, but mostly dorsally projecting setiferous arms; gnathos absent; transtilla weak, incomplete mesially; juxta a strongly sclerotized, U-shaped element bearing preapically, on inner margin, groups of small setae; valva short, trilobed; cucullus divided into posterior, elongate costal lobe, that bears distal, robust, spinelike process, and anterior, setiferous, clublike lobe (anterior setae of lobe enlarged and spinelike); base of anterior lobe with setiferous, elongate protuberance; sacculus partially separated from cucullus distally and resulting lobe hooklike; aedoeagus elongate, simple; vinculum shorter than greatest width. Female genitalia (Fig. 78) with apophyses anteriores arched and with bases fused mesially; ductus bursae simple, about as long as corpus bursae; posterior half of corpus bursae with faint microspines; signum a well developed spine with an enlarged, keeled base; ductus seminalis attached to corpus bursae near junction of ductus bursae and corpus bursae.

Based on the general appearance of the male genitalia, *Ohigginsia* is closely related to *Gabinius* Heinrich. The male antenna of the two genera differ in that *Ohigginsia* has a shallow sinus in the base of the shaft that bears distally a short, robust, slightly curved, flattened sensillum (Fig. 28), whereas the male antenna of *Gabinius* is simple. Also, the valva of the male genitalia (Fig. 52) of *Ohigginsia* has the cucullus deeply divided and the sacculus partially separated from the cucullus; in *Gabinius* the cucullus is only slightly lobed and the sacculus fused over its entire length to the cucullus. The most salient difference between the two genera can be found in the female genitalia. In *Ohigginisa* the apophyses anteriores are unusually arched and their bases fused mesially (Fig. 78); the apophyses anteriores of *Gabinius* are approximately straight and broadly separated basally, as is the condition in other phycitines.

Ohigginsia diversa **Neunzig and Goodson, NEW SPECIES**

Figs. 11, 22, 28, 52, 53, 78

Type locality.—Lago Nahuel Huapí, Puerto Blest, 770 m, Rio Negro Province, Argentina.

Diagnosis.—The male and female genitalia (Figs. 52, 53, 78), as outlined in the description of the genus, are diagnostic for *O. diversa.*

Description.—*Length of forewing:* 8.5–12.0 mm. *Head* with front pale brown to pale brownish red, sometimes partially fuscous; vertex paler than front, usually mostly pale brown; labial palpus white basally, brown or mixture of brown, brownish red, and sometimes fuscous, distally; maxillary palpus usually pale brown, sometimes with a few white, fuscous, brown or brownish red scales. *Thorax* with dorsum usually pale brown with mixture of few to many, brown, brownish red, and fuscous scales, sometimes entirely pale brown; collar similar to dorsum. *Forewing* with ground color fuscous; most specimens with white and brownish red subbasal patch and white longitudinal streak between transverse lines in costal half; an elongate, pale brown, brownish red, or brownish red and fuscous costal patch anterior to white streak; some moths with white streak missing and entire medial area brownish red and fuscous, giving wing a transversely banded appearance; subbasal area in posterior half usually brownish white and brownish red; antemedial line mostly obscure, usually white near costa; postmedial line indistinct, its presence, in some specimens, indicated by dark, transverse band; terminal area with varying amounts of white, brownish white, and brownish red scales; discal spots usually obscure. *Hindwing* smoky fuscous, darker along veins and near costal and outer margins. *Male and female genitalia* (Figs. 52, 53, 78) as in description of genus.

Distribution.—Southwestern Neuquén and Rio Negro Provinces, and northwestern and western Chubut Province, Argentina, and eastern Orsono Province, Chile. Mainly collected in forests dominated by *Nothofagus* spp.

Holotype.—♂—Lago Nahuel Huapí, Puerto Blest, 770 m, Rio Negro Province, Argentina, 27 Nov 1978, Mision Cientifica Danesa, genitalia slide 2973 HHN (ZMUC).

Paratypes.—Argentina. Chubut Prov.: (South of) El Bolsón, Lago Puelo, 250 m, 3 ♂, 1 ♀, 22 Oct 1981; 1 ♂, 2 ♀, 23 Oct 1981, Nielsen & Karsholt. Esquel, Lago Menéndez, El Sagrario Puerto, 600 m, 2 ♂, 7 ♀, 2–4 Jan 1982, Nielsen & Karsholt. Neuquén Prov.: Junín de Los Andes, Laguna Verde, 1000 m, 1 ♂, 1 ♀, 25 Nov 1981, M. O. Gentili. Lago Lacar, 5 km E of Hua-Hum, 640 m, 1 ♂, 5 Oct 1981; 1 ♀, 5–6 Nov 1981, Nielsen & Karsholt. Lago Lacar, 5 km E of Hua-Hum, 1 ♂, 6 Nov 1981; 2 ♂, 1 ♀, 25 Nov 1981; 1 ♀, 26–27 Dec 1981, Nielsen & Karsholt. Lago Tromen, Rodeo Grande, 900 m, 1 ♂, 30 Nov 1978. Mision Cientifica Danesa. San Martín de Los Andes, 640 m, 2 ♂ 21–27 Sep 1981; 4 ♂, 29 Sep 1981; 1 ♂, 7 Oct 1981; 1 ♂, 8 Oct 1981; 2 ♂, 10–12 Oct 1981; 2 ♂, 13 Oct 1981; 1 ♀, 16 Oct 1981, Nielsen & Karsholt. San Martín de Los Andes, Piedra Trampul, 1000 m, 2 ♂, 15 Oct 1981, Nielsen & Karsholt. San Martín de Los Andes, 1 ♀, 11 Dec 1950, S. Shachovskoj. Rio Negro Prov.: El Bolsón, Cerro Piltriquitron. 1 ♂, 30 Oct 1961; 1 ♂, 31 Oct 1961; 1 ♀, 7 Nov 1961, Gy. Topál, ♂ genitalia slide 2964 HHN. El Bolsón, Cerro Piltriquitron, 500–1000 m, 1 ♂, 20 Oct 1961, Gy. Topál. Lago Frias, Puerto Frias, 780 m, 1 ♂, 7 Dec 1981, Nielsen & Karsholt, ♂ genitalia slide 2974 HHN. Lago Nahuel Huapí, Puerto Blest, 770 m, 1 ♂, 7 Nov 1978; 1 ♂, 12 Nov 1978; 1 ♂, 2 ♀, 27 Nov 1978; 1 ♀, 4 Dec 1978; 4 ♂, 8 ♀, 17 Dec 1978; 2 ♂, 11 ♀, 18 Dec 1978; 1 ♂, 6 ♀, 20 Dec 1978; 5 ♂, 3 ♀, 22 Dec 1978; 1 ♀, 23 Dec 1978; 4 ♀, 24 Dec 1978; 1 ♀, 30 Dec 1978; 1 ♀, 2 Jan 1979, Mision Cientifica Danesa, ♂ and ♀ genitalia slides 2964, 2965, 2967, 2968, 2969 HHN. Lago Nahuel Huapí, Puerto Blest, 770 m, 1 ♂, 21 Oct 1981; 3 ♂, 22 Nov 1981; 1 ♂, 1 ♀, 22–30 Nov 1981; 2 ♂, 3 Dec 1981; 2 ♂, 5 ♀, 3–8 Dec 1981; 1 ♀, 9–21 Dec 1981; 1 ♀, 22–31 Dec 1981; 2 ♀, 1–6 Jan 1982, Nielsen & Karsholt, ♂ genitalia slides 2975, 2988 HHN. San Carlos de Bariloche, Colonia Suiza, 800 m, 1 ♂, 22 Sep 1981; 1 ♂, 28–30 Sep 1981; 2 ♀, 12 Oct 1981; 2 ♂, 13–17 Oct 1981; 1 ♀, 22–23 Oct 1981; 1 ♂, 12–20 Nov 1981; 2 ♂, 2 ♀, 23 Nov 1981; 1 ♀, 20–30 Nov 1981; 1 ♀, 2 Dec 1981; 1 ♀, 3 Dec 1981; 1 ♀, 7 Dec 1981, Nielsen & Karsholt, ♂ genitalia slides 2976, 2977, HHN. San Carlos de Bariloche, Colonia Suiza, 810 m, 1 ♂, 5 Nov 1978; 2 ♀, 7 Dec 1978; 1 ♂, 11 Dec 1978, Mision Cientifica Danesa. San Carlos de Bariloche, Pampa del Toro, 900 m, 4 ♂, 22–23 Oct 1981, Nielsen & Karsholt. Paratypes in ZMUC.

Chile. Orsono Prov.: Parque Nacional Puyehue, Agua Calientes, 450 m, 1 ♂, 12 Dec 1981, Nielsen & Karsholt, genitalia slide 3052 HHN. Paratype in ZMUC.

Ragonotia confluenciana
Neunzig and Goodson,
New Species

Figs. 12, 31, 56, 57, 79

Type locality.—(North of) San Carlos de Bariloche, Confluencia, 690 m, Neuquén Province, Argentina.

Diagnosis.—Based on the wing venation, the distinctive male antenna (Fig. 31) (longitudinal rows of rather long sensillae), the much reduced haustellum, the large porrect labial palpus of both sexes and the appearance of the female genitalia (particularly the setation of the papilla analis), *confluenciana* belongs to Grote's *Ragonotia.* The Argentine species is easily separated from its North American counterpart (*Ragonotia dotalis* (Hulst)) on the basis of differences in the male genitalia. *Ragonotia dotalis* males have a strongly developed club-shaped clasper on the valva, and an aedoeagus with a spinelike cornutus; both the clasper and cornutus are lacking in *R. confluenciana.*

Description.—*Length of forewing:* 12.0–15.0 mm. *Head* with front and vertex mostly white, spotted with brown, fuscous or black; antenna of male (Fig. 31) with sensilla trichodea on shaft about 2 × as long as basal diameter of shaft and arranged in two longitudinal rows; antenna of female simple; labial palpus white, rather heavily suffused with brown, fuscous or black, porrect in both sexes, extending forward about twice length of head; maxillary palpus mostly white, simple in both sexes. *Thorax* with dorsum mostly brown or dark brown; partially white and pale brown, particularly posteriorly; collar mostly white, mixed with pale brown, brown, fuscous and black. *Forewing* mostly a combination of white and fuscous or black, giving wing, viewed through the microscope, a speckled appearance; antemedial line weakly formed, with an irregular, rather indistinct fuscous or black line delineating its distal border; postmedial line similar to antemedial line, bordered basally by fuscous or black line; patches of ochre or pale brown sometimes present, particularly in posterior half of wing; discal spots usually obscure; underside, of male, without costal fold or sex-scaling. *Hindwing* smoky fuscous, darker along veins and near costal and outer margins. *Male abdominal segment 8* without scale tufts. *Male genitalia* (Figs. 56, 57) with uncus subtriangular, gnathos with strongly formed apical hook; transtilla weakly developed, incomplete mesially; juxta a V-shaped plate; valva simple; aedoeagus sclerotized, slender, without cornutus; vinculum distinctly broader than long. *Female genitalia* (Fig. 79) with papilla analis bearing many long setae; ductus bursae shorter than corpus bursae, sclerotized near junction with corpus bursae, corpus bursae membranous without signum; ductus seminalis attached to ductus bursae at or near sclerotized part of ductus bursae.

Distribution.—Known only from southern Neuquén Province. *R. confluenciana* occurs in a steppe environment.

Holotype.—♂—(North of) San Carlos de Bariloche, Confluencia, 690 m, Neuquén Province, Argentina, 17 Oct 1981, M. O. Gentili, genitalia slide 2918 HHN (ZMUC).

Paratypes.—Argentina. Neuquén Prov.: Rio Limay, Arroyito, 1 ♀, 16 Nov 1978; 1 ♀, 17 Nov 1978, Mision Cientifica Danesa, genitalia slide 2920 HHN, Zapala, El Marucho, 870 m, 3 ♀, 26 Oct 1981. M. O. Gentili, genitalia slide 2919 HHN. Paratypes in ZMUC.

Passadena argentina **Neunzig and Goodson, New Species**

Figs. 13, 54, 55, 81

Type locality.—Fitz Roy, Rio Deseado, Santa Cruz Province, Argentina.

Diagnosis.—The only other species in *Passadena* is *flavidorsella* (Ragonot), a predominantly pale gray species with a subbasal ridge of raised scales on the forewing, and complete, distinct, black, transverse, distal and proximal patches bordering the antemedial line of the forewing; *P. argentina* is mostly fuscous, has no scale ridge, and the antemedial line is only partially bordered with black. Also, the labial palpus of *P. argentina* is more than twice the length of the head, whereas in *P. flavidorsella* the labial palpus is shorter, extending forward less than twice the length of the head. Genitalic differences also exist. For example in the male the limits of the sacculus and cucullus are clearly evident in *P. flavidorsella* (a sclerotized process of the clasper almost completely separates them, and the cucullus is distinctly reduced in width); this separation is only barely perceptible in *P. argentina*. In addition, the vinculum is broad in *P. flavidorsella* and narrow in *P. argentina*. The female genitalia of *P. flavidorsella* have a large spinose plate and a much smaller spinose plate in the wall of the corpus bursae; in *P. argentina* the plates, comprising the signa, are more similar in size.

Description.—*Length of forewing:* 10.5–11.5 mm. *Head* with front and vertex with white-tipped fuscous or black scales; antenna of male with sinus and associated scale tuft near base of shaft; labial palpus with basal segment mostly white, and other segments with white-tipped fuscous or black scales, porrect (second segment slightly oblique, third segment small, directed forward); maxillary palpus of male aigrettelike, of female filiform and white and fuscous, or black. *Thorax* with dorsum and collar with white-tipped and white-lined fuscous or black scales. *Forewing* with ground color fuscous to black, entire wing lightly dusted with white; in addition to presence of many white-tipped scales, some scales not tipped with white but with 1–2 small white dots just before tip of scale, or with white lines; antemedial line white, well developed only in posterior half of wing; dark patch of scales adjacent to antemedial line proximally in posterior half and distally in costal half of wing; sometimes obscure patch of brown scales also associated with antemedial line; postmedial line white, indistinct; discal spots black, moderately distinct, separate; underside, of male, without costal fold or sex-scaling. *Hindwing* brownish white, darker along veins and near costal and outer margins. *Male abdominal segment 8* with two pairs of simple scale tufts. *Male genitalia* (Figs. 54, 55) with uncus triangular; apical process of gnathos a strongly developed hook; transtilla weakly developed, incomplete mesially; juxta a U-shaped plate with short, setiferous lateral arms; valva rather wide throughout its length and with strongly developed clasper from edge of cucullus; vinculum slightly longer than greatest width; aedoeagus armed with several rows of closely spaced spines. *Female genitalia* (Fig. 81) with ductus bursae shorter than corpus bursae, with patch of dense microspines near genital opening, and sclerotized for slightly over half its length; corpus bursae membranous with signa consisting of two strongly developed spinose plates (one plate about twice as large and with twice as many spines as other plate); ductus seminalis attached to corpus bursae near junction of ductus bursae and corpus bursae.

Distribution.—Collected in southern Neuquén and northeastern Santa Cruz Provinces, Argentina. Probably also occurs in intervening Rio Negro and Chubut Provinces. *P. argentina* is associated with the Patagonian steppe.

Holotype.—♂—Fitz Roy, Rio Deseado, Santa Cruz Province, Argentina, 11 Feb 1979, Mision Cientifica Danesa, genitalia slide 3045 HHN (ZMUC).

Paratypes.—Argentina. Neuquén Prov.: Rio Limay, Arroyito, 1 ♂, 16 Dec 1978, 1 ♂, 17 Dec 1978, Mision Cientifica Danesa. (North of) San Carlos de Bariloche, Confluencia, 690 m, 1 ♂, 15–24 Nov 1981, M. O. Gentili, genitalia slide 2942 HHN. Zapala, El Marucho, 870 m, 2 ♂, 26 Oct 1981, M. O. Gentili, genitalia slide 2941 HHN. Santa Cruz Prov.: same collection data as for holotype, 1 ♀, genitalia slide 3046 HHN. Paratypes in ZMUC.

Discussion.—*Passadena argentina* fits well into Hulst's genus despite the smooth (without scale ridge) forewing. Several phycitine genera such as *Acrobasis* Zeller and *Dioryctria* Zeller include species with and without a scale ridge, and therefore, the presence or absence of this feature is of importance only at the species level.

***Pseudopassadena* Neunzig and Goodson, NEW GENUS**

Gender.—Feminine.

Type species.—*Pseudopassadena gentilii* Neunzig and Goodson.

Antenna (Fig. 26) simple in both sexes; sensilla trichodea of shaft of male moderately abundant and about as long as basal diameter of shaft. Front convex, somewhat roughly scaled. Labial palpus of both sexes oblique basally, becoming porrect. Maxillary palpus simple in both sexes. Haustellum well developed. Ocellus present. Basal ½ of costa of forewing of male (Fig. 23) straight to slightly convex; underside, of male, without costal fold or sex-scaling. Forewing with weak subbasal ridge of raised scales; with 11 veins; R_2 from cell; R_{3+4} and R_5 stalked for about ½ their lengths; M_1 from below upper angle of cell; M_2 and M_3 stalked for about ⅓ their lengths; CuA_1 from lower angle of cell; CuA_2 from before lower angle of cell. Hindwing (Fig. 23) with 8 veins; $Sc + R_1$ and R_S approximate beyond cell for short distance; M_1 fused with R_S at base; M_2 and M_3 long-stalked (for over ⅔ their lengths); CuA_1 from stalk of M_2 and M_3; CuA_2 from before, but near, lower angle of cell; cell about ½ length of wing. Eighth abdominal segment of male with pair of ventral, rather weakly developed scale tufts (each tuft composed of a loose fascicle of moderately short, approximately straight, scales). Male genitalia (Figs. 58, 59) with uncus subtriangular, somewhat broadly rounded apically; gnathos with apical process slightly enlarged and rounded distally, sometimes with a small hook; transtilla weak, incomplete mesially; juxta a small, U-shaped plate; valva with a strongly developed clasper arising from edge of cucullus; aedoeagus with large, strongly sclerotized, elongate cornutus; vinculum about as long as wide. Female genitalia (Fig. 84) with slightly more than posterior ⅓ of ductus bursae enlarged and spinulose and most of remainder strongly sclerotized; corpus bursae with dorsum partially sclerotized; signum a ventral, U-shaped line of large spines more or less fused at their bases; ductus seminalis attached to corpus bursae near junction of ductus bursae and corpus bursae.

Pseudopassadena is a monobasic genus. Although it superficially resembles *Passadena* Hulst it is most closely related to *Eu-*

passadena Neunzig and Goodson. *Pseudopassadena* differs from *Eupassadena* in having the male antenna simple rather than bearing a tuft of scales, in possessing male genitalia with the apex of the gnathos enlarged, as opposed to attenuated, and in having female genitalia that lack toothed ridges in the anterior wall of the ductus bursae. Both *Pseudopassadena* and *Eupassadena* can be separated from *Passadena* in that they possess a large, well developed cornutus in the aedoeagus, and the corpus bursae is partly sclerotized.

Pseudopassadena gentilii Neunzig and Goodson, NEW SPECIES

Figs. 14, 23, 26, 58, 59, 84

Type locality.—Zapala, El Marucho, 870 m, Neuquén Province, Argentina.

Diagnosis.—The general appearance of *P. gentilii* is similar to that of *Eupassadena karsholti* Neunzig and Goodson. However, *P. gentilii* is more heavily dusted with white, and the black maculation more distinct than in *E. karsholti.* Many differences also exist in the male antenna, the maxillary palpus and male and female genitalia of the two species as described under the generic descriptions of *Pseudopassadena* and *Eupassadena.*

Description.—*Length of forewing:* 8.0–9.0 mm. *Head* with front and vertex white mixed with black; labial palpus mostly white in basal half and mostly fuscous or black in distal half; maxillary palpus mostly white. *Thorax* with dorsum mostly fuscous or black with some patches of white (tegulae mostly white with some pale brown, brown, fuscous and black); collar similar to tegulae. *Forewing* mostly white, irrorated with fuscous or black; antemedial line white, rather indistinct, blending with general white color of wing; pale brown subbasal patch bordering basal posterior margin of antemedial line; fuscous or black, and white, raised scale ridge just proximal to subbasal patch; distinct patch of fuscous or black bordering distal costal margin of antemedial line; postmedial line white, rather obscure, bordered proximally with fuscous or black, particularly in costal half; faint suffusion of pale brown in posterior half between transverse lines and in terminal area; discal spots fuscous or black, distinct, fused. *Hindwing* brownish white, darker along veins and near costal and outer margins. *Male and female genitalia* (Figs. 58, 59, 84) as in description of genus.

Distribution.—Known only from the type locality.

Holotype.—♂—Zapala, El Marucho, 870 m, Neuquén Prov., Argentina, 26 Oct 1981, M. O. Gentili, genitalia slide 2925 HHN (ZMUC).

Paratypes.—Argentina. Neuquén Prov.: sama data as for holotype, 1 ♂, 1 ♀, genitalia slides 2926, 3087 HHN. Paratypes in ZMUC.

Eupassadena Neunzig and Goodson, NEW GENUS

Gender.—Feminine.

Type species.—*Eupassadena karsholti* Neunzig and Goodson.

Antenna of male (Fig. 29) with sinus and associated scale tuft near base of shaft, of female simple; sensilla trichodea of shaft of male moderately abundant and about ½ as long as basal diameter of shaft. Front convex, more or less roughly scaled. Labial palpus of both sexes oblique basally, becoming porrect distally. Maxillary palpus aigrette-like in male, simple in female. Haustellum well developed. Ocellus present. Basal ½ of costa of forewing of male (Fig. 24) straight to slightly convex; underside, of male, without costal fold or sex-scaling. Forewing with weak subbasal ridge of raised scales; venation as in *Pseudopassadena.* Eighth abdominal segment of male with two pairs of ventral, well developed scale tufts; each tuft composed of a rather compact cluster of slender, simple, approximately straight scales. Male genitalia (Figs. 60, 61) with uncus triangular; gnathos slender apically, developed into a sharply pointed hook; transtilla weakly developed, incomplete mesially, juxta a half-round, weakly formed plate; valva simple; aedoeagus with large, strongly developed, spinelike cornutus; vinculum longer than greatest width. Female genitalia (Fig. 82) with ductus bursae with slightly over posterior ⅓ enlarged, slightly sclerotized and spinulose, and anterior ⅓ heavily sclerotized; series of longitudinal ridges, some toothed, in anterior wall of heavily sclerotized part of ductus bursae; corpus bursae with dorsum partially sclerotized; two signa in corpus bursae consisting of large clusters of well developed spines with incompletely fused together flattened bases (small clear areas visible between bases of spines); ductus seminalis attached to corpus bursae near junction of ductus bursae and corpus bursae.

Eupassadena shares many features with *Pseudopassadena* and *Passadena.* Differences are mentioned in the generic description of *Pseudopassadena.*

Eupassadena karsholti
Neunzig and Goodson,
New Species

Figs. 15, 24, 29, 60, 61, 82

Type locality.—Rio Limay, Arroyito, Neuquén Province, Argentina.

Diagnosis.—Differences between *E. karsholti* and its nearest known relative, *Pseudopassadena gentilii,* were discussed under the description of the latter species.

Description.—*Length of forewing:* 7.5–8.5 mm. *Head* with front mostly white, or brownish white, vertex a mixture of white, brownish white and fuscous or black; labial palpus a mixture of white and fuscous and black; maxillary palpus of male mostly pale reddish brown, of female fuscous basally, white distally. *Thorax* with dorsum usually mostly fuscous anteriorly, mostly brownish white posteriorly (tegulae a mixture of white, brownish white, brown and fuscous or black); collar similar to tegulae. *Forewing* mostly white, irrorated with fuscous or black; pale brown basal patch in posterior half of wing; antemedial line white, distinct near costa; pale brown subbasal patch bordering antemedial line; fuscous or black, and white, raised, scale ridge proximal to subbasal patch; postmedial line white, indistinct; patches of pale brown between transverse lines in posterior half of wing and near discal spots; postmedial line bordered distally with pale brown and black or fuscous, darkest near costa; discal spots black, relatively distinct, fused. *Hindwing* smoky fuscous; darker along veins and near costal and outer margins. *Male and female genitalia* (Figs. 60, 61, 82) as in description of genus.

Distribution.—Collected only in southeastern Neuquén Province, Argentina, at a site with bush steppe and Patagonian steppe vegetation.

Holotype.—♂—Rio Limay, Arroyito, Neuquén Province, Argentina, 16 Nov 1978, Mision Cientifica Danesa, genitalia slide 2921 HHN (ZMUC).

Paratypes.—Argentina. Neuquén Prov.: Piedra del Aquila, 1 ♀, 23 Dec 1978, Mision Cientifica Danesa. Rio Limay, Arroyito, 3 ♂, 3 ♀, 16 Nov 1978; 3 ♂, 6 ♀, 17 Nov 1978; 1 ♀, 22 Dec 1978. Mision Cientifica Danesa, 1 ♂, 1 ♀ genitalia slide 2922, 2946. Paratypes in ZMUC.

Honora nirihuauensis
Neunzig and Goodson,
New Species

Figs. 16, 64, 65, 85

Type locality.—San Carlos de Bariloche, Nirihuau, Rio Negro Province, Argentina.

Diagnosis.—In contrast to other species of *Honora, nirihuauensis* and the next species (*Honora palliolella* Neunzig and Goodson) have the forewing with a narrow black line basally along the costal margin that extends distally and to the upper surface to border the upper part of a smoothly curved antemedial line (line sometimes partially ochre in *H. palliolella*). Both *H. nirihuauen-*

sis and *H. palliolella* also have the clasper of the valva of the male genitalia much reduced, and the aedoeagus without spinelike cornuti. *Honora nirihuauensis* differs from *H. palliolella* in being a distinctly darker species, and in having more spines, generally distributed, in the corpus bursae of the female.

Description.—*Length of forewing:* 10.5–13.5 mm. *Head* with front and vertex white laterally, brown or reddish brown mesially; antenna simple in both sexes; labial palpus mostly brown dusted with white in basal half, mixed with reddish brown in distal half, oblique basally, becoming porrect distally; maxillary palpus white, simple in both sexes. *Thorax* with dorsum a mixture of white, pale brown, reddish brown and fuscous or black; collar similar to dorsum but usually paler. *Forewing* with ground color fuscous; most of wing dusted with white, particularly in costal half; basal ¼ with black streak along costal margin that extends to upper surface to become distal border of antemedial line; antemedial line white, rather indistinct, curved; postmedial line white, indistinct; overlay of varying amounts of pale reddish brown, concentrated mostly in posterior half of wing; discal spots black, separate, moderately distinct to obscure; underside, of male, without costal fold or sex-scaling. *Hindwing* pale smoky fuscous, darker along veins and near costal and outer margins. *Male abdominal segment 8* with pair of ventral scale tufts; tufts rather short, composed of approximately straight, slender scales. *Male genitalia* (Figs. 64, 65) with uncus triangular; gnathos with strongly formed apical hook; transtilla weakly developed, incomplete mesially; juxta platelike, without distinct lateral processes; valva simple, with very short, weakly formed clasper arising from sacculus near base of cucullus; aedoeagus short, simple; vinculum shorter than greatest width. *Female genitalia* (Fig. 85) with ductus bursae membranous; corpus bursae membranous with signum a strongly developed, large, round, densely spined plate; many additional, rather large spines, separate from signum, also present in corpus bursae; ductus seminalis attached to corpus bursae near junction with ductus bursae.

Distribution.—Associated with sites having Patagonian steppe vegetation in Chubut, Rio Negro, and Santa Cruz Provinces, Argentina.

Holotype.—♂—San Carlos de Bariloche, Nirihuau, Rio Negro Province, Argentina, 30 Dec 1978, Mision Cientifica Danesa, genitalia slide 3022 HHN (ZMUC).

Paratypes.—Argentina. Chubut Prov.: Esquel, 550 m, 1 ♂, 1 Jan 1982, Nielsen & Karsholt, genitalia slide 2982 HHN. Rio Negro Prov.: Ñorquincó, 5 ♂, 21 Jan 1961; 1 ♂, 1 ♀, 25 Jan 1961; 1 ♀, 17 Feb 1961, Gy Topál, 3 ♂, 2 ♀ genitalia slides 2962, 2963, 2970, 2994, 2995 HHN. San Carlos de Bariloche, Nirihuau, 1 ♂, 2 Jan 1979, Mision Cientifica Danesa. Santa Cruz Prov.: Lago Argentino, El Calafate, 200 m, 1 ♂, 12 Jan 1979, Mision Cientifica Danesa, genitalia slide 3041 HHN. Paratypes in ZMUC.

Discussion.—Roesler (1973) made *Honora* a junior synonym of *Oncolabis* Zeller. We have not followed this interpretation because of major differences in the male antennae of the two genera.

Honora palliolella Neunzig and Goodson, NEW SPECIES

Figs. 17, 66, 67, 80

Type locality.—N. of Chos Malal, Barrancas, 850 m, Neuquén Province, Argentina.

Diagnosis.—*H. palliolella* is predominantly white, making it paler than other species in the genus. Also, information as to how *palliolella* is distinguished from other Honora is given in the diagnosis of the previous species (*Honora nirihuauensis*).

Description.—*Length of forewing:* 10.0–11.0 mm. *Head* with front and vertex white, ochre mesially; antenna simple in both sexes; labial palpus white and ochre, oblique basally becoming porrect distally; maxillary palpus white, simple in both sexes. *Thorax* with dorsum and collar white, suffused with ochre. *Forewing* mostly white with thin black, or black and ochre, basal streak along costal margin extending to upper surface to become distal margin of antemedial line; additional black scales mostly in posterior half (usually most abundant in medial area near wing margin) and basad of postmedial line (mostly near apex); a few black scales forming an incomplete terminal line, and, with some specimens, a very few additional black scales generally distributed over wing; antemedial line white, blending with ground color, curved; postmedial line white, indistinct; obscure longitudinal streaks or patches of ochre mostly in posterior half, and, with some specimens, a few additional ochre scales generally distributed over wing; discal spots black, usually distinct, upper spot sometimes reduced; underside, of male, without costal fold or sex-scaling. *Hindwing* pale, whitish fuscous, slightly darker along veins and near costal and outer margins. *Male abdominal segment 8* as in *H. nirihuauensis. Male genitalia* (Figs. 66, 67) very similar to genitalia of *H. nirihuauensis*; generally somewhat more robust; clasper on valva reduced, but slightly larger than in *H. nirihuauensis. Female genitalia* (Fig. 80) with ductus bursae membranous; corpus bursae membranous with signum a large, round, densely spined plate, and with a few separate spines; ductus seminalis attached to corpus bursae near junction with ductus bursae.

Distribution.—Known only from the type locality in northwestern Neuquén Province, Argentina. Associated with Patagonian steppe.

Holotype.—♂—N. of Chos Malal, Barrancas, 850 m, Neuquén Province, Argentina, 22 Mar 1979, Mision Cientifica Danesa, genitalia slide 2881 HHN (ZMUC).

Paratypes.—Argentina. Neuquén Prov.: 6 ♂, 3 ♀, same data as for holotype, ♀ genitalia slide 2882 HHN. Paratypes in ZMUC.

Ocala megajuxta Neunzig and Goodson, NEW SPECIES

Figs. 18, 62, 63, 83

Type locality.—Rio Limay, Arroyito, Neuquén Province, Argentina.

Diagnosis.—As indicated by the specific name, *megajuxta* has robust, lateral arms associated with the juxta that extend posteriorly well beyond the posterior margin of the inner plate of the juxta (Fig. 62). Only one other species of *Ocala* (*dryadella* Hulst) has been described; it occurs in North America (Florida). In *O. dryadella* the lateral arms of the juxta are small, reaching only as far posteriorly as the posterior margin of the inner plate. Additional differences in the male genitalia include: the outer margin of the cucullus concave in *O. megajuxta* and straight in *O. dryadella*; the aedoeagus spined in *O. megajuxta* and smooth in *O. dryadella*; the vinculum about as long as greatest width in *O. megajuxta* and not as long as greatest width in *O. dryadella.*

Description.—*Length of forewing:* 7.0–8.5 mm. *Head* with front and vertex brown and fuscous, rather heavily dusted with white; antenna of male with sinus and associated scale tuft near base of shaft, of female simple; labial palpus brown and fuscous, rather heavily dusted with white, porrect (second segment slightly oblique, third segment directed forward and slightly downward) in both sexes; maxillary palpus aigrettelike in male, in female simple, white. *Thorax* with dorsum and collar mostly pale brown or brownish white with some darker brown scales. *Forewing* with ground color fuscous, rather heavily dusted with white; basal patch of pale reddish brown in posterior half; antemedial line pale reddish brown, distinct in posterior half but not developed near costa, preceded in posterior half by black patch; postmedial line indistinct, white; on some specimens longitudinal streak of pale reddish brown in posterior half between transverse lines and extending into terminal area; discal spots usually rather distinct, black, separate; underside, of male, without costal fold or sex-scaling. *Hindwing* pale smoky fuscous, darker along veins and near costal and outer margins. *Male abdominal segment 8* with pair of stout ventrolateral scale tufts and a lateral pair of eversible lobes bearing longer tufts of scales. *Male genitalia* (Figs. 62, 63) with uncus triangular; gnathos with well developed hooklike process; transtilla not developed; juxta platelike with rather long, robust, lateral lobes bearing many short setae; valva with transverse sclerotized ridge extending across base of cucullus; basal part of ridge with setiferous lobe; outer margin of cucullus slightly concave; aedoeagus very slender, needlelike, armed with rows of small, dentate spines in distal half; vinculum about as long as greatest width. *Female genitalia* (Fig. 83) with ductus bursae very slender in posterior half, inflated in anterior half; corpus bursae membranous, attached to ductus bursae near its middle, without signum; ductus seminalis arising from narrow posterior part of ductus bursae.

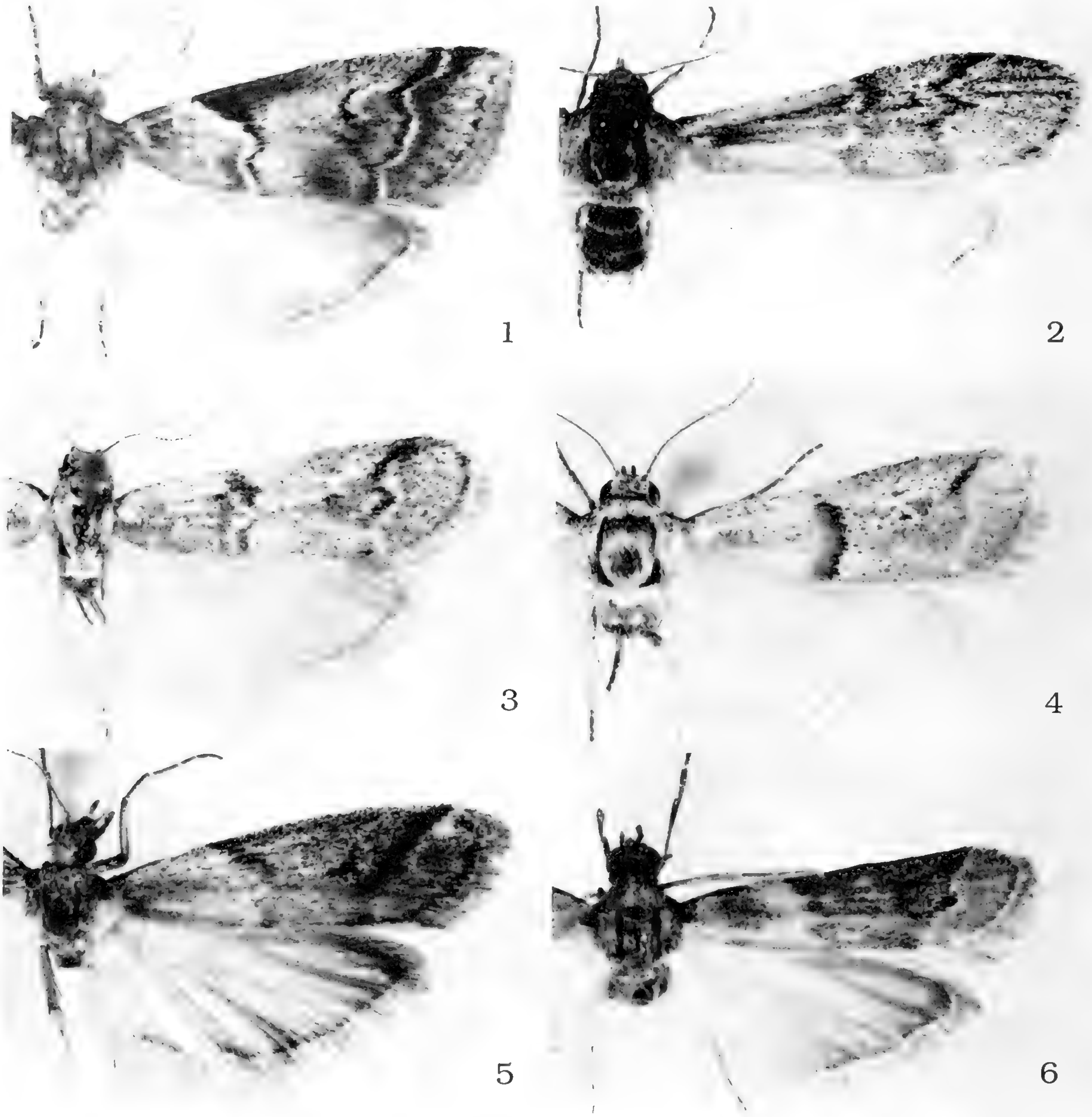
Distribution.—Collected in southern Neuquén and western Rio Negro Provinces.

Holotype.—♂—Rio Limay, Arroyito, Neuquén Province, Argentina, 22 Dec 1978, Mision Cientifica Danesa, genitalia slide 2923 HHN (ZMUC).

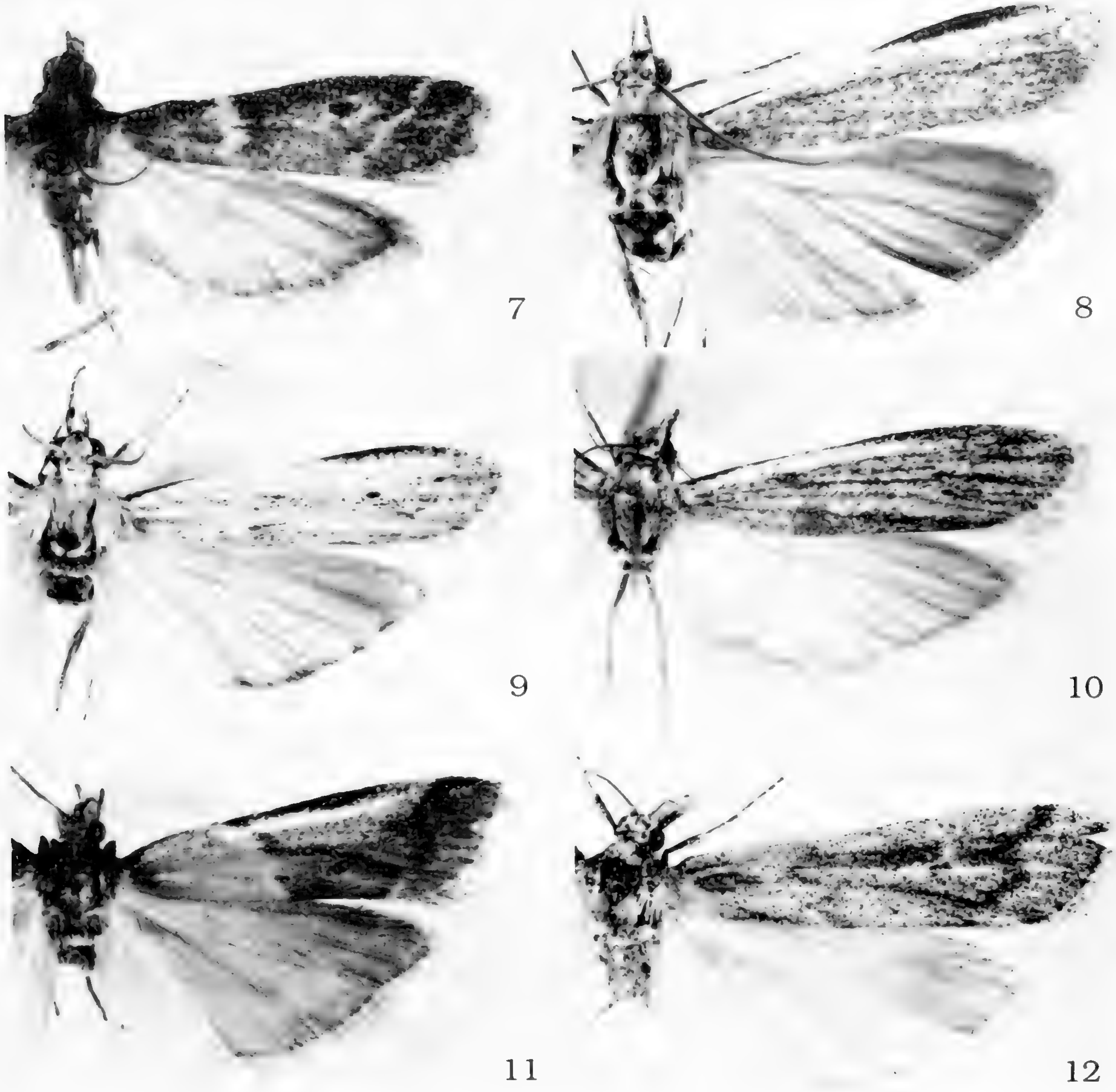
Paratypes.—Argentina. Neuquén Prov.: Lago Lacar, Pucara, 750 m, 5 ♂, 3 Dec 1978, Mision Cientifica Danesa, genitalia slides 2928, 2944 HHN. Piedra del Aguila, 1 ♂, 18 Nov 1978, 1 ♀, 19 Dec 1978, 1 ♀, 23 Dec 1978, Mision Cientifica Danesa, 2 ♀ genitalia slides 2924, 2959 HHN. Rio Limay, Arroyito, 2 ♂, 17 Dec 1978, Mision Cientifica Danesa, genitalia slide 2938 HHN. Rio Negro Prov.: San Carlos de Bariloche, Colonia Suiza, 880 m, 1 ♀, 11 Dec 1978, Mision Cientifica Danesa, genitalia slide 3003 HHN. Paratypes in ZMUC.

ACKNOWLEDGMENTS

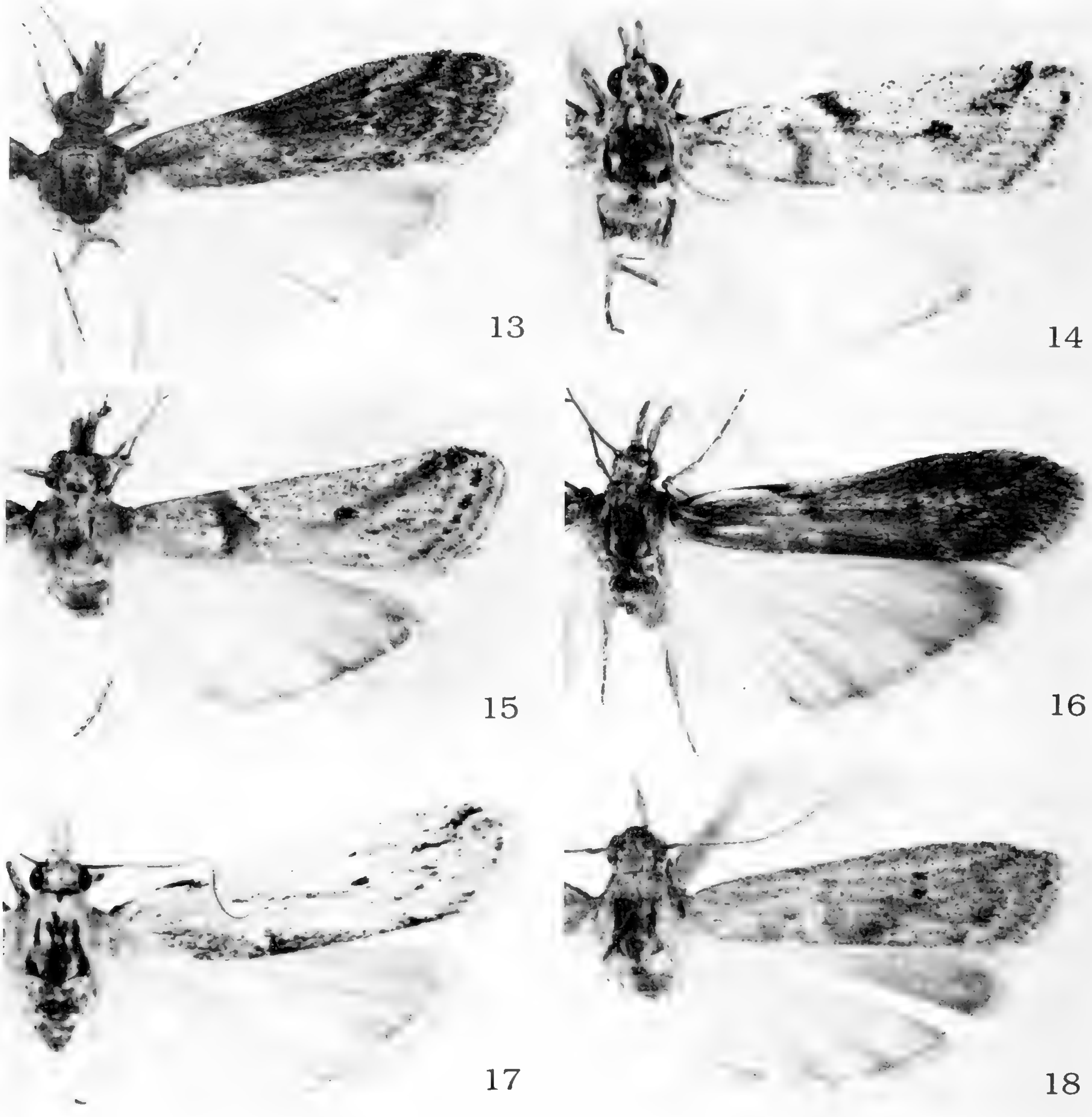
We are grateful to O. Karsholt for allowing us to study the southern South American phycitines in the collection of the Zoological Museum of the University of Copenhagen (ZMUC), and we thank R. L. Blinn, L. L. Deitz, M. H. Farrier, M. A. Solis and D. L. Stephan for critically reading and making suggestions for the improvement of the paper.



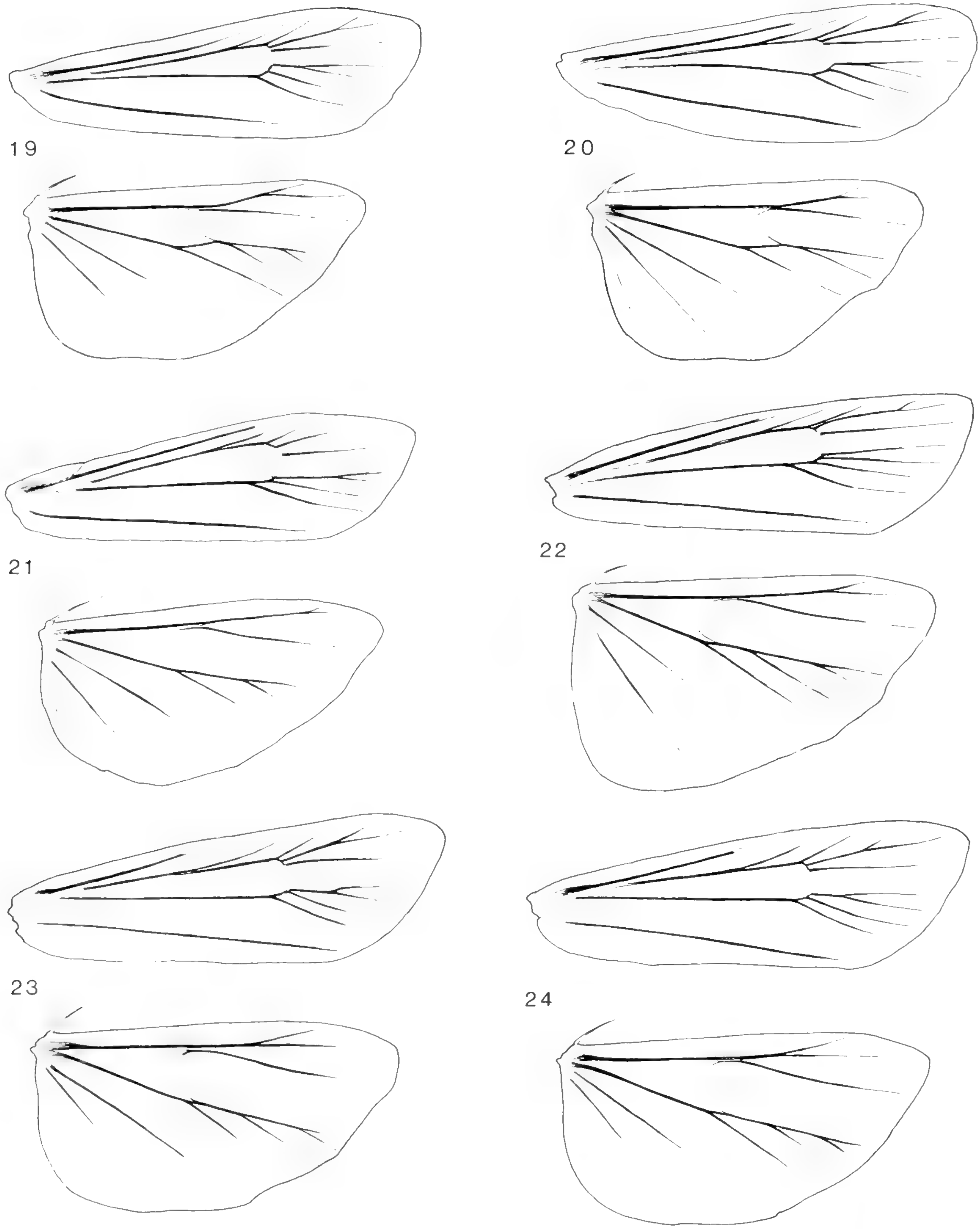
Figs. 1–6. Male adults. 1, *Ectomyelois austrella* n. sp., holotype (10.5 mm). 2, *Pseudocabima australis* n. sp., holotype (13.8 mm). 3, *Cabimoides patagoniensis* n. sp., holotype (9.7 mm). 4, *Apocabimoides neuquenensis* n. sp., holotype (7.6 mm). 5, *Inverina suizensis* n. sp., holotype (8.8 mm). 6, *Ephestiodes argentinus* n. sp., holotype (6.1 mm). (Length of forewing in parentheses.)



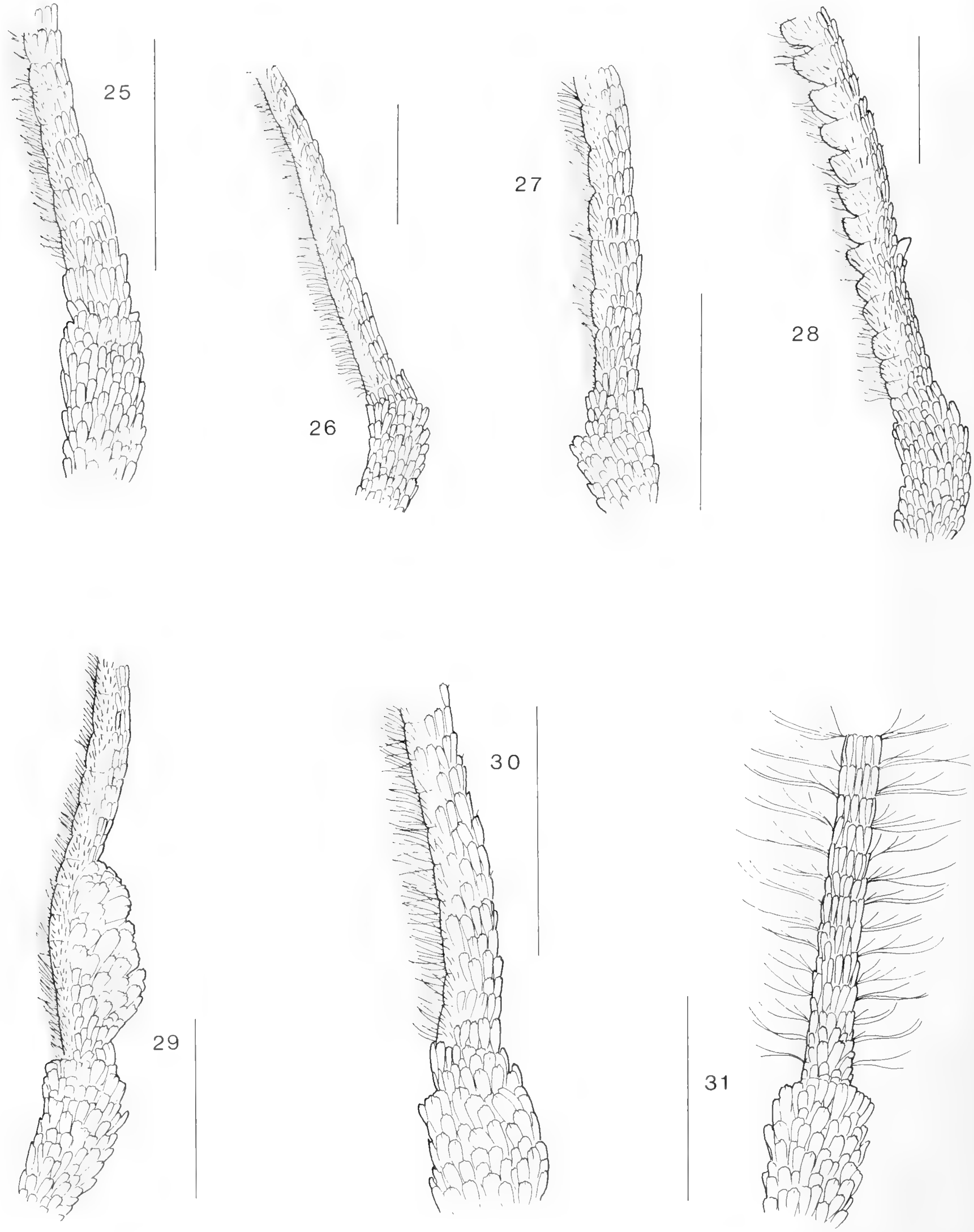
Figs. 7–12. Male adults. 7, *Erelieva steppeiana* n. sp., holotype (7.2 mm). 8, *Homoeosoma strongylognathosum* n. sp., holotype (11.2 mm). 9, *Homoeosoma eurygnathosum* n. sp., holotype (11.2 mm). 10, *Homoeosoma pauroaichmetes* n. sp., holotype (9.2 mm). 11, *Ohigginsia diversa* n. sp., holotype (11.2 mm). 12, *Ragonotia confluenciana* n. sp., holotype (15.5 mm). (Length of forewing in parentheses.)



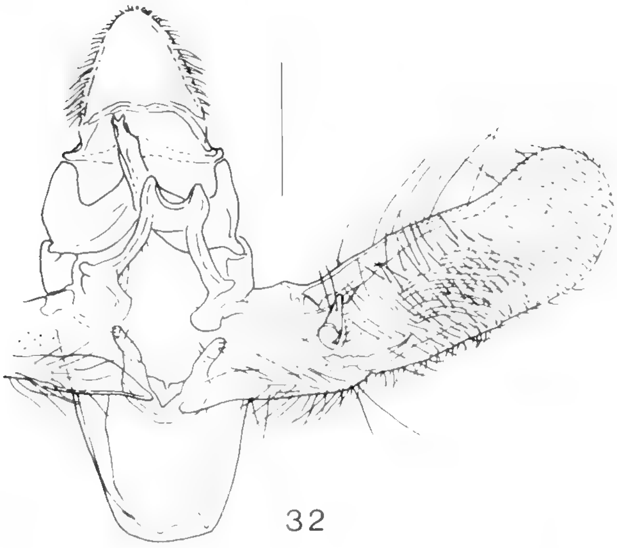
Figs. 13–18. Male adults. 13, *Passadena argentina* n. sp., holotype (10.1 mm). 14, *Pseudopassadena gentilii* n. sp., holotype (8.5 mm). 15, *Eupassadena karsholti* n. sp., holotype (8.5 mm). 16, *Honora nirihuauensis* n. sp., holotype (13.0 mm) 17, *Honora palliolella* n. sp., holotype (10.0 mm). 18, *Ocala megajuxta* n. sp., holotype (7.6 mm). (Length of forewing in parentheses.)



Figs. 19–24. Male wing venation. 19, *Cabimoides patagoniensis* n. sp. (11.0 mm). 20, *Apocabimoides neuquenensis* n. sp. (7.5 mm). 21, *Inverina suizensis* n. sp. (8.0 mm). 22, *Ohigginsia diversa* n. sp. (11.9 mm). 23, *Pseudopassadena gentilii* n. sp. (8.5 mm). 24, *Eupassadena karsholti* n. sp. (8.2 mm). (Length of forewing in parentheses.)



Figs. 25–31. Male antennae. 25, *Inverina suizensis* n. sp., posterior view of base. 26, *Pseudopassadena gentilii* n. sp., posterior view of base. 27, *Apocabimoides neuquenensis* n. sp., posterior view of base. 28, *Ohigginsia diversa* n. sp., posterior view of base. 29, *Eupassadena karsholti* n. sp., posterior view of base. 30, *Cabimoides patagoniensis* n. sp., posterior view of base. 31, *Ragonotia confluenciana* n. sp., posteromedial view of base. (All scale lengths 0.5 mm.)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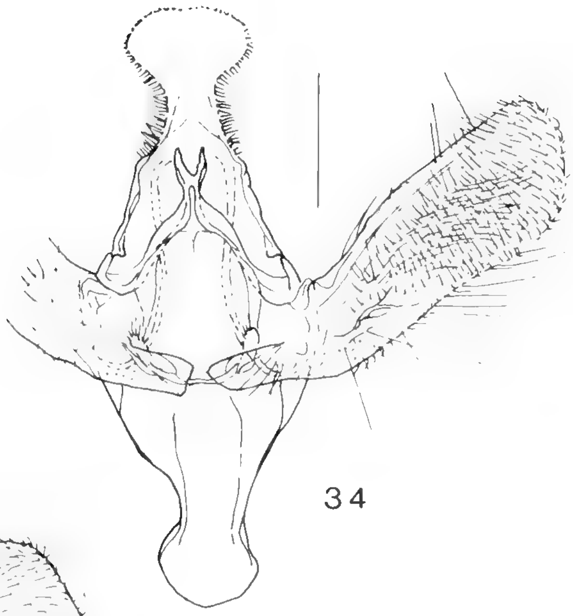
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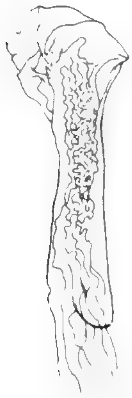
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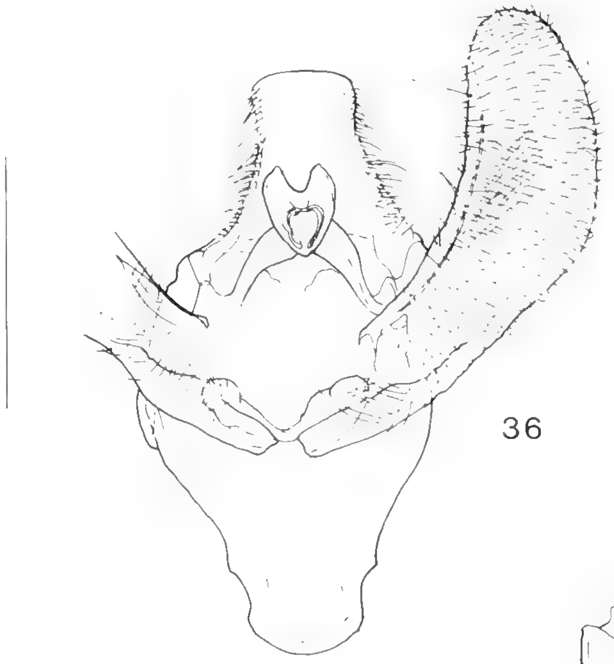
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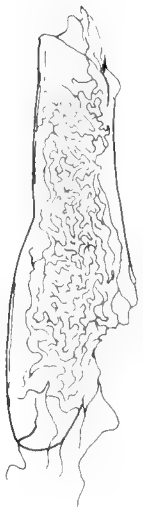
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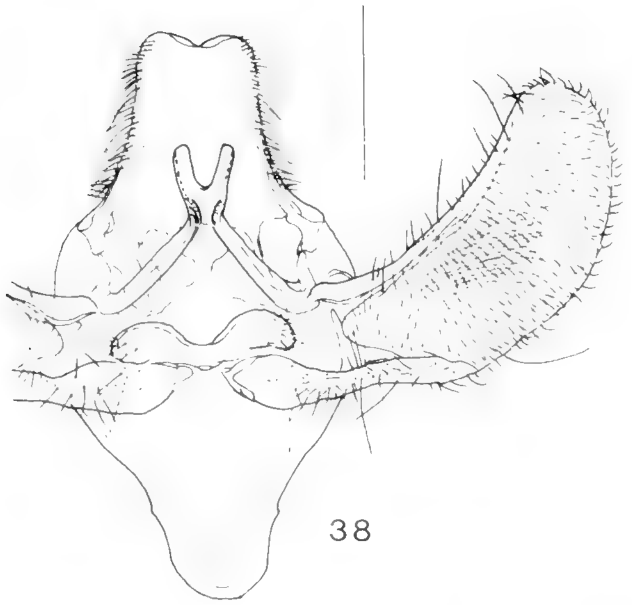
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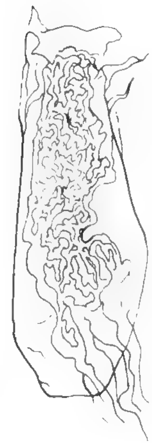
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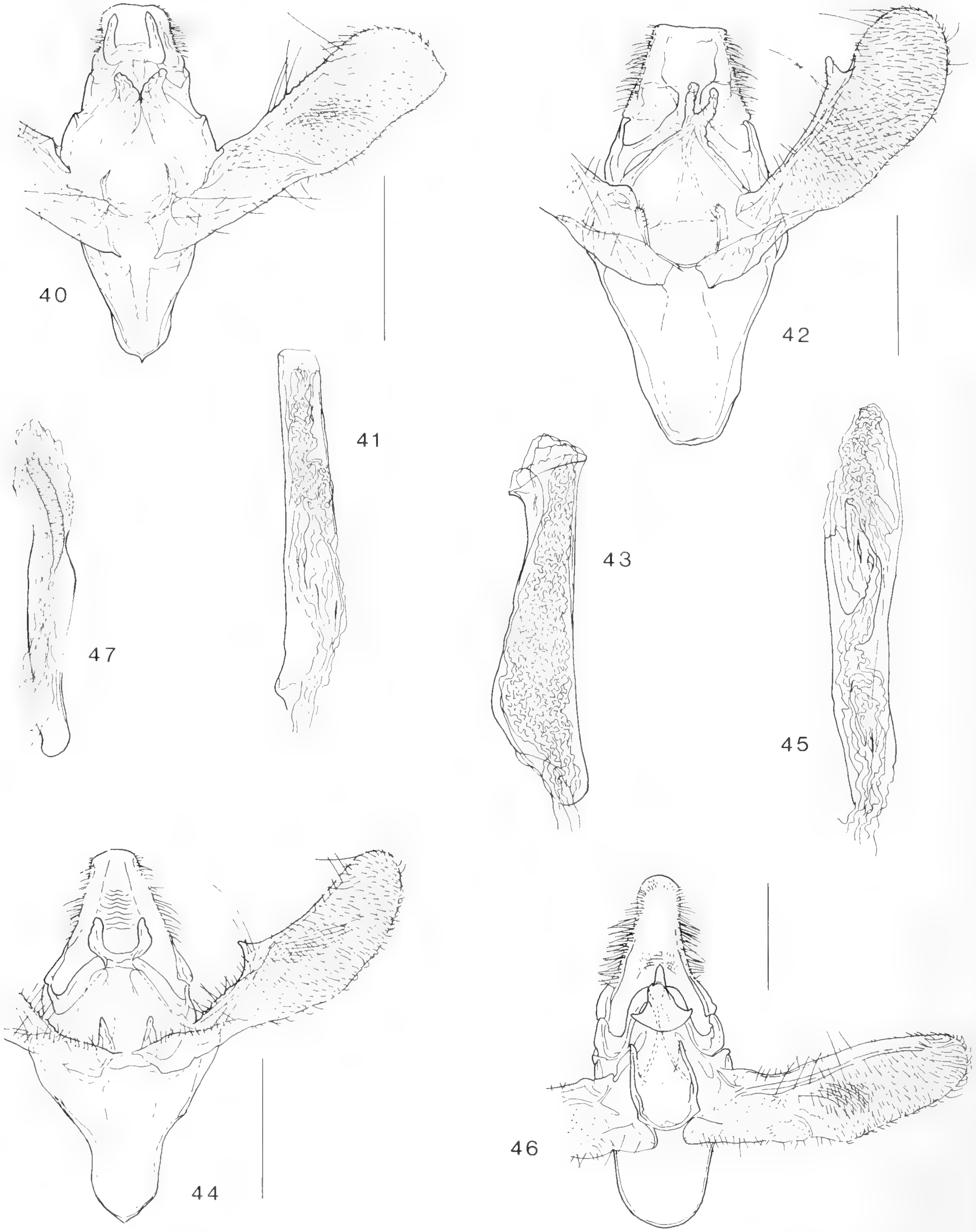
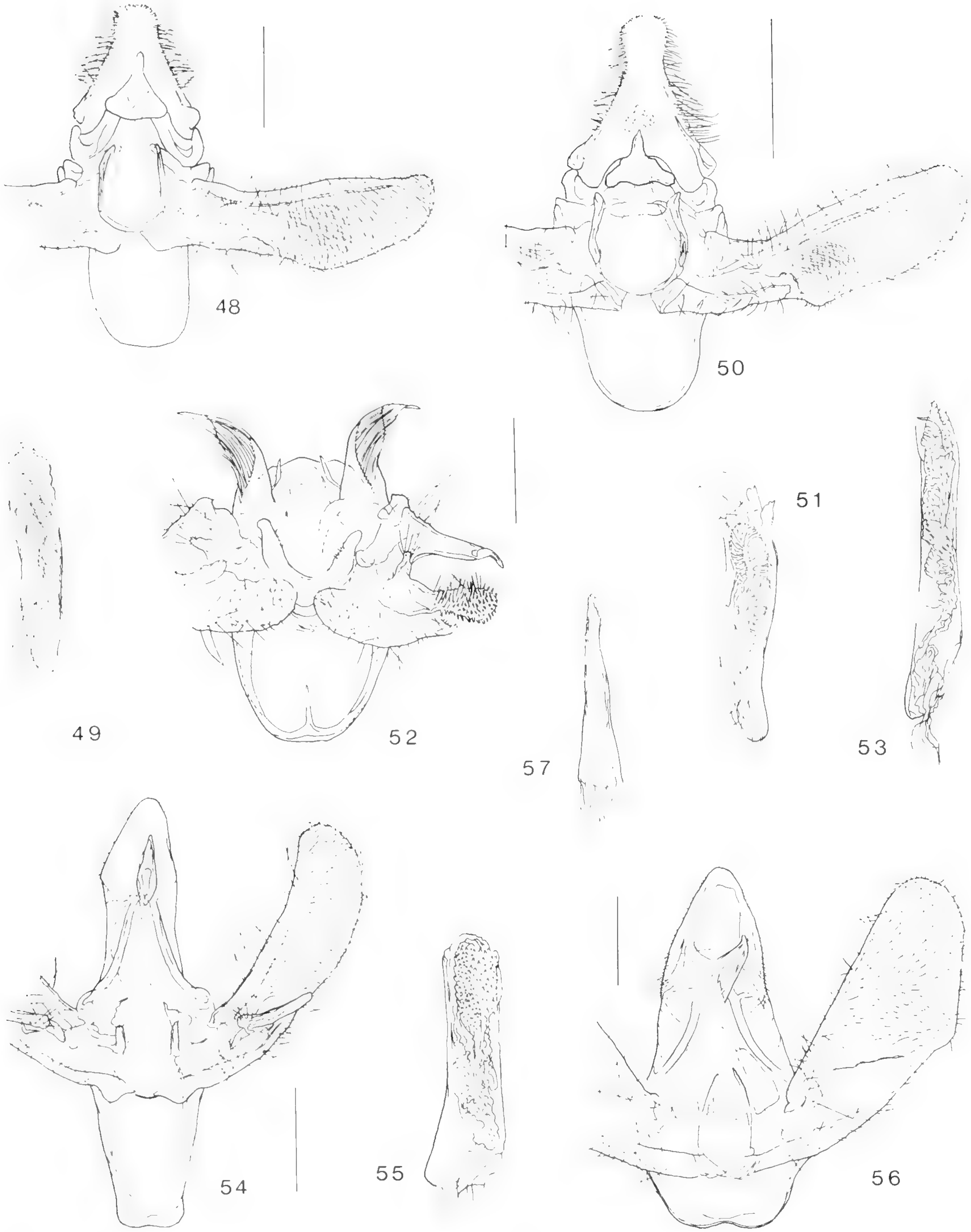
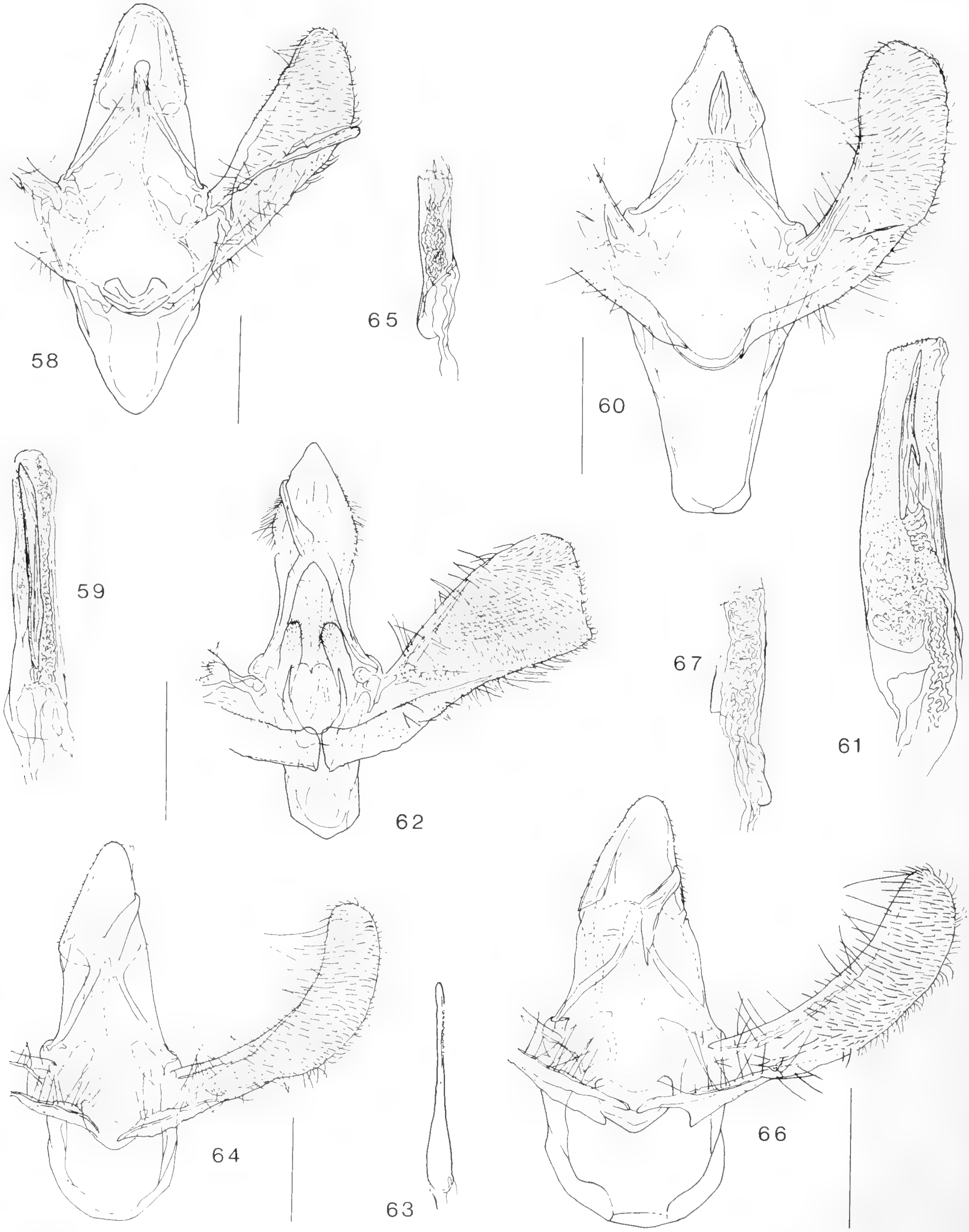
Figs. 32–39. Male genitalia. 32, *Ectomyelois austrella* n. sp., holotype, ventral view, aedoeagus removed. 33, aedoeagus. 34, *Pseudocabima australis* n. sp., holotype ventral view, aedoeagus removed. 35, aedoeagus. 36, *Apocabimoides neuquenensis* n. sp., holotype, ventral view, aedoeagus removed. 37, aedoeagus. 38, *Cabimoides patagoniensis* n. sp., holotype, ventral view, aedoeagus removed. 39, aedoeagus. (All scale lengths 0.5 mm.)



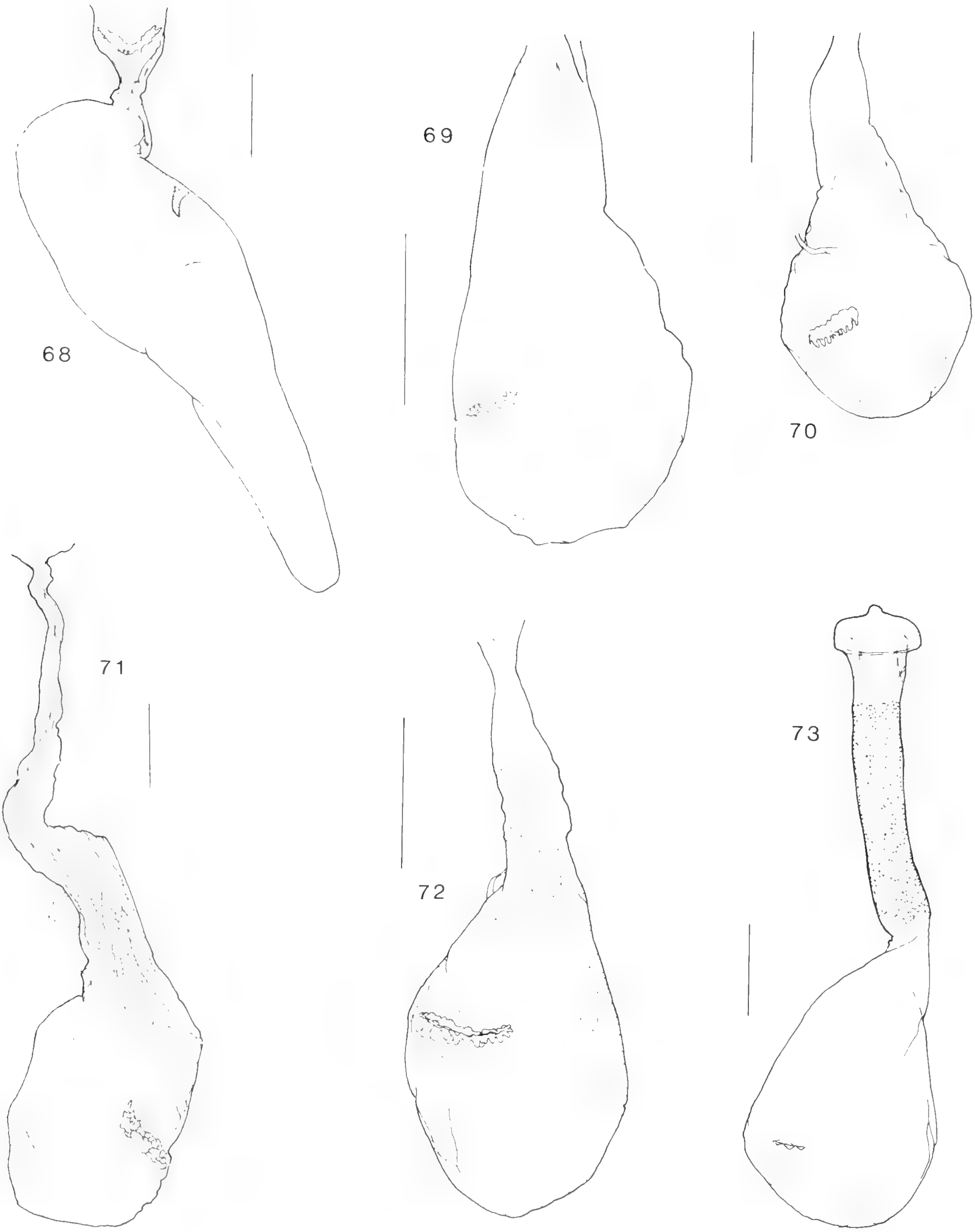
Figs. 40–47. Male genitalia. 40, *Ephestiodes argentinus* n. sp., holotype, ventral view, aedoeagus removed. 41, aedoeagus. 42, *Erelieva steppeiana* n. sp., holotype, ventral view, aedoeagus removed. 43, aedoeagus. 44, *Inverina suizensis* n. sp., holotype, ventral view, aedoeagus removed. 45, aedoeagus. 46, *Homoeosoma strongylognathosum* n. sp., holotype, ventral view, aedoeagus removed. 47, aedoeagus. (All scale lengths of 0.5 mm.)



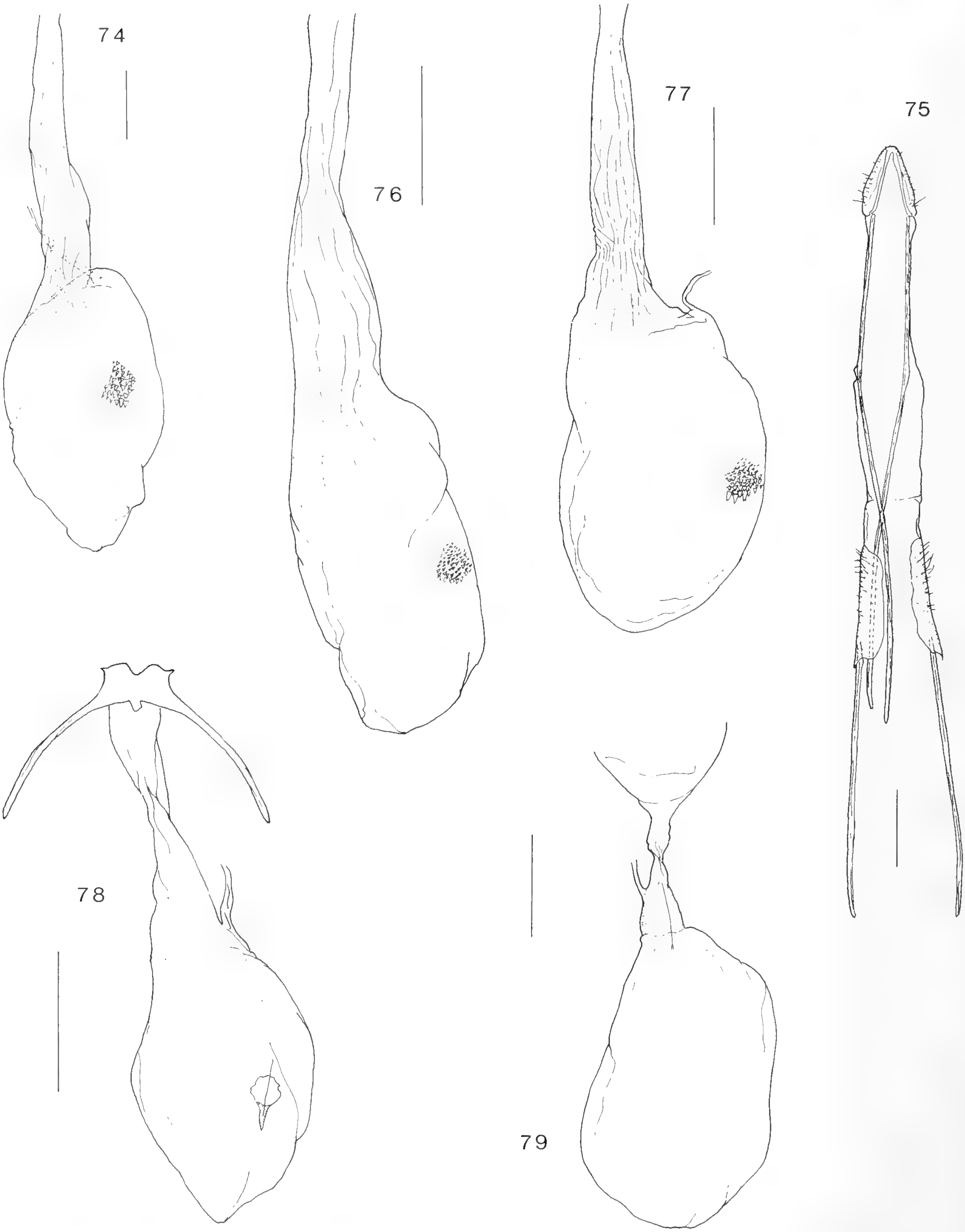
Figs. 48–57. Male genitalia. 48, *Homeosoma pauroaichmetes* n. sp., holotype, ventral view, aedoeagus removed. 49, aedoeagus. 50, *Homoeosoma eurygnathosum* n. sp., holotype, ventral view, aedoeagus removed. 51, aedoeagus. 52, *Ohigginsia diversa* n. sp., holotype, ventral view, aedoeagus removed. 53, aedoeagus. 54, *Passadena argentina* n. sp., holotype, ventral view, aedoeagus removed. 55, aedoeagus. 56, *Ragonotia confluenciana* n. sp., holotype, ventral view, aedoeagus removed. 57, aedoeagus. (All scale lengths 0.5 mm.)



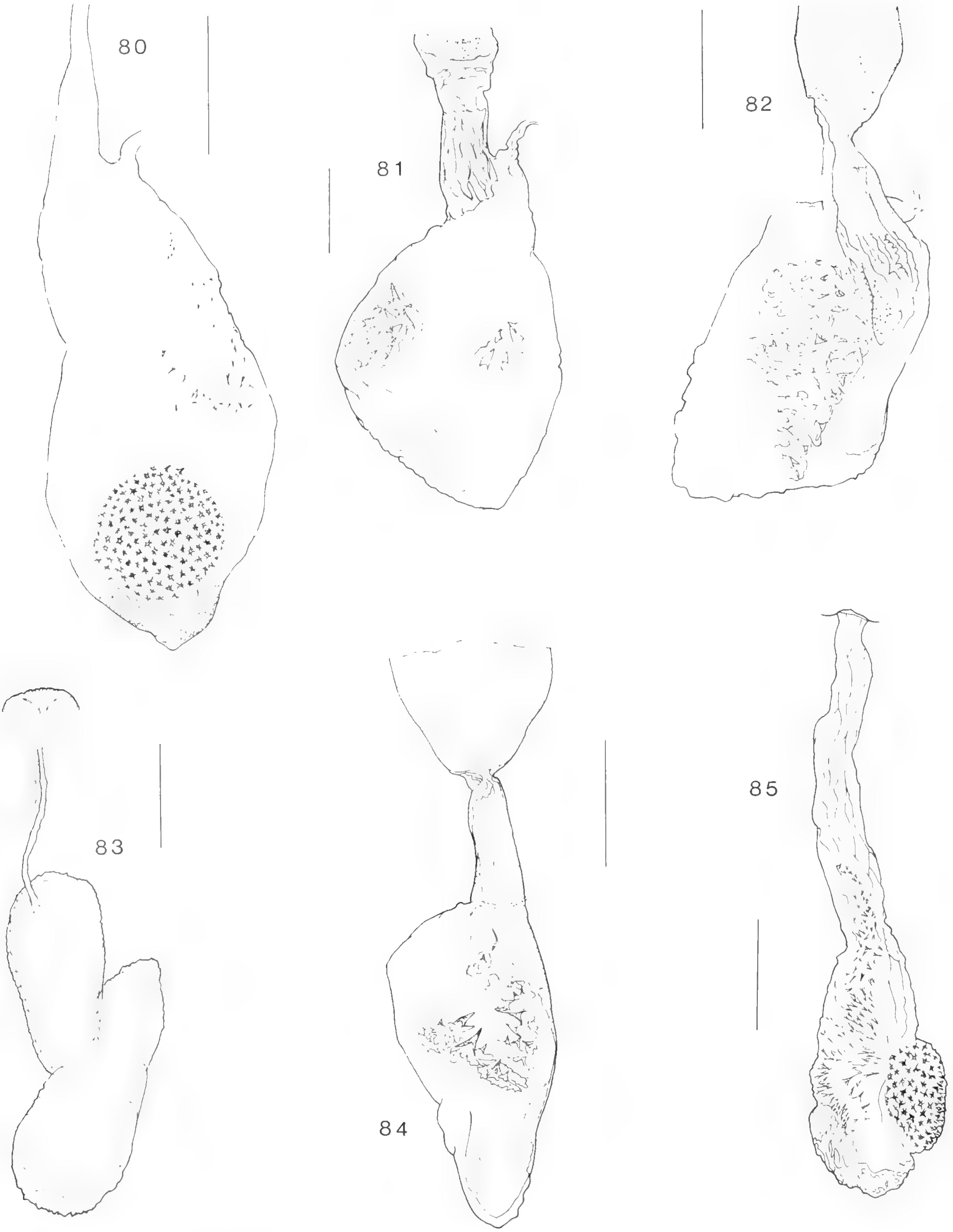
Figs. 58–67. Male genitalia. 58, *Pseudopassadena gentilii* n. sp., holotype, ventral view, aedoeagus removed. 59, aedoeagus. 60, *Eupassadena karsholti* n. sp., holotype, ventral view, aedoeagus removed. 61, aedoeagus. 62, *Ocala megajuxta* n. sp., holotype, ventral view, aedoeagus removed. 63, aedoeagus. 64, *Honora nirihuauensis* n. sp., holotype, ventral view, aedoeagus removed. 65, aedoeagus. 66, *Honora palliolella* n. sp., holotype, ventral view, aedoeagus removed. 67, aedoeagus. (All scale lengths 0.5 mm.)



Figs. 68–73. Female genitalia. 68, *Ectomyelois austrella* n. sp., ventral view, ductus bursae and corpus bursae. 69, *Inverina suizensis* n. sp., ventral view, ductus bursae, corpus bursae, and ductus seminalis (in part). 70, *Cabimoides patagoniensis* n. sp., ventral view, ductus bursae, corpus bursae and ductus seminalis (in part). 71, *Pseudocabima australis* n. sp., ventral view, ductus bursae, corpus bursae and ductus seminalis (in part). 72, *Apocabimoides neuquenensis* n. sp., ventral view, ductus bursae, corpus bursae, and ductus seminalis (in part). 73, *Ephestiodes argentinus* n. sp., ventral view, ductus bursae and corpus bursae. (All scale lengths 0.5 mm.)



Figs. 74–79. Female genitalia. 74, *Homoeosoma pauroaichmetes* n. sp., ventral view, ductus bursae, corpus bursae and ductus seminalis (in part). 75, *Homoeosoma strongylognathosum* n. sp., ventral view, papillae anales, apophyses, and sclerotized collar. 76, ventral view, ductus bursae and corpus bursae. 77, *Homoeosoma eurygnathosum* n. sp., ventral view, ductus bursae, corpus bursae and ductus seminalis (in part). 78, *Ohigginsia diversa* n. sp., ventral view, apophyses anteriores, ductus bursae, corpus bursae and ductus seminalis (in part). 79, *Ragonotia confluenciana* n. sp., ventral view, ductus bursae, corpus bursae, and ductus seminalis (in part). (All scale lengths 0.5 mm.)



Figs. 80–85. Female genitalia. 80, *Honora palliolella* n. sp., ventral view, ductus bursae, corpus bursae and ductus seminalis (in part). 81, *Passadena argentina* n. sp., ventral view, ductus bursae, corpus bursae and ductus seminalis (in part). 82, *Eupassadena karsholti* n. sp., ventral view, ductus bursae, corpus bursae and ductus seminalis (in part). 83, *Ocala megajuxta* n. sp., ventral view, ductus bursae, corpus bursae and ductus seminalis (in part). 84, *Pseudopassadena gentilii* n. sp., ventral view, ductus bursae, corpus bursae and ductus seminalis (in part). 85, *Honora nirihuauensis* n. sp., ventral view, ductus bursae and corpus bursae. (All scale lengths 0.5 mm.)

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WORLD SPECIES OF THE WASP GENUS *HOLOTACHYSPHEX* DE BEAUMONT (HYMENOPTERA: SPHECIDAE)

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Abstract.—Species of *Holotachysphex* de Beaumont are revised for the first time. The revision includes a redescription of the genus, a key to the species, a phylogenetic analysis of species, a summary of the known life history, distribution records, and maps. Four species are recognized and redescribed using previously observed and newly discovered characters, but *Holotachysphex prosopigastroides* (Gussakovskij, 1952) remains a nomen dubium. Two new synonyms are established: *Holotachysphex turneri* var. *transvaalensis* (Arnold, 1924) = *turneri* (Arnold, 1923), and *pentapolitanus* (de Beaumont, 1960) = *mochii* (de Beaumont, 1947).

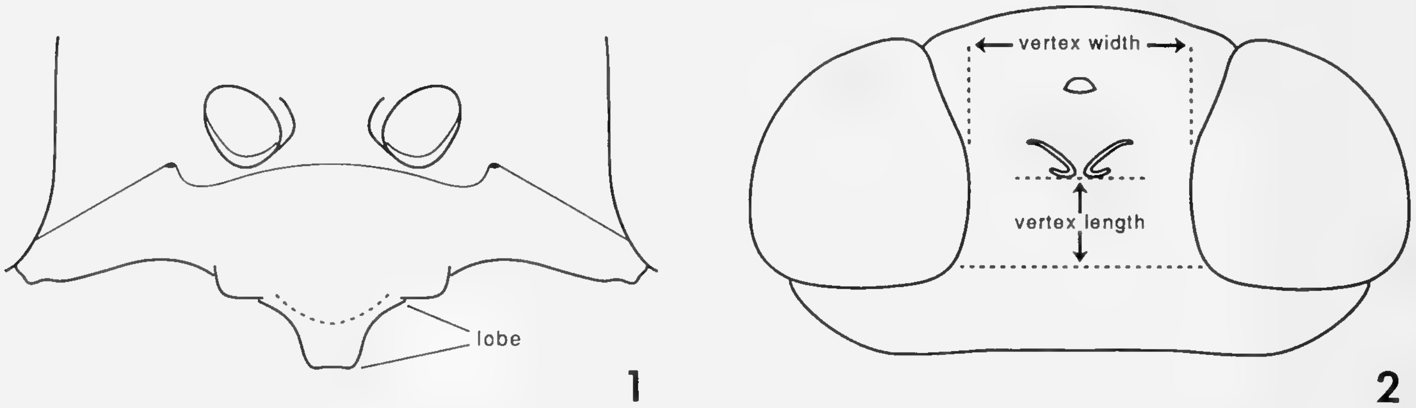
Key Words: Life history, phylogenetic analysis, redescription, distribution

Holotachysphex is a small Old World genus of four or five species which was properly defined only recently. Specimens are rarely collected. Most species were originally described in *Tachysphex,* but de Beaumont (1940) established *Holotachysphex* (as a subgenus) to include *holognathus* Morice, 1897. Later Arnold (1951) proposed *Phytosphex* to include *Tachysphex turneri* Arnold, 1923, and Gussakovskij (1952) described *Haplognatha* for his new species *prosopigastroides.* Subsequently, de Beaumont (1955) synonymized *Haplognatha* with *Holotachysphex,* and Pulawski (1971) recognized *Holotachysphex* as a genus based on previously known and some newly-found characters; he included *Phytosphex* as a subgenus. Bohart and Menke (1976) redescribed *Holotachysphex* in detail but did not use subgenera because of the small number of the species, I share their opinion. The present paper is the first revision of the genus.

Technical terms.—Generally, I follow Bohart and Menke (1976) in their use of morphological terms, but Michener and Fraser's (1978) terminology is used for the mandible. A few terms not included in these publications are defined below and a few others need clarification or are redefined for convenience:

Clypeal lobe: the projecting anterior part of clypeus (Fig. 1).
Mandible (Figs. 13, 16):

- —adductor ridge: extends distad from the adductor swellings and gradually becomes visible from the outside (constituting the distal part of the mandibular posterior margin); the two portions differ in size, the distal one being higher than the basal one;
- —condylar ridge: arises from the condyle, extends distad, and forms the basal portion of the posterior mandibular margin; it is angulate distally in many Larrinae (including most *Gastrosericus*);
- —condyle: mandibular articulation on the occipital side of the head capsule;
- —notch: an emargination on the posterior



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Figs. 1–2. *Holotachysphex*: 1—clypeus, 2—head in top view.

margin, delimited basally by the condylar ridge and distally by the expanded portion of the adductor ridge;

—posterior margin: extends between the condyle and mandibular apex; called externoventral margin by Bohart and Menke (1976) and lower margin by Michener and Fraser (1978); it actually consists of two components: the condylar ridge basally and the adductor ridge distally (the term *posterior* is preferred because the head is hypognathous, and this edge is thus oriented posterad);

—trimmal carina (Figs. 13, 16): begins at some distance from the mandibular base and constitutes the inner mandibular margin (= cutting edge), except distally.

Sternum, tergum: shortened terms for gastral sternum, gastral tergum.
Vertex (Fig. 2):

—length: the distance between a hindocellus and an imaginary line connecting eye hindcorners (i.e. the point where the inner and the posterior portions of the orbit meet);

—width: the shortest interocular distance in the ocellar region.

Sources of material.—Institutions that sent material for study or that are mentioned as type depositories are referred to in the text by the following abbreviations:

AMG	Albany Museum, Grahamstown, South Africa (Friedrich W. Gess);
BMNH	British Museum (Natural History), London, England (Colin R. Vardy);
CAS	California Academy of Sciences, San Francisco, California, USA;
MNHN	Muséum National d'Histoire Naturelle, Paris, France (Janine Casewitz-Weulersse);
MS	Maximilian Schwarz, Ansfelden near Linz, Austria (personal collection);
OXFORD	Oxford University Museum, Hope Department of Entomology, Oxford, England (Christopher O'Toole);
SAM	South African Museum, Cape Town, South Africa (Vincent B. Whitehead);
TMP	Transvaal Museum, Pretoria, South Africa;
USNM	United States National Museum (= Smithsonian Institution), Washington, D.C., USA (Karl V. Krombein, Arnold S. Menke);
ZIN	Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia.

Genus Holotachysphex

Holotachysphex de Beaumont, 1940:179 (as subgenus of *Tachysphex*). Type species: *Tachysphex holognathus* Morice, 1897, by monotypy.—Pulawski, 1971:10 (raised *Holotachysphex* to full generic status).

Phytosphex Arnold, 1951:153. Type species: *Tachysphex turneri* Arnold, 1923, by original designation and monotypy.—Pulawski, 1971:10 (as subgenus of *Holotachysphex*). Synonymized with *Holotachysphex* by Bohart and Menke, 1976: 44, 282.

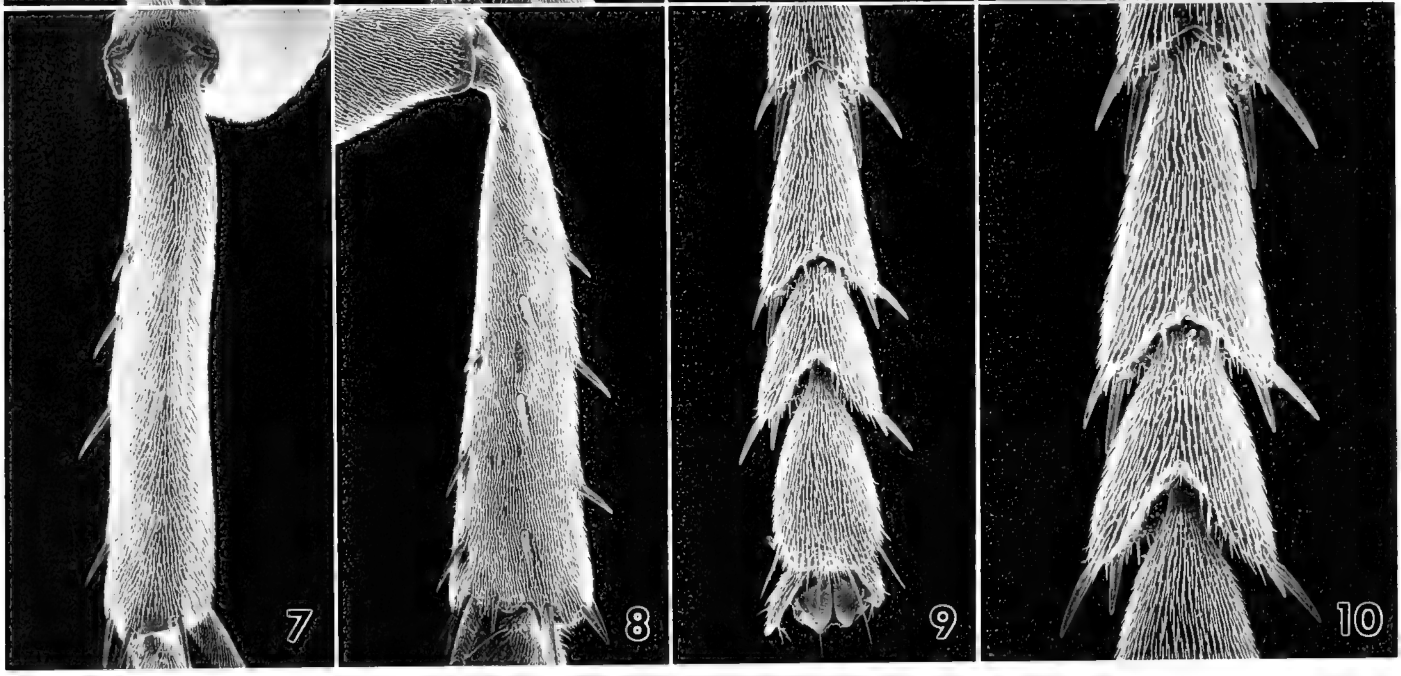
Haplognatha Gussakovskij, 1952:248. Type species: *Haplognatha prosopigastroides* Gussakovskij, 1952, by original designation and monotypy. Synonymized with *Holotachysphex* by de Beaumont, 1955: 222.

Diagnosis.—The flattened, elongate hindocellus is an apomorphy that places *Holotachysphex* in Larrini (Bohart and Menke, 1976). The following nine autapomorphies differentiate the genus from the other members of the tribe: 1. no foretarsal rake in either male or female (outer margin of forebasitarsus without preapical spines); 2. hindtibial dorsum with one or two, inconspicuous, nearly appressed bristles instead of spines (Figs. 3, 4); 3. no pygidial plate in female (plate indicated only apically by two vestigial structures, a slightly inflected integument and a row of setigerous punctures); 4. clypeal lobe pointed (sharply or roundly), not angulate laterally but flanked by small tooth or oblique carina adjacent to free margin (Figs. 1, 17, 24, 26), although tooth and carina are evanescent in some specimens: 5. male hindtarsomeres II–IV almost parallel-sided except basally (Figs. 5, 6); 6. tergum II carinate laterally (the carina is barely visible in Fig. 11); 7. male sterna II and III or II-IV with large patches of velvety pubescence (Figs. 11, 12); 8. nests established in hollow twigs; and 9. pyrgomorphid Acridoidea used as prey (but see number 9 in next paragraph).

For comparison, the character states found in other Larrinae are: 1. foretarsal rake present at least in the female (except absent in *Paraliris*), forebasitarsus with at least three rake spines; 2. hindtibial dorsum with one to several suberect spines (Figs. 7, 8); 3. pygidial plate well defined except rudimentary in *Tachysphex erythropus* (Spinola), *mendozanus* Brèthes, and *nepharius* Pulawski; 4. clypeus either not pointed or, when pointed, with no lateral tubercle or carina; 5. male hindtarsomeres II–IV broadening evenly toward apex (Figs. 9, 10), with a few exceptions such as the strongly expanded hindtarsomere II of *Liris haemorrhoidalis* Fabricius; 6. tergum II not carinate laterally in most genera, but carina present in most *Prosopigastra* (rudimentary or absent in *creon* (Nurse) and *nubigera* Gussakovskij), a weak, longitudinal carina also present in some large Australian *Tachysphex,* especially females (e.g. *hypoleius* F. Smith, *persistans* R. Turner, *pugnator* R. Turner, and *stimulator* R. Turner); 7. male sterna without specialized areas except sterna III and IV with fimbriate or setal patches in several *Gastrosericus*; 8. nesting takes place in the ground (unknown in *Paraliris*); and 9. prey other than Pyrgomorphidae: mostly various other orthopteroids, but also lepidopterous larvae (some *Tachytes,* some *Parapiagetia*), Heteroptera (*Prosopigastra*), teneral asilids (*Gastrosericus asilivorus* Pulawski), and cicadellids (*Gastrosericus chalcithorax* Arnold); this information may be insufficient: many Pyrogomorphidae greatly resemble Acrididae, a common prey of *Tachysphex* and *Tachytes,* and are perhaps used as well.

Description.—*Holotachysphex* was described in detail by Bohart and Menke (1976), but is redescribed here to include characters not used by them. Major structural characters, other than the apomorphies discussed in the Diagnosis, are the following.

Mandible: posterior margin emarginate in some species (Fig. 16), entire in others (Fig. 25); trimmal carina without cleft but with prominent tooth (Fig. 13); distal portion of adductor ridge not expanded, straight or weakly convex (roundly expanded in *Tachysphex*). Frons without swellings or carinae, but with oblong glabrous tubercle

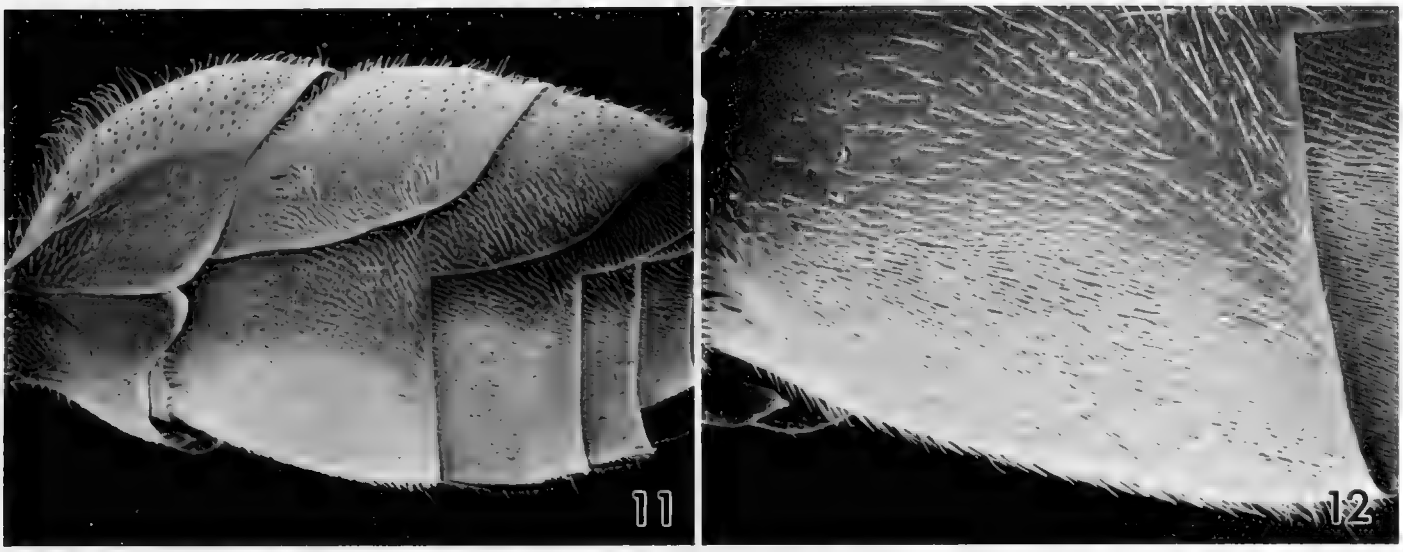


Figs. 3–6. *Holotachysphex holognathus*: 3—female hindtibia dorsally, 4—female hindtibia, outer side, 5—male hindtarsomere II–V, 6—male hindtarsomere III–IV.

Figs. 7–10. *Tachysphex pompiliformis* (Panzer): 7—female hindtibia dorsally, 8—female hindtibia, outer side, 9—male hindtarsomere II–V, 10—male hindtarsomere III–IV.

above each antennal socket (tubercles convergent above). Hindocellar scars diverging anterolaterad (Fig. 2), moderately elongate (scar shorter than distance that separates it from midocellus). Occipital carina joining hypostomal carina. Propodeum short, distance betwen metanotum and spiracle less than spiracle's length; dorsum setose throughout. No additional sclerites between metasternal apex and propodeum. Third submarginal cell present, not petiolate. Forecoxal apex not expanded into apical process. Foretarsomere I with three or four ventral spines in female and one in male (length of spines no more than tarsomere apical width). Hindtarsomere II 0.6–0.7× length of hindtarsomere I. Gastral punctures conspicuous. Tergum I without short, oblique carina extending from anterolateral corner, tergum II carinate laterally. Female: tarsal claws without tooth; tergum VI fairly convex, markedly more so than in *Prosopigastra*; sting including sheaths circular in cross section. Male: tergum VII not depressed apically.

Additional characters that vary in related



Figs. 11–12. *Holotachysphex holognathus*: 11—male gaster obliquely, 12—male sternum II obliquely.

genera but which are universal in *Holotachysphex* include the following. Labrum flat, narrow (markedly more so than in *Tachysphex*), emarginate apically; stipes flat. Mouthparts not elongate. Paramandibular process broadly separated from back side of clypeus (mandibular socket open). Clypeus produced into a mesal lobe. Inner orbits convergent above. Vertex broad, width at least 1.5× length (not clearly species-specific). Mesothoracic punctures coarse, mesopleural punctures less than one diameter apart (most specimens) or several punctures about one diameter apart (some *turneri*). Episternal sulcus incomplete (ending near anteroventral mesothoracic margin). Propodeal dorsum and hindface rugose, side coarsely, irregularly ridged (ridges evanescent anteriorly). Marginal cell long (foremargin 3.4–3.9× maximum width). Hindcoxa: inner dorsal carina not expanded basally. Foretibia without spines on outer side. Hindtibia not ridged. Female: forefemoral venter with minute punctures; outer side of foretibia without spines; apicoventral margin of tarsomere IV shallowly concave; and apicoventral margin of tarsomere V straight. Male: forecoxa and foretrochanter unmodified; forefemur emarginate basally; tergum VII with evanescent lateral carina; sternum VIII emarginate apically. Setae erect or nearly so adjacent to hypostomal carine.

Relationships to other Larrini.—In their dendrogram of larrin genera, Bohart and Menke (1976) indicated that *Holotachysphex* was a sister group of *Tachysphex* + *Parapiagetia* and that *Prosopigastra* and *Kohliella* were closely related. The dendrogram was presumably based on 50 larrin characters listed on page 224. However, branches were not supported by character distribution, and plesiomorphic character states may have been used as well. Pulawski (1979) recognized additional apomorphies and analyzed phylogenetic relationships of *Holotachysphex* and the latter three genera. My current analysis indicates that *Holotachysphex* belongs to a holophyletic lineage that also includes *Kohliella, Parapiagetia,* and *Tachysphex* (but not *Prosopigastra*) and which is characterized by a unique synapomorphy: an oblong, glabrous swelling above each antennal socket. In addition, all four genera lack a basal oblique carina on tergum

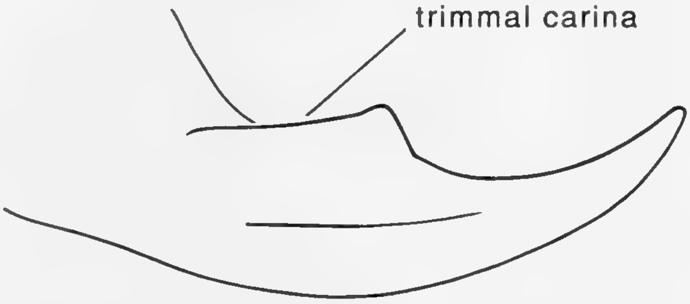


Fig. 13. *Holotachysphex turneri*: mandible, anterior face.

I, an apomorphy also shared with *Gastrosericus.* The carina is also absent in many *Tachytes* and one *Larropsis* (*chilopsidis* Cockerell and W. Fox), apparently a parallelism, but present in the remaining Larrinae and also in most other Sphecidae (species with petiolate gaster such as Sphecinae and most Pemphredoninae are obvious exceptions). Within the lineage, *Holotachysphex* is most closely related to *Tachysphex,* sharing two apomorphies with the latter (Pulawski 1979): sting, including sheaths, circular in cross section and male forefemur emarginate (the entire forefemur of several specialized *Tachysphex* is clearly a reversal). *Holotachysphex* has nine autapomorphies (see Diagnosis), but *Tachysphex* appears to be paraphyletic; at least no autapomorphies have been found so far. Most probably, *Holotachysphex* was derived from a *Tachysphex*-like ancestor by switching from ground-nesting to twig-nesting, with subsequent loss of structures no longer used in digging: the foretarsal rake, hindtibial spines, and pygidial plate. Four other apomorphies have no known function (a sharply-pointed clypeus, parallel-sided male hindtarsomeres, lateral carina of tergum II, and velvety patches on male sterna).

Character analysis.—Eight characters were analyzed, of which the first seven have been polarized and one remains unpolarized. The polarized characters are (0: plesiomorphic, 1: apomorphic):

1. Posterior mandibular margin: 0. stepped (notched), 1. straight (entire).

An entire mandible is clearly plesiomorphic within the Sphecidae as a whole, and the notched mandible of most Larrinae is clearly derived (Menke 1988). In taxa with a primarily entire mandible (e.g. Pompilidae, *Sphex, Chlorion*), the adductor ridge is a single, continuous structure, gradually increasing in size toward the apex but not differentiated. This is the plesiomorphic condition. In Larrinae with emarginate mandibles, the ridge is differentiated into proximal and distal portions, separated from each other by an angle, a gap, or a slight overlap. This is the apomorphic condition. In *Holotachysphex,* the two portions are clearly differentiated, with a small overlap between them (the overlap area is shiny and difficult to see), indicating that the entire mandible of some species is a reversal rather than the primitive state. In *Holotachysphex,* the mandible is notched in *sacalava* and *turneri,* and entire in *holognathus* and *mochii.*

2. Apical emargination of male sternum VIII: 0. broad shallow, 1. narrow, deep.

Male sternum VIII is broadly, shallowly emarginate in *Tachysphex* and most *Holotachysphex* (e.g. Figs. 18, 27), but narrowly, deeply emarginate in *Holotachysphex holognathus* (Fig. 31).

3. Volsellar setae: 0. of equal length, 1. short or absent mesally.

The former condition is found in *Tachysphex* and *Holotachysphex sacalava* and *turneri,* the latter in *Holotachysphex holognathus* and *mochii.*

4. Forefemoral notch of male: 0. bottom flat, with low carina, 1. bottom compressed into a conspicuous, longitudinal carina.

The notch bottom is flat in the vast majority of *Tachysphex,* but it is compressed into a crest in a few species such as *apricus* Pulawski and *erythropus* Spinola, specialized members of their respective lineages. It is also flat in *Holotachysphex holognathus,* but compressed in the other three species.

5. Hindtibial dorsum: 0. setose throughout, 1. glabrous.

The hindtibial dorsum is setose throughout in *Tachysphex* and *Holotachysphex* except narrowly glabrous in *Holotachysphex turneri.*

6. Tergal punctures: 0. fine or medium size, 1. coarse.

Tergal punctures of *Holotachysphex holognathus* are coarser than in other species of the genus and in *Tachysphex.*

7. Tergal setae: 0. all setae short, 1. basal setae of tergum I long.

Tergal setae are short in *Tachysphex* except basal setae of tergum I are long in *al-*

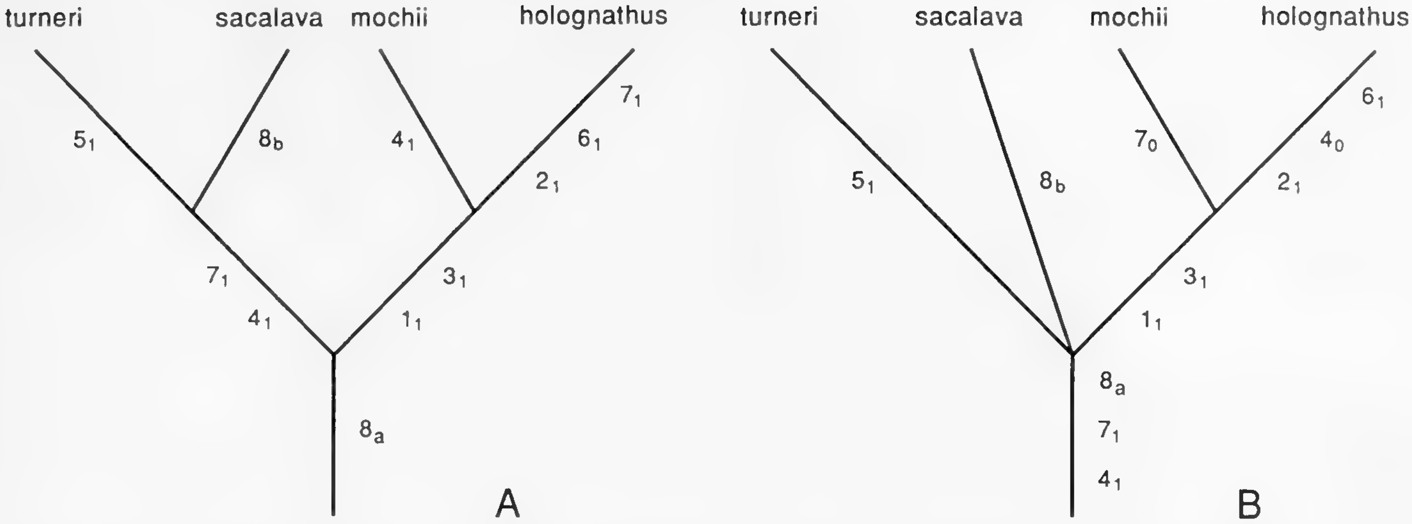


Fig. 14. Phylogenetic relationships among species of *Holotachysphex*. Numbers represent apomorphic character states discussed on page 228. Numerical subscripts indicate the originally polarized characters, and the alphabetical subscript the originally unpolarized character. 1—posterior mandibular margin entire, 2—male sternum VIII deeply emarginate, 3—volsellar setae shortened or absent mesally, 4—forefemoral notch with compressed bottom, 5—hindtibial dorsum glabrous, 6—tergal punctures coarse, 7—setae of tergum I elongate basally, 8—clypeal lobe pointed or rounded (A), clypeal lobe truncate (B).

bocinctus (Lucas), *laticauda* Gussakovskij, *maculipennis* Pulawski, *nubilipennis* de Beaumont, *pilosulus* R. Turner, and *priesneri* de Beaumont. These species (except *priesneri*) are the most specialized within the genus (Pulawski 1971), thus their long tergal setae are apparently apomorphic. The setae are short in *Holotachysphex mochii* and long in the other three.

I was unable to polarize the following character:

8. Clypeal lobe: a. sharply pointed or rounded apically, b. truncate apically.

The lobe is truncate in *Holotachysphex sacalava* and pointed or rounded in the other three species. A variety of shapes is found in *Tachysphex* and other Larrini in general.

Phylogenetic analysis.—Of the eight binary characters considered, four were synapomorphies (1, 3, 4, 7), three were autapomorphies (2, 5, and 6), and one was unpolarized (8). Two equally parsimonious cladograms of 10 steps each (Fig. 14A, B) were generated using Hennig86 version 1.5, a parsimony computer package by James F. Farris. One is fully resolved and symmetrical, the other is unresolved, and the consistency index (for characters other than autapomorphies) is 0.71. Both trees suggest that the two species of the Northern Hemisphere, *holognathus* and *mochii,* are sister species (thus closer to each other than either to *sacalava* or *turneri*) and that the apically truncate clypeal lobe of *sacalava* is derived. The resolved tree (Fig. 14A) suggests that:

1. *Holotachysphex sacalava* and *turneri* also are sister species.

2. The compressed femoral notch was convergently acquired twice: by the common ancestor of *sacalava* + *turneri* and by *mochii*.

The unresolved cladogram (Fig. 14B), which requires no convergence, suggests that:

1. *Holotachysphex sacalava* and *turneri* originated independently from the common ancestor of the genus.

2. The originally noncompressed femoral notch (4) evolved into a carinate notch in *Holotachysphex* and then reverted to noncompressed in *holognathus*; similarly, the originally short tergal setae first evolved into long and then reverted into short in *mochii*.

I see no reason to prefer one interpretation over the other.

Life history.—Studied only in *Holotachysphex turneri* (see this species for details and references). Nests are made in hollow stems, and nymphs of pyrgomorphid grasshoppers (Acridoidea) are used as prey. The lack of a foretarsal rake and a pygidial plate in the female suggests that other species also nidify in stems rather than in the ground.

Geographic distribution (Fig. 15).—Africa, Greece (only Peloponnesus), Turkey and adjacent Mediterranean islands (Crete, Cyprus, Rhodes), Israel, Arabian Peninsula, Iran, Tajikistan, India, and Sri Lanka. Ranges of individual species overlap in Ghana and Kenya (*holognathus* and *turneri*) and in the eastern Mediterranean region (*holognathus* and *mochii*).

KEY TO THE SPECIES

1. Mandibular posterior margin notched (Fig. 16). 2
– Mandibular posterior margin entire (Fig. 25). 3
2. Clypeal lobe sharply pointed (Fig. 17); tibiae red to brown; hindtibial dorsum narrowly glabrous (Fig. 20); Subsaharan Africa. .... *turneri* (Arnold)
– Clypeal lobe truncate apically (Fig. 24); tibiae partly or all black; hindtibia setose throughout; Madagascar. .... *sacalava* (Arnold)
3. Clypeus with narrow, fingerlike process (Fig. 36); Tadjikistan .... *prosopigastroides* (Gussakovskij) [perhaps a synonym of *mochii*]
– Clypeus different (Figs. 26, 30). 4
4. Setae straight on vertex, appressed on tergum I, setal length about one midocellar diameter; free margin of clypeal lobe convex basally and concave distally; male sternum VIII shallowly, broadly emarginate (Fig. 27); Libya to Iran. . ... *mochii* (de Beaumont)
– Setae sinuous on vertex, erect on tergum I, setal length markedly more than one midocellar diameter; free margin of clypeal lobe evenly concave (Fig. 30); male tergum VIII deeply emarginate apically (Fig. 31); Africa north of Equator to Sri Lanka .... *holognathus* (Morice)

DESCRIPTIONS OF SPECIES

***Holotachysphex turneri* Arnold**
(Figs. 16–23)

Tachysphex Turneri Arnold, 1923:165, ♀, ♂ (as Brauns's manuscript name), incorrect original capitalization. Holotype: sex not indicated, South Africa: Cape Province: Willowmore (SAM).—In *Phytosphex*: Arnold, 1951:153 (new combination, type species of *Phytosphex*), 154 (Ethiopia).—In *Holotachysphex*: Bohart and Menke, 1976:282 (new combination, listed); Gess, 1978:209 (nest, prey); Gess and Gess, 1980:52 (nest); Gess, 1981:30 (South Africa), 34, 66, 68, and 69 (nesting).

Tachysphex Turneri var. *transvaalensis* Arnold, 1924:66, ♀. Holotype: ♀, South Africa: Transvaal: Lichtenburg (TMP). New synonym.—As *Holotachysphex turneri transvaalensis*: Bohart and Menke, 1976: 282 (new combination, listed).

Diagnosis.—*Holotachysphex turneri* differs from other species by the combination of a notched mandible and a sharply pointed clypeal lobe (Fig. 17), and the narrowly glabrous hindtibial dorsum is also distinctive. The tibiae are all red (brown in some specimens), a subsidiary recognition feature.

Description.—Mandible (Fig. 16): posterior margin notched (condylar ridge acutely expanded apically, distal portion of adductor ridge convex). Clypeal lobe sharply pointed, its free margin evenly concave on each side of apex (Fig. 17). Punctures of terga I and II somewhat larger than those adjacent to hypostomal carina.

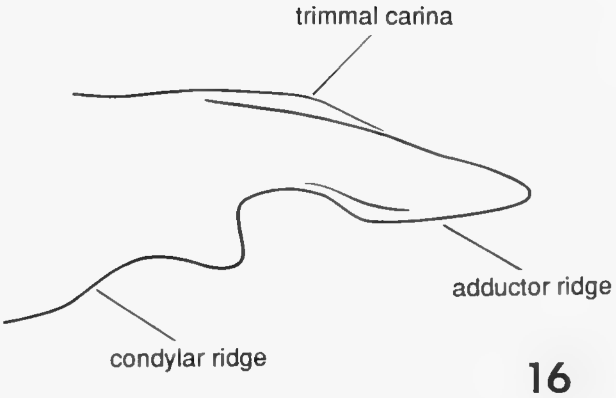
Setae partly sinuous on head and thorax, erect and markedly longer than midocellar diameter on vertex and tergum I. Hindtibial dorsum narrowly glabrous dorsally (Fig. 20).

Gaster varying from all red to all black (see Variation below for details). Femora black except red apically in most specimens. Tibiae and tarsi either red (most specimens) or brown (one male from Hilton).

Female.—Dorsal length of flagellomere I 1.8–1.9× apical width. Vertex width 1.9–2.3× length. Length 7.0–9.5 mm.

Male.—Dorsal length of flagellomere I 1.9× apical width. Vertex width 2.3–2.5× width. Bottom of forefemoral notch asetose, compressed into well-defined, longitudinal crest (Figs. 21, 22). Sternum VIII shallowly,

Fig. 15. Overall geographic distribution of the genus *Holotachysphex* (shadowed area).



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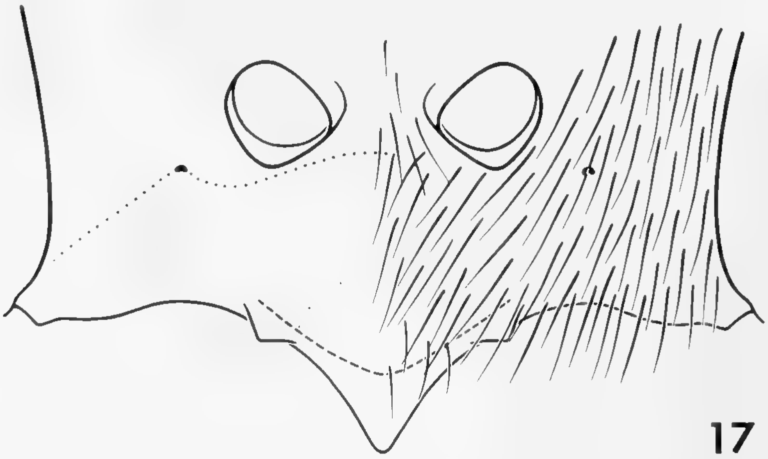

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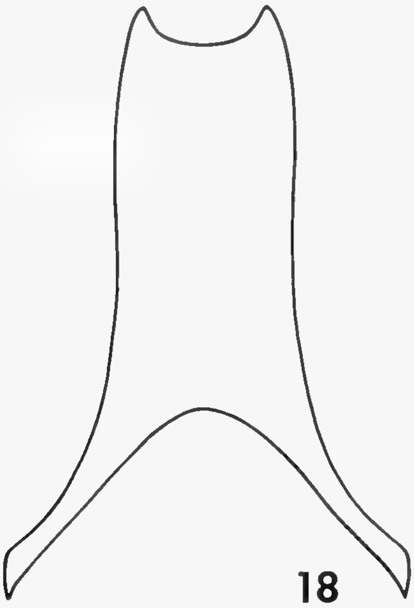

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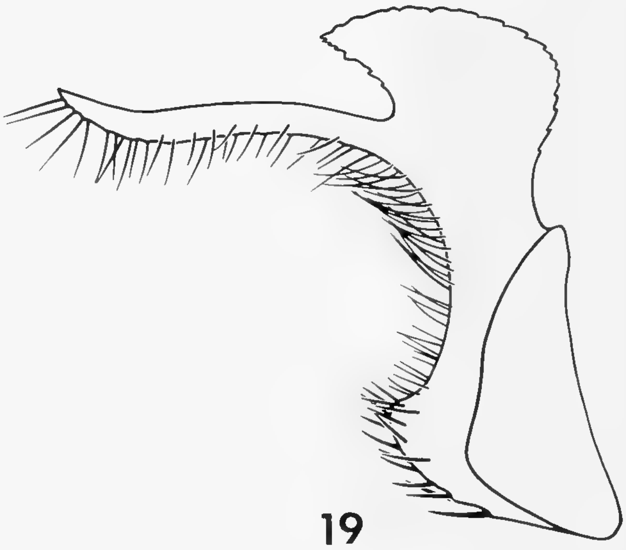

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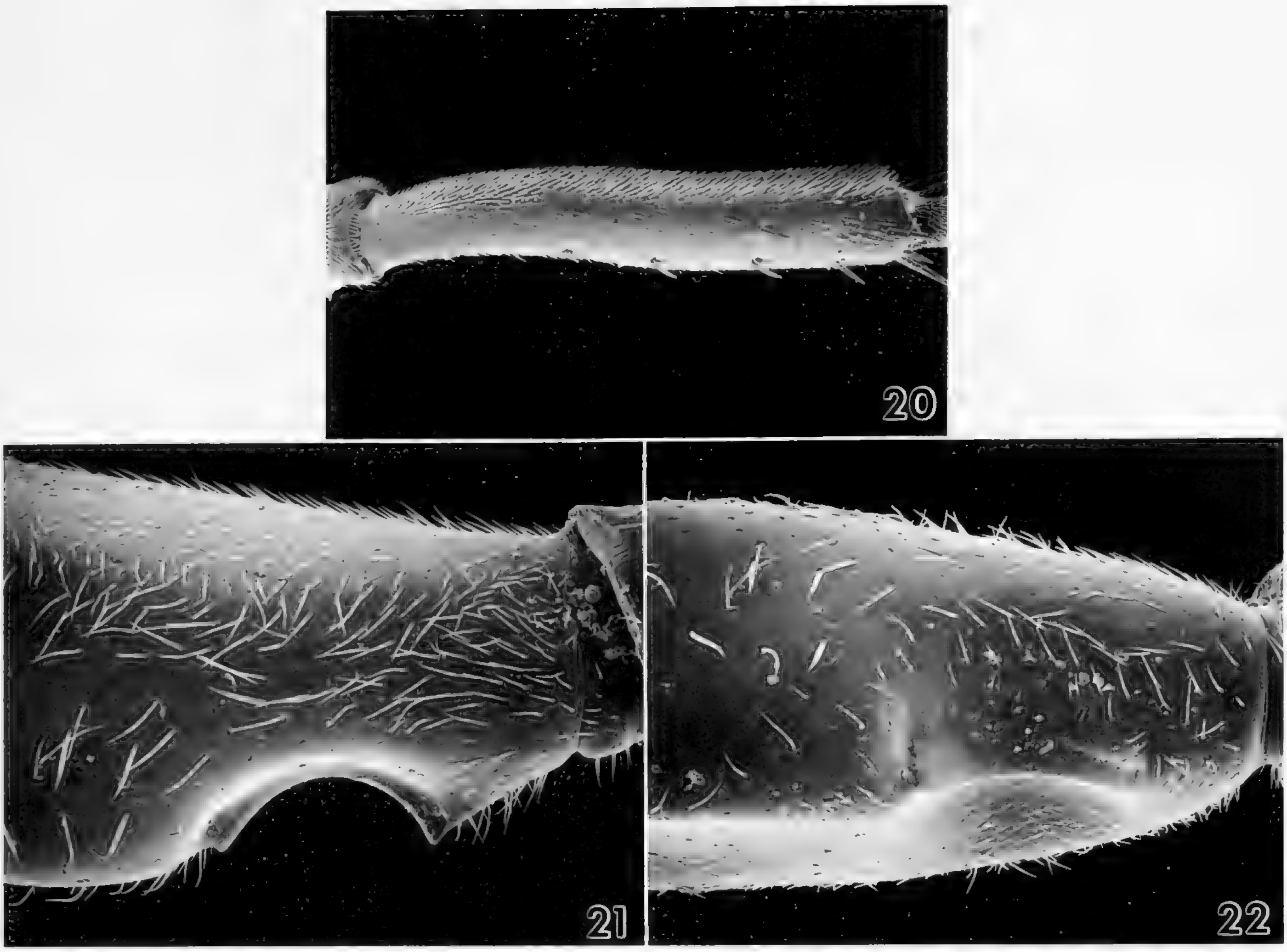
Figs. 16–19. *Holotachysphex turneri*: 16—female mandible, outer side, 17—female clypeus, 18—male sternum VIII, 19—volsella.

roundly emarginate apically (Fig. 18), slightly less so than in *holognathus*. Length 6.0–7.5 mm. Gonostyle ventrally with numerous setae that become shorter toward gonostyle apex. Volsella (Fig. 19): ventral margin setose from base to apex.

Color variation and recognition of subspecies.—Gastral color of *turneri* varies both geographically and individually. Generally, the further south from the equator the darker the specimens: the gaster is all red in Ghanaian and Kenyan specimens, but tergum I is black basally in those from Zambia, Zimbabwe, and Transvaal; and the black covers base of tergum I as well as tergum III and the following terga in most specimens from Cape Province and also in some from Zimbabwe (two such males from Bubi Valley have been examined). Individual variation occurs in specimens from Bubi Valley (Zimbabwe) as well as Willowmore and Hilton (Cape Province). In the first locality, the male gaster is either all red (except the basal spot) or partly black as described above. In males from Willowmore, tergum II is either all red or largely black (except red basomedially and laterally). In the females from Hilton, tergum III is either black or reddish; and in the males, the gaster is either all black or partly red (the red covering tergum I posteriorly, tergum II, and sternum II). One of these color forms, the one from Transvaal, was named var. *transvaalensis* by Arnold (1924) and then raised to the subspecies rank by Bohart and Menke (1976). In my opinion, color forms of *turneri* do not warrant formal names as they are mostly clinal and not clearly delimited. Consequently, I re-



Figs. 20–22. *Holotachysphex turneri*: 20—female hindtibia with asetose dorsum, 21—male forefemoral notch in profile, 22—same, bottom view.

gard *transvaalensis* as a junior synonym of this species

Life history.—Arnold (1923) first noticed the unusual nesting habits of *turneri,* which were subsequently studied in detail by Gess (1978). Nests are a linear series of cells founded in hollow stems, e.g. of *Aloe* and *Datura* (Arnold 1923), or abandoned galleries of *Xylocopa caffrariae* Enderlein in internodes of *Phragmites australis* (Cav.) Steud. (Gess and Gess 1980). The stems used can be lying on the ground or up to 2 m above. A terminal plug of clay or detritus is constructed at the bottom of the gallery, and individual cells are separated by similar plugs (intercellular plugs consist of detritus on the inner side and earth on the outer side). Small nymphs of a short-horned grasshopper, probably *Pyrgomorpha* or *Pyrgomorphella* (Pyrgomorphidae, Acridoidea), are used as prey. They are stored head in and not completely paralyzed. The number of prey per cell (4–32) is inversely proportional to their size (length 3.2–12.0 mm). The wasp's egg or later the larva is positioned across the prey's body, with the mouth end just behind the prothoracic coxa.

Geographic distribution (Fig. 23).—Ghana and Ethiopia to southern South Africa.

Records.—ETHIOPIA: Addis Ababa (Arnold 1951).

GHANA: Kawampe, 8°30′N, 1°35′W, 45 km N Kintampo (4 ♂, CAS).

KENYA: Archer's Post on Ewaso Ngiro River (1 ♀, 1 ♂, CAS).

SOUTH AFRICA: Cape Province: Hilton 18 km WNW Grahamstown (1 ♀, CAS; 8 ♀, 4 ♂, AMG), Willowmore (1 ♀, 1 ♂, BMNH; 1 ♀, 2 ♂, SAM). Transvaal: Lichtenburg (Arnold 1924).

Fig. 23. Geographic distribution of *Holotachysphex sacalava* and *turneri.*

ZAMBIA: Mid Luangwa Valley (2 ♀, BMNH).

ZIMBABWE: Bubi Valley (3 ♂, SAM), Bulawayo (1 ♀), Hillside (1 ♀, BMNH), Nyamandhlovu (1 ♀, BMNH), Redbank (1 ♀, SAM), Rhodesdale Ranch (Arnold 1924).

Holotachysphex sacalava **Arnold**
(Figs. 23, 24)

Tachysphex Turneri sacalava Arnold, 1945: 106, ♀, ♂. Lectotype: ♀, Madagascar: Bekily (MNHN), present designation.—As *Holotachysphex sacalava*: Menke *in* Bohart and Menke, 1976:282 (new status, new combination, listed).

Diagnosis.—*Holotachysphex sacalava,* known only from Madagascar, has a unique clypeus: the lobe is truncate apically, and the free margin is evenly concave on each side of the truncation (Fig. 24). The all red gaster is also diagnostic in combination with partly black tibiae.

Description.—Mandible: posterior margin notched (condylar ridge acutely expand-

Fig. 24. *Holotachysphex sacalava*: female clypeus.

ed apically, distal portion of adductor ridge convex). Clypeal lobe pointed, truncate apically, free margin evenly concave on each side of apex (Fig. 24). Punctures of terga I and II about as large as those adjacent to hypostomal carina.

Setae of vertex and tergum I erect, sinuous, markedly longer than midocellar diameter. Hindtibia setose throughout.

Gaster red. Femora black; tibiae and tarsi partly brown or reddish, remainder black.

Female.—Dorsal length of flagellomere I 1.9–2.2× apical width. Vertex width 1.7–1.9× length. Length 8.0–11.0 mm.

Male.—Dorsal length of flagellomere I 1.9× apical width. Vertex width 1.8× length. Bottom of forefemoral notch asetose, compressed longitudinally into sharp crest, as in *turneri* (see Figs. 21, 22). Sternum VIII roundly emarginate apically, as in *turneri* (see Fig. 18). Length 7.3–9.0 mm. Gonostyle ventrally with numerous setae that become shorter toward gonostyle apex. Volsella as in *turneri* (see Fig. 19).

Geographic distribution (Fig. 23).—Madagascar.

Records.—MADAGASCAR: Bekily (1 ♀, 1 ♂, BMNH; 1 ♀, CAS; 10 ♀, 2 ♂, including lectotype and paralectotype of *sacalava*, MNHN; 1 ♀, USNM), Bereboka 60 km NE Morondava (1 ♀, 1 ♂, BMNH; 1 ♀, CAS).

***Holotachysphex mochii* de Beaumont**

(Figs. 25–29)

Tachysphex mochii de Beaumont, 1947b: 676, ♀. Holotype: ♀, Greece: Rhodes Island: no specific locality (A. Mochi collection, Rome), examined by Pulawski, 1972:818.—In *Holotachysphex*: Pulawski, 1972:818 (new combination, taxonomy); de Beaumont, Bytinski-Salz and Pulawski 1973:13 (recorded from Israel); Bohart and Menke, 1976:282 (listed).

Tachysphex pentapolitanus de Beaumont, 1960:241, ♀. Holotype: ♀, Libya: Cyrenaica: Barce, now Al Marj (BMNH), examined. New synonymy.—In *Holotachysphex*: Bohart and Menke, 1976:282 (new combination, listed).

Tachysphex schwarzi Pulawski, 1967:408, ♀, ♂. Holotype: ♂, Turkey: Mersin Province: Mut (M. Schwarz collection, Linz), reexamined in 1989. Synonymized with *Holotachysphex mochii* by Pulawski, 1972:818.

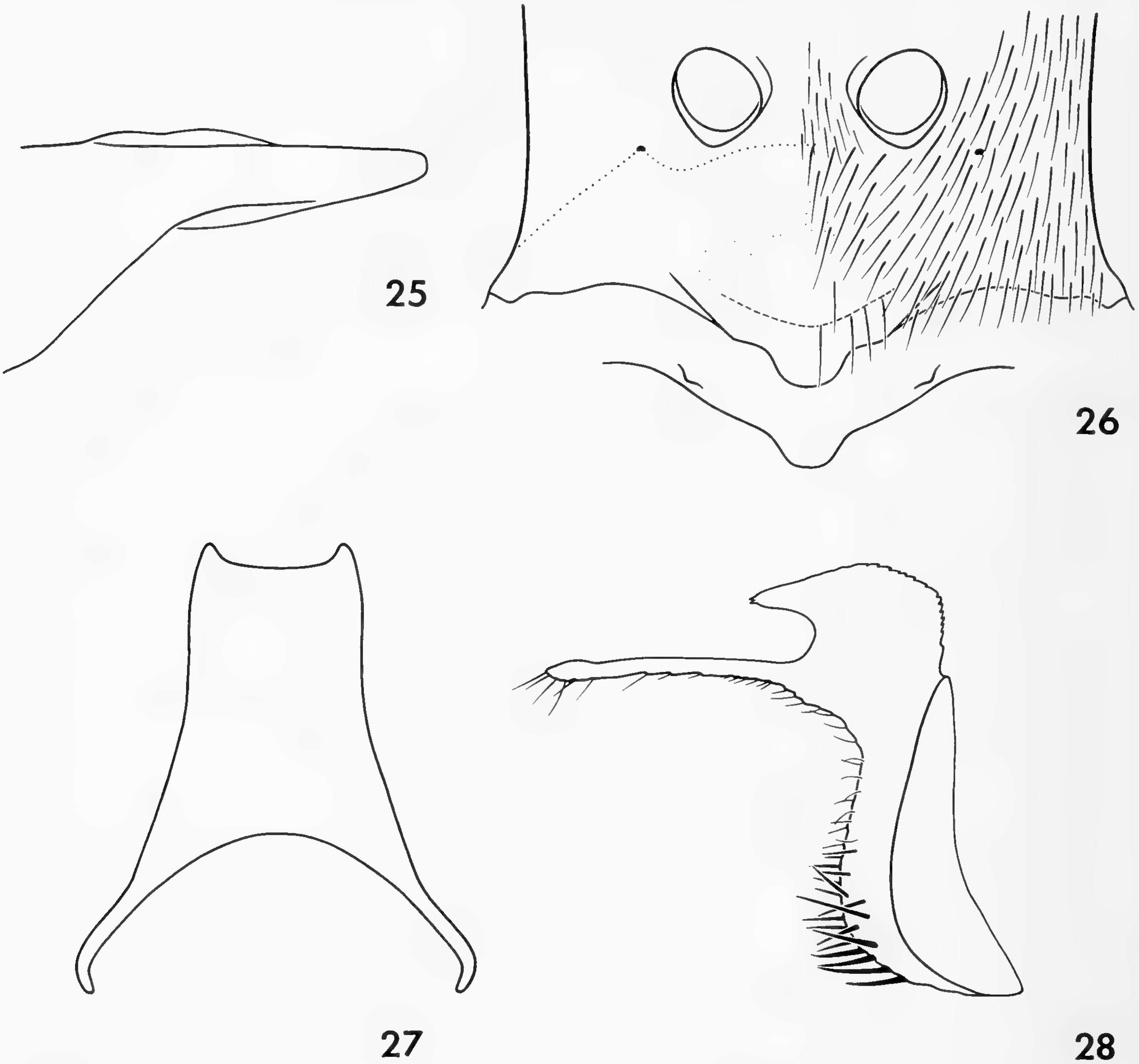
Diagnosis.—*Holotachysphex mochii* is unique in having the following: the setae are straight, short on vertex (about one midocellar diameter long) and appressed on tergum I; and male sternum VIII is broadly, shallowly emarginate (Fig. 27). In all other *Holotachysphex*, the setae, on both vertex and tergum I, are sinuous, erect, and markedly longer than one midocellar diameter; and male sternum VIII is roundly emarginate (compare Figs. 18, 31).

Description.—Mandible (Fig. 25): posterior margin gently curved (condylar ridge not expanded apically, distal portion of adductor ridge straight). Clypeal lobe rounded apically, free margin convex basally and concave apically on each side of apex (Fig. 26). Tergal punctures finer than in other species, about as large as those adjacent to hypostomal carina.

Setae straight, appressed or nearly so; setal length about 1.3–1.5 midocellar diameter on vertex, about 1.0 midocellar diameter on tergum I. Hindtibia setose throughout.

Female.—Dorsal length of flagellomere I 1.7× apical width. Vertex width 1.5–1.6× length. Length 9.0–10.0 mm.

Gaster nearly all black (sternum II red) to largely red (terga III and V mesally and



Figs. 25–28. *Holotachysphex mochii*: 25—female mandible, outer side, 26—female clypeus, 27—male sternum VIII, 28—volsella.

tergum IV except laterally black). Legs black (Libyan specimen) or femora, tibiae, and tarsi red (femora black basally in some specimens).

Male.—Dorsal length of flagellomere I 1.5–1.6 × apical width. Vertex width 1.6–1.8 × length. Bottom of forefemoral notch asetose, compressed into sharp, longitudinal crest, as in *turneri* (see Figs. 21, 22). Sternum VIII: apical margin shallowly, broadly concave (Fig. 27). Length 6.0–8.8 mm. Gonostyle ventrally with only a few, short, inconspicuous setae. Volsella (Fig. 28): setae of ventral margin shortened mesally.

Gaster black or tergum I brown reddish mesally. Femora black (except apically), tibiae black (Iranian male) or reddish dorsally and dark brown ventrally.

Geographic distribution (Fig. 29).—Turkey and adjacent Mediterranean islands (Rhodes, Cyprus), Israel, Iran, also Libya (Cyrenaica).

Records.—CYPRUS (Pulawski 1972): Polemidia Hills, Yermasoyia River.

GREECE: Rhodes Island: Ixia (Pulawski 1972).

ISRAEL: Tiberias (1 ♂, CAS).

IRAN: Khorasan: Fathabad 38 km NW Mashad (1 ♂, CAS).

LIBYA: Cyrenaica: Barce, now Al Marj (1 ♀, BMNH).

TURKEY: Mersin: Mut (3 ♂, CAS; 1 ♀, 2 ♂, MS). Urfa: Birecik (1 ♀, CAS).

Holotachysphex holognathus **Morice**

(Figs. 29–35)

Tachysphex (?) *integer* Morice, 1897:308, ♀, ♂. Lectotype: ♂, Egypt: Zeitun in Cairo area (OXFORD), present designation. Nec *Tachysphex integer* Kohl, 1892 = *Parapiagetia genicularis* (F. Morawitz, 1890).

Tachysphex holognathus Morice, 1897:434, new name for *Tachysphex integer* Morice.—de Beaumont, 1940:179 (revision, recorded from Egypt), 1947a:212 (revision, recorded from Egypt), 1961:50 (recorded from Crete Island), 1965:53 (recorded from Crete Island).—In *Holotachysphex*: Pulawski, 1972:818 (new combination, taxonomy); de Beaumont, Bytinski-Salz and Pulawski, 1973:13 (recorded from Israel); Bohart and Menke, 1976 (listed); Krombein, 1980:123 (Sri Lanka).

Tachysphex pollux Nurse, 1903:516, ♂, examined by Pulawski, 1975:312. Holotype: ♂, India: Gujarat: Deesa (BMNH). Synonymized with *Holotachysphex holognathus* by Pulawski, 1975:313.

Tachysphex sp.: de Beaumont, 1961:50 (Crete Island).

Diagnosis.—*Holotachysphex holognathus* can be recognized by combination: posterior mandibular margin entire and setae of tergum I erect. Also, punctation of terga I and II is coarser than in other *Holotachysphex* (punctures larger than those adjacent to hypostomal carina). In the male, the forefemoral notch is flat, not compressed into a longitudinal crest (compressed in the other species).

Description.—Mandible: posterior margin straight (condylar ridge not expanded apically, distal portion of adductor ridge straight). Clypeal lobe roundly pointed, with free margin evenly concave on each side of apex (Fig. 30). Tergal punctures coarser than in other *Holotachysphex,* punctures of terga I and II conspicuously larger than those adjacent to hypostomal carina.

Setae partly sinuous on head and thorax; on vertex and tergum I erect, markedly longer than midocellar diameter. Hindtibia setose throughout.

Gaster black. Tibiae and tarsi black (most specimens), brown (female from Kerdasa, males from Crete), or red (male from Kenya).

Female.—Dorsal length of flagellomere I 1.8–2.0× apical width. Vertex width 1.5–1.8× length. Legs black. Length 8.5–11.5 mm.

Male.—Dorsal length of flagellomere I 1.7–1.8× apical width. Vertex width 1.7–1.8× length. Sternum VIII roundly emarginate apically (Fig. 31), emargination somewhat deeper than in *turneri.* Bottom of forefemoral notch setose, broad, with low, longitudinal ridge but not compressed into crest (Figs. 33–35). Length 7.5–8.5 mm. Gonostyle ventrally with only a few, short, inconspicuous setae. Volsella (Fig. 32): ventral margin setose only basally.

Geographic distribution (Fig. 29).—Senegal to Kenya to Egypt, Greece (Crete Island and Peloponnesus), Israel and Arabian Peninsula to India and Sri Lanka.

Records.—EGYPT: Cairo area: Cairo (1 ♀, 1 ♂, BMNH; 1 ♀, OXFORD), Ghiza (1 ♀, CAS), Kerdasa (1 ♀, USNM), Koubba (1 ♀, OXFORD), Zeitun (1 ♂, OXFORD, lectotype of *integer* Morice).

GHANA: Kawampe 45 km N Kintampo, 8°30′N, 1°35′W (1 ♀, 2 ♂, CAS), Legon 12 km NNE Accra (4 ♀, 1 ♂, CAS).

GREECE: Crete Island: Gortis and He-

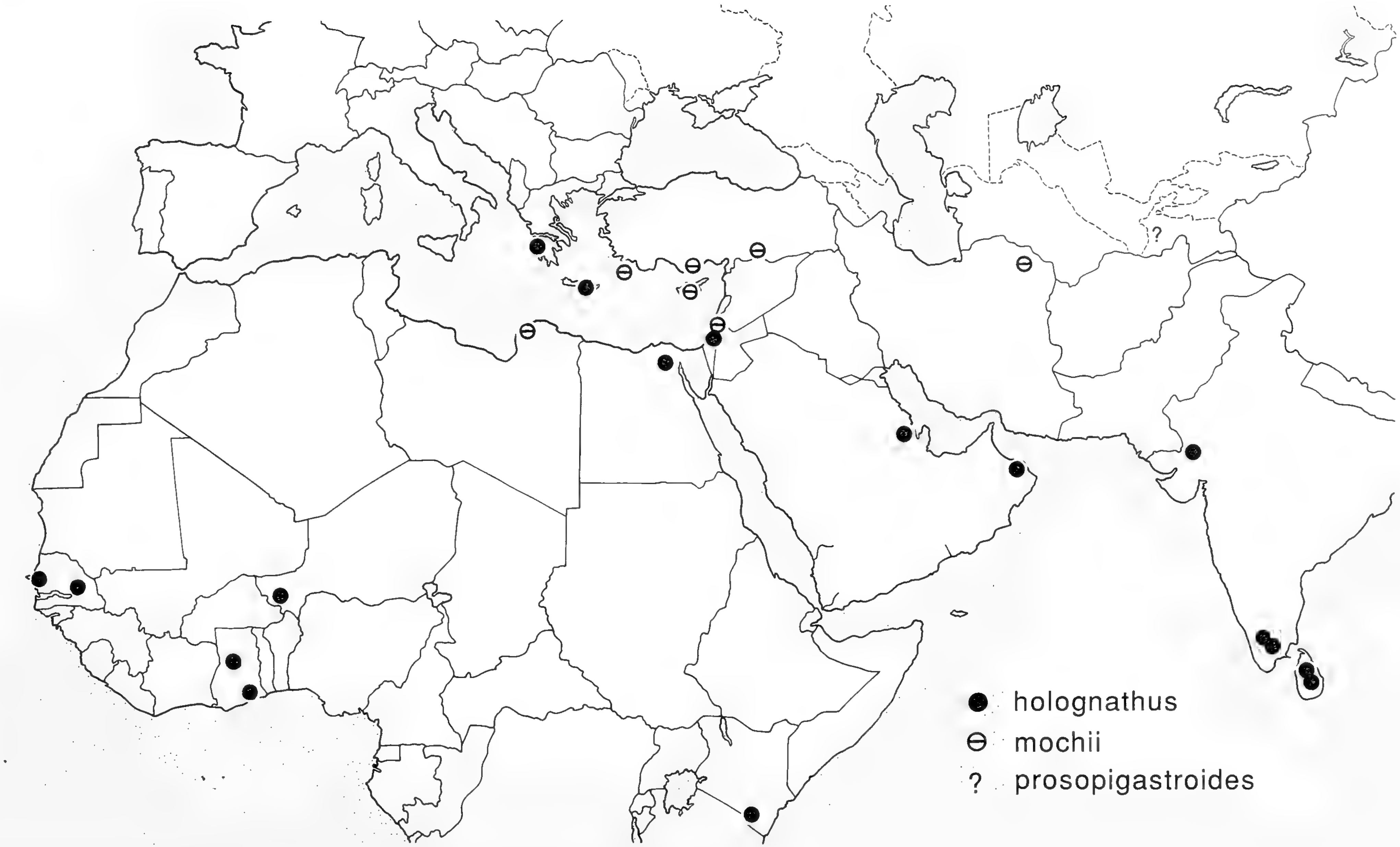
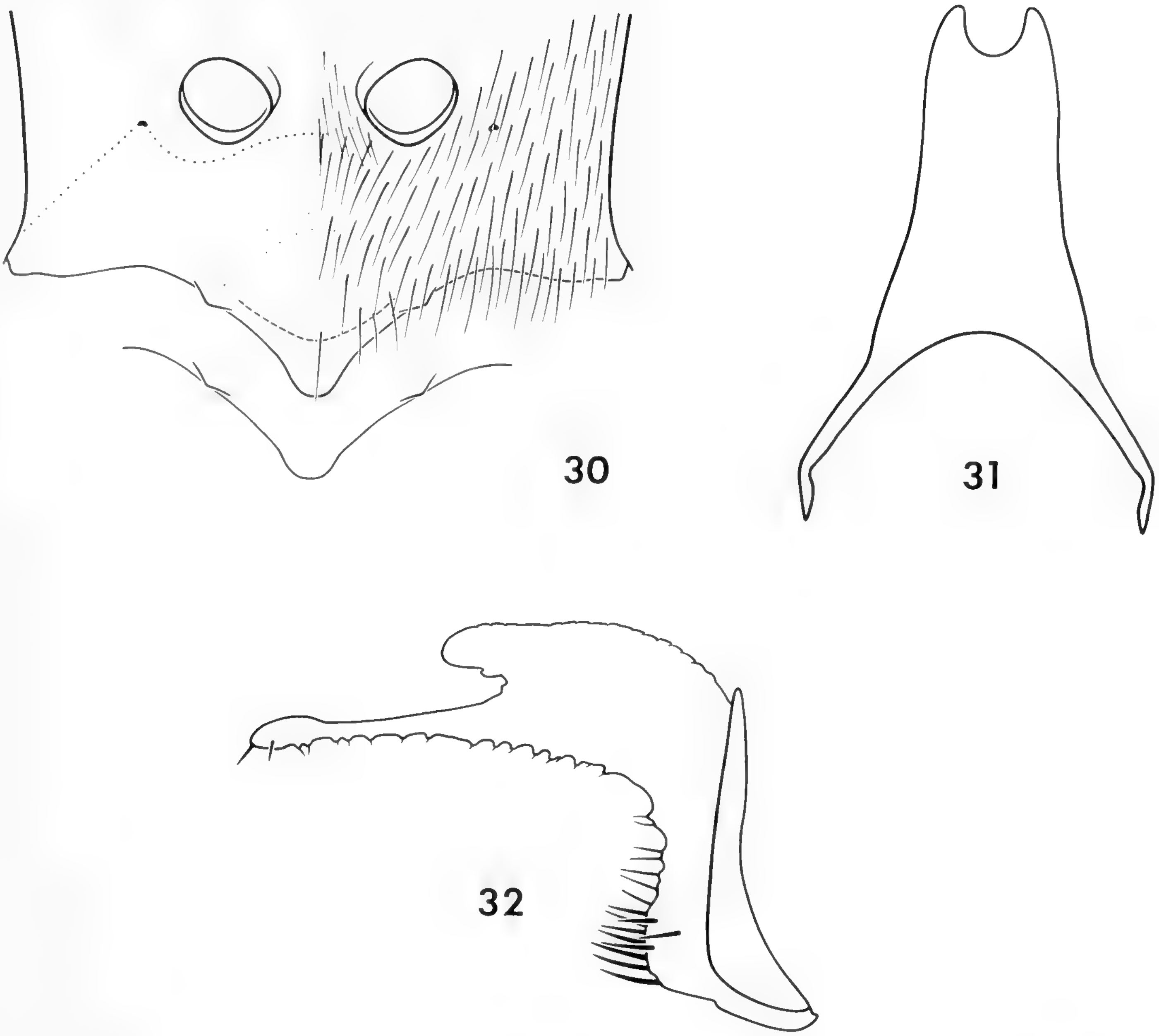


Fig. 29. Geographic distribution of *Holotachysphex mochii, holognathus,* and *prosopigastroides.*



Figs. 30–32. *Holotachysphex holognathus*: 30—female clypeus, 31—male sternum VIII, 32—volsella.

raklion (de Beaumont, 1961), Knossos (1 ♂, CAS), Yortys (1 ♂, CAS). Ilia (in Peloponnesus): mouth of Alfios River (1 ♂, BMNH).

INDIA: Gujarat: Deesa (1 ♂, BMNH, holotype of *Tachysphex pollux*). Tamil Nadu: Alagar Kovil in Madurai District (1 ♂, BMNH), Coimbatore (1 ♀, USNM).

ISRAEL: Jericho (de Beaumont, Bytinski-Salz and Pulawski 1973).

KENYA: Kitani Lodge in Tsavo National Park (1 ♂, CAS).

NIGER: Say (1 ♂, BMNH).

OMAN: Rostaq (1 ♀, 1 ♂, BMNH).

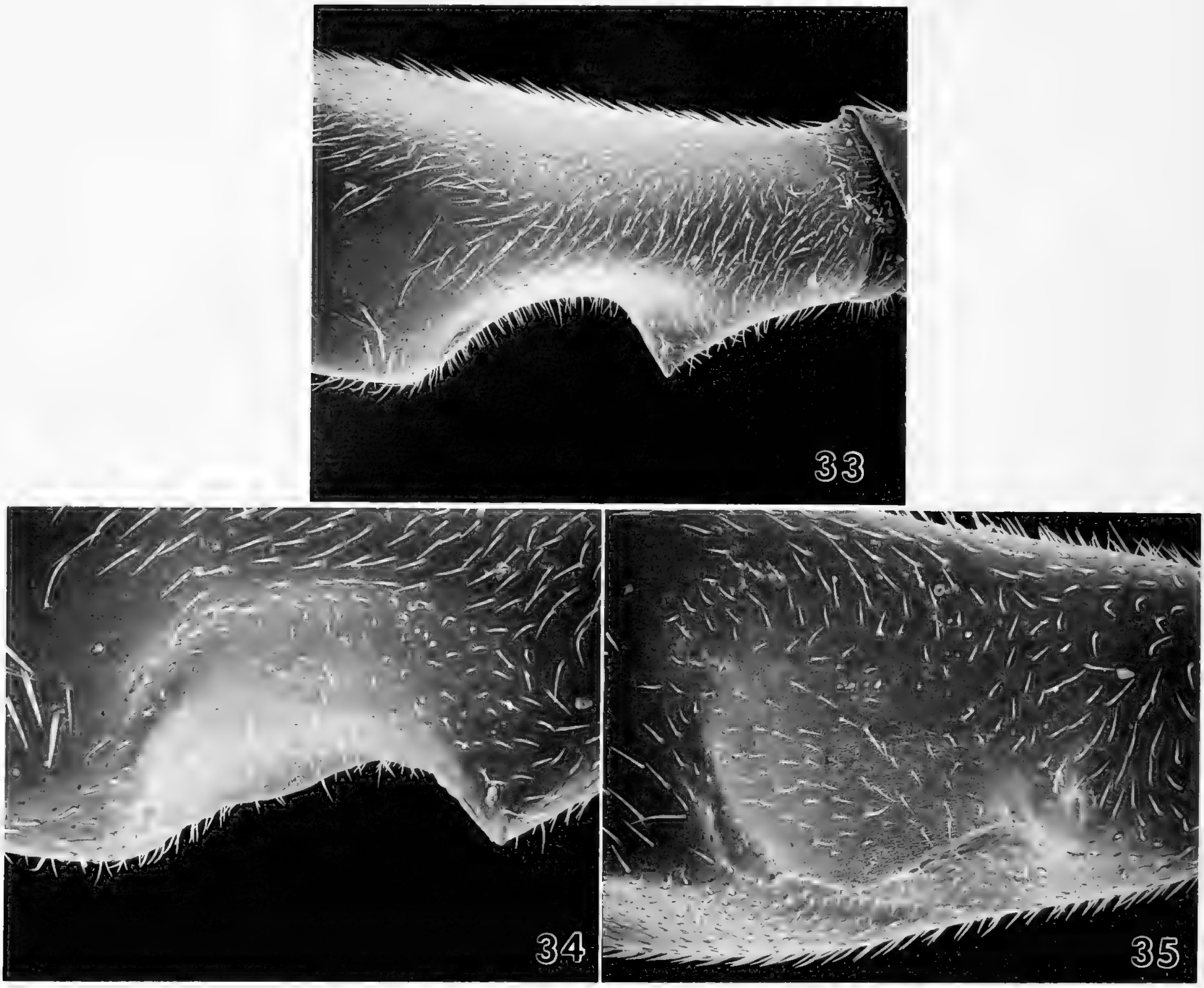
SAUDI ARABIA: Hofuf (1 ♀, 1 ♂, BMNH).

SENEGAL: Tambacounda (1 ♀, CAS), 5 km SW Thiès (2 ♀, 3 ♂, CAS).

SRI LANKA: Anuradhapura: Amarivayal (2 ♀, CAS, USNM), Hunuwilagama (1 ♀, USNM), Padaviya (2 ♀, USNM). Kandy: 5 mi NW Mahiyangana (1 ♀, USNM). Trincomalee: Tennamaravadi (1 ♀, CAS).

Holotachysphex prosopigastroides Gussakovskij
(Fig. 36)

Haplognatha prosopigastroides Gussakovskij, 1952:248, ♀. Holotype: ♀, Tajikistan:



Figs. 33–35. *Holotachysphex holognathus,* male: 33—forefemoral notch in profile, 34—same, oblique view, 35—same, bottom view.

foothills of Hissar Mts. near Stalinabad, now Dushanbe (ZIN, lost?).—In *Tachysphex*: de Beaumont, 1955:222 (*Haplognatha* synonymized with subgenus *Holotachysphex*).—In *Holotachysphex*: Bohart and Menke, 1976:282 (new combination, listed).

Diagnosis.—At the present time, *prosopigastroides* cannot be identified with certainty because the unique type was apparently lost (I searched for it in vain during many visits to the Zoological Institute, St. Petersburg, 1963–1980). Gussakovskij's illustration of the head, here redrawn as Fig. 36, shows a clypeus that is unique in the genus, but I suspect that the figure is inaccurate. Possibly Gussakovskij (or his illustrator) made a mistake analogous to my own inaccurate representation of the clypeus in the original description of *schwarzi* Pulawski (1967:409). If so, the dark area on each side of the clypeal process may in fact be a part of the clypeal lobe. Possibly *prosopigastroides* is a synonym of *mochii,* a hypothesis that can only be verified by collecting additional material in Tajikistan or adjacent areas of Afghanistan.

Description (selected from Gussakovskij 1952).—Posterior mandibular margin entire. Clypeal free margin with fingerlike projection (Fig. 36). Scutum coarsely, sparsely punctate. Punctures on terga I and II slightly finer than in *Prosopigastra orientalis* de Beaumont; on tergum I most interspaces smaller than punctures. Length 8.5 mm.

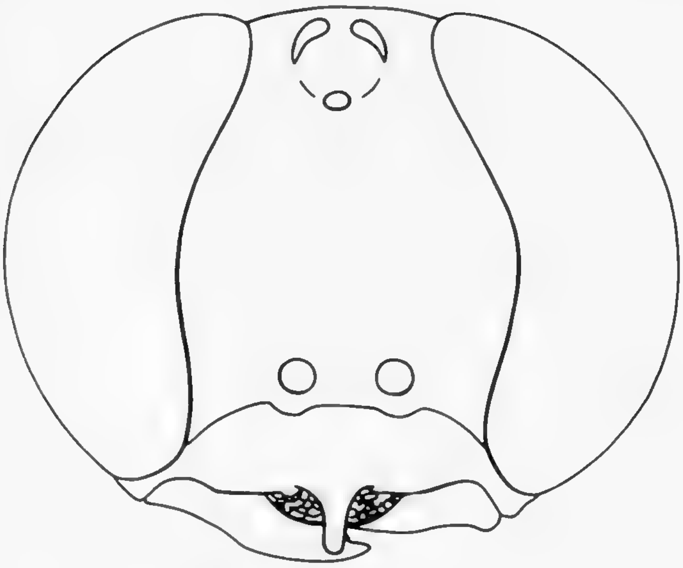


Fig. 36. *Holotachysphex prosopigastroides*: female head in frontal view (redrawn from Gussakovskij 1952).

Gaster black except sternum II largely red. Femoral apex, tibiae, and tarsi ferrugineus except foretibia somewhat darkened mesally.

Geographic distribution.—Known only from type locality in Tajikistan.

Record.—Tadjikistan: Dushanbe (Gussakovskij 1952).

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CARIBBEAN *HORAMA* (LEPIDOPTERA: ARCTIIDAE: CTENUCHINAE) WITH NEW SPECIES AND NOTES ON MIMICRY

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Abstract.—*Horama* **margarita**, new species, is described from Cuba and *Horama* **rawlinsi**, new species, is described from Haiti and the Dominican Republic. These two species have been confused with *Horama diffissa.* The male of *Horama diffissa* is described and illustrated for the first time. Mimicry with the paper wasp, *Polistes exclamans,* is noted. *Bourreria ovata* [Boraginaceae] and *Chrysobalanus icaco* [Rosaceae] are reported as sources of nectar for *Horama diffissa. Horama zapata,* previously kown only from Cuba, is reported from the Bahamas.

Key Words: Caribbean, mimicry, distribution, *Horama margarita, Horama rawlinsi*

On Great Exuma Island in the Bahamas, I observed many *Horama diffissa* Grote (1867) nectaring at the blossoms of Strongback, *Bourreria ovata* Miers (Boraginaceae), and Coco Plum, *Chrysobalanus icaco* Linneaus (Rosaceae). The moths could be easily collected in the daytime but would also come to an ultra-violet light after dark. Adult diurnal activity began in the late afternoon, about 1600 hours, EST, and lasted one to two hours with another peak in activity at dusk. Based on field observations from November through April, and on museum records, the peak flight appears to be in January. Several pairs were taken in copula and it was obvious only one brown *Horama* species was present. *Horama zapata* Dietz and Duckworth, a gray species, also occurred on the island, but in this case diurnal activity was not observed. This represents the first report of *H. zapata* outside of Cuba and the first report for *H. diffissa* in the Bahamas.

On Exuma, *H. diffissa* was a Batesian mimic of a paper wasp, *Polistes exclamans* Viereck [Vespidae]. Both wasp and moth were abundant around blossoms of Coco Plum. In flight, the mimicry was very striking as the two species were nearly indistinguishable. As with many mimetic and chemical-protected arctiids the body is very elastic allowing it to be pinched without being crushed. Another vespid, *Misschocyttarus cubensis* (Sauss.), and a second *Polistes* species were also present and represent Muellerian mimics of the dominant wasp, *P. exclamans,* forming a complex mimetic assemblage.

A genitalic dissection of a male *H. diffissa* disclosed structures very dissimilar to those previously associated with this species. Based on a study of a small series of adults, Dietz and Duckworth (1976) had concluded all represented a single, sexually dimorphic species. Based on additional specimens and field observations, I determined that three species were involved. Dietz and Duckworth had only representatives of females of *H. diffissa* and only males of two other species from Cuba and Haiti. The type of *H. diffissa* was examined to ascertain its status with regards to the other species involved. The "male" type of *H. diffissa,* in the Academy of Natural Sciences, Philadelphia, has the abdomen missing and is actually a female! I was able to associate the abdomenless female type with additional females of *H. diffissa* from Cuba and, ultimately, with a large series of females from the Bahamas. This made it possible to associate males by way of mated pairs from Exuma Island in the Bahamas. The actual male of *H. diffissa,* associated for the first time, is illustrated (Figs. 10, 11).

In view of the striking yet identical morphological features of the female genitalia (see Dietz and Duckworth 1976, fig. 19, for an illustration of a Cuban specimen), the two populations appear conspecific and the population from the Bahamas will not be named at this time. The Bahamian population probably represents a smaller race of *H. diffissa*; wing expanse averaging 42 mm in Cuba, 32 mm in the Bahamas. Besides the size differences, color pattern is also distinctive: Cuban *H. diffissa* have yellow scaling on the frons which extends to the base of the antennae, in Bahamian *H. diffissa* the yellow extends to the head above the bases of the antennae; the abdomen is brown in Cuba, black in the Bahamas; the long hairs at the apex of the hind tibia are yellow in Cuba, black in the Bahamas (i.e. the yellow hairs begin on the tarsi in Bahamian specimens). Examination of the genitalia of a Cuban male might be revealing, but the type of variation observed can be expected amongst mimetic species using different models.

Herrich-Schäffer's (1866) *H. pretellus* type has not been located, but he refers to it as being larger than *H. pretus* [which is 31–36 mm in expanse] and Dietz and Duckworth (1976) are undoubtedly correct in treating it as a synonym of *H. diffissa.* This leaves a small Cuban species with no name. In addition, the Haitian specimen illustrated by Dietz and Duckworth as male *H. diffissa* is distinct from *H. diffissa* and is described as new. It has recently been collected in the Dominican Republic.

Horama margarita, New Species

Male (Fig. 1).—Head dark gray-brown with yellow scaling covering upper frons; palpi yellow, tinged with brown dorsally; antennae yellow with dark brown band from base to beyond middle and at tip, weakly serrate; tegulae yellow with curving black band in middle; patagia gray-brown; dorsum of thorax gray-brown; metepimeron yellow and white, metameron yellow; abdomen with first tergite white, sides bulbous, middle filled with yellow, second tergite gray-brown with medial yellow spot and yellow and white spots laterally; third tergite lacks median yellow; remaining tergites gray-brown. First abdominal sternite brown; second sternite white; remaining sternites brown with yellow margins; legs yellow, brown at joints. Forewing orange-brown; hindwing marginal band similar, but basal half orange.

Wing expanse.—27 mm.

Male genitalia (Figs. 8, 9).—Upper portion of valves with lightly chitinized flanges; uncus elongate and bifurcate at apex; aedoeagus with an expanded proximal portion and a simple distal portion.

Female.—Unknown.

Deposition of type material.—Holotype male in the National Museum of Natural History, Washington, D.C.

Holotype data.—P. Cardero, VI-1964, Turquino, Cuba.

Diagnosis.—*Horama margarita* has yellow scaling behind the eye (this region black in both races of *H. diffissa*) in addition to having yellow extend on the front to above the bases of the antennae. The hind tibia have black scaling at the apex (unlike sympatric *H. diffissa* in Cuba, but similar to Bahamian *H. diffissa*); abdomen very similar to Cuban *H. diffissa* (unbanded). *Horama margarita* is the smallest of the three species, only 27 mm in expanse, making it easy to separate from sympatric *H. diffissa* (42 mm). The male genitalia exhibit a deeply notched uncus in *H. diffissa* contrasting with the rounded, blunt tip of the uncus in *H. margarita.*

Horama margarita's bifurcate uncus readily separates it from *H. rawlinsi.* External morphology of these two species appear identical but, in the small sample before me, the metepimeron is white in *H. rawlinsi* and yellow and white in *H. margarita.* Positive identification requires genitalic comparison.

***Horama rawlinsi,* NEW SPECIES**

Male (Fig. 4).—Head dark gray-brown with yellow scaling covering upper frons; palpi yellow, tinged with brown dorsally; antennae yellow with dark brown band from base beyond middle and at tip, weakly serrate; tegulae yellow with curving black band in middle; patagia gray-brown; dorsum of thorax gray-brown; metepimeron white, metameron yellow; abdomen with first tergite white, sides bulbous, middle filled with yellow, second tergite gray-brown with medial yellow spot and yellow and white spots laterally; third tergite lacks median yellow; remaining tergites gray-brown. First abdominal sternite brown; second sternite white; remaining sternites brown with yellow margins; legs yellow, brown at joints. Forewing orange-brown; hindwing marginal band similar, but basal half orange.

Wing expanse.—33 mm.

Male genitalia (Figs. 5–7).—Valves with conical, projecting protuberances on dorsal-lateral edge; uncus nearly parallel-sided and rounded at apex; aedoeagus sickle-shaped (Fig. 5 is a lateral view), lacking the proximal extensions of the other two species illustrated (Figs. 9, 10).

Female.—Unknown.

Deposition of type material.—Holotype male is deposited in the Carnegie Museum of Natural History. One paratype male (Haiti, Port-au-Prince, ca. 300 ft., 21–29 March) in the American Museum of Natural History.

Holotype data.—Dominican Republic, Pedernales, 26 km N Cabo Rojo, 18-06N, 71-38W, 730 m, 31 July 1990, J. Rawlins, C. W. Young, S. Thompson.

Diagnosis.—The male genitalia of *H. rawlinsi* was illustrated (as *H. diffissa*) by Dietz & Duckworth (1976; p. 35, figs. 7a, b, c). This species is nearly indistinguishable from *H. margarita.* See diagnosis under *H. margarita.*

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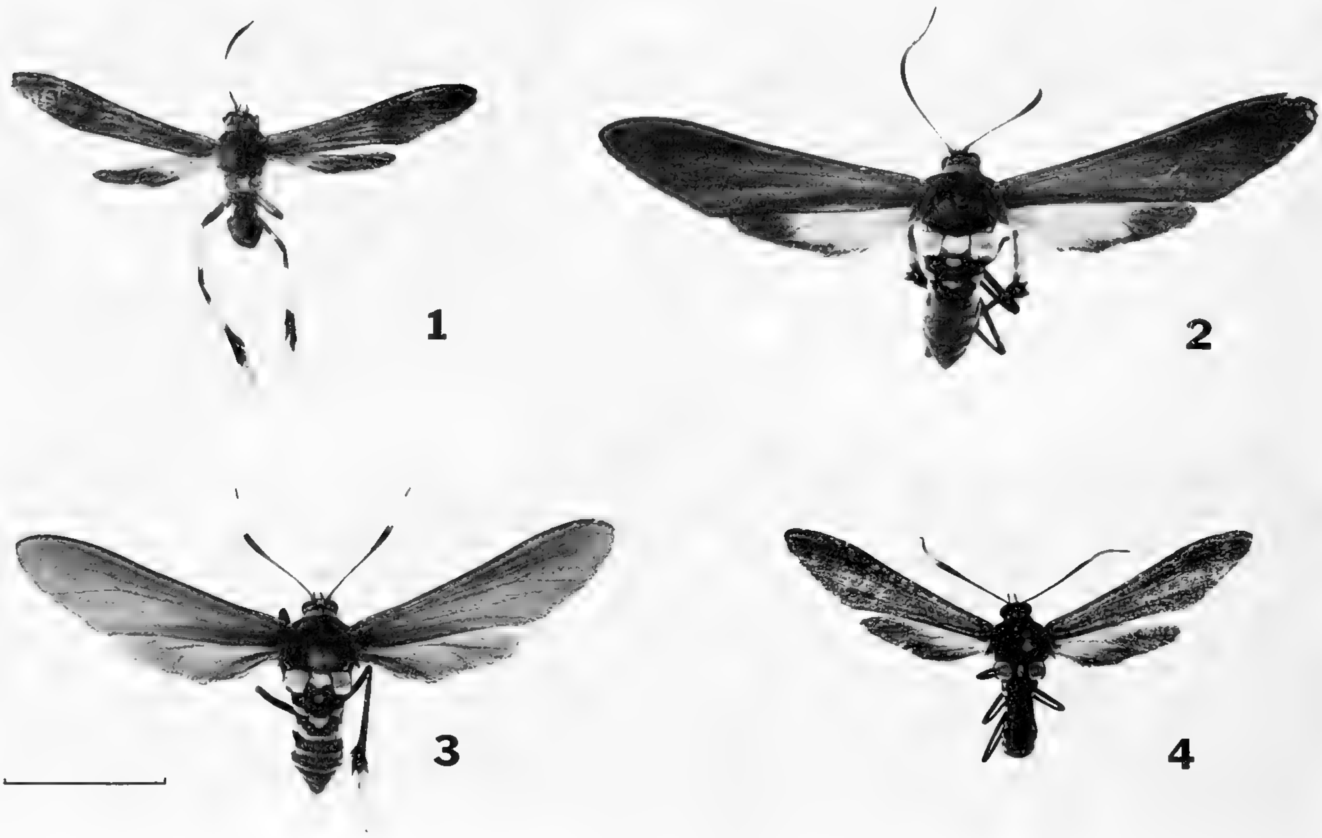
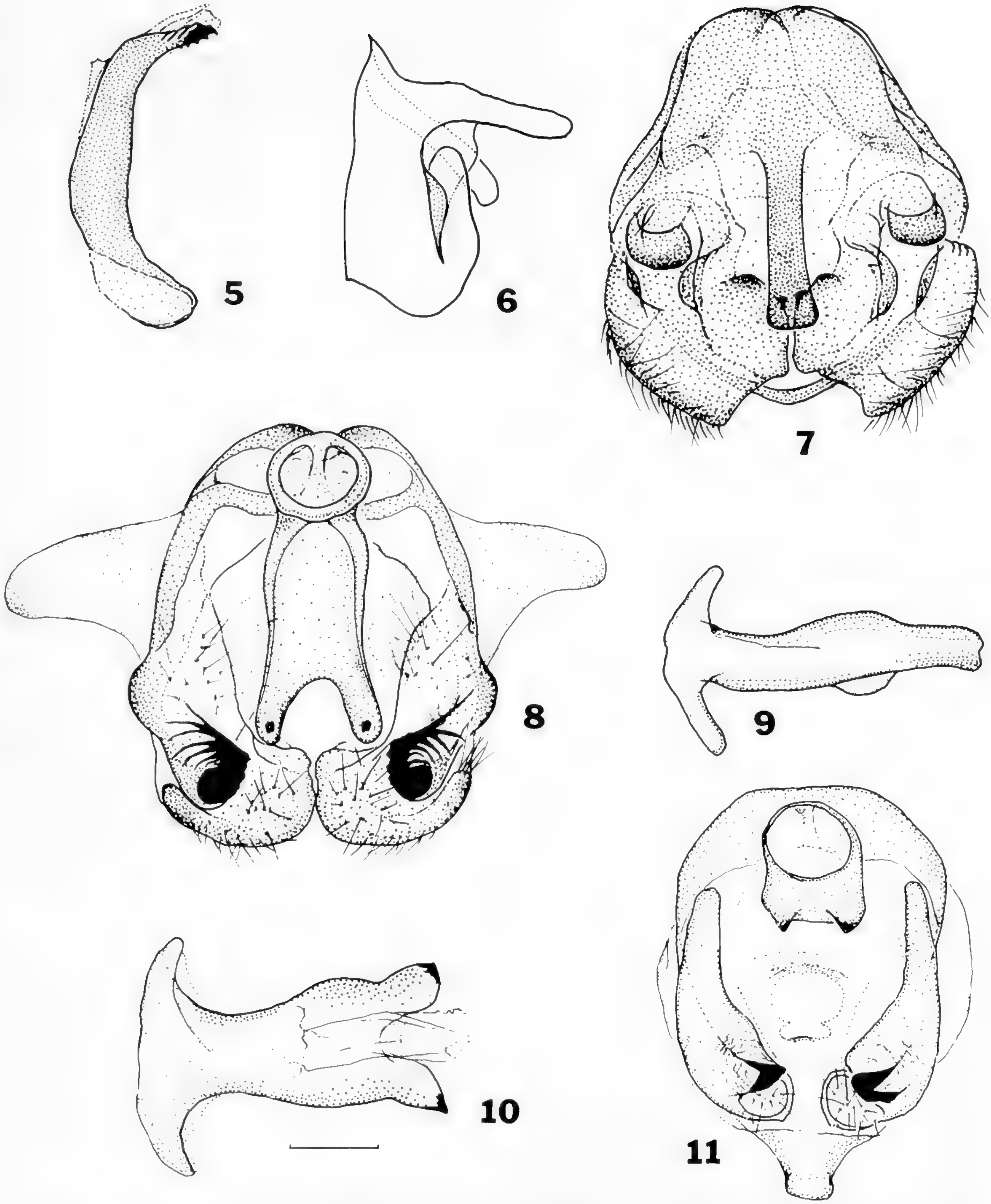
Contribution number 692 of the New York State Science Service.



Figs. 1–4. 1, *Horama margarita,* Holotype male, Alto de Cardero, Turquino, Cuba, June 1964, Alayo. 2, *Horama diffissa,* female, same data. 3, *Horama diffissa,* female, Bahamas, Great Exuma Island, Simon's Point, N. lat. 23°31′50″ W. long. 75°47′30″, December 31, 1981, T. L. McCabe. 4, *Horama rawlinsi,* Holotype male, Port-au-Prince, Haiti, 21–29 March. Scale line = 10.0 mm.



Figs. 5–11. 5, *Horama rawlinsi,* aedoeagus of holotype, lateral view. 6, *Horama rawlinsi,* lateral view of valves, diagrammatic, reduced. 7, *Horama rawlinsi,* male genitalia of holotype, dorsoventral view, Dominican Republic [Figs. 5–7 drawn from McCabe slide no. 1962]. 8, *Horama margarita,* male genitalia of holotype, dorsoventral view, Cuba. 9, *Horama margarita,* male aedoeagus of holotype, ventral view [Figs. 8–9 drawn from McCabe slide no. 1331]. 10, *Horama diffissa,* male aedoeagus, ventral view, Bahamas (Great Exuma Island, Simon's Point, lat. 23°31′50″ N. long. 75°47′30″ W., January 21, 1980, T. L. McCabe). 11, *Horama diffissa,* male genitalia, dorsoventral view, same data [Figs. 10–11 drawn from McCabe slide no. 575]. Scale line = 0.27 mm.

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CHINAOLA QUERCICOLA REDISCOVERED IN SEVERAL SPECIALIZED PLANT COMMUNITIES IN THE SOUTHEASTERN UNITED STATES (HETEROPTERA: MICROPHYSIDAE)

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Abstract.—Described from a female collected in Florida in 1927, *Chinaola quercicola* Blatchley has been known only from the holotype, which was thought to have been destroyed. That specimen has been found, and populations of this native microphysid have been discovered in South Carolina and Virginia. Its occurrence in specialized community types—granite outcrops, a shale barren, and a pitch pine-scrub oak barren—and its association with lichen-covered branches of red cedar, *Juniperus virginiana,* and scrub oak, *Quercus ilicifolia,* are discussed. Maryland, another new state record, is given on the basis of a specimen from the National Museum of Natural History collection.

Key Words: Insecta, granite outcrops, shale barrens, pitch pine-scrub oak barrens, lichens

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Microphysids belong to one of the smallest heteropteran families. Of the 25 to 30 species that have been described (Kerzhner 1964, Slater 1982), none was known from North America when Van Duzee (1917) catalogued the fauna occurring north of Mexico. In the current North American catalog, Henry (1988) lists four species from Canada and the continental United States: *Mallochiola gagates,* described in *Idiotropus* by McAtee and Malloch (1924); *Chinaola quercicola,* described by Blatchley (1928); and the recently detected Palearctic *Loricula pselaphiformis* Curtis (Kelton 1980) and *Myrmedobia exilis* (Fallén) (Kelton 1981). Since the catalog, two Old World species have been added, the Old World *Myrmedobia coleoptrata* (Fallén) from New York (Schwartz 1989), and *Loricula bipunctata* (Perris) from British Columbia (Schwartz et al. 1991).

Habitat preferences of the two native species are unknown, and no more than two North American localities have been recorded for any of these five Microphysidae. *Chinaola quercicola* has been known only from one specimen taken in Florida in 1927 (Blatchley 1928). The holotype, however, was presumed to have been destroyed in a flood in the insect collection at Purdue University (Schwartz 1989).

I report here the rediscovery of *C. quercicola*—the holotype and also populations from several specialized community types in the Southeast. New state records are given for Maryland, South Carolina, and Virginia. Information on host plants, association with foliose lichens on host branches, and seasonal occurrence is given.

Chinaola quercicola Blatchley

Blatchley (1928) described this species from a female beaten from foliage of water oak [probably *Quercus nigra* L.] at Dunedin, Florida, March 10, 1927. With apparent loss of the holotype, the placement of this monotypic genus in the Microphysidae has been uncertain (Schwartz 1989).

I first found *C. quercicola* while collecting insects at Forty Acre Rock, a well-known granite outcrop in Lancaster County, South Carolina. T. J. Henry was able to identify

Fig. 1. Red cedar (*Juniperus virginiana*) in granite outcrop; inset shows the lichens that charcteristically harbor *Chinaola quercicola.*

specimens through comparison with the holotype, which was discovered in the Drake Collection at the National Museum of Natural History, Washington, D.C. (USNM).

Additional collecting at Forty Acre Rock, surveys of other granite outcrops, and collections made in other specialized habitats have produced the following records of *C. quercicola.* All are based on specimens taken by the author except the Maryland record from the USNM collection. Voucher specimens have been deposited at the American Museum of Natural History, New York (AMNH); Cornell University, Ithaca, New York (CUIC); and USNM. Host plant and microhabitat associations are given in the next section.

Distribution.—MARYLAND: *Montgomery Co.,* 4 mi. SW of Ashton, malaise trap, 7 June 1986, G. F. & J. F. Hevel, 1 ♂. SOUTH CAROLINA: *Lancaster Co.,* Forty Acre Rock, nr. Taxahaw, 7 May 1989, 8 ♂, 2 ♀; 19 May 1989, 6 ♂, 19 ♀; 16 Apr. 1990, 1 instar II, 3 III, 1 IV. *York Co.,* granite outcrop, S. edge of Clover, 20 May 1989, 2 ♂, 10 instar V. VIRGINIA: *Alleghany Co.,* Rt. 18, 10.6 mi. SW of Covington, 19 May 1990, 1 instar III; *Augusta Co.,* Big Levels, George Washington Natl. For., 12 mi. SW of Waynesboro, 26 Aug. 1990, 1 ♀.

Community types, hosts, and microhabitat.—*Chinaola quercicola* was collected in two granite outcrops in South Carolina (Forty Acre Rock and a smaller flatrock at Clover), a shale barren in Virginia (along Potts Creek, Alleghany Co.), and a pitch pine-scrub oak barren in Virginia (Big Levels). In the granite outcrops and the shale barren, specimens were beaten from branches of red cedar, *Juniperus virginiana* L. Red cedar sometimes is so common in the vicinity of granite outcrops that these communities are called "cedar rocks" (McVaugh 1943). This plant also is present on many shale barrens (e.g. Platt 1951).

The bugs were collected only from branches of old red cedars covered with a foliose lichen (probably *Parmelia* sp.) (Fig. 1), and it is the lichen rather than its host substrate that appears to be the key in locating a microphysid population. Lichens were particularly numerous on branches of dying red cedars at Forty Acre Rock. McVaugh (1943) observed a high percentage of dead or dying red cedar on southeastern flatrocks because the bare rock habitat is unfavorable for growth. When placed on a lichen-covered piece of red cedar bark in the laboratory, the mainly black adults and dark red nymphs invariably moved to the dark lower surface of the lichen.

At Big Levels (Augusta Co., Virginia), a quartzite plateau barren (elevation about 1000 m) similar to northeastern pitch pine-scrub oak barrens (Wheeler 1991), *C. quercicola* was beaten from branches of scrub oak, *Quercus ilicifolia* Wangenh. Although it was not noted whether the bug was collected from a lichen-covered branch, lichens were present on some scrub oaks at Big Levels.

Seasonal history.—Overwintering appears to take place in the egg stage, a habit typical of the family (Southwood and Leston 1959, Péricart 1972). The presence of second to fourth instars in mid-April suggests that hatching occurs at least by early April in South Carolina. Adults were collected in early May at Forty Acre Rock, the dominance of males in the population suggesting that adults had been present only a short time. Females predominated at this site on 19 May, although the following day mainly fifth instars and two males were observed in another South Carolina population (at Clover). No individuals could be collected at Forty Acre Rock in mid-August, suggesting *C. quercicola* is univoltine like other microphysids that have been studied (Péricart 1972). On the basis of small numbers collected in Virginia, development may be about a month behind that of South Carolina populations.

DISCUSSION

Chinaola quercicola apparently has habits similar to those of other microphysids. In addition to overwintering as eggs and having a univoltine life cycle, it appears closely associated with lichens. In Europe, species of *Loricula* and *Myrmedobia* are found on lichens, including *Parmelia* spp. (Carayon 1949, Scudder 1956, Southwood and Leston 1959, Péricart 1972). Other Microphysidae also have been observed on old, dry trees (Butler 1923). If *C. quercicola* is typical of the family, it can be expected to prey on various arthropods that live in lichens (see Gerson and Seaward's [1977] review of lichen-invertebrate associations).

Although *C. quercicola* conforms to the habitus—it resembles a tiny anthocorid—and size (about 1.5 mm) of most microphysids, it does not show the sexual dimorphism prevalent in the family (Carayon 1949, Miller 1971). Females of Old World species have shortened, leathery or coleopteroid hemelytra that lack a membrane, and their abdomen is much widened. In some species ocelli are absent in females (Butler 1923, Southwood and Leston 1959, Kerzhner 1964, Kelton 1980). Females of *C. quercicola* are macropterous, not broadly oval, and have ocelli; they do not differ noticeably from males.

Biological rareness obviously is a subjective designation. One might assume a species such as *C. quercicola,* which has been known from one specimen collected more than 60 years ago, is indeed rare. That apparently is not the case. Because of its cryptic habits and small size, it has been overlooked by collectors. Even when lichen-covered branches likely to harbor these bugs are beaten over a tray or shallow net, nymphs and adults are difficult to see among pieces of bark and other debris that is dislodged.

Although abundant but patchily distributed in some granite outcrops and detected in a shale barren and a pitch pine-scrub oak barren, this bug is not restricted to specialized community types. The Maryland collection was made in a residential area. *Chinaola quercicola,* however, may prefer the xeric conditions of granite outcrops and perhaps shale barrens.

If not actually rare, *C. quercicola* should at least be considered uncommon. Surveys for this bug in granite outcrops in Alabama, Georgia, and North Carolina were negative, even though old, lichen-covered red cedars were numerous. But further collecting, with emphasis on foliose lichens growing on old or dying trees, should produce additional records of this little-known species.

ACKNOWLEDGMENTS

I thank T. J. Henry (USDA, PSI, Systematic Entomology Laboratory, Washington, D.C.) for identifying *C. quercicola,* providing the Maryland record, and reviewing the manuscript; J. R. Allison (Georgia Natural Heritage Inventory, Social Circle) for directions to several granite outcrops, accompanying me to look for the microphysid at Heggies Rock in Georgia, and the photographs used in Fig. 1; S. H. Bennett (South Carolina Heritage Trust, Columbia) for permission to collect at Forty Acre Rock; T. J. Rawinski (Virginia Division of Natural Heritage, Richmond) for taking me to the Big Levels barren; G. L. and M. K. Miller (Department of Entomology, Auburn University) for companionship in the field to search for the microphysid in an Alabama granite outcrop; and M. D. Schwartz (Biosystematics Research Centre, Agriculture, Ottawa, for access to information in a paper in press.

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ETHOLOGY OF *NEOARATUS ABLUDO* DANIELS (DIPTERA: ASILIDAE) IN SOUTH AUSTRALIA, WITH NOTES ON *N. PELAGO* (WALKER) AND *N. RUFIVENTRIS* (MACQUART)[1]

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Abstract.—The predatory and mating behaviors of *Neoaratus abludo* Daniels were studied in paddocks south of Aldinga, SA. Although prey taken by *N. abludo* represented five insect orders, 62.5% of the prey were honey bees. The majority of matings, in the tail-to-tail position, took place in the afternoon. Incidental data are included on the distribution and behavior of *Neoaratus pelago* and *N. rufiventris.*

Key Words: Diptera, Asilidae, *Neoaratus abludo,* predatory behavior, mating, *Neoaratus pelago, Neoaratus rufiventris*

The present paper is the fourth in a series dealing with the behavior of South Australian robber flies. Previous papers dealt with *Neoitamus vittipes* (Macquart) (Lavigne 1982a), *Neoscleropogon elongatus* (Macquart) (Lavigne 1982b), and *Neocerdistus acutangulatus* (Macquart) (Lavigne 1984). In the first paper, definitions of asilid flight terminology were presented and therefore need not be repeated here.

While on sabbatical at the Waite Agricultural Research Institute (November 1978–May 1979), the author and his wife encountered a population of an undescribed species of *Neoaratus,* 8.5 km south of Aldinga, SA. The species, *Neoaratus abludo,* was subsequently described by Daniels (1983).

The population of *N. abludo* inhabited three hillside paddocks dominated by *Avena barbata* Pott ex Link, intermixed with *Echium plantagineum* L. (Salvation Jane), *Hypocheoris radieata* L., and *Scabiosa atropurpurea* L. (Fig. 1). The paddocks contained occasional trees, *Ficus macrophylla* Desj., *Albizzia lophantha* (Willd.) Benth. and *Acacia pycnantha* Benth., which had at one time received irrigation. A deep swale lined with *Pinus halepensis* Mill. (Aleppo pine) separated two of the paddocks. Within the swale were several additional flowering plants attractive to bees and wasps, *Cirsium vulgare* (Savi) Ten., *Convolvulus erubescens* (Willd.) Benth., *Carthamus lanatus* L. and *Sonchus olevaceus* L. At the west end of one paddock there was a stand of *Eucalyptus* trees within the eastern edge of which stood a row of 12 honey bee hives.

N. abludo was studied by the author and his wife during the period January 5 to 23, 1979 at this site. It was estimated that the asilid population contained approximately 150 individuals.

Because so little is known about the behaviors of members of the genus *Neoaratus,* notes on the behaviors of two additional species, *N. pelago* (Walker) and *N. rufiventris* (Macquart) have been included in this paper.

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Fig. 1. Paddock, 8.5 km south of Aldinga, SA, in which *Neoaratus abludo* was studied. Honey bee hives were located at the base of the *Eucalyptus* trees at the top of the picture.

Materials and Methods

Two methods of gathering data were utilized: (1) continuously observing single asilids for extended periods of time of varying lengths and (2) traversing of the area to obtain as large a number of behavioral observations for individual asilids as possible. On certain days, strong winds caused such extensive movement of the wild wheat that behavioral observations were impossible.

Observations, recorded in notebooks on site, included detailed records of foraging, feeding, mating and oviposition. Time of day and temperature for each activity also were recorded. As in previous studies, permanent photographic records of each behavior were obtained with the aid of a Nikon 35 mm, single lens reflex camera with a Micro-Nikkor-P.C. Auto 1:3.5, 55 mm lens.

Prey collections were made at every available opportunity by netting feeding robber flies or collecting prey at the termination of feeding. The asilids were then released unharmed and the prey were placed in a 7.5 ml vial with information on sex of predator, date and time of day. Prey were subsequently measured in the laboratory (from front of head to apex of abdomen) for prey size preference. Feeding asilids were sometimes observed for the duration of the feeding to obtain data on time spent feeding, prey manipulation and methods of prey discard. Fifteen specimens of each sex of the asilid were collected during the course of the study for size measurement in order to obtain a predator-prey ratio. This ratio is useful in comparing prey selection among asilid species (Dennis and Lavigne 1975), because apparently the size prey taken by individual species is limited in part by the size of the predator, the strength of its mouthparts, the predator's speed and the density of optimum sized prey in the asilid's environment (Lavigne and Holland 1969). Additionally it has been shown that female asilids discriminate between different shapes and colors (Dennis et al. 1975).

Prey were identified in so far as possible and then submitted to specialists for verification or identification beyond Order and Family, where necessary. The prey collec-

Fig. 2. *Neoaratus abludo* female feeding on the honeybee, *Apis mellifera,* in paddock dominated by *Avena barbata,* but containing many Salvation Jane plants attractive as nectar sources for honey bees.

tion is housed at Waite Agricultural Research Institute in Glen Osmond, Adelaide, SA.

BEHAVIOR

Foraging and Feeding Behavior

The selection of perch sites by *N. abludo* was presumably a function of chance, since stalks of lodged *Avena barbata* were the most dominant site in the environment.

The heights on plants, where resting and/or foraging individuals were observed, varied from 20 to 120 cm. Unlike many other asilid species, *N. abludo* was never noted landing on substrates other than vertical or semi-vertical plant stalks. Temperature control was maintained largely by moving to the shady side of the plant stalk when absorbed heat became excessive. When temperatures exceeded 36–37° C, asilids flew into the lower branches of trees or landed on fencing at greater heights than were available in the understory. At these higher temperatures, no foraging occurred.

All forage flights were directed at airborne insects. Distances covered in forage flights ranged from 20 cm to 2.2 m. Despite the large size (mean 31.85 mm) and rapid flight of *N. abludo,* prey sometimes eluded it. In one case a female landed dorsally on a honey bee, but was unable to hang on to it. Another time a female hovered behind a honey bee, but apparently misjudged the speed of the bee and missed it. Moths eluded asilids by zigzaging through the vegetation with the robber fly making several short darting flights at its target.

Once prey were captured, asilids would land on nearby vegetation, mainly *A. barbata,* or occasionally on paddock fences. Heights on vegetation where asilids fed on prey ranged from 15 cm to 1 m (mean 47 cm). Ordinarily, the impaled prey was held between the venter of the asilid and the stalk, with the predator's legs, fore and mid tarsi, being used to maintain position, thus encircling the prey (Fig. 2). The hind tarsi were sometimes used to grasp the stalk, also. Unless disturbed, the predator would remain on the landing site throughout the feeding. Occasionally the asilid would fly out 5 to 10 cm from the plant stalk, hover, manip-

Table 1. Relation between length of *Neoaratus abludo* and that of its prey.

Sex	Predator Length (mm)*			Prey Length (mm)			No. Prey Measured	Mean Ratio of Predator : Prey
	Min.	Max.	Mean	Min.	Max.	Mean		
Male	18.0	24.0	21.9	6.5	22.5	12.6	52	1.7
Female	19.0	24.5	21.9	4.0	23.0	12.1	117	1.8
Combined	18.9	24.5	21.9	4.0	23.0	12.2	169	1.8

* 15 predators of each sex were measured.

ulate the prey with all six tarsi and reland. Manipulation while hovering is exhibited also by *Neoitamus vittipes* (Lavigne 1982a). Upon completion of feeding, either prey were pushed off the asilid's proboscis on site, or, more often, dropped near the feeding site as the asilid flew after another potential prey.

One complete feeding encompassing 52 minutes was monitored. A male captured a moth, *Heliothis punctigera* Wallengt., in flight at 1428 h. Immediately, the asilid carried its prey ca. 2 m and landed on a dead plant stalk; the prey was impaled upon landing. The prey was held between the venter of the asilid and the stalk; the fore and mid tarsi grasped the stalk, while the hind tarsi rested on the prey's partially outstretched wings. At 1448 h, the asilid hovered for ca. 30 seconds, manipulated the prey with all six tarsi, repositioned its proboscis in the moth and relanded. At 1502 h the action was repeated. Thirteen minutes later, the asilid flew twice to new stalks, each time a distance of ca. 14 cm. At 1520 the male buzzed its wings and took flight after a honey bee, dropping the moth as it left its perch.

A partial (capture not observed) feeding time for a male *N. abludo* on the same species of moth two days earlier was 45 minutes. On two occasions, females, in copula, were observed to feed on honey bees for 40 to 50 minutes each.

Based on 169 measured prey of *N. abludo,* the "preferred" prey length was 12.2 mm; the size of the prey taken ranged from 4 to 23 mm (Table 1). Males and females were approximately the same size and tended to capture prey within the same size range. While males exhibited relatively equal "preference" for Hymenoptera (43%) and Lepidoptera (38%), females concentrated on Hymenoptera (81% of the prey taken). Distribution of prey selectivity for insect Orders is presented in Table 2. The mean predator to prey size ratio for *N. abludo* is 1.8, as compared to 2.9 for *Neoitamus vittipes* (Lavigne 1982a), meaning that *N. abludo* took much larger prey in comparison to its size than did *Neoitamus vittipes.*

Previous records of prey of members of the genus *Neoaratus* are few. Box (1953) listed *Pseudoholophylla furfuracea* as prey of *Neoaratus* sp. in Queensland. Nicholson (1931) photographed the capture of a honeybee (*Apis mellifera* L.) by *N. hercules* Wiedemann, while Hardy (1935) noted the capture of the same species by *N. inglorius* Macleay. While commenting on asilids feeding on asilids, Hardy (1950) reported on the capture of a male *N. murinus* Macquart by a female *N. hercules* Wiedmann. He additionally recorded the wasp, *Thynnus apterus* Oliver (Hymenoptera: Tiphiidae) as prey of a female *N. hercules.* More recently, Bristowe (1971) has recorded *Podalonia suspiciosa* (Hymenoptera: Sphecidae), *Apis mellifera* (Hymenoptera: Apidae) and an unidentified tachinid (Diptera) as prey of *N. pelago* Walker. No other published records of prey capture are known to the author.

In the present study 184 prey of *N. abludo* were collected over an 18 day period. On some days strong winds, those exceeding 28 km/h, interfered with the flight habits of both predator and potential prey. Predators did not fly, nor did potential prey, and thus no records were obtained. On days of extreme calm, as many as 11 prey per hour

Table 2. Numbers and percentage of prey of different Orders taken by *Neoaratus abludo.*

Order	Male		Female		Unknown		Total	
	#	%	#	%	#	%	#	%
Coleoptera	6	3.3	5	2.7			11	6.0
Diptera	4	2.1	1	0.5			5	2.7
Hemiptera-Heteroptera	1	0.5	2	1.1			3	1.6
Hymenoptera	25	13.6	97	52.7	6	3.3	128	69.6
Lepidoptera	22	12.0	15	8.2			37	20.1
Total	58	31.5	120	65.2	6	3.3	184	100.0

were collected from asilids by the observers at peak feeding times.

As can be seen in the following list, collected prey represented five Orders of insects. Selection of prey from such a limited number of Orders implies a stenophagic habit (Lavigne and Holland 1969). This narrowness of preference is further supported by the fact that 62.5% of the prey were honey bees and a further 12.5% were *Heliothis punctigera.* That *N. abludo* was selectively choosing honey bees is also supported by the fact that large numbers of males and females could be found in early afternoon resting on *Avena* stalks over a semi-circular area fronting the row of honey bee hives, usually at a distance of approximately five meters from the hives. Honey bees were particularly vulnerable to attack on days when wind speed exceeded 16 km/h. Because of the position of the hives, worker bees were forced to fly more or less directly into the wind on their outward foraging flights, thereby being slowed. Additionally their dark color, contrasted with the light background of drying *Avena* stalks, made them easily visible over long distances. The habit of asilids preying largely on honeybees is not unique and has been documented on numerous occasions (Adamovic 1963, Bromley 1930, 1942, 1945, 1946, 1948).

Herein is a list of prey taken by *N. abludo.* Specific identifications were obtained for the majority of prey, but because of the state of knowledge in some groups only genus and/or family designations can be included at this time. The number of records and sex of the predator are indicated in parenthesis following the prey record.

COLEOPTERA, Chrysomelidae: *Cassida mera* Germ., 19.i.79 (♀); Scarabaeidae: *Liparetrus* 8.i.79 (♀), 9.i.79 (5 ♂, ♀), 18.i.79 (♂, ♀), 19.i.79 (♀). DIPTERA, Calliphoridae: *Calliphora nociva* Hardy, 16.i.79 (♂). Muscidae: *Australophyra rostrata* (R.-D.), 6.i.79 (♀). Tachinidae: *Chaetophthalmus* sp., 5.i.79 (♂), 10.i.79 (♂). Tipulidae: *Austrolimnophora* sp., 8.i.79 (♂). HEMIPTERA-HETEROPTERA, Pentatomidae: *Cermatulus nasalis nasalis* (Westw.), 8.i.79 (♂); *Dictyotus caenosus* (Westw.), 19.i.79 (♀), 23.i.79 (♀). HYMENOPTERA, Apidae: *Apis mellifera* L., 5-23.i.79 (20 ♂, 89 ♀, 6 ?). Halictidae: *Lasioglossum lanarium* Sm., 6.i.79 (♀), 10.i.79 (♂), 18.i.79 (♀); *Lasioglossum* sp., 23.i.79 (♀). Ichneumonidae: *Lissopimpla excelsa* (Costa), 16.i.79 (♀), *Netelia* sp., 5.i.79 (♂). Pompilidae: *Cryptocheilus* sp., 10.i.79 (♂). Sphecidae: *Podalonia suspiciosa* Sm., 19.i.79 (♀). Tiphiidae, Thynninae, 8.i.79 (♂), 9.i.79 (♂, ♀). LEPIDOPTERA, Lycaenidae: *Zizula otis labradus* (Godart), 16.i.79 (♂). Noctuidae: *Agrotis infusa* (Boisduval), 10.i.79 (♂); *Heliothis punctigera* Wallengt., 8.i.79 (♀), 9.i.79 (2 ♂, 2 ♀), 10.i.79 (♂), 11.i.79 (♂), 16.i.79 (4 ♂, 2 ♀), 18.i.79 (4 ♂, 2 ♀), 19.i.79 (2 ♂, 2 ♀); *Pseudaletia convecta* (Waller), 5.i.79 (♀). Pyralidae: *Etiella* sp., 11.i.79 (♀); Phycitinae, 10.i.79 (♂), 19.i.79 (♀), 23.i.79 (♀).

Orientation Flights

Long flights of 10^{+} m were often initiated by asilids after they remained in one loca-

Fig. 3. Mated pair of *Neoaratus abludo* in tail-to-tail position with male holding onto stalk below female.

tion for an extended period. Presumably this was a response to lack of potential prey in the immediate vicinity. However, it could also be a strategy used by males to relocate, when sufficient time has passed without a female being sighted.

Mating

Initiation of mating was observed in 10 instances out of 113 observed pairs in copula. No evidence of courtship behavior was exhibited by these males. The male would fly up from a resting position and intercept a female flying by or in the process of landing. In five out of 10 cases, the accosted female was carrying prey when forced into the vegetation for copulatory purposes. Out of the 113 mated pairs, 14% of the females were feeding on prey when observed, 69% of which were honey bees. It is assumed that females had obtained prey prior to copulating, although females of some species fly out after prey while in copula.

Males, in the presence of females, acted somewhat differently on two occasions. In one instance, a male flew into the vicinity of a stalk of Salvation Jane upon which a female was resting, and three times performed an arcing flight in front of her. The female then flew off with the male in pursuit. On another occasions a male three times circled a stalk upon which a female was resting and then landed on her dorsum and copulated with her.

The entire mating sequence was observed on three occasions. In each case the male flew out of the vegetation and accosted a female in flight (2 times) or just after landing (once). In the former instances copulation took place where the female was forced down into the vegetation. The initial position taken was that of male atop female, but within seconds the pairs took the tail-to-tail position which they maintained thereafter. Once this position was attained, the pair remained quiet throughout the copulatory period. As can be seen in Fig. 3, the male may take a somewhat abnormal rotated position in relation to the female, depending on the availability of vegetation to grasp. The male is able to do this because, like many other Dasypogoninae, it has a hypopygium rotated around the longitudinal axis of the abdomen (Snodgrass 1902, Hardy 1944, Karl 1959). Occasionally during a mating when the pair took a vertical position on an *Avena* stem, the female would be observed clutching the stem with all six tarsi while the male hung in mid-air, with only his claspers maintaining contact.

Pair separation was observed on 12 occasions. Twice pairs separated in flight after being disturbed. Seven times males merely released their claspers and flew off leaving the female on site. On three occasions females were observed pushing with their hind

Fig. 4. Female *Neoaratus abludo* ovipositing within the glume of a shattered seed head of *Avena barbata.*

tarsi at the genitalic juncture. Total times in copula for the three complete matings were 40, 45 and 50 minutes.

Mated pairs were observed (Fig. 5) at all times from 1000 to 1707 h, although the greatest number were observed between 1200 and 1300 h. Daniels (1983) observed pairs in copula between 0830 hr and 1230 hr. Temperatures taken at the heights mated pairs were observed ranged from 24° to 38°C (mean 31.3°C). Mated pairs were observed resting on stalks of *A. barbata* at heights ranging from 15 to 91 cm (mean 37.5 cm). On days when temperatures exceeded 33°C, mated pairs would sometimes fly onto the lower branches of trees at heights of 2 to 2.5 m, presumably to reduce heat absorption.

Male to male encounters were common, presumably because of the inability of males to recognized females until a close encounter occurred. In these instances the asilids would rise straight up in the air 3–4 m, "squaring off" in front of each other. Occasionally brief contact would occur. Although not monitored, it is presumed that males exhibited searching flights that would place them in the vicinity of females, a strategy used by males of some other asilid species, such as *Efferia benedicti* (Bromley) and *E. pallidula* (Hine) (Lavigne et al. 1976, Lavigne and Holland 1969).

Oviposition

A description of the eggs and oviposition behavior have been published by Lawson and Lavigne (1984). Figure 4 illustrates the position taken by the female during oviposition

Daily Rhythm of Activity

Detailed information on daily activity patterns has been published for a variety of species of Wyoming asilids (Dennis and Lavigne 1975, Lavigne et al. 1976), but for only one Australian species, *Neocerdistus acutangulatus* (Lavigne 1984). In Fig. 5, data are presented for *N. abludo.* While the majority of oviposition by females of *N. acutangulatus* occurs in early afternoon, females of *N. abludo* deposit eggs mostly in the morning. While females are searching for oviposition sites, it is unlikely that they

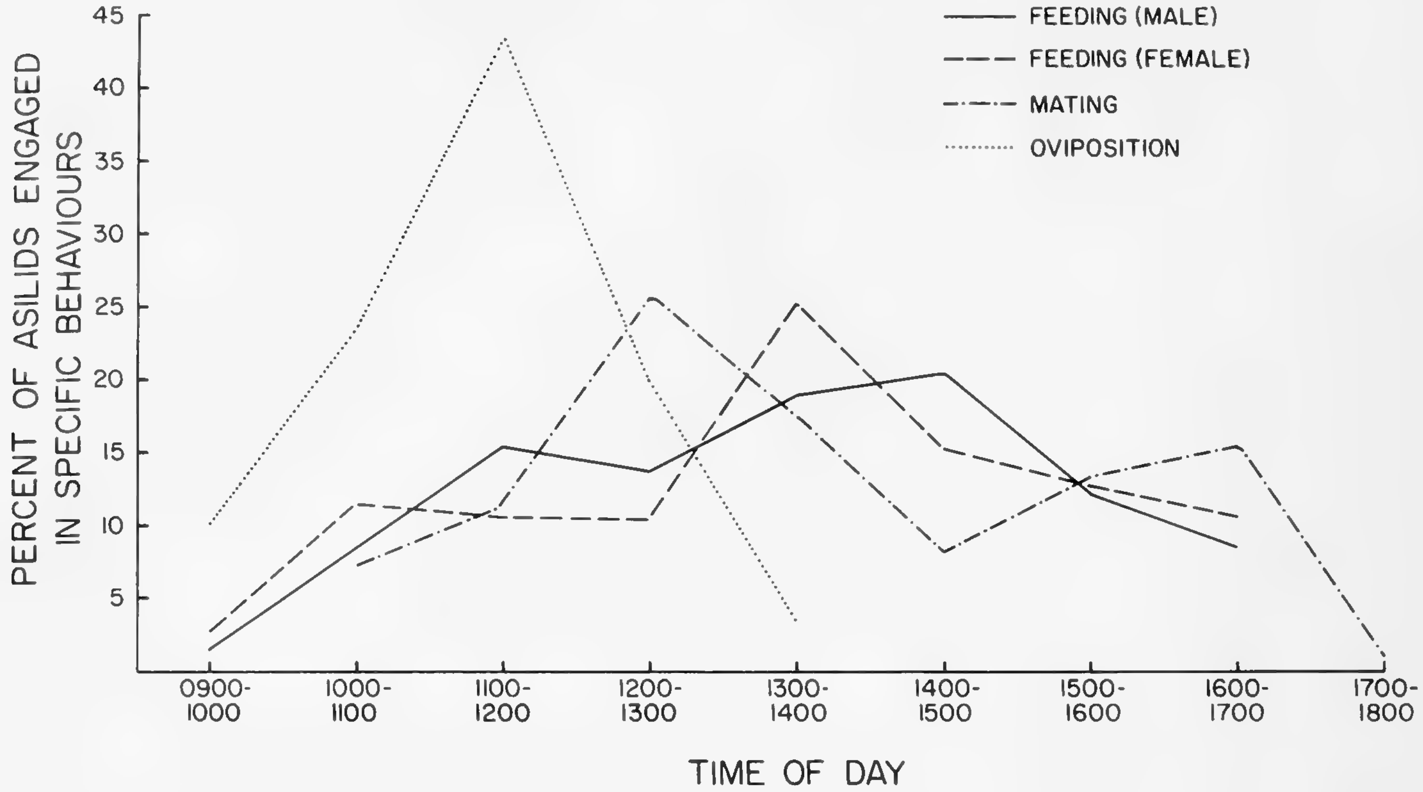

Fig. 5. Mean diurnal rhythm of activity for *Neoaratus abludo* 8.5 km south of Aldinga, SA. Percentage of asilids engaged in specific behavior patterns was calculated from the total number of observations for each behavior.

would be interested in feeding or be available for copulation, and this is reflected in Figure 5. Peak feeding by females and peak mating periods occur in the afternoon. Males of *N. acutangulatus* fed primarily in the morning, whereas *N. abludo* males tend to feed in early afternoon between the two mating peaks.

Predators

While it is assumed that some *N. abludo* fell prey to birds, since birds have been noted commonly as asilid predators (McAtee 1932, Adamovic 1963), the only observed acts of predation against this species were by spiders. Asilids probably become entangled in the vertical webs of large spiders in the process of chasing prey. On four occasions specimens of *N. abludo* were removed from webs containing the common large spider, *Araneus transmarinus* Keyserling (Fig. 6). Honey bees also were found in the webs of these spiders, wrapped in silk.

Fig. 6. A spider, *Araneus transmarinus*, with a specimen of *Neoaratus abludo* in its grasp.

***Neoaratus pelago* (Walker)**

This species, originally placed in the genus *Asilus*, was described by Walker in 1849. Ricardo (1913) recorded it from Swan River and Adelaide, South Australia, while Hardy (1920) discovered it in Perth, Western Australia. By 1935, the latter author had accumulated specimens from Victoria and Queensland as well, noting that "this fly evidently occurs wherever Mallee and sclerophyll woodlands, and scrub of a similar nature, are to be found" (Hardy 1935).

Specimens of *N. pelago* were collected at only two locations in South Australia: 5 km west of Sedan (5.ii79) and Ferries-McDonald Conservation Park, South of Monarto (31.i.79, 1.ii.79). The vegetation complex at both sites was Mallee scrub. The overstory at Ferries-McDonald consisted of *Melaluca uncinta* and *Eucalyptus* sp., while the understory was composed largely of *Helichrysum leucopsideim* DC., *Hibbevtia stricta* (DC) F. Muell., *Cryptandra leuchophraeta* Schldl., *Hypolaena fastigiata* R. Br. and *Lepidosperma carphoides* F. Muell.

Zigzag orientation flights of 3 to 6 m among upright vegetation were made between non-vegetated sandy areas, whereas straight flights of less than 1 m were made within these clearings. Asilids in flight produced a loud buzzing sound. Landings were made on small rocks and broken limbs of Mallee lying on the sand. Three to five minutes were spent in each non-vegetated area. At Ferries-McDonald one robber fly made a foraging flight of one meter making contact with a large wasp, but was unable to subdue it and the prey escaped. At the site west of Sedan, a female *N. pelago* was collected with a grasshopper of an undescribed genus as prey. During a period of 12 minutes, the asilid three times flew out 5 cm from the feeding site, hovered, manipulated the grasshopper using all six tarsi, reinserted its proboscis and landed on a nearby branch.

***Neoaratus rufiventris* (Macquart)**

Originally described by Macquart in 1838 in the genus *Asilus,* this species has been found in Queensland (Toowomba), New South Wales, Victoria (Moreton Bay) and South Australia (Ricardo 1913, Hardy 1920, 1935).

Specimens of *N. rufiventris* were encountered at only two locations in South Australia by the author: 16 km north of Kingston, at the edge of a dryland lucerne field, opposite the Coorong Game Reserve (18.xii.78) and within a wood just off the freeway outside Mt. Barker (2.iii.79). The latter location contained an overstory of *Eucalyptus leucoxylon* FrM. with an understory of *A. barbata,* intermixed with *Cirsium* sp. and a patch of *Ulex europaeus* L.

A single observed male at the Coorong site was collected with a beetle, *Liparetrus* sp. (Coleoptera: Scarabaeidae) as prey.

At the Mt. Barker site the population consisted of a very few individuals. A captured specimen had badly frayed wings suggesting that it had emerged several weeks earlier. Orientation flights initiated from dry plant stalks, bent *A. barbata* stems, and fallen *Eucalyptus* limbs, covered distances of ca. 8 m.

A mated pair in the tail-to-tail position was observed at Mt. Barker (2.iii.79) at 1145 h resting on a dry plant stalk at a height of 0.7 m. The temperature at the mating height, under an overcast sky, was 25°C. The pair moved several times during the ensuing 18 minutes always landing on dry plant stalks at the same approximate height. During one weaving flight at a height of 1.7 m, a male accosted the mated pair in the air landing atop the female as the pair landed. In this position the second male made a number of copulatory attempts prior to being dislodged several seconds later. A few minutes later, 1203 h, the mated pair separated upon landing with the male flying away. The female remained on the landing perch and cleaned her wings, hind tarsi and ovipositor in succession. At 1310 h a dense fog inundated the site and individuals were observed flying up into the lower branches of the *Eucalyptus* trees.

ACKNOWLEDGMENTS

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CORRECTIONS AND ADDITIONS TO THE "CATALOG OF THE HETEROPTERA, OR TRUE BUGS, OF CANADA AND THE CONTINENTAL UNITED STATES"

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Abstract.—The catalog of the Heteroptera of Canada and the United States, appearing in December 1988, contains entries for more than 675 genera and 3800 species. Through use and the efforts of the coeditors and cooperating colleagues, a list of corrections and additions is provided for the 958-page volume. Changes range from extra periods and parentheses around authors names to omitted taxa. Added to the North American list are the berytid *Jalysus balli* Harris, the coreid *Mozena obtusa* Uhler, the corixid *Glaenocorisa quadrata* Walley, and the mirids *Apachemiris vigilax* (Van Duzee), *Hyalopsallus diaphanus* (Reuter), *Mexicomiris texanus* Carvalho and Schaffner, *Polymerus rubroornatus* Knight, and *Labopidea simplex nigriventris* Knight. The lygaeid *Peritrechus convivus* (Stål) is recognized as the senior synonym of *P. distinguendus* (Flor) and the mirid *Psallus haematodes* (Gmelin), the senior synonym of *P. roseus* (F.).

Key Words: Omitted taxa, gender, derivation, berytid, coreid, corixid, mirids, lygaeid

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It has been more than two years since the *Catalog of the Heteroptera, or True Bugs, of Canada and the Continental United States* (Dec. 12, 1988, E. J. Brill Publ., Leiden and New York) appeared (available through Sandhill Crane Press, Inc., 2406 NW 47th Terrace, Gainesville, FL, USA 32606; $58.50). Now that some time has passed to test its accuracy through use, we feel that it is appropriate to present corrections for some of the errors and omissions we have discovered and those kindly pointed out by our colleagues. We offer no excuses for the list that follows, but only restate a sentence included in the catalog's introduction (p. xv): "We . . . realize, more than anyone, the immensity of . . . the present task and the probability for error or omission." We are pleased that the scientific community, despite the errors that crept into the volume, has responded favorably to it (Schuh, R. T. 1989, J. New York Entomol. Soc., 97: 243-245; Steyskal, G. C., 1989, Proc. Entomol. Soc. Wash., 91: 649; and C. W. Schaefer, 1990, Ann. Entomol. Soc. Am., 84: 132-134).

A particularly problematic aspect of the catalog involved the agreement of gender for generic and specific names. In the list that follows, we attempt to correct a few more names (with much aid from I. M. Kerzhner and G. Steyskal), with an indication of their gender or derivation. Also, several colleagues pointed out the problem with specific patronymic names ending in "ii" (see our discussion on p. xvi of the catalog). The overwhelming response was that the original spelling should be retained. We agree and encourage users of the Heteroptera volume to follow.

A few colleagues pointed out literature

not found in the catalog that appeared after the indicated cut-off date. We reemphasize the literature review for the Heteroptera Catalog ended Dec. 31, 1986, as stated on page xv.

Finally, we recognize those people who took the time to inform us about the errors they discovered in the catalog. We are especially grateful to S. I. Frommer (Univ. California, Riverside), I. M. Kerzhner (Zool. Inst., Leningrad), J. T. Polhemus (Univ. Col. Mus., Englewood, Colorado), C. W. Schaefer (Dept. Ecol. Evol. Biol., Univ. Conn., Storrs), J. C. Schaffner (Dept. Entomol., Texas A&M Univ., College Station, Texas), G. C. Steyskal (Syst. Entomol. Lab (SEL), ARS, USDA, % USNM, Washington, D.C., retired), and A. G. Wheeler, Jr. (Bur. Plant Ind., Pa. Dept. Agric., Harrisburg, Pennsylvania) for their time-consuming reviews and numerous comments, which have made the following list much more complete. R. W. Hodges (SEL), R. W. Poole (SEL), P. J. Spangler (USNM), and A. G. Wheeler, Jr. kindly reviewed this manuscript.

CORRECTIONS AND ADDITIONS

p. xvii. To the Canadian abbreviations add "N.S." for Nova Scotia; to the United States abbreviations add "Miss." for Mississippi and "Wyo." for Wyoming.

p. xix. Under original artwork correct "Gustava" Hormiga to "Gustavo."

p. 6. Herrich-Schaeffer date for *Alydus pilosulus* heading should be 1847.

p. 9. Leptocorisinae should be Leptocorinae.

p. 9. Change *Stenocoris furcifer* to *furcifera.*

p. 13. Author and dates for subfamily Anthocorinae and tribe Anthocorini should be Fieber, 1837.

p. 14. Add B.C. to distribution of *A. confusus.*

p. 15. Italicize *Elatophilus brimleyi* Kelton.

p. 20. *Paratriphleps* is feminine; change *laeviusculus* to *laeviuscula* (also italicize) and *pallidus* and *pallida.*

p. 23. The type species for *Lyctocoris* Hahn is *Lyctocoris domesticus,* Hahn, 1836, a junior secondary homonym of *Cimex domesticus* Schilling, 1834, a junior synonym of *Acanthia campestris* Fabricius, 1794. The next available name for *L. domesticus* Hahn is *Lyctocoris nidicola* Wagner, 1955 [See Kerzhner, 1979, Trudy Zool. Inst. Akad. Nauk SSR, 81: 23].

p. 25. *Nidicola* is masculine; change *marginata* to *marginatus.*

p. 25. *Scoloposcelis* is feminine; change *basilicus* to *basilica.*

p. 33. In the 1903 reference under *Aradus aequalis,* correct the spelling of "Osborn."

p. 58. Remove period after date in generic heading of *Neides.*

p. 59. Type species for *Jalysus* should read *Metacanthus macer,* not *Jalysus macer.*

p. 59. Add the following species entry:

Jalysus balli Harris, 1941
1941 *Jalysus balli* Harris, Bull. Brooklyn Ent. Soc., 36: 106. [Ariz.].
Distribution: Ariz. (Mexico).

p. 69. In second column, 1st paragraph, 4th line, change "here" to "where."

p. 71. To the section discussing Coreidae excluded from the catalog, add the following:

Blöte reported *Althos inornatus* (Stål) [in genus *Margus*] (1935, Zool. Meded., 18: 193) and *Molchina hopei* (Perty) (1836, Meded, 19: 24) from California. The 1935 record probably refers to "Lower California" [Baja], Mexico and the 1936 report, recorded with a question, probably is based on a mislabeled specimen. Both species are excluded from the U.S. fauna.

p. 74. In note under *A. terminalis,* change date for Yonke and Medler reference from 1963 to 1969.

p. 74. Under the genus *Acanthocerus* and its type species, *Cimex cruciger* Tigny, 1813 [1801] is considered a distinct species now placed in the genus *Machtina* Amyot and Serville.

p. 75. Author of tribe Anisoscelidini should be Laporte, 1832, not Amyot and Serville, 1843.

p. 79. Date for *Chariesterus* Laporte in title should be 1833.

p. 80. *Chelinidea* is feminine; change *vittiger* to *vittigera.*

p. 81. Change date for De Geer after *Anasa tristis* heading to 1773.

p. 83. Under the genus *Hypselonotus,* dates for Hahn should be 1833, three times.

p. 85. Osuna (1981, Rev. Tribe Leptoscelini, p. 75) described a new genus for the species *Cimex pictus* Drury; therefore, replace genus *Phthia* with the following:

Genus *Dallacoris* Osuna, 1981

1981 *Dallacoris* Osuna, Rev. Tribe Leptoscelini, p. 75. Type-species: *Cimex pictus* Drury, 1770. Original designation.

p. 86. Change heading *Phthia picta* (Drury), 1770 to *Dallacoris pictus* (Drury), 1770. After 1919 McAtee entry add:

1981 *Dallacoris pictus*: Osuna, Rev. Tribe Leptoscelini, p. 77.

p. 87. Add the following species entry after *Mozena lurida*:

Mozena obtusa Uhler, 1876
1876 *Mozena obtusa* Uhler, Bull. U.S. Geol. Surv. Terr., 5: 30. [N.M., Tex.].
Distribution: Ariz., N.M., Tex.
Note: Torre-Bueno (1941, Ent. Am., 21: 55), through a lapsus, keyed this species twice; therefore, the species name and distribution in couplet 1 should be referred to *M. obesa.*

p. 88. *Piezogaster* is feminine; change *auriculatus* to *auriculata* and *indecorus* to *indecora.*

p. 90. Meropachydinae, based on the type genus *Meropachys,* should be Meropachinae.

p. 93. Second column, last paragraph, 7th line, remove "slash" from "provides."

p. 100. Under genus *Hesperocorixa* in Kirkaldy (1908) reference, correct spelling of *Arctocorixa* to *Arctocorisa.*

p. 102. "Wash." in distribution for *H. minor* and *H. nitida* should be referred to "D.C."

p. 110. Type designation for subgenus *Subsigara* Stichel should be "Original designation."

p. 111. Add Neb. to distribution of *Sigara alternata.*

p. 116. Remove colon after *Trichocorixa verticalis verticalis* in subspecies heading.

p. 117. Add following species after *Glaenocorisa propinqua:*

Glaenocorisa quadrata Walley, 1930
1930 *Glaenocorixa* [*sic*] *quadrata* Walley, Can. Ent., 62: 78. [Que.].
1944 *Glaenocorisa quadrata*: Hungerford, Bull. Brooklyn Ent. Soc., 39: 32.
Distribution: Alk., N.T., Nfld., Que. (Norway).

p. 120. Second column, last paragraph, 11th line, change Slater and Baranowski reference date from 1878 to 1978.

p. 120. Add B.C. to distribution of *A. pallidus.*

p. 122. Under *Cyrtomenus ciliatus,* date for Palisot should be 1818.

p. 130. Note that tarsi in fig. 35 should have only 2 tarsomeres each as indicated in the family introduction.

p. 134. *Hymenocoris* is masculine; change *formicina* to *formicinus.*

p. 142. *Gerris* is masculine; change *ampla* to *amplus,* both under species and subspecies.

p. 144. Change spelling of *Gerris incognitis* to *incognitus,* two times.

p. 162. Under *Acinocoris lunaris,* date for Gmelin should be 1790.

p. 176. Following Kerzhner (1981, Bull. Zool. Nomen., 38: 205-207), date for *Ischnodemus brunnipennis* Germar should be 1838, not 1837.

p. 178. *Toonglosa* is feminine; change *T. umbratus* to *umbrata.*

p. 195. Near bottom of page, move "*M. bistriangularis bistriangularis*: Maldonado, Proc. Ent. Soc. Wash., 76: 26." to line above following "1974."

p. 210. Following Kerzhner (1981, Bull. Zool. Nomen., 38: 205-207), dates for Germar under genus *Pachygrontha* should be 1838, not 1837.

p. 216. Date for Banks' reference under *G. walleyi* should be 1910, not 1938.

p. 221. Add to distribution of *Trapezonotus arenarius* "Europe to Siberia."

p. 223. *Lamprodema* is neuter; change *maura* to *maurum.*

p. 224. "Fabricius" in "Synonymized with *Megalonotus chiragra* Fabricius. . ." under Van Duzee, 1928, reference should be parentheses.

p. 227. *Froeschneria* is feminine; change *multispinus* to *multispina.*

p. 230. *Ligyrocoris sylvestris* also occurs across the USSR to Japan.

p. 243. *Peritrechus distinguendus* (Flor) is now a junior synonym of *P. convivus* Stål. Modify the entry for this species as follows:

Peritrechus convivus (Stål), 1851
1851 *Rhyparochromus convivus* Stål, Stett. Ent. Zeit., 19: 180. [USSR].
1860 *Pachymerus distinguendus* Flor, Rhyn. Livl., p. 266. [Livlands]. Synonymized by Puchkov, 1969, Faun. Ukraine, Lygaeidae, p. 294.
1969 *Peritrechus convivus*: Puchkov, Faun. Ukraine, Lygaeidae, p. 294.

p. 245. Under *Stygnocoris sabulosus,* Barber (1918) reference to *Stygnocoris pedestris* should be dated 1916.

p. 248. Type species for *Mesovelia* should be spelled *fuscata* not *furcata.*

p. 255. First column, 4th line, date for Schuh, 1976, Am. Mus. Nov., 2585: 1–26 should be 1975.

p. 255. Second column, second full paragraph, 7th line, change spelling of "*lineolarus*" to "*lineolaris.*"

p. 257. Second column, 13th line from bottom, remove extra comma after "problems."

p. 264. Under genus *Macrolophus* and Type-species, date for Herrich-Schaeffer should be 1835.

p. 266. Change *Halticotoma cornifer* to *cornifera.*

p. 267. In the note under *Hesperolabops gelastops,* the spelling "*Labos*" should be changed to *Lobos* as in the Marlatt, 1896, entry for that species.

p. 268. Correct the spelling of "*Sixeonotopis*" to *Sixeonotopsis* Carvalho and Schaffner, 1974, four times.

p. 273–274. *Clivinema* is neuter; change *detecta* to *detectum, fusca* to *fuscum, fuscinervis* to *fuscinerve, medialis* to *mediale, regalis* to *regale, serica* to *sericum, sinuata* to *sinuatum, sulcata* to *sulcatum,* and *villosa* to *villosum.* Modify index accordingly.

p. 290. Under Isometopinae note, 2nd paragraph, should be modified to read: "proposed *to resurrect* the name Myommaria [*sic*] *McAtee and Malloch.*" Also, "P13," in parentheses preceding above statement should be changed to "p. 13."

p. 294. Add following generic and species entries to Herdoniini after genus *Heidemanniella*:

Genus *Mexicomiris* Carvalho and Schaffner, 1974
1974 *Mexicomiris* Carvalho and Schaffner, Rev. Brasil. Biol., 33 (supl.): 42. Type-species: *Mexicomiris myrmecoides* Carvalho and Schaffner, 1974. Original designation.

Mexicomiris texanus Carvalho and Schaffner, 1974
1986 *Mexicomiris texanus* Carvalho and Schaffner, Ann. Soc. Ent. France (N.S.), 22: 217. [Tex.].
Distribution: Tex.

p. 296. Add Europe and Asia or Palearctic to distribution of *Agnocoris rubicundus.*

p. 299. Under *Calocoris norvegicus,* change date for Gmelin to 1790, two times.

p. 301. Under distribution for *Capsus cinctus,* change Siberia to USSR.

p. 302. We discovered that *Deraeocoris purgatus* Stål (1860, Öfv. Svens, Vet.-Akad. Handl., 2(7): 51) had been transferred to *Creontiades* and placed in synonymy with *C. rubrinervis* (Stål), 1862, by Carvalho (1959, Arq., Mus. Nac., 48: 77). Because of Carvalho's (1959) incorrect published date (as 1852) for the original description of *C. rubrinervis* (although we cited the correct date), we overlooked *C. purgatus* as the senior synonym. However, Carvalho (1989, An. Acad. Brasil. Ci., 60: 477) now has considered them separate species, thus, eliminating the need to treat *C. rubrinervis* as a junior synonym.

p. 312. *Lygidea* Reuter, 1875 is not a *nomen nudum,* and the type designation of *deraeocoris illotus* Stål, under *Lygidea* Reuter, 1879, should read "First included species."

p. 314. To the distribution of *L. lucorum* add Asia, North Africa.

p. 317. Add to distribution of *Lygocoris contaminatus* Europe and Asia or Palearctic.

p. 328. *Monalocorisca* is feminine; change *maculatus* to *maculata.*

p. 329. *Monalocorisca* is feminine; change *rostratus* to *rostrata.*

p. 333. Change *Phytocoris albiesi* to *abietis.*

p. 342. Alphabetize *Phytocoris juniperanus* Knight and *P. junipericola* Knight.

p. 345. Italicize *Phytocoris plenus* Van Duzee.

p. 358. Add the following species after *P. rubrocuneatus*:

Polymerus rubroornatus Knight, 1926
1926 *Polymerus rubroornatus* Knight, Can. Ent., 58: 164. [Col.].
Distribution: Col., N.M., Ut.

p. 360. Original spelling of *Proba californica* should be *Pinalitus "californicus."* Also correct index.

p. 374. Correct tribal spelling Resthenini to Restheniini.

p. 384. Under *Leptopterna dolabrata,* change "van" to "var." in Reuter (1875) reference.

p. 386. Add the following to the synonymy of *Megaloceroea recticornis*:

1973 *Megaloceraea* [*sic*] *recticornia* [*sic*]: Akingbohungbe et al., Univ. Wis. Res. Bull., R2561: 2.

p. 386. ICZN, Opinion 898, regards *Stenodema* neuter; change *dorsalis* (p. 387) to *dorsale* and *vicina* (p. 388) to *vicinum.*

p. 388. Add following note to genus *Teratocoris*: Kelton (1966, Can. Ent., 98: 1270) provided a key to the Nearctic species.

p. 389. Correct for spelling of "coelestialium" to *T. caelestialium.* All workers have misspelled this name subsequent to the original description.

p. 398. Add to list of synonymy for *Ceratocapsus setosus* Reuter, 1909:

1927 *Ceratocapsus setuosus* [*sic*]: Knight, Ohio J. Sci., 27: 148.

p. 400. Under *Schaffneria schaffneri,* Ariz. record should be Alta. (Alberta).

p. 400. Authorship for tribe Halticini should be Costa, 1853, not Kirkaldy, 1906.

p. 403. Add to genus *Apachemiris* Carvalho and Schaffner, 1974:

Apachemiris vigilax (Van Duzee), 1923.
1923 *Orthotylus vigilax* Van Duzee, Proc. Cal. Acad. Sci., 12: 155. [Mexico].
1974 *Apachemiris vigilax*: Carvalho and Schaffner, Rev. Brasil. Biol., 33 (supl.): 68.
Distribution: Ariz., Cal. (Mexico).

p. 410. *Fieberocapsus flaveolus* also occurs across the USSR.

p. 416. Add the following subspecies of *Labopidea simplex*:

Labopidea simplex nigriventris Knight, 1928

1928 *Labopidea simplex nigriventris* Knight, Can. Ent., 55: 235. [Col.].
Distribution: Cal., Col.
Note: This subspecies was not mentioned by Kelton (1979, Can. Ent., 111: 753–754) and probably is only a color form of the nominate subspecies.

p. 422. The original spelling of *Lopidea nigridea* should be corrected to *nigridia,* two times.

p. 428. The first combination for *flavosparsus* in the genus *Melanotrichus* is Knight, 1927, Can. Ent., 59: 142, not Knight, 1941.

p. 442. Transfer genus *Phoradendrepulus* Polhemus and Polhemus, 1985 and *P. myrmecomorphus* Polhemus and Polhemus, 1985 to subfamily Phylinae, tribe Hallodapini on p. 456, following *Orectoderus.* Change index accordingly and note that "myrmecomorphus" should be in lowercase without italics as valid name.

p. 458. Add to 1931 *Cyrtorhinus pubescens* Knight entry (first line) the following: Synonymized by Carvalho and Southwood, 1955, Bol. Mus. Goeldi, 11: 28.

p. 459. *Atomoscelis* is feminine; change *modestus* to *modesta.*

p. 461. *Beamerella* is feminine; change *personatus* to *personata.*

p. 467. *Europiella* is feminine; change *nigrofemoratus* to *nigrofemorata.*

p. 468. Add the following genus and species:

Genus *Hyalopsallus* Carvalho and Schaffner, 1974
1974 *Hyalopsallus* Carvalho and Schaffner, Rev. Brasil. Biol., 33: 19. Type-species: *Atomoscelis diaphanus* Reuter, 1907. Original designation.

Hyalopsallus diaphanus (Reuter), 1907
1907 *Atomoscelis diaphanus* Reuter, Öfv. F. Vet. Soc. Förh., 49: 24. [Jamaica].
1982 *Hyalopsallus diaphanus*: Henry and Wheeler, Fla. Ent., 65: 234.
Distribution: Fla. (Jamaica).

p. 471. Add following entry to synonymy of *Macrotylus amoenus*:

1909 *Macrotylus amoemus* [*sic*]: Van Duzee, Bull. Buffalo Soc. Nat. Sci., 9: 182.

p. 477. *Monosynamma bohemani* should be *M. bohemanni.* [*sic*] should be deleted from Hussey (1922) and Kelton (1980) and added to Horvath (1908), Knight (1917), and Carvalho (1958).

p. 483. *Plagiognathus chrysanthemi* also occurs across the USSR.

p. 491. *Pronotocrepis* is feminine; change *ruber* to *rubra.*

p. 491. Under genus *Psallus* and Type-species: *Cimex roseus* Fabricius, change 1776 to 1777 and add: Preoccupied by *Cimex roseus* Miller, 1776. New name *Cimex haematodes* Gmelin, 1790.

p. 492. According to I. M. Kerzhner (pers. comm.), *P. ancorifer* does not occur in the USSR (Asia Minor).

p. 494. Change entry for *Psallus roseus* (Fabricius), 1777, as follows:

Psallus haematodes (Gmelin), 1790
1777 *Cimex roseus* Fabricius, Gen. Ins., p. 300. [Europe]. Preoccupied by *Cimex roseus* Miller, 1776.
1790 *Cimex haematodes* Gmelin, Sys. Nat., 13: 2169. New name for *Cimex roseus* Fabricius, 1777.
1970 *Psallus haematodes*: Kerzhner, Acta Ent. Mus. Nat. Prag., 38: 143.
1983 *Psallus roseus*: Kelton, Can. Ent., 115: 325.

p. 502. In species heading for *P. polita,* correct generic spelling to *Paramixia.*

p. 502. Under 1907 *Sthenarus plebejus* Reuter entry, "Synonymized by Henry . . ." should read "Synonymized and lectotype designated by Henry . . ."

p. 515. Add 2nd paragraph to note under

genus *Nabis*: The name "*Nabis perennis* Fitch, Ms.," listed by Walker (1893, Cat. Hem. Brit. Mus., p. 143) and Van Duzee (1917, Cat. Hem., 2: 282) is a *nomen nudum* and, therefore, not included in the following list of species. Add "*perennis, Nabis*" to index.

p. 519. Correct *P. fusca nigripes* entry as follows.

Pagasa fusca nigripes Harris, 1926
  1926 *Pagasa fusca* var. *nigripes* Harris, Ent. News, 37: 287. [Col.].
  1928 *Pagasa fusca nigripes*: Harris, Ent. Am., 9: 26.

p. 525. Change spelling of genus *Syncollis* to *Syncollus,* two times. Also correct index.

p. 526. Authorship of the subfamily Naucorinae should be Leach, 1815, not Stål, 1876.

p. 529. Authorship of the subfamily Nepinae should be Latreille, 1802, not Douglas and Scott, 1865.

p. 531. Remove parentheses around Montandon in *Ranatra fusca edentula.*

p. 536. The tribe Nychini should be spelled Nychiini.

p. 537. The type-species for *Notonecta* was designated by Latreille, 1810, Cons. Gén., p. 434, not Lamarck, 1801.

p. 54. Under genus *Apateticus,* date for Herrich-Schaeffer should be 1840.

p. 552. The genus *Mineus* should be reduced to a junor synonym of the genus *Perillus* on p. 553. Synonymized by Hoffman, 1971, Va. Polytech. Inst. St. Univ., Res. Div. Bull., 67: 53.

p. 553. At top of page under *Oplomus dichrous,* dates for Herrich-Schaeffer should be 1838, three times.

p. 554. Add Ont. to distribution of *Picromerus bidens* (Linnaeus).

p. 563. Change spelling of tribal name Mediceini to Mecideini.

p. 564. Add Mexico to distribution of *Mecidea major* Sailer.

p. 565. Original spelling of *A. pensylvanicum* (Gmelin), with one "n," should be retained.

p. 571. Add Mexico to distribution of *Chlorochroa faceta* (Say) and *C. osborni* (Van Duzee).

p. 581–82. Add B.C. to distribution of *Holcosthethus piceus.*

p. 582. Add to synonymy under *Hymenarcys aequalis* (Say): 1867 *Pentatoma dentata*: Walker, Cat. Hem. Brit. Mus., 2: 288.

p. 589. Under *Oebalus insularis, querini* should be *guerini,* two times.

p. 600. Add Ga. to distribution under *Macrocephalus cimicoides.*

p. 603. Correct the spelling of "Costa Rica," under *Phymata granulosa.*

p. 604. Add Cal. to distribution under *Phymata pennsylvanica.*

p. 605. In family title, remove Spinola from authorship.

p. 619. Correct the spelling of *crassipes* under subspecies heading.

p. 625. Change date for tribe Metapterini Stål from 1859 to 1874.

p. 628. *Emesopsis* is feminine; change *E. nubilus* to *nubila.*

p. 632. *Atrachelus* is masculine; change *mucosa* to *mucosus.*

p. 637. Under Subgenus *Diplacodus,* Kirkaldy citation should read:

  1900 *Zelus* (*Diplacodus*) Kirkaldy, Ent. 33: 242. New name for *Dilodus* Amyot and Serville, 1843.

p. 639. Our reason for using the subfamily name Microtominae is based on the authority of the ICZN, Article 40(b): If a family-group name has been replaced before 1961 because of such synonymy [nominate generic name placed in synonymy], and the replacement has won general acceptance, it is to be maintained. Usage between 1924 and 1961:

Hammacerinae: Blatchley (1926), China and Miller (1959), Davis (1961; used interchangeably with Microtominae).

Microtominae: Costa Lima (1935),

Neiva and Lent (1936), Usinger (1943), Wygodzinsky (1949), Fracker and Usinger (1949), Davis (1961; used interchangeably with Hammacerinae).

p. 640. Add Ecuador to distribution of *Homalocoris maculicollis* Stål.

p. 641. Under genus *Melanolestes* and Type-species, date for Herrich-Schaeffer should be 1846.

p. 644. Add author and date "Stål, 1859" to subfamily Saicinae.

p. 649. The type-species of *Triatoma* should be *Cimex gigas*, not *Nabis gigas*.

p. 652. In family title, authorship for Corizidae should be Costa, 1853, not Douglas and Scott, 1865.

p. 653. Chorosomini, based on the type genus *Chorosoma*, should be Chorosomatini. Tribal heading should read: "Tribe Chorosomatini Fieber, 1860," not Chorosomini Douglas and Scott, 1865.

p. 666. Fig. 141, labeled *S. comatula*, should be referred to *S. pexa* (See Polhemus and Chapman, 1979, Bull. Cal. Ins. Surv., 21: 31).

p. 674. Add parentheses around Jakovlev for *Micracanthia bergrothi*.

p. 674. According to Vinokurov (1975, Zool. Zh., 54: 1407), *M. fennica* does not occur in Siberia.

p. 680. Add "Asia" to distributions of *S. pallipes* and *S. palustris*.

p. 683. Delete "Wash." distribution for *Glyptocombus saltator* Heidemann. Error for "Wash., D. C."

p. 687. The type-species for *Phimodera*, *Podops gulgulina*, is a junior synonym of *Tetyra humeralis* Dalman, 1823. Add the latter to the index.

p. 689. Under *Chelysomidea guttata*, date for Herrich-Schaeffer should be 1837.

p. 697. *Xylastodoris* is feminine; change *luteolus* to *luteola*.

p. 708. Date for family name Tingidae Laporte should be 1832.

p. 709. Dates for subfamily Tinginae and tribe Tingini should be Laporte, 1832.

p. 733. Date for *Dictynota fuliginosa* Costa should be 1853, two times.

p. 735. Under *Microvelia* and the synonymic genus *Hydroessa*, the type-species *Hydroessa reticulata* is no longer considered a junior synonym of *Velia pygmaea*.

p. 737. *Microvelia umbricola* Wroblewski, 1838 has been synonymized under *M. buenoi* (Kanyukova, 1986, Sistematika i ekologiya nasekomykh Dal'nego Vostoka, Valdivostok, p. 13), and therefore the distribution of *M. buenoi* includes the Palearctic.

p. 744. Add "t" to Anthocoridae in Anderson and Kelton (1963) reference.

p. 748. Add the following reference:

Barber, H. G. 1916. [Note on *Stynocoris rusticus* and *S. sabulosus*]. Journal of the New York Entomological Society, 24: 104.

p. 750. Delete hyphen in Novitates of Barber (1954) Bimini Island reference.

p. 754. Add the following references:

Blöte, H. C. 1935. Catalogue of the Coreidae in the Rijksmuseum van Natuurlijke Historie. Part II. Coreinae, first part. Zoologische Mededeelingen, 18: 181–227.

Blöte, H. C. 1936. Catalogue of the Coreidae in the Rijksmuseum van Natuurlijke Historie. Part III. Coreinae, second part. Zoologische Mededeelingen, 19: 23–66.

p. 757. According to the original wrapper on Brullé's "Histoire naturelle" in the J. T. Polhemus library, the correct date of publication for part 9 is 1836, not 1835.

p. 758. Capitalize "É" in Études of 1958 Carayon reference.

p. 760. Add following references:

Carvalho, J. C. M. 1986. On a new genus and three new species of myrmecomorphic Miridae with two taxonomical notes (Hemiptera). Annales de la

Société Entomologique de France (new series), 22: 215–221.

Carvalho, J. C. M. and J. C. Schaffner. 1974. Neotropical Miridae, CLIV: *Bicurvicornis, Hyalopsallus* and *Nigrimiris,* new genera of Phylini (Hemiptera). Revista Brasileira de Biologia, 33 (suplementum): 17–22 (1973).

Carvalho, J. C. M. and J. C. Schaffner. 1974. Neotropical Miridae, CLVII: *Adpiasus* and *Mexicomiris,* new genera of Mirinae (Hemiptera). Revista Brasileira de Biologia, 33 (suplementum): 39–46 (1973).

p. 764. Add following reference (see also Guérin-Méneville, p. 782):

Cowan, C. F. 1971. On Guérin's Iconographie: Particularly the insects. Journal of the Society for the Bibliography of Natural History, 6: 18–29.

p. 779. According to Kerzhner (1981, Bull. Zool. Nomen., 38: 205–207) Germar's (Rev. Ent. Publ. Sibermann) work should be dated 1838, not 1837.

p. 782. See Cowan (1971, J. Soc. Biblio. Nat. Hist., 6: 18–29) for further clarification on the dates of Guérin-Méneville's "Iconographie." Apparently, the correct date for the entire text is 1844, not 1831–1838 as determined by Dupuis (1953).

p. 790. The correct pagination for Hoebeke and Wheeler's (1982) *Rhopalus tigrinus* paper is 213–224, not 213–218.

p. 790. Add following reference: Hoffman, R. L. 1971. The insects of Virginia: No. 4. Shield bugs (Hemiptera; Scutelleroidea: Scutelleridae, Corimelaenidae, Cydnidae, Pentatomidae). Virginia Polytechnic Institute and State University, Research Division Bulletin, 67: i–v + 61 pp.

p. 793. Add following reference:

Hungerford, H. B. 1944. Synonymic notes in the genus *Glaenocorisa* Thomson (Hemiptera, Corixidae). Bulletin of the Brooklyn Entomological Society, 39: 32–34.

p. 799. Remove hyphen from Canadian in Kelton's (1976) *Xylocoris* paper.

p. 800. Add following references:

Kerzhner, I. M. 1970. Zur nomenklatur einiger europäischer Blindwanzen (Heteroptera, Miridae). Acta Entomologica Musei Nationalis Pragae, 38: 141–145 (1969).

Kerzhner, I. M. 1979. New Heteroptera from the Far East of the USSR. Trudy Zoologicheskogo Instituta Akademii Nauk SSSR, 81: 14–65. (In Russian).

p. 815. Remove "Mailloux, G. and H. T. Streu (continued)" from middle of Mailloux and Streu, 1979, reference and close space.

p. 826. Add following reference:

Osuna, E. 1981. Revision generica de la tribu Leptoscelidini (Hemiptera, Heteroptera, Coreidae). Universidad Central de Venezuela, Instituto de Zoologia Agricola Publication Maracay. 113 pp., 102 figs., 4 maps.

p. 828. In Péricart, 1972, reference, correct spelling of "L'Quest" to L'Ouest.

p. 829. Correct spelling of "Pimental" (in Pimental and Wheeler, 1973) to Pimentel.

p. 832. Add following reference:

Puchkov, V. G. 1969. Fauna of the Ukraine (Lygaeidae). Kiev, 21 (3): 387.

p. 842. Remove two hyphens from Insectorum in Schouteden's (1907) paper.

p. 846. Delete last (1983 *Lygaeus turcicus*) paper under Alex Slater. This was incorrectly duplicated from the J. A. Slater papers.

p. 847. Transpose "ei" in Society of Slater (1956) *Megaloceraea* paper.

p. 847. Pagination for Slater (1964a) should be 1168, not 1688.

p. 861. In the 2nd Uhler (1978) reference, correct the spelling of "Geographical."

p. 862. Correct the initials of Gillette in Uhler (1895) reference from "G." P. to C. P.

p. 863. Add "l" to Polyctenidae in Usinger (1946) reference.

p. 867. Add "i" to Miridae in Wagner (1970–78) citation.

p. 875. REMINDER ABOUT INDEX: Currently used names in Roman; synonyms, misidentifications, and obsolete combinations in italics; bold for currently used names above species level.

p. 875. Change page number for **Acrosternum** from 382 to 564.

p. 878. Add to 2nd column, as 13th entry from bottom, "*amoemus, Macrotylus* 471."

p. 881. Change "x" to "v" in Kormilev for arizonicus Kormilev, Neuroctenus entry.

p. 896. The generic spelling under *cuneotinctus* (Van Duzee) should be *Sthenarus,* not *Stenarus.*

p. 898. Add to 1st column, as 32nd entry, "*diaphanus Reuter, Atomoscelis* 468" and, as 33rd entry, "diaphanus (Reuter), Hyalopsallus 468."

p. 906. Second column, 6th line from bottom, the generic name "gastrodes" should be capitalized and bold.

p. 911. Add to 1st column, as 19th entry, "**Hyalopsallus** Carvalho and Schaffner 468."

p. 918. Remove dangling "a" before *luctuosum, Mecomma.*

p. 918. Page number for **Macrocephalus** Swederus should be 600, not 500.

p. 921. Add to 2nd column, as 2nd entry from bottom "**Mexicomiris** Carvalho and Schaffner 294."

p. 924. Change page number for genus **Murgantia** Stål from 485 to 585.

p. 926. Add to 1st column as 5th entry from bottom: nigridia Uhler, Lopidea 422. Also in index, the correct author of existing entry should be Uhler, not Knight; to correct with above addition, delete Knight.

p. 926. Add to 3rd column, as 9th entry, "nigriventris Knight, Labopidea 416."

p. 928. Add to 3rd column, as 26th entry after *obtusa, Edessa* the species, "obtusa Uhler, Mozena 87."

p. 937. Change "y" to "t" in Knight of pubescens (Knight), Tytthus entry.

p. 938. Add to 2nd column, as 39th entry, "*quadrata, Glaenocorixa*" and, as 40th entry, "quadrata Walley, Glaenocorisa 117."

p. 939. Add to 2nd column, as 4th entry, "*recticornia, Megaloceraea* 386."

p. 941. Add to 3rd column, as 13th entry, "rubroornatus Knight, Polymerus 358."

p. 945. Add to 3rd column, as 25th entry, "*setuosus, Ceratocapsus* 398."

p. 948. Add page number 23 to "stalii (Reuter), Lyctocoris" entry.

p. 948. Correct the spelling of **Stenomarca** to **Stenomacra.**

p. 951. Add to 1st column, as 25th entry, "texanus Carvalho, Mexicomiris 294."

p. 953. Page number for genus **Tytthus** should be 457, not 501.

p. 956. Add to 2nd column, as 11th entry, "vigilax (Van Duzee), Apachemiris 403"; add to 2nd column, as 13th entry, "*vigilax* Van Duzee, *Orthotylus* 403."

p. 952. Under the entry "*trivittatus, Leptocoris,*" page numbers should read "652, 662," not 552, 562.

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THE IDENTITY OF TWO UNPLACED NEARCTIC TORYMIDAE (HYMENOPTERA)

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Abstract.—Two unplaced Nearctic taxa of Torymidae are recognized. A neotype is designated for the species *Diomorus biorhizae* Ashmead (1887) based upon topotypic, reared specimens. The species is **transferred** to the genus *Torymus* and *Torymus axillaris* Ashmead (1894) is placed as a **junior subjective synonym**. *Lochites punctata* Ashmead (1887) is recognized as the male of *Platykula albihirta* (Ashmead 1887) and is **synonymized** under the latter name.

Key Words: Nomenclature, identification, Torymidae

In the 1979 "Catalog of Hymenoptera of America North of Mexico," two species of the family Torymidae were listed as unplaced taxa (Grissell 1979). One of the species, *Diomorus biorhizae* Ashmead, has been unrecognized since its description and its type has never been found. The other species, *Lochites punctata* Ashmead, is known only from its male type collected in Florida. During the course of preparing a generic reclassification of the Monodontomerinae-Toryminae complex I was able to establish the identity of both taxa. The purpose of this paper is to report the identity and correct nomenclature of the only two Nearctic species of the family Torymidae yet remaining as unplaced species.

Torymus biorhizae Ashmead, NEW COMBINATION

Diomorus biorhizae Ashmead 1887: 186. Neotype female, herein designated, Toronto, Ontario, Canada (USNM, examined).

Torymus axillaris Ashmead 1894: 333. Holotype female, Morgantown, West Virginia, USA (USNM, examined). NEW SYNONYMY.

Diomorus biorhizae was described by Ashmead (1887) from one female collected in Toronto, Canada, and "bred from gall *Biorhiza forticornis* Walsh sent me by Mr. Wm Brodie" [sic]. The species has been unrecognized since its description and the type has never been located. Burks (1967: 250) commented without explanation that the species probably belonged to *Torymus* and that the type was "apparently lost." Since 1967 the species has been listed as "unplaced" (Burks 1967, Grissell 1979), and its generic placement was uncertain.

Some years ago I located the type material of 2 presumed lost Brodie species in the Brodie Collection now housed in the United States National Collection (Grissell 1976). It occurred to me that the lost Ashmead type might also reside there since taxonomists sometimes deposit types of new species in the collection from which the specimens were borrowed. There are well over 15,000 specimens in the Brodie Collection, and unfortunately most are identified only by a simple locality label and a collection number. The record book with corresponding numbers and data for Hymenoptera appears to be lost. Fortunately Brodie was meticulous about keeping the galls from which material emerged and then labelling the gall and its inhabitants with the *same number.* In this way I first located the gall specimens of *Biorhiza forticornis* [now = *Xanthoteras quercusforticorne*] (Hymenoptera: Cynipidae) from which *Diomorus biorhizae* was reared. These were labeled as follows: "Toronto, Ont., 34-91, Collection Wm Brodie." Using the number 34-91 to backtrack through the Brodie Collection, I was able to find 5 female and 4 male specimens associated with this number. All of these specimens bear the same labels as the host gall, but none is distinguished in any other manner. Therefore, it must be assumed that none of these specimens is the specimen seen by Ashmead and that the type, if it exists at all in the Brodie Collection, is unmarked.

There is no doubt that the specimens I found represent the species *Diomorus biorhizae* as described by Ashmead. Ashmead's description fits the specimens found in the Brodie Collection in every detail, including the posterior femora which "have a distinct tooth beneath near apex," the body with "some distinct, larger, coarser punctures" and a slight shading of the wing beneath the stigmal vein. The species is, in fact a member of the genus *Torymus* as defined by my earlier study of the nearly 100 known Nearctic species of the genus (Grissell 1976). It has a combination of characters found only in the 6 species that make up the *fullawayi* species-group.

Since the original description of *D. biorhizae* in 1887, Ashmead's holotype has not been found in over 100 years of work on the USNM collection. It also has not been found in the Brodie Collection. In Burks' opinion (1967) and in my opinion the type is lost. The extant material in the Brodie Collection is certainly topotypic and from the same host as the type. It matches the description in every way and is what Ashmead meant by the name *D. biorhizae.* It is a member of the genus *Torymus,* and because this is such a speciose genus (over 450 names world-wide), because the species are extremely difficult to delimit, and because the nomenclature is fraught with problems, I believe it is important to establish nomenclatural stability in the genus whenever this can be done. I therefore select and label as neotype a female from among the Brodie specimens to act as the namebearer for the species *biorhizae.*

In 1894 Ashmead described the species *Torymus axillaris* from a single female from Morgantown, West Virginia. It has not been collected since. It, too, is a member of the *fullawayi* group and falls within the range of variation found in the 9 specimens of *T. biorhizae.* In Grissell (1976) I keyed *T. axillaris* on the basis of the median carina being confined to the anterior one-third of the propodeum, but after examining *T. biorhizae* it is apparent that this carina varies from being weakly broken and almost absent to entire and strongly expressed within the single series. Based upon these data, I place *T. axillaris* as a subjective junior synonym of *T. biorhizae.*

In couplet 4 of my key to Nearctic females of the *fullawayi* species-group (Grissell 1976), I used the state of the propodeal carina as a key character to separate the eastern species *T. axillae* (now = *T. biorhizae*) from the western species *T. denticulatus* (Breland) and *T. fullawayi* (Huber). This character is not adequate to distinguish these species. Therefore couplets 4 and 5 of my key should be restructured as follows:

4. Upper surface of costal cell distally with at most 1 seta, lower surface essentially bare (eastern Nearctic) . . . . *biorhizae* (Ashmead)
   Upper and lower surfaces of costal cell distally each with row of several setae (western Nearctic) 5
5. Propodeum without carina; hindfemur with

denticulate angle; basal vein asetose .... *denticulatus* (Breland)
Propodeum with carina; hindfemur with distinct tooth; basal vein setose ..*fullawayi* (Huber)

Platykula albihirta Ashmead

Syntomaspis albihirta Ashmead 1887: 187. Holotype female, Jacksonville, Florida (USNM, examined).

Lochites punctata Ashmead 1887: 185. Holotype male, Jacksonville, Florida (USNM, examined). New Synonymy.

Ashmead (1887) described both *Lochites punctata* (male) and *Syntomaspis albihirta* (female) in the same paper from single specimens "taken at large" presumably from Florida (although this was not specifically stated). Labels on both specimens state Jacksonville, Florida as the type locality. The species *L. punctata* has long been unplaced because it is difficult to place male specimens of torymids to species. Also the head, one pair of wings, and some legs were broken off in past times and this has confounded its recognition. I have been working at the species level in this group for many years, and I was able to recognize an important autapomorphy in *L. punctata* known so far only in the monotypic genus *Platykula.* This is the enlarged, bristle-like hindtibial spur. In no other genus does the spur exist in this form.

In 1927, Huber described the new genus *Platykula* for *Syntomaspis albihirta.* This is the only known species in the genus, and I have seen dozens of specimens, both males and females. When I examined the male type of *L. punctata* it was clear that it is conspecific with *P. albihirta.* As both species were described in the same paper either name could have priority, but I chose *P. albihirta* because this type is in better condition and is based upon the female. Thus, *L. punctata* becomes a subjective junior synonym of *Platykula albihirta.*

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A NEW GENUS OF CERATOPOGONINI (DIPTERA: CERATOPOGONIDAE) FROM BRAZIL

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Abstract.—**Bahiahelea**, new genus is described from Bahia, Brazil, with type-species **Bahiahelea brasiliensis**, new species. The species is illustrated and characters are given to distinguish the genus from other predaceous midges of the tribe Ceratopogonini.

Key Words: Diptera, Ceratopogonidae, Ceratopogonini, predaceous midges, Brazil

Recent collections from emergence traps in a cacao plantation in Bahia, Brazil, yielded midges apparently representing a new genus of the predaceous midge tribe Ceratopogonini. The midges resemble species of *Neurohelea* Kieffer and *Neurobezzia* Wirth and Ratanaworabhan in the tribe Heteromyiini, but a close examination of structural details, especially of the male and female genitalia, indicates that they are members of the tribe Ceratopogonini.

For an explanation of ceratopogonid terminology see the publications by Wirth et al. (1977) and Downes and Wirth (1981). The holotype and allotype are deposited in the Museu de Zoologia, Universidade de Sao Paulo, Sao Paulo, Brazil. Paratypes will be deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C.; British Museum (Natural History), London; Museum National d'Histoire Naturelle, Paris; Canadian National Collection, Agriculture Canada, Ottawa; Instituto Oswaldo Cruz, Rio de Janeiro, Brazil; and Museo de La Plata, La Plata, Argentina.

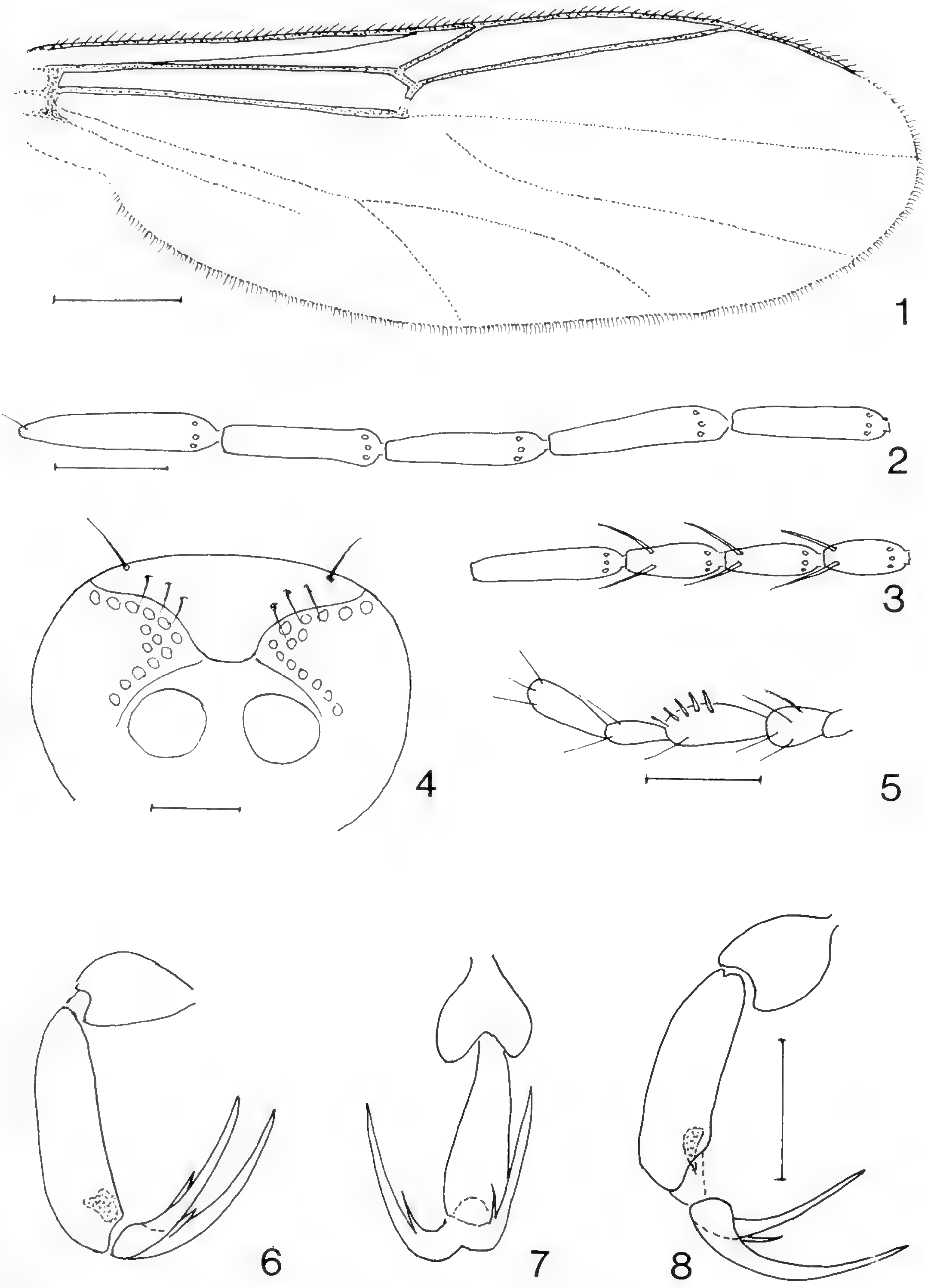
***Bahiahelea* Wirth, NEW GENUS**

Type-species, *Bahiahelea brasiliensis,* NEW SPECIES, by present designation.

Diagnosis.—Small blackish midges with unmarked wings and unarmed legs; wing length 1.1–1.4 mm.

Head: Eyes (Fig. 4) broadly separated, bare. Antenna (Figs. 2, 3) moderately long, distal five segments slightly elongated in female, distal four elongated in male; male antenna with well-developed plume. Palpus (Fig. 5) 5-segmented, elongate, third segment slightly swollen, without pit but a few sensilla borne on ventromesal surface. Female mandible with seven well developed teeth.

Thorax: Robust, without strong bristles or anterior spine or tubercle (Fig. 9). Legs moderately slender, femora unarmed; tarsi with strong ventral spines only at apices of tarsomeres 1–3 of mid leg; ventral palisade setae (bulbous hairs) only on hind basitarsus; tarsomere 4 short and more or less cordiform (Figs. 6–8); tarsomere 5 slender and elongate, unarmed ventrally, not inflated on fore leg. Female claws (Figs. 6–8) long and slender, gently curved, subequal, each with slender basal inner tooth. Wing (Fig. 1) of both sexes with costa produced beyond tip of R4 + 5 to 0.9 of wing length; one radial cell, extending to 0.8 of wing length in female, radial cell broad, especially at base; media forking slightly past r-m crossvein,



Figs. 1–8. *Bahiahelea brasiliensis,* female: 1, wing. 2, antennal segments 11–15. 3, antennal segments 8–11. 4, eye separation. 5, palpus. 6, fourth and fifth tarsomeres and claws of fore leg. 7, same, mid leg. 8, same, hind leg. Scale bar = 200 microns, Fig. 1; 50 microns, Figs. 2–8.

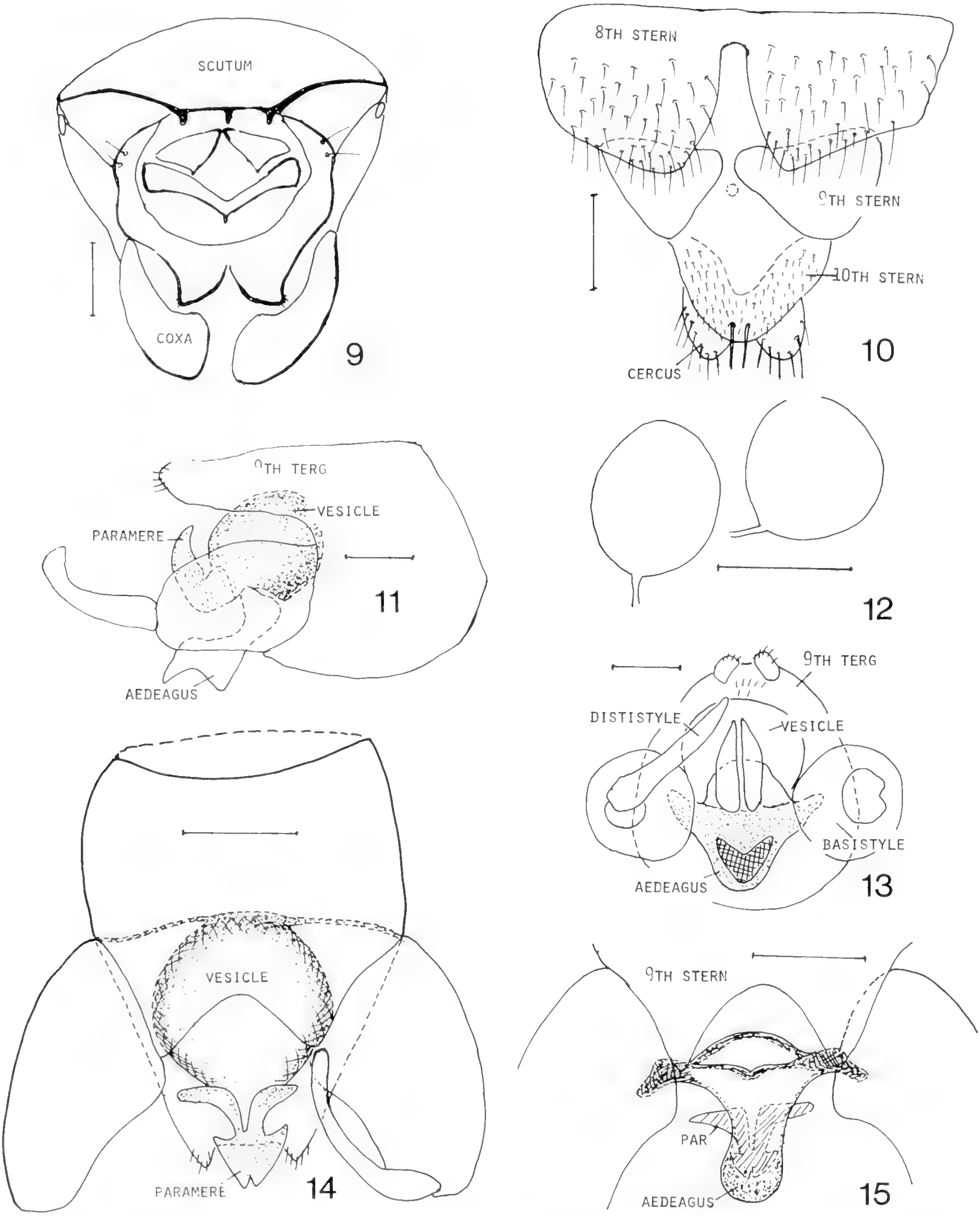
fork thus with short petiole, vein M2 narrowly interrupted at base.

Abdomen: Female abdomen moderately stout, eighth sternum (Fig. 10) cleft mesally nearly to anterior margin, the lobes setose; lobes of ninth sternum strongly sclerotized near gonopore. Two subspherical to short-oval spermathecae (Fig. 12), each with slender neck. Male genitalia (Fig. 14) large and strongly sclerotized; ninth segment forming a cylindrical structure slightly longer than broad; tergite 9 tapering caudally to blunt apex; sternite 9 (Fig. 15) with deep caudomedian concavity, the bluntly angular sublateral lobes articulating distally with mesal angulation of basistyles and lateral arms of aedeagus. Basistyle (Fig. 14) stout, swollen at base, with distinct mesal protuberance at basal third; dististyle long and slender, hooklike. Aedeagus (Fig. 15) strongly sclerotized, basal arms directed laterad, basal arch absent; distal process in ventral view (Fig. 15) broad with rounded tip, in lateral view (Fig. 11) bilobate and directed posteroventrad. Parameres (Fig. 14) small and displaced caudad by a large, globular, sclerotized anterior vesicle (Fig. 11) that fills the space between bases of basistyles and distal portion of ninth sternite; parameres themselves with boomerang-shaped basal arms articulating with mesal protuberance of basistyle; fused on distal halves, the distal portion caplike with sharp lateral subapical points directed dorsad; cerci located at apex of tergite 9.

Discussion.—The bare wing with the media forking distad of the r–m crossvein, vestigial empodium, elongate female claws, and presence of palisade setae on the hind basitarsus will place *Bahiahelea* in the tribe Ceratopogonini of the subfamily Ceratopogoninae. *Bahiahelea* will key out in Wirth and Grogan's (1988) revision of the tribe Ceratopogonini to couplet 19 with *Brachypogon (Brachypogon)* Kieffer (1899) and *Afrohelea* Wirth (1965), but due to the artificial nature of the key it is not closely related to them. *Bahiahelea* lacks sensilla coeloconica on antennal segments 3 (a valuable character for determining relationships in this tribe) thus differing from *Brachypogon,* and the male antenna is plumose (as usual), thus differing from *Afrohelea.*

Bahiahelea appears to be most closely related to a group of genera in the Ceratopogonini in which, at least in the female, the (second) radial cell is elongate, extending to at least 0.80 of the wing length, and the costa continues past its apex nearly to the wing tip. Wirth and Grogan (1988: 49) presented a table of characters comparing these genera. *Parabezzia* Malloch (1915) differs in its 4-segmented palpus, female tarsal claws usually unequal, the male fore coxae with dense long spinelike bristles, and male genitalia of typical ceratopogonine structure but with poorly developed parameres. *Diaphanobezzia* Ingram and Macfie (1931) resembles *Parabezzia* in differing from *Bahiahelea,* but has only sparse spinelike setae on the male fore coxae, straplike halteres, and equal female tarsal claws. *Fittkauhelea* Wirth and Blanton (1970) has pubescent eyes, 4-segmented palpus, female tarsal claws subequal to slightly unequal, female spermathecae without necks, and male parameres absent. *Heteroceratopogon* Wirth and Grogan (1988) differs in having two well-developed radial cells on the wing, fore femur greatly swollen with numerous stout ventral spines, female tarsal claws subequal to slightly unequal, and male parameres absent. The male genitalia of *Bahiahelea* somewhat resemble those of several genera of Ceratopogonini, but are so highly modified in the shape and arrangement of the ninth sternite, aedeagus, and parameres, and especially the strange internal vesicle, that they cannot be closely compared with any other known genus of Ceratopogonidae.

Bahiahelea bears a close superficial resemblance to the genera *Neurohelea* Kieffer (1925) and *Neurobezzia* Wirth and Ratanaworabhan (1972) in the tribe Heteromyiini,



Figs. 9–15. *Bahiahelea brasiliensis,* 9–10, 12, female; 11–15, male: 9, anterior view of thorax, diagrammatic. 10, eighth, ninth, and tenth sternites and cerci, ventral view. 11, genitalia, lateral view. 12, spermathecae. 13, posterior view of genitalia, diagrammatic. 14, genitalia, ventral view. 15, detail of aedeagus, ventral view, with portions of ninth sternite and basistyles, and parameres (cross-hatched). Scale bar = 100 microns, Fig. 9; 50 microns, Figs. 10–15.

in body size and habitus; wing with elongate radial cell and costal extension; equal, elongate tarsal claws with well-developed inner basal teeth; slender, unmodified femora; and cordiform fourth tarsomeres. The male genitalia of *Neurohelea,* however, are typically Heteromyiine, resembling those of the genus *Pellucidomyia* Macfie (1939). I have the undescribed pupa of *Neurohelea nigra* Wirth (1952), which resembles that of *Parabezzia,* differing from the pupa of *Clinohelea* Kieffer (1917) in the Heteromyiini, and indicating that *Neurohelea* (and possibly *Neurobezzia,* whose male and pupa are undescribed) may belong in the Ceratopogonini near *Bahiahelea.* Grogan and Wirth (1979) discussed generic relationships in the tribe Heteromyiini and gave a key to the genera. Clastrier (1983) described a second species of the genus *Neurobezzia.* The male of *Neurobezzia* remains undescribed, as the male described by Grogan and Wirth (1978) and attributed to *N. granulosa* (Wirth) (1952) is a species of *Palpomyia* Meigen (1818).

Bahiahelea brasiliensis **Wirth,**
NEW SPECIES
(Figs. 1–15)

Female holotype.—Wing length 1.36 mm; breadth 0.50 mm.

Head: Dark brown including antennae and palpi. Antenna with lengths of flagellar segments in microns: 61-43-43-43-43-43-47-47-79-82-86-90-87; antennal ratio (11-15/3-10) 1.07. Palpus with lengths of segments in microns: 14-36-47-32-47. Mandible with seven strong teeth distally and 4–5 barely perceptible proximal ones.

Thorax: Dark brown; mesonotum with sparse, fine, hairlike, brownish setae, stronger above wing bases; scutellum with 18 fine setae. Legs dark brown on femora and tibiae, tarsomeres 1–2 whitish, 3–5 brownish; femora and tibiae moderately stout, tibiae without strong extensor setae; hind tibial comb with eight slender spines, the spur short and inconspicuous. Hind leg with lengths from femur to tarsomere 5 in microns: 690-620-288-100-72-43-85. Mid tarsus with one strong spine at base of tarsomere 1, two apical spines on tarsomeres 1–3; hind basitarsus with abrupt bend at base. Claws (Figs. 6–8) long, slender and equal on all legs, each with short, slender, basal inner tooth; lengths: 86 microns on fore leg, 72 on mid leg, and 79 on hind leg. Wing (Fig. 1) slightly infuscated due to coarse microtrichia, veins brownish; one radial cell extending to 0.81 of wing length; costa produced further to 0.90 of wing length, less conspicuous distally; media with short petiole, vein M2 narrowly interrupted at base. Halter pale.

Abdomen: Pale brown, with sparse short brownish setae arising from pigmented sockets; segments 8 and 9 more strongly pigmented; sternum 8 setose, divided on midline; lobes of sternum 9 blunt, deeply pigmented (Fig. 10). Spermathecae (Fig. 12) two, slightly unequal, short oval to subspherical, with slender necks; measuring 61 by 59 microns and 58 by 50 microns, necks 11 to 17 microns long.

Male allotype.—Wing length 1.11 mm; breadth 0.39 mm.

Similar to the female with the usual sexual differences. Antenna with dense brown plume arising from segments 3–12; lengths of flagellar segments in microns: 83-50-47-47-47-43-43-43-54-72-86-86-90; antennal ratio (12-15/3-11) 0.73. Palpus with lengths of segments in microns: 17-28-43-32-43. Hind leg with lengths from femur to tarsomere 5 in microns: 516-454-220-94-65-36-79. Claws equal on all legs, stout and curved to sharp points, length 29 microns. Wing as in female but costa shorter, costal ratio 0.84.

Genitalia (Figs. 11, 13–15): As in generic diagnosis, large and strongly sclerotized. Ninth segment as in Fig. 14. Basistyle (Fig. 14) stout, swollen at base, tapering and mesally somewhat concave distally; dististyle (Fig. 14) long and slender, somewhat curved hooklike. Aedeagus (Figs. 11, 15) with strongly sclerotized basal arms directed laterad at level to tips of lobes on ninth sternum, without basal arch but with low basal convexity; distal process broad with rounded tip. Parameres as in Figs. 11, 13–14.

Distribution.—Brazil.

Types.—Holotype female, Brazil, Bahia, Itajuipe, Fazenda Almirante, 9.xii.1988, J. A. Winder, in emergence trap. Allotype male, same data but date 21.x.1988. (Holotype and allotype deposited in the Museu Zoologia, Universidade de Sao Paulo, Sao Paulo, Brazil). Paratypes, 7 males, 9 females, same data but dates 21.x.1988, 18.xi.1988, 9,15,23.xii.1988, 19.iv.1989, 3.vii.1989, 6,8,13.xii.1989, 17.22.x.1990, 2.xi.1990.

Discussion.—Since *Bahiahelea brasiliensis* is the only known species of the genus, refer to the discussion under the generic diagnosis.

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PLECOPTERA OF HEADWATER CATCHMENTS IN THE FERNOW EXPERIMENTAL FOREST, MONONGAHELA NATIONAL FOREST, WEST VIRGINIA

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Abstract.—The Fernow Experimental Forest is a research facility of the U.S. Forest Service located on the Allegheny Plateau in the northern part of Monongahela National Forest in Tucker Co., WV. This 1474-ha experimental forest encompasses the entire drainage of Elklick Run, a 4th order tributary to the Black Fork of the Cheat River. As part of several ongoing studies of the ecology of streams in the Fernow Experimental Forest, we conducted a survey of adult aquatic insects in 6 of these small catchments. From this survey, we identified 27 species of Plecoptera including 1 species of Pteronarcyidae, 1 of Peltoperlidae, 1 of Taeniopterygidae, 2 of Capniidae, 7 of Leuctridae, 4 of Nemouridae, 5 of Chloroperlidae, 1 of Perlidae, and 5 of Perlodidae.

Key Words: Plecoptera, species list, Fernow Experimental Forest, West Virginia

The Fernow Experimental Forest is one of several experimental forest areas operated by the Northeastern Forest Experiment Station of the U.S. Forest Service for catchment-level research in forestry and watershed management. It is 5 km south of Parsons in Tucker County, West Virginia in the northern part of Monongahela National Forest (39°3′N, 79°40′W) (Fig. 1). Established in 1951, the 1474-ha experimental forest is in the Allegheny Plateau Province of the central Appalachians (Aubertin and Patric 1974) and includes the entire catchment of Elklick Run, a 4th order tributary of the Black Fork of the Cheat River. The experimental forest includes 9 gauged experimental catchments and several ungauged catchments (Fig. 1).

Our research in the Fernow Experimental Forest on the effects of acid precipitation and the nontarget effects of the application of the forest pesticide, diflubenzuron, has included work on the macroinvertebrate communities of the 2nd order streams that drain several of these headwater catchments (Griffith and Perry 1991). Only two previous studies have produced surveys of streams in the Fernow Experimental Forest. Case (1983) collected kick samples of aquatic nymphs from Watersheds 1, 4, and 6 and three catchments outside the experimental forest. Harris (1973) collected adults with emergence traps and nymphs with an Eckman dredge from the weir ponds of Watersheds 1, 3, 4, 6, and 7. Both studies identified the insects primarily to genus. Also, little collecting has been done by other active Plecoptera researchers in this part of West Virginia (R. Kirchner, pers. comm.).

To facilitate ongoing research at the Fer-

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[1] The Unit is jointly sponsored by the West Virginia Department of Natural Resources, West Virginia University, the U.S. Fish and Wildlife Service, and the Wildlife Management Institute.

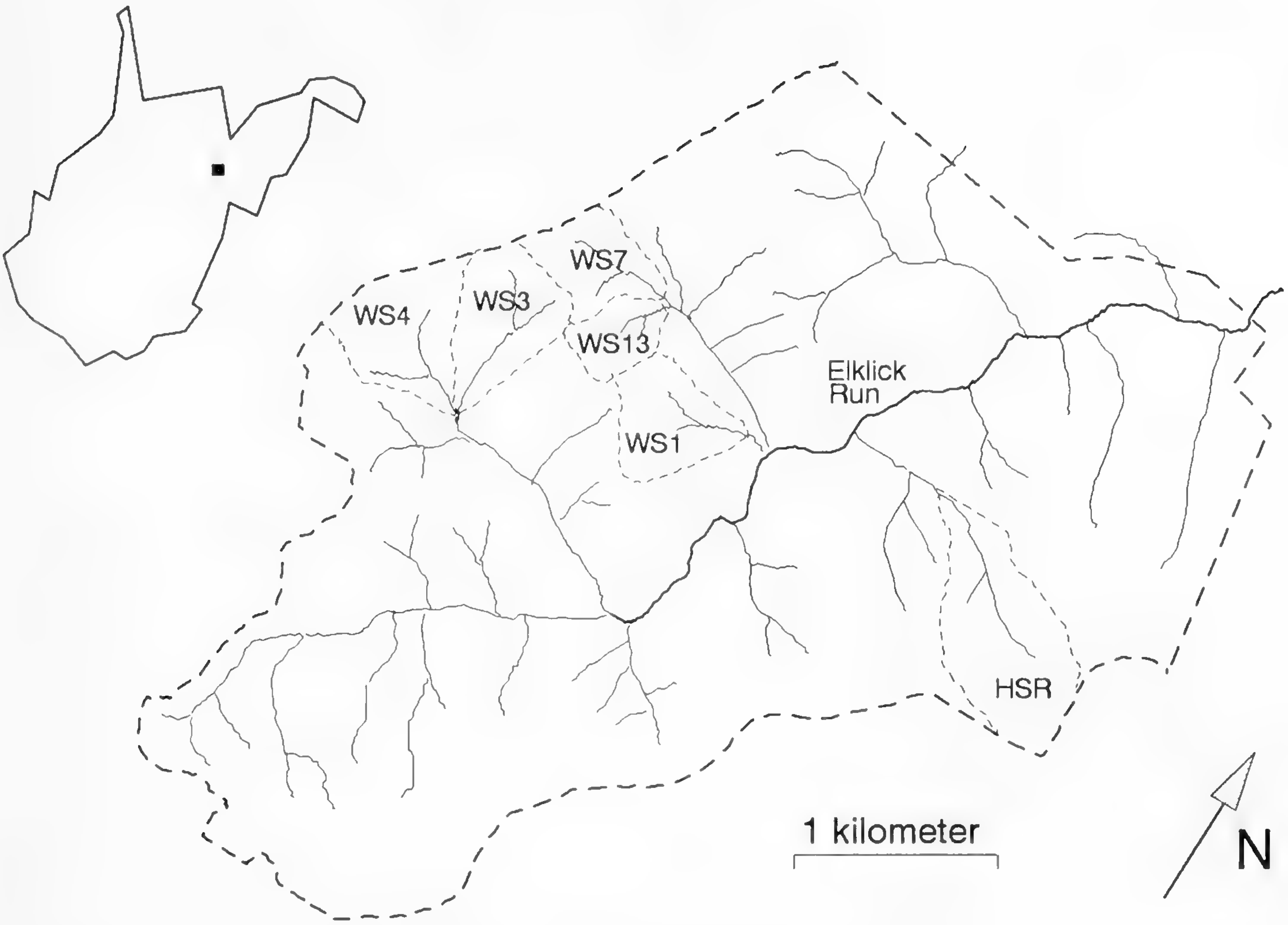

Fig. 1. Fernow Experimental Forest with the locations of study catchments.

now Experimental Forest, we conducted a survey of aquatic insects in the streams draining the catchments used in our present studies. From these collections, we present a species list of the Plecoptera.

STUDY SITES

The study sites include 1 ungauged and 5 gauged streams that drain 2nd order catchments in the Fernow Experimental Forest (Table 1). Watershed 1 (WS1), Watershed 3 (WS3), Watershed 4 (WS4), Watershed 7 (WS7), and Watershed 13 (WS13) drain gauged catchments on the north side of Elklick Run (Fig. 1) and are underlain by shale and siltstones of the Hampshire formation. Soils in the catchments are primarily Calvin silt loams with some Earnst silt loams

Table 1. Physical and chemical characteristics of study streams in the Fernow Experimental Forest, Tucker County, West Virginia.

	WS1	WS3	WS4	WS7	WS13	HSR
Order	2nd	2nd	2nd	2nd	2nd	2nd
Catchment Area (ha)	29.9	38.2	41.0	24.3	14.5	230.3
Mean Altitude (masl)	704	819	812	768	743	852
Last Logged	1958	1969	1910	1969	1910	1910
Mean Discharge (m^3/sec)	0.0070	0.0085	0.0097	0.0076	0.0045	0.0248
pH	6.16	6.09	6.02	6.18	6.14	7.53
Alkalinity (mg/l $CaCO_3$)	2.03	0.83	0.59	1.30	1.24	35.80

Table 2. Checklist of Plecoptera collected from streams in the Fernow Experimental Forest, Monongahela National Forest, West Virginia, 1989–1991.

	HSR	WS1	WS3	WS4	WS7	WS13
Order Plecoptera						
Suborder Arctoperlaria						
Group Euholognatha						
Superfamily Nemouroidea						
Family Taeniopterygidae						
Subfamily Brachypterinae						
Strophopteryx appalachia Ricker and Ross			X			
Family Nemouridae						
Subfamily Amphinemourinae						
Amphinemoura nigritta (Provancher)	X	X	X	X	X	
**A. wui* (Claassen)		X	X	X	X	X
Subfamily Nemourinae						
Ostrocerca complexa (Claassen)		X	X	X		X
**Soyedina washingtoni* (Claassen)	X		X	X		
Family Leuctridae						
Subfamily Leuctrinae						
Leuctra alexanderi Hanson				X		X
L. grandis Banks	X		X	X		X
L. ferruginea (Walker)	X	X	X	X	X	X
L. sibleyi Claassen	X		X	X	X	X
L. tenella Provancher		X	X	X		X
L. truncata Claassen	X	X	X			X
Paraleuctra sara (Claassen)				X		
Family Capniidae						
Allocapnia frisoni Ross and Ricker			X	X		
Paracapnia angulata Hanson	X	X	X			
Group Systellognatha						
Superfamily Pteronarcyoidea						
Family Pteronarcyidae						
Pteronarcys biloba Newman			X			
Superfamily Peltoperloidea						
Family Peltoperlidae						
Subfamily Peltoperlinae						
Peltoperla arcuata Needham	X	X	X	X	X	X
Superfamily Perloidea						
Family Perlodidae						
Subfamily Isoperlinae						
Isoperla slossonae (Banks)	X	X	X	X	X	X
**Isoperla* sp. A		X	X	X	X	X
Subfamily Perlodinae						
Malirekus hastatus (Banks)	X		X			
Remenus bilobatus (Needham and Claassen)			X			
Yugus bulbosus (Frison)	X	X	X	X	X	X
Family Perlidae						
Subfamily Acroneurinae						
Acroneuria carolinensis (Banks)	X					

Table 2. Continued.

	HSR	WS1	WS3	WS4	WS7	WS13
Family Chloroperlidae						
Subfamily Chloroperlinae						
Alloperla aracoma Harper and Kirchner	X					
A. usa Ricker	X	X	X	X		
Suwalia marginata (Banks)	X	X				
Sweltsa lateralis (Banks)	X		X	X	X	X
S. onkos (Ricker)	X	X	X	X		X

* New state record for West Virginia.

(Losche and Beverage 1967). WS4 and WS13 are reference catchments that have undergone little disturbance since about 1910, except for the removal of dead American chestnuts (*Castanea dentata* (Marsh.) Borkh.) in the 1940's (Aubertin and Patric 1974). They currently support mature forest stands dominated by red oak (*Quercus rubra* L.), sugar maple (*Acer saccharum* Marsh.), and American beech (*Fagus grandifolia* (Ehrh.). WS1, WS3, and WS7 are experimental catchments that were last logged in 1958, 1969, and 1969, respectively. WS1 supports a 30-year-old forest stand dominated by yellow poplar (*Liriodendron tulipifera* L.), red maple (*Acer rubrum* L.), and black birch (*Betula lenta* L.). WS3 and WS7 support 20-year-old forest stands dominated by black cherry (*Prunus serotina* Ehrh.) and black birch (J. Kochenderfer, U.S. Forest Service, pers. comm.).

The North Fork of Hickman Slide Run (HSR) drains an ungauged catchment on the south side of Elklick Run (Fig. 1) and is underlain by limestones and shales of the Greenbriar and Mauch Chunk formations. Soils in the catchment are primarily Calvin silt loams and Belmont stony loams (Losche and Beverage 1967). Little research has been conducted on catchments on the south side of the Fernow Experimental Forest, and HSR has undergone little disturbance since about 1910, except for the removal of dead American chestnuts in the 1940's (Aubertin and Patric 1974). HSR currently supports a mature forest stand similar to that of WS4 and WS13. Because of the presence of limestone in its catchment, HSR is characterized by higher pH and alkalinity than the other streams (Table 1).

MATERIALS AND METHODS

The survey was conducted primarily with emergence traps modified from the WEEK design of LeSage and Harrison (1979). These collections were supplemented by periodic light trapping with blacklight traps and collections by hand when adults were observed during other sampling. One species, *Remenus bilobatus* (Needham and Claassen), has not been collected in the adult stage and was identified from nymphs in benthic samples.

Trapping of emerging insects on WS3 and WS4 began in June 1989. Trapping of emerging insects in WS4 continued through June 1991, whereas the emergence trap on WS3 was removed in May 1990. Trapping of emerging insects on HSR started in May 1990 and was continued through June 1991. Emergence traps on WS1, WS7, and WS13 were placed in May 1990 and trapping continued through June 1991 except for a period in December 1990 and January 1991. Sampling intervals varied from 1 week to 4 weeks.

All collected material was preserved in 85% ethanol. Voucher specimens have been placed in the collection of the West Virginia Cooperative Fish and Wildlife Research Unit in the Division of Forestry at West Virginia University. Specimens of *Soyedina* *washingtoni* (Claassen) have been placed in the entomology collection of the Smithsonian Institution.

Results and Discussion

We collected 27 species of 19 genera and 9 families of Plecoptera from headwater streams in the Fernow Experimental Forest (Table 2). Tarter and Kirchner (1980) reported a total of 106 species of 37 genera and 9 families of Plecoptera for the entire state of West Virginia. By confining our survey to these headwater reaches, some species which may occur in larger streams in the Elklick catchment were missed. A collection from Elklick Run produced adults of the nemourid, *Prostoia similis* (Hagen).

We collected 2 species that were new records for the state of West Virginia: *Soyedina washingtoni* and *Isoperla* sp. A. Our collections of *S. washingtoni* from the Fernow Experimental Forest seem to represent the southern-most records of this species, which is found primarily in New England (Hitchcock 1974). *Isoperla* sp. A is an undescribed species in the *Isoperla montana* group which has been previously reported from the piedmont of Virginia, North Carolina, and South Carolina (S. W. Szczytko, University of Wisconsin, La Crosse; pers. comm.). Our collections represent an extension of the range of this species into the Appalachians.

West Virginia appears to be an area of transition for the distribution of many species of Plecoptera in the Appalachians. Tarter and Kirchner (1980) suggest that West Virginia was a glacial refuge, and our collections include a number of species whose distributions occur largely to the north of West Virginia. In addition to *Soyedina washingtoni,* species in this group include *Paracapnia angulata, Ostrocerca complexa, Sweltsa onkos, Peltoperla arcuata,* and *Isoperla slossonae.* A number of other species, however, exhibit more southerly distributions including *Leuctra alexanderi, Amphinemoura wui, Alloperla usa,* and *Yugus bulbosus* (Stark et al. 1986).

A number of species exhibited patterns of presence or absence between the streams. Most species that were collected in only 1 or 2 streams, particularly those emerging in the winter, were probably under-collected. Examples of this include *Allocapnia frisoni* and *Paraleuctra sara.* Others such as *Strophopteryx appalachia* and *Suwallia marginata* are probably rare. *Pteronarcys biloba* is common in downstream reaches of Elklick Run but has not been collected in benthic samples from the study reaches, and we probably collected an adult which had flown from downstream (M. Griffith, pers. obser.).

One important pattern may be the presence or absence of species in the more alkaline stream, HSR, that are absent from or occur in the other streams. *Acroneuria carolinensis* and *Alloperla aracoma* were collected only from HSR. *Amphinemoura wui, Ostrocerca complexa, Leuctra tenella,* and *Isoperla* sp. A were not collected from HSR but were found in several of the other streams. These observations are tentative because we only observed emergence from one alkaline stream, but they suggest that water chemistry may be influencing the distribution of some species of Plecoptera in these headwater streams. Research has shown that some Plecoptera are resistant to low pH associated with the problem of acid precipitation, and Plecoptera tend to dominate the invertebrate community of such streams. Simpson et al. (1985) found *Leuctra ferruginea* to be the dominant species in low pH streams in the Adirondacks. Perlic (1985) found *Amphinemoura* sp. and *Leuctra* sp. to be dominant in low pH streams in the Laurel Highlands of Pennsylvania just to the north of the Fernow. There are few other studies which have compared stonefly species assemblages between neutral and more alkaline streams, but Plecoptera are often replaced as the dominant shredder in alkaline streams in the Appalachians by the amphipod, *Gammarus minus* (Glazier and Gooch 1987).

Another pattern may be the presence of

Leuctra alexanderi only in the two streams draining the control catchments, WS4 and WS13. This suggests that catchment management history may also influence the distribution of some species of Plecoptera in these streams.

In general, a number of factors may influence the distribution of Plecoptera between streams even within a small area. Unfortunately, most researchers work only with the nymphal stage, for which identification to the species level is often impossible. This may obscure the effect of environmental factors on these species assemblages. Surveys such as this study may give insights into more subtle changes in species assemblages between streams. Also, the species lists they produce provide a basis for recognition of species in benthic studies which will improve research conducted in established research areas such as the Fernow Experimental Forest.

ACKNOWLEDGMENTS

P. Edwards and J. Kochenderfer of the Timber and Watershed Laboratory, Fernow Experimental Forest, provided the background data on the catchments. R. F. Kirchner and Dr. S. W. Szczytko verified the identifications. D. Eaton and E. Harrahy assisted with collection of emergence trap samples. Dr. D. C. Tarter provided critical review of the draft manuscript. This research was supported by grants from the Fernow Experimental Forest and the Appalachian Integrated Pest Management project of the Northeastern Forest Experimental Station, U.S. Forest Service and a Swiger Doctoral Fellowship to the first author from West Virginia University.

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NOTE

Japanagromyza polygonivora (Diptera: Agromyzidae) from Florida, a synonym of *J. polygoni*

Japanagromyza polygonivora Wiegmann, recently described from Florida (Wiegmann 1991, Proceedings of the Entomological Society of Washington 93: 62–66) mining the leaves of *Polygonum,* is a junior synonym of *J. polygoni* Spencer 1973. Since its publication, several colleagues have informed me of the synonomy of this species, first described by Spencer (1973, Revista Fac. Agron., Maracay 7(2): 5–108) from Venezuela. Genitalic characters such as the forked surstylus and shape of the aedeagus, as well as the host association with *Polygonum,* confirm the identity of the two species. Its discovery in Florida is the first record of *J. polygoni* Spencer from the United States.

Brian M. Wiegmann, *Department of Entomology, University of Maryland, College Park, Maryland 20742.*

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OBITUARY

Henry K. Townes, Jr.
20 Jan. 1913–2 May 1990

The death of Dr. Henry Townes has left the entomological community much diminished. He was widely known for his work on Hymenoptera systematics, particularly the large and difficult family Ichneumonidae. His influence, by published research and interaction with his peers, was enormous.

An appreciation of Henry's life and work was published in 1982 by V. K. Gupta (Contrib. American Ent. Inst. 20: 1–14) and the interested reader is referred there for details. Henry was born in Greenville, South Carolina. He enrolled at Furman University (in Greenville) at the age of 16, and graduated in 1933 with a B.S. in biology and a B.A. in languages. His Ph.D was obtained at Cornell University (1933–1937) under J.C. Bradley. It was Bradley who suggested Henry work upon Ichneumonidae; Henry's original interests leaned toward Chalcidoidea but Bradley discouraged him with the advice that chalcidologists ruined their eyesight and were prone to mental instability. A number of jobs followed graduation from Cornell, including a fellowship at the Academy of Natural Sciences of Philadelphia (1940–1941) to work on a catalogue of Nearctic Ichneumonidae. Employment with the U.S. Department of Agriculture in Washington, D.C., began in 1941 and he was assigned to work on Diptera, Orthoptera, Neuroptera, and aculeate Hymenoptera before being appointed as specialist on Ichneumonidae upon R. A. Cushman's retirement. Henry left the USDA in 1949 for a faculty appointment at North Carolina State University, working on insects attacking tobacco. Except for a two-year interlude as an advisor to the Philippine government on pests of rice and corn (1952–1954), he stayed in North Carolina until 1956. In that year, R. R. Dreisbach, a Dow Chemical Company chemist and amateur hymenopterist, arranged grant support from Dow Chemical for Henry to work on ichneumonid systematics. Henry and his family moved to Ann Arbor, Michigan, where his research and collection were initially associated with the University of Michigan. The move allowed Henry the freedom to pursue ichneumonid studies uninterruptedly. Starting in 1957, various grants were obtained from the National Science Foundation and the National Institutes of Health; the results of these grants (and those from Dow Chemical) were published in 1959–1978 as three volumes of the *Bulletin of the U.S. National Museum* and ten *Memoirs of the American Entomological Institute* (including the four volume revision of the genera of Ichneumonidae).

From about 1933, Henry had been building up a collection of Hymenoptera (with special emphasis on the Ichneumonidae) with the assistance of his wife, Marjorie Chapman Townes. Malaise traps began to be used by Henry for collecting in the late 1950's, both on his own expeditions and by supplying them to others to collect for him. The collection followed the Townes through their various moves and was stored in a variety of private dwellings and university facilities. The collection (and associated library) moved to a private collection building on the home property of the Townes' in 1964 and the American Entomological Institute was established in the same year as a non-profit organization for the collection and library. By the late 1970's, the collection comprised more than 700,000 specimens and the question of what was to become of it and the library preoccupied the Townes. It was decided to relocate the American Entomological Institute to Gainesville, Florida, where it would function as a fully independent organization dedicated to Hymenoptera systematics, with emphasis on the Ichneumonoidea. This move was made in 1985. The Institute's collection numbered approximately 935,000 Hymenoptera specimens in 1990, with 571,000 ichneumonids.

Henry was best known for his ichneumonid research. It is hard for workers outside of ichneumonid systematics to comprehend the chaotic nature of the group's taxonomy when Henry started in the 1930's. To call Henry's efforts "remarkable" is to damn with faint praise, considering that it took one person only 30 years to bring order to a group with over 60,000 species and almost 2900 available generic names. Either on his own or with the collaboration of others, Henry produced the aforementioned four volume revision of the world genera, five catalogues of the world fauna (excepting the Western Palearctic), six volumes of comprehensive revisions of the Nearctic fauna of various subfamilies (with a seventh posthumous volume in preparation), and numerous smaller papers.

The specimen base for this research was assembled by extensive fieldwork on the part of both Henry and his wife, Marjorie. They collected on all continents except Australia and Antarctica, and visited, among other places, Argentina, South Africa, Taiwan, the Philippines, and Ellesmere Island (the latter as a solo trip by Henry). At least seven cumulative years were spent in the field. These efforts resulted in a collection of Ichneumonidae that is unrivaled for geographic and taxonomic diversity.

Henry's contributions to systematic entomology did not end with ichneumonids.

When he started his studies in the 1930's, many, if not most, workers relied upon the published literature for species identifications. Henry initially attempted to identify the Cornell University Tryphoninae in this manner but found many gaps and much confusion. He then began to travel to see types, to compare specimens from his own collection with them, and to make detailed notes on what he saw. This was, in his estimation, a good twelve or so years before this practice became common in North America. J. C. Bradley was undoubtedly influential by his travels to Europe to examine types of Scoliidae in the 1920's and 1930's.

While in Washington, Henry initiated the project to write a cooperative catalogue of Nearctic Hymenoptera. With several of his colleagues in the U.S. National Museum and with the collaboration of a number of other specialists, this catalogue was completed and published in 1951.

Henry always maintained a keen eye for aculeate Hymenoptera and the American Entomological Institute has about 90,000 specimens of this group from around the world. Pompilidae are especially well represented with 25,000 specimens. The interest in pompilids dates from his USDA service when he cataloged the subfamilies Pepsinae and Ceropalinae. He later revised them for the Nearctic. Taxonomy, however, was not the only area where he had influence on aculeate studies. During his North Carolina period, Henry suggested the use of *Polistes* for biological control in tobacco. His work with Robert Rabb was one of the first to intensively investigate prey preferences for various *Polistes* species and quantify their impact on prey populations, laying the groundwork for the resulting large body of information about their biology and behavior assembled by other entomologists.

Henry was widely known for his refusal to follow the *International Code of Zoological Nomenclature* or to recognize the validity of certain Opinions of the International Commission on Zoological Nomenclature. Having observed modifications to the *Code* over the years, he believed it too changeable and conflicting to be the basis of a stable classification. His idiosyncratic system was based on a principle of strict priority and its ramifications (for a full exposition of his position, see: Townes, H. 1969. Mem. American Ent. Inst. 11: 15–20). Two competing nomenclatures in Ichneumonidae have resulted, although his applications of this system to other groups are not accepted.

A few years ago, Marjorie Townes prepared a short biography of Henry. I'd like to close with the last two paragraphs of her narrative:

"Over the years, particularly since the end of World War II, there have been real changes in the approach to and presentation of taxonomic research. Revisions are usually more comprehensive, and, if not covering the subject worldwide, at least take the world fauna into consideration. Interpretations of species and genera are based on the studies of types. . . . The format of revisionary publication has been modified to make them easier to use, with more illustrations more accurately rendered in drawings, photographs and scanning electron microscope photographs, with more thorough records of collecting localities and with maps to illustrate the distribution of species. . . . In many of these practices, if Henry has not been the pioneer he has been in the forefront of those adopting them. With the specimens in collections the raw materials of the taxonomist, thorough sampling of a fauna has been facilitated by the use of the Malaise trap which was introduced in the USA after Henry had inspected the one developed by Malaise and modified the design for more practical dimensions and construction.

"When Henry spoke of the Nearctic catalogue at a meeting of the Entomological Society of Washington in the mid-1940's, R. A. Cushman, then the specialist on Ichneumonidae at the National Museum, wondered how he had been able to accomplish so much in so short a time. This has been possible because of Henry's strong committment to become the best and because of his persistent and concentrated efforts to attain that goal."

Res ipsa loquitur.

David Wahl
Gainesville, Florida

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Reports of Officers

SUMMARY FINANCIAL STATEMENT FOR 1991

	General Fund	Special Publications Fund	Total Assets
Assets: November 1, 1990	$14,166.97	$ 99,415.97	$113,582.94
Total Receipts for 1991	62,917.62	7,819.83	70,737.45
Total Disbursements for 1991	66,470.63−	2,557.85	65,028.48−
Assets: October 31, 1991	10,613.96	104,677.95	115,291.91
Net Changes in Funds	$ 3,553.01−	$ 5,261.98	$ 1,708.97

Audited by the Auditing Committee, December 3, 1991, consisting of Gary F. Hevel, Robert V. Peterson, and Paul M. Marsh, Chairman. Presented to the membership at the meeting of December 5, 1991.

Respectfully submitted,
Norman E. Woodley, *Treasurer*

Corresponding Secretary's Summary of Major Activities for Calendar Year 1991

Five thank you letters were sent to outgoing officers. Eighteen letters were sent to new members. Two members, Drs. Shands and Kingsolver, were welcomed to emeritus status. Eight letters were written thanking our guest speakers. Thirty-two letters were written thanking contributors to the special fund.

Holly B. Williams,
Corresponding Secretary

List of New Members for 1991

Robert S. Anderson
Charles Bellamy
Charles F. Brodel
Edward H. Brodie
Josie Bubin
Michael A. Floyd
Henry Frania
Patrick Gomes
Jill M. Gordon
Bernard N. Guirey
James Hill
Pedro Lozada
Teresa Meikle
James R. Ott
Lionel Pagan
John Loren Patterson
Sue Perry
David A. Rider
Nathan Schiff
Scott A. Shaw
Natalia Vandenberg
Susan T. Weller

Total: 22
(includes two members not reported in 1990 annual figures)

Russell D. Stewart,
Membership Chairman

Editor's Report

A total of 137 articles, 17 notes, and one book review were published in 1991 for a total 976 pages. The Society helped defray the cost of three articles per issue, on average.

The April 1991 issue was a memorial in memory of Don Whitehead. Thirty authors contributed to that issue to make the largest of the year.

I thank those reviewers who took the time to examine the many manuscripts processed during 1991, particularly members of the U.S.D.A. Systematic Entomology Laboratory and the Smithsonian Institution's Department of Entomology. Again, I thank Marie Westfall for her help in routing of manuscripts through review, for her many trips to the post office, and for preventing many errors that would otherwise have gone unnoticed.

Robert D. Gordon, *Editor*

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SOCIETY MEETINGS

969th Regular Meeting—October 2, 1991

The 969th Regular Meeting of the Entomological Society of Washington was called to order by President David R. Smith in the Naturalists' Center in the National Museum of Natural History, Washington, D.C., at 8: 00 pm on October 3, 1991. Twenty-five members and seven visitors were present. Minutes of the May meeting were read by the President and approved as read.

Membership Chairman, Russell D. Stewart, read the names of the following applicants for membership: Robert S. Anderson, Canadian Museum of Nature, Ottawa, Canada; Edward Brodie, Rockville, Maryland; Sue A. Perry, West Virginia University, Morgantown, West Virginia; Scott Shaw, University of Wyoming, Larami, West Virginia.

President David R. Smith announced the following miscellaneous business. The Entomological Society of Washington is affiliated with the Washington Academy of Sciences and ESW is a co-sponsor for the program on October 17 (7–9:30 pm at the Potomac Electric Power Company auditorium at 1900 Pennsylvannia Avenue NW). The title is "An Evening of International Medicine and Health: Schistosomiasis and Malaria." The responsibility of ESW is to announce the program to our members. Applications for membership in the Washington Academy of Sciences were distributed. President Smith has appointed the auditing committee: Paul Marsh, Gary Hevel, and Bob Peterson. Wayne Mathis was thanked for organizing this year's banquet. Ralph Eckerlin has agreed to be Hospitality Chairman until November, but President Smith asked if anyone else was interested in fulfilling this very important job starting in December.

The presentation of notes and specimens were as follows: Jeff Aldrich brought pheromone traps he developed to attract predators. Dave Smith had some sawflies Ed Barrows collected on Virginia pines in the shale barrens of Green Ridge State Forest. Ed Barrows tried to grow hibiscus and larvae devastated the plant. He had slides of the damage and Dave Smith thought it was caused by a sawfly. William Bickley announced the death of Dr. Elizabeth Haviland on November 2, 1990. She was Assistant Professor Emeritus at the University of Maryland and was very supportive of the society. He also announced the meeting of the Maryland Entomological Society on October 18 at the University of Maryland where Dr. Steve Sheppard will speak on Africanized honeybee population genetics. He also announced that Manya Stoetzal has been elected Governing Board Representative to the ESA Eastern Branch. Curt Sabrosky, Honorary President, was introduced.

The speaker for the evening was Dr. Jeffrey R. Aldrich, USDA, ARS, Plant Sciences Institute, Insect Chemical Ecology Laboratory, Beltsville, Maryland, whose talk was entitled "Mr. President Goes to Australia: Bugs Down Under." This was a travelog of his trip from October to May in Eastern Australia. His travels started in Tasmania and proceeded north to Syndey, Brisbane, Canberra, and finally to the Great Barrier Reef. He saw the typical Australian animal fare of kangaroos and koala bears. He described Tasmania as a beautiful, cold place with varied habitats to visit including forests of eucalyptus trees, 300 feet tall with a tree fern understory. Sydney is a big city and it takes little time to reach the outskirts of Sydney where it is relatively desolate. North of Sydney and just south of Brisbane is the Gold Coast with developed beaches. Namboor Horticultural Research Station, found north of Brisbane is about 15 km inland. His host at the station was Jeff White.

Crocodiles made swimming and boating dangerous. He also visitied a butterfly sanctuary in the Tanacaran, a commercial business that rears and releases butterfly species, some of which are protected, in the greenhouse. He went to the barrier reef area to talk to avocado growers, who funded part of his trip, about pest control and to explain biochemical methods. He carries one hundred and fifty chemical compounds as standards to help with the identification of pheromones. He was investigating fruit-spotting bugs that cause spotting and loss of fruit on passionfruit, pineapple, papaya, bananas, macadamia nut trees, avocadoes, lichee, and guava. He found that the bugs move in from Eucalyptus trees onto whatever is fruiting early. He is hoping to come up with a synthetic pheromone to trap the two species of coreids and lessen the amount of spraying that has to be done. Males produce a pheromone whose major compound is a derivative from plant terpenes.

He was surprised by the true bug fauna especially with regards to stink gland placement and was able to observe the uniqueness of the Australian fauna first hand. He showed various species of true bugs he encountered in Australia. He hopes to continue studies on the glands and their pheromonal chemistry and their role on the true bugs as pests and predators. Of special note: he found spirochaetals, a compound never found before in true bugs, found previously only in yellow jackets, bark beetles, and tephritid fruit flies. Finally, he displayed specimens collected during the trip and the *Insects of Australia* book by Ian Common. He noted that he found stink bugs to occur in large numbers, and other families such as mirids to occur in smaller numbers.

Our visitors were introduced and the meeting was adjourned at 9:26. After the meeting, refreshments were provided by Mr. Ralph P. Eckerlin.

M. Alma Solis, *Recording Secretary*

970th Regular Meeting—November 7, 1991

The 970th meeting of the Entomological Society of Washington was called to order by President Dave Smith in the Naturalists' Center of the Natural History Building at 8:30 pm on November 7, 1991. Twenty-one members and seven guests were present. President Smith pointed out that on March 4, 1934, the meeting was held at the Cosmos Club and 151 people attended. Minutes of the October meeting were read by Recording Secretary Alma Solis. They were corrected and approved.

Membership Chairman, Russell D. Stewart read the names of the following applicants for membership: Charles Brodel, PPQ-APHIS, Miami, Florida, David A. Rider, Dept. of Entomology, North Dakota State University, Fargo, North Dakota, Nathan Schiff, Beneficial Insects Laboratory, Beltsville, MD, and Natalia Vandenberg, Systematic Entomology Laboratory, Washington, D.C.

Nominating Committee Chairman, Chris Thompson, provided a slate of officers produced by the Nominating Committee that included Don Anderson and Ed Barrows.

President—Wayne Mathis
President-Elect—Russ Stewart
Membership Chairman—Ralph Eckerlin
Program Chairman—Chris Dietrich
Custodian—Natalia Vandenburg

The remaining officers remain the same. The slate will be voted on at the December meeting.

President Smith introduced new members who were present: Charles Brodel and Nathan Schiff. He also announced a change of the next meeting date from January 2 to January 9 and summarized the results of the survey on reduced banquet prices. The survey had a response rate of 30% and members overwhelmingly agreed to reduced banquet prices for students.

Mr. John Fales presented some observations of Hurricane Bob damage on monarch butterflies. He illustrated the damage on the wings with drawings and found 11% of the butterflies he captured were damaged. Also, a severe storm in late October and November (as a result of Hurricane Grace) also caused wing damage. Still, he found that this was the best year for monarchs since 1987. Ed Barrows had a copy of "Insects: Little Giants of the Earth" by Discovery which included a computer interactive program with movies, slides, workbook, computer software, and video disc. He also brought in two books by Jiri Zahradnik and published in Prague, entitled "The Illustrated Book of Insects" and "A Field Guide in Color to Insects." Dave Smith identified the Hibiscus Sawfly brought to the last meeting by Ed Barrows. Dave Nickle brought a calendar produced by Grass Instrument Co. entitled "Insects: Signals & Survival" with a reference for each illustration. The artwork is by Trudy Nicholson of the Smithsonian Institution. Ed Saugstaad brought in for identification a photo of a longhorn grasshopper being carried off by wasp. Finally, Dave Smith announced that John Kingsolver has been elected Emeritus Member by the Executive Committee.

Wayne Mathis introduced the speaker for the evening, Dr. Brian Brown, a Postdoctoral Fellow at the University of Maryland, whose talk was entitled "The Strange Lives of Coffin Flies (Diptera: Phoridae)." Phorids are small and average 2 mm in length. The family with over 3000 species is distributed throughout the world, but is most diverse in the tropical rain forest. Brian's dissertation was a revision of the nearctic phorids, but he also worked on the higher-level problem of the subfamilies and their relationships. He found that the Phorinae was not a natural group and erected a new subfamily, the Hypocerinae. He has done extensive work on the biology of some species. In many phorids the females are degenerate with, for example, wings and eyes reduced, and the males are relatively unknown. Brian traveled to Thailand in 1990 and reared larvae associated with a species of ponerine ants. He was able to rear the males and found that they had been described in a totally different genus. More importantly he found that the maggots were not parasitoids as previously believed, but were scavengers because they fed on dead insects, they had projections on the body and pharyngeal filters. He also plotted the feeding habits of the maggots of the genus on a cladogram and found that closely related genera in the subfamily were also scavengers. Brian went on to describe the natural history of various other phorid species that are parasites on ants and beetles, particularly cantharids. Finally, he described the relevance of the study of phorid flies to man with respect to the possible control for fire ants in the southeastern U.S. Foraging studies by others have shown that the introduction of phorid flies to a colony of ants causes the rate of food retrieval to drop dramatically.

Our visitors were introduced and the meeting was adjourned at 9:22 pm. After the meeting, refreshments were provided by Mr. Harry Painter.

M. Alma Solis, *Recording Secretary*

971st Annual Meeting—December 5, 1991

The 971st Annual Meeting of the Entomological Society of Washington, was called to order by President David R. Smith in the Naturalists' Center of the Natural History Building at 8:09 pm on December 5, 1991. Twenty-five members and six guests were present. Minutes of the November meeting were read by Recording Secretary Alma Solis. They were corrected and approved.

President Smith called for officers' reports. Membership Chairman, Russell D. Stewart read the name of one applicant for membership, R. Edward DeWalt from Baton Rouge, Louisiana, and reported a total of 20 new members for 1991. The total membership is 471 members. The editor's report was read by President Smith. 187 articles were published for a total of 976 pages. The society defrayed the cost of publication for three articles and the April issue was a memorial issue. Corresponding Secretary, Holly Williams, reported writing a number of letters on behalf of the society. The custodian's report was read by President Smith. Orders were filled for 49 copies of the memoirs and Jeff Aldrich helped move boxes of issues from one locale to another. President-Elect Wayne Mathis reported on the annual banquet. Jim Miller was the speaker and John Burns was the Master of Ceremonies. He also pointed out that the society subsidized the banquet with $300.00 and that over half of the responses suggested holding future banquets in localities other than the National Museum of Natural History. He thanked Holly Williams for coordinating the ticket sales. President Smith read the financial report by Treasurer Norman Woodley that showed the society to be solvent. President Smith summarized the year: nine regular meetings were held, four issues of the proceedings were published, three amendments were added to the bylaws, a membership survey was sent out, and the society is financially solvent. He thanked the officers and the auditing and nominating committees. He offered special thanks to Don Anderson for the help in setting up for the meetings, the hospitality group of Ralph Eckerlin, Harry Painter, and William Bickley, and all the reviewers of the journal articles.

The slate of officers for 1992 was presented by Nominating Committee Chairman, Chris Thompson:

President—Wayne N. Mathis
President-Elect—Russell D. Stewart
Recording Secretary—M. Alma Solis
Corresponding Secretary—Hollis B. Williams
Treasurer—Norman E. Woodley
Program Chairman—Christopher Dietrich
Membership Chairman—Ralph Eckerlin
Custodian—Natalia Vandenburg
Editor—Robert D. Gordon

The slate was voted upon and accepted by the members present.

President Smith called for notes and special business. Ed Barrows showed slides of the president, Dave Smith, collecting in West Virginia. J. H. Fales reported that in 1990 only a single return was obtained of 22 Silver-spotted Skippers (*Epargyreus clarus*) tagged at a single location. Between July 22 and August 3, 1991, 54 individuals were tagged by marking the white spots of the lower hind wings with different colored fluorescent pens. A 12% return was obtained for the tagged specimens. William Bickley announced that Ted Bissell, Honorary Member, will be 92 years old. As a tribute to Don Whitehead, President Smith described his strong involvement in the society, professional accomplishments, and personal interests. Chris Thompson said a few words in remembrance of Don Whitehead, and his wife, Jo Whitehead, was presented with three bound copies of the April issue of the proceedings which was a memorial issue in honor of Don Whitehead.

Dave Smith introduced the speaker for the evening, Dr. Steven L. Keffer, Postdoctoral Fellow, Department of Entomology, Smithsonian Institution, whose talk was entitled "Danger: Waterscorpions." The first thing he pointed out was that waterscorpions are not dangerous and, in fact, they freeze, or stop moving, when approached. He began with an overview of the systematics of the Nepidae. The family is divided into two subfamilies, the Ranatrinae and the Nepinae. Representatives of the Nepinae live in stagnant water and have strong profemora. The Ranatrinae are long, stick-like animals with weak profemora and are usually found on plants. He presented research on the placement and relationship of three species (*hoffmanii, cinerea, apiculata*) of *Nepa* based primarily on genitalic characters. He also presented results of the revision of the genus *Curicta.* He described waterscorpion copulation: there is no courtship behavior; the male flexes the abdomen down and part of the genitalia telescopes out into the female spermatheca. But the male genitalia provided very few characters and so the search for non-genitalic characters became important. Characters that had been used to describe new species were really examples of intraspecific variation. He found good characters at the species level, for example, in the sculpturing on the pronotum and toothlike structures on the profemora. His character matrix consisted of 28 characters and 16 taxa and after the study he was able to synonymize many species names. During his tenure at the Smithsonian he has been working on the phylogeny of the family. He now has a matrix of 14 genera and 35 characters. Again he encountered characters in the literature that really are just states of intraspecific variation, but he did find male genitalia to be useful at supraspecific levels. He has found *Curicta* to be basal to other genera.

Our visitors were introduced and President Dave Smith transferred the gavel to President-Elect Wayne Mathis. Wayne Mathis recognized Dave Smith's contributions to the society in the past year. Wayne Mathis adjourned the meeting at 9:32 pm and refreshments were provided by Chris and Betty Thompson.

M. Alma Solis, *Recording Secretary*

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Both papers on cynipid galls	6.00
Identification of Alaskan Black Fly Larvae, by Kathryn M. Sommerman	1.00
Unusual Scalp Dermatitis in Humans Caused by the Mite *Dermatophagoides,* by Jay R. Traver	1.00
A Short History of the Entomological Society of Washington, by Ashley B. Gurney	1.00
Pictorial Key to Species of the Genus *Anastrepha* (Diptera: Tephritidae), by George C. Steyskal	1.50
Taxonomic Studies on Fruit Flies of the Genus *Urophora* (Diptera: Tephritidae), by George C. Steyskal	2.00
A Handbook of the Families of Nearctic Chalcidoidea (Hymenoptera), by E. Eric Grissell and Michael E. Schauff	10.00

MEMOIRS OF THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

No. 1.	The North American Bees of the Genus *Osmia,* by Grace Sandhouse. 167 pp. 1939	$15.00
No. 2.	A Classification of Larvae and Adults of the Genus *Phyllophaga,* by Adam G. Boving. 95 pp. 1942	(out of print)
No. 3.	The Nearctic Leafhoppers, a Generic Classification and Check List, by Paul Wilson Oman. 253 pp. 1949	15.00
No. 4.	A Manual of the Chiggers, by G. W. Wharton and H. S. Fuller. 185 pp. 1952	15.00
No. 5.	A Classification of the Siphonaptera of South America, by Phyllis T. Johnson. 298 pp. 1957	15.00
No. 6.	The Female Tabanidae of Japan, Korea and Manchuria, by Wallace P. Murdoch and Hirosi Takahasi. 230 pp. 1969	15.00
No. 7.	Ant Larvae: Review and Synthesis, by George C. Wheeler and Jeanette Wheeler. 108 pp. 1976	11.00
No. 8.	The North American Predaceous Midges of the Genus *Palpomyia* Meigen (Diptera: Ceratopogonidae), by W. L. Grogan, Jr. and W. W. Wirth. 125 pp. 1979	12.00
No. 9.	The Flower Flies of the West Indies (Diptera: Syrphidae), by F. Christian Thompson. 200 pp. 1981	10.00
No. 10.	Recent Advances in Dipteran Systematics: Commemorative Volume in Honor of Curtis W. Sabrosky. Edited by Wayne N. Mathis and F. Christian Thompson. 227 pp. 1982	11.00
No. 11.	A Systematic Study of the Japanese Chloropidae (Diptera), by Kenkichi Kanmiya. 370 pp. 1983	18.00
No. 12.	The Holarctic Genera of Mymaridae (Hymenoptera: Chalcidoidae), by Michael E. Schauff. 67 pp. 1984	5.00
No. 13.	An Identification Manual for the North American Genera of the Family Braconidae (Hymenoptera), by Paul M. Marsh, Scott R. Shaw, and Robert A. Wharton. 98 pp. 1987	18.00

Back issues of the Proceedings of the Entomological Society of Washington are available at $25.00 per volume to non-members and $13.00 per volume to members of the Society.

Prices quoted are U.S. currency. Postage extra except on prepaid orders. Dealers are allowed a discount of 10 per cent on all items, including annual subscriptions, that are paid in advance. All orders should be placed with the Custodian, Entomological Society of Washington, c/o Department of Entomology, NHB 168, Smithsonian Institution, Washington, D.C. 20560.

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of the
ENTOMOLOGICAL SOCIETY
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THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

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A REVIEW OF *MELOE* (*TAPHROMELOE*), INCLUDING A DESCRIPTION OF THE FIRST-INSTAR LARVA OF *M.* (*T.*) *ERYTHROCNEMUS* AND COMMENTS ON THE CLASSIFICATION OF THE TRIBE MELOINI (COLEOPTERA: MELOIDAE)

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Abstract.—The first-instar larva of *Meloe* (*Taphromeloe*) *erythrocnemus* Pallas is described and compared to larvae of other components of the genus. The bionomics, distribution and taxonomy of this subgenus are reviewed. Larvae of *Taphromeloe* are similar to those of the subgenus *Meloegonius.* The intermediacy of several traits in these subgenera between the nominate subgenus and *Eurymeloe* questions the validity of the latter as a distinct genus. The recent expansion of the Meloini by Selander (1985, 1987, 1988) to include genera in addition to *Meloe* is only tentatively adopted because of its reliance solely on traits associated with larval phoresy.

Key Words: Meloidae, *Meloe, Taphromeloe,* systematics, first-instar larvae, phoresy

Meloe is a large genus of wingless and brachyelytrous blister beetles with phoretic first-instar larvae. Seventeen subgenera of *Meloe* are currently recognized based primarily on adult phenetic similarities (Bologna 1991). All occur in the Old World with two extending into North America. *Taphromeloe* Reitter (1911) is an exclusively Old World subgenus containing two species. Included are *M. erythrocnemus* Pallas (1782), a Turanian-Mediterranean species, and the poorly known *M. foveolatus* Guérin de Méneville (1842), distributed primarily in northwestern Africa. The latter has been considered either as a variety of *M. erythrocnemus* (Cros 1935, Mařan 1942, Iablokoff-Khnzorian 1983) or as a distinct species (Peyerimhoff 1949, Pinto and Selander 1970, Bologna 1991). A third nominal species, *M. roubali,* described and added to *Taphromeloe* by Mařan (1942), was recently synonymized with *M. foveolatus* by Bologna (1991).

The primary purpose of this paper is to describe the first-instar larva of *M.* (*Taphromeloe*) *erythrocnemus,* and to compare it with larvae of other *Meloe* subgenera. Bionomic, distributional and taxonomic characteristics of *Taphromeloe* also are summarized. Certain features of *Taphromeloe* larvae intermediate to the nominate subgenus and the subgenus *Eurymeloe* question the validity of the most recent classification of the Meloini presented by Selander (1985, 1987, 1988). Our concerns with this classification are summarized.

First-instar Larva of *Meloe erythrocnemus*

Twelve slide-mounted specimens hatching from the same egg mass and numerous individuals in alcohol were examined for this description. Quantitative data reported below represent means or ranges taken from three randomly selected individuals.

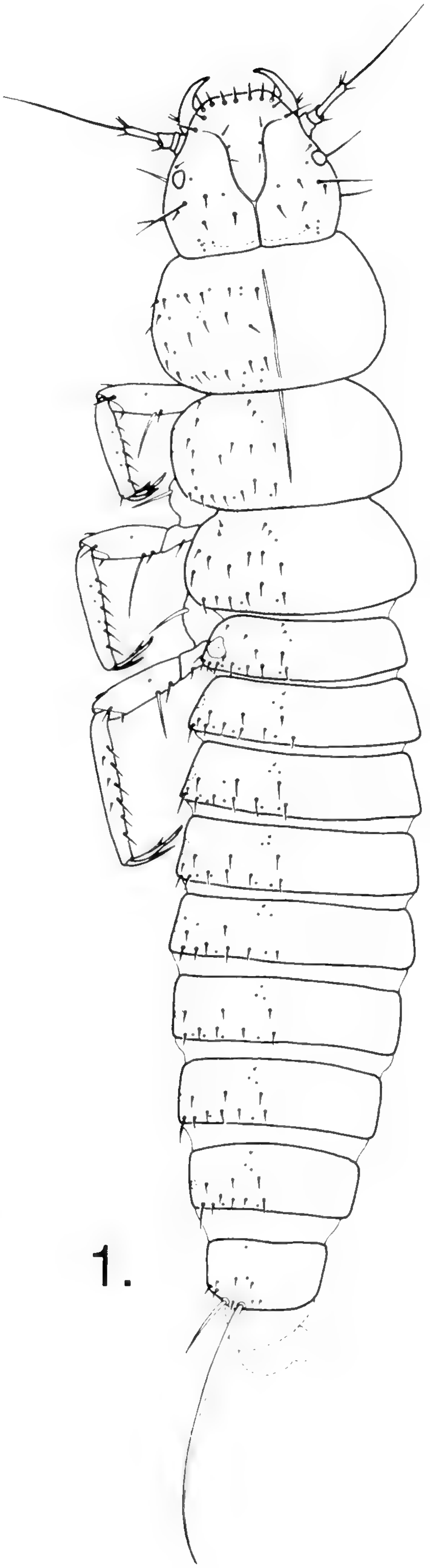
Color golden brown, head and legs slightly darker. Cuticle, including that of head, reticulate; reticulae about as broad as long on head, thorax and abdomen. Membranous areas of thoracic venter pebbled, microspinose adjacent to sternites. Line of dehiscence present on pro- and mesonotum, present at extreme apex of metanotum or entirely absent, absent on abdominal tergite I.

Body length 1.9–2.0 mm (slide-mounted specimens); length of longest pair of caudal setae 0.45–0.48 mm.

Head 0.9 as long as wide, widest at point about half the distance from eyes to base of head; sides arcuate posterior to antennae, straight and convergent anterior to eyes, anterior margin of head truncate; basal elevation absent but posterior margin of head thickened internally; epicranial suture with lateral arms weakly divergent at base, subparallel to level of antennae, then curved strongly laterad, not attaining antennal base; basal stem of epicranial suture elongate, 0.3 length of head and 0.4 length of entire suture. Eye large, strongly protuberant, diameter about 1.2× greatest width of antennal segment II. Epicranial setation as in Fig. 1; major ocular seta distinctly longer than other setae, spiniform, 1.2× the length of antenna, positioned well behind eye. Labrum transverse, not visible dorsally, a distinct clypeolabral suture present (Fig. 4). Gula well differentiated, anterior margin notched at center, gular setae subequal in length to antenna, positioned at anterior margin. Antenna (Fig. 3) with length/width of segments I, II and III 11/25, 24/20, 42/10, respectively; terminal seta about 3.5× length of segment III; segment II not widened apically but asymmetrical, longer along dorsal margin, its apex oblique; sensory organ disk-like (Fig. 5), its surface slightly convex, positioned at apex of II ventral to insertion of segment III. Mandible with base broad, apical half abruptly narrower, inner margin smooth, posterior condyle large, mandible moving in an obliquely vertical plane. Maxilla (Fig. 2) with mala simple; stipes with one long seta, three shorter setae and two sensory pits; palpi directed laterally, segments I and II short, subequal in length, I broader than II, III elongate, subcylindrical, about 7× the length of II and slightly narrower, subequal in length to antennal segment III, apex of III slightly obliquely truncate with a prominent 2-segmented sensory appendix and several shorter papillae. Labial palpi elongate; apical segment subequal in length to antennal segment II, its apex with a prominent 2-segmented sensory appendix and several shorter papillae, sensory appendix about half the length of apical segment.

Thorax: Thoracic segments broader than head. Pronotum subrectangular, 0.6 as long as wide, 1.2× width of head, broader at basal half, considerably membranous apically, with 40 setae. Mesonotum subequal in width to pronotum, almost twice as broad as long, with 28 moderately long setae and 4 minute anterior setae; base membranous. Metanotum slightly broader and shorter than mesonotum, with 26 elongate setae and 4 minute anterior setae. Prosternite with 3 (rarely 4) pair of setae; meso- and metasternite with 4 pair; anterior pair of setae on meso- and metasternite much shorter than others, posterior pair longer than second and third pair. Meso- and metasternites occupying entire length of segment, well developed; prosternite poorly sclerotized, confined to area between legs.

Legs with only profemur slightly swollen; width to length ratio of pro-, meso- and metafemur 0.38, 0.35, 0.30, respectively. Tibiae moderately tapered, with apical width about ¾ maximum width near base. Femora each with a long ventral seta at basal third, seta about twice maximum width of femora; setae on tibiae moderately long, length of longest tibial seta relative to tibial width 0.75, 1.0, 1.2 on pro-, meso- and



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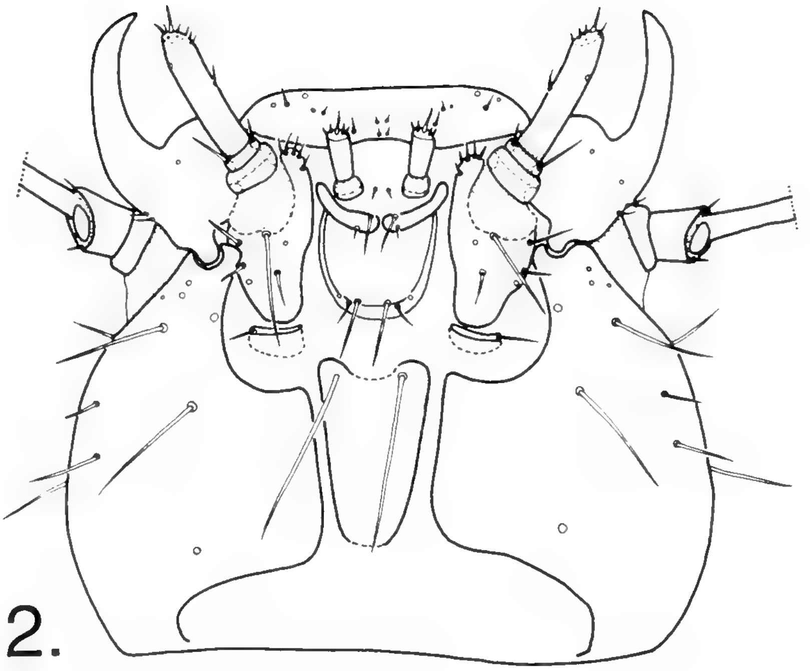

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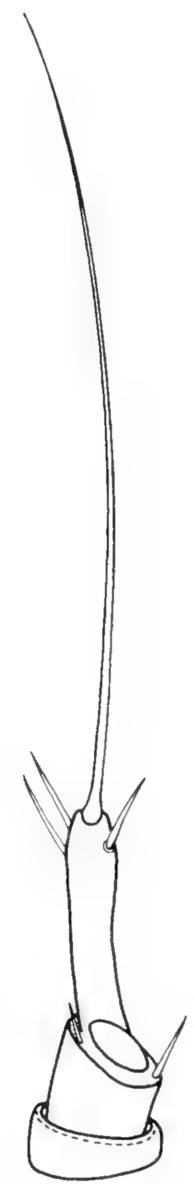

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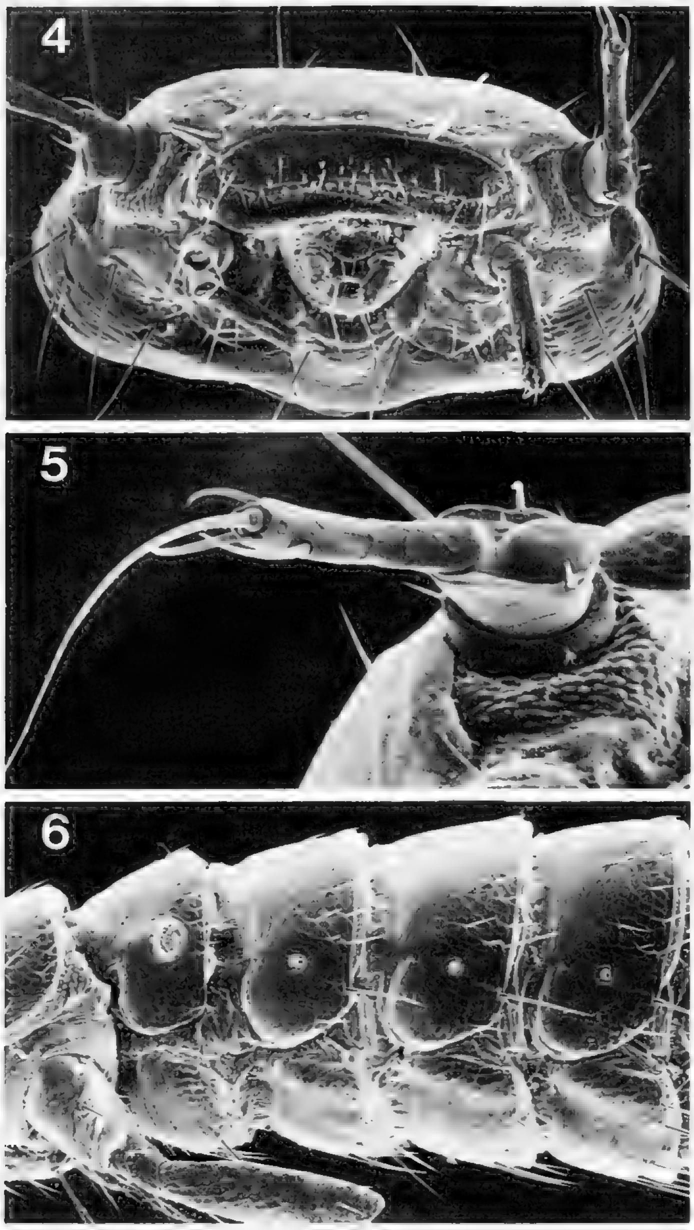
Figs. 1–3. Fig. 1. First-instar larva of *Meloe* (*Taphromeloe*) *erythrocnemus*. Dorsal view. Fig. 2. Head of first-instar larva of *M. erythrocnemus*. Ventral view. Fig. 3. Antenna of first-instar larva of *M. erythrocnemus* (ventral view).



Figs. 4–6. Fig. 4. Head of first-instar larva of *M. erythrocnemus* (anterior view, 372×). Arrow points to clypeolabral suture. Fig. 5. Antenna of first-instar larva of *M. erythrocnemus* showing disk-like sensory appendix at apex of segment II (810×). Fig. 6. Lateral view of abdomen in first-instar larva of *M. erythrocnemus* showing dorsal displacement of abdominal spiracle I relative to those which follow (203×).

metatibia, respectively. Claw compressed; basal pair of setae narrowly spatulate, together forming a trident-like structure; hind leg with claw 0.4 length of tibia.

Abdomen fusiform; pleurite I fused to tergite I, other pleurites very narrowly separated from adjacent tergite (narrow membranous line between tergite and pleurite visible in cleared specimens). Tergite I with 28 setae, 14 in posterior row, lateralmost seta in this row thicker and longer than others; tergites II–VIII with 22 setae, only 12 in posterior row. Sternites subrectangular, all heavily sclerotized and undivided; I with 14 setae, anterior pair very small; II–VIII each with 12 setae, 8 along posterior margin much thicker and longer than others; IX emarginate anteriorly, with only 10 setae, 6 in posterior row. Pleurites each with 3 setae, 1 short seta anterior to spiracle, two others posteriorly near margin. 2 pair of caudal setae present, medial pair as long as segments VI–IX combined, lateral pair shorter, only 0.25 length of medial pair. Abdominal apex with a weakly bilobed pygopod.

Spiracles: Mesothoracic spiracle large, lateral in position, suboval, positioned in membrane at anterior ⅓ of segment. Abdominal spiracle I dorsal (Fig. 6), similar in size to mesothoracic spiracle, occupying about ⅓ the length of tergum, not projecting noticeably beyond sides of abdomen; remaining abdominal spiracles on pleurites, more ventrally placed, much smaller, subequal, only about half the diameter of spiracle I.

Material studied: About 70 larvae hatching (31-v-1982) from eggs laid by a female from TURKEY, Antalya Prov., near Seki (between Korkuteli and Fethiye), 1350 m, 30-iv-1982, M. A. Bologna leg.; and 3 larvae hatching from eggs laid by a female from TURKEY, Antalya Prov., Sonğuk, near Seki, 1400 m, 30-iv-1982, C. Manicastri leg.

FIRST-INSTAR LARVA OF *MELOE FOVEOLATUS*

We have not examined the larva of *M. foveolatus.* Its description by Cros (1918) indicates only slight differences, if any, from the larva of *M. erythrocnemus.* Characteristics of *M. foveolatus* which appear to differ include: (a) color of head and thorax dark brown (golden brown in *erythrocnemus*); (b) head longer than wide (wider than long in *erythrocnemus*); (c) antennal segment II only slightly longer than I (twice as long as I in *erythrocnemus*); (d) antennal segment III twice as long as I and II combined (only about 1.3× as long in *erythrocnemus*); (e) pronotum clearly wider than head (only 1.2× as wide in *erythrocnemus*).

Other differences suggested are probably in error. Thus, Cros states that there are only 2 caudal setae in *foveolatus.* It is probable that the two shorter lateral setae were not considered. Also, Cros's figure of the antenna of *foveolatus* is almost certainly erroneous in showing a conical (rather than disklike) sensory organ at the apex of segment II. In his description he states "Je n'ai pas pu arriver à discerner nettement à la surface du deuxième article, en arrière et à coté de l'insertion du troisième segment un organ sensoriel analogue à celui que existe sur l'antenne du *Meloe tuccius*" (i.e. of the conical type typical of the subgenus *Eurymeloe*).

DIFFERENCES BETWEEN ADULTS OF *TAPHROMELOE*

The revision of *Taphromeloe* by Mařan (1942) treated *foveolatus* as a variety of *erythrocnemus* which lacked red femora. As indicated by Bologna (1991), however, *foveolatus* was unknown to Mařan. He mistakenly followed Cros (1918, 1935) in assuming that the specimen of *erythrocnemus* with dark femora cited by Leoni (1907) from Tuscany (Giglio Island) was the *foveolatus* of Guérin. We have examined this specimen, currently preserved in the Genoa Museum, and find that the femora are not black as in *foveolatus.* Although they are dark red in the apical half, they retain the bright red coloration characteristic of *erythrocnemus* basally.

Mařan (1942) went on to describe *M. roubali* on the basis of two specimens from Valencia, Spain. His description corresponds to *foveolatus* in all differentiating traits, especially with regard to pronotal shape, elytral rugosity and male genitalia. The examination of a syntype of *roubali* in the Prague National Museum of Natural History, its comparison to topotypic material of *foveolatus* from Tripoli and to specimens from other Maghrebian localities, as well as the correspondence of *roubali* to the original description of *foveolatus,* confirm their synonymy.

Adults of *M. erythrocnemus* and *M. foveolatus* were recently redescribed, and distinguished by Bologna (1991). Briefly, they can be separated as follows: *M. erythrocnemus*—femora red, black only at apex; pronotum with medial incision of basal margin broadly arcuate; elytra deeply and coarsely punctate; male genitalia with fused gonostyli medially impressed. *M. foveolatus*—femora entirely black; pronotum with medial incision of basal margin more narrowly arcuate; elytra shallowly punctate; male genitalia with fused gonostyli not medially impressed.

DISTRIBUTION AND BIONOMICS OF *TAPHROMELOE*

A detailed account of geographic distribution and bionomic data is given by Bologna (1991). *M. erythrocnemus* is broadly distributed in the southern Palaearctic from the Tien Shan Mts. in western China, west through Turkey, Greece, and western Yugoslavia to central and southern Italy, Sicily, and northwestern Africa (northern Tunisia, northern Algeria, and northern and central Morocco). The range of *M. foveolatus* is more restricted. It occurs primarily in northwestern Africa [Libya (Tripolitania), northern and central Tunisia, northern Algeria], where it may be sympatric with *M. erythrocnemus.* Also, it is apparently relictual in southeastern Spain and southeastern Italy. It is uncommonly collected throughout its range.

Specific locality records of *M. foveolatus* based on material in the Paris, Prague and M. Bologna collections are as follows: ALGERIA: Mascara. ITALY: Brindisi. LIBYA: Tarabulus (= Tripoli) (type locality). SPAIN: "Arragon" or "Arragou" (Caceres Prov.?); Valencia (type locality of *roubali* Mařan). TUNISIA: Gafsa; Mahdia; Nabeul; El Skihrra; Sfax.

The bionomics and ontogeny are similar in both species of *Taphromeloe.* Adults are active primarily in spring, from March (rarely February) to May. Both species are diurnal, although *M. foveolatus* probably is also active at night. The eggs are similar in form but differ in color (yellow in *foveolatus,* white in *erythrocnemus*). In *M. erythrocnemus,* summer is probably passed in the sixth instar (= coarctate); adults apparently overwinter (De Stefani Perez 1885, Grandi 1934, Bologna 1991). Cros (1918, 1920b) described the larval instars and the pupa of *M. foveolatus.* Grandi (1934, 1961) and Cros (1935) discussed characters of the second and sixth larval instars and the pupa in *M. erythrocnemus* but didn't describe them.

Taphromeloe adults are known to feed on a variety of plants. *Meloe erythrocnemus* has been recorded from species of Asteraceae and Apiaceae; *M. foveolatus* has been associated with Resedaceae, Poaceae, and, questionably, Asteraceae. Both species are parasites of Apoidea (Megachilidae) as larvae. *Meloe erythrocnemus* has been associated only with *Chalicodoma muraria* Fabricius (Frauenfeld 1861, De Stefani Perez 1885, Leoni 1909, Grandi 1934, 1961, Bologna 1991). *Osmia saundersi* Vachal is a host of *M. foveolatus* (Cros 1918).

Sexual behavior of *M. foveolatus* was described by Cros (1918), and that of *M. erythrocnemus* was recently studied by Bologna and Marangoni (1986). Courtship is relativley simple in both and only minor differences occur in the dorsal and genital phases (Bologna and Marangoni 1986).

CHARACTERISTICS OF *TAPHROMELOE*

First-instar larvae: Moderately large, ca. 2.5 mm in length. Head with anterior margin truncate; antennal segment II twice as long as I (*erythrocnemus*) or subequal in length to I (*foveolatus*), and much shorter than III; apex of II oblique and with a disk-like, slightly convex sensory organ ventrally. Femora subcylindrical, slightly swollen at most; tibiae moderately tapered; tarsungulus compressed, basal pair of setae narrowly spatulate, together forming a trident-like claw. Abdominal sternites completely sclerotized and undivided; abdominal spiracle I on tergite, not projecting beyond sides of segment; four caudal setae, medial pair much longer.

Adults: Body completely black, or with femora red in part; surface shiny; setation black, short, extremely sparse on head, pronotum and elytra; vestiture not noticeable macroscopically. Head subtriangular, broadest at tempora; without a longitudinal depression behind eyes; frons longitudinally impressed; coarsely, deeply, moderately densely punctate; interpunctal areas shagreened; eyes small. Antennae short, subclavate, segments submoniliform, V–VIII not noticeably modified in male. Pronotum transverse; sides parallel or convergent posteriorly, rounded anterolaterally to apex, subperpendicular to base; basal margin with a broad, arcuate incision at middle, narrowly bordered; disk relatively flat but with three distinct longitudinal furrows, two shorter ones laterally and a medial furrow usually extending entire length of disk; punctation as on head. Elytra coarsely, deeply rugose; punctures larger than on head and pronotum but not as distinct, confluent in part. Abdominal tergites broad, well sclerotized. Male genitalia with gonostyli very narrow apically.

The larva of *Taphromeloe* is similar to that of *Meloegonius* Reitter (1911). The latter includes only two species, *M. cicatricosus* Leach and *M. rufiventris* Germar. The first instar of what, according to Selander (1989), was almost certainly *M. cicatricosus* was first described by Zakhvatkin (1932) as an unidentified species. It was recently redescribed by Selander (1989). This larva can be separated from those of *Taphromeloe* primarily by the structure of the first abdominal spiracle. According to Selander, in *Meloegonius* this spiracle is "transversely oval, projecting beyond sides of abdominal segment." In *Taphromeloe* the spiracle is enlarged and suboval as in all *Meloe,* but it does not project beyond the sides of its segment. Also, in *Meloegonious,* several of the epicranial setae are lengthened and thickened, and antennal segment II is symmetrical. In *Taphromeloe,* only the major ocular setae are noticeably modified, and antennal segment II is oblique. Fig. 1 in Selander (1989) also indicates that the sensory organ at the apex of antennal segment II is more prominent in *Meloegonius* than in *Taphromeloe.*

Adults of *Taphromeloe* are separable from those of *Meloegonius* by traits associated with the antenna, pronotum and genitalia. *Meloegonius* lacks the arcuate basal emargination and discal furrows on the pronotum. Also the sides of the pronotum are distinctly angulate anterolaterally in *Meloegonius,* not rounded as in *Taphromeloe.* The antenna is somewhat longer in *Meloegonius* and is not subclavate as in *Taphromeloe.* In *Meloegonius* the gonostyli of the male genitalia are robust and not as narrow as in *Taphromeloe.*

Comments on the Classification of the Meloini

The larvae of *Taphromeloe* force a reexamination of the current classification of the Meloini, one of the tribes in the subfamily Meloinae (Selander 1964, Bologna 1991). The group is delimited from other Meloinae by first-instar larval traits presumably associated with phoresy primarily on adult Apoidea. The primary traits defining the tribe as listed by Selander (1985) include the following: clypeus not distinct from frons; labrum not visible from above, closely appressed to venter of head capsule; mandibles moving in an oblique dorsoventral plane; presence of an extrusible pygopod at apex of abdomen. The latter trait is associated with locomotion on smooth plant surfaces before larvae attach to their host. The head characters are believed to aid larvae to grasp the vestiture of hosts with their mandibles.

Studies by Pinto and Selander (1970), and Selander (1985, 1986, 1989) considerably modified the limits of the tribe. As defined by MacSwain (1956) and Selander (1964), the Meloini consisted only of *Meloe,* an apterous genus, and the only taxon of Meloinae known prior to 1970 to be phoretic as first-instar larvae. The discovery by Pinto and Selander that the North American and alate *Spastonyx* had larval traits that, in *Meloe,* are associated with phoresy, prompted its transfer to the Meloini. More recently, Selander (1985, 1987, 1988) treated the South American *Spastomeloe* and *Lyttomeloe,* and the Old World *Cyaneolytta* as Meloini upon discovering that their larvae also possessed phoretic traits. Bologna et al. (1990) followed this classification in their description of *Cyaneolytta* larvae which are phoretic on carabid beetles. There are no adult characters that can convincingly argue for these tribal assignments. *Spastonyx* and *Cyaneolytta* were previously assumed to be Lyttini (Selander 1964) and *Lyttomeloe* was either placed in the Lyttini (Denier 1920) or tentatively assigned to the Meloini (Kaszab 1969).

The expansion of the Meloini prompted Selander (1985) to redefine *Meloe.* Because the larvae of *Spastomeloe* and *Meloe* (*Eurymeloe*) (the more primitive type I larva of Selander) were more similar to one another than either was to the more derived larvae of other *Meloe* subgenera (type II larva of Selander), he considered the genus polyphyletic and thus elevated *Eurymeloe* (including *Coelomeloe* as a synonym) to generic status. The type II larva of *Spastonyx* provided further support for this change since it resembled nominate *Meloe* and related subgenera more than *Eurymeloe* did.

Eurymeloe was recently reviewed by Bologna (1988) and Bologna et al. (1989). Those studies, as we do here, continue to treat the group as a subgenus of *Meloe* and to tentatively recognize *Coelomeloe* as a distinct subgenus. We consider the elevation of *Eurymeloe* to genus to be premature for two reasons. First, as more larvae of this group (see Bologna et al. 1989) and other elements of *Meloe* (such as those of *Taphromeloe*) become known, the gap between types I and II larvae is narrowing. Secondly, we are not convinced that the larval characters now defining the Meloini, i.e. those which forced the elevation of *Eurymeloe* in the first place, are homologous, and not simply homoplasies motored by the independent acquisition of phoresy in two or more of the genera now included in the tribe.

The two types of larvae in the Meloini were first recognized by Cros (1920a) and were recently characterized as follows by Selander (1985): Type I larvae—Antenna: segment II subequal in length to I, much shorter than III; sensory organ of segment II conical, prominent. Thoracic line of dehiscence absent from metanotum. Abdominal sternites entire. Two elongate caudal setae. Femora not swollen; tibiae tapered with elongate setae. Claw normal in shape, conicofalcate, with basal pair of setae setiform. Type II larvae—Antenna: segment II much longer than I, at least as long as III; sensory organ of antenna hemispherical or disk-like. Line of dehiscence partially developed on metanotum; 2–4 elongate caudal setae. Femora swollen; tibiae cylindrical, with very short setae. Claw and two basal setae flat, spatulate forming a trident-like structure.

According to Selander (1985, 1987, 1988) and Bologna et al. (1990), type I larvae occur in *Eurymeloe, Spastomeloe* and *Cyaneolytta*; type II larvae occur in *Meloe, Lyttomeloe* and *Spastonyx.* However, the larvae of several species bridge these original distinctions. *Cyaneolytta* larvae vary with regard to the length of antennal segment II. In *C. fryi* it is elongate, as in type II larvae (Selander 1987). In other species it is considerably shorter (Bologna et al. 1990). Also, in certain *Cyaneolytta* the thoracic line of dehiscence is present on the metanotum (Bologna et al. 1990). In his recent description of the larva of *M.* (*Meloegonius*) *cicatricosus,* Selander (1989) does not assign the larva to type, noting that it is intermediate to *Meloe* and *Eurymeloe* with respect to the length of the antennal segments, but similar to *Meloe* based on claw and leg structure, and in the form of the antennal sensory organ. The larvae of *Taphromeloe* and *Meloegonius* have traits of both types, and those of the former are perhaps more clearly intermediate. Type I traits include the virtual absence of a line of dehiscence on the metanotum, the undivided abdominal sternites, and elongate tibial setae. Type II traits include the trident-like tarsungulus, 4 long caudal setae, and the disk-like sensory organ of the antenna. Traits intermediate to the two types include the only slightly swollen femora, the moderately tapered tibiae, and the intermediate length of antennal segment II. Obviously, the original definitions of types I and II larvae are not useful predictors of variation in this group of Meloinae.

The intermediacy of *Taphromeloe* larvae cloud the distinction between *Eurymeloe* and *Meloe* as defined by Selander. Only on the basis of tarsungulus structure can it clearly be assigned to *Meloe.* In addition to the problem of intermediacy, we are unaware of a single derived trait that can be used to define *Eurymeloe* as a monophyletic taxon at any level. For this reason also, we prefer to retain the group within *Meloe* at least until relationships are better resolved.

As defined here, *Meloe* includes, as before, all wingless and brachyelytrous Meloinae with phoretic larvae. We note that the larvae of all species (including those in *Eurymeloe*) have at least one derived trait lacking in *Cyaneolytta, Spastomeloe, Lyttomeloe,* and *Spastonyx.* This is the position of the first abdominal spiracle. In *Meloe* this spiracle is more dorsal than the other abdominal spiracles (Fig. 6) and is positioned on the tergite. In the other genera the spiracle is more ventrally placed and either positioned on the pleurite or on the membrane between the tergite and pleurite.

Returning *Eurymeloe* to *Meloe* resurrects the problem of extreme larval heterogeneity within *Meloe.* This posed no problem before the discovery of larvae of the other four genera now residing in the Meloini, and it is a concern now only if we assume the phoresy-correlated characters in *Meloe* and these other genera are homologous. We note that perhaps similar heterogeneity also occurs in *Cyaneolytta* (Bologna et al. 1990). Clearly, a detailed character analysis is called for. We are now in the early stages of such a study and thus only tentatively follow Selander's definition of the tribe.

We believe that the presumed monophyly of the Meloini should be validated by derived traits that are not associated with phoresy. This has not been done. All of the derived anatomical and behavioral characters currently used to argue the monophyly of the tribe are believed to be associated with phoresy (Selander 1988). It should be noted that several of these features also occur in larvae of the Nemognathinae (tentatively including the Tetraonycini), a very distinct meloid subfamily consisting entirely of phoretic species (MacSwain 1956). For example, the very distinctive trident-like "claw," the only clearly derived trait available to define *Meloe* (*sensu* Selander 1985), occurs in some species of *Nemognatha* (e.g. Blochtein and Wittmann 1988) and in *Stenoria* (Cros 1940). The head shows similar modifications in the Meloini and Nemognathinae, and an extrusible pygopod occurs in both groups. Of course the phylogenetic distance between the Meloini and Nemognathinae is sufficiently great that these similarities can easily be attributed to homoplasy. We suggest that homoplasy may also have resulted in the striking similarity among larvae of genera now placed in the Meloini but that it is not as easily detected owing to the relative phylogenetic proximity of these taxa. In our opinion, only non-phoretic characters can convincingly test the monophyly of the tribe.

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LIFE HISTORY OF *EPIMECHUS CANOIDES* FALL (COLEOPTERA: CURCULIONIDAE) ON SEEPWILLOW, *BACCHARIS SALICIFOLIA* (R.&P.) PERS. (ASTERACEAE)

Paul E. Boldt and Thomas O. Robbins[1]

Abstract.—The weevil *Epimechus canoides* fed on leaves or flowerheads of seepwillow, *Baccharis salicifolia,* in New Mexico, Texas and northern Mexico. There was one generation per year. In no-choice tests, adults fed on leaves of *B. neglecta* and *B. halimifolia.* Weevils oviposited in swollen or slightly opened flowerhead buds, from July to September. Adults and immatures were more numerous in female than in male flowerheads and in plants nearer the water than in dry soil. In 1985, infestations were 20 to 27% greater in female than male flowerheads; in 1986, they were 13 to 22% greater. One egg was deposited per flowerhead and larvae fed to pupation on the receptacle and developing achenes. Up to 66% of the female and 41% of the male flowerheads were infested. There were three larval instars. Pupation occurred in the flowerhead.

Key Words: Coleoptera biology, Curculionidae, *Epimechus, Baccharis salicifolia,* seepwillow, Texas

The genus *Epimechus* Dietz (Coleoptera: Curculionidae: Anthonomini) contains 14 species of small, brown to off-white colored weevils which occur in the western United States (O'Brien and Wibmer 1982). Three little-known species occur in the Southwest on unisexual composite plants of the genus *Baccharis. Epimechus canoides* Fall and *E. arenicolor* Fall occur east and west of the Continental Divide, respectively (Boldt and Robbins 1990). Adult weevils feed on leaves and flowers of seepwillow, *Baccharis salicifolia* (R.&P.) (= *glutinosa* Pers.) (Asteraceae) and larvae feed in the flowerheads. Descriptions of larvae and pupae are given for *E. arenicolor* but not for *E. canoides* (Ahmad and Burke 1972, Burke 1968). Larvae of *Epimechus curvipes* Dietz feed in galls on *B. bigelovii* Gray and *B. pteronioides* DC. in Arizona, New Mexico, and Mexico (Boldt and Robbins, unpublished manuscript).

Epimechus is considered to be closely related to *Anthonomus* Germar but differs from it by the presence of simple tarsal claws (Fall 1901). Claw appendiculation, however, is variable between species and is not a reliable generic characteristic. Lack of identifiable characters led Fall (1901), Burke (1968), and Ahmad and Burke (1972) to express doubt as to the validity of *Epimechus* as a distinct genus.

Seepwillow, *Baccharis salicifolia,* is a problem weed in streams and rivers of the southwestern United States and southern South America. Thickets of unisexual, woody shrubs, 3 to 4 m in height, sometimes block waterways, causing stream banks to fail. The plant has no value as forage for animals (Gatewood et al. 1950, Fletcher and Elmendorf 1955, Boldt 1989). Leaves are narrow, elongate, and glutinous. Each plant produces tens of thousands of

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[1] Contribution from the U.S. Department of Agriculture, Agricultural Research Service, USDA-ARS, 808 East Blackland Road, Temple, TX 76502.

whitish male or female flowerheads in flat-topped clusters of 25 to 150 flowerheads per cluster. A single female flowerhead contains 10 to 20 florets and a male contains about 50 florets. In Texas, flowering occurs from July to October (Correll and Johnston 1979).

We studied the life history of *E. canoides* in the Chihuahuan desert of west Texas as part of a long-term study of the native, phytophagous insects of *Baccharis* (Boldt and Robbins 1987, 1990, Boldt et al. 1988).

Materials and Methods

Field studies.—Observations of *E. canoides* were made periodically from 1985 to 1988 at two stream sites, Cibolo Creek, Shafter (Presidio Co.), and Musquiz Creek, Fort Davis (Jeff Davis Co.), Texas. Each site consisted of ca. 1 ha of more than 500 seepwillow plants growing along the banks of the stream or in the water, partially restricting its flow. The number of weevil larvae, pupae, and adults was assessed monthly from March to October in 1985 and from July to October in 1986 by sweeping 25 male and 25 female plants. In addition, 100 flowerheads from male and female plants located in an open area in Cibolo Creek and 7 to 10 m from the creek, and in partial shade 12 to 25 m from the creek, were sampled without bias on September 4, 1985. Flowerheads were dissected and the number of infested male and female flowerheads from each sample was recorded. Means were analyzed with the analysis of variance and Duncan's multiple range tests (MSTAT 1985).

Laboratory studies.—Experiments and observations were conducted at room temperature of 22° to 26°C, relative humidity of 40 to 60%, and a 14:10 h L:D photoperiod under fluorescent light. Egg size was determined by measuring live, 0 to 48 h-old eggs dissected from flowerheads. The number of larval instars was determined by measuring head capsule widths of 54 larvae collected in August, 1984, at Cibolo Creek and preserved in 70% ethanol. Measurements were made with a calibrated ocular micrometer in a stereomicroscope. No-choice adult feeding tests were conducted by holding an adult in a petri dish on freshly excised leaves of selected plants. Ten weevils were tested on each plant species. Leaves were replaced three times weekly and the amount of damage was determined by counting puncture marks in the leaf. Plants used were collected in western Texas and held outdoors in pots.

Insect voucher specimens have been deposited in the National Museum of Natural History, Washington, D.C., and the Insect Collection of the Department of Entomology, Texas A&M University, College Station.

Results and Discussion

Specimens of *E. canoides* were collected on seepwillow at the following locations: Marfa, Fort Leaton, Shafter (Presidio Co.), Alpine (Brewster Co.), and Fort Davis, Texas; Kingston (Sierra Co.), New Mexico; and Jimenez and Chihuahua City (Chihuahua State) Mexico. Fall (1913) originally described *E. canoides* from four specimens collected at El Paso (El Paso Co.), Texas. We made an extensive search of seepwillow and four other species of *Baccharis* in the southwestern United States, but found *E. canoides* only on seepwillow east of the Continental Divide (Boldt and Robbins 1990, Boldt unpublished data). Larvae of *E. canoides* were identified by rearing them to adults since they could not be distinguished from larvae of *E. arenicolor*. Scales on the elytral disc were denser and the male aedeagus was broader in *E. canoides* than in *E. arenicolor* adults.

Adult stage.—Length of the adult weevil was 2.10 to 2.22 mm ($n = 10$, $\bar{x} = 2.12 \pm 0.09$ mm). This range overlapped the 2.00 to 2.15 mm given by Fall (1913). Teneral adults were golden-brown in color in October, but lightened with age and became grayish-white by the following spring. Adult feeding punctures were small, round to oblong circles, 0.01 to 0.03 mm in diameter

Table 1. Number of adult *E. canoides* on each seepwillow and percent of plants infestated in Cibolo Creek, 1986.

	Plants			
	Female		Male	
Date	No. of Adults per Plant[a]	% Infestation of Flowers[b]	No. of Adults per Plant[a]	% Infestation of Flowers[b]
10 July	21.6	47.2 ± 8.3	—	—
14 August	7.6	53.5 ± 15.6	6.1	35.5 ± 13.4
18 September	13.4	45.5 ± 14.2	16.1	23.0 ± 14.8
15 October	7.4	31.0 ± 16.8	5.6	18.0 ± 7.4

[a] Mean number of adults per 25 plants swept.

[b] Mean ± SD of 4 replications of 25 flowerheads per date.

and up to 0.5 mm deep into leaf tissue. Feeding was about equally divided between upper (55.9%) and lower (44.1%) sides of leaves but 1044 (86.0%) of 1215 observed punctures occurred along the margins of the leaf as opposed to in the center. Adults fed on leaves or small stems until July when they also began to feed on the flowerheads.

In no-choice tests, adults fed and survived for one week on leaves of seepwillow, *Baccharis neglecta* Britt., and *B. halimifolia* L. but died within three to five days with little or no feeding on *B. pilularis* DC., *B. brachyphylla* Gray, *B. pteronioides* DC., *Gutierrezia sarothrae* (Pursh) Shinners, *Gymnosperma glutinosum* (Spreng.) and *Isocoma wrightii* (T.&G.) Greene (Asteraceae).

There was one generation per year. Oviposition occurred from July to October in swollen or slightly opened male and female flowerhead buds. Many of the 540 adults sampled in July 1986 were mating or ovipositing but those sampled in September and October were teneral, indicating a new generation. To oviposit, the female chewed a hole through a phyllary into the pappus, inserted an egg, and closed it with a plug. This plug was composed of fecal material mixed with a clear sticky liquid which, on drying, became brown in color. Usually, one egg was laid per flowerhead. Of 1200 infested flowerheads dissected in 1986, only one contained a second immature weevil. Eggs of *Trioza collaris* Crawford (Homoptera: Psyllidae) and *Lioptilodes parvus* (Walsingham) (Lepidoptera: Pterophoridae) also were commonly present in seepwillow flowerheads, and their immature stages sometimes competed with larvae of *E. canoides.*

Female weevils oviposited more in female than in male flowerheads as indicated by a higher infestation rate. In 1985, infestations of female flowerheads were 20 to 27% greater than in male flowerheads, and in 1986 they were 13 to 22% greater (Tables 1 and 2). Weevils also were found to feed and oviposit more on plants growing in wet soil near the water than on plants growing in dry soil (df = 2,12; $P = 0.05$) (Table 2). For male flowerheads, differences in the percentage of infestations between open and shaded areas in dry soil were nonsignificant.

Teneral adults emerged from seepwillow flowerheads between August and October and fed for one to three months before en-

Table 2. Percentage of seepwillow flowerheads infestated by immature *E. canoides,* 1985.

	Sample Sites[a]		
Flowerheads	Partial Shade, Dry Soil	Open Area, Dry Soil	Open Area, Wet Soil
Female	28.0[c] ± 6.6	42.0[b] ± 1.7	66.3[a] ± 5.9
Male	18.3[d] ± 4.0	15.7[d] ± 5.7	41.0[b] ± 4.6

[a] Means (±SD) of 3 replications of 100 male and female flowerheads per site.

Means followed by the same letter are not significantly different ($P = 0.05$).

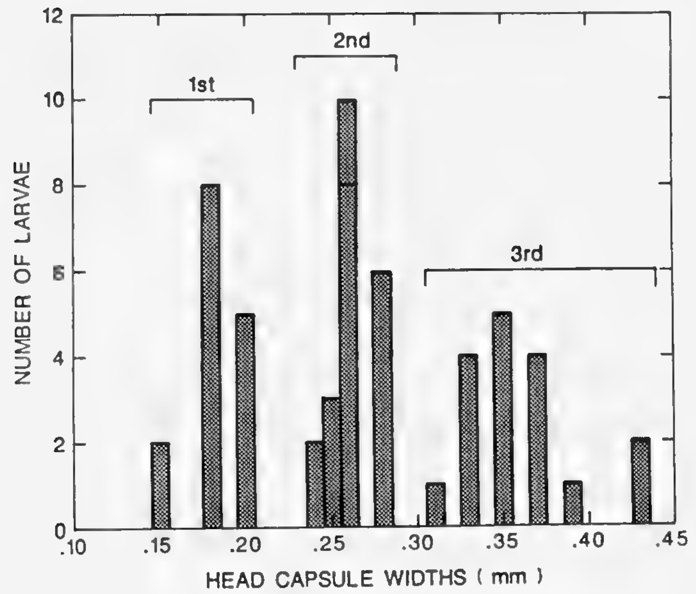

Fig. 1. Frequency distribution of head capsule widths (mm) of first, second, and third instar larvae of *Epimechus canoides,* Presidio County, Texas.

tering diapause and overwintering in ground debris. Their reappearance the following April coincided with production of new leaves on the plant.

Immature stages.—Eggs of *E. canoides* were smooth and white to pale yellow in color, darkening slightly with age. Mean lengths and widths (± standard deviation) of 21 eggs were 0.43 ± 0.02 and 0.30 ± 0.02 mm, respectively. There were three larval instars (Fig. 1). Mean head capsule widths were 0.18 ± 0.01 (n = 15), 0.23 ± 0.01 (n = 13), and 0.35 ± 0.02 (n = 15) mm for the first, second, and third larval instar, respectively. Larvae destroyed most of the achenes and pappus and much of the receptacle of the flowerhead. As larvae neared maturity, they glued the uneaten pappus hairs together with saliva and fecula to form a cell and pupated in the flowerhead. Mean length of the pupa was 2.21 ± 0.24 mm (n = 15). Adult emergence occurred through the side of the flowerhead just above the involucre.

Natural enemies.—The following hymenopteran parasites, reported in part by Boldt and Robbins (1990), were occasionally reared from larvae or pupae of *E. canoides: Zatropis* sp., *Catolaccus* sp. (Pteromalidae), *Tetrastichus* sp., and *Aprostocetus* sp. (Eulophidae). The hyperparasite *Horismenus* sp. (Eulophidae) was also reared.

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SINHALOHELEA, A NEW GENUS OF PREDACEOUS MIDGE FROM SRI LANKA (DIPTERA: CERATOPOGONIDAE)

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Abstract.—**Sinhalohelea gansi,** a new genus and species of predaceous midge of the tribe Ceratopogonini is described and illustrated. This new genus forms the sister group of four genera (*Brachypogon, Ceratoculicoides, Nannohelea, Rhynchohelea*). Characters are discussed that allow *Sinhalohelea* to be distinguished from morphologically similar taxa.

Key Words: Diptera, Ceratopogonidae, Ceratopogonini, *Sinhalohelea,* new genus, Sri Lanka, predaceous midges

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The predaceous midges of the tribe Ceratopogonini have recently received comprehensive treatment by Wirth and Grogan (1988), in which they illustrated and provided a key for 45 extant genera and a list of species for each genus. Four recently described genera were not included in that review: *Chimaerohelea* Debenham (1987) from Australia, *Bothamia* Meiswinkel (1987) from South Africa, *Neohelea* Clastrier (1988) from Guinea, and *Boreohelea* Clastrier and Delecolle (1990) from Guinea.

We recently examined specimens collected in 1974 from Sri Lanka and now housed in the National Museum of Natural History in Washington, D.C., USA (USNM). These specimens represent a new genus of predaceous midges of the tribe Ceratopogonini, which we describe herein.

For an explanation of general ceratopogonid terms, see Downes and Wirth (1981); for special terms dealing with the tribe Ceratopogonini, see Wirth and Grogan (1988). Actual values for antennal flagellomere and palpal proportions may be obtained by multiplying by 0.000148 mm.

Sinhalohelea Grogan and Borkent, NEW GENUS

Type-species.—*Sinhalohelea gansi* Grogan and Borkent, new species.

Diagnosis.—The only genus in the tribe Ceratopogonini with the following combination of characters. Eyes pubescent, contiguous. Antenna with sensilla coeloconica on flagellomere 1; male flagellum with all flagellomeres separate. Palpus 5-segmented; segment 3 moderately slender with a well defined pit. Female wing with single long radial cell, costa extending 0.71–0.75 of wing length; vein M2 absent or only apical portion present. Male wing with two small radial cells and distal portion of M2 present. Legs of female moderately stout, unarmed; tarsomere 4 of fore leg swollen, cylindrical on mid and hind legs, all bearing apical sinuate setae; fore claws large, unequal; mid and hind claws small, equal sized, with small basal inner tooth on each talon. Katepisternum with single lateral seta. Female abdomen with segment 8 entire, not divided by pleura; two spermathecae. Male genitalia small, reduced in size, without apicolateral processes on tergite 9; aedeagus broadly triangular; parameres separate.

Etymology.—The genus name is a reference to the Sinhalese, the non-Dravidian majority people of Sri Lanka.

Comparison with similar genera.—*Sinhalohelea, Brachypogon* Kieffer, *Ceratoculicoides* Wirth and Ratanaworabhan, *Nannohelea* Grogan and Wirth and *Rhynchohelea* Wirth and Blanton are apparently closely related by virtue of the fact that they all possess at least one seta on their katepisternum (Fig. 9). Of these other four genera, *Brachypogon* most closely resembles *Sinhalohelea,* but differs in having a wing with a shorter costa that extends less than 0.65 of wing length, the radial cells of which are extremely variable, from both cells being obsolete to one or two small cells present, and flagellomeres 2–11 of the male antenna are fused. In addition, if the female fore claws are enlarged in *Brachypogon,* the mid and hind claws usually are enlarged as well.

Ceratoculicoides differs from *Sinhalohelea* in having the posterior margin of the anepisternum dissected and usually bearing one or more setae on posterior extensions, and only flagellomeres 6–11 of the male antenna fused.

Rhynchohelea differs from *Sinhalohelea* by its shorter costa (costal ratio 0.41 or less), short truncate labium bearing setae on cuticular extensions, and the female antenna reduced to 12 flagellomeres (males are unknown for this genus).

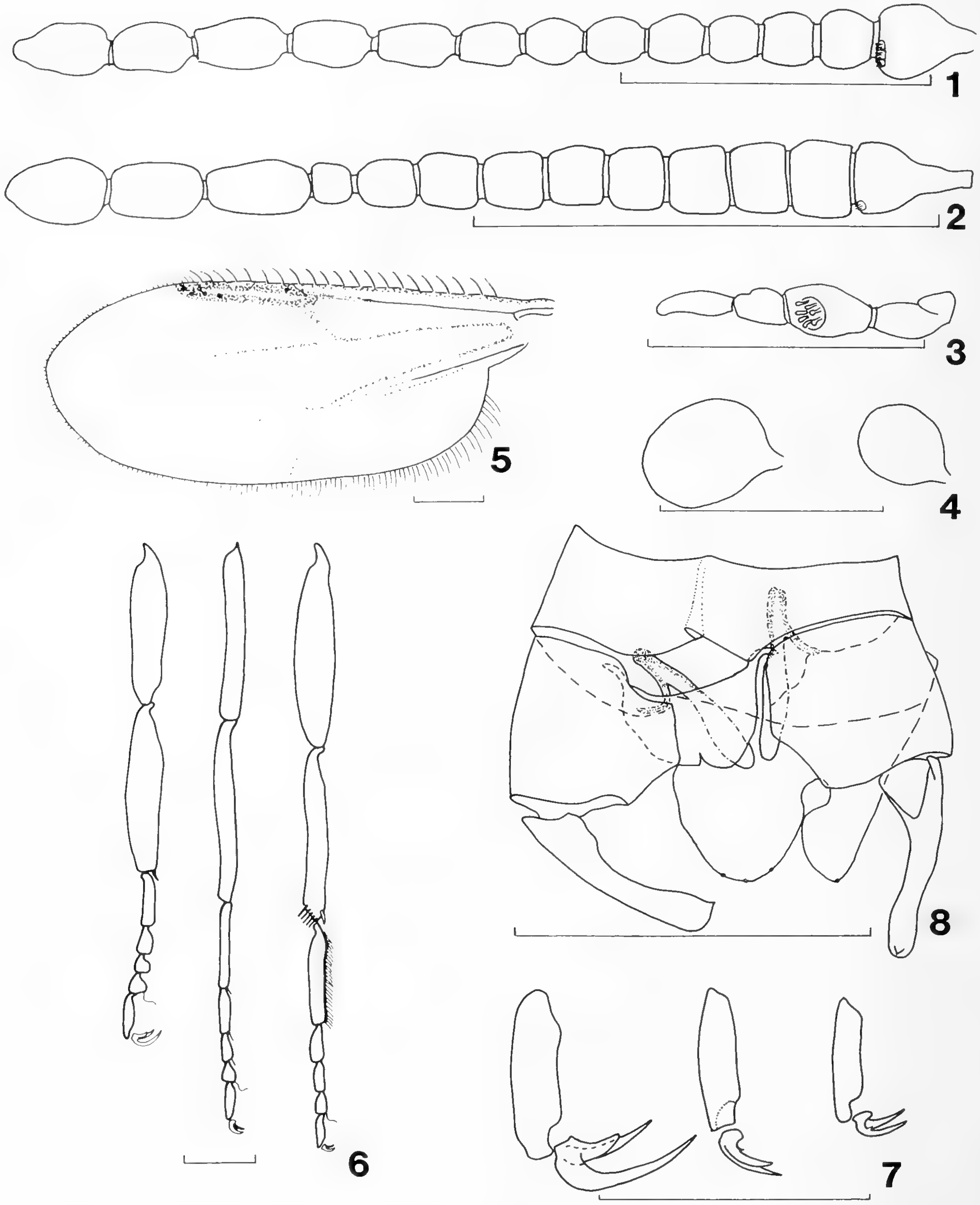
The four genera forming the sister group of *Sinhalohelea* are keyed in Borkent (1991).

Afrohelea, Alluaudomyia, Diaphanobezzia, Fittkauhelea, Parabezzia, and *Stilobezzia* (*Eukraiohelea*) all have wings with a single long radial cell but differ from *Sinhalohelea* in possessing a well developed vein M2 and lacking sensilla coeloconica on flagellomere 1. *Baeodasymyia, Baeohelea,* some *Camptopterohelea, Leptohelea* and *Nannohelea* all have wings with a single radial cell but the cell is of a different configuration than *Sinhalohelea*; these small reduced genera also have very short small claws (single in *Camptopterohelea*) and a reduced 2 or 3-segmented palpus. All other genera of the tribe Ceratopogonini differ from *Sinhalohelea* in either having two radial cells in their wing or lacking sensilla coeloconica on flagellomere 1 (Wirth and Grogan 1988).

Sinhalohelea gansi **Grogan and Borkent, New Species**

Figs. 1–8

Female.—Wing length 0.73 (n = 3); breadth 0.33, 0.32–0.33 (n = 3) mm. *Head:* Dark brown. Eyes pubescent, contiguous. Antenna with short scape bearing 3–4 setae; pedicel very dark brown; flagellum (Fig. 1) with flagellomere 1 bearing 3 apical sensilla coeloconica, all flagellomeres bearing subbasal whorl of sensilla chaetica, proximal 8 with subapical pair of long sensilla trichodea, distal 5 with subapical short sensilla trichodea; lengths of flagellomeres in proportion of 23-12-12-12-13-14-14-15-19-19-22-19-23; antennal ratio 0.90, 0.89–0.93 (n = 3). Clypeus with 3 pairs of submarginal setae. Palpus (Fig. 3) moderately long, segment 5 extending beyond tip of proboscis; segment 3 with well defined circular pit bearing capitate sensilla; lengths of segments in proportion of 4-9-10-6-8; palpal ratio 1.82. Mandible with 8 large curved teeth. *Thorax:* Dark brown. Scutum with shallow humeral pits, covered with minute pubescence, sparse large setae in more or less longitudinal rows; scutellum with 4 bristles. Legs (Fig. 6) with fore, hind femora thicker than mid femur; fore tibia nearly twice as thick as mid, hind tibiae, hind with apical plumose spur, comb with 5–6 setae; tarsi light brown on proximal 4 tarsomeres, these bearing a pair of apical spines, hind tarsomere 1 with well developed palisade setae, tarsomere 3, 4 of fore leg swollen, tarsomere 4 of mid, hind legs cylindrical,



Figs. 1–8. *Sinhalohelea gansi*. 1, female flagellum; 2, male flagellum; 3, female palpus; 4, spermathecae; 5, female wing; 6, female legs; 7, female tarsomeres 5 and claws; 8, male genitalia. Scales = 0.1 mm.

tarsomere 4 of all legs bearing pair of sinuate apical setae, tarsomere 5 of fore leg slightly enlarged with large subequal claws, largest talon bearing a large basal tooth, tarsomere 5 of mid, hind legs slender bearing small equal sized claws with small basal inner teeth (Fig. 7). Wing (Fig. 5) membrane lightly infuscated, covered with microtrichia only, macrotrichia restricted to wing margin and a few scattered along radius; wing moderately broad, 2.3 times longer than broad, anal lobe well developed; veins dark brown, one long slender radial cell present, r-m crossvein set at oblique angle, M1 obsolete on extreme apex near wing tip, M2 absent or present apically, cubitus forking just beyond level of r-m crossvein, forks obsolete at extreme tips, anal veins clearly marked; costal ratio 0.73, 0.71–0.75 (n = 3). Halter brown. *Abdomen:* Brown. Segment 8 not divided by pleura, forming a continuous ring; sternite 9 divided medially, each half with slender tip directed slightly posteriorly; sternite 10 with pair of large setae; 2–3 ovoid spermathecae with short necks (Fig. 4).

Male.—Wing length 0.57; breadth 0.24 mm. Smaller but otherwise similar to female with the following notable sexual differences: Antennal flagellum (Fig. 2) with only a single sensilla coeloconica on flagellomere 1; flagellomere 10 very short, much narrower than others; plume well developed, extending past flagellomere 12; lengths of flagellomeres in proportion of 43-15-16-15-15-16-16-16-12-10-26-22-24; antennal ratio 0.44. Palpus with smaller sensory pit on segment 3. Mandible vestigial, without teeth. Legs with small equal sized claws with bent bifid tips. Wing narrower, with 2 radial cells and M1 barely visible at midportion; costal ratio 0.57. Genitalia (Fig. 8) short, reduced; sternite 9 with shallow caudomedial excavation; tergite 9 difficult to discern due to distortion, without apicolateral processes, cerci large, prominent, bearing large apical setae. Gonocoxite short, broad, covered with setae; gonostylus slightly longer than gonocoxite, tapering distally from base with broader tip, rounded apex with single, small, well developed tooth. Aedeagus somewhat crushed, broader than long, tip broadly rounded with slight medial concavity; small lateral, lobelike prongs; basal arm more heavily sclerotized than main portion. Parameres separate, heavily sclerotized; a small curved basal arm set at nearly a right angle to main portion; distal portion straight with rounded slightly bulbous tip.

Type material.—Holotype male, allotype female, two female paratypes labelled "SRI LANKA: Bad. Dist., 5 mi E Mahiyangana Hasalaka, 200 feet, 16 November 1974, Collectors: C. Gans, P. Fernando, S. Farook"; holotype, allotype, one paratype deposited in National Museum of Natural History (USNM), one paratype deposited in Canadian National Collection, Ottawa (CNCI).

Etymology.—Named for one of the collectors, Carl Gans, a world renowned herpetologist with the University of Michigan.

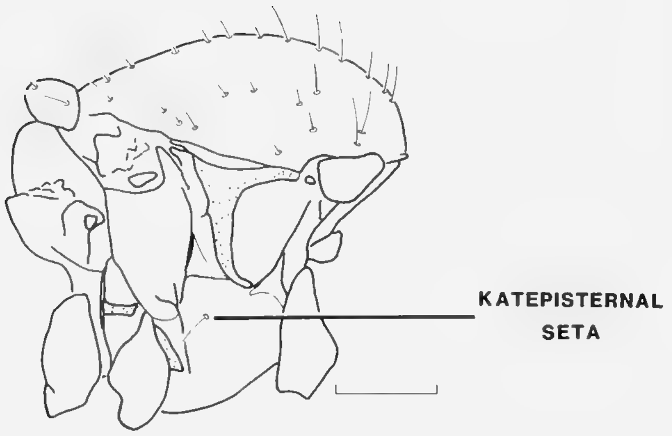
Phylogenetic relationships.—Proposing and recognizing new taxa above the species level should generally be within a context of an understanding of cladistic relationships (Wiley 1981). As such, we have examined the phylogenetic placement of *Sinhalohelea* within the Ceratopogonidae.

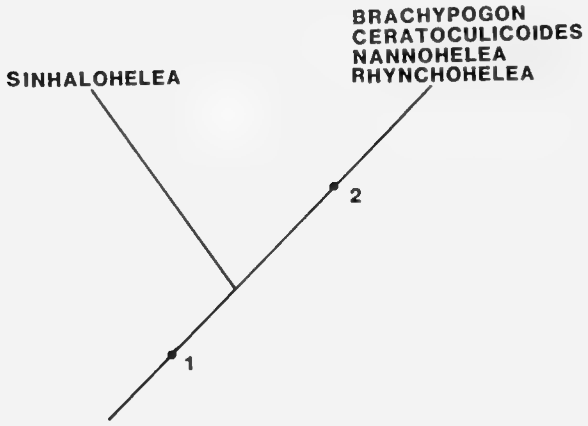
Our interpretation of character state polarity follows the cladistic principle of outgroup comparison discussed elsewhere by Borkent (1984). To obtain a better understanding of character state polarity and distributions, we have examined virtually every ceratopogonid genus with the exception of recently described ones mentioned above or a few monotypic genera based upon a few specimens housed in distant museums. In addition, examples of all other families within the Culicomorpha were also examined.

The following provides a character analysis in which the number corresponds to our concluding cladogram in Fig. 10.

1. Katepisternal setae absent (plesiomorphic); at least one katepisternal seta present (apomorphic) (Fig. 9).

Within the Ceratopogonidae, the apomorphic state is present in only a few other taxa. Species of *Leptoconops* have setae on the lateral and ventral portions of the katepisternum. *Phaenobezzia, Paryphoconus, Johannsenomyia* and *Mackerrasomyia* also have katepisternal setae. However within





Figs. 9–10. Fig. 9. Lateral view of thorax of a male *Brachypogon* (*Isohelea*). Scale = 0.1 mm. Fig. 10. Cladogram showing relationship of *Sinhalohelea* to some other Ceratopogonidae. Numbers refer to character states discussed in text.

the tribe Ceratopogonini the condition is unique and katepisternal setae are lacking in immediate outgroups (Borkent et al. 1987).

In the Culicomorpha, katepisternal setae are otherwise present in the Culicidae, Chaoboridae, some Dixidae and some Chironomidae. We have only seen one Simuliidae with a single lateral katepisternal seta (*Parasimulium crosskeyi* Peterson).

Even though members of *Leptoconops*, as the earliest lineage of Ceratopogonidae, also have katepisternal setae, we consider this to be independently derived. Alternatively, it is possible that the presence of katepisternal setae is plesiomorphic within the Culicomorpha. In that case, the presence of the setae in the group under consideration here would still be considered derived (on the basis of successive outgroup comparisons) but perhaps representing an atavistic reacquisition of the character.

2. Male antennal flagellomeres separate (plesiomorphic); flagellomeres 5–11 fused (apomorphic).

Within the Ceratopogonidae, fused male flagellomeres occur in some other genera but never in the same configuration as that described here. In all these other taxa flagellomere 11 is always free, indicating that the above fusion of flagellomeres 5–11 is correctly interpreted as a synapomorphy grouping *Ceratoculicoides, Brachypogon, Nannohelea* and *Rhynchohelea.*

Further fusion of flagellomeres 2–5 occurs in all known *Brachypogon* and may be a synapomorphy uniting species of that genus. The male of *Rhynchohelea* is unfortunately not known and therefore the character state cannot yet be appraised for this genus.

The appraisal of this character for *Nannohelea* is complicated by a reduction in the number of flagellomeres. In *N. bourioni* (Clastrier), 8 flagellomeres are present but 5 and 6 are fused (pers. obs.). From the elongate appearance of the terminal three flagellomeres, we assume that these are homologous to flagellomeres 11–13 of most other ceratopogonids. Hence, the fusion of flagellomeres 5 and 6 in *N. bourioni* probably indicates a homologous character state of fusion of flagellomere 11 with previous flagellomeres. If flagellomere 5 of *N. bourioni* is homologous to flagellomere 5 of other ceratopogonids, the data would indicate that *N. bourioni* has fused flagellomeres 5–11 but that these are markedly reduced.

The remaining three species of *Nannohelea* (Grogan and Wirth, 1990) have only 7 flagellomeres with the terminal 3 elongate. In at least two of these (*N. tamil* Grogan and Wirth, *N. clastrieri* Grogan and Wirth) the third last flagellomere has at least a double row of elongate setae arranged near its base (Grogan and Wirth 1980, 1990). In other ceratopogonids with a full complement of 13 flagellomeres, flagellomere 11 has only a single row of basal elongate setae. The double row in these *Nannohelea* species indicates that flagellomere 5 is actually flagellomere 11 fused with at least one more basal flagellomere.

Fusion of antennal flagellomeres also occurs in a few, certainly derived Chironomidae (i.e. well within the family) but is otherwise unknown within the Culicomorpha.

Conclusion.—The phylogenetic position of *Sinhalohelea* as the sister group of *Brachypogon* + *Rhynchohelea* + *Nannohelea* + *Ceratoculicoides* justifies its recognition as a new genus. Although its present monotypic status ensures that *Sinhalohelea* is monophyletic, we are presently unable to suggest an autapomorphy for the genus. Perhaps future investigations of the phylogenetic relationships between the genera of the Ceratopogonini (Borkent, in prep.) will allow for further interpretation of characters which now appear markedly homoplastic (i.e. number of radial cells; relative length of costa; presence or absence of apicolateral processes).

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BIOLOGY AND IMMATURE STAGES OF *CHAETOPSIS MASSYLA* (DIPTERA: OTITIDAE), A SECONDARY INVADER OF HERBACEOUS STEMS OF WETLAND MONOCOTS

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Abstract.—The life cycles and larval feeding habits of *Chaetopsis massyla* (Walker), a saprophagous species that is a secondary invader of wetland monocots, are elucidated. The immature stages are described and illustrated. Suggestions are made concerning the possible evolution of larval feeding habits in the family Otitidae.

Key Words: Diptera, Otitidae, *Chaetopsis,* life cycles, feeding habits

The family Otitidae, containing some 650 species in the world, is divided into two subfamilies. The subfamily Otitinae is primarily north temperate in distribution, whereas the Ulidiinae is particularly well developed in the Neotropics. The family is widely distributed, with 178 species in the Palaearctic Region (Soos 1984, Zaitzev 1984); 130 in the Nearctic (Steyskal 1987); 285 in the Americas south of the United States (Steyskal 1968); 21 in the Afrotropical (Steyskal 1980); 11 in the Oriental Region (Steyskal 1977); and 25 in the Australasian and Oceanian Regions (Evenhuis 1989).

Information on life histories and larval feeding habits of Otitidae is available in Allen and Foote (1967), Foote (1976), and Ferrar (1987). The larval feeding habits are known for less than 32% of the Nearctic species, and immature stages have been described for only some 10%. Most of the larvae have saprophagous habits, although a few genera contain phytophagous larvae that are primary invaders of living plant tissue (Table 1).

In North America the genus *Chaetopis* is represented by five species: *C. aenea* (Wiedemann), *C. apicalis* Johnson, *C. major* (Wulp), *C. massyla* (Walker), and *C. quadrifasciata* Curran. The first two species are largely restricted to salt marshes along the Atlantic and Gulf Coasts, but the remaining three can occur in freshwater habitats.

Biological information is available for three Nearctic species. Larvae of most species apparently are saprophagous, having been found in damaged stems of corn (Gossard 1919), sugar cane (Braydon 1918), and cattail (Foote 1976). They have also been found in rotting pineapples (Illingworth 1926) and bananas (Oglivie 1925), as well as decaying bulbs of narcissus (Blanton 1938) and onion (Severin and Severin 1915, Merrill 1951, Merrill and Hutson 1953). The larvae of a few species may be phytophagous. Chittenden (1895) presented information on the life cycle of *C. aenea* and described the eggs and mature larvae, stating that the larvae damaged cereals such as wheat, oats, corn, and sugarcane. S. E. Neff (personal communication) collected larvae and puparia of *C. apicalis* from the pithy material of big cordgrass [*Spartina cynosuroides* (L.) Roth] growing on the shoreline of a brackish marsh. He felt that the larvae were primary invaders, as no larvae of other phytophagous insects were found. In contrast to these earlier workers who assumed a phytophagous way of life for *C. aenea* and *C. apicalis,* Strong et al. (1984) stated that these two species were saprovores in stands of smooth cordgrass (*Spartina alterniflora* Loisel) in northwestern Florida. No larval stages of any species of the genus have been described (Ferrar 1987).

The present paper elucidates the life cycle of *C. massyla* and describes its immature stages. A tabular summary of the larval foods of Otitidae is presented, and possible evolutionary trends in larval feeding habits within the family are discussed.

MATERIALS AND METHODS

Collecting techniques: Most of the field collections were made near Kent in Portage County, Ohio. A small burrow pit, located seven miles east of Kent bordered on the east and west by a vernal marsh and a small pond was the site of most of the field observations. A second productive site was a small marsh located along Horning Road in Kent.

Adults were collected by sweeping suitable habitats with a standard insect aerial net measuring 40 cm in diameter. Larvae were collected by examining damaged stems of wetland monocots. Puparia were collected in early spring by pushing emergent vegetation beneath the water surface.

Rearing techniques: The temperature of the rearing room ranged from 22 to 25°C. Adults collected in nature were placed in 5 × 7 cm breeding jars for mating and oviposition. The bottom of each jar contained a moist layer of commercial peat moss. A moistened pellet of brewer's yeast mixed with honey supplied the nutritional requirements of the adult flies. A small piece of decaying cattail stem served as an oviposition stimulant. As eggs appeared, they were removed from the jars with a fine jeweler's forceps or camel hair brush, counted, and transferred to the surface of moist peat moss in small (6.5 × 1.5 cm) petri dishes.

Larvae were reared individually or col-

Table 1. Larval foods of North American Otitidae.

Genus	Larval Food
	Otitinae
Callopistromyia	Decaying cambium of deciduous trees
Cephalia	Unknown
Ceroxys	Decaying vegetation, manure
Curranops	Unknown
Delphinia	Decaying vegetation
Diacrita	Rot pockets in cactus
Dyscrasis	Unknown
Haigia	Unknown
Herina	Unknown
Hiatus	Unknown
Idana	Decaying vegetation
Melieria	Unknown (phytophagous?)
Myrmecothea	Decaying vegetation
Myiomyrmica	Unknown
Notogramma	Rot pockets in cactus, decaying fruits
Psaeropterella	Unknown
Pseudotephritina	Decaying cambium of deciduous trees
Pseudotephritis	Decaying cambium of deciduous trees
Pseudoseioptera	Decaying vegetation
Seioptera	Decaying vegetation, manure
Tetanops	Sugarbeet roots, decaying bulbs
Tetropismenus	Unknown
Tritoxa	Onion and garlic bulbs
Tujunga	Unknown
Ulidiotites	Unknown
Xanthracrona	Unknown
	Ulidiinae
Acrosticta	Unknown
Axiologina	Decaying tissues of palm trees
Chaetopsis	Decaying vegetation, stems of salt marsh grasses
Eumecosomyia	Inflorescences of corn (damaged?)
Eumetopiella	Inflorescences of grasses
Euxesta	Decaying vegetation, fruits, cambium, cactus, manure
Homalocephala	Decaying subbark tissues of coniferous trees
Oedopa	Unknown
Paroedopa	Rot pockets in cactus
Physiphora	Decaying vegetation
Steneretma	Unknown
Stenomyia	Unknown
Stictomyia	Rot pockets in cactus
Texasa	Unknown
Zacompsia	Unknown

lectively in small petri dishes containing either lengths of decaying cattail stem or rotting bits of lettuce. The rearings were inspected daily to determine larval feeding behavior, time spent in each of the three larval stadia, and site of pupation. Food and water were added as needed. As puparia appeared, they were transferred to eight-dram shell vials (one puparium per vial) containing a moistened peat moss substrate. Recently emerged adults were placed into breeding jars for information on premating and preovipositional periods, number of eggs laid, and longevity.

Preparation techniques: Eggs were preserved and stored in Peterson's egg preservative. For gross examination eggs were removed from the preservative and placed in a small depression slide containing KAAD solution. A representative sample of the eggs for each species was measured.

Larvae were killed in hot water and stored in 80% ethanol. To study gross morphological structures, larvae were transferred to a petri dish containing KAAD. The spiracular discs were removed with a pair of iridectomy scissors and placed on a microscope slide in a small amount of glycerin jelly.

To study minute morphological structures, larvae were cut along the mid-dorsal line and the soft parts teased away from the integument with #3 insect pins. Anterior and posterior spiracles were dissected from the integument with insect pins that were sharpened to a fine point. To prepare permanent slides, the parts were carefully positioned on a slide, dehydrated in 80% ethanol, cleared in xylol, and finally mounted in Permount. Temporary wet mounts were prepared by mounting these structures in a small drop of glycerine.

The cephalopharyngeal skeletons were either dissected from preserved larvae or recovered from cast exuviae. The skeletons were first treated in a warm KOH solution for two or three minutes and then cleared in glacial acetic acid. Permanent slides of the sclerites comprising the cephalopharyngeal skeleton were prepared. A representative sample of the cephalopharyngeal skeleton for each instar was measured.

Larvae were prepared for SEM by immersing them in Super Skipper for 30–60 seconds, and then placing them in Carl's Solution for 24 h (Grodowitz et al. 1982). They were subsequently dehydrated in a standard ethanol series, subjected to critical point desiccation, and finally sputter-coated with gold/palladium. Prepared larvae were examined with a Cambridge Stereoscan Electron Microscope. Photographs were obtained with a high resolution camera and Polaroid film No. 52.

Puparia which failed to produce adults were fixed in KAAD and stored in 80% ethanol. Puparia which had produced adults were placed in #4 gelatin capsules and pinned beneath the adult. A representative sample of the puparia was measured.

Voucher specimens have been deposited in the insect collections of Kent State University and Ohio State University.

FIGURE ABBREVIATIONS

AS, anterior sclerite; AT, accessory tooth; DC, dorsal cornu; DS, dentate sclerite; HS, hypostomal sclerite; IP, interspiracular process; M, mandible (bp, basal part; hp, hook part); PB, parastomal bar; Pa, papilla; PhR, pharyngeal ridge; PP, perianal pad; PS, posterior sclerite; SO, spiracular opening; SP, spiracular plate; SS, spiracular scar; TS, tentoropharyngeal sclerite; VC, ventral cornu.

LIFE HISTORY

A strictly Nearctic species, *C. massyla* ranges from Alberta to Maine, and south to New Mexico (Steyskal 1965). We collected adults most commonly in open marshes and barrow pits containing stands of cattail (*Typha latifolia* L.), sedges (*Carex* spp.), and rushes (*Juncus* spp.). Most were taken between early June and late September and were particularly common during mid and late June. The earliest collection was made on May 6 (1 male); the latest, November 6 (1 male).

Adults were not very active until approached, when they suddenly ran sideways and retreated to the opposite side of the cattail leaf. The lateral movements were as fast or faster than the forward movements. Both sexes constantly flicked their wings. Adults were not attracted to sweet smelling fragrances, and Frost (1929) collected only 2 adults (as *C. fulvifrons* (Macquart)) during a two year period using sugarwater bait pails. Adults were frequently seen running up and down the leaves of common cattail. However, they were not confined to that species and were nearly equally abundant in stands of cattail, reed canary grass (*Phalaris arundinacea* L.) and two species of sedges (*C. lacustris* Willd., *C. stricta* Lam.) during our summer-long study of a freshwater marsh near Kent (Fig. 12).

Laboratory-reared adults lived 15–62 days ($\bar{x}$ = 25, n = 8). Wild caught females lived 40–45 days (n = 4); males, 30–36 days (n = 6). The premating period was not determined, although it was probably less than 2 or 3 days, as viable eggs were obtained from reared females within 3 days after emergence. No mating was observed either in the laboratory or field.

Gravid field-collected females placed in breeding jars with pieces of mechanically damaged cattail leaves began ovipositing 1–2 days after capture. They inserted their ovipositors into decaying portions of the cattail leaves, and clusters of 3–10 eggs subsequently were found between the epidermal layers. Very few eggs were laid on the sides of the jars, on decaying lettuce, or on the peat moss substrate. Fecundity for reared females (n = 4) ranged from 150 to 398. Larvae hatched by rupturing the chorion near the micropylar end of the egg. The incubation period lasted 2–3 days (n = 12).

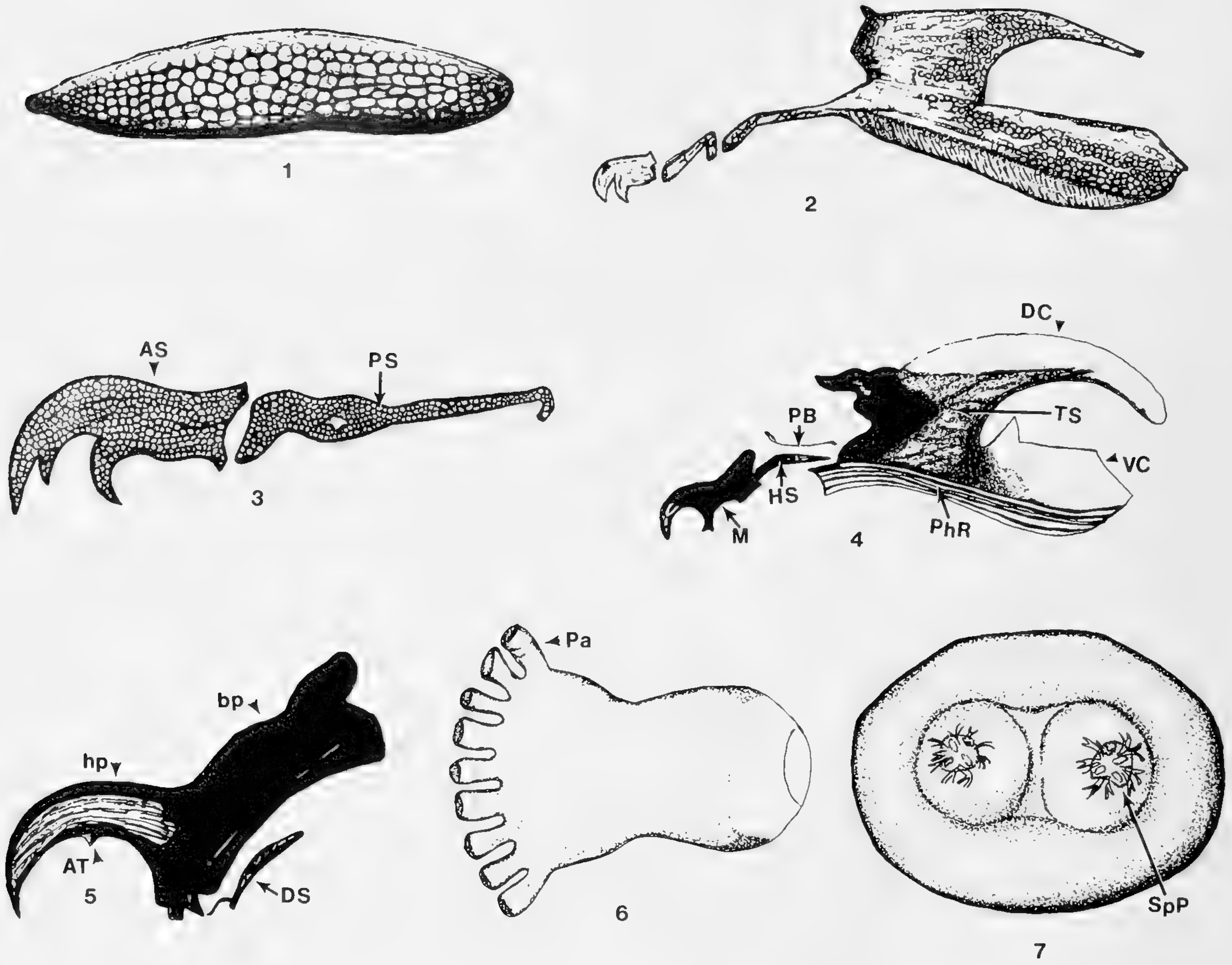
Newly hatched larvae were reared on decaying cattail leaves, lettuce, watermelon and pumpkin rind, and guinea pig and woodchuck dung. Larvae feeding on decaying cattail leaves required 12–23 days ($\bar{x}$ = 19) to complete development (n = 10). They spent 2–4 days ($\bar{x}$ = 3) in the first instar; 3–7 ($\bar{x}$ = 5), in the second; and 7–15 ($\bar{x}$ = 11), in the third. Larvae of all three instars were found in nature feeding as secondary invaders in decomposing tissues of cattail stems that had been damaged by moth larvae belonging to the family Noctuidae. Up to 40 larvae were found in each damaged stem. Apparently there was little movement away from moth-damaged tissues, as eggs, larvae of all three instars, and puparia commonly co-occurred in such sites. A few larvae were found in *C. lacustris* Willd. stems damaged by larvae of *Epichlorops exilis* (Coquillett) (Diptera: Chloropidae).

Puparia usually were formed in damaged stems near the site of larvae feeding, although several puparia were found floating in water within stands of emergent macrophytes. The pupal period lasted 8–10 days for females (n = 8), and 7–9 days for males (n = 5). Many puparia produced adults that failed to spread their wings.

At least in northeastern Ohio, *C. massyla* was a multivoltine species. In the laboratory, the whole life cycle was completed in 33 days. Reproduction occurred continuously during the warm season, stopping only in response to low temperatures in early fall. Overwintering occurred as larvae, prepupae, and pupae. Larvae collected in nature during late December and March quickly resumed feeding on decaying cattail in the laboratory, suggesting that overwintering does not involve a larval diapause. The first seasonal record for puparia was obtained in early March in a stand of cattail. The early and late capture records for adults, May 6 and November 6, indicate a flight period of ca. 180 days.

DESCRIPTIONS OF IMMATURE STAGES

Egg (Fig. 1): Length 0.86–0.94 mm; maximum width 0.15–0.18 mm. White, semipolished. Spindle shaped. Chorion striated.



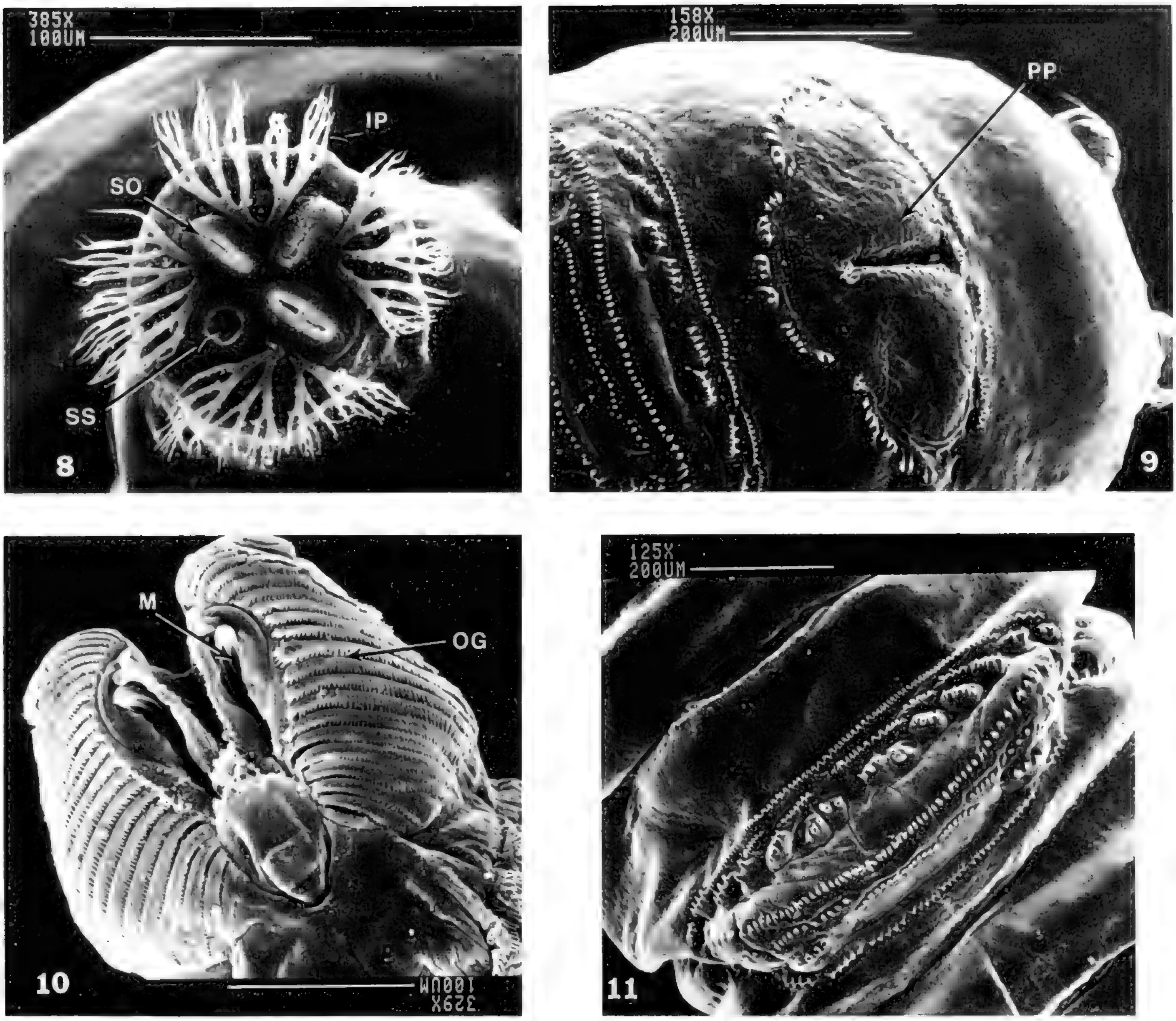
Figs. 1–7. *Chaetopsis massyla.* 1, Egg. 2, Cephalopharyngeal skeleton of first instar. 3, Mandible of first instar. 4–7, Third-instar larva. 4, Cephalopharyngeal skeleton. 5, Mandible. 6, Anterior spiracle. 7, Posterior spiracular disc.

Terminal micropyle shielded by small tubercle (n = 20).

First-instar larva: Similar to third instar except in following characters. Length 1.12–2.14 mm; maximum width 0.15–0.32 mm. White, integument transparent. Intersegmental constrictions well defined. No anterior spiracles. Posterior spiracular plates raised on two dome-like spiracular tubes; each plate with B-shaped opening and four branched interspiracular processes. Cephalopharyngeal skeleton (Fig. 2) length 0.26–0.31 mm; maximum width 0.04–0.07 mm (n = 5). Tentoropharyngeal sclerite lightly to deeply pigmented, lacking parastomal bars. Each mandible (Fig. 3) with two sclerites; anterior sclerite bearing three teeth, with accessory tooth lying in same plane as hook; posterior sclerite with small window (n = 20).

Second-instar larva: Similar to third instar except in following characters. Length 2.24–4.85 mm; maximum width 0.26–0.58 mm. Anterior spiracles rosette shaped, with 9–12 fingerlike marginal papillae. Posterior spiracular plates with three oval openings; trabeculae reduced in number; interspiracular processes two- or three-branched at base. Cephalopharyngeal skeleton length 0.46–0.60 mm; maximum width 0.14–0.21 mm (n = 20).

Third-instar larva: Length 4.50–9.90 mm; maximum width 0.57–1.28 mm. Subshining white, integument transparent; fat bodies becoming yellowish just prior to pupation. Conical cylindrical, tapering anteriorly



Figs. 8–11. Third-instar larva of *Chaetopsis massyla*. 8, Posterior spiracular plate. 9, Perianal pad. 10, Facial mask. 11, Creeping welt of segment 5.

from second abdominal segment, bluntly rounded posteriorly. Cephalic segment bilobed apically, each lobe bearing short fleshy two-segmented antenna anteriorly and maxillary palp ventrally, palps without basal sclerotized rings; facial mask (Fig. 10) with 20–25 unbranched grooves leading into oral opening, each groove bordered anteriorly by single row of 5–20 unpigmented spinules. Spinule bands restricted to eight ventral creeping welts (Fig. 11). Perianal pad (Fig. 9) ellipsoidal, slightly protruding; bordered by single row of unpigmented spinules.

Anterior spiracles (Fig. 6) posterolateral on segment 2 (prothoracic), yellowish tan, fan shaped with 9–12 ($\bar{x}$ = 10) fingerlike marginal papillae.

Posterior spiracular plates at tips of short spiracular tubes (Fig. 7); each plate (Fig. 8) with circular spiracular scar, three spiracular slits arranged in "T" configuration, and four branched interspiracular processes; each process two- or three-branched at base; spiracular tubes, slit margins and trabeculae dark brown, interspiracular areas and slits yellowish white.

Cephalopharyngeal skeleton (Fig. 4) length 0.99–1.10 mm; maximum width 0.29–0.34 mm. Tentoropharyngeal sclerite mostly

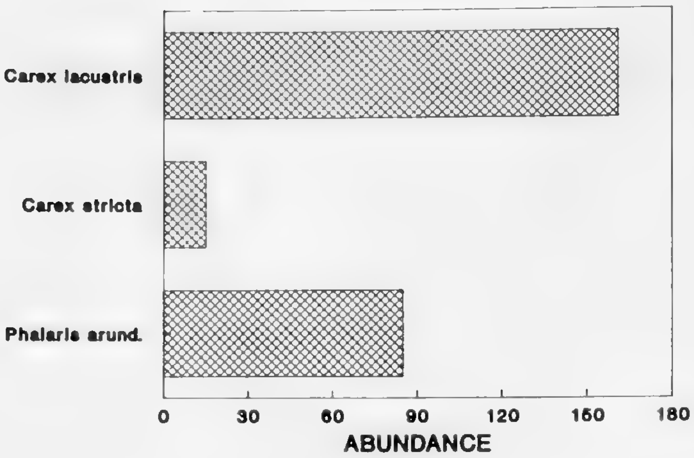


Fig. 12. Occurrence of adults of *C. massyla* in stands of *Carex lacustris, C. stricta*, and *Phalaris arundinacea* at the Horning Rd. marsh in Kent, Ohio during 1990.

lightly pigmented, deeply pigmented on dorsal bridge, each ventral cornu with distinct dorsal projection near base; tentoropharyngeal and hypostomal sclerites fused; dorsal cornua joined anterodorsally by bridge; floor of tentoropharyngeal sclerite with numerous ridges; parastomal bars well developed and reaching nearly to mandibles; hypostomal sclerite bent abruptly downward anteriorly in lateral view and H shaped in ventral view, lightly pigmented except near anterior end. Mandibles (Fig. 5) deeply pigmented except at tips, each with basal window, not connected dorsally; narrow, elongate paired dentate sclerite lying ventrad of each mandible (n = 20).

Puparium: Length 3.06–5.50 mm; maximum width 0.96–1.63 mm. Reddish brown, smooth and translucent, darker near cephalic caps and posterior spiracles. Cylindrical, rounded posteriorly; narrowed anteriorly, flattened dorsoventrally to form lateral ridges on cephalic caps. Anterior spiracles on anterolateral margins of dorsal cephalic cap, fan shaped, reddish brown, yellowish at tips, with 9–12 ($\bar{x}$ = 10) marginal papillae. Posterior spiracles on two knoblike spiracular tubes; tubes black, spiracular slits reddish yellow. Perianal pad ellipsoidal, slightly depressed (n = 20).

DISCUSSION

The known larval foods of 23 of the 41 North American genera of Otitidae are summarized in Table 1. The numerous gaps in our knowledge of many genera reduces the usefulness and value of the table in detecting evolutionary trends in food utilization, especially in the subfamily Otitinae where only 50% of the genera have known larval feeding habits. However, it is possible to derive a few generalizations about trophic diversification in the family.

The basic food of otitid larvae probably is decaying organic matter, particularly accumulations of rotting plant material occurring in moist to mesic terrestrial habitats. Twelve of the 26 North American genera of Otitinae and eight of the 15 genera of Ulidiinae have larvae that are saprophagous. The otitid flies thus largely retain the primitive acalyptrate dipterous habit of utilizing compost (Oldroyd 1964). Such genera as *Ceroxys, Delphinia, Idana, Myrmecothea, Pseudoseioptera, Seioptera, Euxesta* and *Physiphora* appear to have the most generalized feeding habits in that their larvae apparently are capable of developing in a wide spectrum of decaying vegetation. In contrast, other genera seemingly have somewhat more specialized saprophagous habits, as they concentrate or even restrict their larval feeding to particular kinds of rotting vegetable matter. For example, larvae of species of *Callopistromyia, Pseudotephritina, Pseudotephritis,* and *Homalocephala* feed on decomposing cambial and other tissues under the bark of dead and dying trees (Allen and Foote 1967, Steyskal 1979). Further specialization has occurred even within this group, as larvae of the first three genera are associated with deciduous trees, whereas *Homalocephala* larvae have been found only under bark of conifers. A second set of saprophagous genera are specialized for feeding on rotting cactus tissues in the arid lands of the Southwest (Foote 1976). This feeding habit undoubtedly represents convergent evolution, as the genera involved, *Diacrita, Notogramma, Paroedopa,* and *Stictomyia,* belong to both subfamilies and certainly did not evolve from a single common ancestor. A third group of saprophytic genera, including *Chaetopsis* and possibly *Eumecosomyia,* are secondary invaders of herbaceous plants that have been damaged by other, truly phytophagous insect species.

Saprophagous larvae of Diptera probably ingest and assimilate populations of decomposer microorganisms that flourish in rotting vegetation. Some studies have shown that decomposed vegetable matter when sterilized is unsuitable as larval food. Larvae of numerous species of *Drosophila* consume the abundant yeast flora that develops in fermenting plant tissues (Wagner 1944, Cooper 1960), and larvae of some species of saprophagous Ephydridae are postulated to ingest bacteria (Eastin and Foote 1970). Other saprophagous dipterous larvae, including some species of Lauxaniidae that develop in rotting leaf litter (Miller and Foote 1975, McDonald et al. 1974), may utilize bacteria and/or fungi. A detailed study of saprophagous otitid larvae may well show that each species utilizes a particular spectrum of microorganisms. Thus, species that co-occur in rotting plant tissues (e.g. rot pockets in cactus) may actually be in different trophic niches, even though they occupy the same spatial and temporal niches. Rearings of different saprophagous species of otitid larvae in monocultures of a variety of bacterial, fungal and yeast substrates would give meaningful insights into trophic niche segregation occurring within the family.

A second generalization concerning larval food preferences in Otitidae is that several genera have abandoned the saprophagous way of life and are now phytophagous. Adoption of herbivory apparently has occurred repeatedly during the evolutionary history of the family as shown by the fact that the phytophagous genera do not constitute a single phyletic line. Phytophagous habits occur in at least two Nearctic genera of Otitinae (*Tetanops* and *Tritoxa*) and one genus of Ulidiinae (*Eumetopiella*).

Larvae of the phytophagous genera attack a fair diversity of plant hosts, although there is a strong tendency to utilize herbaceous monocots. Larvae of *Eumecosomyia* and *Eumetopiella* attack grasses (Gramineae) (Steyskal 1966, Valley et al. 1969), and those of *Tritoxa* feed on bulbs of wild onion and garlic (Liliaceae) (Allen and Foote 1975). At present, only larvae of *Tetanops myopaeformis* (Roder) are known to attack a species of Dicotyledoneae (sugar beet, Chenopodiaceae) (Mahrt and Blickenstaff 1979). Specialization for particular plant parts has also occurred. Thus, larvae of *Tetanops* attack roots, those of *Tritoxa* feed within bulbs, larvae of *Chaetopsis apicalis* may be stem borers, and larvae of *Eumecosomyia* and *Eumetopiella* consume reproductive tissues in developing inflorescences.

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THE LIFE HISTORY AND IMMATURE STAGES OF A MARINE SHORE FLY, *HECAMEDE ALBICANS* (DIPTERA: EPHYDRIDAE)

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Abstract.—The coastal marine habitat distribution and life cycle of *Hecamede albicans* (Diptera: Ephydridae) are described for the first time. In vitro, *H. albicans* completed development on putrefying *Mytilus edulis* (blue mussel) in 10–15 days. *Hecamede albicans* eggs are also described for the first time, and previous descriptions of the third-instar larva and puparium are augmented and/or modified. Differences in third-instar larval and puparial length ranges suggest that the quality and quantity of nutrient resources may affect morphometric parameters.

Key Words: *Hecamede albicans,* Ephydridae, life history

The Ephydridae (Diptera) are well represented in aquatic, semi-aquatic, and coastal marine habitats. The first in depth investigations of marine shore-fly ecology and distribution were completed in Scandinavia (Ardö 1957, Dahl 1959). Simpson (1976) reviewed the biology and distribution of Nearctic ephydrids that inhabit marine beaches and coastal marshes. Additionally, Barnby and Resh (1984) investigated the habitat distributions of adult shore flies within a California coastal marsh. Although the distributions of shore-fly adults from aquatic (Deonier 1965, Scheiring and Foote 1973, Deonier and Regensburg 1978b, Steinly and Deonier 1980, Steinly 1984, 1990, Steinly et al. 1987) and marine habitats (Dahl 1959, Barnby and Resh 1984, Steinly 1986) have been reported, less than 15% of ephydrid life histories and immature stages have been described from the Nearctic Region (Deonier and Regensburg 1978a, Zack 1983).

On the island of Guam, Bohart and Gressitt (1951) collected *Hecamede persimilis* Hendel third-instar larvae and puparia from a human cadaver that was washed up on a marine beach. Adults of *Hecamede persimilis* are common inhabitants of Hawaiian seashores, where they are found on decaying fish and crabs and have been reported developing in stranded marine seaweed (marine wrack) (Tenorio 1980). Both *H. persimilis* (Bohart and Gressitt 1951) and *H. albicans* (Meigen) (Norrbom 1983) have been reported associated with excrement. Adults of *H. albicans* have been collected in Scandinavian dune heath on dead herring (Ardö 1957), marine wrack, and the Hockenya (supralittoral) habitats (Dahl 1959). Although *H. albicans* has been reared on rotting lettuce (Simpson 1976), *Mytilus edulis* L. (blue mussel) (Steinly and Runyan 1979), and *Limulus polyphemus* L. (horseshoe crab) (Norrbom 1983), these reports did not exhaustively discuss life history characteristics.

This paper describes the life cycle and

coastal marine habitat distributions of *H. albicans.* Previous descriptions of the *H. albicans* third-instar larvae, puparium, and cephalopharyngeal skeleton (Norrbom 1983) are augmented and/or modified. Additionally, the discrepancies in third instar and puparia dimensions that were reported by Norrbom (1983) and compiled during this investigation are discussed.

Materials and Methods

Adults of *H. albicans* were collected at Anchor Beach, Milford, Connecticut. The marine beach was divided into distinct habitats that were characterized by plant and substrate types (Deonier 1979) and tidal effects (Neumann 1976). During submersion and emersion episodes, beach organisms are exposed to changing biological, chemical, and physical conditions. These conditions vary with intertidal range and are related to the magnitude of the tides. The supralittoral division of the intertidal zone (Neumann 1976) is flooded during storms and the marine tidal extremes of the equinoxes. The supra-midlittoral boundary is submerged biweekly by spring tides. The midlittoral is inundated by tides once or twice daily, and its sublittoral fringe is exposed only during the low waters of the spring tide. The land-to-sea dimensions of these intertidal divisions depend on the amplitude of the local tides and shore topography (Neumann 1976). Collecting was concentrated over marine wrack (supra-midlittoral boundary), midlittoral sand and rock, marine grass (sublittoral), and high sand beach (supralittoral) habitats.

Adults were collected with a modified aerial net (Regensburg 1977) or individually captured with a vial during June 1978 and 1979, and July and August of 1980 and 1981, respectively. Adults were aspirated from the aerial net, and single gravid females were transferred into 13 dram snap-cap vials (Plastic Container Corp.) that contained a freshly collected blue mussel. These oviposition vials were stored for 48 h in total darkness. After eclosion, individual first-instar larvae were isolated, and all stadia were exposed to a natural day/night cycle. In the absence of controlled laboratory conditions, rearing temperature fluctuated between 21° and 27°C. The morphological terminology of Teskey (1981) has been adopted to describe the immature stages.

Subsamples of eggs, larvae, and puparia were removed from the rearing vials and preserved in 80% ethanol. Additionally, viable and empty puparia were collected in the field from stranded decaying blue mussels, common spider crabs (*Libinia emarginata* Leach), and horseshoe crabs.

Larvae and pupae were dehydrated in an ethanol series before critical point drying in a Sandri 790 (Tousimis Research Corporation). Dried specimens were mounted on aluminum stubs with double-sided tape and sputter coated with gold-paladium (SPI Sputter). Specimens were coated twice at different angles to ensure complete coverage and to reduce charging effects. Life stages were examined with an Information Scientific Instrument DS-130 scanning electron microscope and photographed with Polaroid type 55 positive/negative film.

Life History

At Anchor Beach, adults of *H. albicans* were rarely collected over the supralittoral sand beach and rocks and sublittoral sand habitats. Although *Hydrellia griseola* (Fallén) was present on marine grass, and *Cirrula gigantea* Cresson, *Glenanthe litorea* Cresson, *Scatella favillacea* Loew, *S. obsoleta* Loew, and *S. paludum* (Meigen) were collected on algal encrusted rocks, *H. albicans* was not found within these sublittoral habitats during low tide. *Hecamede albicans* adults were collected over marine wrack rows and decaying marine animals that were located on the supralittoral-midlittoral boundary and in midlittoral sand beach habitats, respectively. Large numbers of adults were collected from decaying fish, spider crabs, horseshoe crabs, jelly fish, and blue mussels that were stranded within the supralittoral and midlittoral habitat divisions. Adults were also routinely observed roosting in moist wrack rows but were not collected in marine marsh habitats near Anchor Beach.

Field observations and rearings confirm that *H. albicans* deposited eggs on the interior surfaces of decomposing spider crabs, blue mussels, and fish. After the limbs are broken, gravid females immediately enter the carcasses of horseshoe and spider crabs. *H. albicans* puparia were field-collected from horseshoe crab gill surfaces and empty blue mussel shells.

In total darkness, females deposited 5–14 eggs on the interior and exterior valve surfaces of blue mussels. Oviposition was completed in 48 h, and eggs hatched within 1–2 days. Comparable groups of gravid females subjected to a natural day/night cycle did not lay eggs.

Larval development on decaying blue mussels was completed in 8–13 days ($\bar{x}$ = 12 days). The duration of the first larval stadium was 1–2 days, the second 3–5 days, and the third 4–6 days. During development, *H. albicans* larvae moved through the liquid that was produced by the putrefaction of blue mussel tissue. Adults emerged in 1–2 days from puparia that adhered to the vial walls above the decomposing tissue. The developmental cycle of *H. albicans* was completed in 10–15 days. The capture of gravid females in June, July, and August and the short developmental cycle suggest that *H. albicans* is a multi-voltine species that produces more than 9 generations per year.

DESCRIPTION OF IMMATURE STAGES

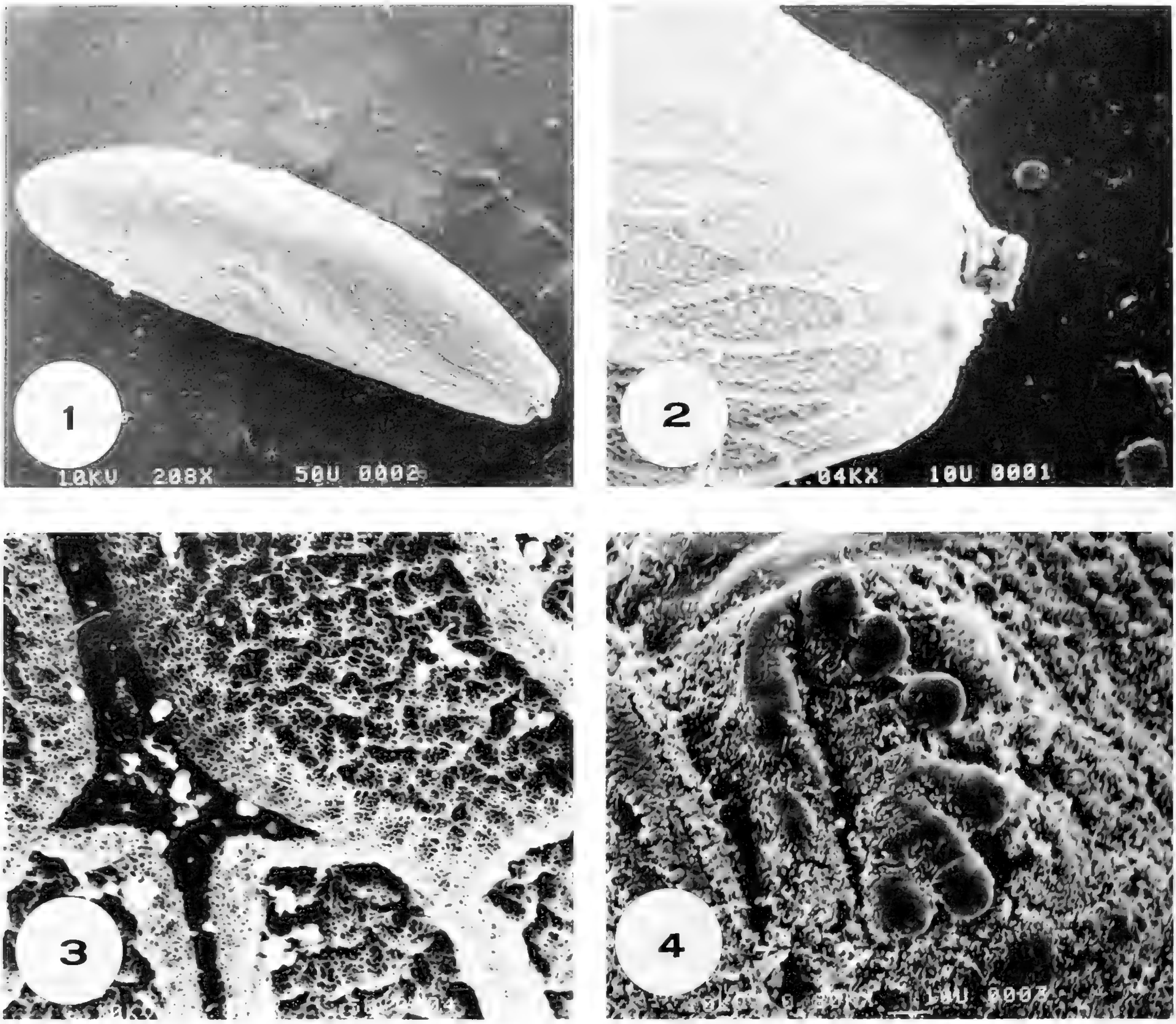
Eggs (Figs. 1–3).—Length 0.49–0.58 mm, $\bar{x}$ = 0.54 mm; width 0.14–0.20 mm, $\bar{x}$ = 0.17 mm (N = 16). Elliptical, slightly flattened ventrally; micropylar end truncate, opposite end bluntly rounded; micropylar disc with 0.012 mm diameter and 0.033 mm thickness, elevated 0.033 mm on a stalk (N = 2) (Fig. 2). Chorion opaque white, transparent at eclosion with distinctly irregular reticular pattern (Figs. 2, 3).

Mature third-instar larvae.—Length 3.89–5.28 mm, $\bar{x}$ = 4.60 mm; width 0.67–1.11 mm, $\bar{x}$ = 0.93 mm (N = 24). Cephalopharyngeal skeleton (CPS) ventral view 0.56–0.68 mm, $\bar{x}$ = 0.64 mm (N = 24). Anterior spiracles rounded apically with central opening (Fig. 4); 0.014 mm wide at base, slightly narrowed apically to 0.012 mm (Fig. 4). Antennae with 2 segments, basal segment ring-shaped (Fig. 5). Ventral surface with distinct creeping welts (Fig. 6). Posterior spiracle tube short, cylindrical with 3 spiracular openings, 4 sets of fine, multi-branched hairs (Fig. 7). See Norrbom (1983) for additional description.

Puparium.—Length 2.70–3.24 mm, $\bar{x}$ = 2.94 mm; width 1.15–1.37 mm, $\bar{x}$ = 1.25 mm (N = 16). Posterior two-thirds of ventral surface flattened. Ten distinct segments, transverse sutures, ridges obvious. Segments 3–10 with lateral swelling. Anterior spiracles 6-lobed. Posterior spiracles short. Puparial emergence opening triangular with apex medially truncate, medial depression on truncate apex. See Norrbom (1983) for additional description.

DISCUSSION

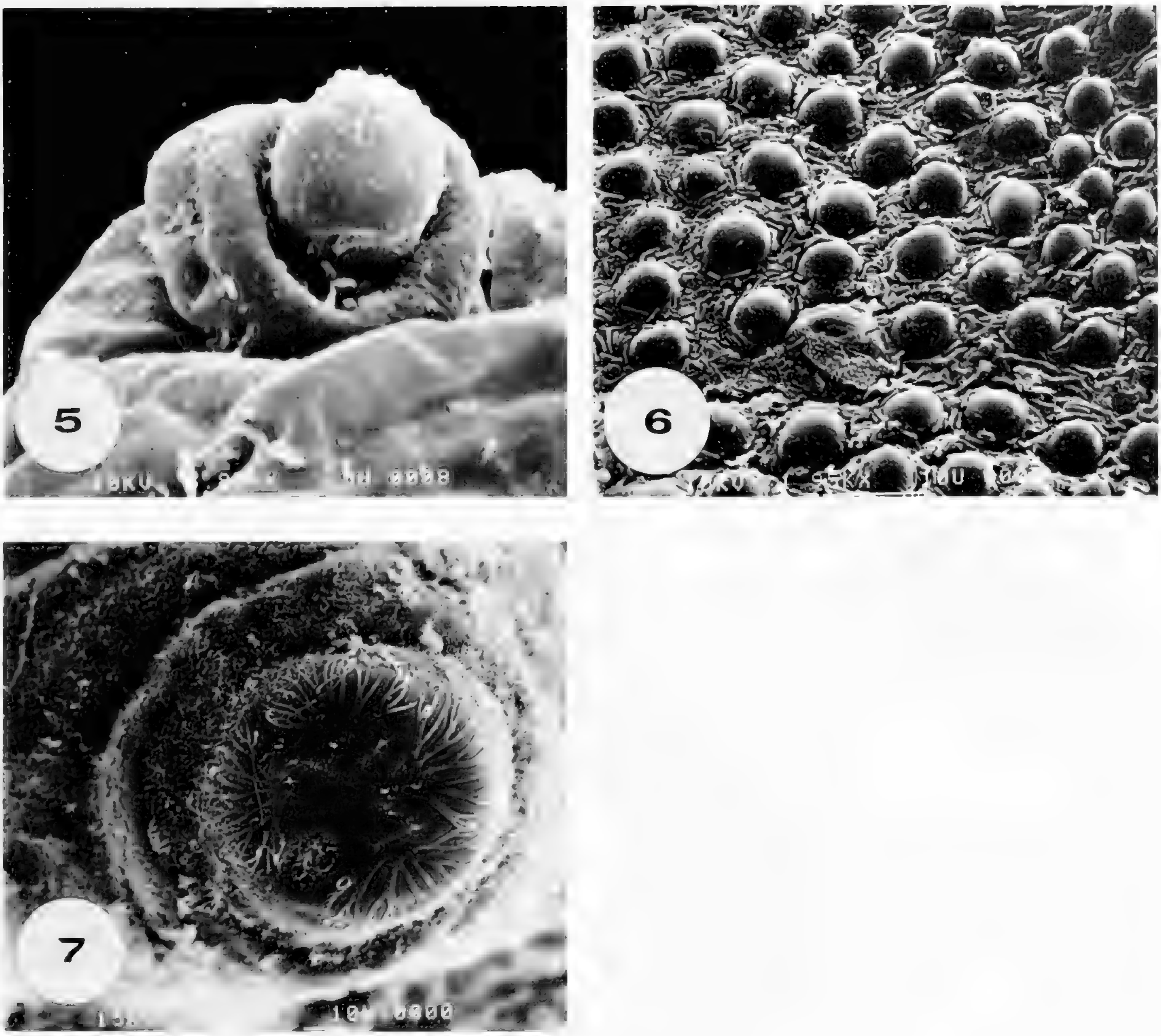
Scattered reports of *H. albicans* (Ardö 1957, Simpson 1976, Steinly and Runyan 1979, Norrbom 1983) and *H. persimilis* (Bohart and Gressitt 1951, Tenorio 1980) on decaying plant and animal remains substantiate the suggestion that these species are generalist scavengers on ephemeral nutrient resources. In the absence of wave action generated by storms, decaying nutrient resources and oviposition habitat in the supralittoral and midlittoral are infrequently inundated. Presumably, *H. albicans* avoids the disruption of ephemeral resources by storms and periodic tidal extremes of the equinoxes with a shortened developmental cycle (Steinly 1986). Shortened life cycles have been reported for *Scatella picea* (Walk-



Figs. 1–4. *Hecamede albicans.* 1, Egg. 2, Micropyle. 3, Areopyle. 4, Third-instar larva (anterior end).

er) and *S. stagnalis* (Fallén) (Diptera: Ephydridae) that commonly colonize freshwater ephemeral mud-shore habitats (Connell and Scheiring 1982, Foote 1979). In all probability, rapid shore-fly development, a temporal adaptation, allows these species to avoid dramatic increases of stream flow and/or wave action associated with storms (Steinly 1986).

Previously, a brief description of immature stages provided the basis for third-instar larvae and puparia identification (Norrbom 1983). Curiously, third-instar larvae and puparia found on decaying horseshoe crabs were smaller (Norrbom 1983) than individuals reared on blue mussels. Norrbom (1983) reported third-instar larvae, puparia, and CPS length ranges of 4.00–4.50 mm, 2.25–2.75 mm, and 0.65–0.70 mm, respectively, whereas third-instar larvae and puparia developing on putrefying blue mussels had length ranges of 3.89–5.28 mm ($\bar{x}$ = 4.60 mm, N = 24) and 2.70–3.24 mm ($\bar{x}$ = 2.94 mm, N = 16). Larvae raised on blue mussels had a CPS length range of 0.56–0.68 mm ($\bar{x}$ = 0.64 mm, N = 24). Although third-instar larval and puparia lengths from Anchor Beach specimens were different from Norrbom's (1983) descriptions and specimens, the life stage morphology and length



Figs. 5–7. *Hecamede albicans.* 5, Third-instar larva, antenna. 6, Third-instar larva creeping welts, ventral surface. 7, Third-instar larva posterior spiracle.

ranges of the CPS were similar. The differences in the length of the larvae and puparia suggest that a considerable amount of size variation exists within and between populations. The amount of CPS range overlap and a mean length within the range reported by Norrbom (1983) suggest that CPS development is less variable.

Variations in the length of *H. albicans* third-instar larvae and puparia may be the consequence of larval food quality, quantity, and availability. Previously, adult shore-fly size variation has been associated with feeding on different species of algae (Foote 1978, Zack and Foote 1978, Foote 1981a, b). These laboratory investigations suggest that the quantity and/or quality of nutrient resources may have a significant impact on larval survival and adult size.

Field examination confirmed that the putrefaction of dead horseshoe and spider crabs was a relatively slow process, whereas blue mussel tissues degenerated within 2 days in vitro. In the field, slow decomposition and the inaccessibility of crustacean viscera, competition, elevated temperature, and wind and solar desiccation may limit the optimal utilization of carrion resources during development. Norrbom (1983) reported that horseshoe crab viscera were dried or consumed by unspecified muscid and calliphorid species in the field. In vitro, rapid degeneration of blue mussels assured that ample quantities of quality food were immediately available to emerging first instar *H. albicans* larvae. Additionally, *H. albicans* larvae were not competing with other dipterous species in vitro for limited nutrient resources, and they were not subjected to extreme physical and biological field conditions.

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NEW *ATHYSANELLA* (HOMOPTERA: CICADELLIDAE) SPECIES FROM SOUTHWESTERN GRASSLANDS: FURTHER EVIDENCE FOR THE IMPORTANCE OF PHENOLOGY AND TAXONOMIC IDIOSYNCRASY IN GENERATION OF BIOLOGICAL DIVERSITY

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Abstract.—Southwestern grasslands are a rich source of species of *Athysanella* Baker; to date 128 species have been recorded. We now describe four new species. ***Athysanella* (*Gladionura*) *maycoba*** n. sp. was collected from short grasses in Sonora, Mexico. ***Athysanella* (*Gladionura*) *itawana*** n. sp. was collected on alkali sacaton (*Sporobolus airoides*) in the Four Corners area of the Colorado Plateau. ***Athysanella* (*Gladionura*) *raisae*** n. sp. was collected from hairy grama (*Bouteloua hirsuta*) in Durango and Zacatecas, Mexico. ***Athysanella galeana*** n. sp. was collected from saltgrass (*Distichlis spicata*) in Chihuahua, Mexico. We also illustrate a common undeveloped form of *Athysanella* (*Gladionura*) *blanda.* Discovery of these new species and the recent discovery of a species endemic to New Mexico gypsum areas confirm previous predictions of *Athysanella* diversity. This diversity appears to be governed by a sedentary life history strategy, the isolation of host grass patches, and marked differences among regional climates that enforce phenological isolation. Future study will probably reveal even more diversity in the genus *Athysanella.*

Key Words: Leafhopper, grasslands, Southwest, brachypterous, phenology

We have previously reported (Hicks et al. 1988) that blue grama (*Bouteloua gracilis* Willd. ex H. B. K.) grasslands of New Mexico were partitioned by *Athysanella* Baker specialists into regions closely allied to recognized climatic regions. Restriction of certain species to short-grass prairie, high plains, Rocky Mountains, and Gila Mountains was documented. Other dominant grasses of the Southwest are similarly partitioned, not only by *Athysanella* species, but also by species of *Flexamia* (Whitcomb and Hicks 1988) and other genera (Whitcomb et al. 1986, 1987, 1988). Given the brachyptery of *Athysanella* species (Ball and Beamer 1940), their high degree of host specificity, and the existence of a vast mosaic of "climatic habitat islands" in the Southwest, where the genus abounds, we asked (Hicks et al. 1988) why there were not in fact many more than the 128 reported *Athysanella* species. In this and a companion publication (Hicks and Whitcomb 1992), we document five new species of *Athysanella,* confirming our suspicion that alpha discovery in the genus *Athysanella* may continue for some time.

In the following descriptions, we have assigned "character codes" as described by Blocker and Johnson (1990a, b).

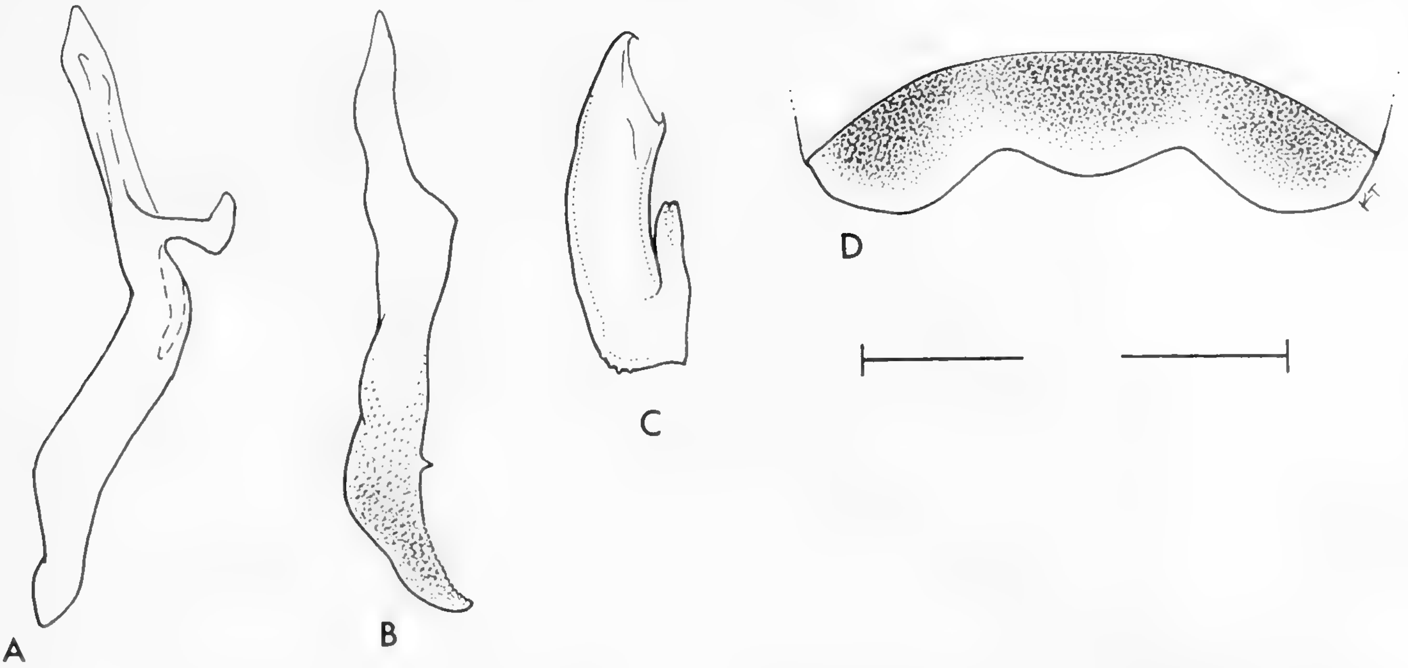

Fig. 1. *Athysanella* (*Gladionura*) *maycoba*. A. Style, ventral aspect; B. Style, lateral aspect; C. Aedeagus, lateral aspect; D. Female sternum VII. Bar = 0.5 mm.

Descriptions of New Species

Athysanella (*Gladionura*) *maycoba* Hicks and Blocker, New Species

Description.—Length of male 2.66–2.92 mm, female 3.48–3.80 mm; head width of male 1.00–1.04 mm, female 1.08–1.14 mm; pronotal width of male 0.93–1.03 mm, female 1.07–1.11 mm; interocular width of male 0.40–0.44 mm, female 0.48–0.52 mm; vertex length of male 0.40–0.44 mm, female 0.44–0.52 mm; pronotal length of male 0.30–0.38 mm, female 0.36 mm.

Vertex and pronotum stramineous, marked with brown. Wings and abdomen greenish to stramineous, marked with brown; face and venter brown to fuscous.

Forewings brachypterous, exposing 3.5–4.5 pregenital abdominal terga; ocellus approximately its own diameter from eye, hind tibial spur approximately ⅘ length of first tarsomere.

Male: Pygofer with caudal margin extended, with acute apical process curved ventrolaterally, short, serrate; anal tube exceeding plates; plates with posterior margin truncate; valve bluntly triangular; connective ½ length of styles. Styles (Fig. 1A, B) curved ventrally at apex, preapically thin with tiny tooth on ventral surface ¼ distance from apex, exceeding both plates and pygofer in length; aedeagus (Fig. 1C) acute apically, slightly curved, closely appressed to dorsal apodeme, which it exceeds in length by ⅓.

Female: Female sternum VII (Fig. 1D) shallowly trilobed.

Character code: 0-1-0-0-1-1-1-0-1-0-1-1-2-2-0-0-1-0.

Type material.—*Holotype male:* Mexico: Sonora, east of Maycoba, 5800 ft, 5 September 1987, A. L. Hicks, IPL 001783, deposited in NMNH, Washington, D.C. *Paratypes:* Six male and four female paratypes, same locality, in California Academy of Sciences, San Francisco, Kansas University, Snow Museum, Lawrence, and NMNH.

Diagnosis.—*Athysanella* (*G.*) *maycoba* is a member of the *diversa-nacazarana* clade. It keys to couplet 18 of the key of Blocker and Johnson (1990a), and within that couplet to *A.* (*G.*) *diversa* Ball and Beamer. It can be distinguished from *diversa* by the shape of the style apex, which is more strongly curved ventrad in lateral aspect and

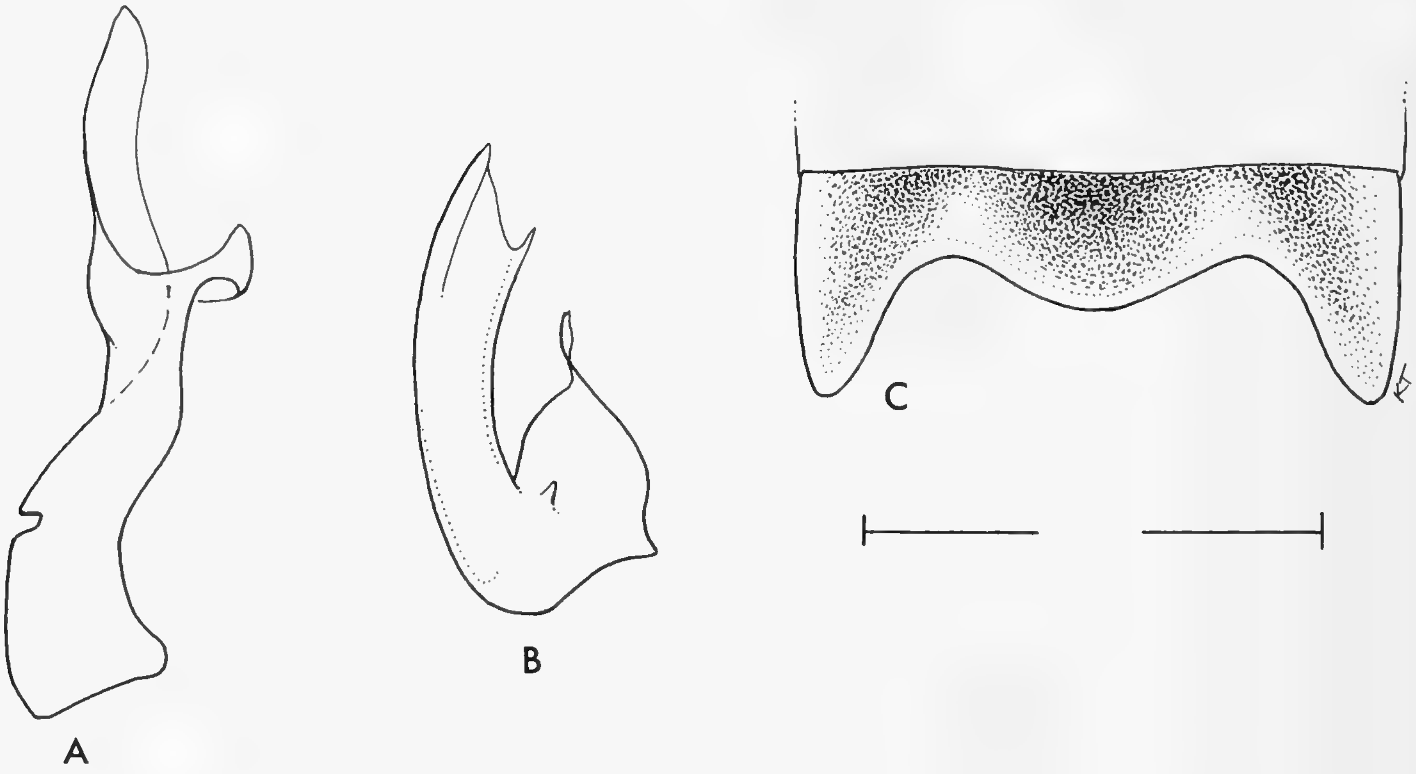

Fig. 2. *Athysanella* (*Gladionura*) *itawana*. A. Style, broad aspect; B. Aedeagus, lateral aspect; C. Female sternum VII. Bar = 0.5 mm.

extends much further beyond the plates. Its styles exceed the plates by a much greater increment than in *A.* (*G.*) *nacazarana* Osborn, with which it could possibly be confused. In addition, the style apices of *maycoba* are acute and curved ventrad.

Hosts.—*Athysanella* (*G.*) *maycoba* was collected only from the type locality in Mexico, where it occurred on mixed short grasses including blue grama (*Bouteloua gracilis*) and curly mesquite [*Hilaria belangeri* (Steud.) Nash].

Etymology.—This species is named for the type locality.

Athysanella (*Gladionura*) *itawana* Hicks and Blocker, New Species

Description.—Length of male 3.24–3.48 mm, female 4.24–4.92 mm; head width of male 1.20–1.28 mm, female 1.36–1.40 mm; pronotal width of male 1.05–1.23 mm, female 1.27–1.33 mm; interocular width of male 0.48–0.52 mm, female 0.52–0.60 mm; vertex length of male 0.40–0.44 mm, female 0.44–0.52 mm; pronotal length of male 0.34–0.36 mm, female 0.38–0.42 mm.

Color stramineous, vertex usually with a pair of fuscous spots; abdomen in dorsal aspect with at least some indication of six irregular fuscous stripes; ventral surface with varying amounts of fuscous along midline, diminishing caudally; wings, face and vertex with varying amounts of fuscous coloring.

Forewings brachypterous, exposing 4.5 pregenital abdominal terga; ocellus approximately its diameter from eye; hind tibial spur approximately ¼ to ⅕ length of first tarsomere.

Male: Pygofer with caudal margin extended, processes long, apically acute, curved ventrad, without serrations; anal tube not reaching apex of pygofer; plates subtruncate, usually slightly embrowned apically; valve with caudal margin broadly rounded. Style (Fig. 2A) in broad aspect with margin bisinuate, expanded subapically with truncate apex angling into prominent medial lobe, lateral lobe small, tiny ventrally directed tooth present near apex. Aedeagus (Fig. 2B) with shaft strongly recurved, ½ to ⅓ longer than dorsal apodeme, with small irregular process on either side of base.

Female: Female sternum VII (Fig. 2C) concave with median lobe slightly shorter than lateral lobes.

Character code: 1-0-0-1-1-1-0-0-1-0-0-2-2-0-1-0-1-0.

Type material.—*Holotype male:* New Mexico: Nageezi, San Juan Co., 6600 ft, 9 August 1985, R. F. Whitcomb, IPL 002360, on alkali sacaton (*Sporobolus airoides* Torr.), deposited in NMNH, Washington, D.C. *Paratypes:* Four male and 5 female paratypes, same collection, have been deposited in Canadian National Collection, Ottawa, Kansas University, Snow Museum, Lawrence, and NMNH.

Diagnosis.—*Athysanella* (*G.*) *itawana* is related to (*A.*) (*G.*) *curtipennis* and will key to this species in the treatment of Blocker and Johnson (1990a). However, it can be distinguished from *curtipennis* by the shape of the styles, which are acute instead of rounded apically, and from the somewhat similar *A.* (*G.*) *blanda* by the bisinuate nature of the styles. This species, which has been collected only at the type locality, was taken from alkali sacaton, *Sporobolus airoides.*

Etymology.—The species is named for Itawana, the term used by modern Zuni Native Americans for the mythological site where the Zunis emerged from the third world into the (contemporary) fourth world (Bunzel 1932). The Zunis are the modern descendents of the Anasazis, who colonized the Four Corners region, establishing pueblos and maize economies (Frazier 1986). Itawana, used by corn maidens in creation myths, is also used today in Zuni ritual poetry invoking rain:

Send forth your massed clouds to stay with us,
Stretch out your water hands,
Let us embrace!
To Itawana you will come
With all your people,
Hiding behind your watery shield . . .

Athysanella (*Gladionura*) *raisae* Hicks and Blocker, New Species

Description.—Length of male 2.76–3.44 mm, female 3.84–4.32 mm; head width of male 0.97–1.05 mm, female 1.09–1.13 mm; pronotal width of male 0.99–1.05 mm, female 1.07–1.15 mm; interocular width of male 0.40–0.46 mm, female 0.48–0.53; vertex length of male 0.37–0.46 mm, female 0.44–0.48 mm; pronotal length of male 0.32–0.36 mm, female 0.34–0.36 mm.

Color stramineous to pale green, vertex and pronotum without fuscous spots, tan and unadorned to marked with dark brown pattern of irregular spots; dorsal portion of abdomen with infuscated anterior margins of abdominal tergites exposed or not, a transverse line of small fuscous dots on each tergite. Venter usually fuscous, legs with variable black spots and stripes. Elytra unadorned.

Forewings brachypterous, exposing 4.0 to 4.4 pregenital abdominal tergites; ocellus approximately twice its own diameter from eye; hind tibial spur about ½ as long as first tarsomere.

Male: Pygofer (Fig. 3C) with caudal margin extending into a short, smooth, robust, laterally curved process (Fig. 3D); anal tube attaining apex of pygofer; plates slightly shorter than pygofer, inner margins evenly curved from separated bases to subacute, outer apex slightly embrowned; valve triangular; style (Fig. 3A) in broad aspect with inner margin irregularly curved, apex acute, caudal margin concave, angling to one of two preapical lobes, widest about ⅓ length from apex; apices exceeding plates, in lateral aspect, two ventrally directed denticulations present, one apical, one subapical on inner margin; aedeagus (Fig. 3B) evenly curved, minutely serrate at basal angle in

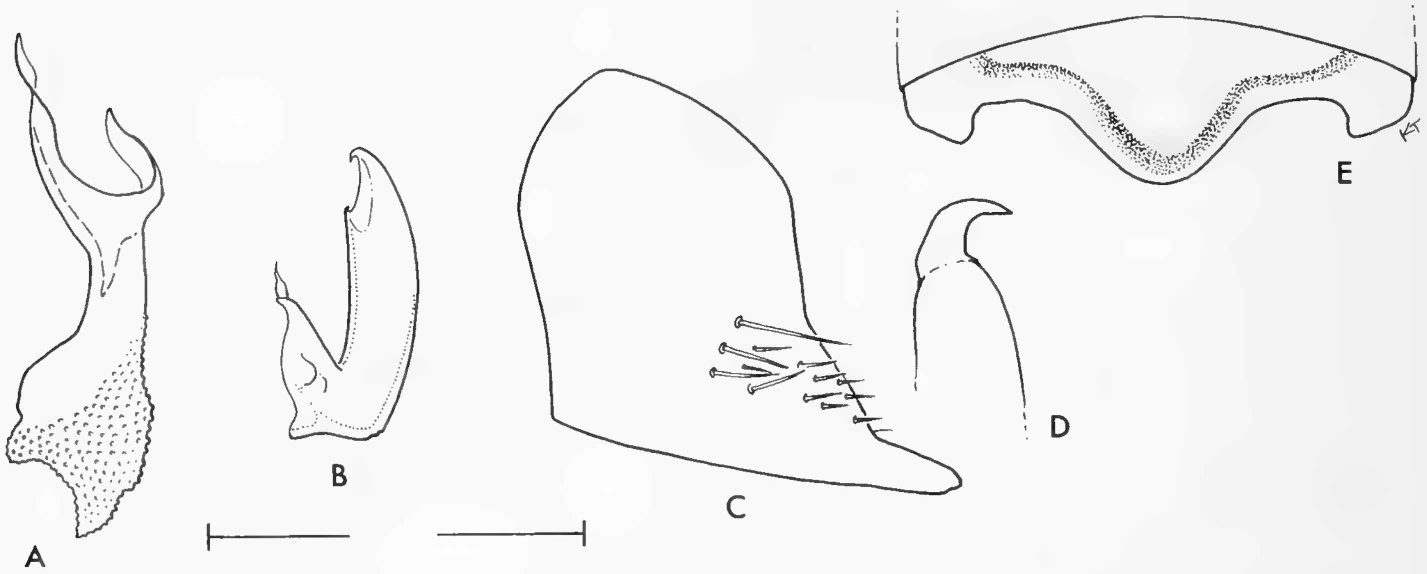

Fig. 3. *Athysanella* (*Gladionura*) *raisae*. A. Style, broad aspect; B. Aedeagus, lateral aspect; C. Pygofer, lateral aspect; D. Detail of pygofer hook, ventral aspect; E. Female sternum VII. Bar = 0.5 mm.

lateral aspect, base slightly expanded in caudal aspect, shaft a little more than twice length of apodeme.

Female: Female abdominal sternum VII often totally or partially fuscous (Fig. 3E), strongly trilobed, medial lobe broadly rounded.

Character code: 0-1-1-1-2-1-1-0-1-0-0-2-2-1-0-0-1-0.

Type material.—*Holotype male:* Mexico: Durango, 7 miles east of Nombre de Dios (Mexican Highway 45), 1 October 1988, A. L. Hicks, from *Bouteloua hirsuta* Lag., IPL 002823, deposited in NMNH, Washington, D. C. *Paratypes:* Three female paratypes, same data as holotype; and 6 males, 1 female from Mexico: Zacatecas, near Sombrete (ca 64 mi east of Durango), 7800 ft, 1 October 1988, A. L. Hicks and P. D. Cubbage, 6 males and 1 female, IPL 002824, have been deposited in California Academy of Sciences, San Francisco, Canadian National Collection, Ottawa, Kansas University, Snow Museum, Lawrence, Kansas State University, Manhattan, and NMNH.

Diagnosis.—*Athysanella* (*Gladionura*) *raisae* is closely related to *A.* (*G.*) *nita* Wesley and Blocker, but, because of the length of its tibial spur, keys (Blocker and Johnson 1990a) to *A.* (*G.*) *gisela* Wesley and Blocker. It can be distinguished from *gisela* by the apex of the style, which has an inner margin that is longer than the outer. *Athysanella* (*G.*) *raisae* can be distinguished from *nita* by the laterally directed pygofer processes and by the apices of the styles, which are broader and extend further beyond the plates, are more acute and longer, and the preapical lobes, which are more produced. It should be noted that (as is often the case in geographical representatives of *Athysanella*) the two collections of *raisae* show some variation in style morphology. Style apices of the eastern population have caudal margins less evenly concave than those of the western population, but not as produced and acute; also, the preapical indentations on the inner margins are less pronounced than those of the western representatives.

Host.—The type specimens were collected on hairy grama (*Bouteloua hirsuta*).

Etymology.—We have named this species in honor of the then first lady of the USSR, in commemoration of her visit to the United States on the occasion of the June 1990 summit visit of President Gorbachev.

Athysanella galeana Hicks and Blocker, New Species

Description.—Length of male 2.96 mm, female 4.36 mm; head width of male 1.08 mm, female 1.16 mm; pronotal width of

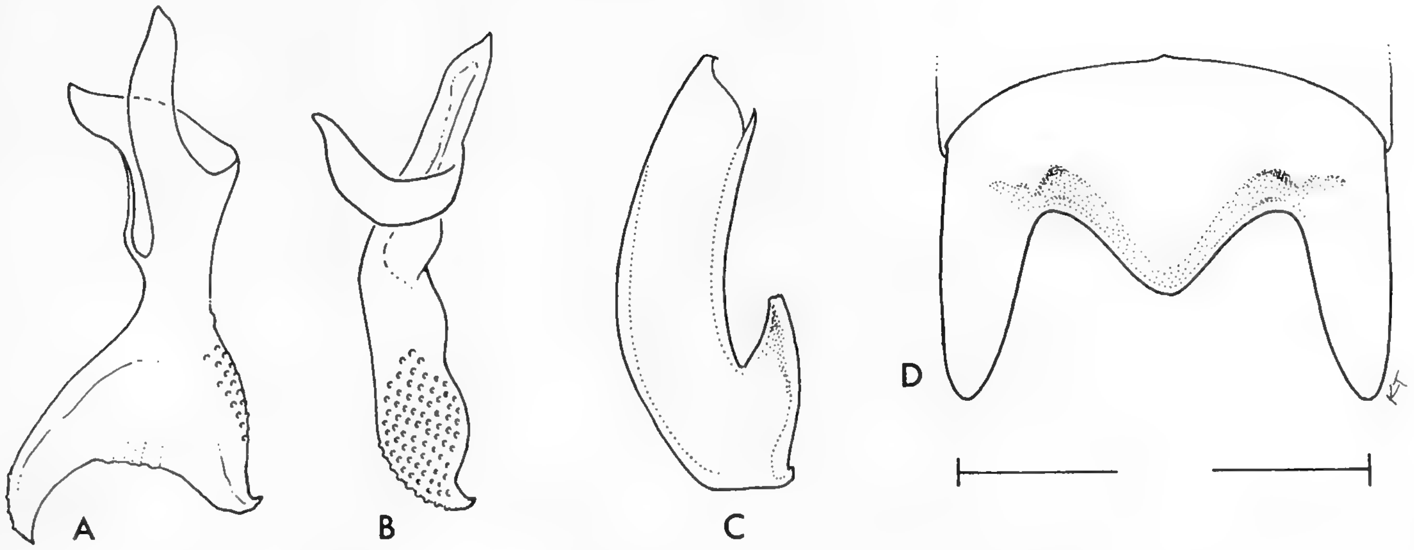

Fig. 4. *Athysanella galeana.* A. Style, broad aspect; B. Style, ventral aspect; C. Aedeagus, lateral aspect; D. Female sternum VII. Bar = 0.5 mm.

male 1.03 mm, pronotum of single female allotype with damaged pronotum; interocular width of male 0.48 mm, female 0.52 mm; vertex length of male 0.48 mm, female 0.52 mm; pronotal length of male 0.34 mm.

Color stramineous, vertex and pronotum marked with indistinct brown pattern, vertex without fuscous spots; abdomen with dark brown pattern, wings plain to alternating light and dark stripes.

Forewings brachypterous, exposing 3.5 to 4.5 pregenital abdominal tergites; ocellus about its own diameter from eye; hind tibial spur slightly shorter than first tarsomere.

Male: Pygofer subquadrate, with few macrosetae; valve broadly rounded; plates rounded apically, separated basally and diverging distally; anal tube attaining apex of pygofer; connective ¾ length of styles; styles (Fig. 4A, B) bifid apically, dorsal arm slender, acute, exceeding caudal margin of pygofer, ventral arm thickened, equalling apex of plates, apices with numerous papillae, particularly on ventral surface; aedeagus (Fig. 4C) recurved, almost parallel-sided, but widest at midlength; slightly tapered in apical half to a small single hook.

Female: Female abdominal sternum VII (Fig. 4D) with medial lobe less than ½ length of prominent lateral lobes on posterior margin.

Character codes: 0-1-0-0-1-0-1-0-0-2-1-1-0-0-1-0-0-0.

Type material.—*Holotype male and female allotype:* Mexico, Chihuahua, Galeana, about 25 mi south of Nuevo Casas Grandes, 3 Sept. 1987, IPL 001775, on saltgrass (*Distichlis spicata* (L.) Greene, deposited in NMNH, Washington, D.C. *Paratype:* A single paratype male, same collection data, is deposited in Kansas University, Snow Museum, Lawrence.

Diagnosis.—*Athysanella galeana* is related to *A. strobila,* to which it keys (Blocker and Johnson 1988), but can be distinguished from it by the shape of the pygofer, which has a truncate caudal margin without a lobe, by the shaft of the aedeagus, which is nearly parallel-sided with the apical hook less developed, and by the female sternum VII, which has a longer medial lobe.

Host.—This species is known only from the type locality, where it was collected on saltgrass.

Etymology.—This species is named for the type locality.

Athysanella (*Gladionura*) *blanda* Ball and Beamer "vana" form

Discussion of confusing variant

Athysanella blanda variety *vana* was described earlier (Ball and Beamer 1940), but

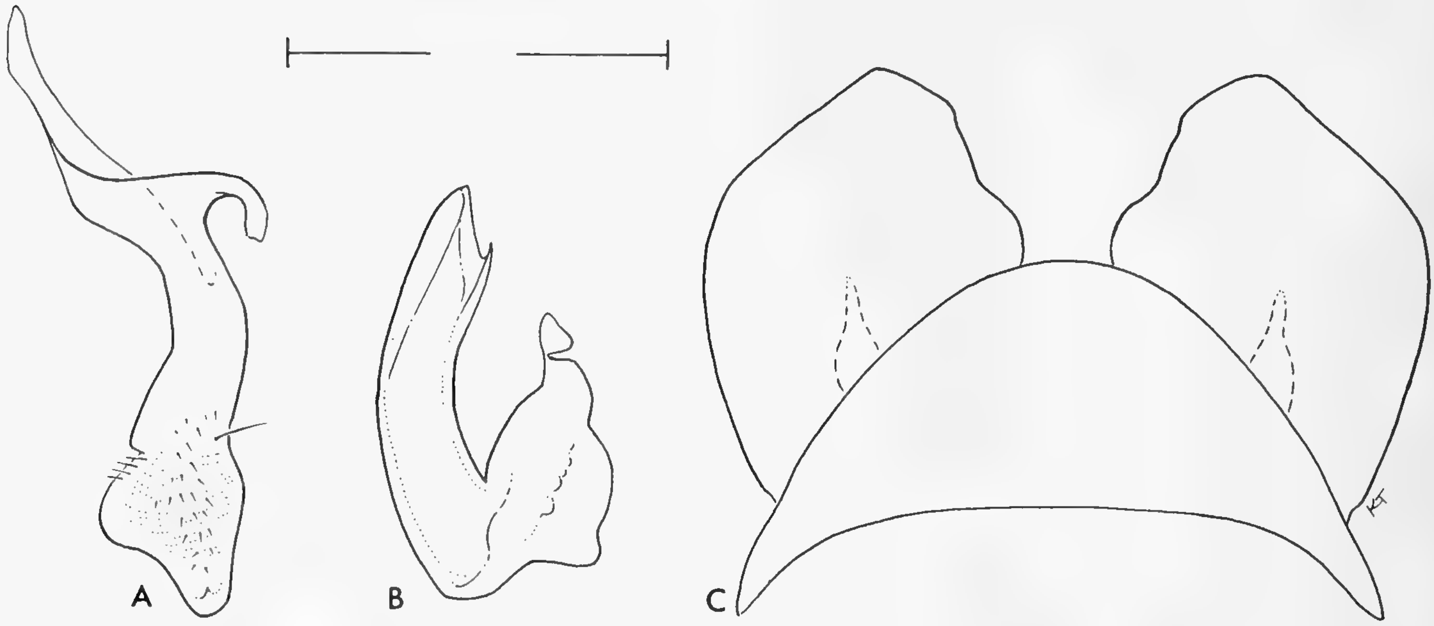

Fig. 5. *Athysanella* (*Gladionura*) *blanda* "vana" form. A. Style, ventral aspect; B. Aedeagus, lateral aspect; C. Male valve and plates, ventral aspect. Bar = 0.5 mm.

not illustrated. Later, this form was synonymized with *A. blanda* by Blocker and Johnson (1990a), who considered it to be an undeveloped form. Because we occasionally found this form in the gyp areas of southeastern New Mexico and found it to be very confusing, we illustrate it here (Fig. 5). The "vana" form is similar to *A.* (*G.*) *blanda* Ball and Beamer, but differs from it by the length and straightness of the pygofer processes, by the shape of the plates, which are not quadrate, and by the apex of the style, which has a rounded apex and does not have the inner margin produced. It should be noted that typical *blanda* and the "vana" form are sympatric and occur together in southeastern New Mexico. Whether the underlying basis for the variation is genetic or environmental is unknown. We believe that these figures will assist in future determinations of *Athysanella* species from this interesting biogeographic region.

Discussion

Three of the four new species described are Mexican. Given the small ranges of many *Athysanella* species, it is reasonable to speculate that these species may not occur in the United States. Like all or most *Athysanella* species (Blocker and Johnson 1988, 1990a, b, Wesley and Blocker 1985) with small ranges, these species were collected only as brachypters.

One of the species, *A.* (*G.*) *maycoba,* was collected from a mixed stand of two short grasses—curly mesquite (*Hilaria belangeri*) and blue grama (*Bouteloua gracilis*). This leafhopper species is a member of a clade (Blocker and Johnson 1990a) of specialists that occur on short grasses (*Bouteloua, Hilaria,* and *Scleropogon* species).

A second Mexican species, *A.* (*G.*) *raisae,* is most closely related to *A.* (*G.*) *nita.* Although it was collected on hairy grama (*Bouteloua hirsuta*), it is unknown whether it is a specialist.

The third Mexican species, *A.* (*A.*) *galeana,* was collected in very small numbers from saltgrass (*Distichlis spicata*) and possibly specializes on that host. It is closely related to *A. strobila* Blocker, a species of the northern Great Basin. The subgenus *Athysanella* appears to have diversified extensively in alkaline and/or saline lowlands, particularly on saltgrass. It is not unlikely that members of the subgenus with unknown host affiliations will also turn out to utilize saltgrass or other grasses that specialize in alkaline and/or saline bottomlands. We predict that other *Athysanella* endemics will be discovered on saltgrass and perhaps other dominants of wet lowlands, which are insularized in the western United States by mountain ranges and other geographic barriers. Colonization of, and radiation in, wet lowlands by subgenus *Athysanella* is dependent on taxonomically idiosyncratic innovations associated with this demanding environment. This is one of many examples of unique evolutionary events that result in biotic enrichment.

A. (*G.*) *itawana* was collected from a dominant grass, alkali sacaton (*Sporobolus airoides*), of the San Juan Basin in northwestern New Mexico. It is related to *A.* (*G.*) *curtipennis* (Gillette & Baker), a specialist of *Sporobolus cryptandrus* (Torr.) Gray. Another recently described species, *Athysanella* (*G.*) *andyi* Blocker was collected from another grass dominant, galleta [*Hilaria jamesii* (Torr.) Benth.], in the same region. Previous collectors may well have overlooked the San Juan Basin as a source of endemics. Indeed, the entire Colorado Plateau and Great Basin regions should be systematically explored for areas that harbor presently unknown endemic species. The climatic (or other) factors that enforce the range boundaries of species like *A.* (*G.*) *itawana* in a region where their hosts are dominant and do not appear to be particularly patchy, are at present unknown.

Discovery of the species reported herein confirms previous speculation (Hicks et al. 1988) that the true diversity of *Athysanella* species has yet to be assessed. This and other recent contributions suggest that *Athysanella* diversity in Mexican and Southwestern grasslands is governed by a sedentary life history strategy that only rarely includes macroptery, isolation of habitat (host grass) patches, and marked interregional differences in climate that enforce phenological isolation.

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We acknowledge P. D. Cubbage for field assistance, K. Allred for identifications of grass specimens, and R. Smith and E. Weber for logistical support for Mexico collection trips. Rick Watson assisted with the interpretation of Itawana that enabled us to use it as a specific epithet. We thank M. Stoetzel and M. Nielson for reviewing the manuscript.

Illustrations.—We especially thank Karen Teramura for her discussions of representation of leafhopper morphology, and for her excellent illustrations.

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SYSTEMATICS OF THE GENERA OF EPYRINAE WITH RAMOSE MALE ANTENNAE (HYMENOPTERA: BETHYLIDAE)

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Abstract.—The genera of Epyrinae with ramose antennae in the male are reviewed. *Calyoza* Westwood, 1837, *Paracalyoza* Cameron, 1909, *Calyozella* Enderlein, 1920, and *Pseudocalyoza* Turner, 1915, are new synonyms of *Epyris* Westwood, 1832. Species described in the first three genera constitute the Staphylinoides species group; the last genus forms the Subramosus species group. *Calyozina* Enderlein, 1912, is a discrete genus. A neotype is described for *Calyoza staphylinoides* Hope, the type-species of the genus.

Epyris ashmeadi (Enderlein) and *E. ramosus* (Meunier) are **new synonyms** of *E. staphylinoides* (Hope). *Epyris niger* (Kieffer), *E. flavipennis* (Turner) and *E. bryanti* (Turner) are **new synonyms** of *E. hirtipennis* (Cameron). ***Epyris puduma*** Krombein, n. sp., is described from Sri Lanka. ***Epyris sumatrensis*** Krombein, n. name, is proposed for *E. flavipennis* (Enderlein), 1920, not *E. flavipennis* (Turner), 1914. *Calyozina ramicornis* Enderlein is redescribed and figured.

Key Words: Bethylid wasps, *Epyris,* ramose male antennae, systematics, new species

Males with ramose antennae are rarities among species of aculeate Hymenoptera, so it is not surprising that several specialists on Bethylidae proposed generic names for some species with such unusual appendages. The relatively few known females exhibit no such sexual characters.

Westwood (*in* Hope 1837) was the first to propose a genus for such a male, *Calyoza,* based on a specimen preserved in gum. It is not known whether the specimen was recent or fossilized. Cameron (1909), Enderlein (1912, 1920), and Turner (1915) proposed additional genera, their names formed by adding a prefix or suffix to the name *Calyoza.*

Based on the descriptions, I suspected that some of these genera might be synonyms of *Calyoza.* I borrowed the type-species insofar as available, and the results of my examination appear below.

Measurements and terminology are as in Evans (1964) as modified by him later (1969). The abbreviations used in the descriptions are as follows:

LH—length of head from middle of clypeal margin to midpoint of vertex;
WH—width of head including eyes;
WF—width of front (i.e., least interocular distance);
HE—height of eye measured in lateral view;
EV—distance from top of eye to crest of vertex in lateral view;
WOT—width of ocellar triangle including posterior ocelli;
OOL—ocello-ocular line, least distance between posterior ocellus and inner eye margin;
LT—length of thorax, collar excluded, from anterior margin of pronotal disk to posterior end of propodeum.

Epyris Westwood, 1832

Calyoza Westwood *in* Hope, 1837: 56. Type-species by monotypy: *C. staphylinoides* Hope. **New Synonymy.**

Paracalyoza Cameron, 1909: 377. Type-species by monotypy: *P. hirtipennis* Cameron. **New Synonymy.**

Pseudocalyoza Turner, 1915: 298. Type-species by monotypy: *P. subramosa* Turner. **New Synonymy.**

Calyozella Enderlein, 1920: 24. Type-species by original designation, *C. flavipennis* Enderlein. **New Synonymy.**

A study of type or other material of the four genus-level taxa listed above shows them to be synonyms of *Epyris* as redefined by Evans (1964, 1969). Their names should be added to the generic synonymy listed by Evans. The males described in *Calyoza, Paracalyoza,* and *Calyozella* are unique in *Epyris* because of the ramose antennae. They constitute the Staphylinoides species group of *Epyris.* They are similar to males of the New World Dodecatomus species group in that the third antennal segment is extremely short, forming a ring-joint (Fig. 2), closely joined to the base of the fourth segment, and in having the scutellar pits connected by a narrow, impressed line (Figs. 3, 4, 11).

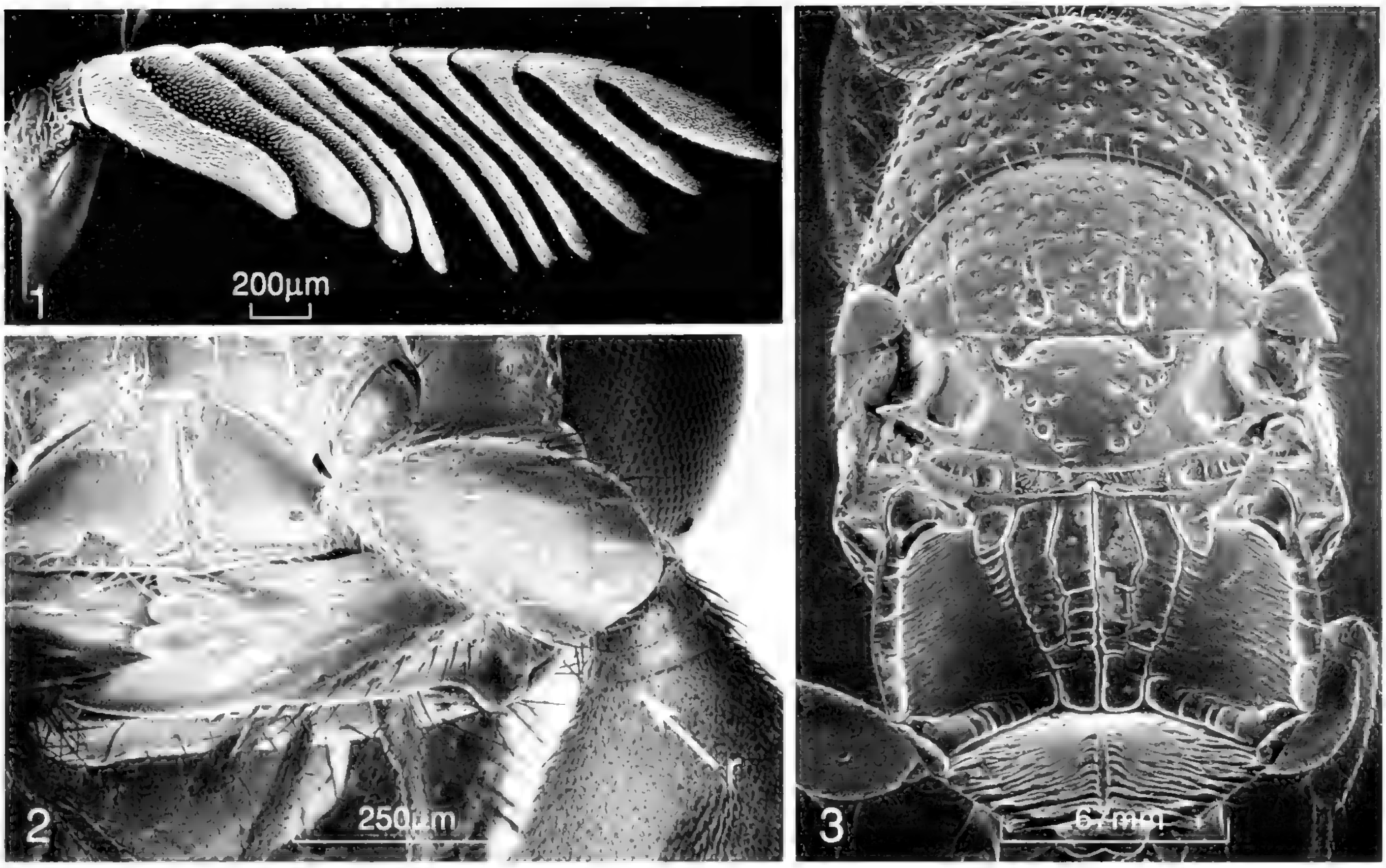
Cameron separated *Paracalyoza* from *Calyoza* on the basis of the basal and transverse median veins being interstitial. These veins, however, are interstitial in *staphylinoides,* and Cameron's error may be traced to inaccuracy in Westwood's illustration (1874, fig. 1).

Enderlein separated *Calyozella* on the basis that the ramus of the 12th antennal segment is shorter or at most as long as the segment itself. (Enderlein called this the 11th segment; he overlooked the tiny ring joint, the third segment.) The unique holotype of *Calyozella flavipennis* from Soekaranda, Sumatra, was in the collection of the Stettin Zoological Museum, and should now be in the Warsaw Zoological Museum. I have been unable to borrow it. Enderlein stated that the ramus of the 12th was shorter than the segment. The unique holotype of *Calyozella sauteri* Enderlein, the other species originally included in the genus, is from Taihorin, Taiwan, and was available on loan from Eberswalde. The 12th segment and its ramus are of equal length. I find no substantive characters on which to separate *Calyoza* and *Calyozella,* and consider that both species of the latter genus are also members of the Staphylinoides species group in *Epyris.* The relative length of the 12th segment and its ramus are variable in the Staphylinoides species group, ranging from a ramus of 0.7× the length of the segment in an unidentified African species, to 1.4× in the specimen described below as the neotype of *staphylinoides* Hope.

Pseudocalyoza Turner is also a synonym of *Epyris* but belongs to a different species group than the Staphylinoides group. It is discussed in more detail subsequently.

Staphylinoides Species-group
Figs. 1–16

Large species, forewing length 3.5–5.2 mm in male, 4.3–5.6 mm in female; body black, abdomen sometimes red apically or entirely. Mandibles of male slender, 3–4 dentate (Fig. 2), those of female stout, 4–5 dentate (Fig. 9), and lower margin with large, blunt, subapical tooth (Fig. 10); anterior margin of male clypeus angulate medially (Fig. 2), about 110°–135°, that of female gently arcuate, occasionally slightly concave in middle (Figs. 9, 13); eyes large, glabrous; ocelli in a compact triangle, front angle 80°–120° in male, 65°–90° in female; male antennae unusual in that segments 4–12 have a subapical ramus that is usually longer than length of segment (Figs. 1, 7), segment 3 a ring joint closely consolidated with 4 (Fig. 2, r). Pronotum with smooth contours; scutellar pits well-separated except in *rufiventris* where distance between them is subequal to pit diameter, the pits connected anteriorly by a narrow impressed line (Figs. 3, 4, 11); propodeum with margins carinate,



Figs. 1–3. *Epyris staphylinoides* male, Ukunda, Kenya. 1, antenna, Au-coated specimen at 20 KV. 2, clypeus, mandible, and base of antenna, r = ring joint, uncoated at 3 KV. 3, thoracic dorsum, wings removed, uncoated at 3 KV.

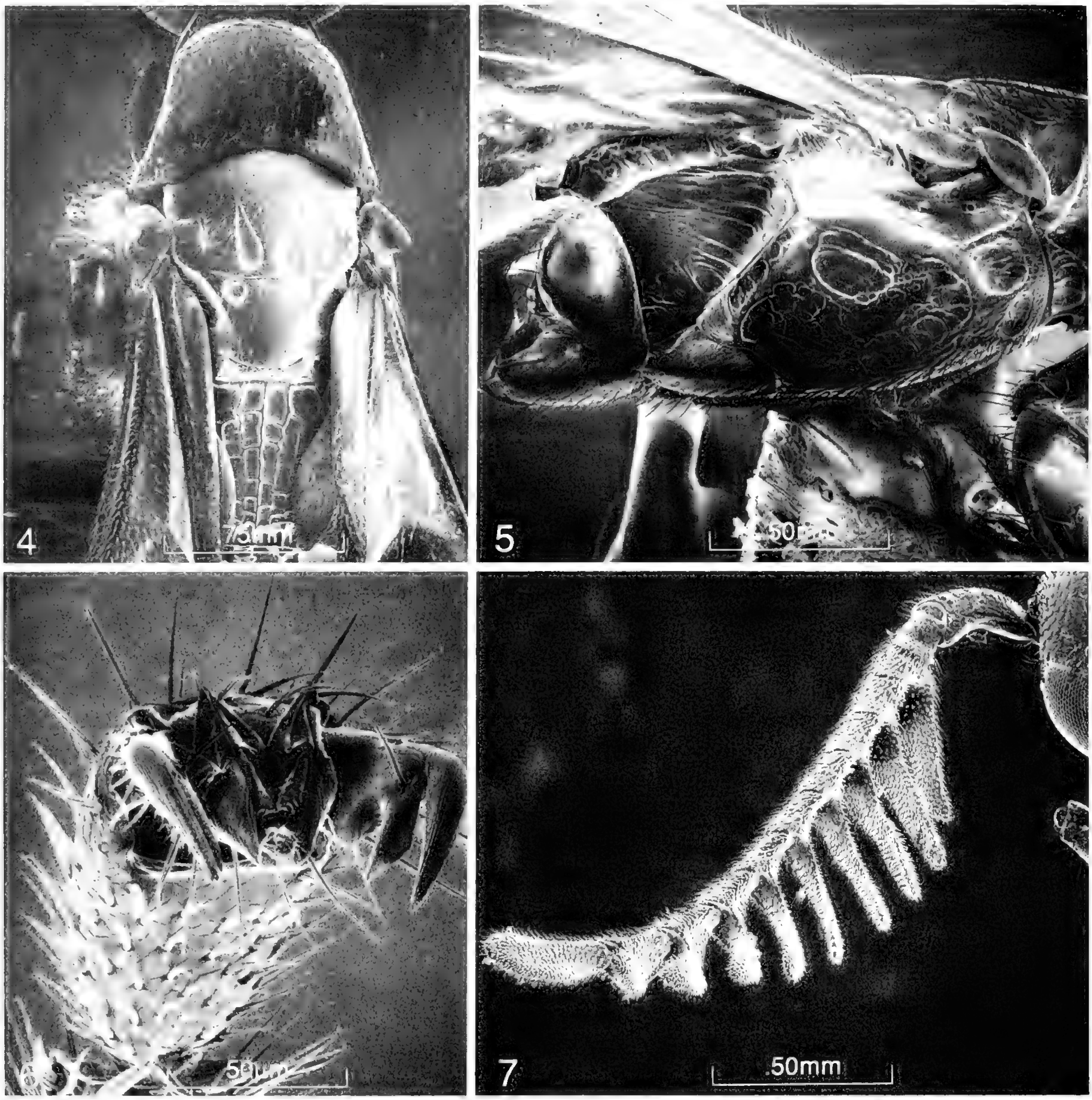
median area with three or five longitudinal carinae (Figs. 3, 4), the median and lateral carinae complete, if with five carinae, the intermediate pair complete or nearly so; mesopleuron with fovea not divided into upper and lower foveae (Figs. 5, 10), except in an undescribed species from the Philippines. Female midtibiae with 2–3 rows of close, short spines; tarsal claw with two teeth, outer longer and more slender, inner short and blunt (Figs. 6, 12, 14). Male genitalia with parameres slender, armed apically with 2–3 long setae; cuspides slender and biramous.

The Staphylinoides species group is similar to the New World Dodecatomus species group in having the first flagellar segment of the male antenna reduced to a narrow ring joint, closely appressed to the base of the second segment. Males of the Dodecatomus group differ from those of the Staphylinoides group in lacking ramose antennae. Females of the Dodecatomus group have the mandible without a subapical tooth on lower margin, the clypeus angulate or subangulate medially, and the hindtibiae have only a few spines, whereas females of the Staphylinoides group have a subapical mandibular tooth, and the midtibiae have 2–3 rows of close, short spines. Other undescribed species groups of Old World *Epyris* have males with the third antennal segment a ring joint, but they lack a ramose antenna. The relationships between these various Old World groups and the New World Dodecatomus group will need consideration when the Old World Epyrinae are revised.

Epyris staphylinoides (Hope), New Combination
Figs. 1–3

Calyoza staphylinoides Hope, 1837: 56, fig. 11 (♂).—Westwood, 1874: 157 (♂, ♀; Natal).

Calyoza Ashmeadi Enderlein, 1901: 214–215 (♂, 2♀; Nord-Kamerun, Johann-Al-

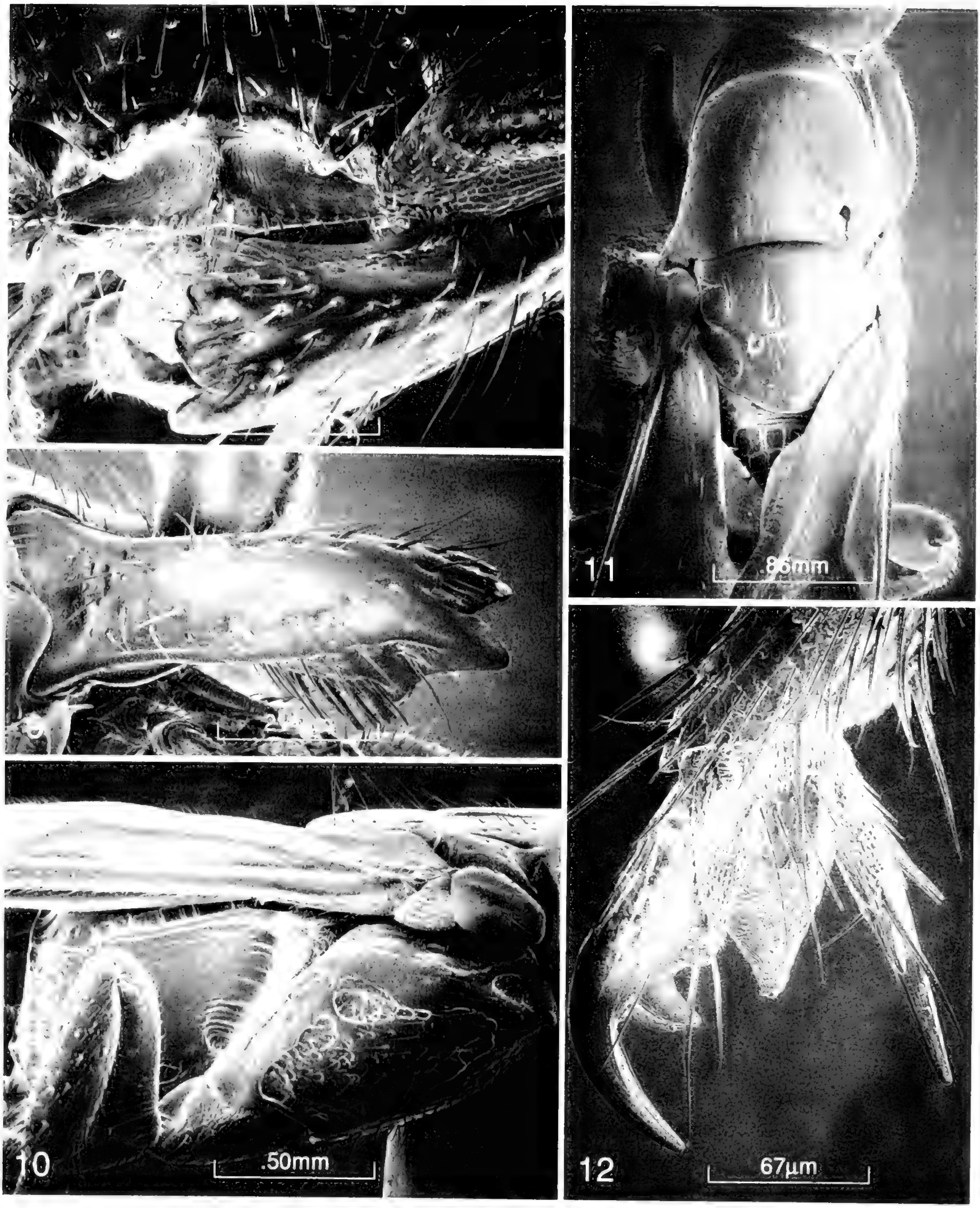


Figs. 4–7. *Epyris puduma* male, uncoated at 3 KV. 4, thoracic dorsum. 5, mesopleuron and anterolateral propodeum. 6, hindtarsal claw. 7, antenna, terminal segments twisted.

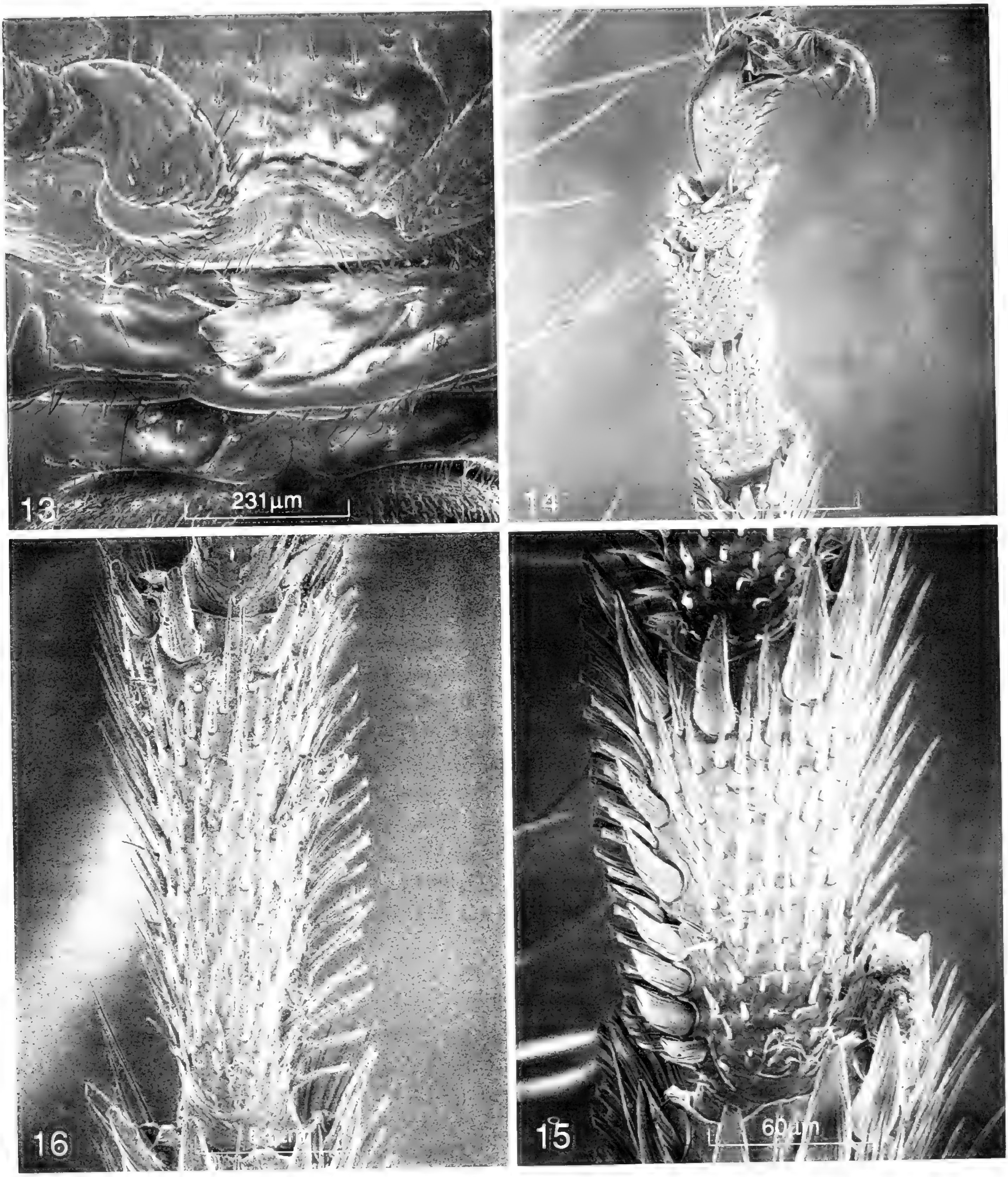
brechtshöhe; syntypes in Museum für Naturkunde der Humboldt-Universität, Berlin). New Synonymy.

Calyoza ramosa Meunier, 1906: 59–60 (♂; Zanzibar; unique holotype in recent or fossil copal; depository unknown; lost?). New Synonymy.

Hope (1837) described a dozen species of insects, primarily Coleoptera, that were trapped in resin from trees belonging to the Dipterocarpaceae of the Old World tropics. The specimens were in the collection of W. Strong, a maker of varnishes in London. Some of the specimens were in resin from *Vateria indica* of Malabar, India, known as gum animé. Hope cited "E Resino Animé" for some species, but not for others including the *Calyoza.* Hope mentioned a Madagascan dipterocarp as providing resin in abundance in which he found insects embedded. From this it might be inferred that



Figs. 8–12. *Epyris puduma* female, uncoated at 3 KV. 8, clypeus and mandible. 9, mandible, frontal aspect, note subapical tooth on lower margin. 10, mesopleuron and anterolateral propodeum. 11, thoracic dorsum. 12, hindtarsal claws.



Figs. 13–15. *Epyris hirtipennis* female, Brunei, uncoated at 3 KV. 13, clypeus and mandible. 14, hindtarsus. 15, second hindtarsal segment. Fig. 16, *Epyris puduma* female, uncoated at 3 KV, second hindtarsal segment.

the species not characterized as being from gum animé came from resin from other sources and localities.

Hope purchased Strong's collection of insects in amber and gum animé in 1837. It was deposited in the University Museum, Oxford in the early 1860s but it was not accompanied by a list of specimens. C. O'Toole, collections manager at the Museum made a thorough search for the unique type of *staphylinoides,* and was unable to find it. He examined 210 pieces of reasonably polished, clear gum aminé in the collection, and other pieces that are on public display. He added: "In the 1960's, a young preparator, no longer with us, was given access to the Strong collection to practice grinding and polishing amber. This may of course be a source of perturbation and loss from the collection. I have traced all the extant material which passed through his hands and cannot match it with the illustrations [i.e., of *staphylinoides*]. I think I have covered all the exits now and I think that we must conclude that either the type of *Calyoza staphylinoides* never reached Oxford or that it suffered during the indifferent treatment the collection was subjected to."

Westwood (1874) redescribed the species from a pair from Port Natal, South Africa, and stated that he had ". . . no hesitation in giving [it, i.e., the male] as identical . . ." with Hope's unique type. This suggests that Westwood might have compared the pinned male with the type. I am designating this male as the neotype of *Calyoza staphylinoides* Hope.

The syntype series of *ashmeadi* consists of a male and two females, one of the latter now lacking an abdomen. The male bears a red label, "Type ♂," and the female lacking an abdomen bears a red label, "Type ♀." The other female bears no type label, but I presume it to be a syntype for it is mentioned in the description. I have designated the male as the lectotype. The species is clearly a synonym of *staphylinoides,* differing only in OOL being 1.6 × WOT in the male, and 1.8 × WOT in the female. The mandibular dentition in both sexes is the same as in *staphylinoides.*

It is probable that Meunier's unique type of *ramosa* is no longer in existence. The specimen is not in any of the institutes of the University of Bonn which house Meunier's collection of recent Diptera and Hymenoptera, and the collection of fossil insects. Meunier described this and two species of Diptera from specimens in copal in the collection of J. Evers, Altona-Bahrenfeld, Hamburg. The specimens probably were returned to Evers, and destroyed during World War II.

Meunier does not mention coloration but his description otherwise is not inconsistent with that of *staphylinoides* which could be expected to occur in Zanzibar. Meunier's Fig. 1 of the head is probably inaccurate for it is not symmetrical. Ratios derived from the figure are: WH equal to LH; WF 1.3 × HE and 0.7 × WH; EV 0.7 × HE; OOL 1.4 × WOT on right side, 1.7 × on left; and ocelli with frontal angle of 105°. His Figures 2 and 3 of forewing and tarsal claws are typical of species of the *staphylinoides* group.

The following description of *staphylinoides* will supplement the very brief Latin diagnosis by Westwood (1874). Westwood dissected a mandible and the palpi from the male (his Fig. 1a–c), breaking off most of the clypeus in the process. The front is split along the midline to a small hole that was made when the mandible and palpi were removed. The posterior third of the right side of the propodeum was broken, and was repaired with glue that covers the right side of the sternum, and the mid- and hindcoxae. He also dissected a mandible and palpi from the female (his Fig. 2a–e).

The male bears two labels in Westwood's handwriting. One is green, and is inscribed, "Natal/Guenzius/5/Higgins 1867." C. O'Toole advised me that the specimen was purchased from Higgins, an employee of the entomological dealer Stevens, for 5 shillings, the current equivalent of £ 30. Beneath this label is a white one, "Calyoza/♂/Westw.Trans Ent S./Thes.Ent.pl.29fl," referring to Westwood's 1837 description and 1874 illustration. The dissected palpi and mandible are glued on a small white rectangle mounted beneath the specimen. The female in the British Museum bears a small green label, "Pt/Natal."

Neotype male.—Length 6.5 mm, forewing 3.9 mm. Black, head and thorax slightly dull, delicately alutaceous, propodeum and abdomen glossy; mandible except basal third and apical teeth, antenna, tegula, inner surface of foretibia at apex, and last three abdominal segments light red; rest of legs dark brown to castaneous. Vestiture of head and thorax sparse, short, suberect, cinereous; flagellar segments with very short, dense, suberect silvery setae. Wings clear, stigma dark brown, forewing veins lighter brown.

Head.—WH 1.1 × LH; WF 1.3 × HE and 0.6 × WH; EV 0.6 × HE; mandible quadridentate (Fig. 2[1]), two inner teeth quite small; eyes slightly protuberant, ocular setae lacking; front with small punctures mostly separated by a puncture's width; ocelli with frontal angle 120°, OOL 0.9 × WOT, posterior pair separated from occiput by nearly 3× their diameter; antenna 13-segmented (Fig. 1), relative lengths of first four segments about 31:4:3:11, segment 3 a ring joint closely joined to 4, 12 half as long as 13; segments 4 through 12 with a subapical ramus beneath each of which is longer than dorsal length of respective segment; ramus of 4 about 3× as long as segment, rami of succeeding segments increasing gradually in length to 7–11 which are 4× as long as respective segments, that of 12 a little less than 2× as long as segment.

Dorsum of thorax (Fig. 3) twice as long as width at pronotal lobe; pronotal disk with punctures somewhat larger than on front, separated by half or more width of puncture; pair of basal pits on scutellum separated by 3× their diameter, connected anteriorly by a narrow, impressed line; propodeal disk 0.6× as long as wide, median enclosure with five longitudinal carinae, middle carina and outer pair stronger and reaching posterior transverse carina, outer pair converging slightly toward apex, middle pair weaker and extending only two-thirds toward apex, areas between carinae with weak transverse carinae, areas laterad of enclosure finely, closely, transversely carinulate.

Female.—Length 7.7 mm, forewing 5.1 mm. Black, the following red: mandible except teeth, antenna, antennal lobe, apex of forefemur, foretibia, all tarsi and last three abdominal segments; tegula, femora and mid- and hindtibiae dark brown. Wings clear, stigma dark brown, forewing veins lighter brown. Vestiture on head and thoracic dorsum, short, subappressed, cinereous.

Head: WH 1.1 × LH; WF 1.7 × HE and 0.7 × WH; EV 0.8 × HE; OOL 1.8 × WOT; front angle of ocelli 90°; first four antennal segments in a ratio of 52:11:10:18, third segment 0.7× as long as wide; mandible quinquedentate, innermost tooth small and truncate, lower margin with large, blunt subapical tooth; front delicately alutaceous, a median groove between antennal tubercles running upward, front with small punctures, those above tubercles separated by about half their diameter, upper front with punctures separated by about twice their width.

Thorax: pronotum delicately alutaceous and punctate like front, 1.4× as wide as long; scutum weakly alutaceous, with a few small punctures laterally, notauli complete, wider posteriorly; scutellar pits narrow, elliptical, oblique, separated from each other by 10× their width, connected anteriorly by a narrow, impressed line; propodeal disk 1.4× as wide as long, median enclosure with five carinae, intermediate pair not quite reaching apex, areas between carinae with close, transverse rugulae; forefemur 2.2× as long as wide; tarsal claw strongly curved, bifid, inner ray short and stout.

Variation.—I collected ten males, 23–25 Jan. 1968, in a narrow strip of jungle between the beach and coastal road 20 mi S of Mombasa, Kenya, near Ukunda. The specimens agree well with the lectotype in

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[1] Figs. 1–3, cited in this description, are from a male from Ukunda, Kenya, that was compared with the neotype.

sculpture but differ as follows: Length 5.5–6.0 mm; only last two abdominal segments red except one having the apex of fifth red; WH 1.1 × LH; WF 1.4 × HE and 0.6 × WH; OOL 1.0–1.1 × WOT; EV 0.6 × HE; apex of clypeus angulate medially at about 135°; ratio of length of first four antennal segments 35:5:5:12 to 35:6:6:13; and ocelli with frontal angle of 115°–120°.

Epyris puduma Krombein, New Species

Figs. 4–12, 16

Male.—Length 6.0 mm, forewing 3.5 mm. Black, mandible, antenna, tegula and legs light red, except apex of mandible and of last antennal segment darker, and forecoxa dark brown. Vestiture of head and thorax sparse, short, suberect, cinereous. Wings with a slight yellowish cast, stigma dark brown, veins light testaceous except radial darker.

Head: WH equal to LH; WF 1.3 × HE and 0.6 × WH; EV 0.5 × HE; mandible tridentate, innermost tooth rounded; clypeus angulate medially at about 110°; front delicately alutacous, with small punctures mostly separated by 1–2× width of a puncture; ocelli with frontal angle about 95°, OOL 1.1 × WOT, posterior pair separated from occiput by 1.8× an ocellar diameter; antenna (Fig. 7[2]) relative length of first four antennal segments about 25:5:5:10, segment 3 half as long as wide.

Thoracic dorsum (Fig. 4), 1.9× as long as width at pronotal lobes; pronotal disk 2.2× as wide as long, with small punctures slightly closer than on front; scutellar pits subcircular, separated by about twice the diameter of pit; propodeal disk 0.7× as long as basal width, enclosure with five complete longitudinal carinae, areas between carinae with close, transverse rugulae, areas laterad of enclosure with numerous fine, oblique carinulae; mesopleuron (Fig. 5); tarsal claw (Fig. 6) strongly curved, bifid, inner ray stout and almost as long as outer.

Female.—Length 7.2 mm, forewing 4.3 mm. Coloration and wings as in male. Vestiture sparser, fine, short, suberect and cinereous on thoracic dorsum and mesopleuron, that on head mostly abraded, propodeum bare, abdomen with very sparse, short, fine, suberect to subdecumbent setae, present only laterally.

Head: WH 1.1 × LH; WF 1.4 × HE and 0.7 × WH; OOL 1.9 × WOT; apical margin of clypeus (Fig. 8) broadly rounded, slightly concave in middle; front angle of ocelli about 65°; first four antennal segments in a ratio of 49:9:10:14, third segment 0.7× as long as wide; mandible (Fig. 8) quinquedentate, innermost tooth small and truncate, lower margin with a large, blunt subapical tooth (Fig. 9); front highly polished, with a short median groove running upward from between antennal tubercles, punctures small, mostly separated by two or more times the diameter of a puncture.

Dorsum of thorax (Fig. 11); pronotum 1.6× as wide as long, polished, weakly alutaceous only at extreme base, punctures as on front; scutum delicately alutaceous, punctures small, closer in middle than laterally, notauli complete, linear on anterior third, widening posteriorly; scutellar pits small, subcircular, separated from each other by 3.7× their diameter; mesopleuron (Fig. 10); propodeal disk 1.3× as wide as long, median enclosure with seven carinae, the three median carinae and lateral carinae complete, the third pair not reaching base, areas between carinae with close, transverse rugulae; forefemur 1.9× as long as wide; first and second hindtarsal segments (Fig. 16) lacking a row of close-set, stout, fluted, conical setae on posterior edge; tarsal claw (Fig. 12) as in male but inner ray only half as long as outer.

Type material.—Holotype ♂, USNM; Sri Lanka, Rat[napura] Dis[trict], 2 mi S of Weddagala, Sinharaja Jungle, 8–12 February 1977, visiting foliage of *Macaranga di-*

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[2] The antennae of both males are curled toward tip, so it is impossible to get a micrograph without some distortion.

gyna, K. V. Krombein. Paratypes, USNM: ♂, same locality but 18–21 June 1976, K.V. Krombein, P. B. & S. Karunaratne; ♀, same locality but 3 mi S of Weddagala, 10–11 February 1977, K. V. Krombein, P. Fernando, D. W. Balasooriya, V. Gunawardane.

Etymology.—The species name is from the Sinhalese noun puduma, surprise, in allusion to the fantastic male antennae in the Staphylinoides group.

Remarks.—The light red appendages and entirely black body distinguish *puduma* from its nearest relative, *staphylinoides* (Hope) from South Africa and Kenya, which has mostly dark legs and the posterior two or three abdominal segments red. The quadridentate mandible of the male, markedly coarser sculpture, and more obtuse ocellar triangle also readily separate *staphylinoides* from *puduma.*

I collected one male visiting a pair of extrafloral nectaries on a cordate leaf of kenda, *Macaranga digyna* (Roxburgh), a euphorbiaceous shrub about 3 m high. The nectaries are located on the upper surface of the leaf near the attachment of the petiole on the lower surface.

***Epyris hirtipennis* (Cameron), NEW COMBINATION**

Figs. 13–15

Paracalyoza hirtipennis Cameron, 1909: 377 (♂, ♀; Kuching, Borneo; type series in BM(NH)).—Turner, 1915: 299 (synonymized *Calyozina flavipennis* Turner).

Calyoza nigra Kieffer, 1922: 79–80 (♂; Puerto Princesa, Palawan; syntypes in Kieffer collection, presumably destroyed). NEW SYNONYMY.

Calyozina flavipennis Turner, 1914: 245–246 (♂; Mt. Matang, Sarawak, 3000 ft; unique holotype in BM(NH)).

Parepyris bryanti Turner, 1928: 133–134 (♀; Mt. Matang, Sarawak, 1000 ft; unique holotype in BM(NH)). NEW SYNONYMY.

Cameron's syntype series of *hirtipennis* consisted of a single pair. He labeled both specimens as "Type." I am designating the male as the Lectotype. It bears the following labels from the top: a red-bordered disk bearing a printed "Type" in red; a label bearing a handwritten "J.Hewitt" and a printed "Kuching"; a third handwritten label, "J.10"; a printed label, "P.Cameron Coll/1914-110"; and a label in Cameron's hand, "Paracalyoza/hirtipennis/Cam. Type/ Borneo." The female is in poor condition, some characters of the thoracic dorsum are obscured by the pin and matting of the wings. A second male of *hirtipennis* from Kuching in BM(NH) bears a manuscript name and "Type" in Cameron's handwriting.

Kieffer described *nigra* from at least two specimens from C. F. Baker's collecting in the Philippines, because he gives the length as 4.5–8 mm. Baker's personal collection was donated to the Smithsonian, but there are no "*Calyoza*" from Palawan in it. There are series of two distinctive new species of the Staphylinoides group from other islands in the Philippines, but no specimens agreeing with the description of *nigra.* Most of Kieffer's collection was destroyed during World War I, but a few specimens are in the Paris Museum; however, none of these is labeled *Calyoza nigra.* The original description of *nigra* agrees very well with fresh males of *hirtipennis* from Borneo, particularly in the sculpture and coloration of the wings. Southwestern Palawan is separated from Borneo to the southwest by some 150 miles across shallow Balabac Strait. It is reasonable to assume that the two areas share some faunal elements, so I place *nigra* as a synonym of *hirtipennis.*

Turner's unique male holotype of *flavipennis* is clearly synonymous with *hirtipennis* as Turner realized subsequently (1915).

The unique holotype of *bryanti* Turner falls within the range of variation to be expected in larger females.

In addition to the material listed above, I have examined a series of six males and one female BM(NH) bearing the following labels: "BRUNEI:Labi/Mixed dipterocarp/forest.200m./viii–ix.1979 Gauld."

The wings of fresh material have a distinct yellowish tinge, the stigma and veins are yellow, and the male antennal flagella range from being dark brown to having the six apical segments mostly reddish.

Characters not noted in the original descriptions of *hirtipennis* and *flavipennis* males are as follows: Length 6.1–6.7 mm, forewing 4.1–4.4 mm; WH 1.0 × LH; WF 1.3–1.4 × HE and 0.7 × WH; EV 0.4–0.6 × HE; OOL 1.2–1.5 × WOT; clypeus angulate medially at about 110°; front angle of ocelli 80°–85°; first four antennal segments in a ratio ranging from 30:5:3:11 to 35:7:5:15, third segment 0.4–0.5× as long as wide; mandible tridentate; scutellar pits circular, separated by twice their width; upper mesopleural fovea subcircular, moderately large, lower fovea an oblique, linear, crenulate groove along lower margin; propodeal disk 1.6× as wide as long, median enclosed area with five carinae, lateral pair converging toward and reaching apical carina, separated at apex by half the distance between them at base, intermediate pair weaker, not reaching apex of disk.

These additional descriptive notes of the female are based on the three specimens examined. Where two measurements or ratios are given, the first figure is of the *bryanti* holotype, the second of the *hirtipennis* cotype: Length 9.9 and 7.6 mm, forewing 5.6 and 4.6 mm; head massive, subquadrate to quadrate as viewed from above; clypeus (Fig. 13) with apical margin broadly and slightly rounded; punctures on front somewhat larger and closer on *bryanti*; WH 0.9–1.0 × LH; WF 1.2–1.5 × HE and 0.6 × WH; EV 0.9 × HE; OOL 1.9–2.1 × WOT, front angle of ocelli 80°; first four antennal segments in ratios of 55:10:10:15 and 42:8:11:13, and third segment 0.6–0.7× as long as wide; scutellar pits elliptical, oblique, separated by 3.5× width of pit; mesopleuron as in male but lower fovea not crenulate; propodeal disk of *bryanti* 1.2× as wide as long, median enclosed area with three carinae, only median reaching apex, lateral carinae weaker than median, converging toward apex and separated there by half the distance between them at base, areas between carinae weakly, transversely carinulate; posterior propodeal surface with median carina; forefemur 2.0–2.1× as long as wide; midtibia dorsally with 2–3 rows of close, short spines; hindtarsus (Figs. 14–15), posterior edge of first two segments with a row of close-set, stout, fluted, conical setae in addition to the few similar setae at apices of first four segments; tarsal claw with two teeth, outer longer and slender, inner short and blunt.

Epyris sumatrana (Enderlein), NEW COMBINATION

Calyoza sumatrana Enderlein, 1917: 396–397 (♂; Sinabong, Sumatra; unique holotype originally in Stettin Zoological Museum).

The description of this species of the *staphylinoides* group suggests that it is close to or a synonym of *hirticornis* (Cameron).

The type of *sumatrana* and of the following species should be in the Institute of Zoology, The Polish Academy of Sciences, (IZ PAS), Warsaw, which houses the types of Braconidae described from the Stettin collection by Enderlein (personal communication, P. M. Marsh). E. Kierych, curator of Hymenoptera, IZ PAS, wrote as follows. "I would like to inform you we have not stored in Museum of IZ PAS any type-specimens of Bethylidae, neither Enderlein's nor any other author's."

Epyris sumatrensis Krombein, NEW NAME

Calyozella flavipennis Enderlein, 1920: 24–25 (♂; Soekaranda, Sumatra; unique holotype originally in Stettin Zoological Museum). Preoccupied in *Epyris* by *flavipennis* (Turner), 1914.

The species appears to be distinct from others of the *staphylinoides* group in having

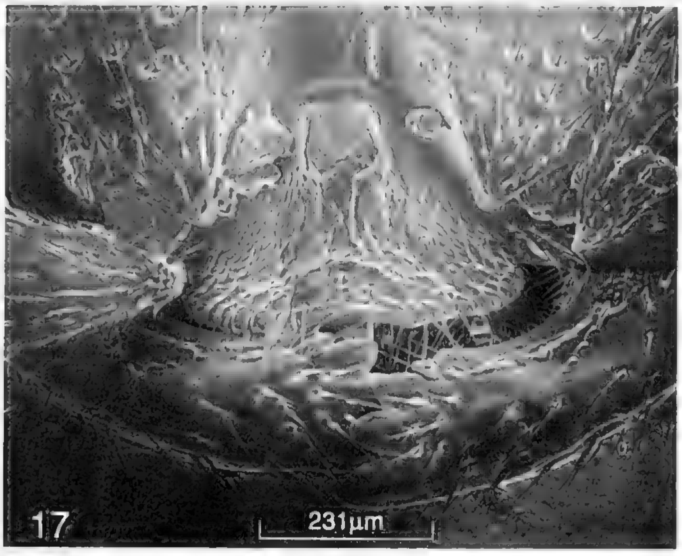

Fig. 17. *Epyris subramosus* female, uncoated at 3 KV, clypeus and mandible.

the antennal rami only slightly longer than the length of the segment. See comment above on *E. sumatrana* concerning the type of *flavipennis.*

***Epyris sauteri* (Enderlein),**
NEW COMBINATION

Calyozella sauteri Enderlein, 1920: 25 (♂; Taihorin, Taiwan; unique holotype in Eberswalde, Germany).

The species is known only from the holotype. The following measurements will supplement Enderlein's description: WH 1.0 × LH; WF 1.4 × HE and 0.6 × WH; EV 0.6 × HE; and OOL 1.3 × WOT. This is the only known male of the *staphylinoides* group in which the head width is less than the length.

***Epyris rufiventris* (Kieffer),**
NEW COMBINATION

Calyoza rufiventris Kieffer, 1907: 288–289 (♂; Mackay, Australia; holotype in BM(NH)).

Characters not noted in the original description are based on the holotype and two topotypic males as follows: Length 8.2–8.4 mm, forewing 4.7–5.2 mm; WH 1.2 × LH; WF 1.4–1.5 × HE and 0.6 × WH; EV 0.4–0.5 × HE; clypeus angulate medially at about 135°; OOL 1.1–1.3 × WOT, front angle of ocelli 105°; first four antennal segments in ratios ranging from 35:5:5:12 to 40:6:5:15, third antennal segment 0.3 × as long as wide; scutellar pits large, circular, separated by 1.1 × their diameter; upper mesopleural fovea large, subelliptical, 1.5 × as long as wide, lower fovea an oblique, linear, crenulate groove along lower margin; propodeal disk 1.5 × as wide as long, enclosed median area tricarinate, twice as wide at base as at apex, disk with a row of large foveae anteriorly, remainder of area closely, transversely rugulose, posterior groove crenulate; posterior surface closely, transversely rugulose, with a median carina; lateral surface closely, longitudinally rugulose.

The female is unknown; the abdomen probably is totally red as in the male.

***Epyris subramosus* (Turner),**
NEW COMBINATION

Fig. 17

Pseudocalyoza subramosa Turner, 1915: 298.

The unique holotype male (BM(NH)) bears a printed label, "Mt. Mlanje/Nyasaland/30-XI-1912/S.A. Neave."

The species is clearly an *Epyris,* and should be considered the only known member of the new Subramosus group. The third antennal segment is a narrow ring joint, but *subramosus* belongs to neither the Staphylinoides group nor the Dodecatomus group both of which also have the narrow ring joint. The male antennae are not ramose, but distinctive in being quite elongate, noticeably flattened beneath, and with the lower apical angle of flagellar segments 2–6 slightly produced. Turner said the male antennae were 12-segmented, but they should be 13-segmented as is normal in *Epyris.* Turner failed to note that the apical segment had been broken off of each antenna; the last four segments of the left hindtarsus are also missing. The male mandible is tridentate but stouter than in the Staphylinoides and Dodecatomus groups.

Other characters of the male not noted in the original description are: Length 8.9 mm, forewing 6.2 mm; WH 1.0 × LH; WF 1.1 × HE and 0.6 × WH; EV 0.6 × HE; OOL 1.6 × WOT, front angle of ocelli 80°; first four antennal segments in a ratio of 21:2:1:16, third segment 0.3× as long as wide; scutellar pits elliptical, oblique, longer than wide, separated by 6× their width; upper mesopleural fovea small, subcircular, lower fovea absent; propodeal disk 1.6× as wide as long; exposed part of paramere very slender, with two long apical setae wavy toward apex, and a shorter straight seta.

The hitherto undescribed female (BM (NH)) bears a printed label, "Mlanje/Nyasaland/8-9-II-1912/S.A. Neave.)" The mandible is quinquedentate, and lacks the subapical tooth on the lower margin that is characteristic of females of the Staphylinoides group.

Female.—Length 8.0 mm, forewing 4.2 mm. Black, mandible, scape, apex of forefemur above, tibiae and tarsi, apex of fourth and last two abdominal segments red; flagellum brown.

Head densely punctate, more coarsely so than in male; WH slightly wider than long (1.02×); WF 1.8 × HE and 0.8 × WH; EV 0.7 × HE; mandible quinquedentate (Fig. 15), upper two teeth small and placed along inner margin somewhat removed from lower, sharper, heavier teeth, lower margin without subapical tooth; clypeus (Fig. 15) with a narrow, slightly concave process at base, apical margin broadly rounded, but shallowly, narrowly concave in middle; OOL 1.4 × WOT, front angle of ocelli 90°; first four antennal segments in a ratio of 40:10:11:12, third segment 0.9× as long as wide.

Thoracic dorsum coarsely punctate, less closely on pronotum than on head and scutum; scutellar pits small, subcircular, separated by about 7× diameter of pit; propodeum dorsally half as long as wide, median area with five carinae, intermediate pair not quite reaching apex; upper fovea of mesopleuron small, lower fovea absent; forefemur 2.3× as long as wide.

Epyris longiceps (Brues)

Calyoza longiceps Brues, 1923: 336–337 (♀; Baltic amber; Zool. Mus., Univ. Königsberg).

Epyris longiceps (Brues), Brues, 1933: 130.

Brues based his original generic assignment on descriptions of female *Calyoza* ". . . by Kieffer . . . combined with those of Ashmead and Westwood" but later (1933) decided that it could not be placed in *Calyoza* after seeing "true" specimens of that genus. After reviewing Brues' description, it appears that he may have assigned it correctly to *Epyris,* but that it cannot be a member of the *staphylinoides* group. Brues stated that the tibiae were "slender and smooth, not at all spinulose," whereas females of the *staphylinoides* group have 2–3 rows of close, short spines on the midtibiae. The unique holotype is presumed lost during World War II.

Calyozina Enderlein

Calyozina Enderlein, 1912: 263. Type-species: *C. ramicornis* Enderlein, by monotypy.

When he described two new Neotropical species of *Calyozina,* Evans (1964) was uncertain whether they were congeneric with *ramicornis* from Taiwan. Enderlein did not state whether the pronotal angles were produced anterolaterally. His type, however, has prominent pronotal angles (Fig. 3), and I believe that Evans' several species are correctly placed in *Calyozina.* The genus is a small, rare one with a disjunct distribution, each of the six species known from a single male only:

ramicornis Enderlein, 1912—Taiwan
amazonica Evans, 1964—Brazil
neotropica Evans, 1964—Panama
mexicana Evans, 1965—Mexico
azurea Evans, 1978—Brazil
caperata Krombein, 1990—Botswana

Turner (1915) incorrectly synonymized *Calyozina* under *Paracalyoza* Cameron, 1909.

Calyozina ramicornis Enderlein
Figs. 18–25

Calyozina ramicornis Enderlein, 1912: 263–264 (♂, Taihorin, Taiwan; unique type in Eberswalde).

Length 5.2 mm, forewing 3.2 mm. Black, head and thorax rather dull from coarse sculpture, the interspaces mostly finely alutaceous, abdomen glossy; antenna, tegula and tarsi red, mandible dark red except at apex, tibiae light brown. Vestiture of head and thorax sparse, suberect, cinereous; flagellar segments with short, moderately dense, erect setae except rami of segments 3–12 with longer, erect, sparser setae about 3× as long as ramus width. Wings clear, stigma light brown, veins testaceous.

Head (Figs. 19, 20): WH equal to LH; WF 1.4 × HE and 0.6 × WH; EV 0.6 × HE; mandible (Fig. 25) quadridentate, three inner teeth subequal, smaller than apical; eyes protuberant, ocular setae sparse, short, no longer than diameter of facet; front and vertex with coarse, shallow, almost confluent pits, interspaces 0.2–0.3 × diameter of pit; ocelli with a frontal angle of about 90°, posterior ocelli separated by a bit less than their diameter from posterior face of vertex; latter abruptly declivous to complete, strong, crenulate occipital carina; antenna (Fig. 18), dorsal length of first four segments about 12:5:5:7, third segment dorsally 1.3× as long as wide; segment 2 roundly protuberant beneath; segments 3–12 each with slender, elongate apical ramus ventrally, rami about 2.5× as long as rest of segment basally, gradually diminishing to about as long at apex, rami ranging from 15× as long as width at base to about 8× at apex; segment 13 1.6× as long as 12.

Thorax (Figs. 20–22); dorsum with length 2.2× as long as greatest width at pronotal lobes, delicately alutaceous; pronotum with anterior face abruptly declivous, disk twice as wide anteriorly as median length, more coarsely and irregularly pitted than head, anterior margin somewhat raised and bluntly angulate laterally; scutum finely alutaceous, parapsidal furrows strong, complete, diverging slightly anteriorly, notauli weakly impressed; scutellum finely alutaceous, margined laterally by a row of small punctures, anteriorly with a pair of deep, large pits that are separated by about half their width, pits not connected by an anterior groove; dorsal propodeal surface 0.8× as long as greatest width, margined posteriorly by a carina, posterolateral angles weakly, bluntly angulate; disk medially with a complete carina, halfway to side with a weaker carina that curves inward posteriorly and does not reach apical carina, areas between median and lateral curved carinae irregularly rugulose, surface laterad with oblique rugulae, at apex with short longitudinal rugulae; lateral surface of pronotum with small, shallow, close pits on upper two-thirds, lower third smooth except for two elongate foveae; mesopleuron with groove above, two moderately large foveae beneath this, and curved carina along ventral margin, area between foveae and ventral carina with shallow, small pits; posterior surface of propodeum rugulosopunctate, lacking median carina; lateral propodeal surface with moderately close, oblique carinules on anterior fourth, narrowly foveolate beneath strong dorsal carina, delicately wrinkled on median half, and with small, close shallow pits posteriorly; forelegs and right hindtarsus missing; tarsal claw (Fig. 24) with small, sharp, erect subbasal tooth; mid- and hindtibiae not spinose; forewing costa not extending beyond stigma.

Abdomen (Fig. 23) with a row of scattered, small, subapical punctures on second to fifth terga; genitalia partially extruded, apex of parameres rounded, with a few submarginal setae.

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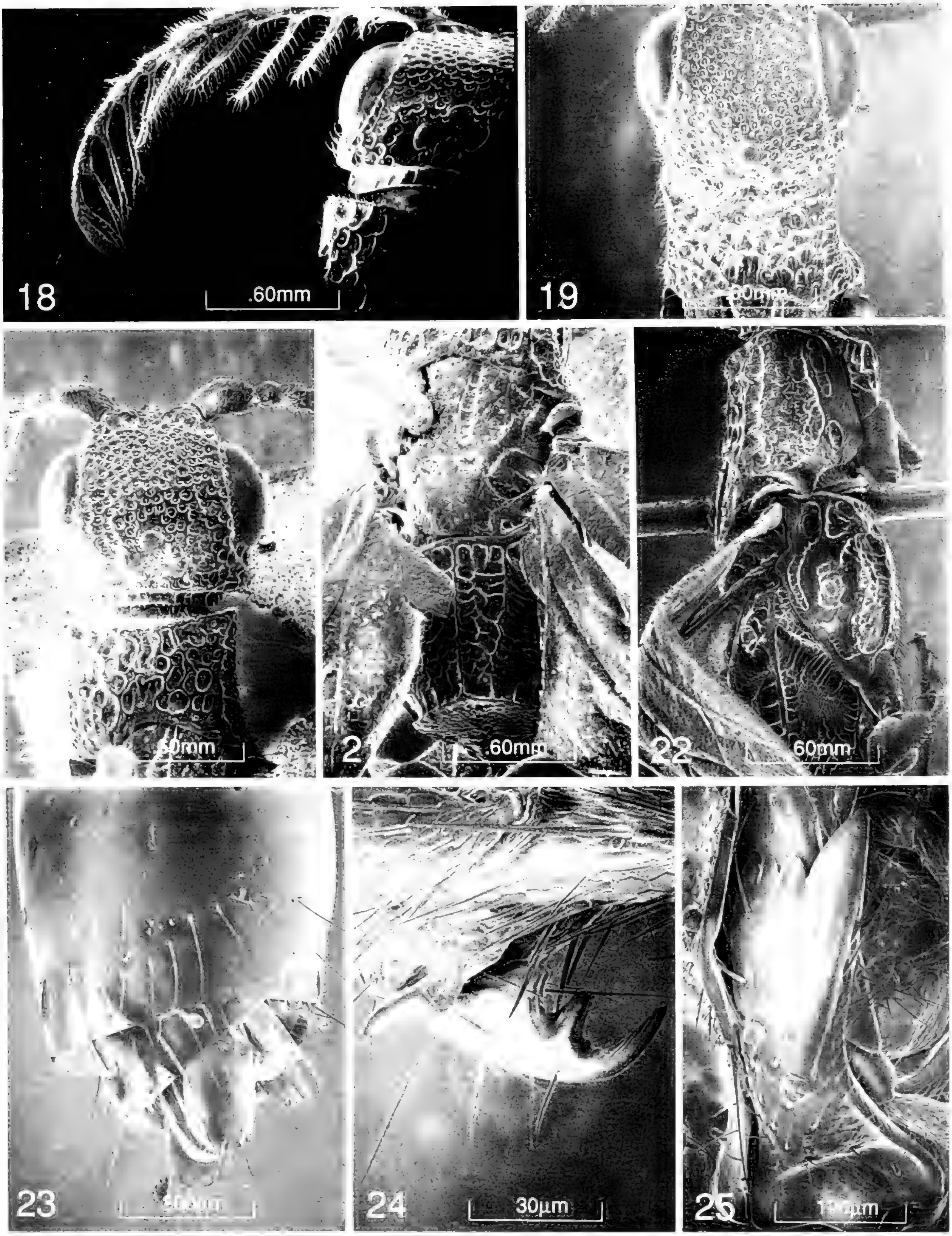

Figs. 18–25. *Calyozina ramicornis* holotype male, uncoated at 3 KV. 18, antenna. 19, front. 20, vertex and dorsum of pronotum. 21, dorsum of scutum, scutellum, metanotum and propodeum. 22, lateral thorax. 23, apex of abdomen, lateral. 24, hindtarsal claw. 25, mandible.

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94(3), 1992, pp. 361–365

A NEW SPECIES OF *CERACLEA* (TRICHOPTERA: LEPTOCERIDAE) FROM THE OZARK MOUNTAINS OF MISSOURI, U.S.A.

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Abstract.—A new species of the *Ceraclea* (*Athripsodina*) *annulicornis* species group is described from the Ozark Mountains of Missouri. ***Ceraclea* (*Athripsodina*) *maccalmonti*** n. sp. represents the ninth member of this group from the world and fourth species known from the Nearctic region. The adult genitalia, larva, and pupa are described and figured from field-collected and reared material. The known distribution of this species may be restricted to Bennett Spring in central Missouri.

Key Words: Trichoptera, *Ceraclea* (*Athripsodina*) *annulicornis* species group, Ozark Mountains, new species

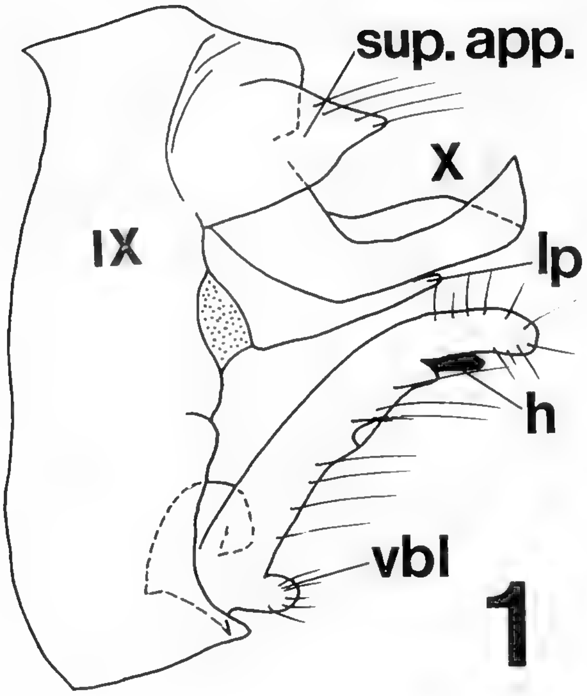
The genus *Ceraclea* is one of the largest and most important groups of caddisflies in North America and the world (Morse 1975). The larvae are found in a variety of aquatic habitats, and have diverse food habits and water quality tolerances (Resh 1976). Eight species are known from the Annulicornis species group (Morse 1975, Yang and Morse 1988); five of which are Palearctic, two Holarctic and one Nearctic. In conjunction with a broader study of the caddisfly fauna of the Interior Highlands, we have discovered a ninth species belonging to this group that appears to be endemic to Bennett Spring in central Missouri. Larvae collected in June 1991 were reared in a Frigid Units Living Stream® for correlation of the life stages.

Morphological terminology and drawings follow the works of Morse (1975) for male genitalia, Nielsen (1980) for female genitalia, and Resh (1976) for larvae and pupae. Deposition of the type material is noted by the abbreviations INHS (Illinois Natural History Survey), NMNH (National Museum of Natural History), or UNT (University of North Texas).

Ceraclea (*Athripsodina*) *maccalmonti* Moulton and Stewart,
NEW SPECIES
Figs. 1–12

Adult.—Length 13 mm. Head yellow with brown setal warts; thoracic sclerites dark brown (in alcohol). Approximately 88 segments in each antennal flagellum; segments dark except for basal segments which each have basal half light colored. Legs lighter in color with tarsal segments darker apically. Wing venation typical of that for genus. Fore- and hind wings with membranes brown. No specific hair patterns are discernable in specimens contained in alcohol.

Male.—Figs. 1–4. Tergum X elongated and upturned with apical and lateral edges forming a high, sharp carina. Mesal area of tergum X forms a ridge best viewed laterally. Finger-like lateral processes of tergum X present and approximately two-thirds the length of the tergum. Superior appendages broad and tapering to rounded apices. Inferior appendages slender, each with harpago greatly reduced to form tooth-like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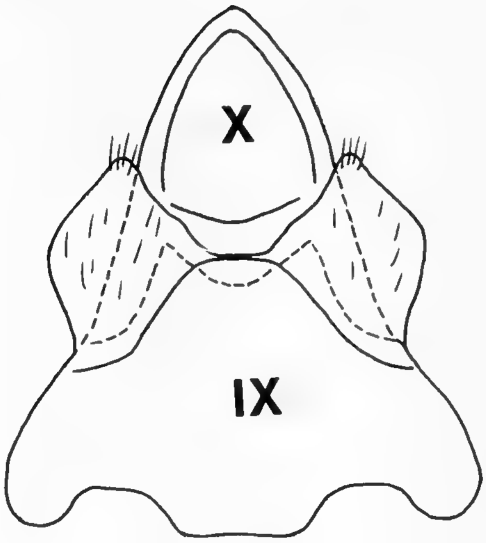
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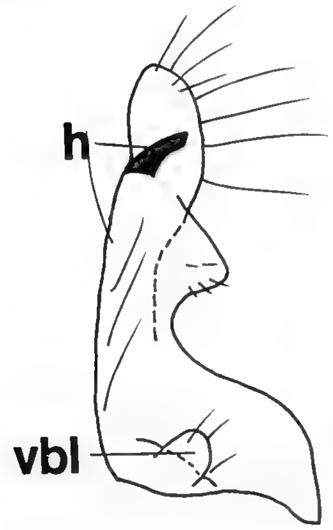
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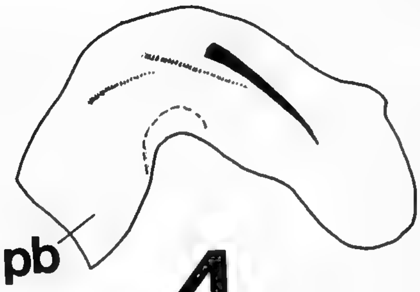
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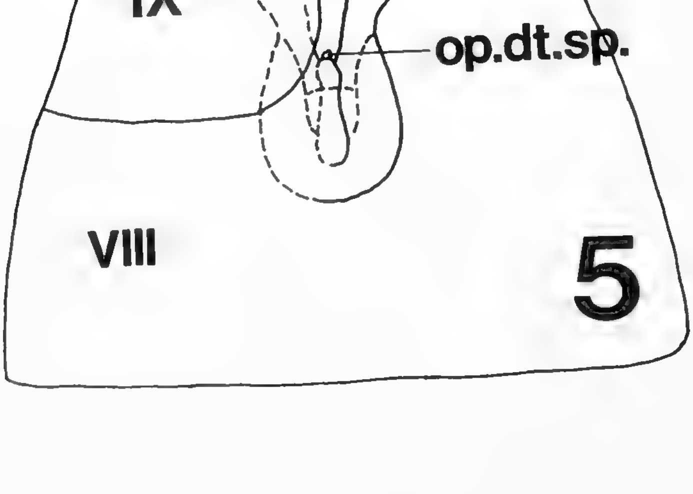
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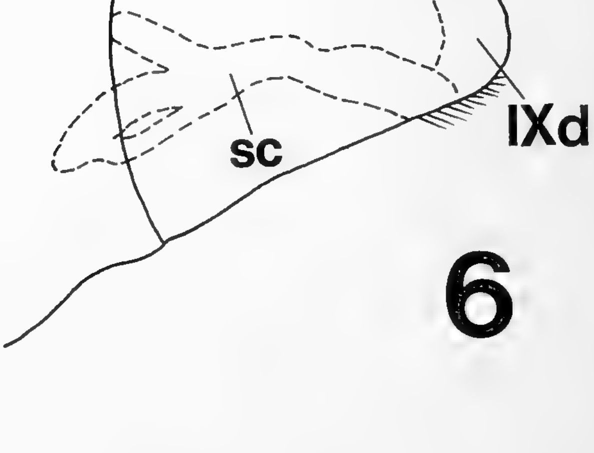
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6

structure directed mesad; ventro-basal lobe of clasper directed caudad and short, its length shorter than the basal width of appendage; phallic guide not protracted. Phallobase directed ventrad and not swollen. Phallus with two or three paramere spines; dorsal spine very prominent, others are more seta-like.

Female.—Figs. 5 and 6. General morphology similar to that of *C. annulicornis.* Rounded sclerites (rs) heavily sclerotized giving appearance of two out-curved hooks when viewed ventrally. Dorsal sclerotic bulge (IXb) long, bifurcate.

Larva.—Figs. 7–9. Length 6–7 mm. Head straw yellow with few light brown patches mostly confined to posterior half. White patches in same area along parafrontal sutures. Parafrontal areas approximately half width of the frontoclypeus. Gular sclerite roughly trapezoidal with anterior and posterior margins emarginate. Mandibles elongate, triangular with single apical tooth and two smaller mesal teeth. Pronotum straw-colored with postero-lateral and postero-mesal areas heavily sclerotized. Few light brown patches present on lateral areas. Anterior margin of pronotum crenulate with 26 setae. Mesonotum largely membranous with well defined, straw-colored mesonotal shields. Mesonotal bars evenly angled.

Pupa.—Figs. 11 and 12. Length 7–8 mm. Morphology typical for that of genus (Resh 1976). Paired presegmental plates on III and IV each with three denticles; V and VII each with four denticles; VI each with four or five denticles. Paired postsegmental plates on V each with 20 denticles. Anal rods each uniformly wide in basal half, tapering abruptly to hooked distal point. Mesal shoulder of each anal rod with well developed medial process.

Case.—Fig. 10. Length to 6–7 mm. Cornucopia-shaped, constructed of large mineral fragments and sand grains. Posterior end strongly curved in lateral view and may be broken off in larger cases.

Etymology.—This species is named in honor of Mr. Robert McCalmont, fly fisherman and aquatic entomology hobbyist, who collected some of the paratypes and generously collected and lent study material for a much larger taxonomic/biogeographic study of the caddisflies in the Interior Highland region.

Holotype, male.—Missouri, Dallas Co., Bennett Spring at source, Bennett Spring State Park (T34N, R18W, Sec. 1), 7 June 1991, S. R. Moulton (NMNH).

Paratypes.—1 male, reared, same data as Holotype (NMNH); 1 male, 2 females, same data as Holotype but 7 July 1988, B. McCalmont (INHS); 1 female, same data as holotype but Laclede Co., Bennett Spring at hatchery (Highbanks Hole) (NMNH); 1 male, 1 female, reared, same data as previous (UNT); 2 males, 5 females, same data as Holotype but 22 July 1990, B. McCalmont (INHS); 9 larvae, same data as previous (UNT).

Discussion: In terms of phylogeny, the short left (anterior) paramere spine(s) and the apico-dorsal ridge of tergum X of the male of *Ceraclea maccalmonti* indicates that it is a member of the monophyletic *C. annulicornis* Group (Morse 1975, Yang and Morse 1988). Most members of the Group (other than *C. annulicornis* (Stephens), *maccalmonti,* and *ruthae* (Flint)) also have a phallic guide of each male inferior ap-

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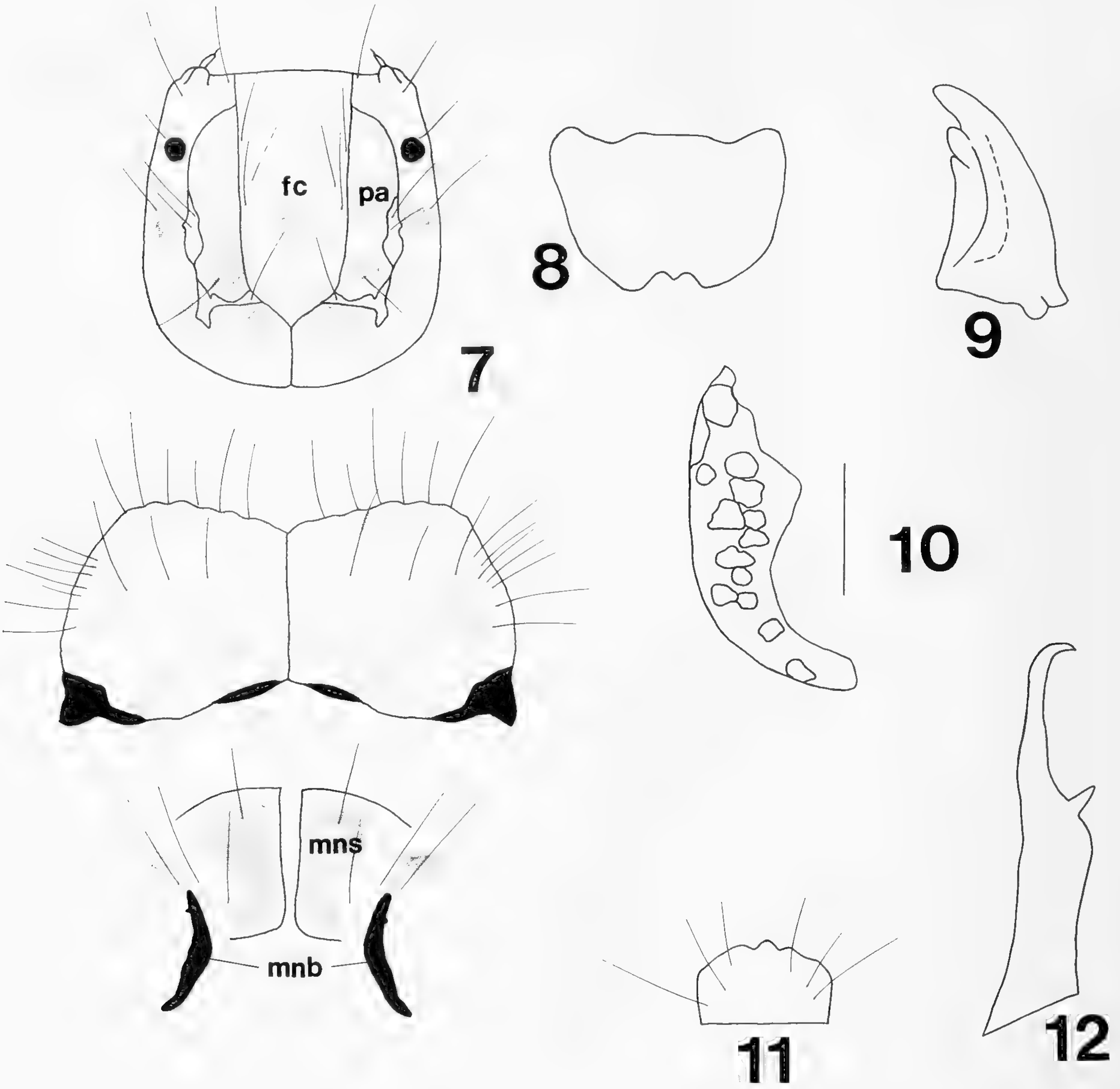
Figs. 1–6. *Ceraclea maccalmonti* genitalia. 1–4, male genitalia: 1, left lateral view; 2, dorsal view; 3, left inferior appendage, caudal view; 4, phallus, left lateral view. 5–6, female genitalia: 5, ventral view; 6, left lateral view. h = harpago, IX = abdominal segment IX, IXb = dorsal sclerotic bulge, IXc = lateral sclerotic bulge, IXd = vertical lamellae, lp = lateral process, op.dt.sp. = opening of the ductus spermathecae, pb = phallobase, rs = rounded sclerite, sc = spermathecal sclerite and associated structures, sup.app. = superior appendage, vbl = ventro-basal lobe of inferior appendage, X = tergum X.



Figs. 7–12. *Ceraclea maccalmonti* larva, larval case, and pupa. 7–9, larva: 7, head, pronotum and mesonotum, dorsal view; 8, gular sclerite, ventral view; 9, right mandible, dorsal view. 10, larval case, right lateral view, scale bar = 2 mm. 11-12, pupa: 11, labrum, dorsal view; 12, right anal rod, dorsal view. fc = frontoclypeus, mnb = mesonotal bar, mns = mesonotal sclerite, pa = parafrontal area.

pendage strongly projected dorsad, parallel with the body of the appendage. Among the nine species of the Group, *C. annulicornis, excisa* (Morton), *globosa* Yang and Morse, *maccalmonti, ruthae,* and *shuotsuensis* (Tsuda) have the short left paramere spine(s) seta-like. All of these species except *C. excisa* and *maccalmonti* also have the anterior basal end of the male phallobase enlarged and subspherical. We infer that *C. annulicornis, excisa,* and *maccalmonti* constitute a monophyletic group because of the synapomorphically smaller ventro-basal lobe of each inferior appendage, shortest in *maccalmonti* where it is shorter than the basal width of the appendage.

In terms of diagnosis, *C. maccalmonti* can be distinguished from other species of *Ceraclea* by the following combination of male characters: (1) an apico-dorsal carina border on tergum X, closed apically (present, but open apically in *hastata* (Botosaneanu); (2) lack of a projecting phallic guide on each inferior appendage; (3) a very short ventrobasal lobe on each inferior appendage, shorter than the basal width of the appendage; (4) a normally developed anterior end of its phallobase (not subspherical); (5) setalike left (anterior) paramere spine(s); and (6) right (posterior) paramere spine not so large as in *C. annulicornis* and without a basal sclerotized plate.

The larva of *C. maccalmonti* is closest to that of *annulicornis.* It can be distinguished from the latter on the basis of the lighter head capsule (dark in *annulicornis*). The larval case of *C. maccalmonti* is easily distinguished from that of other *Ceraclea* species by having the posterior end strongly curved. The size of mineral fragments in the case of *C. maccalmonti* are much larger than those described for *annulicornis* but similar to those of *excisa* (Resh 1976).

Ceraclea maccalmonti represents the ninth species in the *C. annulicornis* Group (Morse 1975, Yang and Morse 1988) known from the world. Other members of this group include *C. annulicornis* (Holarctic), *aurea* (Pictet) (central Europe), *excisa* (Palearctic and northwestern North America), *globosa* (northeastern China), *hastata* (Korea), *ruthae* (eastern Nearctic), *shuotsuensis* (eastern Palearctic), and *sibirica* (Ulmer) (Amur region and Korea) (Morse 1975, Yang and Morse 1988). *Ceraclea maccalmonti* is now the only member of this species group known from the Interior Highland region of the Eastern United States. It appears to be endemic to the spring reach contained within Bennett Spring State Park in central Missouri. Numerous recent collections by the senior author, Bowles and Mathis (1989), Mathis and Bowles (1992) and H. W. Robison (Southern Arkansas University) have failed to locate it elsewhere in the Interior Highland region. *Ceraclea maccalmonti* was probably derived from a relict population of *C. annulicornis* or *excisa* isolated by glacial retreat.

The larva is abundant on the large cobbles found along riffle margins. Emergence occurs in June and July. Water temperatures remain constant year round at about 13°C. Bennett Spring is one of the largest springs found in the Interior Highland region with discharge averaging 100 million gallons per day.

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COMPARATIVE EGG ECOLOGY OF TWO SYMPATRIC MANTIDS (MANTODEA: MANTIDAE)

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Abstract.—We compared numbers and weights of oothecae, hatching success, numbers of eggs and sizes of emerging nymphs of two species of sympatric mantids (*Tenodera sinensis* Saussure and *Mantis religiosa* L.) from two different old field habitats (CHRY and AG). Hatching success and size of emerging nymphs were much greater for *T. sinensis,* whereas numbers of eggs/ootheca were about the same for both species. However, sizes of nymphs varied between oothecae of each species. Numbers and sizes of oothecae for both species were greater at CHRY than AG, probably indicating that the parental generation was less food limited at CHRY.

Key Words: Mantodea, Mantidae, *Mantis, Tenodera,* egg ecology, oothecae, nymphs, habitats

Two mantid species which commonly cooccur in northern Delaware are *Tenodera sinensis* Saussure, introduced from the Orient (Laurent 1898), and *Mantis religiosa* L. from Europe (Gurney 1950). These species, which are also sympatric in China (Yan et al. 1981), inhabit old fields of varying successional maturity and vegetational composition in which they segregate by foliage height: *T. sinensis* typically occurs higher than *M. religiosa* (Rathet and Hurd 1983). Oothecae of both species have an aggregated dispersion in the field (Eisenberg and Hurd 1990). Egg hatch occurs at different times in the spring, *T. sinensis* preceding *M. religiosa* (Hurd and Eisenberg 1989b), however both species mature at about the same time late in the summer (Hurd and Eisenberg 1989a). As the size of these predators determines the size of prey which they can handle, the enhanced disparity in body size resulting from asynchronous egg hatch may serve to alleviate interspecific competition between these two species by reducing overlap in prey size (Hurd and Eisenberg 1990). Such allochronic niche separation also has been proposed as a mechanism for coexistence among plecopterans (Allan 1982).

We undertook a comparative study of aspects of the eggs and newly hatched nymphs of these two species: ootheca size, hatch success rate, and size of emerged nymphs. We compared oothecae from two field sites to examine the influence of habitat differences with respect to these variables.

MATERIALS AND METHODS

Oothecae of *T. sinensis* and *M. religiosa* were collected from two old field habitats in New Castle County, Delaware, on 26 February 1986. One site, designated AG, was an abandoned hayfield on the Experimental Farm of the University of Delaware; the other site (CHRY), about 3 km distant,

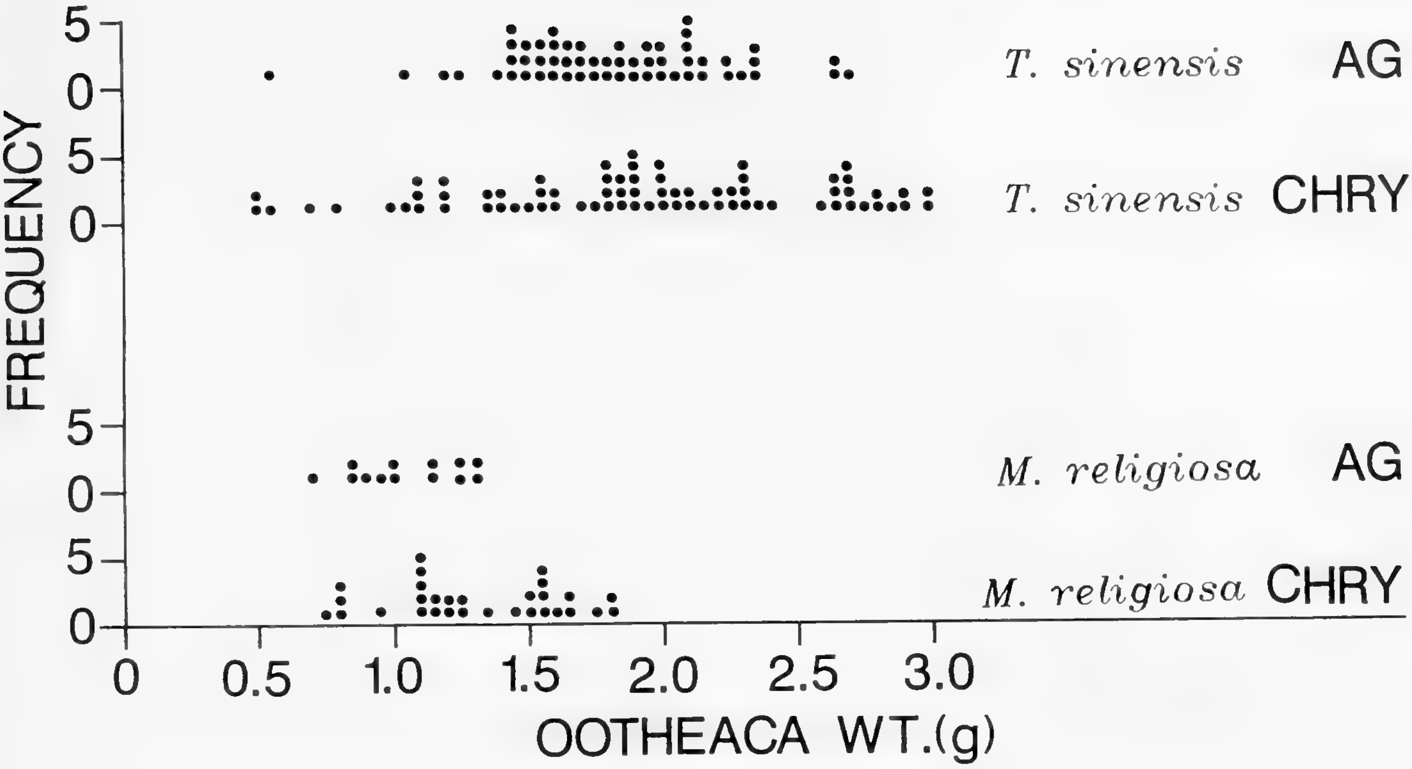

Fig. 1. Frequency (numbers) of live weights of oothecae of *Tenodera sinensis* and *Mantis religiosa* collected from two field sites (AG and CHRY).

was a more mature goldenrod assemblage. Aspects of the comparative ecology of nymphs and adults, as well as the hatching sequence of eggs have been described for both sites (Hurd and Eisenberg 1989a, b).

We carried out standardized time-limited searches (30 min) in each habitat and all oothecae encountered were collected. Oothecae were weighed and 10 of each species from each site, representing the range of weights obtained, were incubated in separate containers at 25°C. Nymphs emerging from these oothecae were counted. Following egg hatch, oothecae were autopsied to determine the proportion of eggs which did not hatch. Dry weights of freshly emerged nymphs were obtained from two or three oothecae from each species and site.

RESULTS

Tenodera sinensis oothecae were more common than those of *M. religiosa* at both sites, and egg cases of both species were more abundant and somewhat larger (especially for *M. religiosa*) in site CHRY than in AG (Fig. 1).

Emergence success of *T. sinensis* was very high (>90%) and very similar in both sites (% hatching, Table 1). Variability in emergence success was very low in both sites for this species (standard errors, Table 1). The values from which these means were obtained ranged from about 85–100% at both sites.

In contrast, *M. religiosa* had lower and more variable hatching success at both sites (Table 1). Variability in emergence success also was 2–7 times greater for this species than for *T. sinensis* (standard errors, Table 1). The values for hatching success ranged from 0–99% in site CHRY, and from 56–96% in AG.

Although *T. sinensis* oothecae in the selected, autopsied sample weighed an average of 1.6 times more than those of *M. religiosa,* the total number of eggs was very similar for both species (Table 1). However, emerging *T. sinensis* nymphs are nearly twice the weight of *M. religiosa* nymphs, with no overlap (Fig. 2). These weights were variable among oothecae for both species, but did not appear to be related either to site or

Table 1. Hatching success and autopsy results for mantid oothecae. Numbers are means (±SE).

Site	Ootheca (g)	Numbers of Eggs			% Hatched
		Total	Unhatched	Hatched	
a. *Mantis religiosa*					
CHRY	1.36 (0.11)	246.0 (16.16)	61.4 (25.43)	184.6 (27.66)	75.6 (10.34)
AG	1.06 (0.07)	238.7 (11.75)	44.0 (10.69)	194.7 (16.39)	81.4 (4.51)
b. *Tenodera sinensis*					
CHRY	1.90 (0.22)	252.1 (24.10)	13.5 (3.28)	238.6 (22.97)	94.2 (1.34)
AG	1.95 (0.14)	262.0 (17.49)	13.5 (4.51)	248.5 (18.05)	94.6 (1.78)

weights of oothecae from which they came (Fig. 2).

Discussion

Evidently site CHRY was better than AG for the parental generation of both species, based upon weights and numbers of oothecae. Both of these variables translate into greater numbers of eggs oviposited at CHRY, undoubtedly as a function of greater food supply for adults there (Eisenberg et al. 1981, Hurd 1989). However neither hatching success nor weight of emerging nymphs was affected by site. Therefore feeding condition of the adult may not determine size or hatching success of the eggs. Alternatively, the differences in these variables might be a function of the variability in feeding success among parental individuals. This kind of variability could have been caused by differences in capture success among juveniles in the parental generation, which can lead to variable rates of development among nymphs (Hurd and Eisenberg 1984, 1989a, Hurd and Rathet 1986), as well as to differences in body size and consequent fecundity of adults (Eisenberg et al. 1981, Fagan and Hurd 1991). Another factor which generates variability within a mantid population is timing of egg hatch with respect to changing ambient conditions during the spring: developmental rate of nymphs is highly dependent upon temperature (Hurd et al. 1989).

It is evident from our data that hatching success for *M. religiosa* eggs is lower than for those of *T. sinensis* at both sites. Eggs of the former species require a cold diapause (Salt and James 1947), whereas those of the latter do not: we routinely have hatched *T. sinensis* eggs in the laboratory without having subjected them to other than room temperature. The winters in Delaware may be too mild for eggs of *M. religiosa,* which have a more northerly distribution than *T. sinensis.*

The fact that first instar nymphs of *M. religiosa* are smaller than those of *T. sinensis,* and that they hatch later in the spring (Hurd and Eisenberg 1989b) than those of *T. sinensis* creates a difference in sizes that may reduce interspecific competition (Hurd and Eisenberg 1990), enabling coexistence in the same habitat. However this disparity in size also may encourage interspecific predation on the smaller species by the larger (Hurd 1988). Since both hatching time and sizes of emerging nymphs also vary within each of these species, intraspecific competition also may be reduced and/or cannibalism encouraged in these populations.

Although ootheca weight in mantids is strongly related to the number of eggs contained therein (Eisenberg and Hurd 1977),

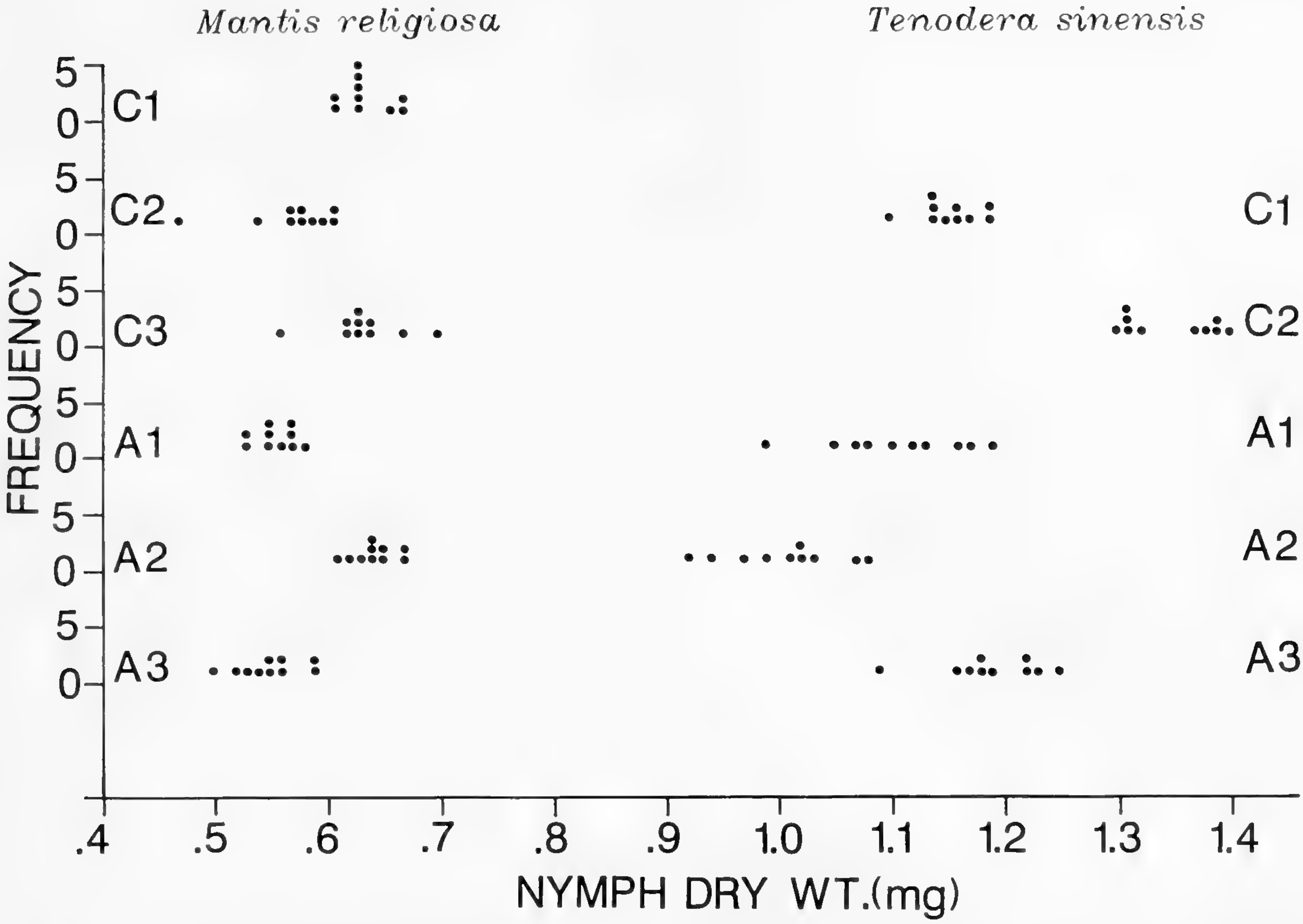

Fig. 2. Frequency (numbers) of dry weights of first instar nymphs of *Mantis religiosa* and *Tenodera sinensis* from two field sites (AG and CHRY). A1–A3 refer to oothecae from site AG; C1–C3 are oothecae from CHRY. N = 10 nymphs for each ootheca.

sizes of emerging nymphs of both species in our study were not related to sizes of oothecae. It is therefore possible that variability in egg size is a function of genetic variability within and between populations. What remains to be determined is whether or not there is a correlation between size of an emerging nymph and its fitness: does a larger first instar nymph have a greater chance of survival and/or greater eventual fecundity than a smaller one?

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A REVIEW OF THE GENUS *CATINATHRIPS* (THYSANOPTERA: THRIPIDAE)

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Abstract.—The genus *Catinathrips* is reviewed. *Catinathrips beshearae,* new species, in leaf galls of *Calycanthus fertilis* Walt. and *C. floridus* L. and two other new species, *C. vaccinicolus* and *C. similis,* which curl the leaves of blueberry, *Vaccinium* spp., are described. Identification keys are provided for the females of the five known species and males of three species.

Key Words: Thysanoptera, Thripidae, *Catinathrips,* new species

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The genus *Catinathrips* known only from eastern Canada and United States consists currently of *C. kainos* O'Neill and *C. vaccinophilus* (Hood), which infest blueberry (*Vaccinium* spp.) in the northeastern United States and adjacent Canadian provinces of New Brunswick, Nova Scotia and Ontario. Two new species, *C. similis* and *C. vaccinicolus,* in Florida and Georgia curl the leaves of blueberry and are described here to provide scientific names for research on blueberry insects now in progress in Georgia. Another new species, *C. beshearae,* is found in leaf galls of *Calycanthus fertilis* Walt. and *C. floridus* L. in Georgia and North Carolina and has been previously reported but misidentified. A generic redescription and synoptic descriptions of the two nominal species are presented. Measurements of all morphological characters are in microns except for the body length which is given in millimeters.

Genus *Catinathrips*

Catinathrips O'Neill, 1967: 854. Type species: *Catinathrips kainos* O'Neill by original designation.

Female: Antennae 8-segmented; segments III and IV each with a sensory trichome. Head with 2 pairs of ocellar setae, ocellar setae I absent, ocellar setae II laterad or posterolaterad of anterior ocellus near inner margin of eyes, setae III between and aligned with caudal or medial part of posterior ocelli; postocular setae small, 2–3 closely grouped just caudad of each posterior ocellus, 1 longer than other two, another posterior of eye; maxillary palpi 2- or 3-segmented. Pronotum with 2 pairs of posteroangular setae, 1 pair of posteromarginal setae; mesothoracic and metathoracic furca and spinula present. Forewings short, about ½ as long as distended body, anterior margin slightly concave, hindvein with few setae, distal ½ of forevein with irregularly spaced setae; fringe cilia straight or slightly wavy. Abdominal segments with posteromarginal flanges, those on sternites lobed between B1–B3 setae; ctenidia absent; tergite VIII with median setae and sensilla on posterior margin, sensilla near median setae, without posteromarginal comb. Sternites without accessory setae.

Male: Macropterous or brachypterous.

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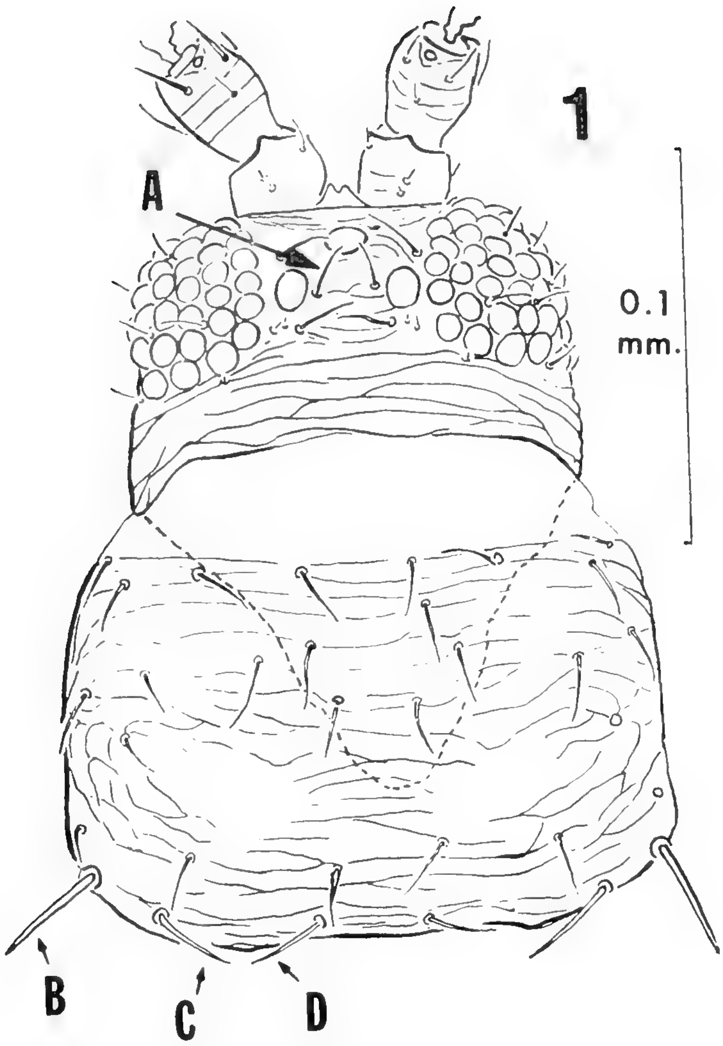

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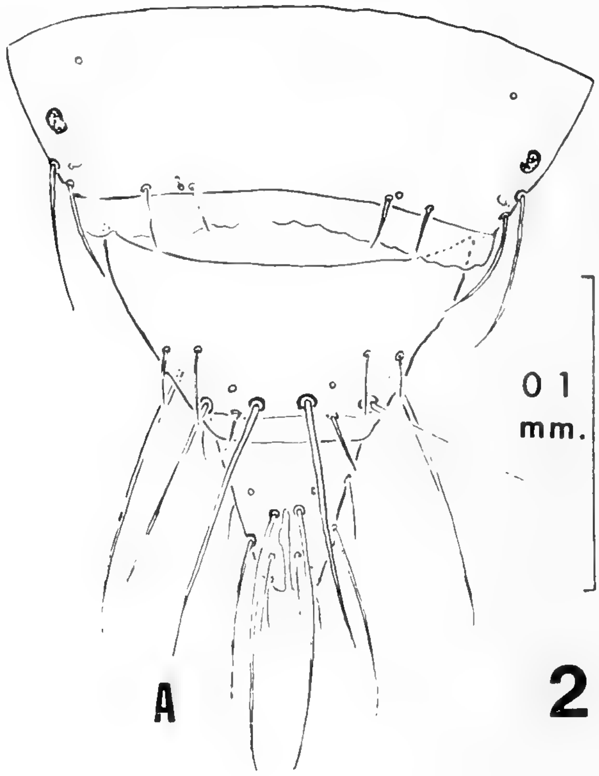

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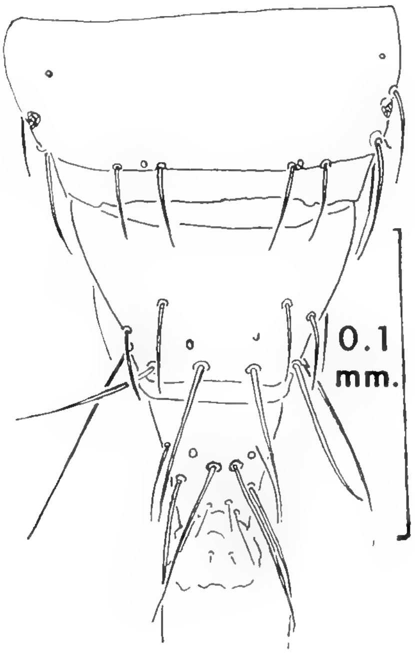

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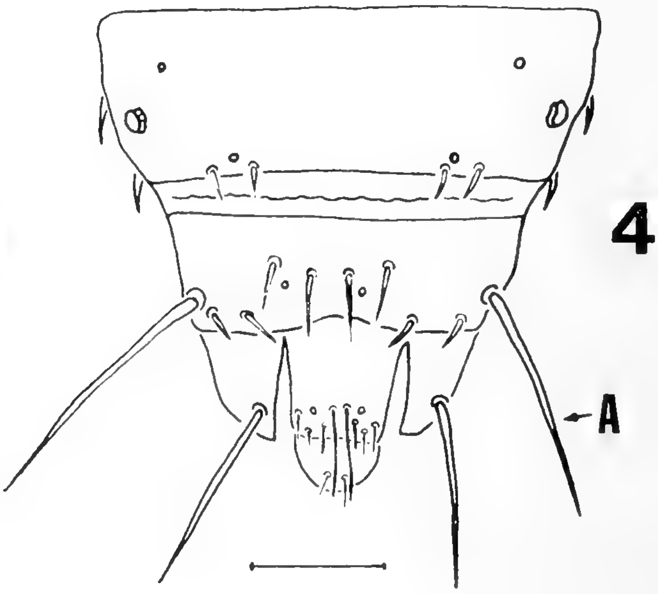

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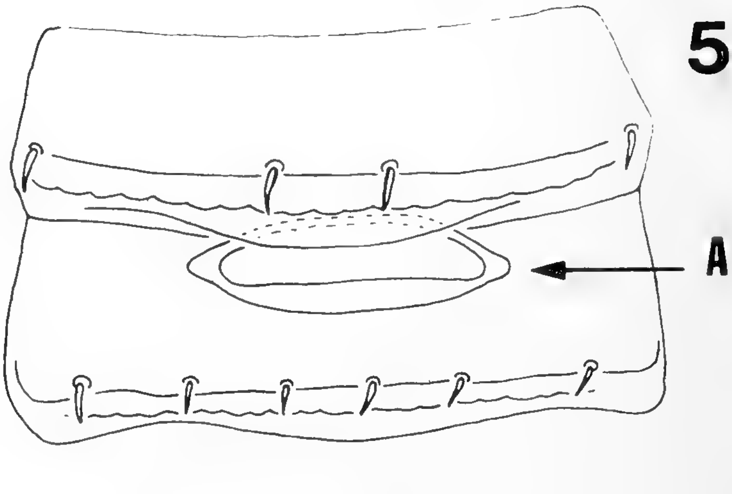

Color and most morphological characters similar to that of female, smaller. Abdominal tergite IX with bristle-like setae; sternite III with or without glandular area.

KEY TO SPECIES

1. Female 2
– Male 6
2(1). Maxillary palps 3-segmented; body light yellow; antennae brown except segments I–II completely pale, III pale in pedicel and extreme base, IV and V paler in extreme base; B1 setae on abdominal tergite IX about as long as tergite X .... *beshearae* n. sp.
– Maxillary palps 2-segmented; other characters various 3
3(2). Posteroangular setae ⅕–⅖ as long as pronotum (Fig. 1), less than ½ as long as B1 setae on abdominal tergite IX (Fig. 2) 4
– Posteroangular setae about ½ as long as pronotum, about ½ as long as B1 setae on abdominal tergite IX or longer 5
4(3). Posteroangular setae about ⅖ as long as B1 setae on abdominal tergite IX; medial sculpture lines on metanotum transverse, forming wide transverse reticles .... *kainos* O'Neill
– Posteroangular setae ⅕–$\frac{3}{10}$ as long as B1 setae on abdominal tergite IX; metanotum reticulated medially .... *similis* n. sp.
5(3). Forewings pale yellow, body light yellow; B1 setae on tergite IX 64–74 long (Fig. 3), 1.25–1.40 times as long as posteroangular setae .... *vaccinophilus* (Hood)
– Forewings light brown with base paler, scale brown; lateral part of mesothorax, mesonotum, metanotum and ocellar area with pale brown shade; B1 setae on abdominal tergite IX 90–100 long, about twice as long as posteroangular setae .... *vaccinicolus* n. sp.
5(1). Abdominal sternite III with oval, glandular area (Fig. 5); major lateral setae on abdominal tergite IX about twice as long as posteroangular setae on pronotum (Fig. 4); brachypterous .... *kainos* O'Neill
– Abdominal sternite III apparently without glandular area; major lateral setae on abdominal tergite IX about as long to 1.66 times as long as posteroangular setae; macropterous 7
7(6). Maxillary palps 2-segmented; major lateral setae on abdominal tergite IX about as long as or slightly longer than posteroangular setae; on blueberry ...... *vaccinophilus* (Morgan)
– Maxillary palps 3-segmented; major lateral setae on abdominal tergite IX about 1.66 times longer than posteroangular setae; on *Calycanthus* sp. .... *beshearae* n. sp.

***Catinathrips beshearae,* NEW SPECIES**

Catinathrips vaccinophilus (Hood): Beshear, 1985: 244 (misidentification).

Female: Body and legs light yellow, abdominal segment X light golden yellow; forewings pale with subbasal part pale yellowish brown, scale pale yellowish brown; setae pale yellow; antennae brown except antennal segments I and II pale, pedicel and base of III pale, gradually light brown distally, basal part of IV and V pale.

Antennal segment III strongly constricted near base, VIII about 1.7 times longer than VII. Head broader than long, part posterior of eyes about ⅓ as long as eye; ocellar setae II posterolaterad of anterior ocellus and near mesal margin of eyes; ocellar setae III aligned with caudal margin of posterior ocelli; postocular setae i about as long as ocellar setae III; beak with 3-segmented maxillary palps. Pronotum with transverse sculpture lines, few, short discal setae; posteroangular setae 0.35–0.45 times as long as pronotum, about twice as long as posteromarginal setae or those of some specimens longer; medial ⅓ of metanotum reticulated, laterally sculptured longitudinally. Forewings with 16–19

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Figs. 1–5. Fig. 1. *Catinathrips kainos* female. Head and pronotum. A, ocellar seta III; B, posteroangular seta outer pair; C, posteroangular seta inner pair; D, posteromarginal seta. Fig. 2. *Catinathrips kainos* female. Abdominal tergites VIII–X. A, B1 seta on tergite IX. Fig. 3. *Catinathrips vaccinophilus* female. Abdominal tergites VIII–X. Fig. 4. *Catinathrips kainos* male. Abdominal tergites VIII–X. A, major lateral seta. Fig. 5. *Catinathrips kainos* male. Abdominal sternites II–III. A, glandular area on abdominal sternite III. (Figs. 1–3 are reproductions from O'Neill (1967) and Figs. 4–5 are from O'Neill and Langille (1971). Scale for figures 4 and 5 = 0.05 mm.)

costal setae, scale with 4 marginal and 1 discal setae; forevein with 2 groups of 2–3 and 3 setae each on proximal ½ of fore vein, 3 setae in distal ½; hind vein with 3 widely spaced setae. Abdominal tergite I with median setae longer than those on II–VII, far apart; third dorsal seta from midline on tergite VI shorter than setae laterad to it; sculpture lines absent medially from tergites IV–VIII, microtrichia on submarginal sculpture lines on tergites V–VIII; B1 setae on abdominal tergite IX about 1.2 times longer than posteroangular setae, about as long as abdominal tergite X.

Male: Macropterous; similar in color and most morphological characters as that of female, smaller; major lateral setae on abdominal segment IX about 1.66 times longer than posteroangular setae; glandular area apparently absent from abdominal sternites.

Measurements of holotype: Body length measured from interantennal process 1.06 mm. Antennae: total length 209; length of segments: I 20, II 30, III 37, IV 32, V 30, VI 35, VII 10, VIII 15. Forewing length 432, width at midlength 24. Setal lengths: posteroangular setae inner pair 44, outer pair 44; posteromarginal setae 22; B1 setae on abdominal tergite IX 52. Length of abdominal segment X 57.

Measurements of allotype: Body length about 0.82 mm. Antennae: total length 161; length of segment I 17, II 24, III 27, IV 24, V 22, VI 30, VII 5, VIII 12. Length of forewing 382. Setal lengths: posteroangular setae inner pair 35, outer pair 37; posteromarginal setae 17; major lateral setae on abdominal tergite IX 59–62.

Type material: Holotype female: Macon Co., North Carolina, *Calycanthus fertilis* Watl., VI-16-81, R. Beshear, RJB-7-82. Allotype: male, Rabun Co., Georgia, ex *Calycanthus* sp., V-29-82, R. Beshear. Paratypes: 4 females with same collection data as holotype; 9 females with same data as holotype except collected VI-1-82; 6 females, Henry Co., Georgia, *Calycanthus floridus* L., IV-25-84, R. Beshear; 1 female, Union Co., Georgia, *Calycanthus* sp. VI-13-84, R. Beshear. Holotype deposited in the Thysanoptera collection of the U.S. National Museum of Natural History (USNM), paratypes deposited in the Department of Entomology, University of Georgia, Georgia Station, Griffin (UGG); Natural History Museum, London (NHM); Florida State Collection of Arthropods, Gainesville (FSCA); Forschungsinstitut Senckenberg, Frankfurt, Germany (FS), and USNM.

Distribution: Georgia, North Carolina.

Host: Sweet-Shrub, *Calycanthus fertilis* Walt. and *C. floridus* L.

Etymology: Named in honor of Ramona J. Beshear, the collector of the species.

Comments: The width of the forewing of the allotype is not given because the wing is slightly twisted. This species is readily distinguished by having maxillary palps with 3 segments instead of 2 present in the other species.

It was incorrectly reported as *C. vaccinophilus* by Beshear (1985) based on a misidentification that I provided her. It induces leaf galls by curling the margins of the leaves.

Catinathrips kainos O'Neill
(Figs. 1–2, 4–5)

Taeniothrips vaccinophilus Hood: O'Neill and Bigelow, 1964: 1228 (misidentification).

Catinathrips kainos O'Neill, 1967: 856; O'Neill & Langille, 1971: 752; Langille & Forsythe, 1972: 1781; Chaisson, 1986: 58.

Female: body pale with orange-yellow internal pigmentation, lateral part of mesothorax and often pronotum, abdominal segment I, sides of II-VII shaded light brown; ocellar crescent orange; antennae light brown except I pale, II pale brown, III with proximal ⅔ paler than brown distal ⅓, bases of IV–V pale, VIII brownish yellow; forewings pale with brown shade in basal ⅓ or shaded pale brown with base pale.

Body length about 1.2 mm. Mouthcone

with 2-segmented maxillary palps. Pronotum with discal setae ½–¾ as long as posteroangular setae; posteroangular setae 27–42 (Fig. 1), ¼–⅖ as long as pronotum, less than ½ as long as B1 setae on abdominal segment IX, inner pair pointed medially; posteromarginal setae ½ to about as long as posteroangular setae, pointed laterally; B1 setae on abdominal tergite IX 84–96 (Fig. 2). Metanotum with medial sculpture lines transverse, forming wide transverse reticles; median setae near anterior margin, about 7 from margin. Third dorsal seta from midline on abdominal tergite VI shorter than two setae laterad to it. Length of abdominal tergite X 62–64.

Male: Brachypterous; similar to female in color and most morphological characters, smaller; tergite IX with major lateral setae 80–90 long (Fig. 4), about twice as long as posteroangular setae; transverse, oval glandular area on sternite III about ½ as wide as sternite (Fig. 5), absent from other sternites.

Distribution: Canada (New Brunswick, Nova Scotia, Ontario), United States (Massachusetts, Maine).

Hosts: Vaccinium angustifolium (Aiton.), *Vaccinium* sp.

Comments: Catinathrips kainos closely resembles *C. similis* but differs by having a brownish yellow antennal segment VIII, longer setae on the pronotum, the sculpturing on the metanotum forming wide transverse reticles medially, and the third dorsal seta on abdominal tergite VI is shorter than the two setae laterad to it; whereas *C. similis* has a brown antennal segment VIII, smaller reticulations on the metanotum and the third dorsal seta on abdominal segment VI is about as long as the two setae laterad to it.

Catinathrips kainos has been confused with two other species, *Frankliniella vaccinii* Morgan and *C. vaccinophilus* (Hood) (previously placed in *Taeniothrips*), which are commonly found on blueberry. In the Maritime Provinces of Canada and New England States, the thrips infesting low-bush blueberry were identified as *F. vaccinii* for many years (Phipps 1930, Lathrop 1942, Wood 1956) until Wood (1960) reported that *C. vaccinophilus,* described from New York State, was also present in New Brunswick and Nova Scotia. He further stated that *C. vaccinophilus* migrated into New Brunswick from the New England States in or about 1951 and had become the predominant species on low-bush blueberry. Based on material from Massachusetts, Maine and New Brunswick, O'Neill (1967) described a new species, *kainos,* which was assigned with *vaccinophilus* to a new genus *Catinathrips.* O'Neill also treated the reports of *C. vaccinophilus* in Wood (1960) and O'Neill and Bigelow (1964) as misidentifications of *C. kainos.* The only material I have seen of *C. vaccinophilus* is the types from New York State and a lot each from New Jersey and Pennsylvania.

Catinathrips kainos caused galls by curling the leaves and damaged low-bush blueberry in New Brunswick (Wood 1960). According to Langille and Forsythe (1972), *C. kainos* is univoltine and overwinters as adults in the soil in Maine. The adults appeared in mid to late May on low-bush blueberry and were very abundant by mid June. By mid July they were at low level and were absent in August. The eggs were laid in leaf galls, and the larvae, which were present by mid June in leaf galls, migrated to the soil in late July. Although only a few males were observed in early June on blueberry, more males were found in soil samples. A nematode, *Howardula aptini* (Sharga), parasitized *C. vaccinophilus* (reported as *Taeniothrips vaccinophilus*) in New Brunswick (Nickle and Wood 1964).

Catinathrips similis, NEW SPECIES

Females: Body generally yellow, shaded brown in ocellar area of head, posterior part of pronotum, mesonotum, lateral part of mesothorax and metanotum, and posterior ½ of abdominal tergites with pale brown tinge; forewings light brown with bases paler brown, scale brown; antennae brown except I paler than head, II yellowish brown, basal parts of III–V lighter than distally.

Head wider than long, eyes about ⅔ as long as head; ocellar setae II laterad or posterolaterad of anterior ocellus, near inner margin of eyes; ocellar setae III between posterior ocellus (cf. Fig. 1); postocular setae I about as long as ocellar setae III; mouthcone with 2-segmented maxillary palps. Pronotum with transverse sculpture lines, discal setae few, ¾ to as long as posteroangular setae; posteroangular setae ⅕–¼ as long as pronotum and about ⅕–$^{3}/_{10}$ as long as B1 setae on abdominal tergite IX, inner pair pointed medially; posteromarginal setae short, pointed laterally, ½ to as long as posteroangular setae. Metanotum completely reticulated, median setae about 12 from anterior margin of notum. Forewing with 18 costal setae; proximal ½ of forevein with two groups of 3 setae, distal ½ with 3 distal setae; hindvein with 3 setae. Abdominal tergite I with median setae longer than those on tergites II–VI; third dorsal seta from midline on tergite VI well developed, as large as two setae laterad to it; sculpture lines absent medially from tergites IV–VIII, short microtrichia on submarginal sculpture lines on tergites VII–VIII.

Male: Unknown.

Measurements of holotype: Body length 1.27 mm (distended). Length of antennae: Total length: 199; length of segment I 20, II 30, III 40, IV 32, V 27, VI 35, VII 7, VIII 15. Forewing length 521, width at midlength 24. Setal lengths: posteroangular setae inner pair 22, outer pair 17–20; posteromarginal setae 17–24; B1 setae on abdominal tergite IX 99. Length of abdominal tergite X 62.

Type material: Holotype female labeled: Columbia Co., Florida, *V. myrsinites* (Lam.) galls, 4-IV-89, R. Beshear (USNM). Paratypes: 5 females with same data as holotype; 2 females, Centerville, Georgia, *V. tenellum* Aiton. curled leaves, 14-IV-89, A. Amis (JP 11059, RJB-37-89). Paratypes in UGG and USNM.

Etymology: Specific epithet derived from Latin "similis." This species closely resembles *C. kainos.*

Distribution: United States (Florida, Georgia).

Hosts: *Vaccinium myrsinites* (Lam.), *V. tenellum* Aiton.

Comments: This species closely resembles *C. kainos.* The morphological differences are discussed in the comments for *kainos.*

Catinathrips similis curls the leaves of blueberry and is a minor pest of wild plants.

Catinathrips vaccinophilus, NEW SPECIES

Female: Body yellow except shaded light yellowish brown in ocellar area, mesonotum and lateral part of mesothorax, metanotum and lateral part of metathorax, abdominal tergite I; legs yellow; ocellar crescent orange; setae brownish yellow; forewings light brown with base pale, scale light brown; antennae brown except I–II pale, pedicel and base of III pale, gradually light brown distally, bases of IV–V pale, VIII light brown or yellow distally.

Antennal segment III constricted near base; head wider than long, part posterior of eyes about ⅓ as long as eye; ocellar setae II laterad of small anterior ocellus; ocellar setae III between posterior ocelli and slightly anterior to caudal margin of posterior ocelli; postocular seta I about as long as ocellar setae III; mouthcone with 2-segmented maxillary palps. Pronotum with transverse sculpture lines, discal setae ⅓–⅖ as long as posteroangular setae; posteroangular setae about ½ as long as pronotum, more than twice as long as posteromarginal setae, about ½ as long as B1 setae on abdominal tergite IX; inner posteroangular setae pointed posteriorly. Metanotum reticulated; median pair of setae positioned in anterior ⅓ to ⅖ of notum. Forewings with 18 costal setae; proximal ½ of forevein with two groups of 3 and 2–3 setae, distal ½ with 3 distal setae; 3 setae on hindvein; scale with 4 marginal and 1 discal setae. Abdominal tergite I with median setae larger than median setae on tergites II–VI; third dorsal seta from midline on tergite VI about as large as two setae laterad to it; medial sculpture lines absent from tergites V–VIII; few microtrichia on submarginal sculpture lines on tergite VIII, 1–2 indistinct dentate ones usually on VII; B1 setae on tergite IX about twice as long as posteroangular setae, about 1.6 to twice as long as tergite X.

Male: Unknown.

Measurements of holotype: Body length measured from interantennal process of head 1.02 mm. Antennae: total length 216; length of segment I 20, II 30; III 40, IV 35, V 30, VI 37, VII 7, VIII 17. Forewing length 432, width at midlength 27 (based on a paratype). Setal lengths: posteroangular inner pair 47, outer pair 47; posteromarginal setae 17; B1 setae on abdominal tergite IX 94. Length of abdominal tergite X 59.

Type material: Holotype female labeled: Peach Co., site #1 Reade, *Vaccinium arboreum* Marshall, 7-VII-89, J. A. Payne (JP 11261) (USNM). Paratypes: 1 female with same data as holotype; 3 females, Peach Co., Georgia, *V. arboreum* (curl-leaves), 3-IV-89, J. A. Payne (JP 11053); 11 females, Peach Co., Georgia, *V. arboreum* (curl-leaves), 3-IV-89, J. A. Payne (JP 11058); 12 females, Peach Co., Georgia, *V. arboreum* leaf curls, 16-IV-89, J. Payne (JP 11060); 1 female, Peach Co., Georgia, *Vaccinium arboreum* curled leaves, 28-IV-89 (JP 11062); 2 females, Peach Co., Georgia, *V. arboreum* leaf curls, 5-V-89, J. A. Payne (JP 11064); 1 female, Peach Co., Georgia, *V. arboreum,* 4-IX-89, J. A. Payne (JP 11272); 1 female, Peach Co., Georgia, *V. arboreum,* 16-IX-89, J. A. Payne (JP 11273); 1 female, Peach Co., Georgia, *V. arboreum,* 3-X-89, J. A. Payne (JP 11274). Paratypes deposited FS, FSCA, Illinois Natural History Survey, NHM, UGG, USNM.

Etymology: Specific epithet is a combination of the host, *Vaccinium,* and Latin "cola" (= inhabitant). This species is found only on *Vaccinium.*

Distribution: Georgia.

Hosts: Vaccinium arboreum Marshall.

Comments: This species closely resembles *C. vaccinophilus,* but differs by having pale brown coloration on the body and forewings. The body and forewings of *C. vaccinophilus* are light or pale yellow.

This species curls the leaves of blueberry and is considered a pest of wild, high-bush blueberries in Georgia.

Catinathrips vaccinophilus (Hood)
(Fig. 3)

Taeniothrips vaccinophilus Hood, 1936a: 1; Wood, 1969: 757; O'Neill and Bigelow, 1964: 1228; Stannard, 1968: 363.

Catinathrips vaccinophilus: O'Neill, 1967: 856; O'Neill & Langille, 1971: 752.

Female: Body pale yellow. Antennae I–II completely pale; III pale except for light brown apex; basal ⅓–½ of IV–V pale, distally light brown; VI pale basally, light brown distally; and VII–VIII light brown, distal part of VIII usually paler. Forewings pale yellow.

Body length 0.88–1.0 mm. Mouthcone with 2-segmented maxillary palps. Pronotum with discal setae less than ½ as long as posteroangular setae; posteroangular setae 45–60, about ½ as long as pronotum, twice as long as posteromarginal setae, inner pair pointed posteriorly; metanotum reticulated medially, pair of median setae positioned in anterior ⅕ to ¼ of notum; third dorsal seta from midline on abdominal tergite VI often decidedly shorter than two setae laterad to it. Tergite IX (Fig. 3) with B1 setae 64–74, 1.25–1.40 times longer than posteroangular setae. Length of abdominal tergite X 50–52.

Male: Similar in color and most morphological characters to females but smaller; macropterous; major lateral setae on abdominal tergite IX 40–55 long, about as long or slightly longer than posteroangular setae on pronotum; abdominal sternites apparently without glandular area.

Distribution: United States (Connecticut, District of Columbia, New Jersey, New York, Pennsylvania).

Hosts: *Smilacina* sp. (false solomon's seal), *Vaccinium* sp., *V. stamineum* L.

Comments: The distribution records for Connecticut and District of Columbia are from Stannard (1968) and these specimens were not examined. The adults from New Jersey, New York and Pennsylvania were collected in early May to mid June.

There is no report of this species causing leaf galls on blueberry. *Smilacina* probably is an incidental host.

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NEW SPECIES OF CADDISFLIES FROM PUERTO RICO (TRICHOPTERA)

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Abstract.—Recent collections from Puerto Rico, primarily made by Malaise and emergence traps, have taken six previously unknown species herein described: *Cariboptila trispinata, Cernotina mastelleri, Alisotrichia circinata, Alisotrichia setigera, Ochrotrichia* (*Metrichia*) *squamigera,* and *Ochrotrichia* (*Metrichia*) *ceer. Leptonema insulanum* is removed from the island list, however larvae of an unknown species of the genus have been collected thereon. Adult females of the unknown species of *Nectopsyche* earlier recorded from the island suggest it is *N. cubana* Bks., which is also recorded from the Dominican Republic for the first time.

Key Words: New species, Trichoptera, Glossosomatidae, Polycentropodidae, Hydroptilidae, Puerto Rico

The caddisfly fauna of the Antilles has been extensively investigated in the last 30 years by several trichopterists—Botosaneanu, Flint, Kumanski—who have personally collected on most major islands. As a result of this collecting effort and subsequent publications our knowledge of the insular faunas has exploded. Cuba now has the largest known fauna with around 90 species and subspecies of caddisflies. Thirty nine species are known from Jamaica, a number that will certainly rise when it is more intensively collected. Puerto Rico, counting those here reported, now holds 42 species. From the island of Hispaniola only about 30 species are reported, but several large collections from this island are now being studied and their publication will raise this number several fold. The Lesser Antillian islands are also being studied (including those species being reported in a separate paper in preparation): Guadeloupe—21, Dominica—36, Martinique—22, St. Lucia—11, St. Vincent—16, Grenada—22, Barbados—2. These counts include genera reported from an island, usually as a result of larval collections, but whose specific identity is not known. My interpretation of these figures leads me to predict that the two largest islands, Cuba and Hispaniola, may each contain somewhat over 100 species, the smaller Jamaica and Puerto Rico only about 50 species, and the Lesser Antillian islands may hold up to 40 species each.

Puerto Rico was studied in the early sixties, and 35 species were reported at that time (Flint 1964). Although few collections have been made or seen from the island in the intervening years, only two new species were discovered in them (*Ochrotrichia verda* by Flint 1968, and *Helicopsyche propinqua* by Botosaneanu and Flint 1991). In early 1989 my colleague, Dr. E. C. Masteller, initiated the first emergence trap collection in an undisturbed forest site at the El Verde

Field Station. This produced the first examples of a remarkable new genus and species, *Kumanskiella karenae* Harris and Flint (1992), and induced me to join Dr. Masteller next season when he returned to resume this work. We used a variety of techniques to obtain material—ultraviolet lights, standard insect nets, emergence traps, and Malaise traps. Interestingly, the older techniques, lights and nets, produced only the same species as previously known from the island (with the exception of a single male of *Cernotina*). The emergence and Malaise traps took, in addition to many of the known species, a variety of species not previously known, often in great quantities. To the best of my knowledge these traps have not been used on other Antillian islands in a manner designed to collect aquatic insects, and until they are I expect that a number of small species not attracted to lights will be overlooked.

The Malaise trap was especially effective, and its use will be mentioned in more detail; another paper is being prepared on the results of the emergence trap collections. I have now used Malaise traps several times in the American tropics, often with great success. The greatest problem is finding a relatively undisturbed, forested, if possible, stream where the trap will not be vandalized. When such a site is found, the trap is placed across the stream, usually one that is 1 to 5 meters in width. The trap is emptied twice a day, dawn and dusk, and caddisflies are sorted from the other insects collected. An attempt is made to mount examples of all species that can be discriminated in the field, and the remaining material is preserved in alcohol.

Two Malaise traps were used in February of 1990, one remained on the Quebrada Prieta, the other was placed for several days over the Quebrada Toronja and then moved for the last few days to a small stream near the El Verde Station itself. The second trap only picked up a very few caddisflies at either situation; obviously I did not select sites where many caddisflies were active. The Quebrada Prieta, however, was exceptionally productive. This trap often collected a hundred caddisflies a half day, and took examples of all the new species described here as well as *Kumanskiella karenae* and *Helicopsyche singulare*!

The new species are being described here to make the names available for the work on the emergence trap collections. Other species are mentioned when new information clarifying their status has been obtained. Type material is deposited in the National Museum of Natural History (NMNH), Smithsonian Institution, Washington, DC; duplicates will be placed in the collection of the University of Puerto Rico and the Zoologisch Museum, Universiteit van Amsterdam, Netherlands.

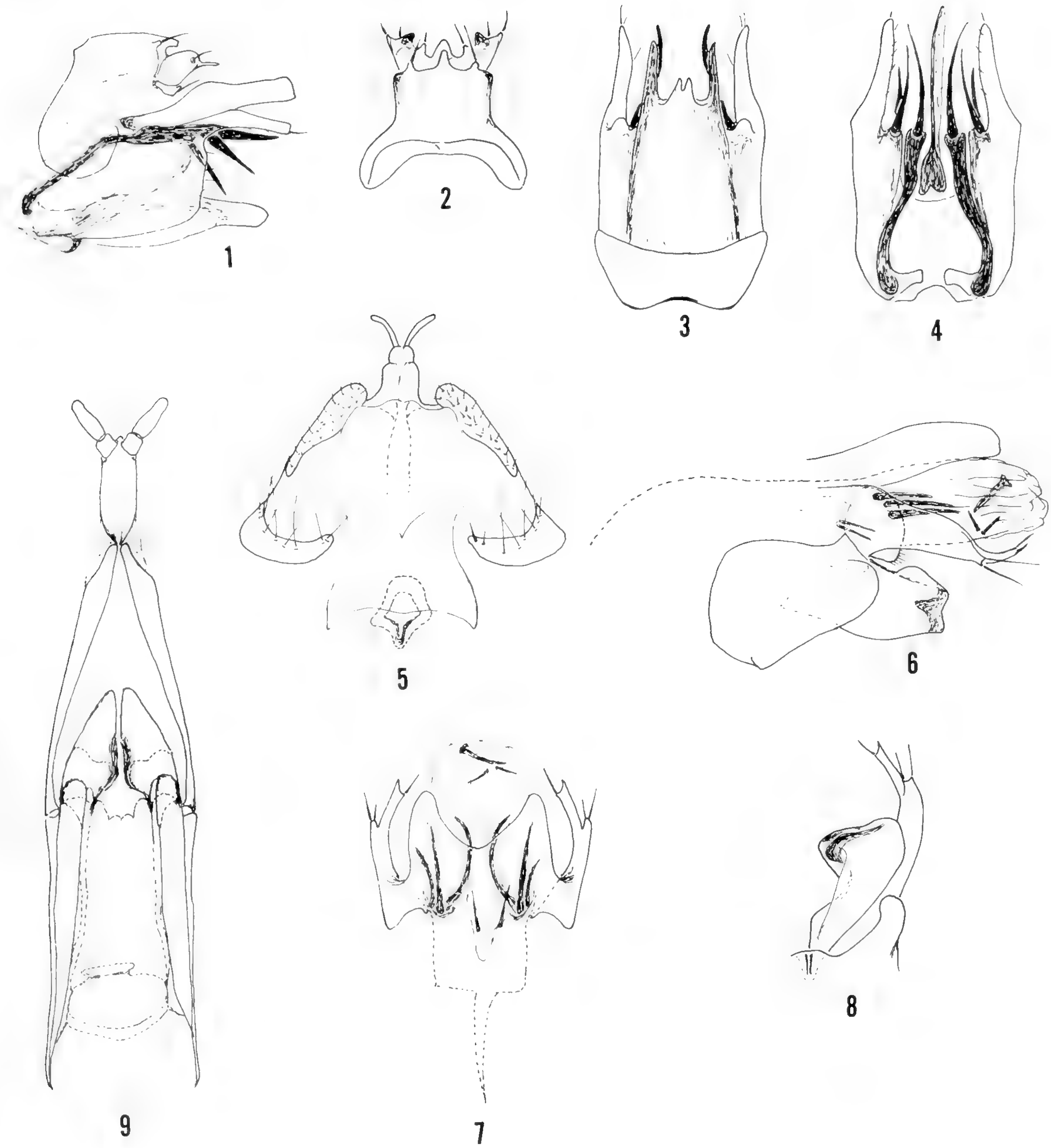
Family Glossosomatidae

Cariboptila trispinata Flint, New Species

Figs. 1–5

This is a very distinct species, not closely related to the other described species. The ventral genital capsule of the male offers a number of unique structures: a thin, dorsomesal lobe, the long, dark process on each side of this lobe that bears terminally a long, dark spine (the dorsalmost of the 3 apparent spines in lateral aspect), the dorsolateral, fingerlike lobe of the lateral plate which also bears from a mesal shelf near the base of this lobe two long, black spines (the mesal and ventral spines of the triad), and the ventral lobes which also seem to be borne, ventromesally, from this lateral plate.

Adult.—Length of forewing 2–2.5 mm. Color golden-brown; forewing golden-brown, posterior margin paler with 2 small, white flecks, anterior margin with a very small, white spot, and a larger more diffuse spot over stigma. Sixth sternum in male with a slender, pointed process, ¾ length of sternum; in female process reduced to a small point. Male genitalia. Ninth tergum small,



Figs. 1–9. *Cariboptila trispinata,* male genitalia. 1, lateral; 2, ninth and tenth terga, dorsal; 3, genital capsule, ventral; 4, same, dorsal. 5, *C. trispinata,* female genitalia, ventral. *Cernotina mastelleri* male genitalia. 6, lateral; 7, tenth tergum, cerci and phallus, dorsal; 8, clasper and cercus, ventral. 9, *C. mastelleri,* female genitalia, ventral.

rounded ventrally, posteromesal margin bearing a small, darkened tooth; sublaterally a pair of setate tubercles. Tenth tergite small, ovate, with a small, posteromesal, dark lobe and several setae. All ventral structures united into a large, oval capsule: lateral plate with dorsolateral angle prolonged into fingerlike lobe, posterior margin of lateral plate shelf-like on inner face, which bears dorsally 2, large, black spines, venter filled by a lightly sclerotized plate which is developed posterolaterally into a thin, apically rounded lobe; internally with a pair of long, black rods arising anteroventrally, each bearing from the apex a single, large, black seta; dorsomesally a thin, elongate plate whose base is enlarged. Female genitalia. Eighth venter laterally with dark, transverse sclerites bearing a row of stout setae; mesally with lightly sclerotized plate, with posterior margin flared laterad. Ninth sternites displaced to posterolateral margins, only seen edge-on in ventral aspect; venter mesally lightly sclerotized, with a short, tubular, interior process from posterior margin. Tenth and eleventh segments fused into conical, apicomesal tube bearing a pair of elongate cerci apically. Vaginal sclerite ring-like, anterior half somewhat pinched-in, posterior half semicircular.

Material.—Holotype, male: Puerto Rico, El Verde Field Station, Quebrada Prieta, 370 m, 6–10 Feb 1990, Malaise trap, O. S. Flint, Jr. NMNH Type. Paratypes: Same data, 5 ♂, 5 ♀; same data, but 14–28 Feb 1990, emergence trap, Masteller & Buzby, 4 ♀; same data, but 5–30 Mar 1990, 2 ♂, 1 ♀; same data, but 11–30 Apr 1990, 1 ♂, 3 ♀; same data, but 24 Sep 1990, 1 ♀.

Family Polycentropodidae

Cernotina mastelleri Flint, New Species

Figs. 6–9

Subfamily Polycentropodinae species.—Flint, 1964: 34 (larva and pupa).

In 1964 I described the larva and pupa of an, at that time, unknown genus of Polycentropodinae. With the subsequent discovery and description of larvae of *Cernotina,* it was apparent that these unknowns were this genus, but no adults were yet known from the island. The first adult, a male, was taken in 1989 and, in the following year, another male and the first female. Although the immatures were taken from the western end of the island and the adults from the eastern, it seems virtually certain that they all pertain to one species.

This species has a distinct, albeit very small, preapical spur on the foreleg. The lack of preapical spur in this genus has been the prime generic character separating it from all other Polycentropodidae, and led Ross (1938) to synonymize the Polycentropodidae with the Psychomyiidae. Now, with the discovery of a small spur in this species, we have evidence that the spur was present primitively in the genus and that it has been lost secondarily.

Based on the lack of the dorsal lobe of the clasper the species is related to the Jamaican *C. caligata* Flint. It is readily distinguished by the shape of the clasper, cercus, and especially the phallus of the male. In *C. mastelleri* the phallus bears several, scattered, small spines, and in addition a pair of three-parted, large, black spines at the level of the base of the cercus (totally unlike anything yet found in any other species of the genus). The female with its extremely elongate genitalia also shows a relationship to *C. caligata*; most females in the genus have very short genitalia (Ross 1944, fig. 267).

Adult.—Length of forewing 3.5–4 mm. Color of body and appendages, tawny, forewings uniformly fuscous; in alcohol, uniformly yellow-brown. Male genitalia. Ninth segment expanded and broadly rounded anteriad. Tenth tergum elongate, membranous, divided dorsomesally. Cercus 2-lobed: dorsolateral lobe tapering, curved mesad with a truncate, lateral knob at midlength, tip with a small spine; ventromesal lobe shallow, rounded, with a fringe of small setae. Clasper with basodorsal lobe very low, not obviously spinose; apex divided into a pair of parallel, transverse, darkened lobes. Phallus with a complex set of internal spines: 2 small, black spines basally beneath a small, lightly sclerotized tube, a pair of clusters, each composed of 3 large, black, spines arising from a common base at the level of base of the cercus, and apically 3 small dark spines, one considerably larger than the others. Female genitalia. Lateral lobes of eighth sternum long and slender. Ninth sternum with a pair of small lobes, meeting on midline; with long, slender, internal apodemes, between which is a vase-like vaginal sclerite. Tenth segment with long, apical cerci.

Material.—Holotype, male: Puerto Rico, El Verde Field Station, Quebrada Prieta, 370 m, 6–10 Feb 1990, Malaise trap, O. S. Flint, Jr. NMNH Type. Paratypes: Same data, but stream below Station, 8–10 Feb 1990, 1 ♀. El Yunque, trail to pool, 650 m, 22 Feb 1989, light trap, E. C. Masteller, 1 ♂.

Family Hydropsychidae

Leptonema species

Leptonema insulanum, nec Banks, Flint 1964: 36.

With the discovery of the true distribution of *L. insulanum* to be the coastal mountains of Venezuela, it is clear that the type was not from Puerto Rico, but mislabelled (Flint, McAlpine & Ross 1987). However, I made a collection of a series of larvae from Maricao that are *Leptonema,* without question. These larvae have been compared to larvae known to be *L. insulanum* and found to be a different species, further substantiating the removal of *L. insulanum* from the island list. No adult of *Leptonema* has been taken in recent years, so the specific identity remains unknown.

Family Hydroptilidae

***Alisotrichia circinata* Flint,**
NEW SPECIES

Figs. 10–14

This species is closely related to the Cuban species *A. flintiana* Bots. and *A. cimarrona* Bots. with both of which it shares the apicoventral hooks of the eighth segment and the anterodorsal rods with very long, stout setae. It differs from both in the structure of the internal complex, especially in the presence of the (frequently) coiled anteroventral plate.

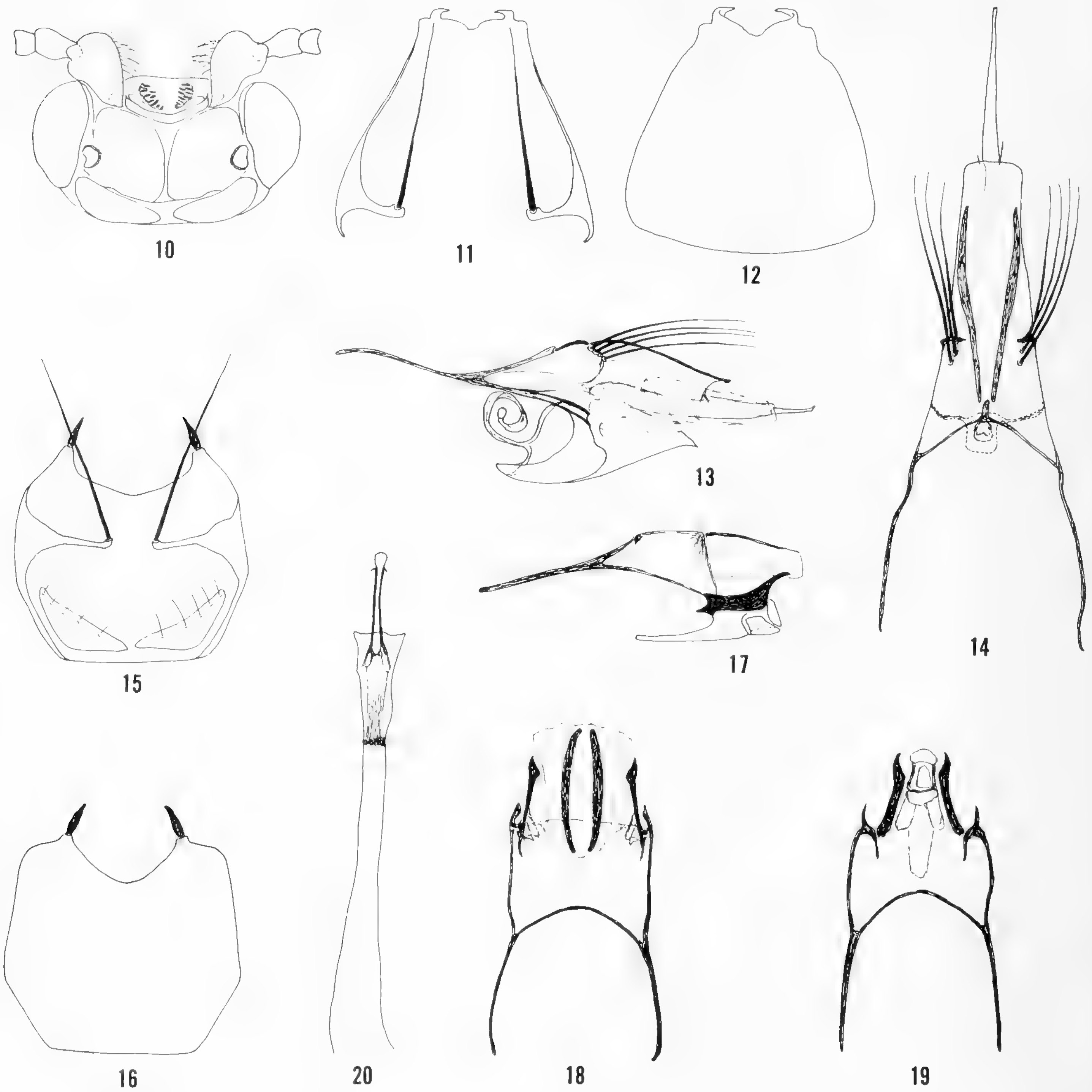
Adult.—Length of forewing 1.5–2 mm. Color basically fuscous marked with silvery white spots: hair tuft on head between antennae, and on forewings at base and apex and on fore and hind margins at ⅓ and ⅔ length of wing. Ocelli 2. Head with frontal area indented and bearing a cluster of short, enlarged scales; palpi not apparently modified; scape enlarged, oddly rounded and bearing on inner surface long hairs (fitting into frontal cavity), pedicel distinctly longer than broad, with 16 flagellar segments each about as broad as long. Spurs 0,2,4. No sternal processes. Male genitalia. Eighth sternum as wide as long, tapering apicad; posterior margin ending in a pair of submesal hooks directed mesad, in dorsal aspect with anterior margin developed into a pair of slender lobes directed mesad and each bearing at apex a very large spine reaching posterior margin of segment. Within eighth sternum lies a complex structure, most of whose homologies are obscure: from anterior margin extend long, lateral apodemes (probably of ninth segment); on dorsal surface extending posteriad lie a pair of long, parenthesis-like sclerites (tenth tergites?); dorsolaterally at midlength a sclerite (ninth tergum?) bearing dorsally several long setae attaining posterior of genitalia; internal structures unclear, but bearing anteroventrally an elongate sclerite often wound-up, springlike (sometimes extended anteriad as a flat, narrow plate); a posteroventral liplike sclerite attached to posteroventral margin of eighth segment. Phallus ending in a long, slender tube which bears from dorsal surface (probably at about midlength of phallus) a pair of stout setae.

Material.—Holotype, male: Puerto Rico, El Verde Field Station, Quebrada Prieta, 370 m, 6–10 Feb 1990, Malaise trap, O. S. Flint, Jr. NMNH Type. Paratypes: Same data, 22 ♂; same data, but 9 Nov 90, emergence trap, K. Buzby & E. C. Masteller, 1 ♂; 6 Jan 92, 1 ♂.

***Alisotrichia setigera* Flint,**
NEW SPECIES

Figs. 15–20

The presence of the setigerous rods from the dorsal margin of the eighth sternum allies this species with the preceding, *A. cir-*



Figs. 10–20. *Alisotrichia circinata,* male. 10, head, dorsal; 11, eighth sternum, dorsal; 12, same, ventral; 13, genitalia, less eighth sternum, lateral; 14, same, dorsal. *Alisotrichia setigera,* male genitalia. 15, eighth sternum, dorsal; 16, same, ventral; 17, genitalia, less eighth sternum, lateral; 18, same, dorsal; 19, same, ventral; 20, phallus.

cinata. However, the presence of a pair of stout, black spines from the posterior margin of the sternum rather than submesal hooks, and the presence of a conspicuous black process from the posterolateral margin of the internal complex renders the two species immediately separable.

Adult.—Length of forewing 1.5–2 mm. Color basically fuscous marked with a silvery-white hair tuft on head between antennae, and forewings marked with silvery-white spot, one at base, another on foremargin at ⅓ and a complete crossband at ⅔ length of wing. Ocelli 2. Head with frontal area indented and bearing a cluster of short, enlarged scales; palpi not apparently modified; scape enlarged, oddly rounded and bearing on inner surface long hairs (fitting into frontal cavity), pedicel distinctly longer than broad, with 16 flagellar segments each about as broad as long. Spurs 0,2,4. Seventh sternal processes hook-like, recurved posteriad. Male genitalia. Eighth sternum as wide as long, almost parallel-sided; posterior margin ventrally with a pair of sublateral, black, spinelike setae, in dorsal aspect at midlength with a pair of slender lobes directed mesad and each bearing at apex a very large spine reaching much beyond posterior margin of segment. Within eighth sternum lies a complex structure, most of whose homologies are obscure: from anterior margin extend long, lateral apodemes (probably of ninth segment), on dorsal surface extending posteriad lie a pair of parenthesis-like sclerites (tenth tergites?); posterolaterally bearing a strong, black, process ending in an apicodorsal point; apicoventrally with a strange, lobate structure. Phallus ending in a slender tube which bears from a subapical expansion a membranous collar; at about third length of phallus a dark ring basad of which phallus is a simple tube.

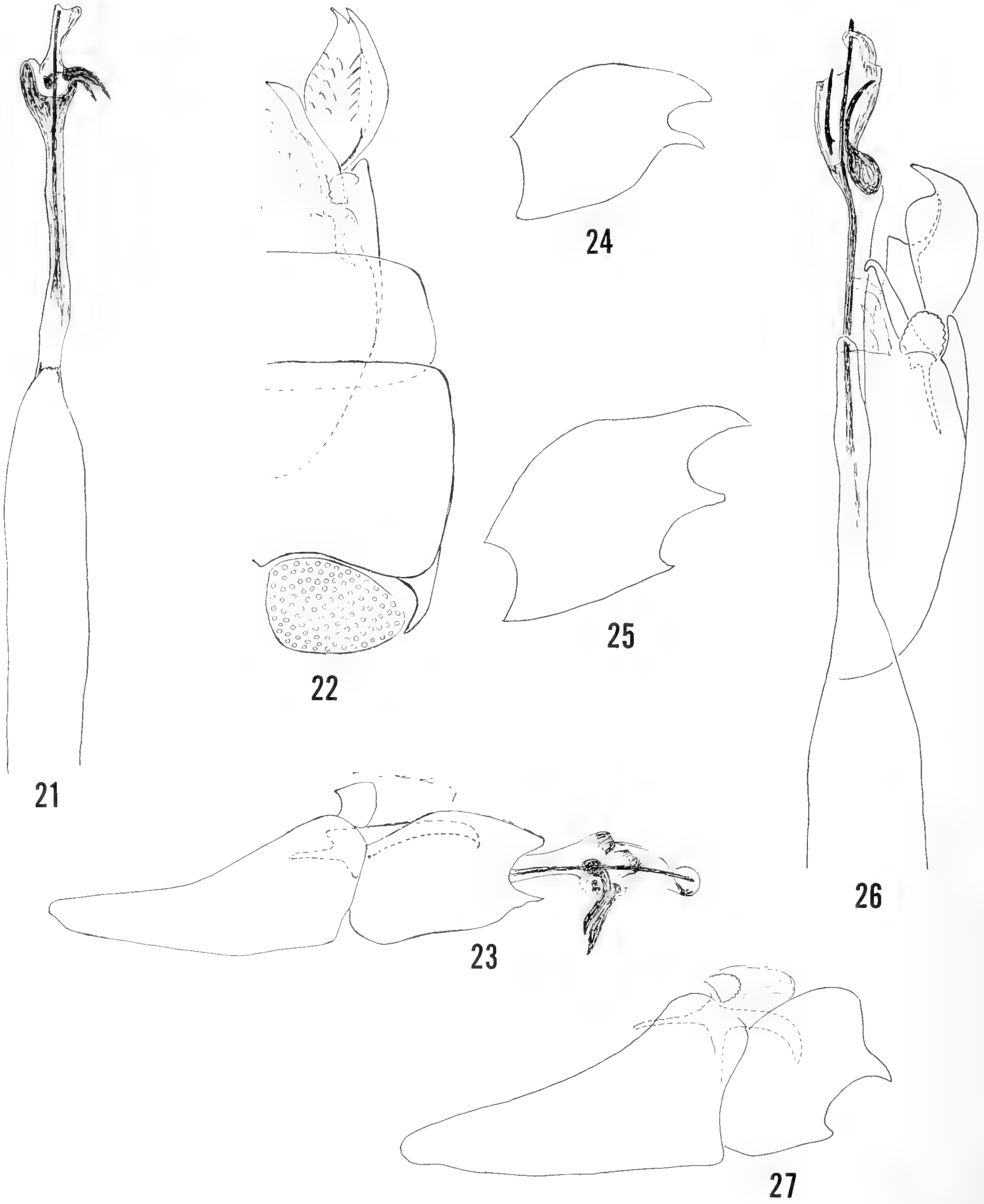
Material.—Holotype, male: Puerto Rico, El Verde Field Station, Quebrada Prieta, 370 m, 6–10 Feb 1990, Malaise trap, O. S. Flint, Jr. NMNH Type. Paratypes: Same data, 50 ♂; same data, but 27 Mar 90, emergence trap, K. Buzby & E. C. Masteller, 1 ♂; 2 Apr 90, 1 ♂; 1 Jun 90, 1 ♂; 15 Jun 90, 1 ♂; 3 Sep 90, 1 ♂; 10 Oct 90, 1 ♂; 17 Oct 90, 1 ♂; 7 Nov 90, 1 ♂; 7 Jan 91, 1 ♂; 27 May 91, 1 ♂; 29 May 91, 1 ♂; 22 Jun 91, 1 ♂; 31 Aug 91 to 3 Feb 92, 19 ♂. Sabana, Bisley stream #3, tributary to Rio Mameys, 3 Jun 91, emergence trap, K. Buzby & E. C. Masteller, 1 ♂.

Ochrotrichia* (*Metrichia*) *squamigera
Flint, New Species

Figs. 21–24

This species is very closely related to *O.* (*M.*) *excisa* Kum. from Cuba. It shares some of the more unusual characteristics with this species: presence of scale-like setae basally on the underside of the forewing and large, round pouches between terga six and seven which are filled with modified, black setae. The male genitalia in the two species are also nearly identical, but differences do exist here. The most clear-cut differences are in the claspers, which in *O. excisa* posses a distinct third point on the ventromesal margin (Fig. 25), which area is smoothly rounded in *O. squamigera* (Fig. 24). In addition the ornamentation of the mesal face of the clasper differs: in *O. squamigera* there are scattered elongate setae here, but in *O. excisa* the ventral third bears many, short, black, peg-like setae. The lateral hooks of the tenth tergum in *O. squamigera* appear narrower and less heavily sclerotized than in *O. excisa.*

Adult.—Length of forewing 2–2.3 mm. Color in alcohol, uniformly fuscous. Undersurface of forewing bearing a patch of flattened, scalelike setae on basal half between costa and cubitus. Abdomen of male bearing a pair of large, oval pouches between terga six and seven, each pouch filled with black, enlarged setae; lateral margins of segments 5 through 8 bearing dense fringes of long, black setae; seventh and eighth terga strongly sclerotized, anterior margin of tergum seven concave on each side to accommodate pouches. Male genitalia. Ninth segment 2½ times as long as high in lateral aspect; posterior margin slightly convex. Cercus small, rounded. Tenth tergum lightly sclerotized basally; lateral hook elongate, tip curved slightly ventromesad and darkened. Clasper longer than high in lateral aspect, apex with two pointed processes, ventromesal margin evenly curved from ventralmost process; inner face with scattered, short, spinate setae. Phallus with inflated basal and slender apical sections of equal length; apical section traversed by a slender, dark ejaculatory duct; subapically with a pair of equal spines arising from enlarged and convoluted bases, tip of phallus projecting, lightly sclerotized.



Figs. 21–27. *Ochrotrichia* (*Metrichia*) *squamigera,* male genitalia. 21, phallus, dorsal; 22, genitalia plus abdominal terga 7 through 9, dorsal; 23, genitalia, lateral; 24, clasper, ventrolateral. 25, *Ochrotrichia* (*Metrichia*) *excisa,* male clasper, ventrolateral. *Ochrotrichia* (*Metrichia*) *ceer,* male genitalia. 26, genitalia and phallus, dorsal; 27, same, lateral.

Material.—Holotype, male: Puerto Rico, El Verde Field Station, Quebrada Prieta, 370 m, 6–10 Feb 1990, Malaise trap, O. S. Flint, Jr. NMNH Type. Paratype: Same data, 1 ♂.

Ochrotrichia (*Metrichia*) *ceer* Flint, New Species

Figs. 26, 27

This species is related to *O.* (*M.*) *espera* Bots. from Cuba. There are distinct differences, however, in the structure of the claspers and phalli between the two species. In *O. ceer* the apical point of the clasper is more distinct and angled mesad and the dorsal lobe is larger, the lateral spine of the phallus is short and truncate, and the ninth segment is fully twice as long as high.

Adult.—Length of forewing 2 mm. Color mostly silvery due to hair on thorax, legs and forewings, with fuscous hair intermixed, especially in oblique bands on forewings; head and antennae with cream-colored hair. Forewing not modified. Abdomen of male bearing a pair of small, darkened, oval sacs between terga four and five; a pair of small, lense-like pockets between terga six and seven, each with a single, dark spot within; lateral margin of segment 5 with an oblique fringe of long, black setae; seventh sternum with a small apicomesal point. Male genitalia. Ninth segment 2 times as long as high in lateral aspect; posterior margin sinuous. Cercus small, rounded. Tenth tergum lightly sclerotized basally; lateral hook elongate, tip curved ventrad, slightly hooked in dorsal aspect. Clasper as long as high in lateral aspect; apex with a pointed process angled apicomesad, ventromesal margin with a distinct angle, dorsal margin developed into a broad lobe; inner face with scattered, short, spinate setae. Phallus with inflated basal section only about third as long as slender apical section and terminating with a blunt process overlaying the apical section just beyond midlength; apical section traversed by a slender, dark ejaculatory duct; subapically with a pair of spines arising from enlarged and convoluted basal sclerites, larger spine with a notably enlarged base; tip flattened and convoluted, lightly sclerotized.

Material.—Holotype, male: Puerto Rico, El Verde Field Station, Quebrada Prieta, 370 m, 6–10 Feb 1990, Malaise trap, O. S. Flint, Jr. NMNH Type. Paratype: Same data, 86 ♂. Sabana, Bisley stream #3, tributary to Rio Mameys, 8 Feb 1990, emergence trap, E. C. Masteller, 1 ♂.

Family Leptoceridae

Nectopsyche ?cubana (Banks)

Leptocella Flint, 1964: 64.

A few adults of the Puerto Rican *Nectopsyche* have finally been taken, but unfortunately none are male. They have been compared with the types of *N. cubana* and other examples from Jamaica and Dominican Republic (new record), and found to be in close agreement in maculation. However, lacking a male from Puerto Rico, I can not confirm this identity on the basis of genitalia. Until males are taken and both maculation and male genitalia can be compared, I prefer to leave the identification questioned.

Material.—Puerto Rico, Rio Mameyes at Rt. 988, Sabana, 8 Jan 1991, E.C. Masteller, 2 ♀.

Puerto Rican Trichoptera

The following is a list of all the species of caddisflies known from Puerto Rico, and reflects current family and generic placement. The total figures are 10 families, 25 genera and subgenera, and 42 species. This may be compared to the totals in 1964 (adjusted for current systematics) 10 families, 24 genera and subgenera, and 35 species.

Family Hydrobiosidae

Atopsyche trifida Denning

Family Glossosomatidae

Campsiophora pedophila Flint
Cariboptila orophila Flint
Cariboptila trispinata Flint

Family Philopotamidae

Chimarra (*Curgia*) *albomaculata* (Kolbe)
Chimarra (*Chimarra*) *maldonadoi* Flint
Chimarra (*Chimarra*) *puertoricensis* Flint

Family Xiphocentronidae

Xiphocentron (*Antillotrichia*) *haitiensis* (Banks)
Xiphocentron (*Antillotrichia*) *borinquensis* Flint

Family Polycentropodidae

Antillopsyche tubicola Flint
Cernotina mastelleri Flint
Polycentropus zaneta Denning

Family Hydropsychidae

Macronema matthewsi Flint
Leptonema species
Smicridea (*Smicridea*) *protera* (Denning)
Smicridea (*Smicridea*) *alticola* Flint

Family Hydroptilidae

Leucotrichia tubifex Flint
Alisotrichia hirudopsis Flint
Alisotrichia circinata Flint
Alisotrichia setigera Flint
Neotrichia iridescens Flint
Kumanskiella karenae Harris & Flint
Hydroptila martorelli Flint
Hydroptila medinai Flint
Oxyethira (*Loxotrichia*) *puertoricensis* Flint
Oxyethira (*Loxotrichia*) *janella* Denning
Oxyethira (*Dampfitrichia*) *arizona* Ross
Ochrotrichia (*Ochrotrichia*) *spinosissima* Flint
Ochrotrichia (*Ochrotrichia*) *gurneyi* Flint
Ochrotrichia (*Ochrotrichia*) *marica* Flint
Ochrotrichia (*Ochrotrichia*) *verda* Flint
Ochrotrichia (*Metrichia*) *juana* Flint
Ochrotrichia (*Metrichia*) *squamigera* Flint
Ochrotrichia (*Metrichia*) *ceer* Flint

Family Leptoceridae

Oecetis pratti Denning
Oecetis inconspicua (Walker)
Nectopsyche ?cubana (Banks)

Family Calamoceratidae

Phylloicus pulchrus Flint

Family Helicopsychidae

Helicopsyche minima Siebold
Helicopsyche ramosi Flint
Helicopsyche singulare Botosaneanu & Flint
Helicopsyche propinqua Botosaneanu & Flint

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OBITUARY

David Allan Young, Jr.
(1915–1991)

Around the world, colleagues, friends, and former students of leafhopper specialist David Young (Fig. 1) will miss his humor, wise counsel, and words of encouragement. On 8 June 1991, David died suddenly, apparently from an aneurism. His devoted wife of 57 years, Irene Rouhier Young, died of cancer a few days later (12 June). Residents of Raleigh, North Carolina, for nearly 34 years, the Youngs are interred in Raleigh Memorial Park; both were members of Saint Michael's Catholic Church in nearby Cary, N.C.

David A. Young, Jr., was born on 26 May 1915, in Wilkinsburg, Pennsylvania. The son of a travelling salesman, he attended grade school and two years of high school in western Pennsylvania, then completed high school in Louisville, Kentucky. He earned his A.B. in natural science at the University of Louisville in 1939. He taught general science in the Louisville Public School System, from 1939 to 1941, and worked toward his M.S. in entomology at Cornell University in the summers of those years and the autumn of 1941, receiving the degree in 1942. In January 1942, he entered the U.S. Armed Forces as a private and was honorably discharged as a first lieutenant in October 1945. Subsequently, he took an instructorship in the Department of Biology at the University of Louisville until 1948. At that time he entered the University of Kansas where he earned his Ph.D. degree in entomology in 1950, under the direction of Dr. R. H. Beamer.

Fig. 1. Dr. David A. Young, Jr.

From 1950 to late 1957, Young served as an insect taxonomist in the United States National Museum, Washington, D.C., employed by the Insect Identification and Foreign Parasite Introduction Section of the United States Department of Agriculture.

In 1957, he accepted a position as associate professor at North Carolina State University, where he continued his systematic research on leafhoppers, administered the NCSU Insect Collection, and taught graduate level courses in insect morphology, taxonomy, and systematics. Young was promoted to professor in 1961. Although he officially retired from NCSU in 1980, he continued working as a professor emeritus until the completion of his long-term study of the subfamily Cicadellinae (Homoptera: Cicadellidae) in 1986 (Fig. 2).

Through a three-month trip to Peru (1960) and other collecting, Young added thousands of specimens to the NCSU Insect Collection. He studied in Europe for one year (1962–1963), examining type specimens in entomological collections of Germany, Austria, Czechoslovakia, Hungary, Poland, Denmark, Sweden, France, and England. The Youngs treasured their memories of this year in Europe—and the friendships formed there—for all their remaining years.

David Young was a fellow of the Washington Academy of Sciences and held memberships in the Entomological Society of Washington, Entomological Society of America, the North Carolina Entomological Society, the Society of Systematic Zoology, and Sigma Xi. For a number of years he was also a member of the Sociedad Entomológica Agrícola del Perú and of the Sociedade Entomológica do Brasil. In 1976, the N.C. Entomological Society presented him its *Award for Outstanding Contribution to Entomology.* Young's research was also recognized in the Smithsonian Institution's circular (1976) *The United States National Entomological Collections,* distributed at the XV International Congress of Entomology, Washington, D.C., and by the N.C. Agricultural Research Service's newsletter (1986) *Research Perspectives* 5(3): 16.

The efforts of Young (bibliography below) and other systematists indicate that the leafhopper family Cicadellidae (Homoptera) is among the ten largest families of insects. Young described 807 new cicadellid species, 7 new subspecies, 207 new genera, 6 new subgenera, and a new tribe. Young's (1968, 1977, 1986) three-part "*Taxonomic Study of the Cicadellinae (Homoptera: Cicadellidae),*" totalling 2061 pages, treated 292 genera from all regions of the world. In a review of Part 2, J. P. Kramer (1978, *Proceedings of the Entomological Society of Washington* 80: 456) called it "the most outstanding and most comprehensive single volume ever produced on a large segment of the Cicadellidae." Also notable are Young's publications on the Western Hemisphere Typhlocybinae (1952), the tribe Alebrini (1957), and the genera *Flexamia* (with B. P. Beirne 1958), *Draeculacephala* (with R. H. Davidson 1959), and *Circulifer* (with N. W. Frazier 1954).

Fig. 2. Dr. Young at a celebration of the publication of Part 3 of his monumental "*Taxonomic Study of the Cicadellinae (Homoptera: Cicadellidae),*" North Carolina State University, Raleigh, September 1986.

Some of Young's contributions lie hidden in the works of others. His "Introductions" to numerous parts of Z. P. Metcalf's "*General Catalogue of the Homoptera*" provide evidence of the role Young played, along with Virginia Wade, in the publication of that series following Dr. Metcalf's death in January 1956. Likewise, the fatherly Young added much to the quality of his students' theses, yet he claimed no coauthorship when these works were published. His graduate students included H. D. Blocker, J. F. Cornell, Jr., D. H. Costes, R. B. Davis, L. L. Deitz, W. P. Dubose, III, W. D. Duckworth, J. E. Flynn, J. F. Greene, Jr., B. G. Hill, W. J. Knight, H. O. Langlitz, J. H. Lopez Parodi, S. H. Mahmood, F. W. Mead, D. L. Stephan, P. S. Southern, and D. M. Weisman.

As models of taxonomic description, Young's works exemplify brevity, clarity, and scholarship—giving all of the essentials, but nothing extraneous. Hundreds of original figures and line drawings illustrate his works. Although he avoided phylogenetic speculation, his diagrams [intuitive graphs based on carefully compiled tables of morphological data] of generic relationships (Young 1968, 1977) provide valuable insights. While only a systematist can appreciate fully the magnitude and excellence of all that David A. Young accomplished, it must be clear to all that he is among the greatest homopterists of all time.

Young is survived by a daughter, Roberta M. Zimmerer, four grandchildren, and four great-grandchildren, all of Independence, Kentucky, and by a sister, Vera C. Clark of Cadiz, Kentucky.

Memorials in honor of Young will be used for the NCSU Insect Collection (send donations payable to "N.C. State University" to: The Young Memorial Fund, ℅ Ms. Pat Robertson, Department of Entomology, Box 7613, NCSU, Raleigh, NC 27695-7613).

May David Young's dedication and scientific rigor continue to inspire those who knew him and those who use his magnificent studies.

Lewis L. Deitz, *North Carolina State University, Raleigh, North Carolina 27695-7613.*

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BOOK REVIEW

Host Specialization in the World Agromyzidae (Diptera). K. A. Spencer, 1990. With illustrations by A. Spencer. Kluwer Academic Publishers, Dordrecht, The Netherlands. xii and 444 pp. Sold and distributed in the USA and Canada by Kluwer Publishers, 101 Philip Dr., Norwell, MA 02061. $199.00.

Systematics of large families of plant-feeding insects can be especially difficult. Their better distinguishing characters are often adaptive and separately derived and so of limited use in divining relationships. But their hosts partly offset this difficulty because their relationships and distribution are so much better known. K. A. Spencer marshalls his substantial experience with Agromyzidae to investigate whether the classification of these flies reflects that of their host plants. The book answers the question as best it can, with a reluctant no. But more than that, the book is the first thorough, factual account of host specialization and geographical distribution of Agromyzidae, which should interest all scientists working on plant-insect evolution.

The Agromyzidae are a family of Diptera comprising about 2500 described species. Adults are relatively small, compact, yellow to black flies. Larvae feed exclusively in plants, mainly in leaf mines. This study is based on 54% of the known species, those actually reared from known hosts or whose hosts can be inferred.

A preface by T. Jermy and an introduction outlining the book's intent and results are followed by six chapters. Each of the first four treats one or two divisions of plants and their agromyzids; the fourth is longest and greatly subdivided, covering as it does the angiosperms. The fifth chapter treats polyphagous species and the sixth is titled, "Concluding remarks: phylogeny, coevolution, colonization." These chapters are followed by a taxonomic appendix with new taxa and other taxonomic information, acknowledgments, references, and a comprehensive index.

After reading the introduction, one might best continue by reading chapter 6 before chapters 1–5. In chapter 6 Spencer gives some background on debates concerning coevolution, discusses the position of Agromyzidae within Diptera, outlines the family's classification, and writes about the evolution of his own thoughts on these subjects. Here we learn that although agromyzids have radiated within many and various plant groups they have probably not affected the evolution of the plants and that many obviously related agromyzids can be found on very different groups of plants. It appears that colonization of Agromyzidae is in large part accidental, that their presence on the various plants is the result of countless switches between unrelated flora. We also get an idea of the difficulty of classifying these flies. Spencer is careful to say here and throughout the book that his is not the last word and that his ideas are based on partial data. He helpfully points up wherever he can the most fruitful paths for future investigation.

In chapters 1–4 details are given for agromyzid distribution summarized in chapter 6. He discusses the modern distribution for each major group of plants and, in probably more detail than necessary, plant evolution and chemistry. These chapters are greatly enhanced by two features. One is Ann Spencer's 1439 line drawings that illustrate many of the anatomical characters and leaf mines referred to in the nearby text and serve to make this book a valuable identification guide. The other highlight, attributed to David and Diane Henshaw, is the tabular lists of plant genera and their agromyzids. These tables very effectively summarize data, some not otherwise referred to in the text.

Reading chapters 1–4, I felt that Spencer began work on the book anticipating a good fit between agromyzid and host classification, that the more primitive agromyzids would occur on the older hosts. The points Spencer makes in these chapters are more extreme than in his summary. Whether one can postulate ancestral hosts from present distribution is problematic at best, and postulated scenarios for distribution invoke travel, often via Beringia. Experience and intuition count for a lot, but some of his hypotheses were not always convincing to me because they were not backed by character evidence. For example, on p. 323 he writes that "*Agromyza* . . . [on Poaceae] . . . [has] three species which have switched almost certainly from Rosaceae, while the majority . . . are possibly related to modern species on Urticaceae." Perhaps so, but he adds that his suppositions are really questions others can test.

The book is large, approximately 11¾″ high by 8¼″ wide. It is jacketless but has a hard, glossy, durable cover with a color photo of an agromyzid fly on the front and a capsule summary on the back. The book has a two-column text, is printed on good paper, and has an overall handsome appearance. The text is engagingly anecdotal in places, and I liked reading that an agromyzid "appears to feed equally happily on [two hosts]" (p. 1). A few minor quibbles: The plant family names of the tables should have appeared directly over the plant genera rather than above the agromyzid names. The agromyzid genera in table 93 (p. 389) should have been rotated 180 degrees because the table now reads best upside down. The index does not appear to be complete for plant names.

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PROC. ENTOMOL. SOC. WASH.
94(3), 1992, pp. 398–399

BOOK REVIEW

Fauna of India, Isoptera (Termites) Volume 1. M. L. Roonwal and O. B. Chhotani. Published by the Zoological Survey of India, Calcutta. 1989, viii + 672 pp. US $60.00. (315 figs.), (hard cover).

It has been noted by cartoonist Gary Larson, among others, that entomologists in general and taxonomists in particular have an inordinate desire to assemble and organize things. This book reflects that passion. This large tome ranks as one of the most comprehensive regional taxonomic compendia of the Isoptera ever produced, treating 22 genera and 98 species. It is however, essentially a compilation of all the previously published taxonomic works of the Indian Region on "lower termites"; it contains no newly described species. This volume is the first of two which will cover the order Isoptera of the Indian Region. The Indian Region is taken to include India, Pakistan, Nepal, Bhutan, Bangladesh, Burma (Myanmar), and Sri Lanka (Ceylon). Volume 1 encompasses all but the family Termitidae, namely, the following six groups which are treated as families: Termopsidae, Hodotermitidae, Kalotermitidae, Rhinotermitidae, Stylotermitidae, and Indotermitidae. It is abundantly illustrated with 315 figures including 24 distribution maps. Most of the illustrations have been taken from previously published works and are therefore quite variable in quality.

Volume 1 is divided into two main parts—an Introductory section and a Systematics Account. The Introductory section covers the following topics: Definition of the Isoptera, History of Termite Study, Characters Useful in Taxonomy, Polymorphism, Sexual Dimorphism & Sex Ratio, and Biology, Ecology, Distribution & Zoogeography. Of particular interest in this section is the descriptive summary of microsculpturing on wing surfaces—a subject extensively elucidated in recent years by the authors. The Systematics Account starts with a review of the History of Termite Classification, Diagnostic Characters of Living Termite Families, and Keys to the Families for imago, soldier and worker castes. This is followed by accounts of each family, subfamily, genus, and species. The section for each family, subfamily, and genus gives the characters which define the group, the group's distribution and composition, and keys to the lower taxa included. The individual species accounts mainly consist of detailed verbal descriptions and measurements. The numerous keys to species for both soldiers and imagoes make the volume an indispensable aid in the identification of termites of the Indian Region. The Systematics Account is followed by a 48-page bibliography and a detailed subject index.

My main criticism of the book is the dubious system of higher classification which the authors have employed. The authors have persisted in using certain family and subfamily designations which other authorities have rejected (see Krishna 1970. *Biology of Termites,* Vol. 2, pp. 138, 142, Academic Press, New York). Their system arises from heavily weighting characters of wing microsculpturing and tarsal segmentation. For example, on the basis of wing microsculpturing they have removed the Porotermitinae and Stolotermitinae from the Termopsidae to the Hodotermitidae. On the basis of reduction of tarsal segments from four to three they have followed Chatterjee and Thakur (1964. Zool. Anz. 173: 149–162) in elevating the rhinotermitid subfamily Stylotermitinae to family rank. Again, on the basis of tarsal reduction they have elevated a genus of the termitid subfamily Apicotermitinae, *Indotermes,* to family status (Roonwal 1975. Biol. Zbl. 94: 27–43). Furthermore, the authors have rejected the subfamily Apicotermitinae Grassé and

Noirot 1954 (validated and modified by Sands 1972. Bull. Brit. Mus. (Nat. Hist.) Entomol., Suppl. 18, pp. 1–244) and retained instead the out-dated concept of Amitermitinae Kemner 1934. The arguments given for this are that verification of the gut characters used to define Apicotermitinae require making "elaborate dissections" and in their view the newer system "does not seem to give particular clarity." In point of fact, elaborate dissections are not necessary since corroborating external characters exist in worker morphology and mandible dentition (Sands *op. cit.*) and to some extent in soldier and alate characters. At least a dozen termite systematists from China, Brazil, Australia, Germany, and South Africa have subscribed to the concept of the Apicotermitinae with descriptions of several new species and genera over the last 15 years. While the concept of the Apicotermitinae has gained greater coherency and acceptance, the authors have correctly pointed out that Sands' decision to combine the remainder of the former Amitermitinae with the Termitinae is a source of considerable confusion. But, rather than retain the old concept of Amitermitinae, as Roonwal and Chhotani have done, it would seem more phylogenetically coherent to retain a restricted concept of the Amitermitinae for the *Microcerotermes-Amitermes* branch (as defined by Ahmad 1950. Bull. Am. Mus. Nat. Hist. 95: 37–86).

Despite my disagreement with certain features of classification, I recommend the book mainly as a useful set of keys for the purpose of making identifications. Without this volume, it would be virtually impossible to quickly identify a lower termite to species from the Indian Region, unless one had already assembled scores of scattered taxonomic works from the region. The volume can therefore be strongly recommended as a reference work for all major entomological collections, natural history museums, and agricultural and forestry libraries. I would also recommend the book to all serious students of termite systematics. Orders may be placed directly to Dr. O. B. Chhotani, Zoological Survey of India, 234/4 A. J. C Bose Rd., Nizam Palace Complex, Calcutta 700 020, India.

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94(3), 1992, pp. 400–402

BOOK REVIEW

Plant-Animal Interactions: Evolutionary Ecology in Tropical and Temperate Regions. Edited by Peter W. Price, Thomas M. Lewinsohn, G. Wilson Fernandes, and Woodruff W. Benson. John Wiley & Sons, Inc., New York, N.Y. 1991. 639 pp. $125.00 (cloth).

Plant-animal ecology, in both temperate and tropical regions, is alive today as never before. As temperate biologists continue to ply plant-animal interactions at every level along the micro- to macroevolutionary gradient, ever-increasing numbers of tropical biologists (many educated and trained in the New World tropics) are making significant contributions to the field. While the pace of research has been quickening in both regions, however, information exchange and collaborative research among scientists working in temperate and tropical regions have not been impressive, and comparative studies between the regions have been limited.

With the aim of partially redressing these shortcomings, an international symposium on the evolutionary ecology of tropical herbivores was held at Campinas State University, Campinas, Brazil, in 1988. *Plant-Animal Interactions: Evolutionary Ecology in Tropical and Temperate Regions* resulted from this symposium. The editors' goals in convening the symposium and organizing the resultant text were to apply fresh perspectives on tropical issues and systems, suggest avenues of future research for tropical workers based on current temperate research programs, and provide background material for decision making on conservation issues in tropical areas.

The proceedings of this symposium provide the reader with a selection of recent and ongoing work, focusing primarily on plant-animal interactions in tropical systems and secondarily on comparative studies of plant-animal relationships between tropical and temperate regions. A total of 49 authors from seven countries contributed to the text's 27 chapters and presented an admixture of descriptive natural history, theory, and experimental studies of both natural and agricultural systems. An introduction (Chapter 1) that covers the historical development and contributions of tropical ecology is included. The subject material is organized into six sections, each accompanied by a brief introduction.

Section one (four chapters) contrasts the structure of, and processes taking place within, tropical and temperate communities. In Chapter 2, P. Coley and T. Mitchell Aide assess and discuss the differences in levels of herbivory and plant defenses between the regions, and in Chapter 3, P. Price reexamines latitudinal patterns of species diversity, host-plant specialization, and competitive interactions of herbivorous insects. A framework to compare species richness, population abundances, and body sizes in insect communities for tropical and temperate regions is presented in Chapter 4. The structure of gall-forming communities in relation to latitudinal, temperature, and moisture gradients is explored in Chapter 5. Of particular interest in this Section are the controversial conclusions of Chapter 3, which challenge conventional thinking by suggesting that biotic interactions are probably no more intense in the tropics than in temperate regions, and the contrasting approaches to the study of pattern and process expounded in Chapters 3 and 4: a case-by-case building of knowledge as opposed to a search for broad patterns.

Section two (three chapters) examines mutualistic relationships between plants and animals. Chapter 6 describes the patterns of diversity in fruit/frugivore interactions, explores the processes underlying these mutualisms, and asks the question, to what extent has the evolution of fruit and frugivore traits been linked? Chapter 7 examines the natural history of ant/plant mutualisms and Chapter 8, the distribution of extrafloral nectaries in the woody flora of western Brazil.

Section three presents five stimulating chapters that explore antagonistic relationships between plants and animals. In Chapter 9, R. Marquis provides an excellent description and assessment of the impact of insect herbivore faunas on several sympatric species of the genus *Piper*. A number of noteworthy conclusions follow from this detailed study, and the important point is made that studies of herbivore impact on a particular plant species may not produce generalizations applicable to other species in the genus even when the congenerics are sympatric. In Chapter 10, D. B. and D. A. Clark detail the results of a 7-year study of the interaction of a tropical wet forest cycad with its single major insect herbivore and interpret the cycad's life-history features as adaptations to reduce the impact of herbivory. The controversy surrounding, and mechanisms underlying, plant responses to herbivory is examined by Whitham et al. in Chapter 11. The authors suggest hypotheses (that await testing) to account for the phenomenon of overcompensation by plants in response to herbivory and provide an excellent synthesis of the problems and progress of the field to date. Chapter 12 discusses the nutritional value of plants as food for herbivores and suggests that increasing levels of carbon dioxide may have dramatic effects on plant-herbivore interactions. In Chapter 13, R. Dirzo and A. Miranda examine the structure of tropical forest canopy and understory in relation to the presence/absence of large mammalian herbivores. The authors suggest that the ongoing loss of the large mammal fauna in the tropics is having dramatic effects on the structure of tropical forest communities.

Section four (five chapters) examines the chemical interactions of three major groups of butterflies, the Ithomiinae, Heliconiinae, and Papilionidae, with their host plants. The interaction between ithomiine butterflies and their solanaceous hosts, including the impact of herbivores on host-plant abundance, distribution, and phenology, is discussed by J. Vasconcellos Neto in Chapter 14. In Chapter 15, P. Feeny examines the chemical constraints involved in the evolution of swallowtail butterflies, and in Chapter 16, Scriber et al. discuss the systematics and patterns of host-plant use in the Papilionidae, with particular attention to the evolution of two species groups. Chapter 17 explores the chemical interactions between neotropical butterflies and their host plants, addressing the ages of associations, evidence of coevolutionary processes, diversification resulting from these interactions, and consequences of these interactions at the community level. The biodiversity of a Central American *Heliconius* community and the evolutionary innovations that may have opened new adaptive zones within the Heliconiinae are reviewed in Chapter 18.

Section five (four chapters) focuses on a central theme of plant-herbivore interactions, the specificity of plant utilization. In Chapter 19, D. J. Futuyma explores the genetic, ecological, and phylogenetic aspects of host specificity in herbivorous insects, discussing the selective advantages of, and the factors that account for, specialization. The behavioral mechanisms underlying patterns of host affiliation and host fidelity in hummingbird flower mites are documented in Chapter 20. The genetic differentiation of biotypes within the herbivore fauna of thistle, the factors thought to be involved in biotype formation, and the role of biotypes as 'ecological templates' for speciation are explored in Chapter 21. The evolutionary ecology of large mammalian tropical herbivores is discussed in Chapter 22.

Section six, the last section of the book, contains five chapters that cover aspects of herbivore community patterns in natural and agricultural systems. Chapter 23 explores the relationships between plant range and the local and total insect richness in flower heads of Asteraceae in Southeast Brazil. The influence of plant attributes, particularly plant size, on local herbivore richness in the extensive Cerrado biome in Brazil is examined in Chapter 24 by M. Cytrynowicz, and the results are compared with those from other tropical and temperate forests. The last three chapters of the book focus on the associations of herbivorous insects with their food plants and the practical consequences of these associations. In Chapter 25, M. Kogan discusses characteristics of the faunas associated with grain legumes in temperate and subtropical America. Using soybean as a model system, Kogan presents a stimulating speculation on the current patterns of niche occupancy based on the action of inducible defenses. Chapter 26 reviews hypotheses proposed to explain herbivore abundance in polycultures and the contributions and limitations of these hypotheses as tools in developing control strategies in tropical agrocommunities. Patterns of arthropod colonization in corn fields and the effects of weeds and pesticides on arthropod communities are examined in Chapter 27.

The strength of *Plant-Animal Interactions* lies in its integrative approach, selection of subject material, diversity of authors and research perspectives, and variation in the levels at which plant-animal interactions are probed. Taken together, the text's 26 chapters show that valuable contributions to the study of plant-animal ecology are provided by every level of analysis. In addition, the text provides a forum for workers in both natural and agricultural systems to communicate and in so doing may help to bridge the gap between basic and applied research. *Plant-Animal Interactions* is stimulating and will be of use to both new and established researchers alike.

The text is, however, not without its shortcomings. As expected from the number and diversity of authors, the text represents a compilation of research programs on tropical/temperate plant-animal interactions rather than a cover to cover discourse on the origin, development, and current state of research into tropical/temperate comparative ecology of plant-animal interactions. The chapters vary considerably in quality. Some chapters present descriptive data, collected in the apparent absence of theoretical underpinning, while others attempt to synthesize existing information and establish frameworks for future research. Unfortunately, few chapters actually compare tropical and temperate systems. Moreover, some of the contributors' messages will already be familiar to readers of the ever-growing plant-animal literature. Finally, the book's price of $125.00 seems excessive. While the publisher is to be commended for bringing together this volume, we question how many researchers, particularly those to whom the wise use of tropical resources will be entrusted, can afford it?

Forging collaborative relationships among temperate and tropical biologists is an important and difficult task. A review of the authors contributing to *Plant-Animal Interactions* suggests how far we have to go to achieve true collaboration among temperate and tropical researchers. Only 2 of 26 chapters represent collaborative efforts between temperate and tropical biologists, and 31 of 49 authors are from research institutions in the United States, England, and Germany. Nevertheless, *Plant-Animal Interactions: Evolutionary Ecology in Tropical and Temperate Regions* is a substantial first step toward achieving this goal.

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ONYPTERYGIA DONATO, A NEW SPECIES FROM COSTA RICA (COLEOPTERA: CARABIDAE: PLATYNINI)

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Abstract.—Based on a unique combination of structural features (especially color pattern of elytra and reduction of the flight mechanism), the new species **Onypterygia donato** is described (type locality, COSTA RICA, Province of Puentarenas, La Amistad National Park) and distinguished from its putatively closest relatives, *O. championi* Bates and *O. iris* Chaudoir.

Key Words: Coleoptera, Carabidae, new species, *Onypterygia donato,* Costa Rica

Proposed by Dejean (1831: 346), the genus *Onypterygia* included several Middle American species, in addition to *O. fulgens* Dejean (1831: 348). Hope (1838: 72) designated the last-named as type species of this genus. Chaudoir (1878: 275) revised it, using the invalid emendation *Onchopterygia,* proposed by Gemminger and Harold (1868: 324). Casey (1920: 224) pointed to relationships of *Onypterygia* with the "Platynid series of genera," an opinion refined by Whitehead (1973: 175), who postulated close relationship between *Onypterygia* and *Platynus* Bonelli (1810). Liebherr (1986: 22 and 26) indicated that *Onypterygia* was related not to the basal stock of *Platynus,* but rather to one of the included lineages.

Reichardt (1977: 413) included *Onypterygia* in his treatment of the Neotropical genera of Carabidae. Liebherr (1986: 28) provided a key to the North American platynine genera, including *Onypterygia.* Erwin et al. (1977: 4.31) provided a list of names of the species of *Onypterygia.*

At the time of his death in 1990, Donald R. Whitehead had prepared a large part of a revision of the Middle American platynine carabid genus *Onypterygia.* The purpose of this paper is to provide information about and a name for a species of this genus that Whitehead had not seen, and to be included in the revision scheduled for completion in the near future.

METHODS

Criteria for ranking.—We infer that the taxon described below is specifically distinct on the basis of a unique combination of striking morphological differences, including reduction in the flight mechanism, and chorological considerations—the specimen in question is in a locality remote from the known ranges of the two species to which it is most similar. This distribution pattern is repeated in numerous species pairs and triplets in Middle America. The evidence at hand satisfies us that the population which the single known specimen represents probably is reproductively isolated from the other known species of *Onypterygia.*

Measurements and ratios.—Those reported indicate size and proportions, and are known to be useful in recognition of species of *Onypterygia.* They were made using an ocular micrometer in a Wild S5 Ste-

Table 1. Diagnostic features of *Onypterygia* species with metallic striped elytra.

Diagnostic Features	Species of *Onypterygia*		
	O. iris Chaudoir	*O. championi* Bates	*O. donato,* n. sp.
Pronotum: lateral margins	not beaded, moderately elevated throughout length	not beaded, slightly elevated throughout length, more so basally	beaded in apical ⅔, slightly elevated basally
Metepisternum	distinctly longer than wide at base	distinctly longer than wide at base	slightly longer than wide at base
Elytra			
setigerous punctures in interval 3	three	three	two
apex	broadly rounded	acuminate	acuminate
apex of suture	rounded	subangulate-acuminate	subangulate
Hind wings	macropt., distinctly longer than elytra	macropt., distinctly longer than elytra	brachypt., less than half length of elytra

reobinocular Microscope, at a magnification of 25×:

length of head—linear distance from antero-lateral angle of clypeus to posterior margin of left eye, measured at a right angle to the long axis of the head;
width of head—linear transverse distance across compound eyes and vertex;
length of pronotum—linear distance from apical (anterior) to basal (posterior) margin, measured along the mid-line;
maximum width of pronotum—greatest linear transverse distance, measured at right angle to mid-line;
width of pronotum at base—linear transverse distance between postero-lateral angles;
length of elytra—linear distance from basal ridge to apex of apical spine of left elytron;
width of elytra—greatest linear transverse distance, from lateral margin to lateral margin, measured at right angles to suture;
length of metepisternum—linear distance from basal to apical margin, measured along the lateral (outer) edge; and
width of metepisternum—maximum linear transverse distance, measured along the basal margin.

These measurements were added or combined in ratios, and designated as follows:

TL—sum of length of head, pronotum and elytra, to express body length, in mm;
WE—width of elytra, to represent maximum width of body in mm;
WP/WH—maximum width of pronotum/width of head;
LP/WP—pronotum: length/maximum width;
WP/WPb—pronotum: maximum width/width at base;
LE/LW—elytra: length/width; and
WMe/LMe—metepisternum: width/length.

TAXONOMIC TREATMENT

Onypterygia donato, NEW SPECIES

Type material.—HOLOTYPE female, labelled: "COSTA RICA: Puentarenas/ La Amistad Nat. Park/ 8°57′N, 82°50′W/ 23 Feb. 1991, 1500m/ Norman D. Penny/ Cal.Acad.Sci. Coll." (California Academy of Sciences Coll.).

Derivation of specific epithet.—Based on the Spanish form of his given name, and used by him on occasion during visits to México, this species is named in honor and in memory of the late Donald R. Whitehead, Systematic Entomology Laboratory, United States Department of Agriculture.

Recognition.—Assignment of this species to *Onypterygia* is based on diagnostic features: a Middle American platynine with tarsal claws pectinate-chelate (i.e. pectinations long and prominent), and tarsomeres 1–4 with ventral vestiture of numerous flattened setae. The holotype of this species exhibits also alternately red and green striped elytra, a feature shared with adults of the Guatemalan-Mexican *Onypterygia iris* Chaudoir (1863: 225), and the Panamanian *O. championi* Bates (1882: 130). Adults of these species differ from one another by the features indicated in Table 1.

Description.—Female, habitus as in Fig. 1. TL 8.1 mm; WE 3.5 mm; WP/WH 1.67; LP/WP 0.80; WP/WPb 1.20; WMe/LMe 0.82, and LE/WE 1.50.

Color: Head and pronotum black, with slight metallic green cast. Antennae, labrum, mandibles, palpi and legs dark piceous to black. Elytra bright metallic, striped alternately cupreous or maroon (sutural margin, intervals 2 and 3, basal part of 4 and 7, and 8) and green (interval 1 [except sutural margin], apical part of 4 and 7, and 5 and 6); epipleura dark greenish-bronze. Ventral and lateral sclerites shiny, dark, black to rather dull bronze.

Microsculpture: Microlines shallow, though distinct over entire surface; sculpticells flat. Mesh pattern as follows: of labrum isodiametric to slightly transverse; of clypeus, frons, vertex, and elytra, isodiametric; of pronotum and lateral and ventral surfaces, markedly transverse.

Luster: Surface shining, but not iridescent.

Head: Eyes not prominent. Genae smooth, not rugose; frons smooth, not sulcate between anterior and posterior supraorbital setigerous punctures.

Prothorax: Pronotum as in Fig. 1; disc slightly convex. Base distinctly wider than apex; sides rounded, not sinuate posteriorly, widest point at about transverse mid-line. Basal and apical lateral angles rounded, apical margin slightly concave, narrowly and distinctly beaded; basal margin slightly convex, distinctly beaded medially; lateral margins slightly elevated anteriorly and posteriorly, distinctly beaded medially, beading evanescent anteriorly and posteriorly. Anterior transverse impression sharp, in median two-thirds; postero-lateral impressions impunctate, linear, narrow, sharply impressed, each isolated laterally from marginal groove by slight surface convexity. Prosternum with apex of intercoxal process rounded.

Fig. 1. Photograph of dorsal surface of Holotype of *Onypterygia donato,* new species.

Pterothorax: Mesepisternum impunctate. Metasternum short, metepisternum slightly longer than wide.

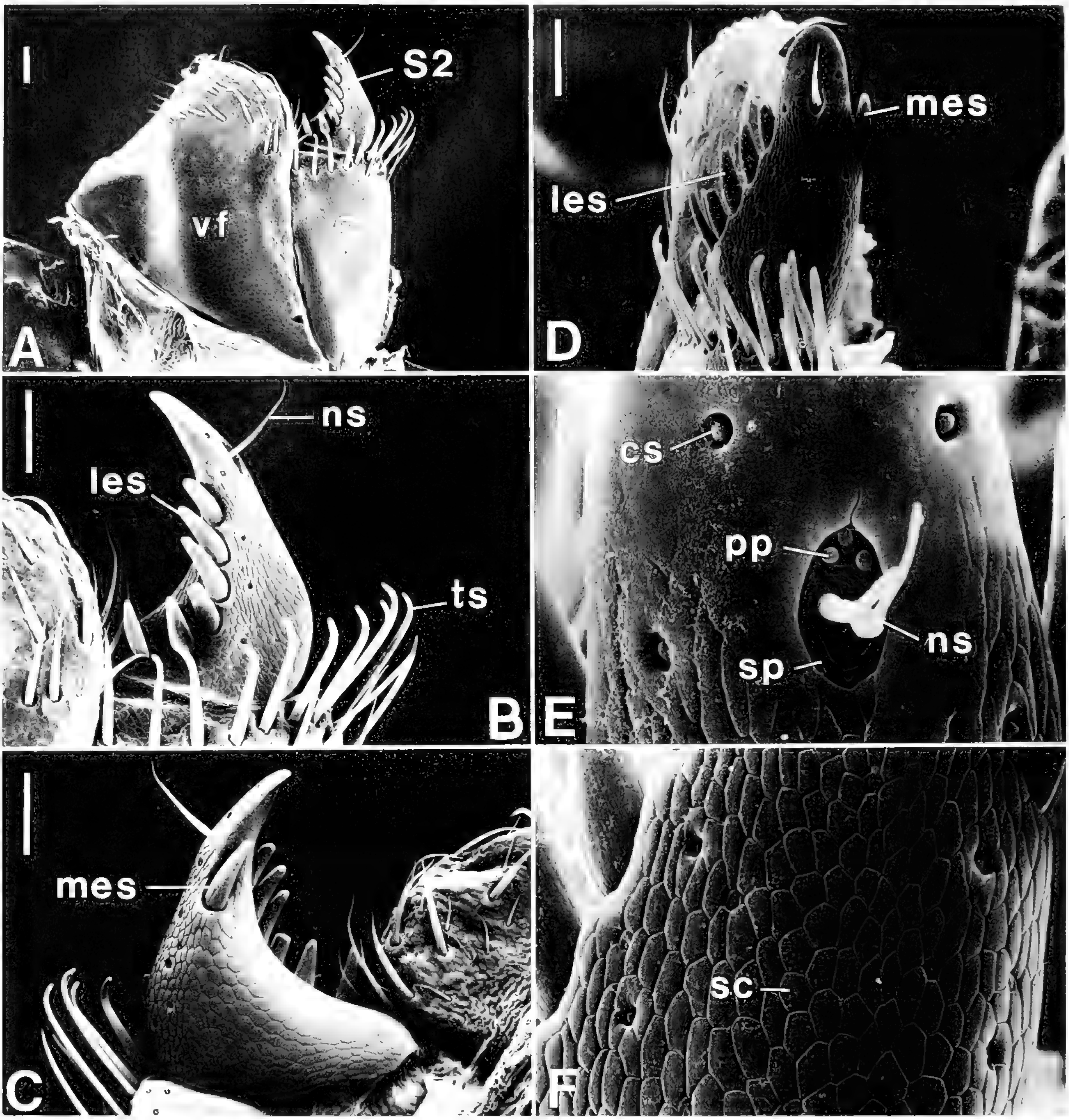

Fig. 2. SEM photographs of left ovipositor sclerites of *Onypterygia donato,* new species. A, Valvifer, and stylomeres 1 and 2, left lateral aspect. B, Stylomere 2 and margins of valvifer and stylomere 1, left lateral aspect. C, Stylomere 2 and margins of valvifer and stylomere 1, medial aspect. D, Stylomere 2 and parts of valvifer and stylomere 1, ventral aspect. E, Stylomere 2, prepapical portion, ventral aspect. F, Stylomere 2, medial portion, ventral aspect. Abbreviations: **cs,** campaniform sensillum; **les,** lateral ensiform seta; **mes,** median ensiform seta; **ns,** nematiform seta; **pp,** pit peg; **sc,** sculpticell (microsculpture); **sp,** sensory pit; **S1,** stylomere 1; **S2,** stylomere 2; **ts,** trichoid seta; and **vf,** valvifer. Scale bars: A–D = 50 μm; E–F = 10 μm.

Elytra: Each elytron with humerus markedly rounded and narrowed; apex with prominent spines; sutural apex denticulate. Prominent preapical callus in intervals 7–8. Interneurs mostly shallow, interneur 1 deepened preapically, interneurs 2–6 absent preapically. Intervals flat, interval 3 with two setigerous punctures—one near middle, and one in apical one-fourth. Lateral umbilicate punctures distinctly foveate.

Hind wings: Narrow and short, each ca. half length of elytron, without reflexed apical portion.

Legs: Hind femora without dorso-apical setae. Hind tarsus with tarsomeres 1 and 2 bisulcate, one groove each side; tarsomere 5 with several setae on ventro-lateral and ventro-medial margins.

Abdomen: Sterna smooth. Sterna 4–7 with ambulatory setae: 4–6 each with one pair; 7 with two pairs.

Ovipositor (Fig. 2A–F) *and internal genitalia:* Valvifer (Fig. 2A, **vf**) with apex subtruncate, and with several rows of trichoid setae. Stylomere 1 (**S1**) with row of trichoid setae apically. Stylomere 2 (**S2**) elongate, falcate; surface with microsculpture, microlines especially distinct on ventral surface, sculpticells short (Fig. 2F, **sc**) to long and narrow; two rows of campaniform sensilla (Fig. 2E, **cs**); dorso-lateral margin with row of six to seven ensiform setae (**les**), medially with single ensiform seta (Fig. 2C, **mes**); ventral sensory pit (Fig. 2E, **sp**) prepical, with pair of nematiform setae (**ns**) and three pit pegs (**pp**).

Internal genitalia with walls of bursa copulatrix with accordion-like, slightly sclerotized folds; spermathecal duct joined to base of common oviduct; spermatheca small, bulb-like; duct of spermathecal gland long (cf. Liebherr 1986: 13, Fig. 5c).

Habitat.—According to the collector, Norman Penny, the holotype was collected in rather dry primary evergreen montane forest, probably from understory vegetation, by beating. From this information, we assume that this species is arboreal, as are most of the other known species of *Onypterygia.*

Geographical distribution.—This species is known from the type locality, only.

Chorological affinities.—The range of *O. donato* is overlapped by the following species of *Onypterygia* that occur in Costa Rica: *O. chrysura* Bates, *O. quadrispinosa* Bates, *O. tricolor* Dejean, and an undescribed species. *O. fulgens* Dejean and *O. angustata* Chevrolat probably occur in Costa Rica, but they are not recorded from there. The ranges of *O. donato* and its postulated close relatives (*O. iris* and *O. championi*) are non-overlapping.

Phylogenetic relationships.—Based on the similarity in the presumably apotypic feature of elytra with long apical spines, *O. donato* and *O. championi* are postulated to be adelphotaxa. The adelphotaxon of the common ancestor of the former species is postulated to be *O. iris,* based on the similarity in the presumed apotypic feature of bicolored elytra.

ACKNOWLEDGMENTS

We are grateful to David H. Kavanaugh (Curator of Entomology, California Academy of Sciences, San Francisco, California) for making available to us for study and description the holotype of *Onypterygia donato.* We appreciate also the information that Norman D. Penny provided about the habitat of *O. donato.*

John S. Scott, of our Department, photographed the holotype and prepared the plates that illustrate so well the habitus and ovipositor of *O. donato.* We acknowledge also the assistance of George D. Braybrook in photographing the ovipositor sclerites.

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NEW SPECIES OF *CHIMARRA* SUBGENUS *CHIMARRA* STEPHENS FROM COSTA RICA (TRICHOPTERA: PHILOPOTAMIDAE)

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Abstract.—Fourteen species of *Chimarra* subgenus *Chimarra* from Costa Rica, Panama, and Ecuador are described: **C. amica** n. sp. (Costa Rica), **C. colmillo** n. sp. (Costa Rica), **C. guanacasteca** n. sp. (Costa Rica), **C. janzeni** n. sp. (Costa Rica), **C. jemima** n. sp. (Costa Rica), **C. lata** n. sp. (Costa Rica), **C. longiterga** n. sp. (Costa Rica, Panama, Ecuador), **C. munozi** n. sp. (Costa Rica), **C. paraortiziana** n. sp. (Costa Rica), **C. peineta** n. sp. (Costa Rica, Panama), **C. pollex** n. sp. (Costa Rica, Panama), **C. solisi** n. sp. (Costa Rica), **C. virgencita** n. sp. (Costa Rica), and **C. yanura** n. sp. (Costa Rica). In addition, *C. angustipennis* Banks and *C. dentosa* Ross are documented from Costa Rica for the first time.

Key Words: Philopotamidae, *Chimarra,* new species, Neotropics

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Chimarra Stephens is a very large, cosmopolitan genus found on all continents (except Antarctica) and also on many islands in the Pacific. It constitutes the largest genus in the family Philopotamidae. The number of described species in the genus is about 340, over half described in just the past 30 years (Fig. 1). Many additional species await discovery and description. Chantaramongkol and Malicky (1989) estimate that there may be over 500 species in Asia alone. One hundred sixteen species have been described to date from the New World. While the diversity in the New World may not equal that of Asia, there are undoubtedly many additional undescribed species. Largely through the efforts of Dr. O. S. Flint, Jr., Dr. J. Bueno-Soria, Dr. L. Botosaneanu, and others, the number of described species in the New World has doubled in just the last 25 years. In this paper fourteen additional species of *Chimarra* are described, all of which have distributions including or confined to Costa Rica. This paper represents the results of an ongoing project, sponsored by the NSF, to discover and describe the caddisfly fauna of Costa Rica. Work has been coordinated under the Instituto Nacional de Biodiversidad (INBio) of Costa Rica, whose goal is to completely document the biodiversity of the country within the next decade.

Compared to North America, Central America is an important center of diversity for the genus *Chimarra* in the New World. In North America north of Mexico, 22 species are recorded in the genus *Chimarra,* all but one in the subgenus *Chimarra,* and the other in the subgenus *Curgia* Walker. This probably constitutes a relatively complete record of the genus for this area. In Costa Rica, by comparison, we have collected specimens of 39 species of *Chimarra,* 26 of them in *Chimarra,* and the remainder in *Curgia.* Fourteen new species in the subgenus *Chimarra* are described in this paper. While it is uncommon for more than two or three species of *Chimarra* to co-occur at one site in North America north of Mexico, in Costa Rica it is common to find six spe-

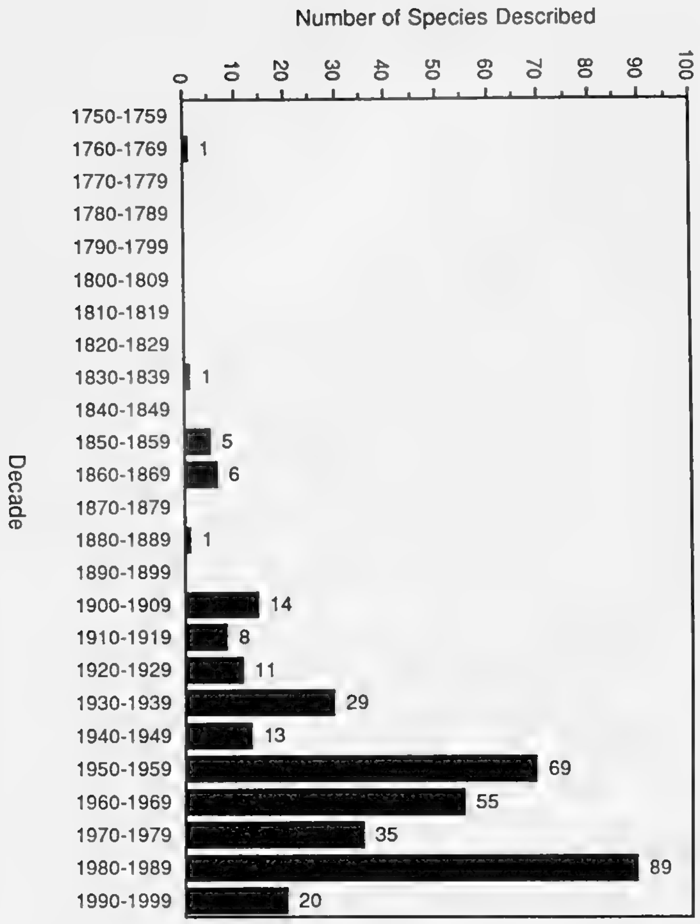

Fig. 1. Number of *Chimarra* species described per decade, based on species currently recognized as valid.

cies of *Chimarra* (*Chimarra*) occurring at one site, and occasionally an equal number of species of *Chimarra* (*Curgia*). From one extraordinary site in Parque Nacional Guanacaste, the Río Orosí at Estación Pitilla (at which site the river is only a small trickling stream), sixteen species of *Chimarra* (*Chimarra*) and three species of *Chimarra* (*Curgia*) were collected between the 22nd and 25th of May in 1990.

Described species of *Chimarra* (*Chimarra*) previously reported from Costa Rica include *C. alata* Bueno, *C. bicolor* (Banks), *C. duckworthi* Flint, *C. elia* Ross, *C. emima* Ross, *C. flinti* Bueno, *C. ortiziana* Flint (probably actually *C. paraortiziana* n. sp. or *C. peineta* n. sp.), *C. picea* (Navás) (described from a female and possibly the same as some other named species), *C. ridleyi* (Denning), *C. rossi* Bueno, *C. spangleri* Bueno, and *C. villalobosi* Bueno. In addition, we report here for the first time collection records of *C. angustipennis* (Banks) and *C. dentosa* Ross. Sources for original descriptions and literature records of species previously recorded from Costa Rica are given by Holzenthal (1988). Sources of original descriptions and additional literature citations for *C. angustipennis* and *C. dentosa* can be found in Bueno-Soria and Flint (1978). Species described in this paper are assigned membership in various species groups under the species descriptions and the approximate membership of those groups is defined. However, these assignments are tentative. A revision and character analysis of Neotropical species of *Chimarra* (*Chimarra*) is in progress by the first author.

Species determinations were made by examination of male genitalia. Male genitalia were cleared in cold 10% KOH overnight and a syringe was used to empty the macerated contents from the abdomen. When possible, males in which the phallus was fortuitously expanded were selected for clearing to reveal details of the phallic morphology. Terminology for male genitalia follows that of Schmid (1980), except that the term lateral lobe of tergum X is used instead of intermediate appendage. The term phallotremal sclerite complex is used to refer to all of the sclerotized structures at the tip of the phallus, due to uncertainty about homology of the structures to those in other groups of Trichoptera. Among the species described in this paper, the phallotremal sclerite complex is consistently composed of a ringlike structure (sometimes with a dorsal sclerous projection), attached to a ventral sclerous strip, or "rod." Surrounding the apicoventral portion of the rod is a membranous structure, often with distinctly sclerotized anterior or dorsolateral edges. This membranous apical structure may not be obvious in many specimens, even though the accompanying sclerites are. Also, the exact structure of the rod and ring apparatus may not be clearly apparent in all of the illustrations, depending on the view illustrated; however, its relatively constant morphology should be kept in mind. Several views of the inferior appendages are includ-

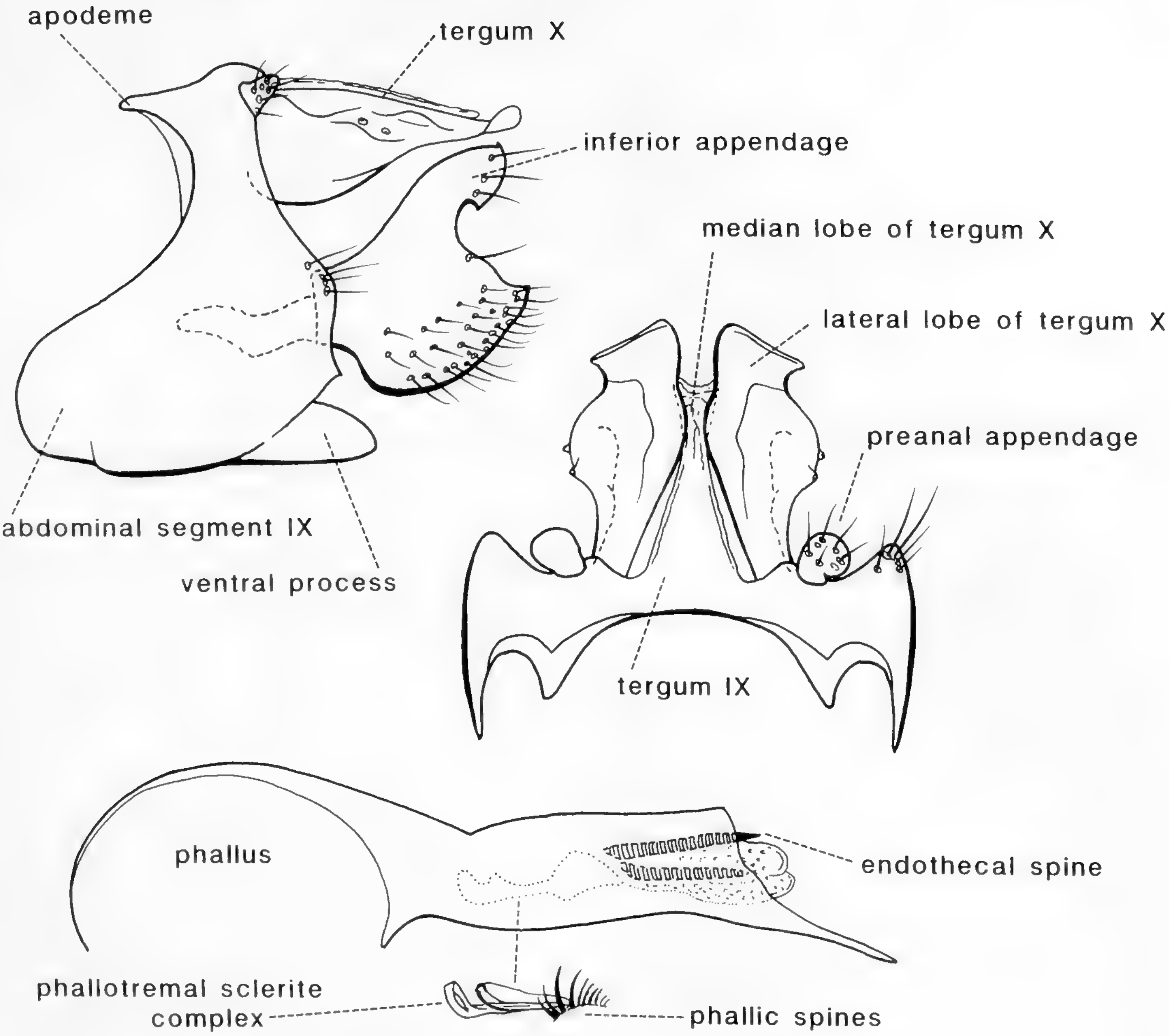

Fig. 2. Terminology for male genitalia of *Chimarra.*

ed in the illustrations because of the usefulness of this character in making species determinations, and because of the difficulty of gaining a dimensional perspective of the appendages from a single view. Views generally illustrated are lateral, dorsal, ventral or caudal, and oblique lateral. The oblique lateral view is provided to give an overall dimensional perspective of the pair of inferior appendages, but its orientation is not constant for all of the species; in general the view is oriented caudally and somewhat ventrolaterally. Genitalic structures are illustrated and labelled in Fig. 2. Forewing measurements are given to the nearest 0.1 mm and generally for males only. Females usually are about 0.5 mm longer. However, great variability in size occurs within species and the measurements only reflect the variability in the specimens at hand.

Because of the close morphological similarity between species and the frequent co-occurrence of numerous species at a single site, it has not yet proven possible to confidently associate females with males. They have accordingly been omitted from the following descriptions. Differences in genitalia, however, do exist and it should prove possible to distinguish at least some of the species in the future when accurate associations have been made.

Holotypes are deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D. C. (NMNH).

Paratypes are deposited in the University of Minnesota Insect Collection, St. Paul, Minnesota (UMSP), the National Museum of Natural History (NMNH), the Instituto Nacional de Biodiversidad, Santo Domingo de Heredia, Costa Rica (INBIO), and the University of California, Riverside, California (UCR), as indicated in the species descriptions. Unless otherwise stated, all material is represented by pinned specimens.

Chimarra amica Blahnik and Holzenthal, New Species

Fig. 3A–F

This species is apparently related to *C. longiterga* n. sp. It shares with that species elongate endothecal spines and a phallus possessing a spinelike process with a basal sclerous curl (although in this species the spinelike process is short and curved rather than elongate). It can be distinguished from *C. longiterga* n. sp., and all other species of *Chimarra,* by the shape of the inferior appendages.

Male: Forewing length 4.3–5.0 mm. Color rather uniformly fuscous, except femora yellowish. Genitalia: Abdominal segment IX with pair of well-developed anterodorsal apodemes; anteroventral margin sinuously elongate; posteroventral process elongate narrow, apex subacute. Tergum X membranous mesally, with pair of sclerotized lateral lobes, rounded at apex, each bearing pair of sensilla on distinct, rounded projection near base. Preanal appendages short, globose. Inferior appendage, in lateral view, with acute apex, approximately forming right angle to posteriorly oriented, dorsal, thumblike process; thumblike process curved proximally (in caudal view); proximal surface of inferior appendage with conspicuous raised ridge and raised setae near base. Phallus with acute apicoventral extension of phallobase; endothecal spines two, slender, elongate, posteriormost distinctly curved and slightly helically rotate; phallus tip (apparently) with minute echinate spines and short, curved, spinelike structure attached to sclerous curl; phallotremal sclerite complex composed of rod and ring structure and apical membranous structure with associated wishbonelike sclerites.

Holotype: ♂, Costa Rica: Guanacaste: Parque Nacional Guanacaste, Estación Maritza, Río Tempisquito, 10.958°N, 85.497°W, el 550 m, 30–31.viii.1990, Huisman, Blahnik, Quesada (NMNH). *Paratypes*: Costa Rica: Guanacaste: 6 ♂, P. N. (Parque Nacional) Guanacaste, Estación Pitilla, Río Orosí, 10.991°N, 85.428°W, el 700 m, 22–25.v.1990, Holzenthal & Blahnik (UMSP); Heredia: 1 ♂, Estación Biológica La Selva, Quebrada Sura, 10.437°N, 84.010°W, el 50 m, 20–21.vi.1986, Holzenthal, Heyn, Armitage (INBIO).

Etymology: Amica, from the Latin *amicus,* for friendly, in reference to an imagined resemblance of the inferior appendage to an outreached hand.

Chimarra colmillo Blahnik and Holzenthal, New Species

Fig. 4A–F

This species is apparently related to *C. ortiziana* Flint, and together with *C. gondela* Flint, *C. platyrhina* Flint, *C. dolabrifera* Flint, *C. villalobosi* Bueno, and other new species described in this paper, including *C. paraortiziana* n. sp., *C. peineta* n. sp., *C. pollex* n. sp., and *C. solisi* n. sp., form what can be called the Ortiziana Group of *Chimarra.* This species can be separated from other members of the Ortiziana Group by the shape of the inferior appendages and the characteristic structure of the lateral lobes of the tenth tergum. The latter structures, in this species, are truncately rounded apically of the lateral sensilla-bearing projections. The two slender, spinelike structures of the phallus (which may appear as a single spine because they are closely apposed) are also unique.

Male: Forewing length 4.4–5.7 mm. Color rather uniformly fuscous black, except femora yellowish-brown (especially in prox-

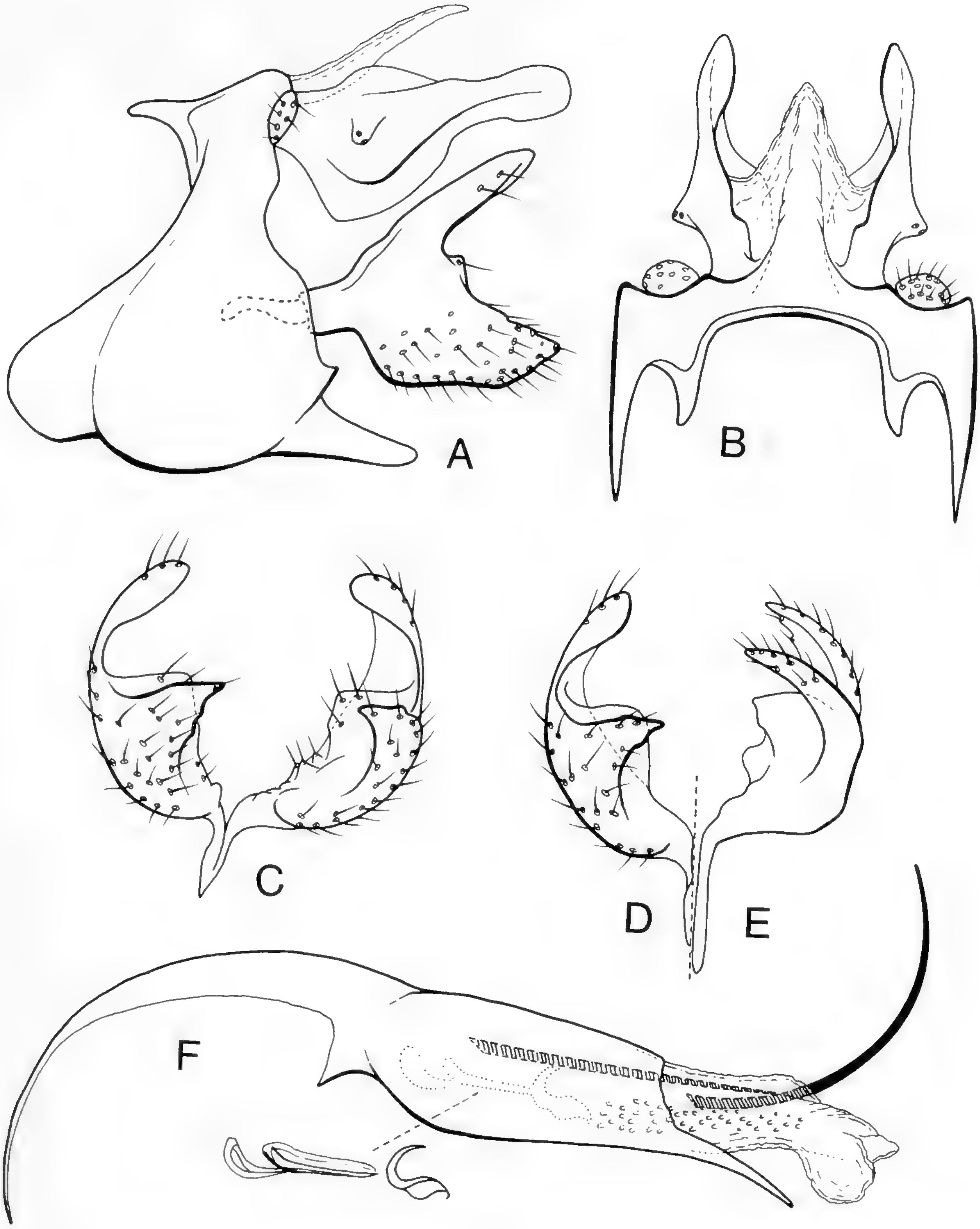

Fig. 3. A–F. *Chimarra amica* new species, male genitalia: A, lateral; B, dorsal; C, inferior appendages, oblique lateral; D, inferior appendage, caudal; E, inferior appendage, dorsal; F, phallus (inset: phallotremal sclerite complex, and sclerous curl and spine).

imal portion). Genitalia: Abdominal segment IX, in lateral view, with very pronounced sinuate extension of the anteroventral margin, and small apodemes from the anterodorsal margin; posteroventral process moderately elongate, subacute apically. Tergum X membranous mesally, with sclerotized lateral lobes, each bearing pair of sensilla on nipplelike projections on the outer margin. Lateral lobe of tergum X truncate, rounded apically, the apical margin continuous with caudal-most nipplelike

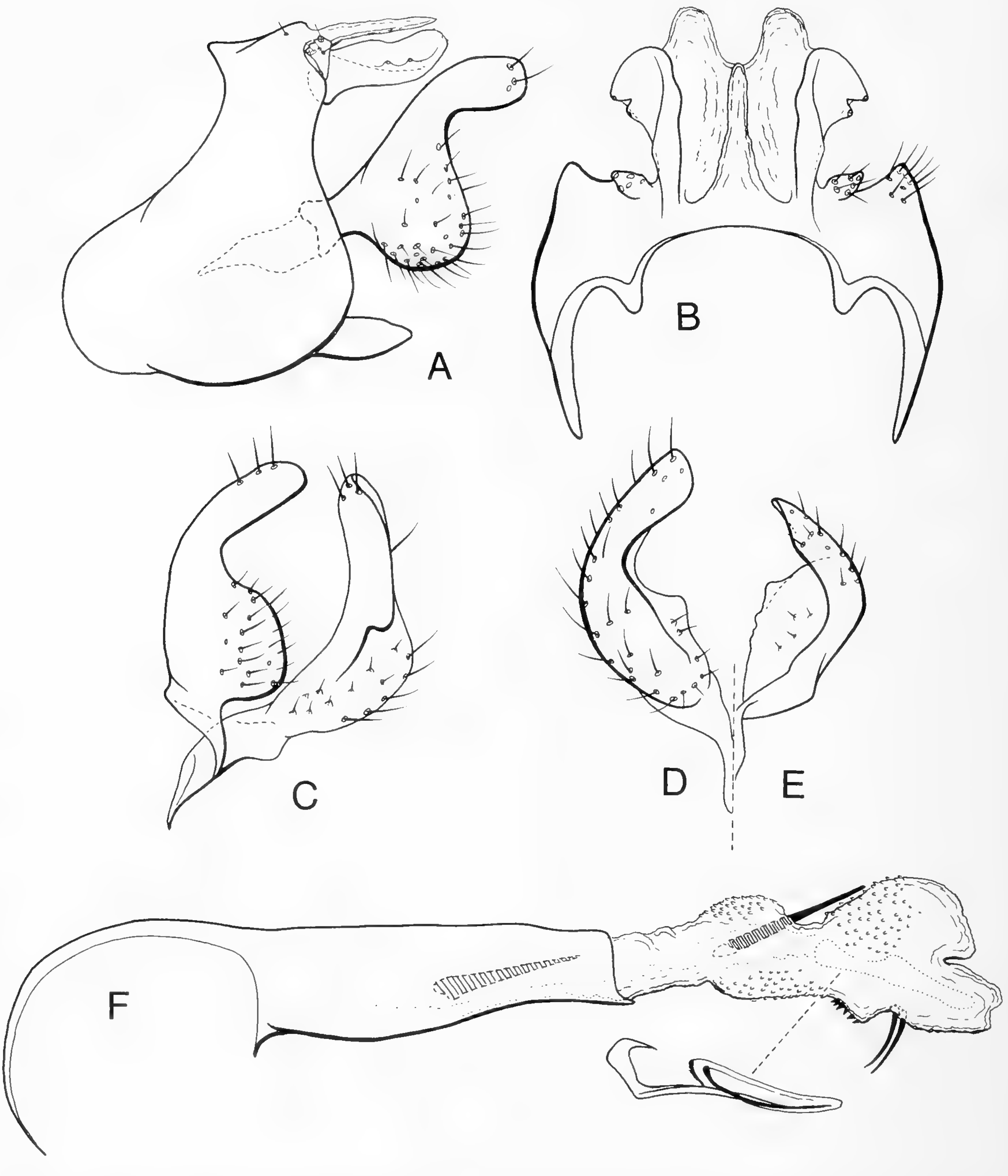

Fig. 4. A–F. *Chimarra colmillo* new species, male genitalia: A, lateral; B, dorsal; C. inferior appendages, oblique lateral; D, inferior appendage, caudal; E, inferior appendage, dorsal; F, phallus (inset: enlargement of phallotremal sclerite complex).

projection. Inferior appendage, in lateral view, with rounded base, abruptly narrowed dorsally to a thumblike projection; thumblike projection flattened and gently curved both posteriorly (as viewed laterally) and proximally (as viewed caudally); proximal surface of base with protuberance as continuation of the caudal edge of thumblike projection, much as if part of surface of base had been curled onto interior, or proximal, surface. Phallus with only slight apicoventral extension of phallobase; endothecal spines two, subequal, not elongate; tip of phallus, when expanded, bulbous, enlarged, with lesser preapical dorsal expansion, both possessing minute echinate spines, these also on ventral surface and forming, near tip of phallus, a sclerously echinate region with two elongate, slender, curved spines. Phallotremal sclerite complex composed of elongate rod and ring structure and apical membranous structure with pair of associated wishbonelike sclerites; when unexpanded, echinate surface of phallus apex appearing as granular region within phallobase, two slender spines closely apposed and appearing as single spine and associated with phallotremal sclerite complex near base of phallobase.

Holotype: ♂, Costa Rica: Guanacaste: Parque Nacional Guanacaste, Río San Josecito, Estación Mengo, 10.922°N, 85.470°W, el 960 m, 03–04.iv.1987, Holzenthal, Morse, Clausen (NMNH). *Paratypes:* Costa Rica: Alajuela: 7 ♂, Cerro Campana, Río Bochinche trib., 6 km (air) NW Dos Ríos, 10.945°N, 85.413°W, el 600 m, 22–23.vii.1987, Holzenthal, Morse, Clausen (INBIO); 9 ♂ (in alcohol), P. N. (Parque Nacional) Rincón de la Vieja, Quebrada Provisión, 10.769°N, 85.281°W, el 810 m, 04.iii.1986, Holzenthal & Fasth (UMSP); 1 ♂ (in alcohol), Reserva Forestal San Ramón, Río San Lorencito and tribs., 10.216°N, 84.607°W, el 980 m, 30.iii.–01.iv.1987, Holzenthal, Hamilton, Heyn (UMSP); Guanacaste: 10 ♂, same data as holotype (NMNH); 24 ♂ (pinned), 10 ♂, 9 ♀ (in alcohol), same location, 28–29.vii.1987, Holzenthal, Morse, Clausen (UMSP); 11 ♂, P. N. Rincón de la Vieja, Río Negro, 10.765°N, 85.313°W, el 810 m, 03.iii.1986, Holzenthal & Fasth (UMSP); 259 ♂, 2 ♀ (in alcohol), P. N. Rincón de la Vieja, Quebrada Zopilote, 10.765°N, 85.309°W, el 785 m, 03.iii.1986, Holzenthal (UMSP); 2 ♂, P. N. Guanacaste, ca. 0.7 km N Estación Maritza, 10.96°N, 85.50°W, el 550 m, 31.viii.1990, Huisman & Quesada (UMSP); Heredia: 3 ♂ (in alcohol), Rara Avis Biol. Station, Quebrada Chiquiza, 10.229°N, 84.032°W, el 550 m, 31.iii.1989, Blahnik & Solís (UMSP); Puntarenas: 1 ♂, Río Guineal, ca. 1 km (air) E Finca Helechales, 9.076°N, 83.092°W, 04.viii.1987, Holzenthal, Morse, Clausen (UMSP); San José: 2 ♂, P. N. Braulio Carrillo, Est. Carrillo, Quebrada Sanguijela, 10.160°N, 83.963°W, 27.iii.1987, Holzenthal, Hamilton, Heyn (UMSP).

Etymology: Colmillo, the Spanish word for fang, in reference to the pair of slender, curved spines at the tip of the phallus.

Chimarra guanacasteca
Blahnik and Holzenthal, New Species

Fig. 5A–F

This species is closely related to *C. curfmani* Ross. Both species undoubtedly belong within what can be termed the Beameri Group of *Chimarra,* and whose other species include *C. beameri* Ross, *C. acuta* Ross, *C. boneti* Ross, *C. fliniti* Bueno, *C. munozi* n. sp., *C. lata* n. sp., and *C. yanura* n. sp. This species can be recognized by the shape of the inferior appendages being less narrow basally than *C. curfmani* and by the equally short lateral lobes of the tenth tergum.

Male: Forewing length 4.4–4.9 mm. Color rather uniformly fuscous, except femora yellowish. Genitalia: Abdominal segment IX with well-developed anterodorsal apodemes; anteroventral margin considerably extended, margin non-sinuously joined to dorsal apodeme; posteroventral process prominent, broad, triangular. Tergum X membranous mesally, with two short, apically rounded, lateral lobes, each possessing two sensilla on slightly raised prominences. Preanal appendages short, globose. Inferior appendage, in lateral view, with rounded base possessing obtuse apex, and prominent, strongly tapering, dorsal projection (in caudal view obvious that caudal apex is actually rounded and proximally curved from caudal edge); whole of inferior appendage with proximal curvature; base of inferior

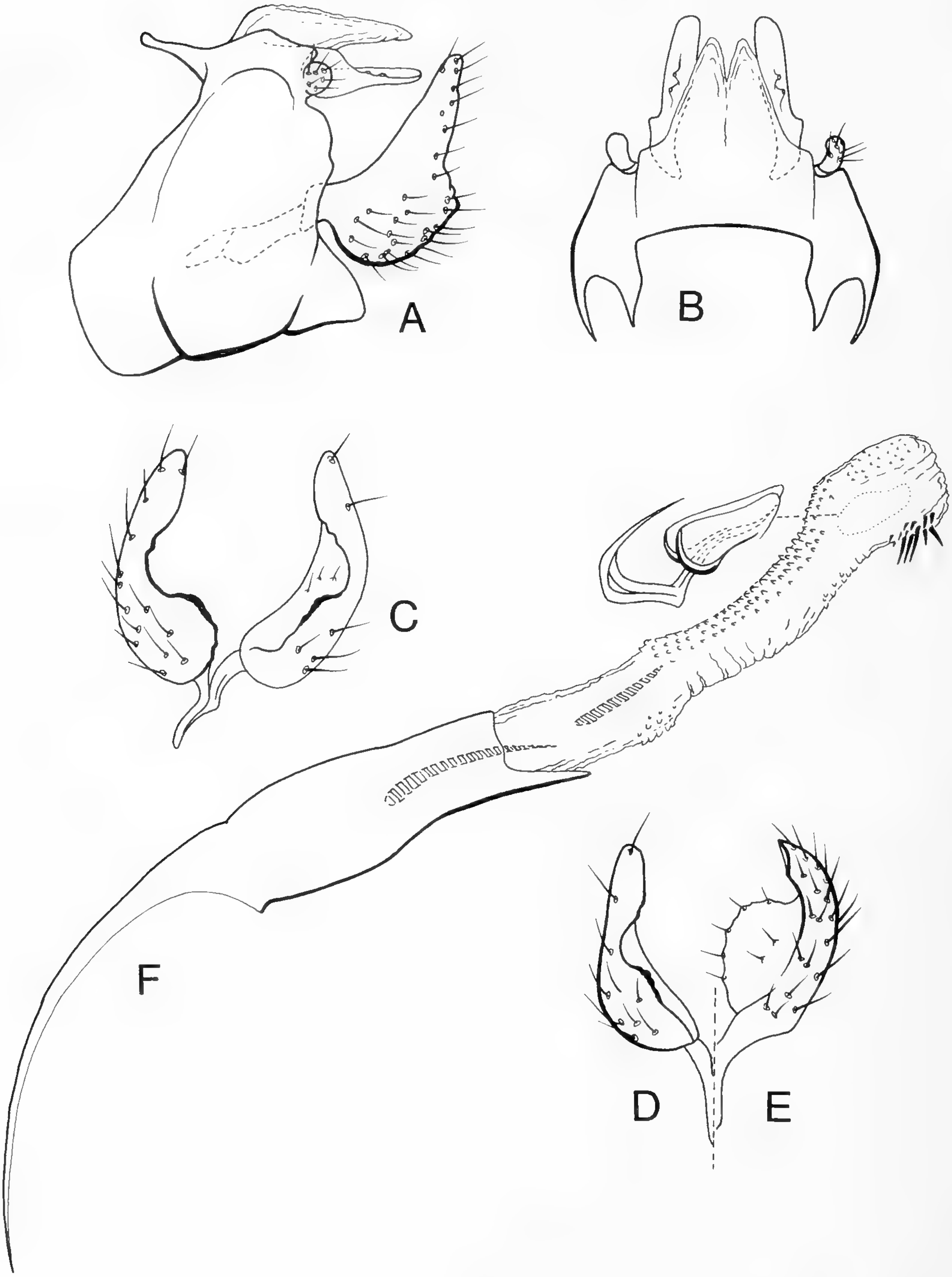

Fig. 5. A–F. *Chimarra guanacasteca* new species, male genitalia: A, lateral; B, dorsal; C, inferior appendages, oblique lateral; D, inferior appendage, caudal; E, inferior appendage, dorsal; F, phallus (inset: enlargement of phallotremal sclerite complex).

appendage with heavily sclerotized, irregular ridge on caudal surface. Phallus with apicoventral extension of apex; endothecal spines two, subequal, of moderate length; endotheca elongate and apex of phallus slightly inflated, minute echinate spines on endotheca and phallus apex, especially dorsally; cluster of enlarged spines apicoventrally; phallotremal sclerite complex composed of rod and ring (rod short and ring with pronounced apicodorsal entension), and membranous apical structure with sclerotized anterior margins (appearing fishhooklike); when unexpanded, apex of phallus appearing as granular region with cluster of spines and associated phallotremal sclerite complex, all within phallobase.

Holotype: ♂, Costa Rica: Alajuela: Río Pizote, ca. 5 km N Dos Ríos, 10.948°N, 85.291°W, el 470 m, 09.iii.1986, Holzenthal & Fasth (NMNH). *Paratypes:* Costa Rica: Alajuela: 12 ♂ (in alcohol), same data as holotype (UMSP); 147 ♂ (in alcohol), Río Pizote, ca. 5 km (air) S Brasilia, 10.972°N, 85.345°W, el 390 m, 12.iii.1986, Holzenthal & Fasth (UMSP); Guanacaste: 1 ♂, P. N. (Parque Nacional) Guanacaste, El Hacha, Quebrada Alcornoque, 11.009°N, 85.577°W, el 250 m, 26.vii.1987, Holzenthal, Morse, Clausen (INBIO); 1 ♂, P. N. Guanacaste, El Hacha, Quebrada Pedregal, 10.983°N, 85.539°W, el 300 m, 27.vii.1987, Holzenthal, Morse, Clausen (NMNH); 2 ♂, P. N. Guanacaste, Estación Pitilla, Río Orosí, 10.991°N, 85.428°W, el 700 m, 22–25.v.1990, Holzenthal & Blahnik (UMSP); 1 ♂ (in alcohol), Quebrada Garcia, 10.6 km ENE Quebrada Grande, 10.862°N, 85.428°W, el 470 m, 08.iii.1986, Holzenthal & Fasth (UMSP).

Etymology: Named for the Cordillera de Guanacaste of Costa Rica where specimens of the species have been collected.

Chimarra janzeni Blahnik and Holzenthal, New Species

Fig. 6A–F

This species is related to a group of species occurring from southwestern United States through Central America, and which can be termed the Primula Group of *Chimarra,* including *C. primula* Denning, *C. ovalis* Ross, *C. volenta* Ross, *C. crena* Bueno, *C. pelaezi* Bueno, and *C. antigua* Flint. All of these species are characterized by having ovate inferior appendages, each with a short, rounded or subtriangular, proximally curved, dorsal appendage. This particular species can be easily identified by the peculiar structure of the lateral lobes of the tenth tergum, each of which appears to terminate in two, diverging, stalked papillae.

Male: Forewing length 4.9–5.2 mm. Color rather uniformly fuscous, head blackish. Genitalia: Abdominal segment IX with pair of well-developed anterodorsal apodemes, anteroventral margin distinctly extended; posteroventral process short, broadly triangular. Tergum X membranous and deeply cleft mesally, with pair of sclerotized lateral lobes marked by distinctly sclerotized dorsal portion and lightly sclerotized, apically rounded, lateral extension; heavily sclerotized portion terminating in two, diverging, stalked sensilla. Preanal appendages short, globose, slightly flattened. Inferior appendage ovate, dorsally with subtriangular, proximally curved extension, ventrally with obtuse medial extension; proximal surface with short, setose projection near base. Phallus with apicoventral extension of phallobase; phallobase somewhat convergent apically; endothecal spines two, distinctly unequal in length, one long, one short; tip of phallus (apparently) with minute echinate spines; phallotremal sclerite complex composed of short rod and ring structure and membranous apical structure.

Holotype: ♂, Costa Rica: Alajuela: Cerro Campana, Río Bochinche trib., 6 km (air) NW Dos Ríos, 10.945°N, 85.413°W, el 600 m, 22–23.vii.1987, Holzenthal, Morse, Clausen (NMNH). *Paratypes:* Costa Rica: Alajuela: 1 ♂, same data as holotype (INBIO); 1 ♂ (in alcohol), Reserva Forestal San Ramón, Río San Lorencito & tribs., 10.216°N, 84.607°W, el 980 m, 02–04.vii.1986, Holzenthal, Heyn, Armitage (UMSP); 2 ♂, same location, 06–10.iii.1991, Holzenthal, Muñoz, Huisman (UMSP).

Etymology: Named for Daniel Janzen, in honor of his many contributions to Costa Rican ecology, systematics, and conservation.

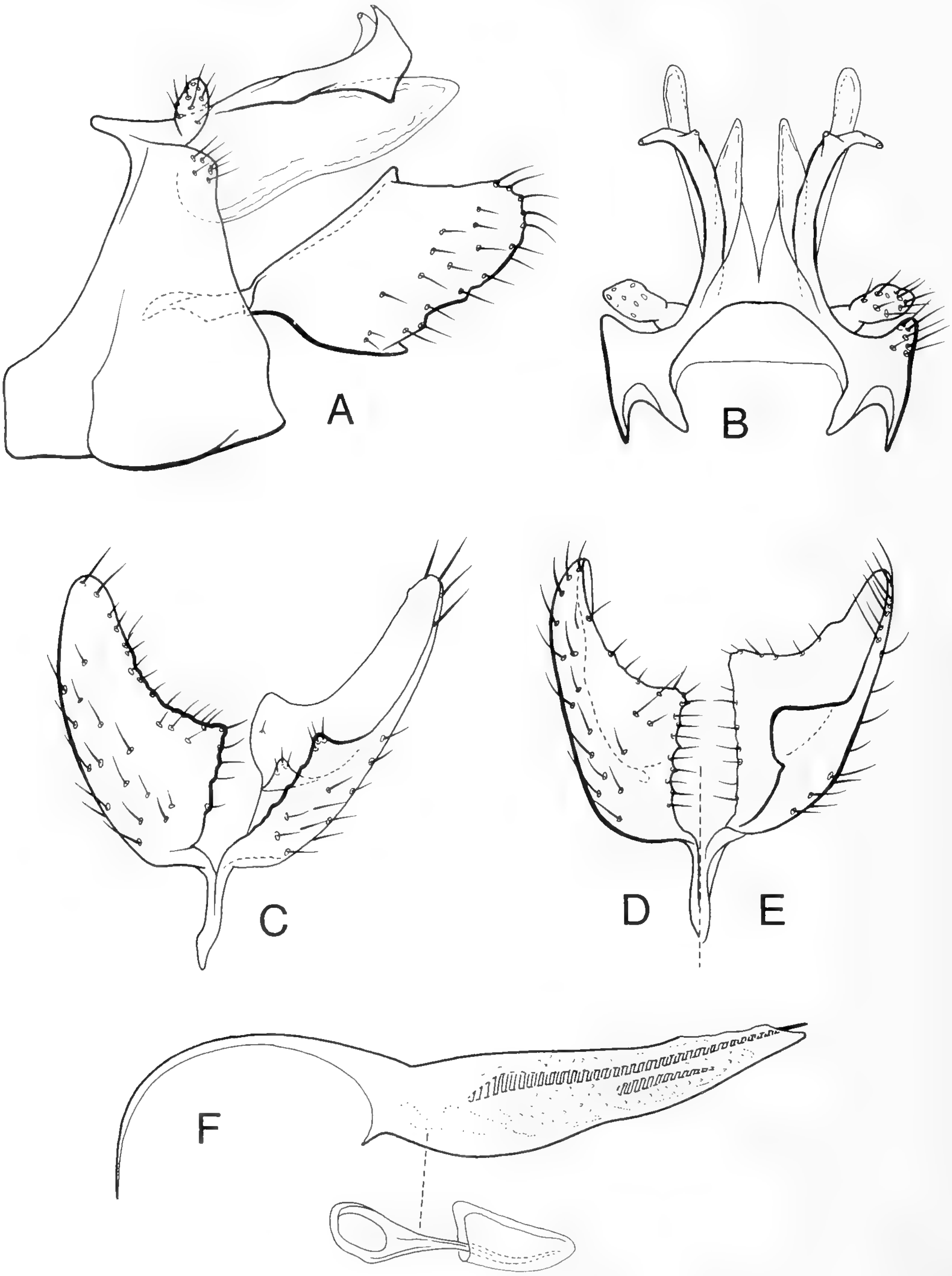

Fig. 6. A–F. *Chimarra janzeni* new species, male genitalia: A, lateral; B, dorsal; C, inferior appendages, oblique lateral; D, inferior appendage, ventral; E, inferior appendage, dorsal; F, phallus (inset: enlargement of phallotremal sclerite complex).

Chimarra jemima Blahnik and Holzenthal, New Species

Fig. 7A–D

This species is closely related to *C. emima* Ross, but differs in having more elongate inferior appendages and a tenth tergum with lateral lobes having broadly rounded lateral projections. It also differs in having a distinct, small, acute projection from the basal portion of the tenth tergum. It belongs to a group of species which can be called the

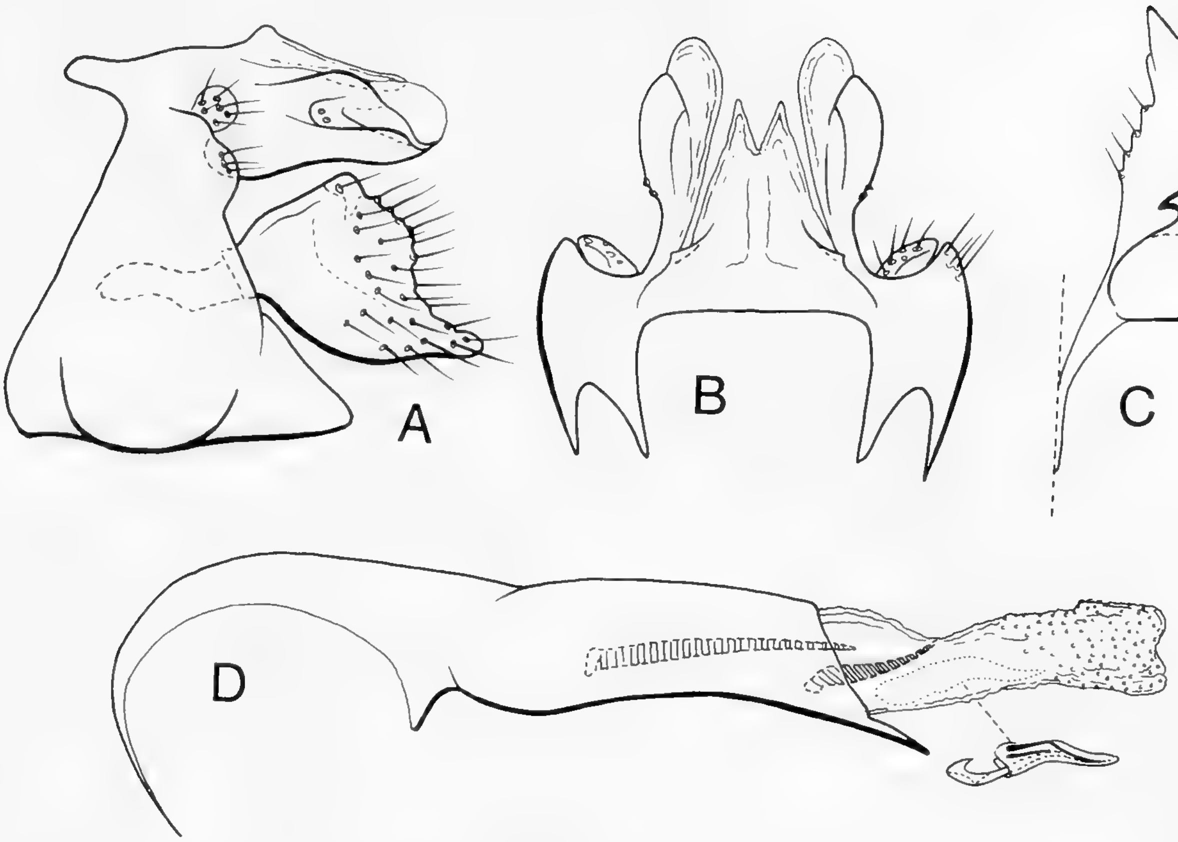

Fig. 7. A–F. *Chimarra jemima* new species, male genitalia: A, lateral; B, dorsal; C, inferior appendage, dorsal; D, phallus (inset: phallotremal sclerite complex).

Emima Group, including *C. emima* Ross, *C. setosa* Ross, *C. creagra* Flint, *C. decimlobata* Flint and *C. onima* Flint.

Male: Forewing length 4.9–5.5 mm. Color rather uniformly fuscous black, except head darker and femora yellowish to yellowish-brown. Head moderately elongate and dorsally flattened. Genitalia: Abdominal segment IX with pair of prominent apodemes from anterodorsal margin; anteroventral margin gradually expanded from dorsal apodemes; posteroventral process broadly triangular and prominent. Tergum X membranous mesally, with two short, sclerotized, lateral lobes, each with broadly rounded lateral projection bearing a pair of sensilla near base, and terminating in a short, rounded membranous tip; base of tergum X with pair of distinct, small, acute projections. Inferior appendages relatively short, tapering to distinct, acute apical point, dorsally with short proximally curved process, appearing as acutely hooked process when viewed dorsally, but actually with rounded tip. Phallobase with acute apicoventral projection; endothecal spines two, of moderate length, one usually longer than other; apex of phallus with minute echinate spines. Phallotremal sclerite complex composed of rod and ring structure, rod relatively short and ring with slight dorsal projection, apically with membranous structure with pair of lightly sclerotized lateral strips near dorsal margin.

Holotype: ♂, Costa Rica: Alajuela: Río Toro, 3.0 km (road) SW Bajos del Toro, 10.204°N, 84.316°W, el 1530 m, 03–04.ix.1990, Holzenthal, Blahnik, Huisman (NMNH). *Paratypes:* Costa Rica: Alajuela: 2 ♂ (pinned), 1 ♂ (in alcohol), Reserva Bosque Nubosa, Monteverde, Río Peñas Blancas, 10.30°N, 84.74°W, el 950 m, 01.iii.1986, Holzenthal & Fasth (UMSP); 4 ♂, Río Sarapiquí, ca. 2 km SE Cariblanco, 10.299°N, 82.172°W, el 710 m, 22.vi.1986, Holzenthal, Heyn, Armitage (UMSP); 4 ♂, Reserva Forestal San Ramón, Río San Lorencito & tribs., 10.216°N, 84.607°W, el 980 m, 05–

09.vii.1986, I. & A. Chacón (INBIO); 3 ♂, same location, 24–27.ii.1987, I. & A. Chacón (UMSP); 7 ♂ (pinned), 53 ♂ (in alcohol), same location, 30.iii.–01.iv.1987, Holzenthal, Hamilton, Heyn (UMSP); 2 ♂ (pinned), 9 ♂ (in alcohol), same location, 02–04.vii.1986, Holzenthal, Heyn, Armitage (UMSP); 6 ♂, same location, 01–04.v.1990, Holzenthal & Blahnik (UMSP); 9 ♂, same location, 28–30.vii.1990, Holzenthal, Blahnik, Muñoz (UMSP); 17 ♂, same location, 06–10.iii.1991, Holzenthal, Muñoz, Huisman (INBIO); 2 ♂ (in alcohol), Cerro Campana, Río Bochinche trib., 6 km (air) NW Dos Ríos, 10.945°N, 85.413°W, el 600 m, 22–23.vii.1987, Holzenthal, Morse, Clausen (UMSP); 1 ♂ (in alcohol), P. N. (Parque Nacional) Rincón de la Vieja, Quebrada Provisión, 10.769°N, 85.281°W, el 810 m, 04.iii.1986, Holzenthal & Fasth (UMSP); 3 ♂, same data as holotype (NMNH); 1 ♂, Quebrada Latas, 8.9 km NE Bajos del Toro, 10.269°N, 84.260°W, el 1030 m, 06.ix.1990, Holzenthal, Blahnik, Huisman (INBIO); 2 ♂, Río Agrio, ca. 3.5 km NE Bajos del Toro, 10.243°N, 84.279°W, el 1290 m, 20.viii.1990, Holzenthal et al. (UMSP); 11 ♂, Río Toro, 3.0 km (road) SW Bajos del Toro, 10.204°N, 84.316°W, el 1530 m, 03–04.ix.1990, Holzenthal, Blahnik, Huisman (UMSP); Cartago: 1 ♂ (pinned), 12 ♂ (in alcohol), Quebrada Platanillo, ca. 5 km E Moravia de Chiripó, 9.821°N, 83.407°W, el 1130 m, 06.viii.1987, Holzenthal, Morse, Clausen (UMSP); 10 ♂, 14 ♀ (in alcohol), Pejibaye, 22–24.iii.1987, W. E. Steiner (NMNH); 1 ♂, 3 ♀ (in alcohol), Turrialba, 17–21.ii.1965, S. S. & W. D. Duckworth (NMNH); 4 ♂, 2 ♀ (in alcohol), Turrialba, 26.viii.1972, G. F. & S. Hevel (NMNH); 4 ♂ (in alcohol), 3 mi W Turrialba, 18–21.vi.1967, Flint & Ortiz (NMNH); 1 ♂ (in alcohol), Chitaria, 19.vi.1967, Flint & Ortiz (NMNH); 1 ♂, Río Chitaria, route 10, 10 km NW Río Reventazón, 9.920°N, 83.604°W, el 740 m, 21.iii.1991, Holzenthal, Muñoz, Huisman (UMSP); 1 ♂, Río Reventazón in CATIE along Sendero Espavales, 9.893°N, 83.651°W, el 500 m, 22.iii.1991, Muñoz (UMSP); Guanacaste: 1 ♂ (in alcohol), Quebrada, Garcia, 10.6 km ENE Quebrada Grande, el 470 m, 08.iii.1986, Holzenthal & Fasth (UMSP); 3 ♂, P. N. Guanacaste, Estación Maritza, Río Tempisquito, 10.958°N, 85.497°W, el 550 m, 30–31.viii.1990, Huisman, Blahnik, Quesada (UMSP); Limón: 1 ♂, Río Barbilla, ca. 8 km W B-Line, 10.067°N, 83.369°W, el 30 m, 31.i.1986, Holzenthal, Morse, Fasth (UMSP); Puntarenas: 6 ♂ (pinned), 7 ♂ (in alcohol), Río Jaba at rock quarry, 1.4 km (air) W Las Cruces, 8.79°N, 82.97°W, el 1150 m, 14.vi.1986, Holzenthal, Heyn, Armitage (UMSP); 7 ♂, same location, 0.9.viii.1990, Holzenthal, Blahnik, Muñoz (UMSP); 11 ♂, same location, 15.iii.1991, Holzenthal, Muñoz, Huisman (UMSP); 1 ♂ (in alcohol), Río Jaba, 2.4 km (air) NW San Vito, 8.832°N, 82.991°W, 13.vi.1986, Holzenthal, Heyn, Armitage (UMSP); 3 ♂ (pinned), 17 ♂, 12 ♀ (in alcohol), Río Guineal, ca. 1 km (air) E Finca Helechales, 9.076°N, 83.092°W, el 840 m, 04.viii.1987, Holzenthal, Morse, Clausen (UMSP); 24 ♂ (in alcohol), same location, 22.ii.1986, Holzenthal, Morse, Fasth (UMSP); 18 ♂ (pinned), 7 ♂ (in alcohol), Río Bellavista, ca. 1.5 km NW Las Alturas, 8.951°N, 82.846°W, el 1400 m, 08–09.iv.1987, Holzenthal, Hamilton, Heyn (UMSP); 1 ♂, same location, 02–03.viii.1987, Holzenthal, Morse, Clausen (UMSP); 1 ♂ (in alcohol), same location, 15–17.vi.1986, Holzenthal, Heyn, Armitage (UMSP); 1 ♂, same location, 16–17.iii.1991, Holzenthal, Muñoz, Huisman (UMSP); 2 ♂, Río Cotón in Las Alturas, 8.938°N, 82.826°W, el 1360 m, 12.viii.1990, Holzenthal, Blahnik, Muñoz (UMSP); 1 ♂ (in alcohol), Río Singrí, ca. 2 km (air) S Finca Helechales, 9.057°N, 83.082°W, el 720 m, 21.ii.1986, Holzenthal, Morse, Fasth (UMSP); San José: 9 ♂, P. N. Braulio Carrillo, Estación Carrillo, Quebrada Sanguijuela, 10.160°N, 83.963°W, el 800 m, 27.iii.1987, Holzenthal, Hamilton, Heyn (UMSP); 2 ♂, same location, 22–28.-

viii.1986, I. & A. Chacón (UMSP); 3 ♂, same location, 11–12.vi.1988, C. M. & O. S. Flint, Holzenthal (NMNH).

Etymology: Jemima, a woman's name, chosen for its aliterative similarity to other described members of this group (*C. emima* Ross and *C. onima* Flint).

Chimarra lata Blahnik and Holzenthal, New Species

Fig. 8A–F

This species is also a member of the Beameri Group of *Chimarra,* but differs from other described species of this group by having much broader inferior appendages.

Male: Forewing length 4.1–4.5 mm. Color rather uniformly fuscous, except femora and distal portion of trochanters yellowish. Genitalia: Abdominal segment IX with prominent anterodorsal apodemes, anteroventral margin distinctly extended, joined linearly from dorsal apodemes to rounded ventrolateral margin; posteroventral process short, broadly triangular. Tergum X membranous mesally, with pair of sclerotized lateral lobes; lateral lobes spatulate, with two sensilla preapically, creased apically along lateral margin. Preanal appendages short, somewhat flattened and knob-like. Inferior appendages angled dorso-posteriorly, proximally curved (in caudal view), of nearly uniform width, except narrowed apically and shallowly, sinuously indentate near middle along caudal edge; inferior appendage serrate caudally near apex, with serrations continuing as ridge along proximal surface of caudal edge; prominent setose projection on proximal surface near base. Phallus with apicoventral extension of phallobase; endothecal spines two, subequal, elongate; tip of phallus (apparently) with minute, echinate spines and irregular cluster of enlarged spines; phallotremal sclerite composed of rod and ring structure (rod short and curved and ring with prominent apicodorsal entension), and membranous apical structure with pair of fish-hook-like sclerites along anterior edge.

Holotype: ♂, Costa Rica: Guanacaste: Parque Nacional Guanacaste, ca. 0.7 km N Estación Maritza, 10.96°N, 85.50°W, el 550 m, 31.viii.1990, Huisman & Quesada (NMNH). *Paratypes:* Costa Rica: Alajuela: 4 ♂ (in alcohol), Río Pizote, ca. 5 km (air) S Brasilia, 10.972°N, 85.345°W, el 390 m, 12.iii.1986, Holzenthal & Fasth (UMSP); Guanacaste: 1 ♂, P. N. (Parque Nacional) Guanacaste, Estación Pitilla, Río Orosí, 10.991°N, 85.428°W, el 700 m, 19–20.vi.1988, C. M. & O. S. Flint, Holzenthal (NMNH); 3 ♂, same location, 22–25.v.1990, Holzenthal & Blahnik (UMSP); Heredia: 1 ♂, Río Bijagual on road to Magsasay, el 140 m, 12.ii.1986, Holzenthal, Morse, Fasth (INBIO); 1 ♂ (in alcohol), Estación Biológica La Selva, Río Puerto Viejo, 10.440°N, 84.012°W, el 30 m, 19.vi.1986, Holzenthal, Heyn, Armitage (UMSP).

Etymology: Lata, from the Latin *latus,* meaning wide or broad, and referring to the broad inferior appendages of this species.

Chimarra longiterga Blahnik and Holzenthal, New Species

Fig. 9A–F

This is a unique species of *Chimarra* with a probable relationship to *C. amica* n. sp., and also possibly with more distant relationships to *C. dentosa* Ross and *C. alata* Bueno. It is readily identified by the elongate lobes of the tenth tergum. Other characteristic features are the elongate endothecal spines, the elongate, deflexed apicoventral extension of the phallobase, the elongate, spinelike process in the phallus with a basal sclerous curl, and the extensively developed anteroventral margin of the ninth abdominal segment. Several of the collection localities for this species were at, or near, shallow spring seeps and trickling waterfalls, suggesting that this may represent the larval habitat for this species. It undoubtedly has an interesting biology in addition to a unique appearance.

Male: Forewing length 4.4–6.0 mm. Color rather uniformly fuscous black, except

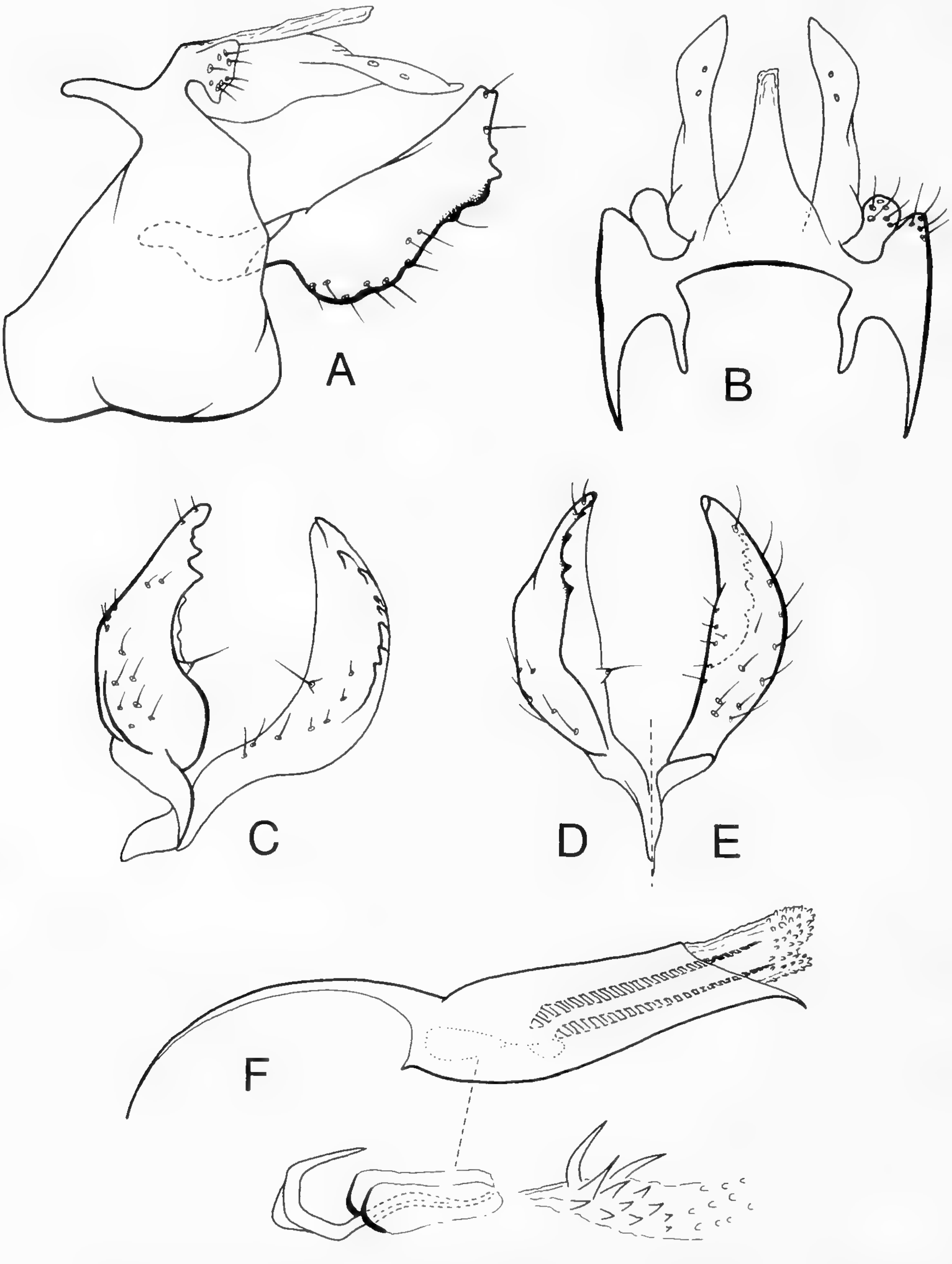

Fig. 8. A–F. *Chimarra lata* new species, male genitalia: A, lateral; B, dorsal; C, inferior appendages, oblique lateral; D, inferior appendage, ventral; E, inferior appendage, dorsal; F, phallus (inset: enlargement of phallotremal sclerite complex and cluster of phallic spines).

femora yellowish-brown. Genitalia: Abdominal segment IX, in lateral view, with anteroventral margin dramatically sinuously elongate, and with pair of well-developed anterodorsal apodemes; posteroventral process of moderate length, narrow, subacute. Tergum X membranous mesally, with two elongate, linear, sclerotized lateral lobes, each with a pair of sensilla on slightly raised prominence near base. Preanal appendages, short, somewhat flattened. Inferior appendages, in lateral view, with rounded base bearing acute caudal apex and elongate, tapered, dorsal process; dorsal process slightly angled posteriorly (in lateral view) and gently curved proximally (in caudal view); proximal surface of base with conspicuous setose process and ridge, formed as if part of edge

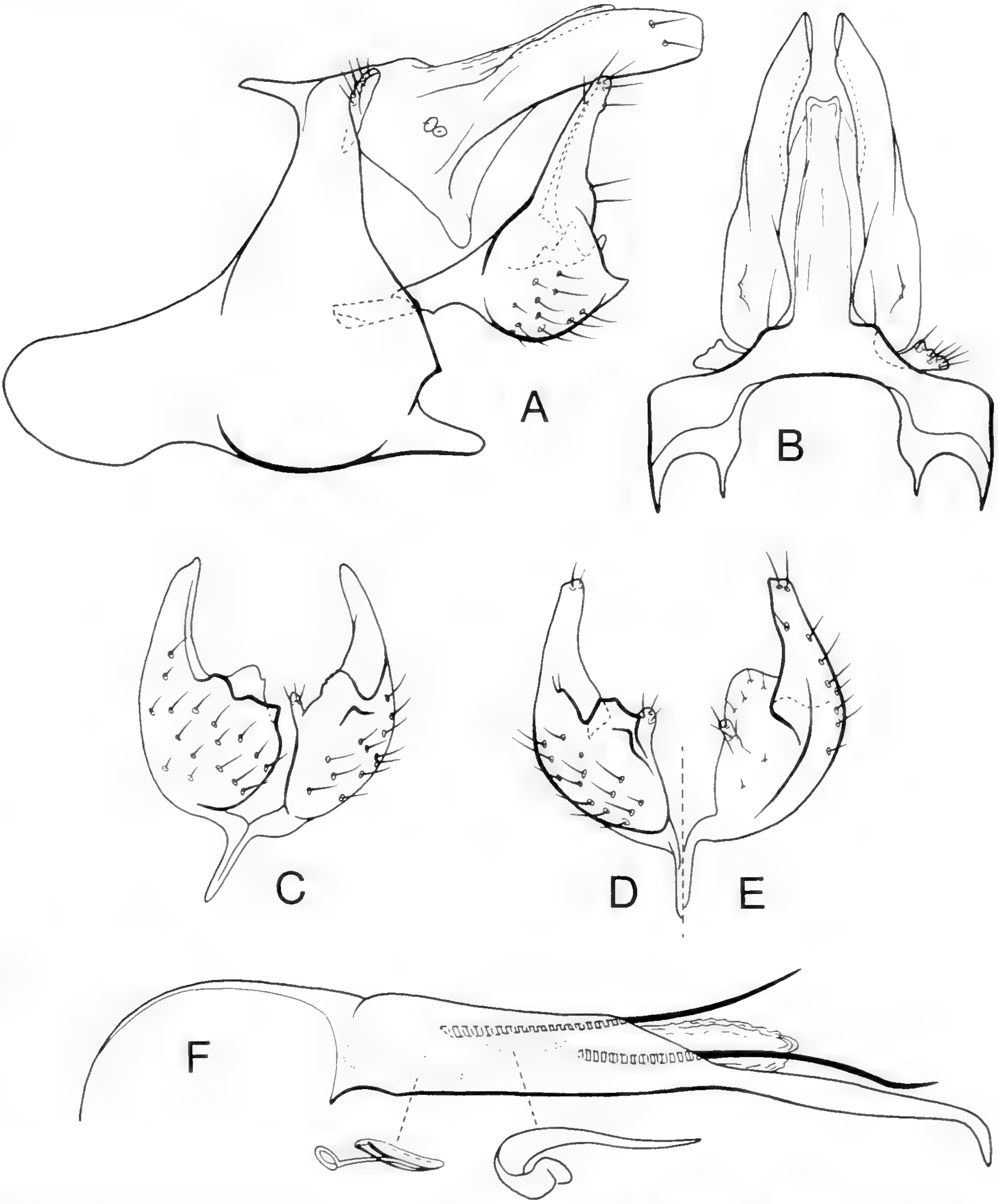

Fig. 9. A–F. *Chimarra longiterga* new species, male genitalia: A, lateral; B, dorsal; C, inferior appendages, oblique lateral; D, inferior appendage, caudal; E, inferior appendage, dorsal; F, phallus (insets: phallotremal sclerite complex, and enlargement of sclerous curl and spine).

of base had been curled onto proximal surface of inferior appendage. Phallus with elongate apicoventral extension to phallobase, extension decurved near apex; endothecal spines two, slender, elongate; tip of phallus (apparently) with pronounced sclerous curl attached to elongate spinelike process, tip of phallus not (or only inconspicuously) echinate; phallotremal sclerite complex composed of rod and ring structure and apical membranous structure with associated pair of wishbonelike sclerites.

Holotype: ♂, Costa Rica: Puntarenas: Parque Nacional Corcovado, Piedra el Arco, 8.582°N, 83.709°W, el 20 m, 10–11.iv.1989, Holzenthal & Blahnik (NMNH). *Paratypes:* Costa Rica: Alajuela: 1 ♂ (in alcohol), Cerro Campana, Río Bochinche trib., 6 km (air)

NW Dos Ríos, 10.945°N, 85.413°W, el 600 m, 22–23.vii.1987, Holzenthal, Morse, Clausen (UMSP); 1 ♂ (in alcohol), P. N. (Parque Nacional) Rincón de la Vieja, Quebrada Provisión, 10.769°N, 85.281°W, el 810 m, 04.iii.1986, Holzenthal & Fasth (UMSP); 1 ♂ (in alcohol), Reserva Bosque Nubosa, Monteverde, Río Peñas Blancas, 10.30°N, 84.74°W, el 950 m, 01.iii.1986, Holzenthal & Fasth (UMSP); 1 ♂, Reserva Forestal San Ramón, Río San Lorencito and tribs., 10.216°N, 84.607°W, 13–16.vi.1988, C. M. & O. S. Flint, Holzenthal (NMNH); 1 ♂, Río Agrio, ca. 3.5 km NE Bajos del Toro, 10.243°N, 84.279°W, el 1290 m, 20.viii.1990, Holzenthal et al. (UMSP); 1 ♂, Quebrada Latas, 8.9 km NE Bajos del Toro, 10.269°N, 84.260°W, el 1030 m, 06.ix.1990, Holzenthal, Blahnik, Huisman (UMSP); Guanacaste: 2 ♂, P. N. Guanacaste, Maritza, Río Tempisquito, 10.958°N, 85.497°W, el 550 m, 19–20.vii.1987, Holzenthal, Morse, Clausen (INBIO); 2 ♂, P. N. Guanacaste, El Hacha, Quebrada Pedregal, 10.983°N, 85.539°W, el 300 m, 27.vii.1987, Holzenthal, Morse, Clausen (INBIO); 1 ♂, P. N. Guanacaste, Estación Pitilla, Río Orosí, 10.991°N, 85.428°W, el 700 m, 22–25.v.1990, Holzenthal & Blahnik (UMSP); Heredia: 4 ♂ (in alcohol), Estación Biológica La Selva, Río Puerto Viejo, 10.440°N, 84.012°W, el 30 m, 19.vi.1986, Holzenthal, Heyn, Armitage (UMSP); Puntarenas: 4 ♂, Río Jaba at rock quarry, 1.4 km (air) W Las Cruces, 8.79°N, 82.97°W, el 1150 m, 09.viii.1990, Holzenthal, Blahnik, Muñoz (UMSP); Panama: 2 ♂, Boquette, 16–17.vii.1967, O. S. Flint, Jr. (NMNH); San Blas: 2 ♂, 4 ♀, Nusagandi, 9°20′N, 78°56′W, el 350 m, 01–06.iii.1985, Flint & Louton (NMNH); Canal Zone: 1 ♂, Barro Colorado Island, 12.iii.1967, M. E. Irwin (UCR); Coclé: 2 ♂, 4 ♀, El Valle, 829 m, 25.v.1983, P. J. Spangler, R. A. Faitoute, W. E. Steiner (NMNH); 4 ♂, 2 ♀, El Valle, 15.vii.1967, O. S. Flint, Jr. (NMNH); Ecuador: Manabi: 1 ♂, Santo Domingo de los Colorados (79 km W), 08.v.1975, A. B. Gurney (NMNH); Pichincha: 1 ♂ (in alcohol), Santo Domingo (47 km S), Río Palenque Biol. Station, el 750 ft, 29.vii.1976, J. Cohen (NMNH).

Etymology: Longiterga, meaning long tergum, in reference to the elongate tenth tergum of this species.

Chimarra munozi Blahnik and Holzenthal, New Species

Fig. 10A–F

This species also belongs within the Beameri Group of *Chimarra.* It is quite similar to *C. beameri* Denning, but can be recognized from that species by the structure of the lateral lobes of the tenth tergum, which in this species are strongly apically deflexed and spatulate in shape. It also resembles *C. yanura* n. sp., but differs in that the apex of the lateral lobes of the tenth tergum lack acute lateral projections, and also by differences in the structure of the apex of the dorsal process of the inferior appendage. Like *C. guanacasteca* n. sp., but unlike *C. beameri* and *C. yanura,* it has a cluster of sclerotized spines associated with the apex of the phallus.

Male: Forewing length 4.1–4.9 mm. Color rather uniformly fuscous to fuscous black, except femora yellowish. Genitalia: Abdominal segment IX with distinct anterodorsal apodemes; anteroventral margin distinctly extended, non-sinuously, from dorsal apodemes; posteroventral process prominent, triangular. Tergum X membranous mesally, with two sclerotized, spatulate, lateral lobes, apically rounded and with two preapical sensilla; apex of lateral lobes ventrally deflexed and with crease along outer margin. Preanal appendages small, globose, slightly flattened. Inferior appendage with rounded base and broad, posteriorly directed, proximally curved, dorsal projection. Phallus with acute apicoventral extension of phallobase; endothecal spines two, subequal, of moderate length; apex of phallus with minute, echinate spines and heavily

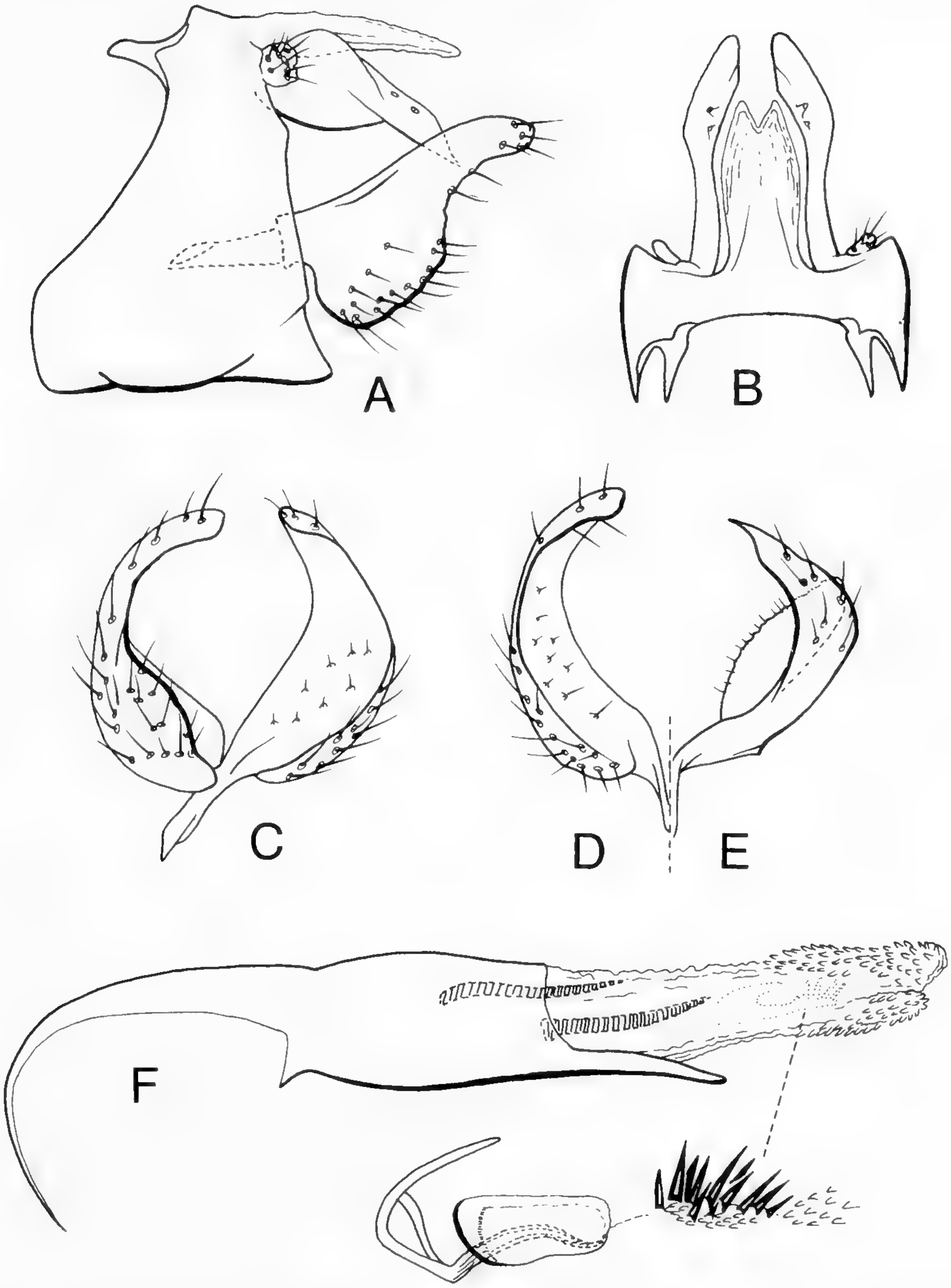

Fig. 10. A–F. *Chimarra munozi* new species, male genitalia: A, lateral; B, dorsal; C, inferior appendages, oblique lateral; D, inferior appendage, caudal; E, inferior appendage, dorsal; F, phallus (inset: enlargement of phallotremal sclerite complex and cluster of phallic spines).

sclerotized cluster of enlarged spines; phallotremal sclerite complex composed of rod and ring structure (rod short and curved, ring with pronounced apicodorsal extension), and membranous apical structure with pair of fish-hooklike sclerites.

Holotype: ♂, Costa Rica: Heredia: Parque Nacional Braulio Carrillo, Estación Magsasay, Río Peje, 10.402°N, 84.050°N, el 130 m, 25–26.viii.1990, Holzenthal, Blahnik, Huisman (NMNH). *Paratypes:* Costa Rica: Alajuela: 5 ♂ (in alcohol), Reserva Forestal San Ramón, Río San Lorencito & tribs., 10.216°N, 84.607°W, el 980 m, 30.iii.–01.iv.1987, Holzenthal, Hamilton, Heyn (UMSP); 1 ♂ (in alcohol), Río Pizote, ca. 5 km N Dos Ríos, 10.958°N, 85.291°W, el 470 m, 09.iii.1986, Holzenthal & Fasth

(UMSP); 1 ♂, Quebrada Latas, 8.9 km NE Bajos del Toro, 10.269°N, 84.260°W, el 1030 m, 06.ix.1990, Holzenthal, Blahnik, Huisman (UMSP); Guanacaste: 3 ♂ (in alcohol), P. N. (Parque Nacional) Guanacaste, Maritza, Río Tempisquito, 10.958°N, 85.497°W, el 550 m, 19–20.vii.1987, Holzenthal, Morse, Clausen (UMSP); 4 ♂, 1 ♀, same location, 17–18.vi.1988, C. M. & O. S. Flint, Holzenthal (NMNH); 9 ♂ (in alcohol), Río Góngora (sulfur mine), 4 km (air) NE Quebrada Grande, 10.887°N, 85.470°W, el 590 m, 21.vii.1987, Holzenthal, Morse, Clausen (UMSP); 1 ♂ (in alcohol), Quebrada Garcia, 10.6 km ENE Quebrada Grande, 10.862°N, 85.428°W, el 470 m, 08.iii.1986, Holzenthal & Fasth (UMSP); 2 ♂, 2 ♀, P. N. Guanacaste, Estación Pitilla, Río Orosi, 10.991°N, 85.428°W, el 700 m, 19–20.vi.1988, C. M. & O. S. Flint, Holzenthal (NMNH); 8 ♂, same location, 22–25.v.1990, Holzenthal & Blahnik (UMSP); Heredia: 29 ♂, same data as holotype (NMNH); 63 ♂, 2 ♀, P. N. Braulio Carrillo, Estación El Ceibo, Río Peje, 10.327°N, 84.078°W, el 480 m, 29–31.v.1990, Holzenthal, Blahnik, Muñoz (UMSP); Limón: 12 ♂, P. N. Braulio Carrillo, Quebrada González, 10.160°N, 83.939°W, el 480 m, 12–14.v.1990, Holzenthal & Blahnik (INBIO); Puntarenas: 2 ♂ (in alcohol), Río Singrí, ca. 2 km (air) S Finca Helechales, 9.057°N, 83.082°W, el 720 m, 21.ii.1986, Holzenthal, Morse, Fasth (UMSP); San José: 1 ♂ (in alcohol), P. N. Braulio Carrillo, Estación Carrillo, Quebrada Sanguijuela, 10.160°N, 83.963°W, el 800 m, 27.iii.1987, Holzenthal, Hamilton, Heyn (UMSP); 1 ♂, P. N. Braulio Carrillo, Estación Carrillo, Quebrada Sanguijuela, 10.160°N, 83.963°W, el 800 m, 27.iii.1987, Holzenthal, Hamilton, Heyn (UMSP).

Etymology: Named for Fernando Muñoz Quesada, INBio curator and member of "Projecto Trichoptera," project name for the effort to completely inventory and describe the caddisfly fauna of Costa Rica.

Chimarra paraortiziana Blahnik and Holzenthal, New Species

Fig. 11A–F

This species is nearly identical to *C. ortiziana* Flint in the shape of inferior appendages and the structure of the phallus, but differs considerably from that species in the structure of the lateral lobes of the tenth tergum. In the latter character, however, it much resembles *C. peineta* n. sp., but differs somewhat in the form of the sensilla-bearing lateral lobes, which in this species are inwardly concave from their anterior margin. It can be identified by the character combination of the structure of the tenth tergum, inferior appendages with relatively straight, dorsal, thumblike projections, and by the possession of a sclerous curl in the phallus, possessing minute sclerotized spines, but no elongate spines.

The Ortiziana Group of species presents much confusion in that the individual species often seem to possess character combinations from other species. However, the various forms show considerable homogeneity within their respective ranges. It may be that *C. paraortiziana* is actually conspecific with *C. ortiziana* Flint, perhaps having acquired characters introgressively from *C. peineta* n. sp. in the region of overlap between the species. Until this (or some other) scenario can be ascertained, it seems best to regard these two and all the other diagnosable forms as distinct species.

Male: Forewing length 4.2–5.3 mm. Color rather uniformly fuscous, except head somewhat darker and femora yellowish-brown. Genitalia: Abdominal segment IX, in lateral view, with distinct sinuous extension of the anteroventral margin and with short apodemelike projections from the anterodorsal margin; posteroventral process rather elongate, triangular. Tergum X membranous mesally, with two heavily sclerotized lateral lobes, each bearing midlateral, broadly rounded, expansion, with two sen-

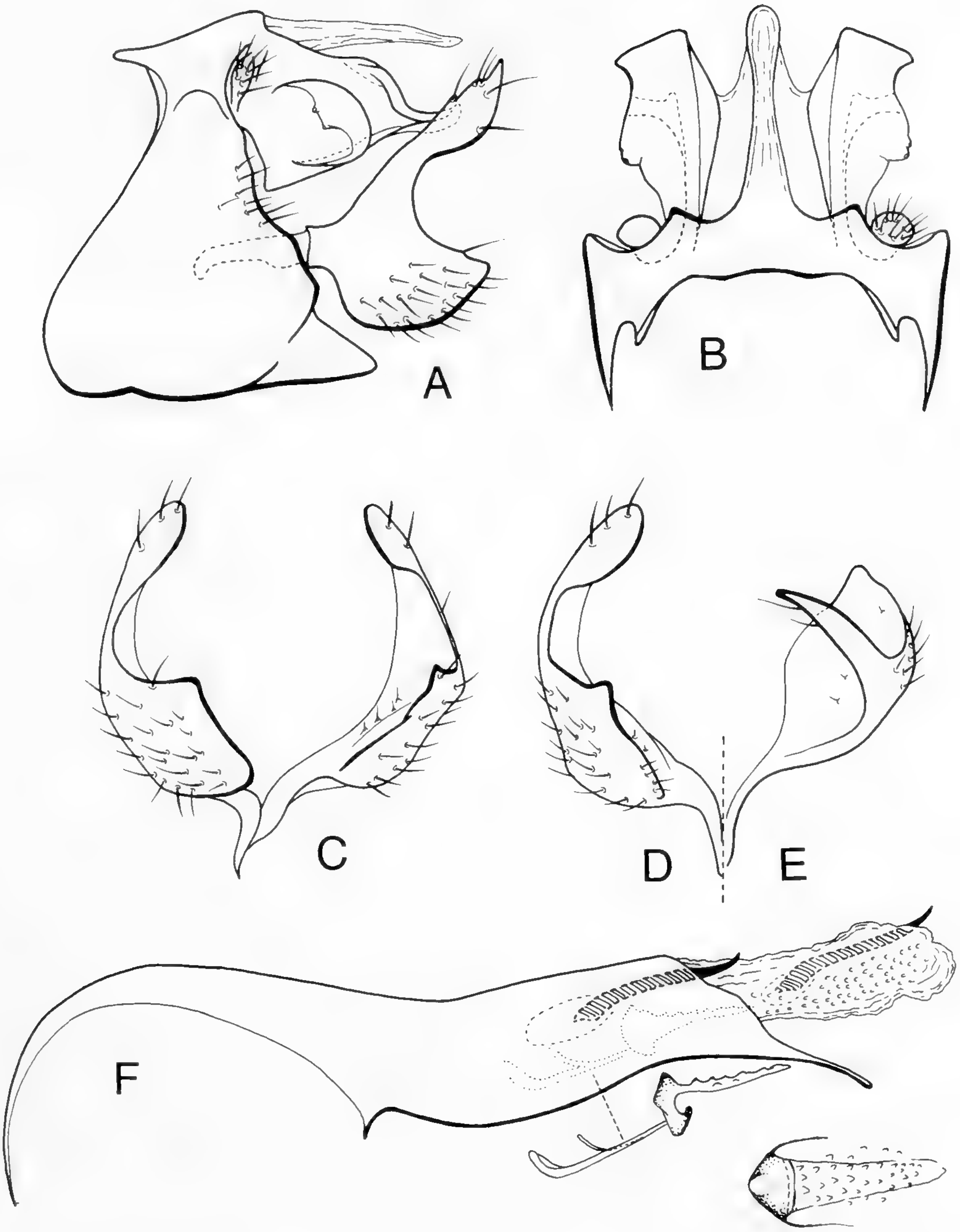

Fig. 11. A–F. *Chimarra paraortiziana* new species, male genitalia: A, lateral; B, dorsal; C, inferior appendages, oblique lateral; D, inferior appendage, caudal; E, inferior appendage, dorsal; F, phallus (insets: phallotremal sclerite complex and sclerous curl, and dorsal enlargement of sclerous curl).

silla on small nipplelike projections; midlateral expansion of lateral lobe inwardly concave from the anterior margin (visible as viewed laterally); terminus of lateral lobe flattened and acutely angled at the outer edge. Inferior appendages, in lateral view, with rounded base and acute apex, sinuously connected from caudal margin to flattened, elongate, dorsal, thumblike projection; thumblike projection only slightly curved posteriorly (as viewed laterally), and moderately curved proximally (as viewed caudally). Phallus with pronounced apicoventral extension of phallobase; endothecal spines two, subequal, relatively short; tip of phallus with minute, echinate spines and distinctive sclerotized region forming a curl, and in which echinate spines are also sclerotized. Phallotremal sclerite complex composed of elongate rod and ring structure, and apical membranous structure with associated pair of wishbonelike sclerites.

Holotype: ♂, Costa Rica: Heredia: Estación Biológica La Selva, Quebrada El Salto, 10.427°N, 84.005°W, el 50 m, 10.ii.1986, Holzenthal (NMNH). *Paratypes:* Costa Rica: Alajuela: 22 ♂ (in alcohol), P. N. (Parque Nacional) Rincón de la Vieja, Quebrada Provisión, 10.769°N, 85.281°W, el 810 m, 04.iii.1986, Holzenthal & Fasth (UMSP); 2 ♂ (in alcohol), Cerro Campana, R. Bochinche trib., 6 km (air) NW Dos Ríos, 10.945°N, 85.413°W, el 600 m, 22–23.vii.1987, Holzenthal, Morse, Clausen (UMSP); 2 ♂ (in alcohol), Reserva Forestal San Ramón, Río San Lorencito & tribs., 10.216°N, 84.607°W, el 980 m, 30.iii–01.iv.1987, Holzenthal, Hamilton, Heyn (UMSP); Cartago: 1 ♂, 1 ♀ (in alcohol), Lago Orosi, 1.9 km SE Ujarrás, 9.824°N, 83.825°W, el 980 m, 29.i.1986, Holzenthal, Morse, Fasth (UMSP); 1 ♂ (in alcohol), Río Platanillo, 2.2 km E Tayutic, 9.82°N, 83.55°W, el 730 m, 30.i.1986, Holzenthal, Morse, Fasth (UMSP); Guanacaste: 1 ♂ (in alcohol), Quebrada Garcia, 10.6 km ENE Quebrada Grande, 10.862°N, 85.428°W, el 470 m, 08.iii.1986, Holzenthal & Fasth (UMSP); 1 ♂ (in alcohol), Río Los Ahogados, 11.3 km ENE Quebrada Grande, 10.865°N, 85.423°W, el 470 m, 07.iii.1986, Holzenthal & Fasth (UMSP); 8 ♂ (in alcohol), P. N. Guanacaste, El Hacha, Quebrada Alcornoque, 11.009°N, 85.577°W, el 250 m, 26.vii.1987, Holzenthal, Morse, Clausen (NMNH); 5 ♂, P. N. Guanacaste, Estación Pitilla, Río Orosí, 10.991°N, 85.428°W, el 700 m, 22–25.v.1990, Holzenthal & Blahnik (UMSP); Heredia: 10 ♂ (in alcohol), Estación Biológica La Selva, Río Puerto Viejo, 10.440°N, 84.012°W, el 30 m, 19.vi.1986, Holzenthal, Heyn, Armitage (INBIO); Puntarenas: 1 ♂, Río Jaba at rock quarry, 1.4 km (air) W Las Cruces, 8.79°N, 82.97°W, el 1150 m, 15.iii.1991, Holzenthal, Muñoz, Huisman (UMSP).

Etymology: From the Greek *para,* for beside, and meaning near Ortiziana, because of the similarity of this species to *Chimarra ortiziana* Flint.

Chimarra peineta Blahnik and Holzenthal, New Species
Fig. 12A–F

This is another member of the Ortiziana Group of species. It can be distinguished by a combination of characters, each of which is very similar to other species in the Ortiziana Group. The inferior appendages are very similar to those of *Chimarra villalobosi* Bueno and *C. pollex* n. sp. They differ from the former in that the dorsal thumblike processes are slightly more strongly flexed and more enlarged and rounded apically, and from the latter by being less globose in contour and with the thumblike processes slightly longer (although very similarly flexed). *Chimarra peineta* is easily separated from these two species, however, in the structure of the tenth tergum. The lateral lobe of tergum X of *C. villalobosi,* which is not figured in the description of that species, is elongate, with a gradually emergent, rounded, sensilla-bearing lateral projection, and a much narrowed apex that is usually abruptly outwardly flexed near its terminus. The clustered phallic spines in *C. villalobosi* are also distinctly less elongate than in *C. peineta.* The structure of tergum X of *C. peineta* is, however, very similar to *C. paraortiziana* n. sp., and the linear array of spines in the phallus much resembles that of *C. platyrhina* Flint and *C. dolabrifera* Flint. All of these latter species, however, have inferior appendages with less flexed thumblike processes. In addition, *C. paraortiziana* has shorter phallic spines than those found in *C. peineta.* Although the characters sepa-

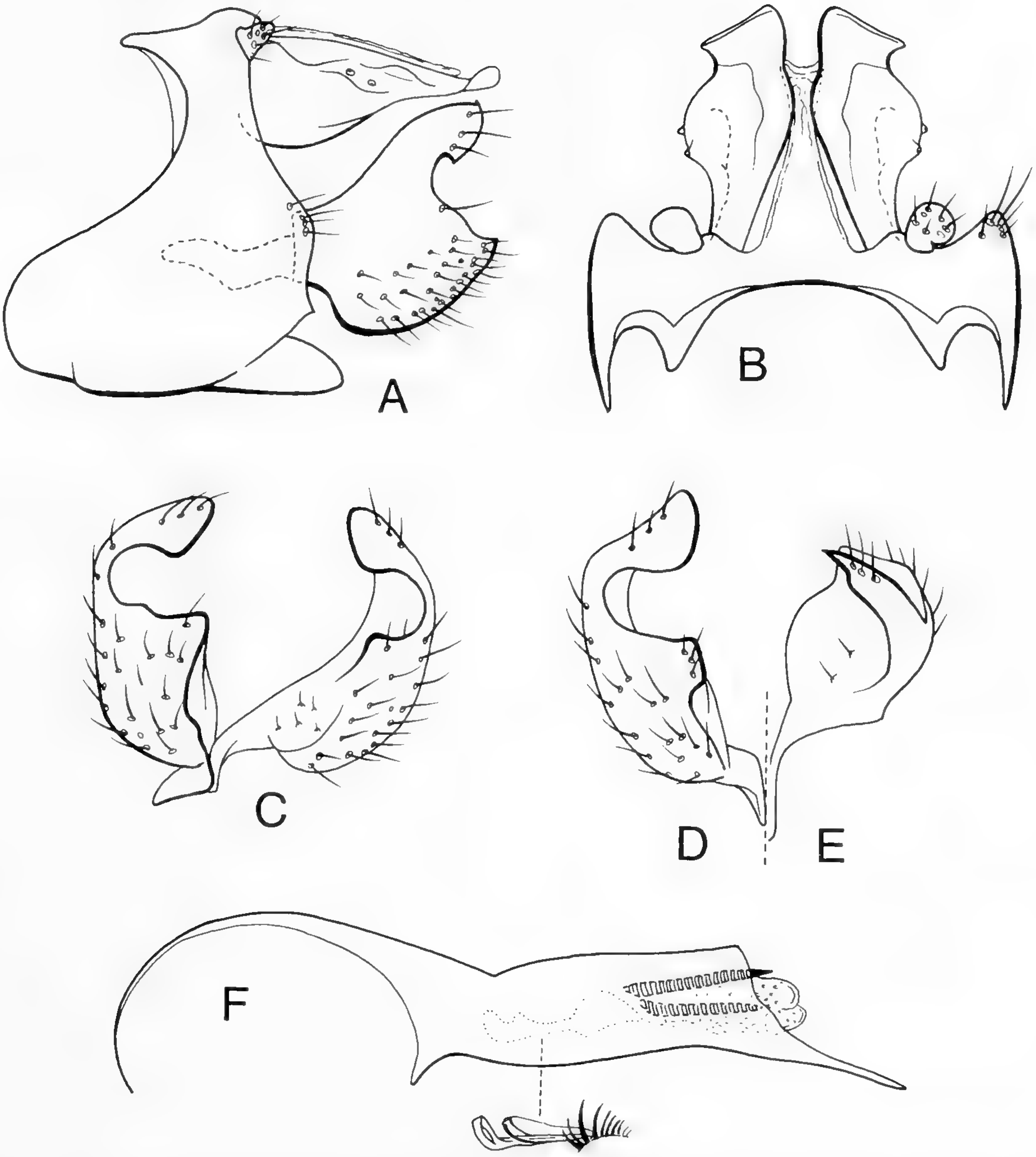

Fig. 12. A–F. *Chimarra peineta* new species, male genitalia: A, lateral; B, dorsal; C, inferior appendages, oblique lateral; D, inferior appendage, caudal; E, inferior appendage, dorsal; F, phallus (inset: phallotremal sclerite complex and phallic spines).

rating the various species may seem of doubtful significance, all of the Costa Rican species have been found in various combinations of sympatric populations, easily separable to species and without intergrading variation.

Male: Forewing length 3.6–4.8 mm. Color rather uniformly fuscous, except head somewhat darker and femora yellowish-brown. Genitalia: Abdominal segment IX, in lateral view, with pronounced sinuous extension of anteroventral margin and with apodemelike projections from the anterodorsal margin; posteroventral process moderately elongate, narrowed apically. Tergum X membranous mesally, with two heavily sclerotized lateral lobes, each bearing broadly rounded expansion midlaterally, with two sensilla raised on small nipplelike projections; terminus of lateral lobe flattened and acutely angled at outer edge. Inferior appendage, in lateral view, with subquadrate base and flattened, thumblike, dorsal extension, flexed caudally (when viewed laterally) and proximally (when viewed caudally); thumblike projection apically rounded and forming distinct notch produced by its flexion with respect to base, much as in C. *pollex* n. sp., but flexion point more angular and length of thumblike process longer than that species. Phallus with pronounced apicoventral extension of phallobase; endothecal spines two, subequal, relatively short; tip of phallus (apparently) with minute, echinate spines and sclerous region possessing bilinear array of radiating, curved spines, graduated in length; paired spines of bilinear array often closely apposed in unexpanded phallus and appearing as single array. Phallotremal sclerite complex composed of elongate rod and ring structure, and apical membranous structure with associated pair of wishbonelike sclerites.

Holotype: ♂, Costa Rica: Guanacaste: Parque Nacional Guanacaste, El Hacha, Quebrada Alcornoque, 11.009°N, 85.577°W, el 250 m, 26.vii.1987, Holzenthal, Morse, Clausen (NMNH). *Paratypes:* Costa Rica: Alajuela: 3 ♂, 1 ♀ (in alcohol), Río Pizote, ca. 5 km N Dos Ríos, 10.948°N, 85.291°W, el 470 m, 09.iii.1986, Holzenthal & Fasth (UMSP); 42 ♂ (in alcohol), Río Pizote, ca. 5 km (air) S Brasilia, 10.972°N, 85.345°W, el 390 m, 12.iii.1986, Holzenthal & Fasth (UMSP); Guanacaste: 1 ♂, P. N. (Parque Nacional) Guanacaste, El Hacha, Quebrada Pedregal, 10.983°N, 85.539°W, el 300 m, 27.vii.1987, Holzenthal, Morse, Clausen (UMSP); 8 ♂ (pinned), 2 ♂ (in alcohol), same data as holotype (UMSP); 1 ♂, P. N. Guanacaste, Estación Pitilla, Río Orosí, 10.991°N, 85.428°W, el 700 m, 22–25.v.1990, Holzenthal & Blahnik (UMSP); Heredia: 4 ♂, Río Bijagual on road to Magsasay, 10.408°N, 84.076°W, el 140 m, 12.ii.1986, Holzenthal, Morse, Fasth (INBIO); 9 ♂ (in alcohol), Estación Biológica La Selva, Río Puerto Viejo, 10.440°N, 84.012°W, el 30 m, 19.vi.1986, Holzenthal, Heyn, Armitage (UMSP); Limón: 1 ♂ (in alcohol), La Lola, nr Matina, 11.iii.1965, S. & W. D. Duckworth (NMNH); Puntarenas: 1 ♂, Reserva Biológica Carara, Quebrada Bonita, 9.775°N, 84.605°W, el 35 m, 11.iii.1991, Holzenthal, Muñoz, Huisman (UMSP); San José: 3 ♂ (in alcohol), P. N. Braulio Carrillo, Estación Carrillo, Quebrada Sanguijuela, 10.160°N, 83.963°W, el 800 m, 27.iii.1987, Holzenthal, Hamilton, Heyn (UMSP); 4 ♂, 4 ♀ 16 mi S San Isidro, 02.vii.1967, Flint & Ortiz (NMNH); Panama: San Blas: 1 ♂, Quebrada Pingadi, 9 km N Nusagandi, 01–02.iii.1985, Flint & Louton (NMNH); Canal Zone: Barro Colorado Island: 1 ♂, 1 ♀, vii.1967, W. W. Wirth (NMNH); 1 ♂ (in alcohol), Poacher's Peninsula, 06–10.iv.1987, H. Wolda (NMNH); 1 ♂ (in alcohol), 27–31.iv.1986, H. Wolda (NMNH); 3 ♂, 12.iii.1967, M. E. Irwin (UCR).

Etymology: Peineta, the Spanish word for a woman's comb, in reference to the array of spines of the phallus.

Chimarra pollex Blahnik and Holzenthal, New Species

Fig. 13A–F

This species is also a member of the Ortiziana Group of species. It is very similar to *C. solisi* n. sp., but differs in the shape of the inferior appendages, which, in this species, are more globose—the dorsal thumblike processes being very short and tightly curled. In the latter character it much resembles *C. peineta* n. sp., but differs from that species by having the lateral lobes of tergum X less sclerotized and with the lateral sensilla on distinct, well-developed, nipplelike projections, and also by lacking a linear cluster of spines in the phallus.

Male: Forewing length 4.2–5.5 mm. Color rather uniformly fuscous black, except femora yellowish to yellowish-brown. Genitalia: Abdominal segment IX, in lateral view, with distinct sinuous extension of anteroventral margin and with small apodemes from the anterodorsal margin; posteroventral process moderately elongate and

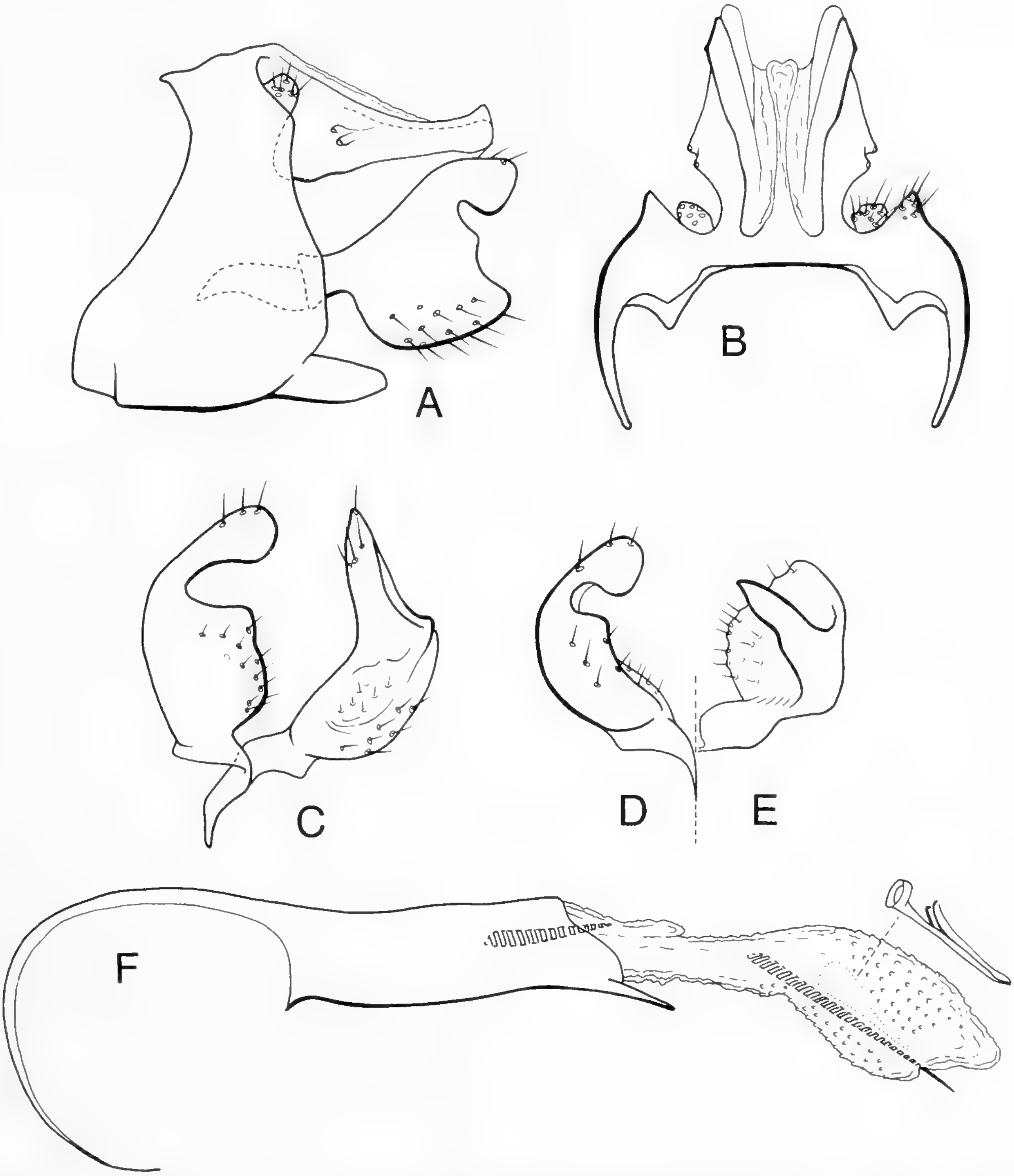

Fig. 13. A–F. *Chimarra pollex* new species, male genitalia: A, lateral; B, dorsal; C, inferior appendages, oblique lateral; D, inferior appendage, caudal; E, inferior appendage, dorsal; F, phallus (inset: phallotremal sclerite complex).

apically rounded. Tergum X membranous mesally, with pair of sclerotized lateral lobes, each with pair of pronounced nipplelike, sensillum-bearing, projections midlaterally; terminus of lateral lobe flattened and forming slight dorsal protuberance by extension of outer margin. Inferior appendage, in lateral view, with subquadrate (but somewhat rounded) base and a short, flattened, thumblike dorsal extension; thumblike extension very strongly curled or flexed, both caudally (when viewed laterally) and proximally (when viewed caudally), forming distinct notch produced by its flexion with respect to base. Phallus with distinct apicoventral extension of phallobase; endothecal spines two, one short and emergent from base of endotheca, posterior one somewhat longer and emergent from middle of endotheca; tip of phallus, when expanded, globose and bearing numerous minute, echinate spines, these appearing as granular area within phallobase of unexpanded phallus; phallotremal sclerite complex composed of elongate rod and ring structure and apical membranous structure with associated pair of wishbonelike sclerites.

Holotype: ♂, Costa Rica: Alajuela: Reserva Forestal San Ramón, Río San Lorencito & tribs., 10.216°N, 84.607°W, el 980 m, 01–04.v.1990, Holzenthal & Blahnik (NMNH). *Paratypes:* Costa Rica: Alajuela: 2 ♂ (pinned), 35 ♂ (in alcohol), P. N. (Parque Nacional) Rincón de la Vieja, Quebrada Provisión, el 810 m, 04.iii.1986, Holzenthal & Fasth (UMSP); 5 ♂ (pinned), 7 ♂ (in alcohol), Cerro Campana, Río Bochinche trib., 6 km (air) NW Dos Ríos, el 600 m, 22–23.vii.1987, Holzenthal, Morse, Clausen (UMSP); 1 ♂, Reserva Forestal San Ramón, Río San Lorencito & tribs., 10.216°N, 84.607°W, el 980 m, 24–27.ii.1987, I. & A. Chacón (UMSP); 5 ♂, 1 ♀ (pinned), 242 ♂ (in alcohol), same location, 30.iii.–01.iv.1987, Holzenthal, Hamilton, Heyn (UMSP); 4 ♂, same location, 02–04.vii.1986, Holzenthal, Heyn, Armitage (UMSP); 18 ♂, 6 ♀ (pinned), 39 ♂, 42 ♀ (in alcohol), same location, 13–16.vi.1988, C. M. & O. S. Flint, Holzenthal (NMNH); 2 ♂, same location, 28–30.vii.1990, Holzenthal, Blahnik, Muñoz (UMSP); 11 ♂, same location, 06–10.iii.1991, Holzenthal, Muñoz, Huisman (INBIO); Cartago: 2 ♂, Quebrada Platanillo, ca. 5 km E Moravia de Chiripó, 9.821°N, 83.407°W, el 1130 m, 06.viii.1987, Holzenthal, Morse, Clausen (UMSP); 12 ♂ (in alcohol), same location, 07.viii.1987, Holzenthal, Morse, Clausen (UMSP); 2 ♂, Quebrada Latas, 8.9 km NE Bajos del Toro, 10.269°N, 84.260°W, el 1030 m, 06.ix.1990, Holzenthal, Blahnik, Huisman (UMSP); 5 ♂, Río Agrio, ca. 3.5 km NE Bajos del Toro, 10.243°N, 84.279°W, el 1290 m, 20.viii.1990, Holzenthal et al. (UMSP); 1 ♂, Río Chitaria, route 10, 10 km NW Río Reventazón, 9.920°N, 83.604°W, el 740 m, 21.iii.1991, Holzenthal, Muñoz, Huisman (UMSP); Guanacaste: 3 ♂ (pinned), 121 ♂ (in alcohol), Quebrada Garcia, 10.6 km ENE Quebrada Grande, 10.862°N, 85.428°W, el 470 m, 08.iii.1986, Holzenthal & Fasth (UMSP); 1 ♂, P. N. Rincón de la Vieja, Río Negro, 10.765°N, 85.313°W, 810 m, 03.iii.1986, Holzenthal & Fasth (UMSP); 3 ♂, 1 ♀ (pinned), 18 ♂ (in alcohol), Río Góngora (sulfur mine), 4 km (air) NE Quebrada Grande, 10.887°N, 85.470°W, el 590 m, 21.vii.1987, Holzenthal, Morse, Clausen (UMSP); 3 ♂ (pinned), 20 ♂ (in alcohol), P. N. Guanacaste, El Hacha, Quebrada Alcornoque, 11.009°N, 85.577°W, el 250 m, 26.vii.1987, Holzenthal, Morse, Clausen (UMSP); 1 ♂ (pinned), 3 ♂ (in alcohol), P. N. Guanacaste, Maritza, Río Tempisquito, 10.958°N, 85.497°W, el 550 m, 19–20.vii.1987, Holzenthal, Morse, Clausen (UMSP); 5 ♂, same location, 30–31.viii.1990, Huisman, Blahnik, Quesada (INBIO); 2 ♂ (pinned), 13 ♂, 23 ♀ (in alcohol), same location, 17–18.vi.1988, C. M. & O. S. Flint, Holzenthal (NMNH); 18 ♂, P. N. Guanacaste, ca. 0.7 km N Estación Maritza, 10.96°N, 85.50°W, el 550 m, 31.viii.1990, Huisman & Quesada (UMSP); 8 ♂ (in alcohol), Río Los Ahogados, 11.3 km ENE Quebrada Grande, 10.865°N, 85.423°W, el 470 m, 07.iii.1986, Holzenthal & Fasth (UMSP); 11 ♂, 15 ♀ (pinned), 7 ♂, 8 ♀ (in alcohol), P. N. Guanacaste, Estación Pitilla, Río Orosí, 10.991°N, 85.428°W, el 700 m, 19–20.vi.1988, C. M. & O. S. Flint, Holzenthal (NMNH); 33 ♂, same location, 22–25.v.1990, Holzenthal & Blahnik (UMSP); Heredia: 2 ♂ (in alcohol), Rara Avis Biol. Station, Quebrada Chiquiza, 10.229°N, 84.032°W, el 550 m, 31.iii.1989, Blahnik & Solís (UMSP); 1 ♂, P. N. Braulio Carrillo, Estación El Ceibo, Río Peje, 10.327°N, 84.078°W, el 480 m, 29–31.v.1990, Holzenthal, Blahnik, Muñoz (UMSP); Limón: 2 ♂, P. N. Braulio Carrillo, Quebrada Gonzalez, 10.160°N, 83.939°W, el 480 m, 12–14.v.1990, Holzenthal & Blahnik (UMSP);

Puntarenas: 2 ♂ (in alcohol), Río Singrí, ca. 2 km (air) S Finca Helechales, 9.057°N, 83.082°W, el 720 m, 21.ii.1986, Holzenthal, Morse, Fasth (UMSP); 5 ♂, Río Jaba at rock quarry, 1.4 km (air) W Las Cruces, 8.79°N, 82.97°W, el 1150 m, 09.viii.1990, Holzenthal, Blahnik, Muñoz (UMSP); San José: 5 ♂ (pinned), 2 ♂ (in alcohol), P. N. Braulio Carrillo, Estación Carrillo, Quebrada Sanguijeula, 10.160°N, 83.963°W, el 800 m, 27.iii.1987, Holzenthal, Hamilton, Heyn (UMSP); 2 ♂, 12 ♀, same location, 11–12.vi.1988, C. M. & O. S. Flint, A. Chacón (NMNH). Panama: Canal Zone: 6 ♂, Barro Colorado Island, 12.iii.1967, M. E. Irwin (UCR); San Blas: 1 ♂, 2 ♀, Nusagandi, 9°20′N, 78°56′W, el 350 m, 01–06.iii.1985, Flint & Louton (NMNH).

Etymology: Pollex, from the Latin for thumb, in reference to the distinctive thumblike extensions from the inferior appendage of this species.

Chimarra solisi Blahnik and Holzenthal, New Species

Fig. 14A–F

This species is another member of the Ortiziana Group of species. It is practically identical to *C. pollex* n. sp. in the structure of the tenth tergum, but differs from that species in the structure of the inferior appendages, which, in this species, have longer, narrower, and less tightly curled, thumblike projections.

Male: Forewing length 4.5–4.8 mm. Color (in alcohol) brownish. Genitalia: Abdominal segment IX, in lateral view, with distinct sinuous extension of anteroventral margin and with small apodemes from the anterodorsal margin; posteroventral process moderately elongate, narrowed apically. Tergum X membranous mesally, with pair of sclerotized lateral lobes, each with pair of pronounced, nipplelike, sensillum-bearing, projections midlaterally; terminus flattened, the outer edge slightly protuberant, much as in *C. pollex* n. sp., but slightly more pronounced. Inferior appendage, in lateral view, with base distinctly quadrate, dorsally with narrowed thumblike appendage, strongly curved caudally (when viewed laterally) and more distinctly curved proximally (when viewed caudally). Phallus with distinct apicoventral extension of phallobase; endothecal spines two, subequal in length, moderately elongate; tip of phallus (apparently) with minute echinate spines, phallotremal sclerite complex composed of a rod and ring structure, and membranous apical structure with associated pair of wishbonelike sclerites.

Holotype: ♂, Costa Rica: Heredia: Rara Avis Biol. Station, Quebrada Chiquiza, 10.229°N, 84.032°W, el 550 m, 31.iii.1989, Blahnik & Solís (NMNH). *Paratypes:* Costa Rica: Heredia: 1 ♂ (in alcohol), same data as holotype (UMSP); 1 ♂ (in alcohol), same data as holotype (INBIO).

Etymology: Named for Angel Solís Blanco, who collected this new species at a site where the first author only managed to fall and break his hand.

Chimarra virgencita Blahnik and Holzenthal, New Species

Fig. 15A–F

This is a unique species with no obvious close relationship to other described species of *Chimarra.* Several characters suggest a distant relationship to *C. amica* n. sp., *C. longiterga* n. sp., and their relatives, but this has not been ascertained. A possible affinity to *C. longiterga* is also suggested by the fact that both collection sites for this species were in the vicinity of small trickling waterfalls. It is easily recognized by the shape of the inferior appendages and the structure of the lateral lobes of the tenth tergum.

Male: Forewing length 5.3–5.6 mm (females 6.1–6.8 mm). Color nearly uniformly fuscous black, except femora yellowish. Genitalia: Abdominal segment IX with well-developed anterodorsal apodemes and a pronounced, sinuous extension of the anteroventral margin; posteroventral process short, narrow, subacute. Tergum X mem-

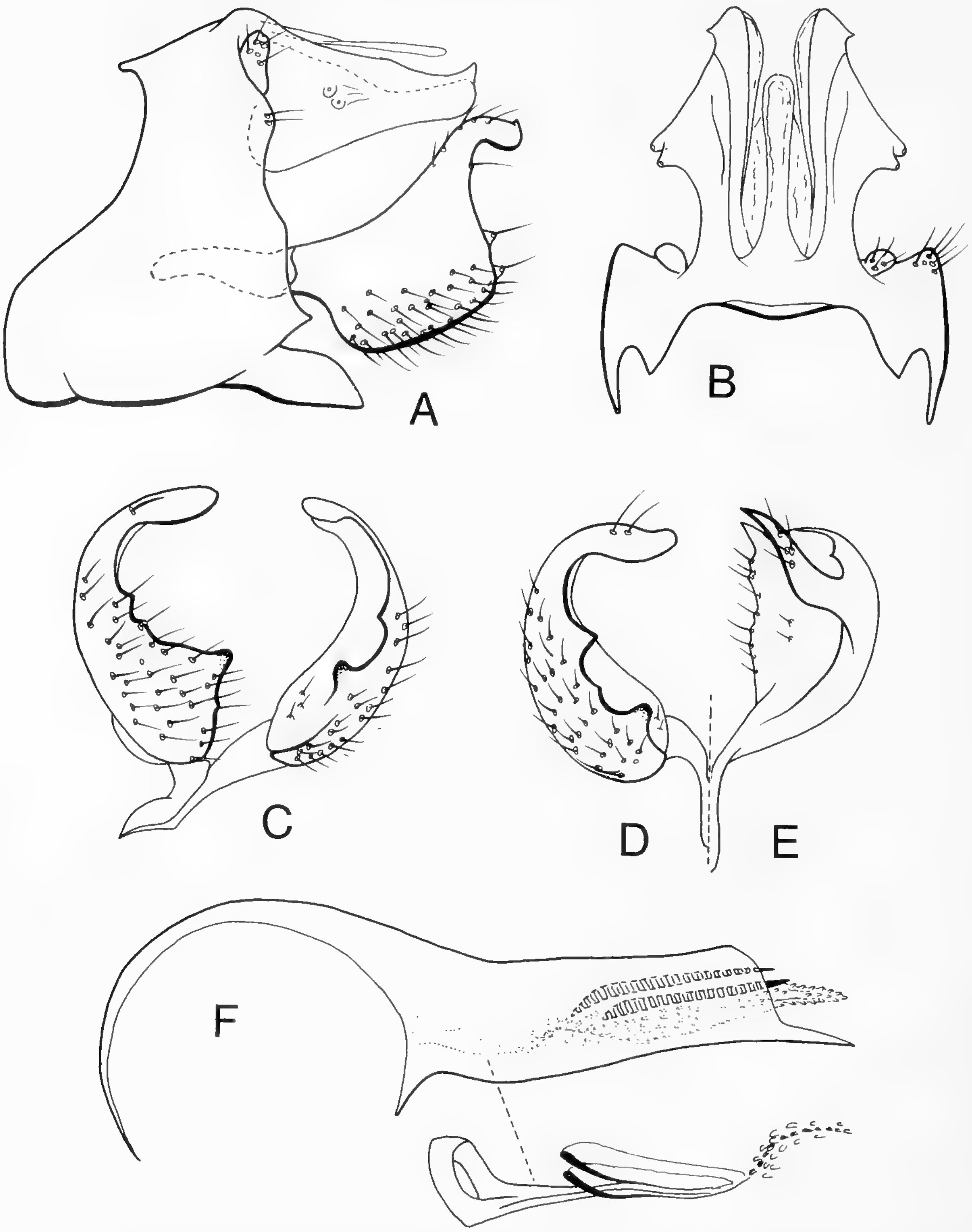

Fig. 14. A–F. *Chimarra solisi* new species, male genitalia: A, lateral; B, dorsal; C, inferior appendages, oblique lateral; D, inferior appendage, caudal; E, inferior appendage, dorsal; F, phallus (inset: enlargement of phallotremal sclerite complex).

branous mesally, with two sclerotized lateral lobes; apex of lateral lobes distinctly spoon-shaped on proximal surface; each lobe with two sensilla located basolaterally. Preanal appendages small, short, rounded. Inferior appendage rather ovate, apically with subequal dorsal and ventral lobes, separated by sinuous excavation; basodorsally with distinct setose protuberance on proximal surface. Phallus with slight apicoventral extension of phallobase; endothecal spines two, short, subequal; apex of phallus (apparently) with minute echinate spines; phallotremal sclerite complex composed of rod and ring structure and membranous apical structure.

Holotype: ♂, Costa Rica: Alajuela: Quebrada Virgencita, 10.2 km S Bajos del Toro,

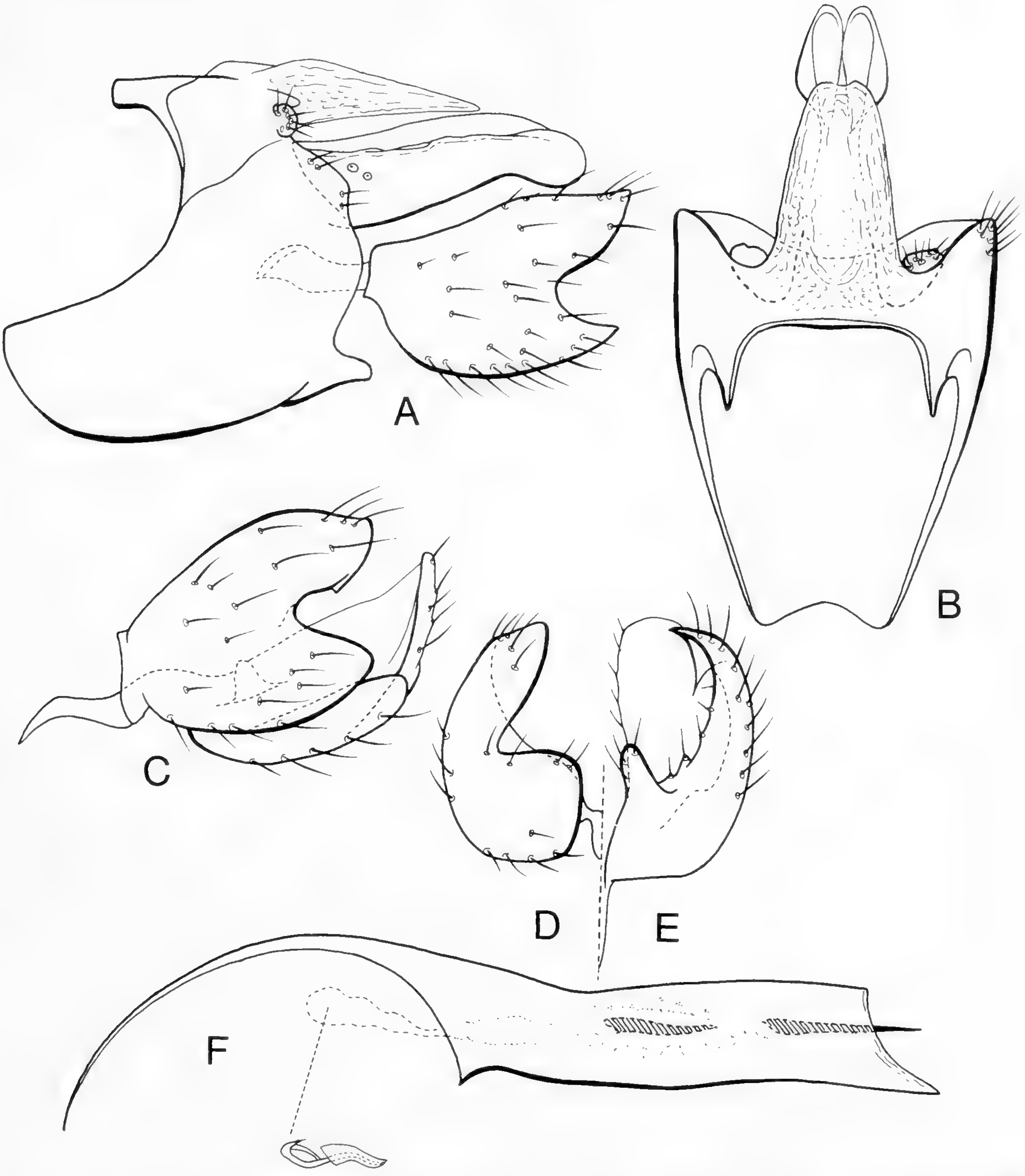

Fig. 15. A–F. *Chimarra virgencita* new species, male genitalia: A, lateral; B, dorsal; C, inferior appendages, oblique lateral; D, inferior appendage, caudal; E, inferior appendage, dorsal; F, phallus (inset: phallotremal sclerite complex).

10.168°N, 84.326°W, el 1780 m, 05–06.ix.1990, Holzenthal, Blahnik, Huisman (NMNH). *Paratypes:* Costa Rica: Alajuela: 5 ♀, same data as holotype (NMNH); Cartago: 3 ♂, 2 ♀, Reserva Tapantí, Río Dos Amigos & falls, ca. 6 km (rd) NW tunnel, 9.704°N, 83.783°W, el 1500 m, 04–05.viii.1990, Holzenthal, Blahnik, Muñoz (UMSP); 1 ♂, same location, 23.iii.1991, Holzenthal, Muñoz, Huisman (UMSP); 2 ♂, Reserva Tapantí, Quebrada Palmitos & falls, 9.72°N, 83.78°W, el 1400 m, 02–03.vi.1990, Holzenthal, Blahnik, Muñoz (INBIO); 1 ♂, 1 ♀, same location, 24–25.iii.1991, Holzenthal, Muñoz, Huisman (UMSP).

Etymology: Virgencita (little virgin), named for the type locality in Costa Rica, Quebrada Virgencita, itself marked by a small shrine of the Blessed Virgin placed overlooking a small waterfall and pool.

Chimarra yanura Blahnik and Holzenthal, New Species

Fig. 16A–F

This species is a member of the Beameri Group of *Chimarra,* and may, in fact, be a geographical variant of *C. beameri* Denning. However, *C. beameri* has rather constant morphology in its distribution from Texas to southern Mexico, and *C. yanura* differs in several respects from this form. In *Chimarra beameri* the apical prominence of the lateral lobe of the tenth tergum extends for about half the length of the lobe and has, at its apex, a distinct dorsal projection, sometimes giving the apex a cup-shaped appearance. In *C. yanura* the apical prominence is shorter and the apical projection, if present, is not prominent. Moreover, in *C. yanura* there is a distinct middorsal projection extending from the posterior edge of the ninth segment, which is absent in *C. beameri.* Also, the inferior appendage, as viewed caudally, is sinuously (less angularly) flexed in *C. yanura,* and posseses at its apex a preapical dorsal process, absent in *C. beameri.* These differences, while slight, have not been demonstrated to have interconnecting variability, and may well indicate species status for the two forms. In the course of the study of Costa Rican *Chimarra,* various pairs of similar species have often proven their distinctness by eventually being found co-existing in the same site, and without intergrading forms being found. It has proven prudent not to casually dismiss apparently minor variability. More complete collection records in the intervening area between southern Mexico and Costa Rica should help resolve the question of the relationship of *C. beameri* and *C. yanura.*

Male: Forewing length 4.3–4.8 mm. Color rather uniformly fuscous, except femora yellowish. Genitalia: Abdominal segment IX with well-developed anterodorsal apodemes, anteroventral margin distinctly extended, joined linearly from dorsal apodemes to rounded ventrolateral margin; posteroventral process broad, subtriangular. Tergum X membranous mesally, with two sclerotized lateral lobes; lateral lobe with apical prominence formed by preapical, lateral spinelike protuberance; each apex of lateral lobe bearing pair of sensilla on slightly raised prominences, and with lateral crease. Tergum IX with middorsal, subtriangular projection. Preanal appendages small, short, somewhat flattened and knoblike. Inferior appendage, in lateral view, with rounded base and wide, tapering, dorsal projection, having truncate apex and preapical dorsal projection; in caudal view, inferior appendage with sinuous proximal curvature; proximal surface of appendage with setose ridge. Phallus with acute apicoventral extension of phallobase; phallobase somewhat convergent apically; endothecal spines two, slightly curved and unequal in length, one long, one of moderate length; apex of phallus (apparently) with minute echinate spines; phallotremal sclerite complex composed of rod and ring structure (rod short and curved and ring with prominent apicodorsal extension), and membranous apical structure with pair of fish-hooklike sclerites along anterior edge.

Holotype: ♂, Costa Rica: Limón: Parque Nacional Braulio Carrillo, Quebrada González, 10.160°N, 83.939°W, el 480 m, 12–14.v.1990, Holzenthal & Blahnik (NMNH). *Paratypes:* Costa Rica: Heredia: 3 ♂ (in alcohol), Estación Biológica La Selva, Río Puerto Viejo, 10.440°N, 84.012°W, el 30 m, 19.vi.1986, Holzenthal, Heyn, Armitage (UMSP); 2 ♂, 1 ♀ (in alcohol), La Selva Field Station nr. Puerto Viejo, 10°26′N, 83°59′W, 01–03.iv.1987, J. Hill (NMNH); Limón: 1

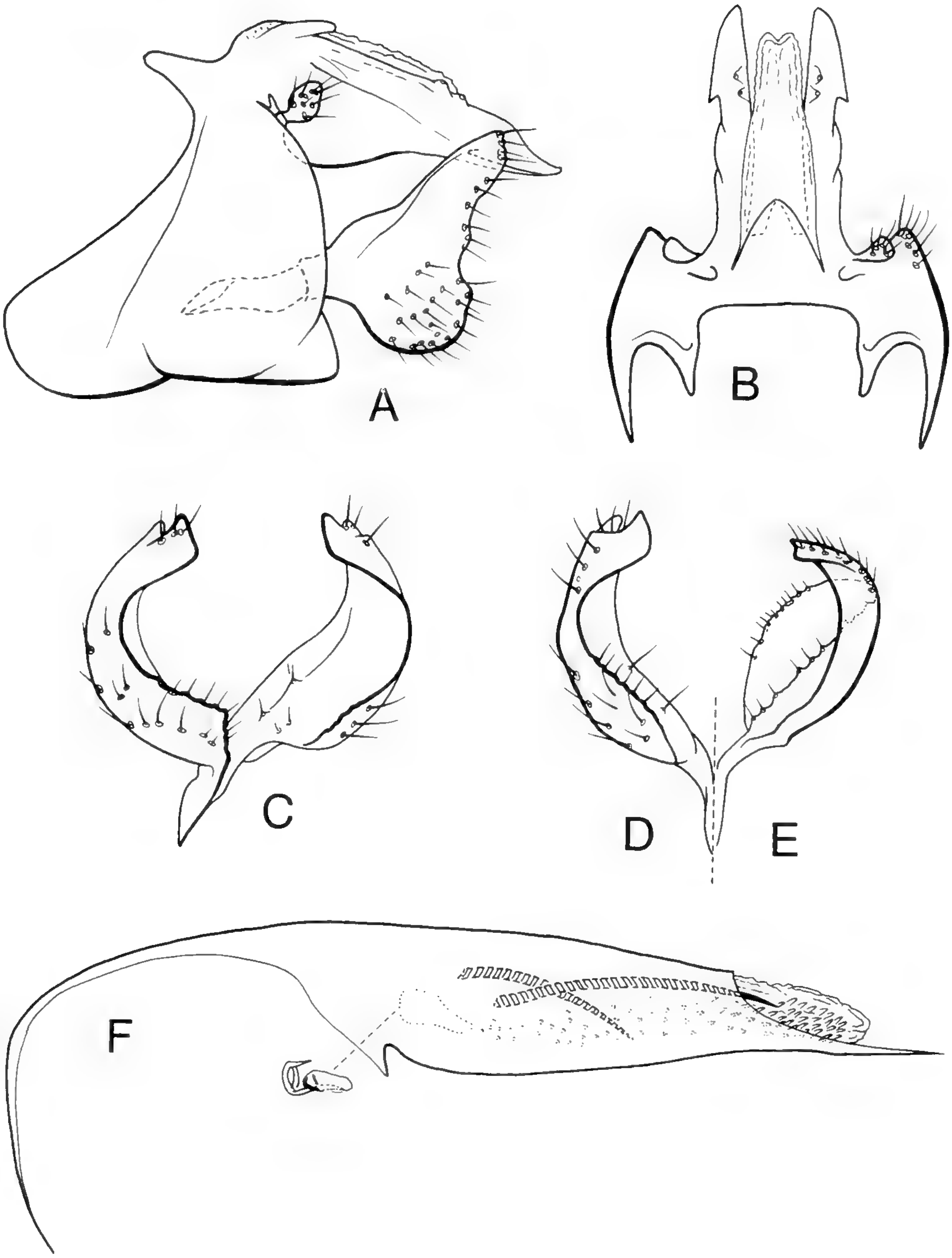

Fig. 16. A–F. *Chimarra yanura* new species, male genitalia: A, lateral; B, dorsal; C, inferior appendages, oblique lateral; D, inferior appendage, caudal; E, inferior appendage, dorsal; F, phallus (inset: phallotremal sclerite complex).

♂ (in alcohol), Río Barbilla, ca. 8 km W B-Line, 10.067°N, 83.369°W, el 30 m, 31.i.1986, Holzenthal, Morse, Fasth (UMSP); 1 ♂ (in alcohol), Río Telire and small trib., SE Suretka, 9.554°N, 82.892°W, el 48 m, 01.ii.1986, Holzenthal, Morse, Fasth (INBIO).

Etymology: Yanura, from the Spanish word *llanura,* meaning lowland, and named for the Atlantic lowland slopes of Costa Rica where this species has been collected.

NEW DISTRIBUTION RECORDS

Chimarra angustipennis Banks 1903

Costa Rica: Guanacaste: 2 ♂, P. N. Santa Rosa, Río Poza Salada, 10.799°N, 85.652°W, el 19 m, 24.vii.1987, Holzenthal, Morse, Clausen (UMSP); 1 ♂, P. N. (Parque Nacional) Guanacaste, Maritza, Río Tempisquito, 10.958°N, 85.497°W, el 550 m, 19–20.vii.1987, Holzenthal, Morse, Clausen (UMSP); 1 ♂, Río Tempisquito, Hda. Tempisquito (Pelón de la Altura), 10.847°N, 85.561°W, el 95 m, 18.vii.1987, Holzenthal, Morse, de la Rosa (UMSP); Puntarenas: 1 ♂, 1 ♀ (in alcohol), Río Rincón, 6.5 km (air) S Rincón, 8.638°N, 83.480°W, el 20 m, 07.iv.1987, Holzenthal, Hamilton, Heyn (UMSP); 2 ♂, 9 ♀ (pinned), 9 ♂, 20 ♀ (in alcohol), Río Seco, NW of Esparta, 23.vii.1967, O. S. Flint, Jr. (NMNH); 12 ♂ (in alcohol), 9 mi NW Esparta, 22.vii.1965, Paul J. Spangler (NMNH); 4 ♂ (in alcohol), Río La Vieja nr Lagarto, 02–03.vii.1967, Flint & Ortiz (NMNH).

Chimarra dentosa Ross 1948

Costa Rica: Guanacaste: 1 ♂, Parque Nacional Santa Rosa, Río Cuajiniquil, 10.881°N, 85.613°W, 25.vii.1987, Holzenthal, Morse, Clausen (UMSP); 2 ♂ (in alcohol), Río Tizate, 7.2 km NE Canas Dulces, 10.773°N, 85.449°W, el 275 m, 28.vi.1986, Holzenthal, Heyn, Armitage (UMSP).

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STUDIES IN AQUATIC INSECTS, XI: SEVEN NEW SPECIES OF THE GENUS *OCHROTRICHIA* (*OCHROTRICHIA*) FROM SOUTH AMERICA (TRICHOPTERA; HYDROPTILIDAE)

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Abstract. — Seven new species in the genus *Ochrotrichia* (*Ochrotrichia*) from South America are described and the male genitalia figured. The species here described are **Ochrotrichia raposa** (Colombia, Ecuador); **O. puyana** (Ecuador); **O. ecuatoriana** (Ecuador, Colombia); **O. oblongata** (Trinidad); **O. unica** (Colombia); **O. yanayacuana** (Ecuador); and **O. concha** (Brasil), the southernmost record for the subgenus *Ochrotrichia* in South America.

Key Words: New species, *Ochrotrichia* (*Ochrotrichia*), Trichoptera, Hydroptilidae, South America

In 1979, Marshall established the tribe Ochrotrichiini in the subfamily Hydroptilinae for the genera *Ochrotrichia* including its two subgenera (the nominate and *Metrichia*) and *Rhyacopsyche.* All members of the tribe are limited to the New World, although other tribes in the subfamily are found in all other regions of the world. Denning and Blickle in their revision (1972) state that the genus, from which they exclude *Metrichia,* is "exclusively North American in distribution, occurring from a few localities in Canada to southern Mexico." In the same year Flint independently recorded twenty species from Mexico to Panama, and in 1981 recorded two species from northern Venezuela, the first records from South America. The recent report of *Ochrotrichia* (*O.*) *tenanga* Mosely from northern Peru was the first indication of the subgenus from the west coast of South America (Flint and Reyes 1991). Other reports (Botosaneanu 1979, 1990, Flint 1968) list the genus from the Greater and Lesser Antillean islands. Thus the distribution of the subgenus *Ochrotrichia* seemed to occur only in the northern and western margins of South America, in marked contrast to that of *Metrichia.* The latter has been recorded only as far north as Texas and Arizona in the United States, but as far south as central Chile (Flint 1983). It is found throughout the Antilles as well, and appears to be especially diverse in the Andean Mountains.

However, recent collections made in South America and placed in the National Museum of Natural History, Smithsonian Institution (USNM) show that the subgenus *Ochrotrichia* is actually more widely distributed and diverse in South America than believed. The species described herein extend the known distribution in northern South America east to Trinidad and fill in gaps in Colombia and Ecuador. The most unexpected record is from the central Amazon near Manaus, Brazil. In spite of these new records, the accumulation of specimens of subgenus *Ochrotrichia* from South America is very slow although many collections have been made there in recent years.

Ochrotrichia (O.) raposa,
New Species

Figs. 1–3

On the basis of the shape of the tenth tergum and inferior appendages, this species appears to be similar to *Ochrotrichia* (*O.*) *pacifica* Flint. The new species is distinguished by the presence of a short, slender, basodorsal process and a long process with the apex twisted on the left side on the tenth tergum.

Adult.—Length of forewing 2 mm. Color in alcohol dark brown. Male genitalia: Ninth segment deeply depressed and produced anteriad. Tenth tergum with short, slender, basal process on the right side; mesally with a stout process and a second stout process with apex curved to the left; another long, slender process with the apex twisted on the left side; in lateral view with short basodorsal process and with three long curved processes. Inferior appendages in lateral view long with the apex rounded; in dorsal and ventral views with a row of black peglike setae around apex and on midbasal ridge. Phallus long and threadlike.

Material.—Holotype, male: COLOMBIA: Dept. Valle del Cauca, Río Raposo, January 1965, V. H. Lee (USNM). Paratypes: ECUADOR: Esmeralda Prov., La Unión, 3 February 1979, Jos. J. Anderson, 1 ♂ (USNM); Los Ríos Prov., Quevedo (5 km S), 14 January 1978, P. J. Spangler & J. Anderson, 1 ♂ (USNM).

Etymology.—*raposa,* Spanish, feminine name for the Raposo River.

Ochrotrichia (O.) puyana,
New Species

Figs. 4–5

This species fits best into the *aldama* group (Flint 1972) on the basis of the shape of the inferior appendages and the tenth tergum. However, it is easily distinguished from all its congeners by the single, elongate mesal lobe of the tenth tergum which has two short curved spines, dorsolaterally.

Adult.—Length of forewing 2.5 mm. Color in alcohol dark brown. Male genitalia: Ninth segment deeply depressed and produced anteriad. Tenth tergum divided at apex with two short stout spines on the left side apically; in lateral view on the dorsal margin with two stout spines. Inferior appendages in lateral view elongate and broad; in dorsal view with an apical row of black peglike setae and with a few black peglike setae on the ventral margin. Phallus long and threadlike.

Material.—Holotype, male: ECUADOR: Pastaza Prov., Puyo, 11 May 1977, P. J. Spangler & D. R. Givens #36 (USNM).

Etymology.—*puyana,* Spanish, feminine for inhabitant of Puyo.

Ochrotrichia (O.) ecuatoriana,
New Species

Figs. 6–8

On the basis of the shape of the tenth tergum and inferior appendages in lateral view, this species appears to be closely related to *O. raposa.* However, the lack of the basodorsal spine on the tenth tergum makes *O. ecuatoriana* easily distinguished from that species.

Adult.—Length of forewing 2.5 mm. Color in alcohol pale brown. Male genitalia: Ninth segment deeply depressed and slightly produced anteriad; in lateral aspect with rounded lobe produced posteriad. Tenth tergum in dorsal aspect with left lobe elongate, apically curving to the right, right lobe wide at the base and narrowed at the slightly sinuous apex; in ventral view with a long

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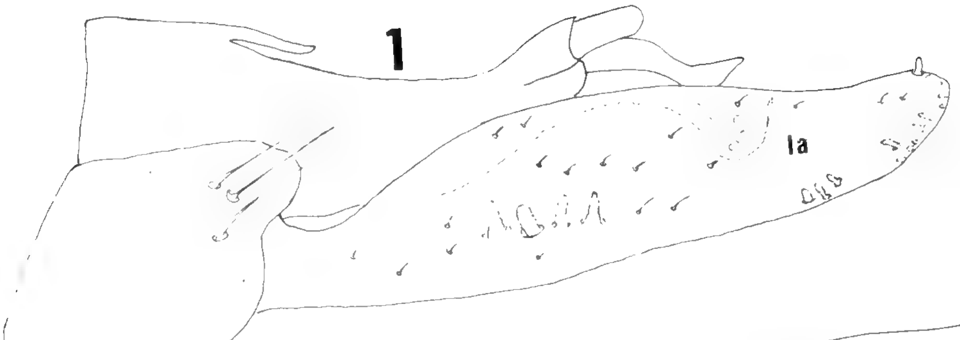
Figs. 1–5. Male genitalia of *Ochrotrichia* (*O.*). 1–3, *raposa.* 1, Left side. 2, Right side. 3, Ninth and tenth terga and inferior appendages, dorsal view. 4, 5, *puyana.* 4, Left side. 5, Ninth and tenth terga and inferior appendages, dorsal view. (9T = Ninth tergum. 10T = Tenth tergum. Ia = Inferior appendage.)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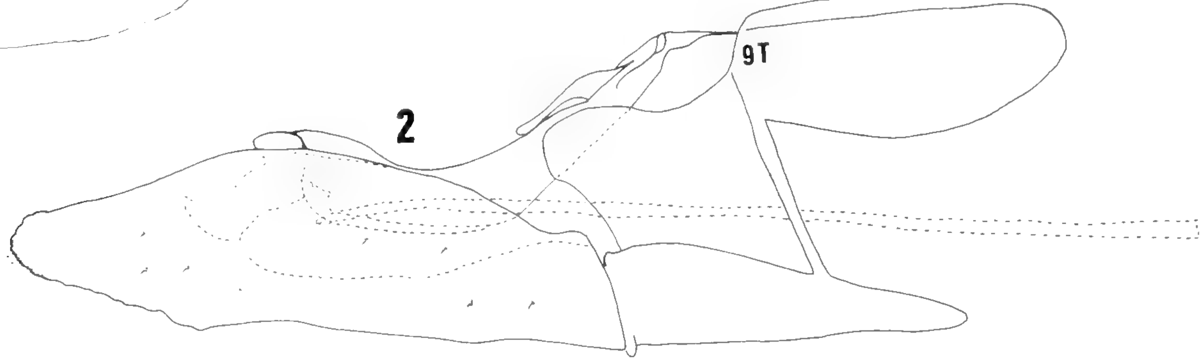
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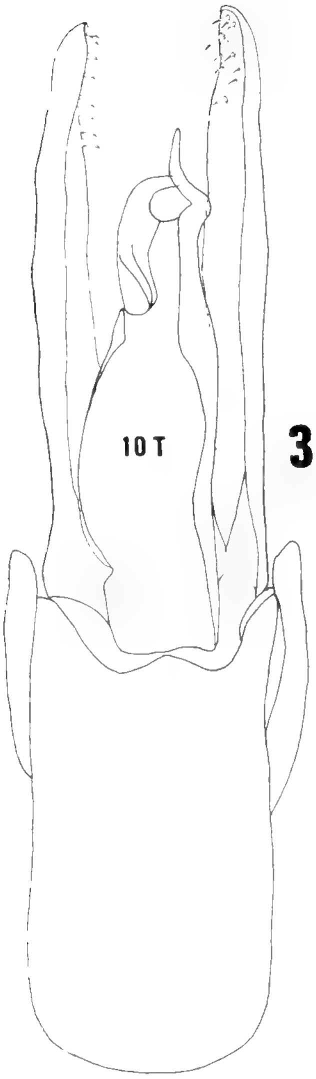
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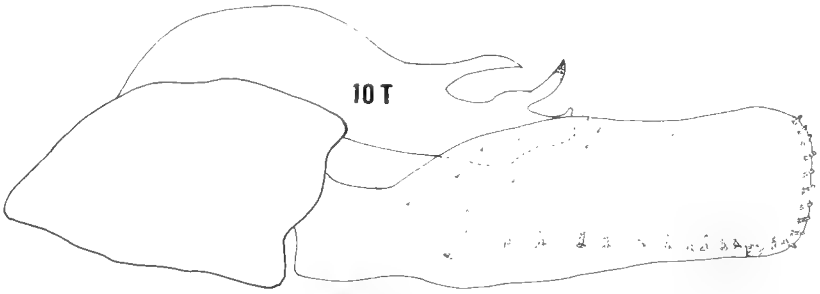
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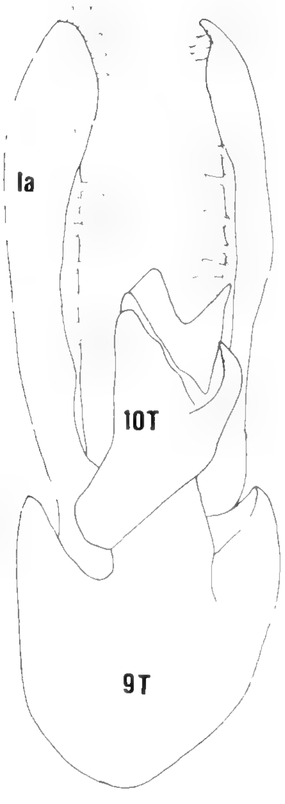
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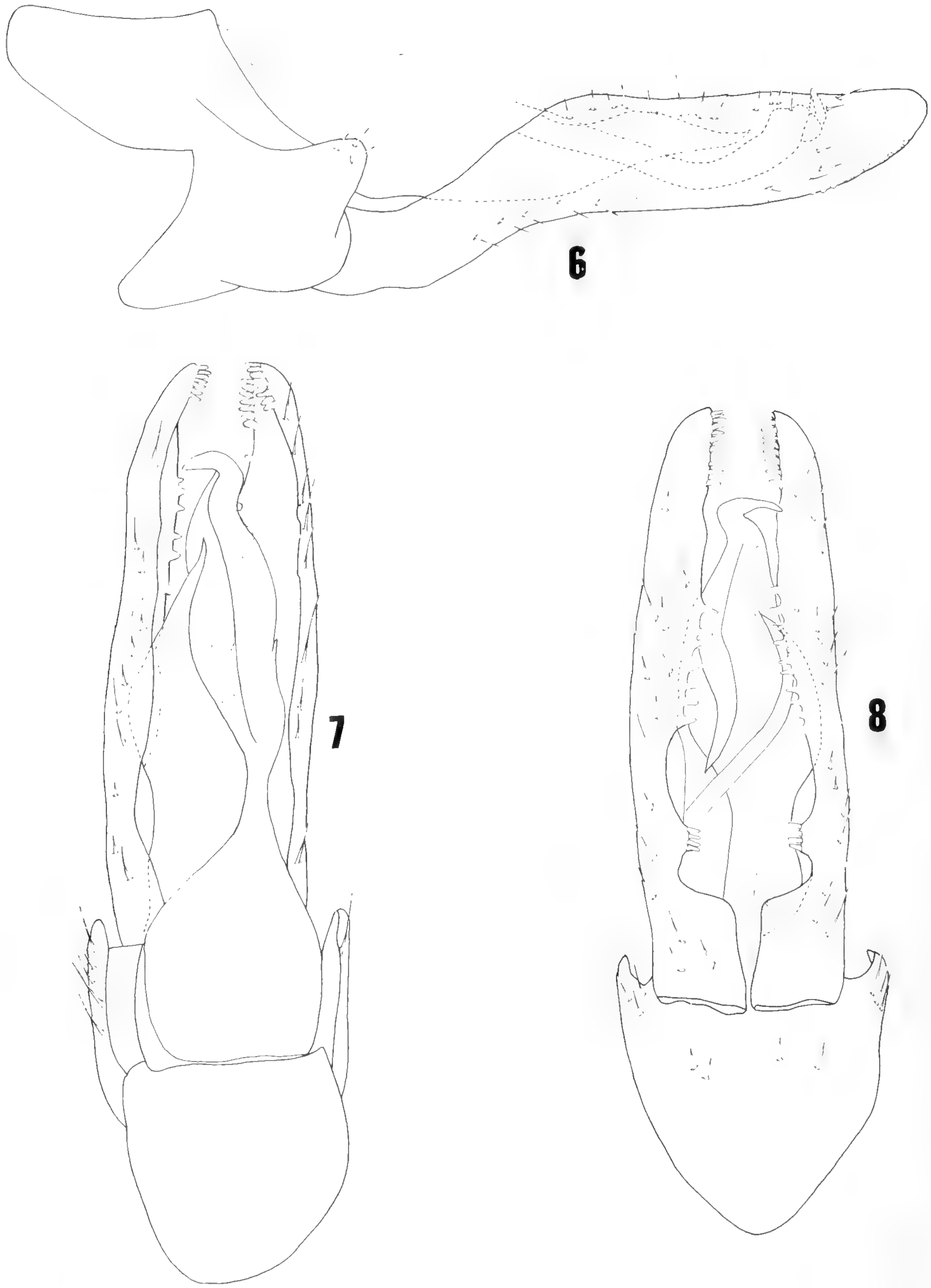


Figs. 6–8. Male genitalia of *Ochrotrichia* (*O.*) *ecuatoriana*. 6, Left side. 7, Ninth and tenth terga and inferior appendages, dorsal view. 8, Ventral view.

spinelike lobe curved and directed posteriad and a short spinelike lobe whose apex is directed anteriad. Inferior appendages very long and slender in lateral aspect, apex rounded; in ventral view the apex and ventral margin with black peglike setae; close to the base a group of peglike setae on a small prominence. Phallus long and threadlike.

Material.—Holotype, male: ECUADOR:

Pastaza Prov., Puyo, 14 May 1977, P. J. Spangler & D. R. Givens (USNM). Paratype: COLOMBIA: Dept. Valle del Cauca, Río Raposo, January 1965, V. H. Lee, 1 ♂ (USNM).

Etymology.—*ecuatoriana,* Spanish for the women from Ecuador.

Ochrotrichia (O.) oblongata, New Species

Figs. 9–11

On the basis of the shape of the tenth tergum and inferior appendages, this species belongs to the *tenanga* group (Flint 1972). However it can be separated by possessing two short spines on the left side and by the placement of two long processes on the right side.

Adult.—Length of forewing 2 mm. Color in alcohol dark brown. Male genitalia: Ninth tergum deeply depressed and produced anteriad. Tenth tergum with an elongate, dark-tipped, middorsal process giving rise to two short, basolateral spines on the left side; right side with two long processes; in lateral view with two long processes, one arising basally and extending ventrally and the other arising from an enlarged base at midlength dorsally, ending in an apex curved ventrad. Inferior appendages in lateral view long, slender, apex rounded; in ventral view the apex and midbasal ridge with a band of black, peglike setae. Phallus long and threadlike.

Material.—Holotype, male: TRINIDAD: Arima cascade, 17 April 1985, V. Jones (USNM).

Etymology.—*oblongata,* Latin, for the longer than broad shape of the inferior appendages.

Ochrotrichia (O.) unica, New Species

Figs. 12–14

On the basis of the tenth tergum and inferior appendages, this species fits in the *xena* group (Flint 1972). However, this species can be recognized by the almost circular shape of the apex of the inferior appendages in lateral aspect and by the rather simple tenth tergum.

Adult.—Length of forewings 2.8 mm. Color in alcohol dark brown. Male genitalia: Ninth tergum deeply depressed and slightly produced anteriad; in lateral aspect almost square. Tenth tergum a simple dorsal plate, almost straight in lateral view. Inferior appendages in lateral view with patch of setae dorsally on one, the apex circular, dark and with many peglike setae. Phallus long and threadlike.

Material.—Holotype, male: COLOMBIA: [Dept. Valle del Cauca], Río Raposo, January 1965, V. H. Lee (USNM). Paratypes: Same data as the holotype, 2 ♂ (USNM).

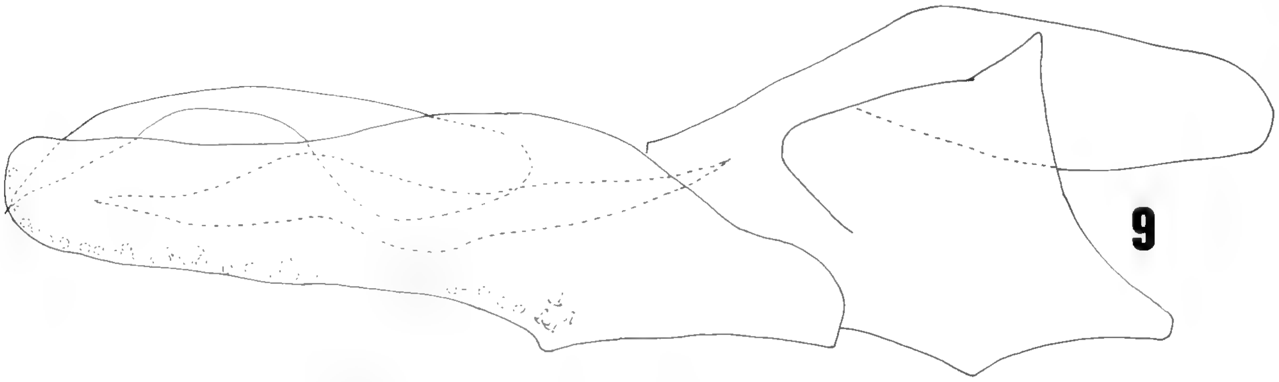
Etymology.—*unica,* Spanish, for unique.

Ochrotrichia (O.) yanayacuana, New Species

Figs. 15–17

Based on the overall appearance of the genitalia, this species appears to be related to *Ochrotrichia* (*O.*) *moselyi* Flint, *O.* (*O.*) *tagala* Flint and *O.* (*O.*) *pectinifera* Flint; however, it can be distinguished from those species by the presence of a large, upturned, black-tipped spine on the inner surface of the right inferior appendage and by the presence of two large spines on the tenth tergum.

Adult.—Length of forewings 2 mm. Color in alcohol dark brown. Male genitalia: Ninth tergum deeply depressed and slightly produced anteriad. Tenth tergum with two, long, narrow, processes, ventral one wider anteriorly, apex acute and directed ventrad; dorsally with two black spines, basal-most larger than the other; in lateral aspect with an acute apex to the ventral lobe. Inferior appendages in lateral view with an elongate, fingerlike, dorsal lobe; midventrally with 5–6 heavily sclerotized spines: on the left appendage with two spines on the middorsal margin and three on the posteroventral margin, on the right appendage with six spines in a row on the lateral margin; basal



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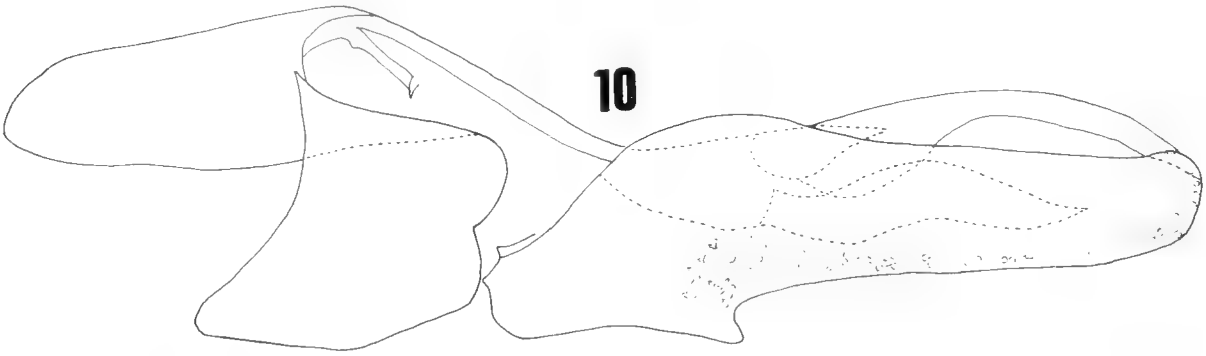

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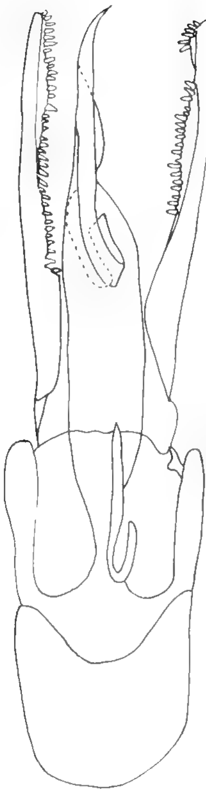

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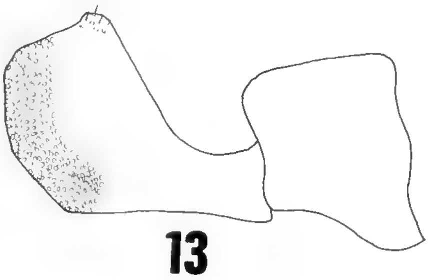

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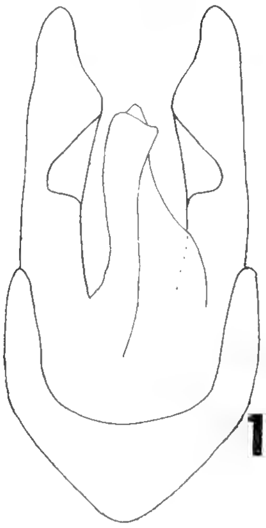

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Figs. 9–14. Male genitalia of *Ochrotrichia* (*O.*). 9–11, *oblongata*. 9, Right side. 10, Left side. 11, Ninth and tenth terga and inferior appendages, dorsal view. 12–14, *unica*. 12, Left side. 13, Right side. 14, Ninth and tenth terga and inferior appendages, dorsal view.

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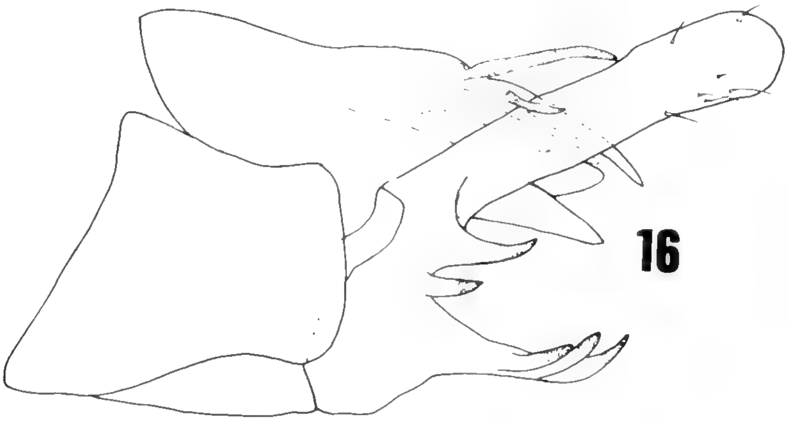
Figs. 15–20. Male genitalia of *Ochrotrichia* (*O.*). 15–17, *yanayacuana*. 15, Right side. 16, Left side. 17, Ninth and tenth terga and inferior appendages, dorsal view. 18, 19, *concha*. 18, Right side. 19, Left side. 20, Ninth and tenth terga and inferior appendages, dorsal view.


15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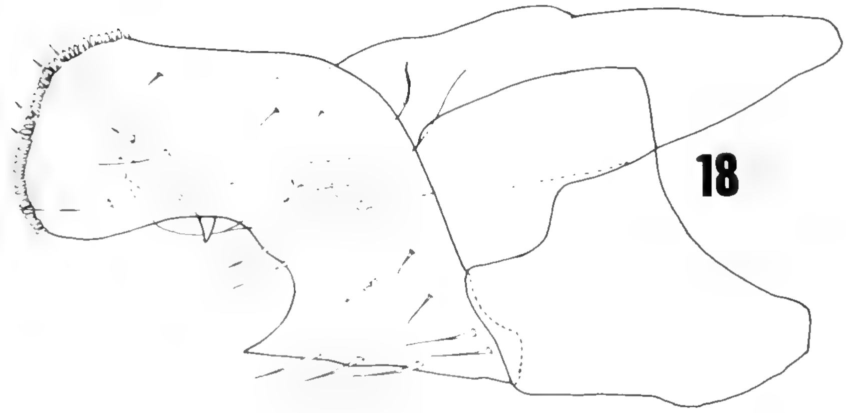
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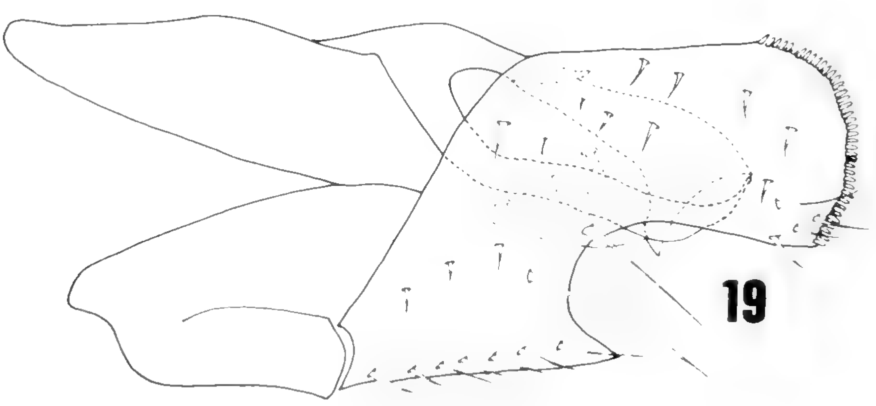
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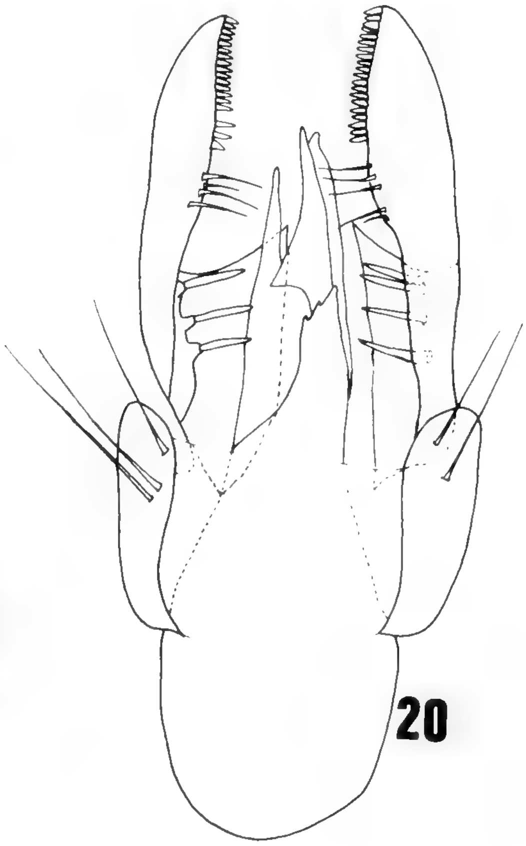
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portion widened. Phallus long and threadlike.

Material.—Holotype, male: ECUADOR: Tungurahua Prov., Yanayacu, 300 m, 29–30 August 1977, L. E. Peña G. (USNM).

Etymology.—*yanayacuana,* Spanish, feminine, for inhabitant of that region.

Ochrotrichia (O.) concha, NEW SPECIES

Figs. 18–20

This species is another member of the *xena* group, with a simple tenth tergum and peculiarly shaped inferior appendages. It may be recognized by possessing two lateral plates on the left side of the tenth tergum, and a long, slightly sinuous process on the right side, whose apex is turned upward in lateral aspect.

Adult.—Length of forewing 2 mm. Color in alcohol dark brown. Male genitalia: Ninth segment deeply divided dorsally, slightly produced anteriad. Tenth tergum basally broad with two long processes on the left side, and a short basodorsal process on the left; in lateral aspect with a large process with apex triangular and ventrally directed; on the left side, long, slightly sinuous process ventrally with the apex turned upward. Inferior appendages in dorsal view with a mesal row of long spines on internal face; in lateral view with apex rounded and trumpet shaped with a row of small, black peglike setae on apical margin. Phallus tubular with conically expanded base.

Material.—Holotype, male: BRASIL: Amazonas State, AM 010, km 246 [ca. 20 km W Itacoatiara], 15–16 July 1979, J. Arias (USNM).

Etymology.—*concha,* Latin, for a trumpet shaped like a snail shell.

ACKNOWLEDGMENTS

We are indebted to Dr. Paul J. Spangler for his invitation to work under a grant from the Smithsonian Institution; to Dr. Oliver S. Flint, Jr., Curator of Neuropteroids of the Department of Entomology, for his suggestions and organization of the manuscript and for the use of the collection; to Miss Nancy Adams, Neuropteroids technician, for her assistance during our stay at the Museum; to our technician, Biol. Rafael Barba, for his contribution with the drawings; and to Mrs. Phyllis Spangler for her help with the initial word processing. Finally to the anonymous reviewer for his valuable suggestions improving the manuscript.

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A NEW SPECIES OF *RONCUS* L. KOCH, 1873, FROM SOUTHEASTERN EUROPE (PSEUDOSCORPIONES: NEOBISIIDAE)

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Abstract.—A new species of neobisiid pseudoscorpion ***Roncus jarilo*** is described based on specimens from southeastern Europe (Yugoslavia); and the diagnostic characters are illustrated.

Key Words: Pseudoscorpiones, Neobisiidae, *Roncus,* new species, Yugoslavia

Over the past two decades there has been a marked increase in our knowledge of the Neobisiidae of southeastern Europe (or the Balkan Peninsula), and especially of the representatives of the genus *Roncus* L. Koch, 1873, which occur in leaf litter, soil and caves (Ćurčić 1982, 1988, Harvey 1990). Increased interest in the soil/litter and cave ecosystems and improved sampling techniques have contributed to this knowledge. During a study of postembryonic development and teratology of pseudoscorpions of a continental deciduous oak forest in Yugoslavia, a hitherto undescribed species of *Roncus* was found.

The present paper provides description of *R. jarilo* n. sp., with some details on the comparative morphology of both sexes and tritonymph.

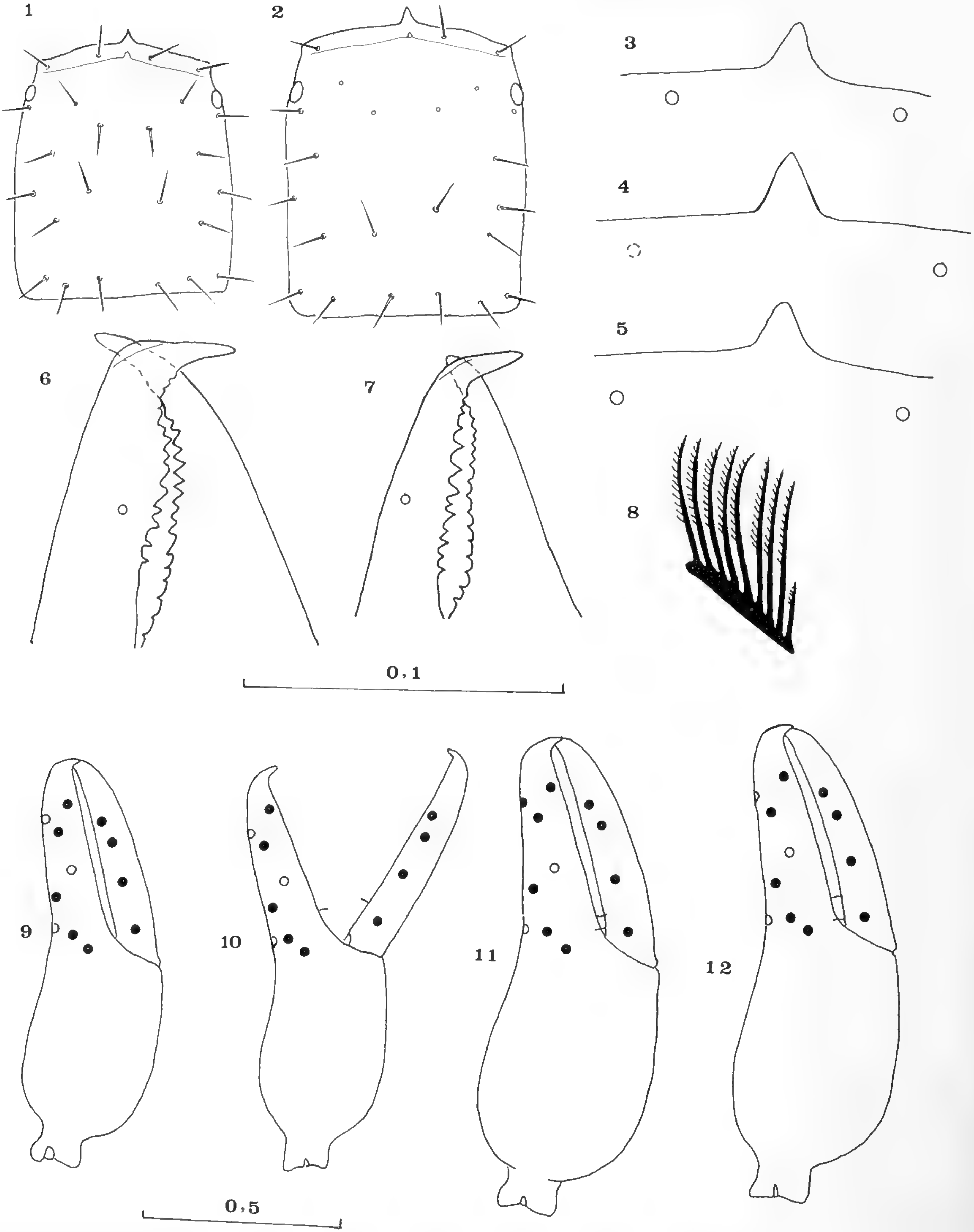
All specimens are mounted on slides in Swan's fluid (gum chloral medium), and all are deposited in the Institute of Zoology, Faculty of Science (Biology), University of Belgrade, Belgrade, Yugoslavia.

Roncus jarilo Ćurčić, NEW SPECIES

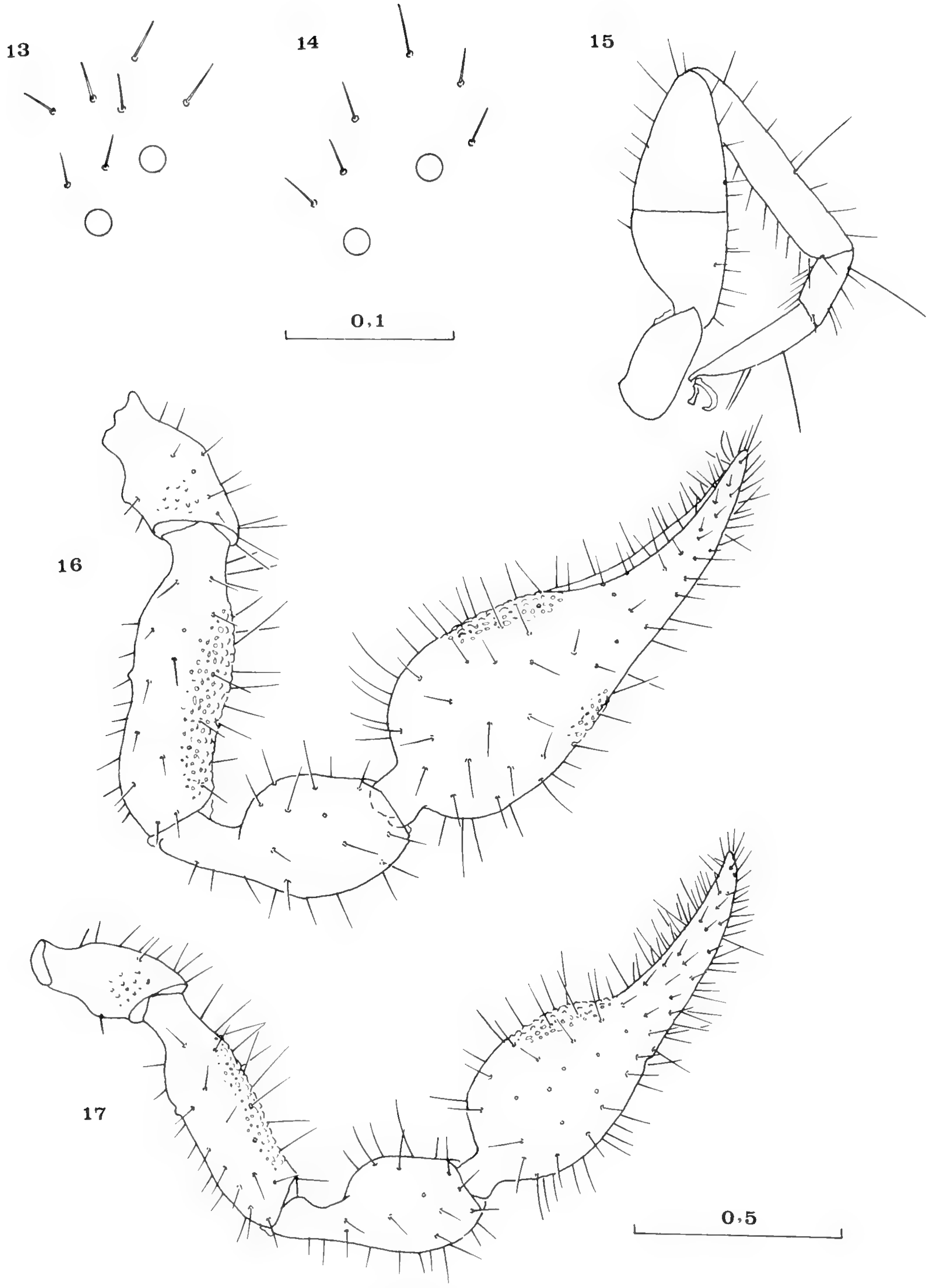
Roncus aff. *lubricus* (B) L. Koch, 1873; Ćurčić, Dimitrijević, Karamata, and Lučić, in press.

Description.—Epistome triangular and apically blunt (Figs. 1–5). Two small eyes present. Setal formulae: 4+6+2+4+2+6 = 24 (male); 4+6+2+4+2+6 = 24, 3+6+2+3+3+6 = 23, 4+1+6+2+3+1+6 = 23 (female) and 4+6+2+4+2+6 = 24 setae (tritonymph).

Tergite I with 6 (adult) or 7 setae (tritonymph), tergite II with 8–11 setae, tergites III–X each with 10–12 (rarely 13 or 14) setae. Male genital area: sternite II with a cluster of 13–23 setae medially and posteriorly. Of these, 7–12 longer setae along posterior sternal border and 6–11 shorter setae midposteriorly, thinning out anteriorly. Sternite III with 4–8 anterior and median setae, 9–12 posterior setae and 3 (rarely 2) microsetae along each stigma. Sternite IV with 8–13 marginal setae and 3 (rarely 2) small suprastigmal microsetae on each side. Female genital area: sternite II with 7–11 setae either constituting a single patch or arranged into two barely distinguishable groups, one on either side of the mid-line; sternite III with 13 or 14 posterior setae, and 2 or 3 microsetae along each stigma. Sternite IV with 8–10 setae and 3 small suprastigmatic setae on each side. Tritonymph: sternite II with 2 setae, sternite III with 7 posterior setae and 2 or 3 microsetae along each stig-



Figs. 1–12. *Roncus jarilo,* n. sp.: 1, carapace, male; 2, carapace, female; 3, epistome, male; 4, epistome, female; 5, epistome, female; 6, cheliceral fingers, female; 7, cheliceral fingers, male; 8, flagellum, male; 9, pedipalpal chela, male; 10, pedipalpal chela, male; 11, pedipalpal chela, female; 12, pedipalpal chela, female. Scales in mm.



Figs. 13–17. *Roncus jarilo,* n. sp.: 13, microsetae distal to *eb* and *esb,* male; 14, microsetae distal to *eb* and *esb,* female; 15, leg IV, male; 16, pedipalp, female; 17, pedipalp, male. Scales in mm.

Table 1. Range in measurements (mm) of various structures, together with selected ratios, in *Roncus jarilo*, new species.

Character	Females	Males	Trito
Body			
Length (1)	2.85–3.47	2.385–3.08	1.67
Cephalothorax			
Length (2)	0.71–0.79	0.61–0.75	0.44
Breadth	0.58–0.65	0.50–0.63	0.42
Abdomen			
Length	2.195–2.74	1.715–2.33	1.23
Breadth	1.03–1.37	0.96–1.10	0.60
Chelicerae			
Length (3)	0.445–0.50	0.37–0.445	0.315
Breadth (4)	0.22–0.26	0.19–0.23	0.16
Length of moveable finger (5)	0.29–0.35	0.26–0.31	0.21
Ratio 3/5	1.37–1.55	1.37–1.52	1.50
Ratio 3/4	1.81–2.08	1.89–2.095	1.97
Length of galea	0.01	0.01	0.01
Pedipalps			
Length with coxa (6)	3.35–3.805	2.77–3.53	2.30
Ratio 6/1	1.02–1.27	1.01–1.33	1.38
Length of coxa	0.535–0.61	0.45–0.555	0.40
Length of trochanter	0.42–0.47	0.35–0.445	0.29
Length of femur (7)	0.67–0.775	0.57–0.71	0.46
Breadth of femur (8)	0.21–0.23	0.17–0.21	0.16
Ratio 7/8	3.045–3.38	3.05–3.76	2.875
Ratio 7/2	0.92–1.00	0.91–1.06	1.045
Length of tibia (9)	0.555–0.67	0.46–0.60	0.36
Breadth of tibia (10)	0.26–0.29	0.21–0.28	0.18
Ratio 9/10	2.07–2.31	2.07–2.33	2.00
Length of chela (11)	1.16–1.29	0.92–1.24	0.79
Breadth of chela (12)	0.38–0.44	0.28–0.38	0.25
Ratio 11/12	2.93–3.24	3.13–3.69	3.15
Length of chelal palm (13)	0.58–0.67	0.43–0.62	0.40
Ratio 13/12	1.49–1.63	1.535–1.72	1.60
Length of chelal finger (14)	0.58–0.64	0.49–0.64	0.39
Ratio 14/13	0.925–1.03	0.95–1.185	0.975
Leg IV			
Total length	2.40–2.56	2.03–2.36	1.655
Length of coxa	0.40–0.425	0.33–0.40	0.27
Length of trochanter (15)	0.29–0.33	0.25–0.31	0.21
Breadth of trochanter (16)	0.135–0.15	0.12–0.14	0.11
Ratio 15/16	2.07–2.44	2.07–2.33	1.91
Length of femur (17)	0.63–0.68	0.58–0.665	0.435
Breadth of femur (18)	0.22–0.25	0.18–0.24	0.155
Ratio 17/18	2.60–3.02	2.77–3.105	2.81
Length of tibia (19)	0.55–0.60	0.45–0.61	0.38
Breadth of tibia (20)	0.11–0.12	0.09–0.12	0.09
Ratio 19/20	4.83–5.36	4.96–6.00	4.22
Length of basitarsus (21)	0.205–0.23	0.18–0.23	0.14
Breadth of basitarsus (22)	0.08–0.11	0.075–0.09	0.07
Ratio 21/22	1.91–2.625	2.25–2.59	2.00

Table 1. Continued.

Character	Females	Males	Trito
Length of telotarsus (23)	0.31–0.34	0.29–0.34	0.22
Breadth of basitarsus (24)	0.075–0.08	0.07–0.08	0.065
Ratio 23/24	3.875–4.53	3.94–4.86	3.38
TS ratio—tibia IV	0.475–0.65	0.53–0.61	0.51
TS ratio—basitarsus IV	0.19–0.23	0.175–0.25	0.24
TS ratio—telotarsus IV	0.265–0.36	0.28–0.36	0.28

ma, and sternite IV with 9 marginal setae and 2 microsetae along each stigma. Sternites V–X each with 12–16 setae. In some specimens sternites VII–X each with 2 median setae only slightly anterior to the row of posterior setae; in the others, all marginal setae at the posterior sternal border.

Cheliceral spinneret (galea) low, slightly more prominent in females and tritonymphs than in males (Figs. 6, 7). Cheliceral palm with 6 setae, movable finger with one seta (both in adult and tritonymph). Fixed cheliceral finger with 16–20 (adult) or 14 or 15 small teeth (tritonymph); movable cheliceral finger with 13–15 (adult) or 11 teeth (tritonymph). Flagellum 8- or 9-bladed (1 short proximal blade and 7 or 8 longer blades distally, all blades denticulate; Fig. 8).

Apex of pedipalpal coxa with 4 long acuminate setae. Pedipalpal trochanter with two small lateral tubercles, and some rare and inconspicuous denticulations dorsally. Pedipalpal femur with a small exterior and lateral tubercle and with interior and dorsal granulations as in Figs. 16 and 17. Tibia smooth; chelal palm with anterior granulations; exteriorly, palm with some rare and inconspicuous surface irregularities or completely smooth. No microsetae proximal to *eb* and *esb* (Figs. 13, 14); however, 1–6 microsetae present distal or laterodistal to *eb* and *esb*. A single tubercle present on the laterodistal side of chelal palm. In both sexes, sensillum located between 9th and 15th tooth (either slightly proximal to, slightly distal to, or at the level of *sb*); in tritonymph, it is situated between the 6th and 7th teeth (somewhat closer to *st* than to *b*). The trichobothrium *ist* closer to *isb* than to *est*. Fixed chelal finger with 46–55 (male), 47–54 (female), and 34 teeth (tritonymph). Movable chelal finger with 42–45 (male), 42–54 (female), and 33 teeth (tritonymph). Chelal fingers generally as long as the chelal palm and shorter than pedipalpal femur (Table 1). Pedipalpal femur shorter than (adult) or equal to carapace (tritonymph; Table 1). Trichobothriotaxy as in Figs. 9–12.

Tibia IV, basitarsus IV, and telotarsus IV each with a single tactile seta (Fig. 15). Tactile seta ratios are presented in Table 1.

Morphometric ratios and linear measurements are presented in Table 1.

Type material.—Holotype ♀, allotype ♂, 9 paratype ♀, 7 paratype ♂, and 1 paratype tritonymph, from the village of Asanovac, Žitoradja, near Prokuplje, Serbia (Yugoslavia), collected from leaf litter in an oak forest, from January to March 1989, by M. S. Zlatković.

Teratology: An anomalous trichobothrial pattern in the number and disposition of the tactile setae *isb, eb,* and *esb* in a single female has been described elsewhere (Ćurčić, Dimitrijević, and Lučić 1992). In another female, two additional setae occur on the right part of sternite VI, so that the setae in this region are arranged into an anterior and posterior row.

Remarks.—*Roncus jarilo* resembles the south European *Roncus lubricus pannonius* Ćurčić, Dimitrijević, and Karamata (type locality: village of Obrež, near Belgrade, northern Serbia, Yugoslavia; Ćurčić et al., in press) in general appearance, but the ratio of chelal finger length to the length of the chelal palm is different (lower in *R. jarilo,* higher in *R. lubricus pannonius*). Other distinctions include the form of the pedipalpal articles (attenuated in *R. lubricus pannonius,* robust in *R. jarilo*), the presence/absence of microsetae proximal to *eb* and *esb* (present in *R. lubricus pannonius,* absent in *R. jarilo*), the relative position of the trichobothrium *ist* (in *R. jarilo,* it is closer to *isb* than to *est,* and in *R. lubricus pannonius* it is closer to *est* than to *isb*), as well as the number of chelal teeth (greater in *R. lubricus pannonius,* lower in *R. jarilo*).

From the southeastern European *R. parablothroides* Hadži (type locality: village of Rašče, near Skoplje, Macedonia, Yugoslavia; Hadži, 1937), *R. jarilo,* n. sp. differs in many important respects: the relative position of the trichobothrium *ist* (in *R. parablothroides,* it is closer to *est* than to *isb,* and in *R. jarilo* it is closer to *isb* than to *est*), in the form of the pedipalpal articles (attenuated in *R. parablothroides,* stout in *R. jarilo*), in the pedipalpal granulation (well-developed in *R. parablothroides,* inconspicuous in *R. jarilo*), in the ratio of pedipalpal femur length to breadth (3.79–4.12 in *R, parablothroides* vs. 3.045–3.76 in *R. jarilo*), in the ratio of the pedipalpal tibia length to breadth (2.41–2.645 in *R. parablothroides* vs. 2.07–2.33 in *R. jarilo*), in the pedipalpal chela length (1.59–1.85 mm in *R. parablothroides* vs. 0.92–1.29 mm in *R. jarilo*), in the femur IV length (0.79–0.84 mm in *R. parablothroides* vs. 0.58–0.68 mm in *R. jarilo*), as well as in the number of teeth on the fixed and movable chelal fingers, respectively (61–70 and 59–65 in *R. parablothroides* vs. 46–55 and 42–54 in *R. jarilo*).

Compared to the phenetically most similar species, *R. svarozici* Ćurčić, from eastern Serbia (type locality: from in front of the "Pećina u selu Vrelo" Cave, village of Jelovica, near Pirot, Serbia, Yugoslavia; Ćurčić, 1992), *R. jarilo* shows considerable distinctions in the relative position of the trichobothrium *ist* (in *R. svarozici,* it is equidistant from *est* and *isb* or slightly closer to *est* than to *isb,* and in *R. jarilo* it is closer to *isb* than to *est*), in the form of the pedipalpal articles (attenuated in *R. svarozici,* stout in *R. jarilo*), in the number of chelal teeth on fixed and movable fingers, respectively (55–61 and 56–63 in *R. svarozici,* 46–55 and 42–54 in *R. jarilo*), and in the length of the chelal finger of the pedipalps (0.70–0.775 mm in *R. svarozici* vs. 0.49–0.64 mm in *R. jarilo*).

Based on present knowledge, *R. jarilo* n. sp. is known from its type locality only.

The species is named for Jarilo, the ancient Slavic god of rain, storm and fertility (Kulišić et al. 1970).

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NEW SPECIES OF MICROCADDISFLIES FROM THE AMAZON REGION, WITH ESPECIAL REFERENCE TO NORTHEASTERN PERU (TRICHOPTERA: HYDROPTILIDAE)

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Abstract.—Four new species of *Neotrichia*, ***N. yanomonoa***, ***N. sucusaria***, ***N. yagua*** and ***N. juntada*** and two new species of *Oxyethira*, ***O. orellanai*** and ***O. teixeirai*** are described from the upper Amazon region in Peru. Three additional new species of *Neotrichia*, ***N. delgadeza*** and ***N. napoensis*** from Ecuador and ***N. cayada*** from Venezuela are also described as they are closely related to the Peruvian specimens. A redescription of *N. filifera* from Uruguay is also included to clarify species relationships.

Key Words: Hydroptilidae, *Neotrichia, Oxyethira,* new species, Peru, Ecuador, Venezuela

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In January 1991, the junior author travelled to the upper Amazon region in Peru as part of an educational expedition sponsored by Samford University. While staying at the Explorama Lodge, on the Rio Yanomono, and the Explornapo Camp, on the Rio Sucusari, several collections of caddisflies were made with ultraviolet light traps. A second trip was made by LJD to the same locations in March 1991, as part of the First International Rain Forest Workshop, and additional material was collected.

The Explorama Lodge is located approximately 50 km NE of Iquitos on the Rio Yanomono, just upstream from its juncture with the Amazon or Marañon (3°23′S, 72°52′W). The Explornapo Camp is located about 70 km NNE of Iquitos (3°10′S, 72°54′W) on the Rio Sucusari (Fig. 1). The general area of these collections can be described as tropical floodplain forest, with water levels fluctuating up to 10 m per year.

This paper deals primarily with new species of Hydroptilidae collected in this region, but in some cases, in order to make comparisons to similar species, it was necessary to reillustrate or describe species from other parts of northern South America. In total, seven new species of *Neotrichia* and two new species of *Oxyethira* are described herein. Morphological terminology follows that of Marshall (1979). Length is measured from the top of the head to the tip of the forewings and is given as a range with more than one specimen. Type material is deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C.

Neotrichia yanomonoa
Harris and Davenport, NEW SPECIES
Fig. 2

Diagnosis.—This species is most similar to *N. browni* Harris in genitalic features. Both species have thin elongate dorsolateral processes from the ninth segment, but *N. yanomonoa* is readily distinguished by the short inferior appendages which are acutely pointed on the inner margin.

Description.—*Male:* Length 1.4 mm. 18 antennal segments. Brown in alcohol. Ninth abdominal segment in lateral view with anterior margin rounded, posteroventral mar-

Fig. 1. Upper Amazon region in northeastern Peru.

gin extended into a long, truncate lobe, posterodorsal margin bearing elongate, thin sclerotized processes which converge posteriorly in dorsal and ventral views; square in ventral aspect, with narrow, elongate lateral extensions. Segment X fused with IX, in lateral view a thin sclerotized shelf over the elongate processes of segment IX; in dorsal view appearing as pair of rounded lobes, sclerotized distally, pair of small setiferous lobes anteriorly. Inferior appendages darkly sclerotized, short and narrow in lateral view, dorsoapically with several short spines; in ventral view somewhat triangular, truncate apically with inner margin produced into a point. Subgenital plate a rounded shelf in ventral view bearing pair of inwardly directed setae; sclerotized in lateral view, posterodorsal portion thin, bearing seta apically, anteroventral portion thin and extending ventrad. Phallus with distal portion tapering apically, apex curved into narrow hook, smaller thin projection subapically; basal portion wide at base narrowing apically, bearing thin paramere encircling shaft.

Type material.—Holotype; Male. Peru, Loreto, small tributary to Rio Yanomono at Explorama Lodge, 13 January 1991, L. J. Davenport.

Etymology.—Named for the Rio Yanomono.

Neotrichia cayada Harris, New Species

Fig. 3

Diagnosis.—This species shares a number of characters with *N. yanomonoa* and

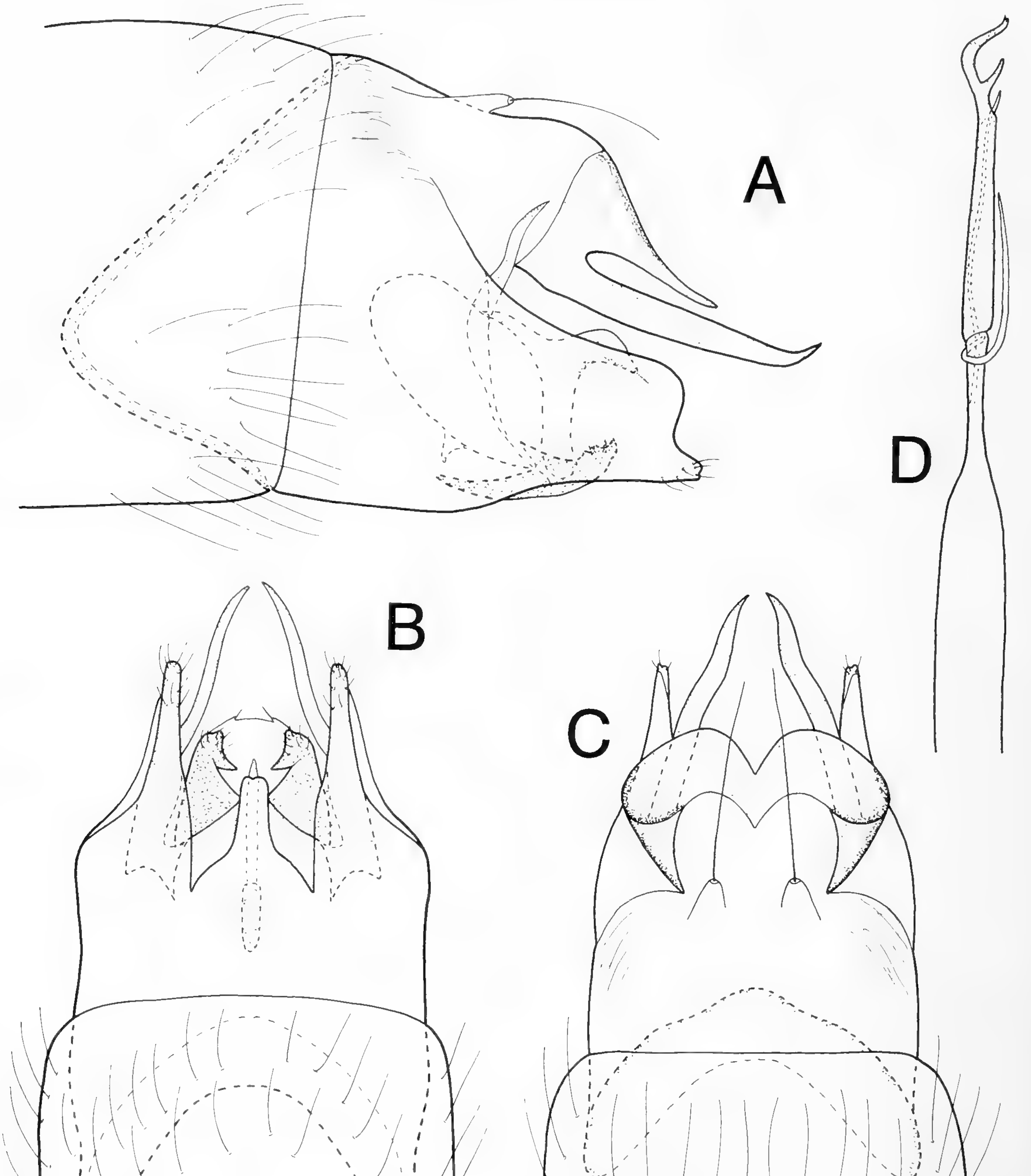

Fig. 2. *Neotrichia yanomonoa,* male genitalia; A. Lateral view, B. Ventral view, C. Dorsal view, D. Phallus, lateral view.

N. browni from Venezuela, including a phallus with a hook-like apex, thin elongate extensions from the dorsolateral margin of the ninth segment and a truncate projection from the posteroventral margin. *Neotrichia cayada* is readily separated on the basis of the truncate inferior appendages and structure of the subgenital plate, as well as by the

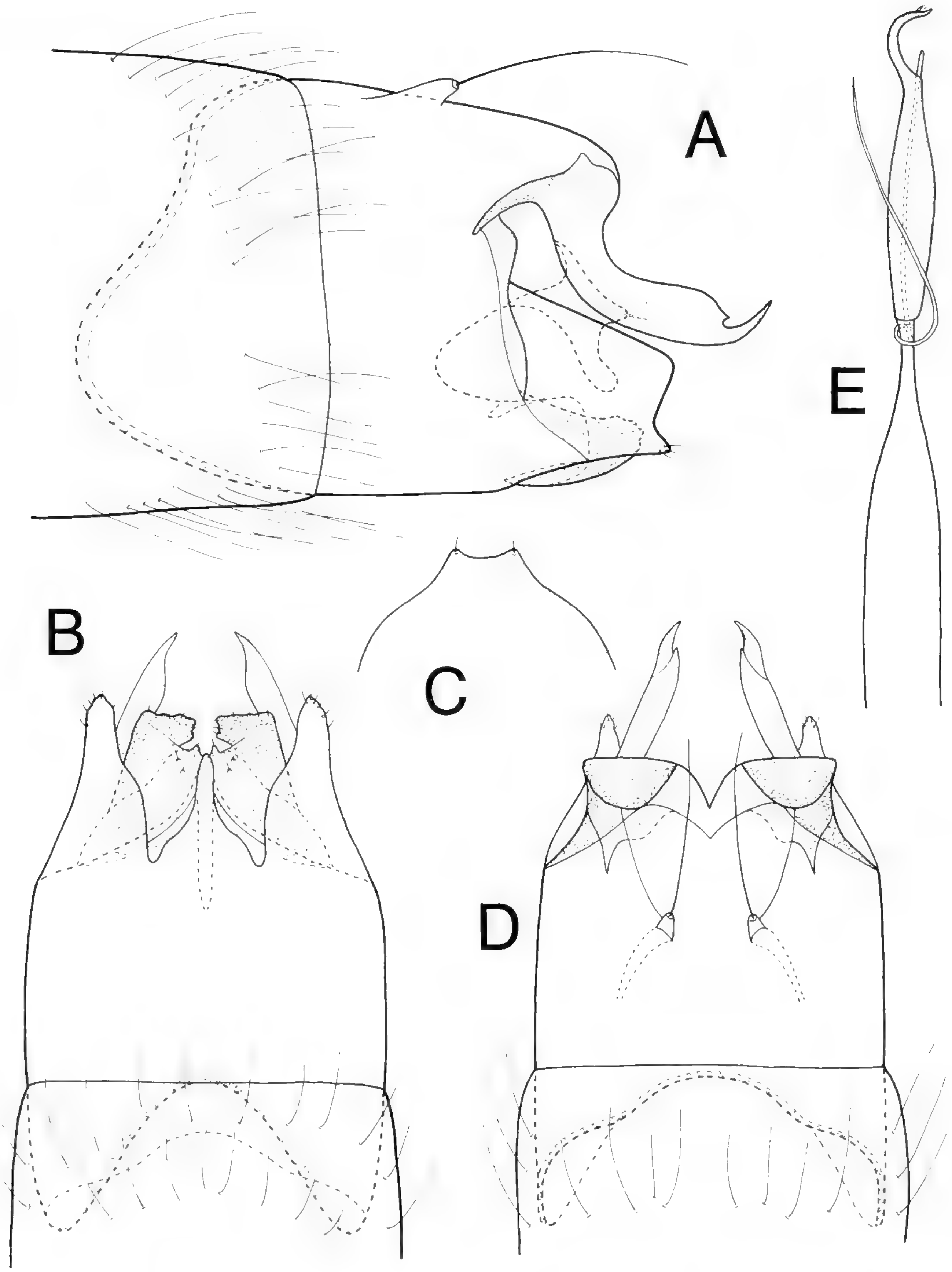

Fig. 3. *Neotrichia cayada,* male genitalia; A. Lateral view, B. Ventral view, C. Distal portion of subgenital plate, ventral view, D. Dorsal view, E. Phallus, lateral view.

configuration of the dorsal processes of the ninth segment.

Description.—*Male:* Length 1.3–1.5 mm. 18 antennal segments. Brown in alcohol. Ninth abdominal segment in lateral view with anterior margin rounded, posteroventral margin extended into a long, truncate lobe which is incised on the distal margin, posterodorsal margin bearing elongate sclerotized processes which are acute and upturned apically, in dorsal view these processes are narrow and slightly convergent; square in ventral view with lateral extensions wide basally, tapering to rounded apices. Segment X fused with IX, in dorsal view with pair of sclerotized truncate lobes, pair of small setiferous lobes anteriorly. Inferior appendages darkly sclerotized, short and narrow in lateral view, rounded distally; in ventral view rectangular in overall appearance, incised on apicomesal margins. Subgenital plate in ventral aspect, rounded laterally, bilobed distally, each small lobe bearing stout seta; in lateral view incised on posterior margin to form elongate ventral projection and dorsal seta-bearing shelf. Phallus with distal portion sclerotized and tapering apically to narrow hook, ejaculatory duct protruding in bend of hook, basal portion wide at base, narrowing apically, bearing thin paramere encircling shaft.

Type material.—Holotype; Male. Venezuela, Territorio Federal Amazonas, Cerro de la Neblina basecamp, 0°50′N, 66°10′W near Rio Baria, 140 m, 10 February 1985, W. E. Steiner. Paratypes. Same data as holotype, 6 ♂, same locality, but 14 February 1985, 2 ♂.

Etymology.—Spanish for shepherd's crook, referring to the distinctive phallus.

Neotrichia delgadeza Harris, New Species

Fig. 4

Diagnosis.—In most respects, this species is similar to *N. filifera* Flint. Both species have the distinctive elongate processes from the dorsum of segment IX. The new species is distinguished by narrow inferior appendages and unmodified subgenital plate.

Description.—*Male:* Length 1.4–1.7 mm. 18 antennal segments. Brown in alcohol. Ninth abdominal segment in lateral view with anterior and posterior margins rounded, posterodorsally bearing elongate, thin processes which curve ventrad and extend beyond the inferior appendages, crisscrossing in dorsal view; thin, elongate bracteoles posteroventrally, in ventral view thin and slightly sinuate distally. Segment X elongate in lateral view, tapering distally; in dorsal view flared laterally near middle, truncate apically. Inferior appendages long, narrow and nearly parallel-sided in lateral view; in ventral view thin and tapering distally, slightly convergent apically. Subgenital plate in lateral view thin and elongate, bearing stout seta subapically; in dorsal view bifid distally, each narrow lobe with seta subapically on mesal margin. Phallus tubular, thin paramere encircling shaft before midlength.

Type material.—Holotype; Male. Ecuador, Pastaza, Tzapino, 400 m, 22 May 1976, J. Cohen. Paratypes. Same data as holotype, 9 ♂.

Etymology.—Spanish, thinness, referring to the appearance of the inferior appendages.

Neotrichia sucusaria Harris and Davenport, New Species

Fig. 5

Diagnosis.—As with *N. delgadeza,* this species is very similar to *N. filifera.* It is readily distinguished by the sclerotization and shape of the inferior appendages.

Description.—*Male:* Length 1.5–1.7 mm. 18 antennal segments. Brown in alcohol. Ninth abdominal segment in lateral view with anterior and posterior margins rounded, posterodorsally bearing elongate, thin, sinuate processes which extend beyond the inferior appendages and crisscross in dorsal view; narrow, elongate bracteoles posteroventrally, in ventral view, thin and slightly curving mesad. Segment X elongate, tapering distally in lateral view; in dorsal view flared outward near base, then narrowing to truncate apex. Inferior appendages heavily sclerotized, narrow and elongate in lateral view, curving slightly upward, dorsal margin with sclerotized points apically and at midlength; in ventral view narrow, tapering distally to rounded apex, incised on mesal

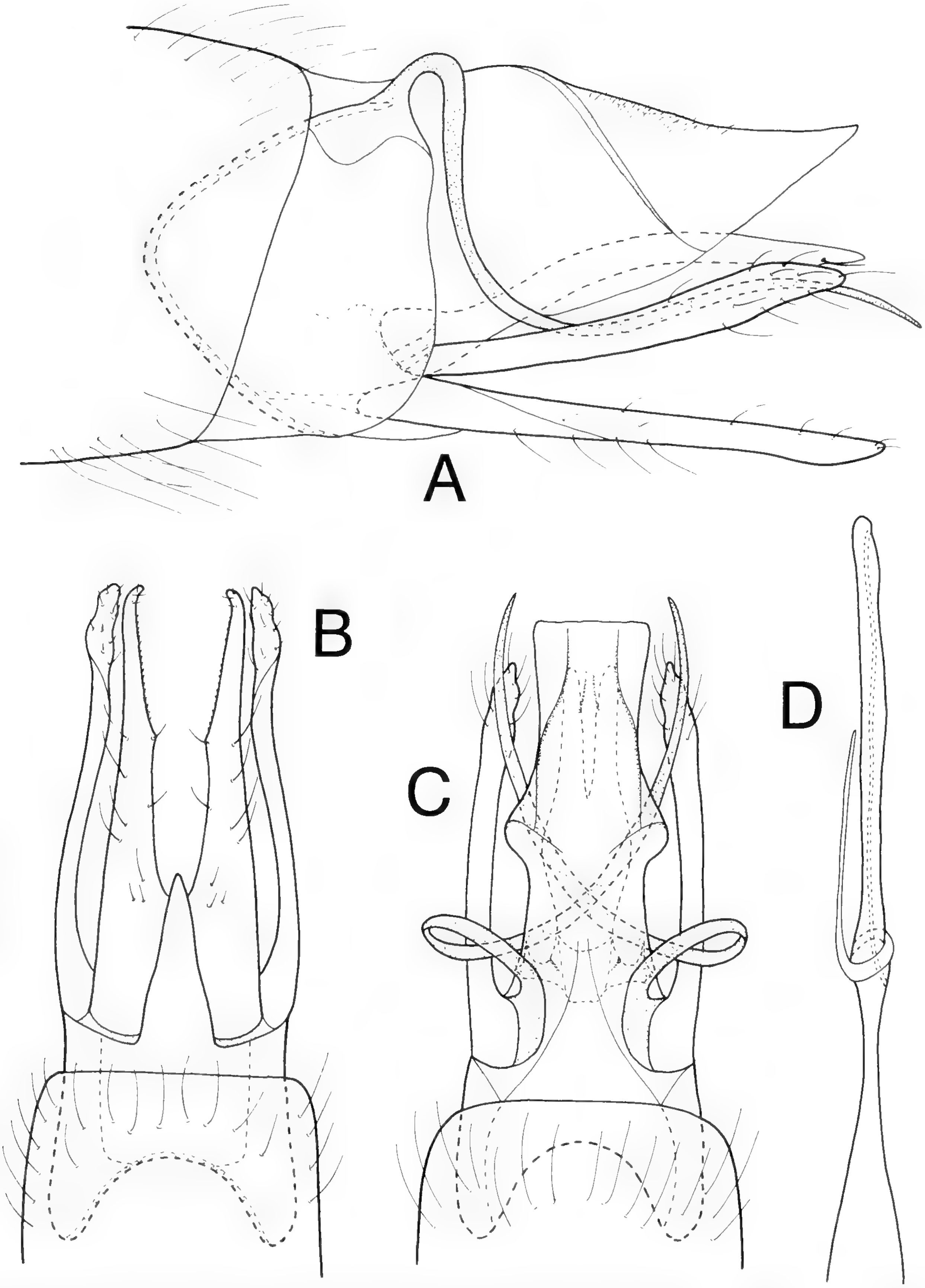

Fig. 4. *Neotrichia delgadeza,* male genitalia; A. Lateral view, B. Ventral view, C. Dorsal view, D. Phallus, dorsal view.

margins to form acute points subapically and at midlength. Subgenital plate in lateral view thin and elongate, bearing stout seta apically; in dorsal view bifid apically, each narrow lobe with seta subapically. Phallus tubular, thin paramere encircling shaft before midlength.

Type material.—Holotype; Male. Peru,

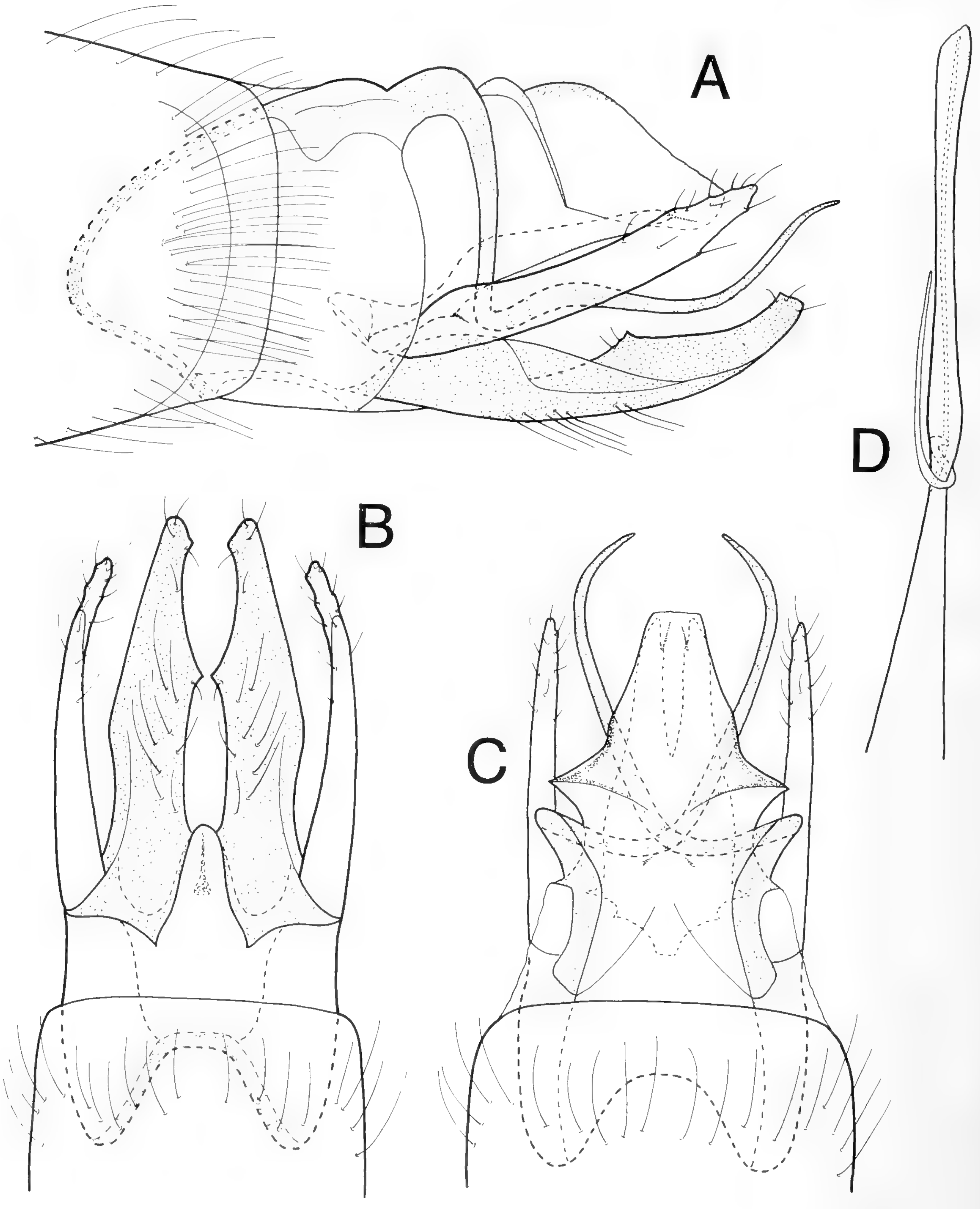

Fig. 5. *Neotrichia sucusaria,* male genitalia; A. Lateral view, B. Ventral view, C. Dorsal view, D. Phallus, dorsal view.

Loreto, Rio Sucusari just upstream from Explornapo Camp, 16 January 1991, L. J. Davenport. Paratype. Peru, Loreto, small tributary to Rio Sucusari at Explornapo Camp, 17 January 1991, L. J. Davenport, 1 ♂.

Etymology.—Named for the Rio Sucusari.

Neotrichia napoensis Harris, New Species
Fig. 6

Diagnosis.—Along with the two preceding species, *N. napoensis* is closely related to *N. filifera.* However, unlike the last two species which were readily separated on the basis of the inferior appendages, this character is similar in *N. napoensis* and *N. filifera.* The new species is best distinguished by the structure of the subgenital plate, which lacks the ventral sclerotized processes seen in *N. filifera.*

Description.—*Male:* Length 1.8 mm. 18 antennal segments. Brown in alcohol. Ninth abdominal segment in lateral view with anterior and posterior margins rounded, posterodorsally bearing elongate, thin, sinuate processes which extend beyond the inferior appendages, crisscrossing in dorsal view; narrow, elongate bracteoles posteroventrally, nearly parallel-sided over length, in ventral view thin and curving outward. Segment X elongate, widening distally in lateral view; in dorsal view flared laterally near middle, truncate posteriorly with several membranous folds. Inferior appendages thin in lateral view, widest near base, tapering to narrow apex; in ventral view thin and tapering distally, slightly divergent apically. Subgenital plate narrow and elongate in lateral view, sclerotized basally, bearing stout seta subapically; in dorsal view bifid distally, each narrow lobe with subapical seta on mesal margin, sclerotized basally forming narrow lateral bands. Phallus tubular, thin paramere encircling shaft before midlength.

Type material.—Holotype; Male. Ecuador, Napo, 7 km N Lago Agrio, 27 September 1975, A. Langley.

Etymology.—Named for the state of Napo.

Neotrichia filifera Flint
Fig. 7

Neotrichia filifera Flint, 1983: 46.

Diagnosis.—*Neotrichia filifera,* with *N. napoensis, N. delgadeza* and *N. sucusaria* form a closely related group. All have several prominent features in common including elongate, thin processes from the posterodorsal margin of segment IX, a simple tubular phallus, elongate narrow bracteoles and thin, elongate subgenital plate. *Neotrichia delgadeza* and *N. sucusaria* are readily distinguished by the inferior appendages; sclerotized and wide in *N. delgadeza* and very thin and elongate in *N. sucusaria.* As well, both of these species have a subgenital plate lacking extensive sclerotization basally. *Neotrichia filifera* and *N. napoensis* are less easily separated. In features of the inferior appendages they are similar, however they differ in the structure of the subgenital plate. Although both species have extensive sclerotization basally, *N. napoensis* lacks the ventral finger-like processes seen in *N. filifera.* They are geographically distinct as well, with *N. filifera* only known from Uruguay, and *N. napoensis* from Ecuador.

Redescription.—*Male:* Length 1.8 mm. 18 antennal segments. Brown in alcohol. Ninth abdominal segment in lateral view with anterior margin rounded, posterodorsally bearing elongate, thin processes curving ventrad and extending beyond inferior appendages; narrow elongate bracteoles posteroventrally, slightly widening distally, in ventral view thin, only slightly tapering posteriorly. Segment X elongate, widening distally in lateral view; in dorsal view flared laterally near midlength, truncate posteriorly. Inferior appendages thin in lateral view, widest near base, tapering to narrow apex;

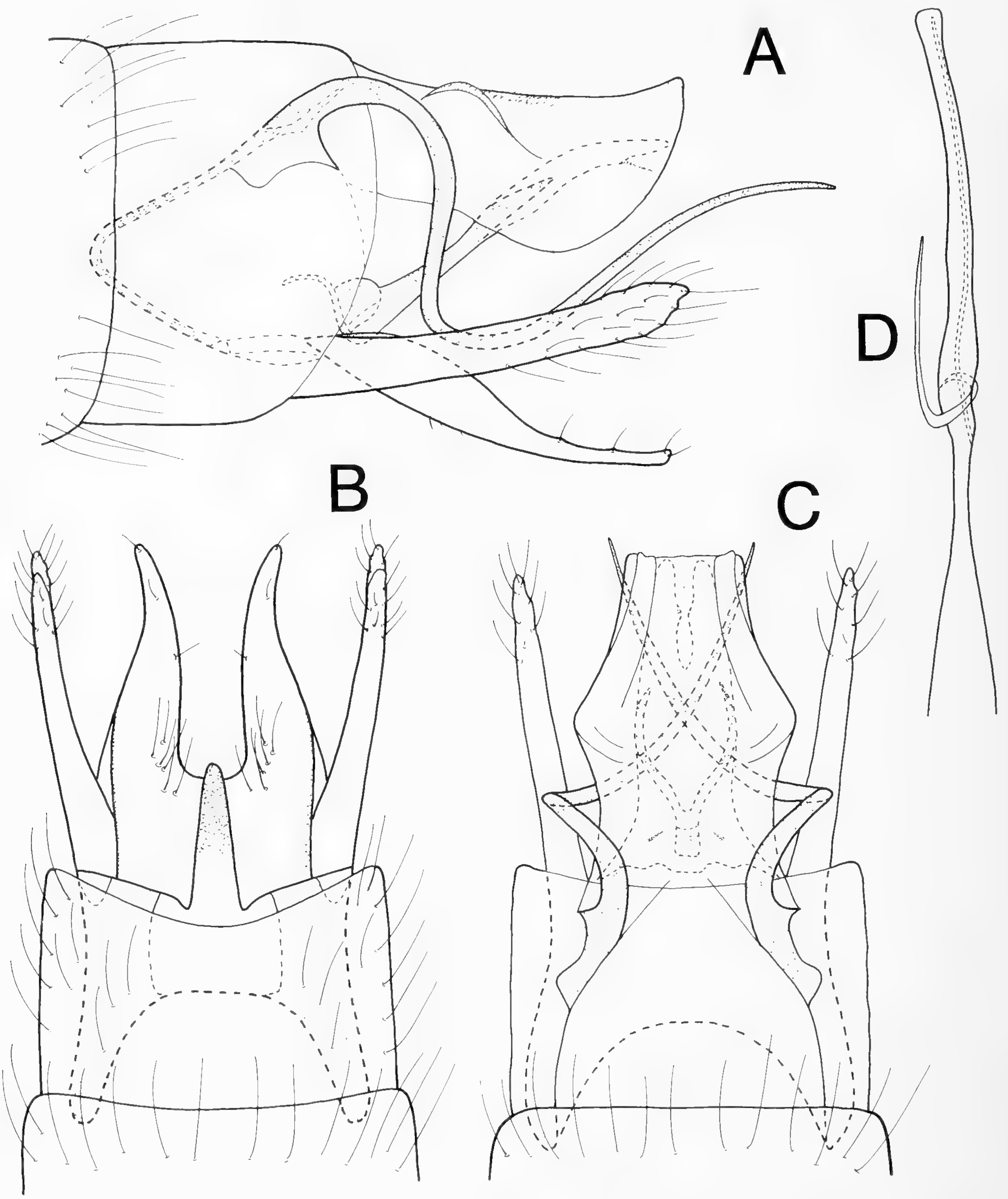

Fig. 6. *Neotrichia napoensis,* male genitalia; A. Lateral view, B. Ventral view, C. Dorsal view, D. Phallus, dorsal view.

in ventral view wide basally, tapering posteriorly to thin, rounded apex. Subgenital plate narrow and elongate in lateral view, sclerotized basally with pair of thin processes projecting ventrad, subapically bearing stout seta; in dorsal view bifid distally, each narrow lobe with subapical seta on mesal margin, sclerotized basally forming narrow lateral bands. Phallus tubular, thin paramere encircling shaft before midlength.

Specimen examined.—Holotype; Male. Uruguay, Dpto. Lavalleja, Rio Cebollati, Picada de Rodriquez, 28 February 1958, C. S. Carbonell. NMNH, Type 100514.

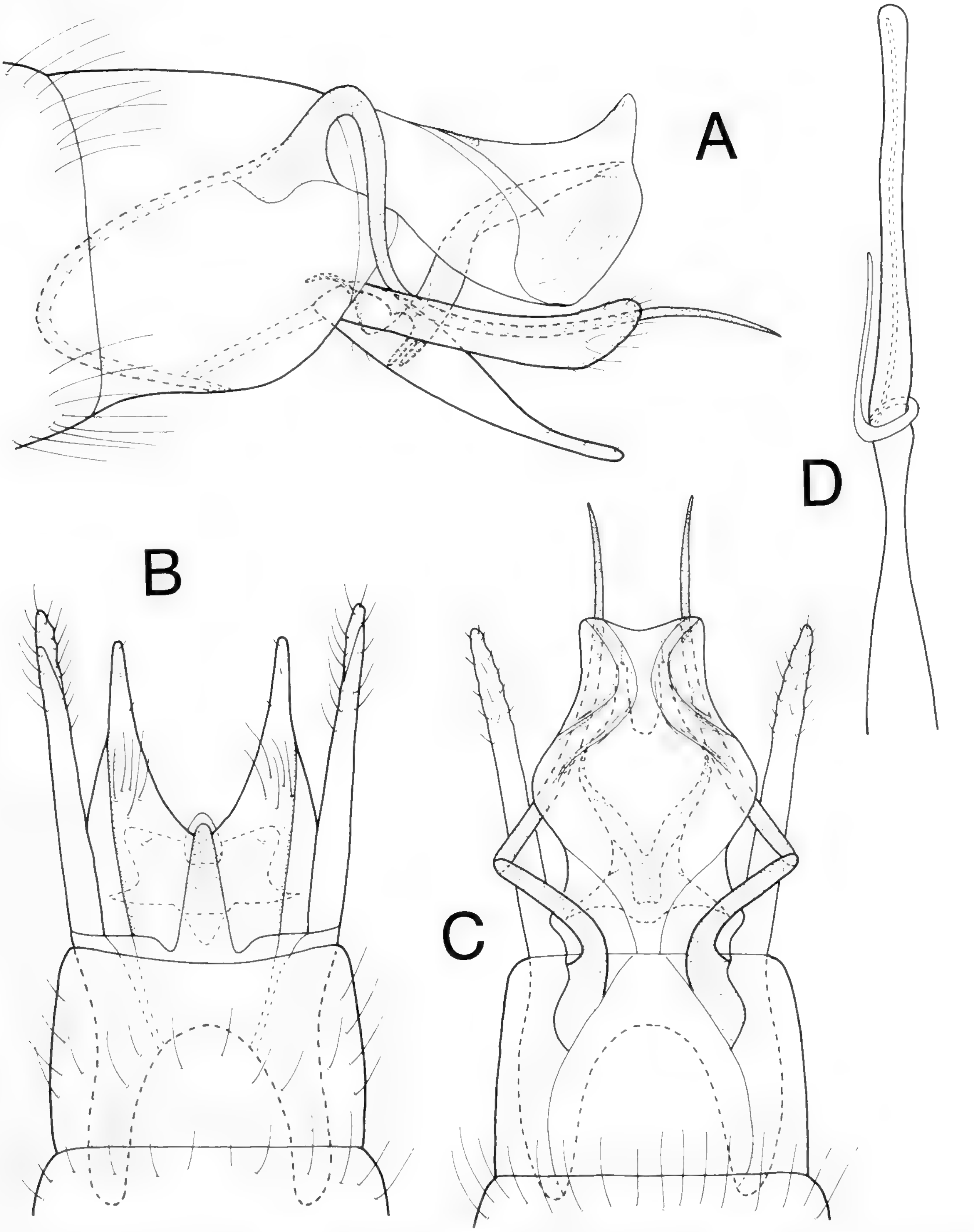

Fig. 7. *Neotrichia filifera,* male genitalia; A. Lateral view, B. Ventral view, C. Dorsal view, D. Phallus, dorsal view.

Neotrichia yagua Harris and Davenport, New Species

Fig. 8

Diagnosis.—In many aspects, *N. yagua* is atypical of *Neotrichia.* The species is considerably larger than other *Neotrichia* and the simple phallus lacks the paramere which encircles the shaft in most of the species.

Description.—*Male:* Length 2.5–2.8 mm. 28 antennal segments. Brown in alcohol. Ninth abdominal segment in lateral view with anterior margin tapering and extending

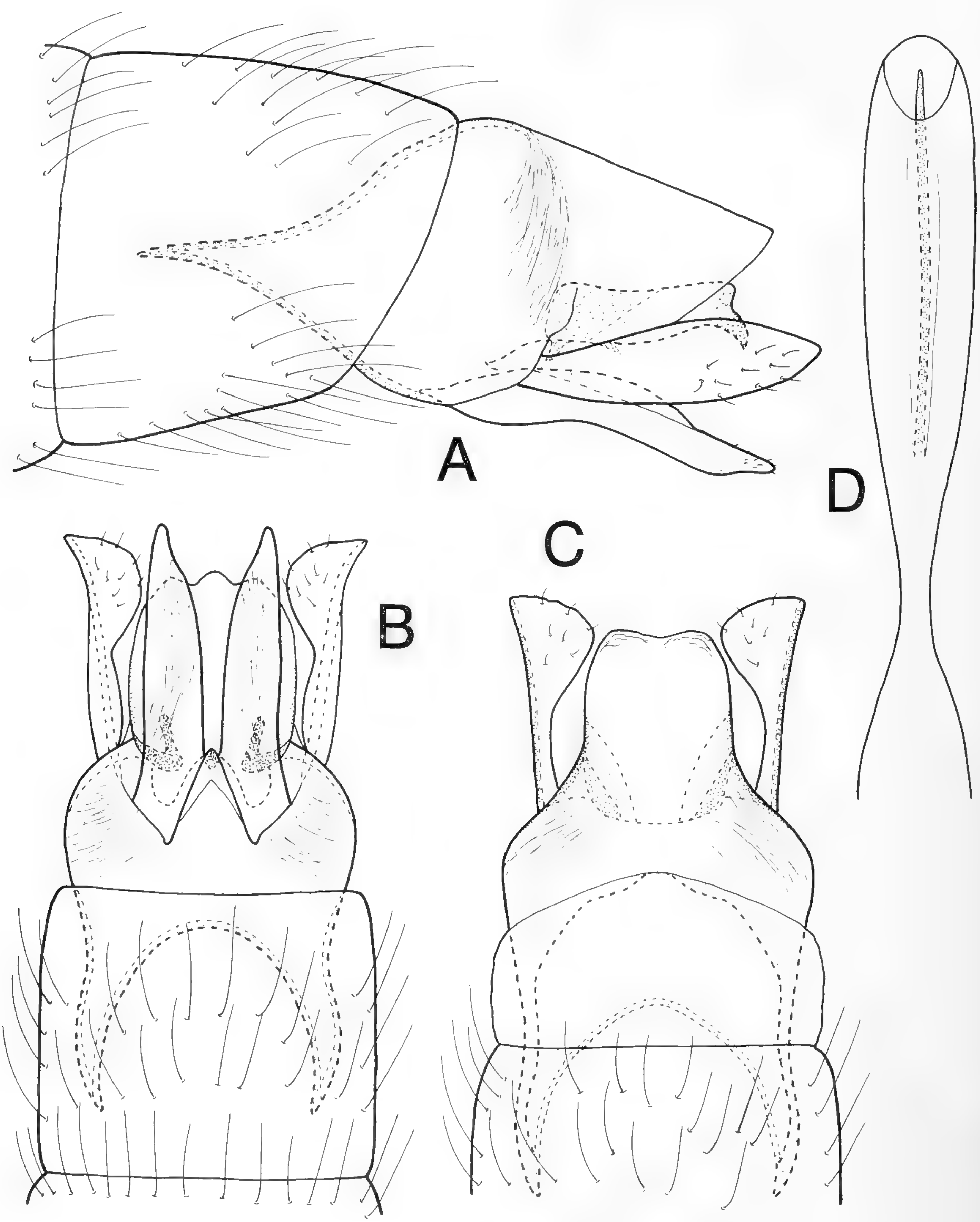

Fig. 8. *Neotrichia yagua,* male genitalia; A. Lateral view, B. Ventral view, C. Dorsal view, D. Phallus, ventral view.

nearly through segment VIII, posteriorly fused with X; elongate bracteoles posteroventrally, narrow at base and apex, in dorsal and ventral views narrow basally, widening to club-like apex. Segment X elongate and tapering distally in lateral view; in dorsal view square in shape. Inferior appendages lightly sclerotized, elongate and thin in lateral view, tapering to rounded apex; in ventral view thin and tapering apically, narrowly separated basally, slightly divergent distally. Subgenital plate in lateral view thin and elongate, acute ventral projection apically; in ventral view square in shape with small mesal lobe on posterior margin. Phallus tubular, narrowing near base then widening distally to rounded apex, elongate spine centrally, protruding apically.

Type material.—Holotype; Male. Peru, Loreto, Rio Sucusari, just upstream from Explornapo Camp, 12 March 1991, L. J. Davenport. Paratypes. Same data as holotype, 2 ♂, same data as holotype, but 16 January 1991, 1 ♂.

Etymology.—Named for the Yagua Indians which inhabit the area.

Neotrichia juntada Harris, New Species

Figs. 9, 10

Diagnosis.—The fused inferior appendages readily distinguish *N. juntada,* although the degree of fusion varies between the series of specimens taken from Peru and Venezuela. The apex of the phallus is also different in the two series, but the basic genitalic plan is the same.

Description.—*Male:* Length 1.5–2.5 mm. 18 antennal segments. Brown in alcohol. Ninth abdominal segment in lateral view with anterior margin tapering and extending through segment VIII, truncate posteriorly; bracteoles posteroventrally, narrow basally and widening apically in lateral view, in ventral view narrow basally, tapering distally to rounded apex. Segment X narrowed posteriorly in lateral view; in dorsal view square in shape, posterior margin slightly incised. Inferior appendages in lateral view wide basally, tapering distally to narrow, slightly upturned apex; fused basally in ventral aspect, pointed apex slightly divided in series from Peru, divided to near midlength in series from Venezuela. Subgenital plate in lateral view thin and elongate, ventral seta subapically; in ventral view divided into two thin lateral arms each narrowing at apex, with seta on mesal margin. Phallus tubular, wide basally, narrow to midlength, apical portion with sclerotized lateral process, central tube incised apically in series from Peru, narrowing to acute point in series from Venezuela.

Type material.—Holotype; Male. Peru, Loreto, tributary to Rio Yanomono at Explororama Lodge, 11 March 1991, L. J. Davenport. Paratypes. Same data as holotype, 14 ♂; same locality, but 10 March 1991, 3 ♂, Rio Sucusari just upstream from Explornapo Camp, 12 March 1991, L. J. Davenport, 22 ♂. Venezuela, Territorio Federal Amazonas, Rio Cataniapo, 10 km S Puerto Ayacucho, 9 March 1984, O. S. Flint, Jr., 3 ♂.

Etymology.—Spanish, joined or united, referring to the fused inferior appendages.

Oxyethira orellanai Harris and Davenport, New Species

Fig. 11

Diagnosis.—On the basis of the elongate ninth segment, this species is placed in the *Tanytrichia* subgenus of Kelley (1984). The short, acute processes which comprise the inferior appendages and venter of segment IX are distinctive for *O. orellanai.*

Description.—*Male:* Length 1.8 mm. 31 antennal segments. Brown in alcohol. Venter of segment VII with short apicomesal process. Segment VIII narrow in lateral view, rounded posteriorly, thin posterodorsally; anterior and posterior margins with mesal incision in dorsal and ventral aspects. Segment IX in lateral view, thin and elongate anteroventrally extending into segment V, truncate posterodorsally, tapering to an acute apex distally, in ventral aspect a mesal acute point posteriorly. Segment X membranous, narrow in dorsal view, rounded apically. Inferior appendages in lateral and ventral views short and acutely triangular. Subgenital plate narrow in lateral view, bending ventrad anteriorly, tapering posteriorly to acute apex; in ventral view wide and rec-

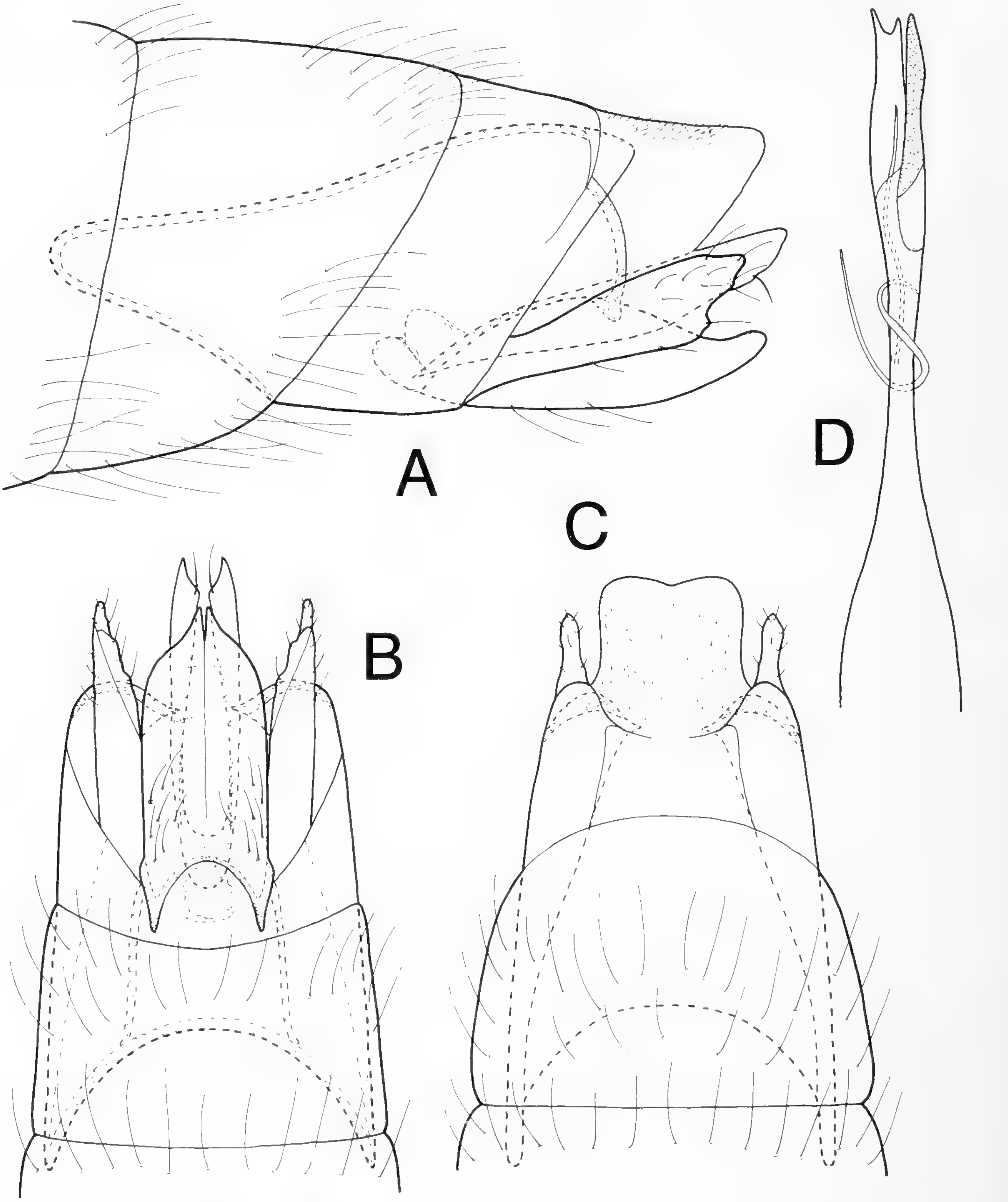

Fig. 9. *Neotrichia juntada,* paratype from Peru, male genitalia; A. Lateral view, B. Ventral view; C. Dorsal view, D. Phallus, dorsal view.

tanguloid. Bilobed process with arms widely separated in ventral view. Phallus thin and tubular with sclerotized sheath-like process encircling shaft posteriorly.

Type material.—Holotype; Male. Peru, Loreto, Rio Sucusari just upstream from Explornapo Camp, 12 March 1991, L. J. Davenport.

Etymology.—Named for Spanish explorer Francisco de Orellana, who in 1541 made the first descent of the Amazon River by way of the Rio Napo.

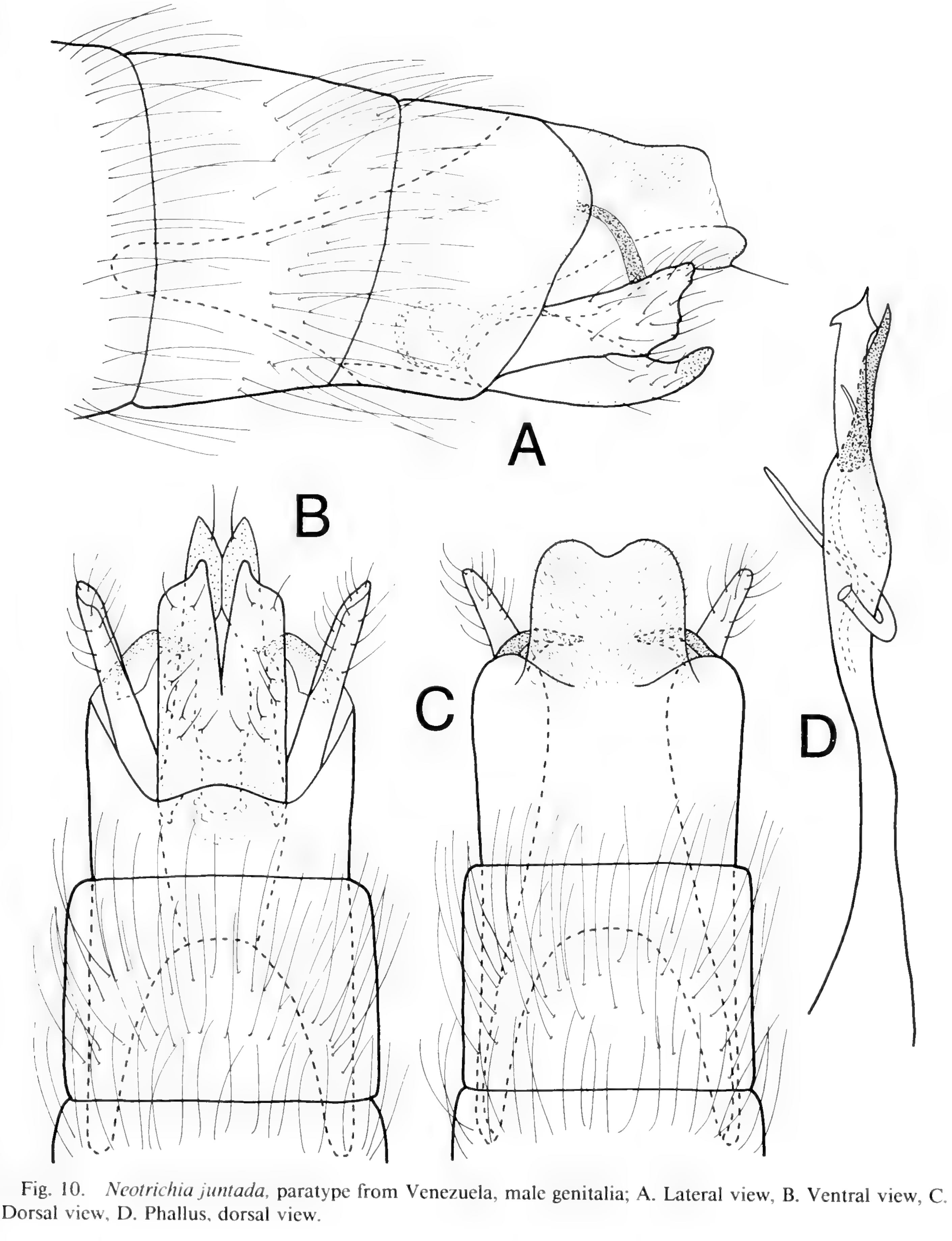

Fig. 10. *Neotrichia juntada,* paratype from Venezuela, male genitalia; A. Lateral view, B. Ventral view, C. Dorsal view, D. Phallus, dorsal view.

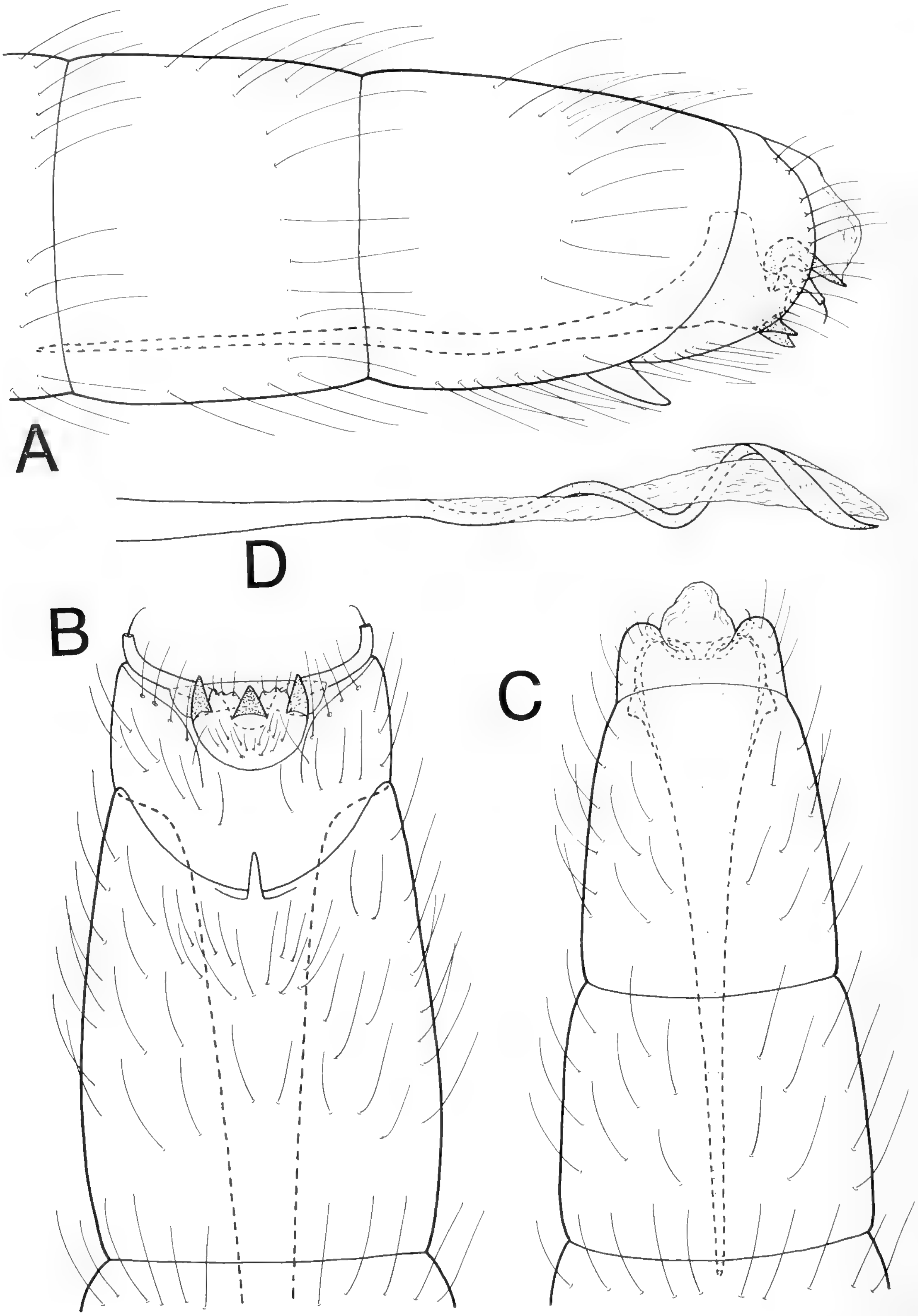

Fig. 11. *Oxyethira orellanai,* male genitalia; A. Lateral view, B. Ventral view, C. Dorsal view, D. Phallus, lateral view.

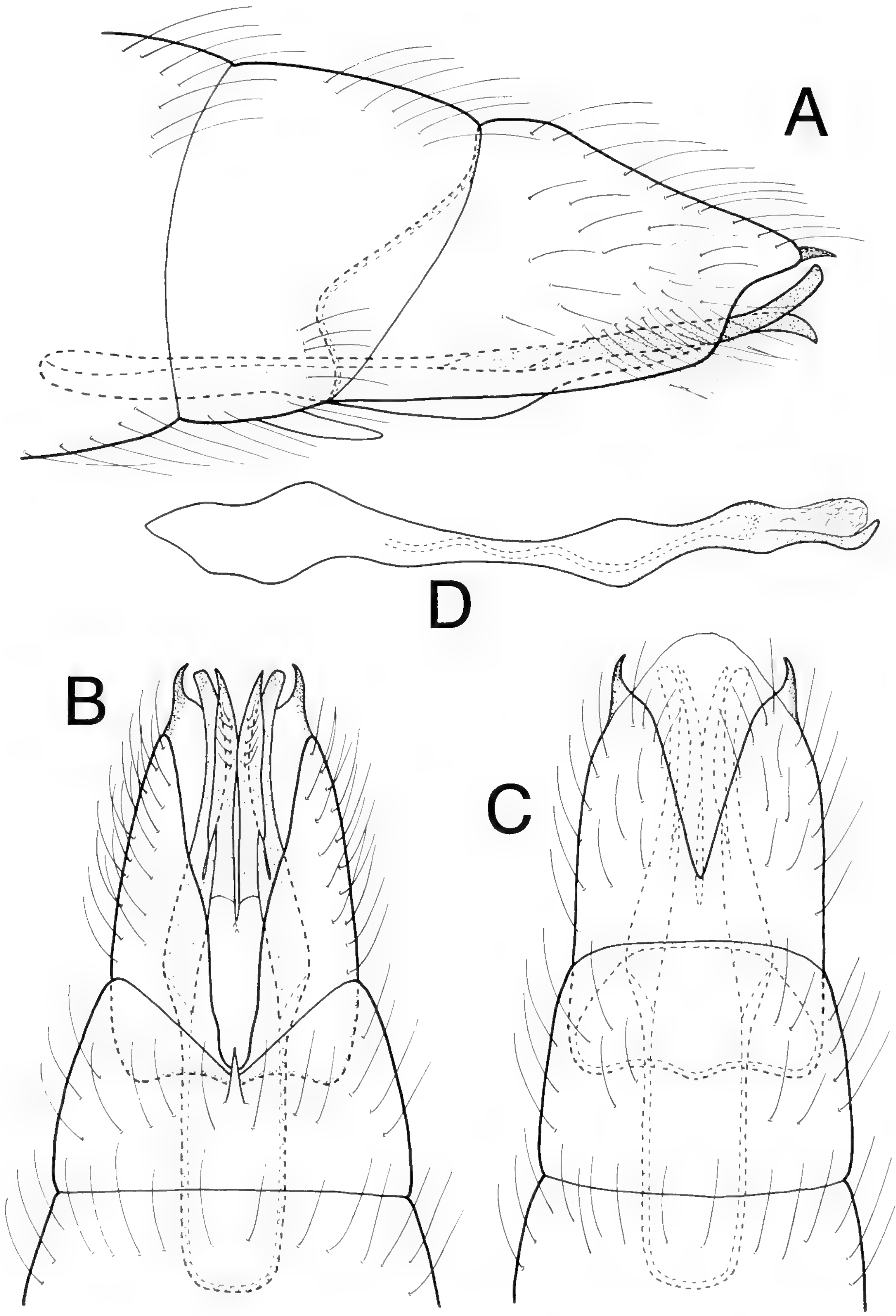

Fig. 12. *Oxyethira teixeirai*, male genitalia; A. Lateral view, B. Ventral view, C. Dorsal view, D. Phallus, lateral view.

Oxyethira teixeirai Harris and Davenport, New Species
Fig. 12

Diagnosis.—On the basis of the elongate narrow segment IX, *O. teixeirai* seems to fall in the *Tanytrichia* subgenus of Kelley (1984) with some similarity to *O. longissima* Flint. The species is distinguished by the simplistic genitalia and the lack of a subgenital plate and bilobed process.

Description.—*Male:* Length 2.5 mm. 30 antennal segments. Brown in alcohol. Venter of abdominal segment VII with short apicomesal process. Segment VIII in lateral view narrowing posterodorsally and tipped with stout spine; deeply incised in ventral and dorsal views, dorsolateral margins narrowed to acute apex. Segment IX thin in lateral view extending anteriorly into segment VI, posteriorly sclerotized and thin, curving dorsad apically; in ventral view divided into two long, thin lateral arms, curving laterad apically. Segment X membranous, rounded apically in dorsal aspect. Inferior appendages sclerotized and thin in lateral view, curving ventrad apically; in ventral view thin and nearly contiguous over length, pointed apices slightly divergent. Subgenital plate and bilobed process absent. Phallus sinuate, apicoventrally with narrow, sclerotized process.

Type material.—Holotype; Male. Peru, Loreto, small tributary to the Rio Sucusari at Explornapo Camp, 17 January 1991, L. J. Davenport.

Etymology.—Named for Portuguese explorer Pedro Teixeira, who in 1638 made the first ascent of the Amazon River reaching Quito via the Rio Napo.

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Buzz Peavy and staff at International Expeditions helped organize the trip to Peru as did Peter Jenson and staff at Explorama Tours in Iquitos. Funds to attend the International Rain Forest Workshop were provided by a Faculty Development Grant from Samford University. The help of Bob Stiles in organizing many aspects of the expedition is also gratefully acknowledged. O. S. Flint, Jr. of the National Museum of Natural History, Smithsonian Institution kindly provided many of the *Neotrichia* specimens included in this paper as well as the type of *N. filifera.*

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TAXONOMIC CHANGES IN NEARCTIC PTEROMALIDAE, WITH THE DESCRIPTION OF SOME NEW TAXA (HYMENOPTERA: CHALCIDOIDEA)

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Abstract.—Numerous taxonomic changes in the placement of Nearctic Pteromalidae are made, and five new species are described. New genera described include ***Ficicola*** Heydon (for *Ormocerus flora* Girault) and ***Collentis*** Heydon (for *Dipara latipennis* Ashmead); new species include ***Sphegigaster grisselli*** Heydon, *S. schauffi* Heydon, *Amphidocius schickae* Heydon & Bouček, ***Tricyclomichus algonquinus*** Heydon, and ***Panstenon poaphilum*** Heydon. New generic synonymies include *Apterolaelaps* Ashmead with *Dipara* Walker; *Parasyntomocera* Girault, *Stigmatocrepis* Ashmead, *Parecrizotes* Girault, and *Mesecrizotes* De Santis with *Gastrancistrus* Westwood; *Lophocomodia* Ashmead with *Psilocera* Walker; *Megatrydymus* Girault with *Acaenacis* Girault; and *Trimeromicrus* Gahan with *Zatropis* Crawford. The current taxonomic status of *Dipachystigma* Crawford, *Spalangiolaelaps* Girault, *Epipteromalus* Ashmead, and *Zatropis* Crawford is discussed. New Nearctic distribution records for *Melancistrus* Graham, *Ablaxia* Delucchi, and *Psilonotus* Walker are published. New species synonymies and combinations are published for the generic synonymies listed above as well as for *Cleonymus* Latreille, *Bairamlia* Waterston, *Macroglenes* Westwood, *Seladerma* Walker, *Sphaeripalpus* Förster, *Ablaxia* Delucchi, *Merisus* Walker, *Psilonotos* Walker, and *Tomicobia* Ashmead.

Key Words: Hymenoptera, Pteromalidae, Nearctic, fig, new genera and species, new synonymy, new combinations

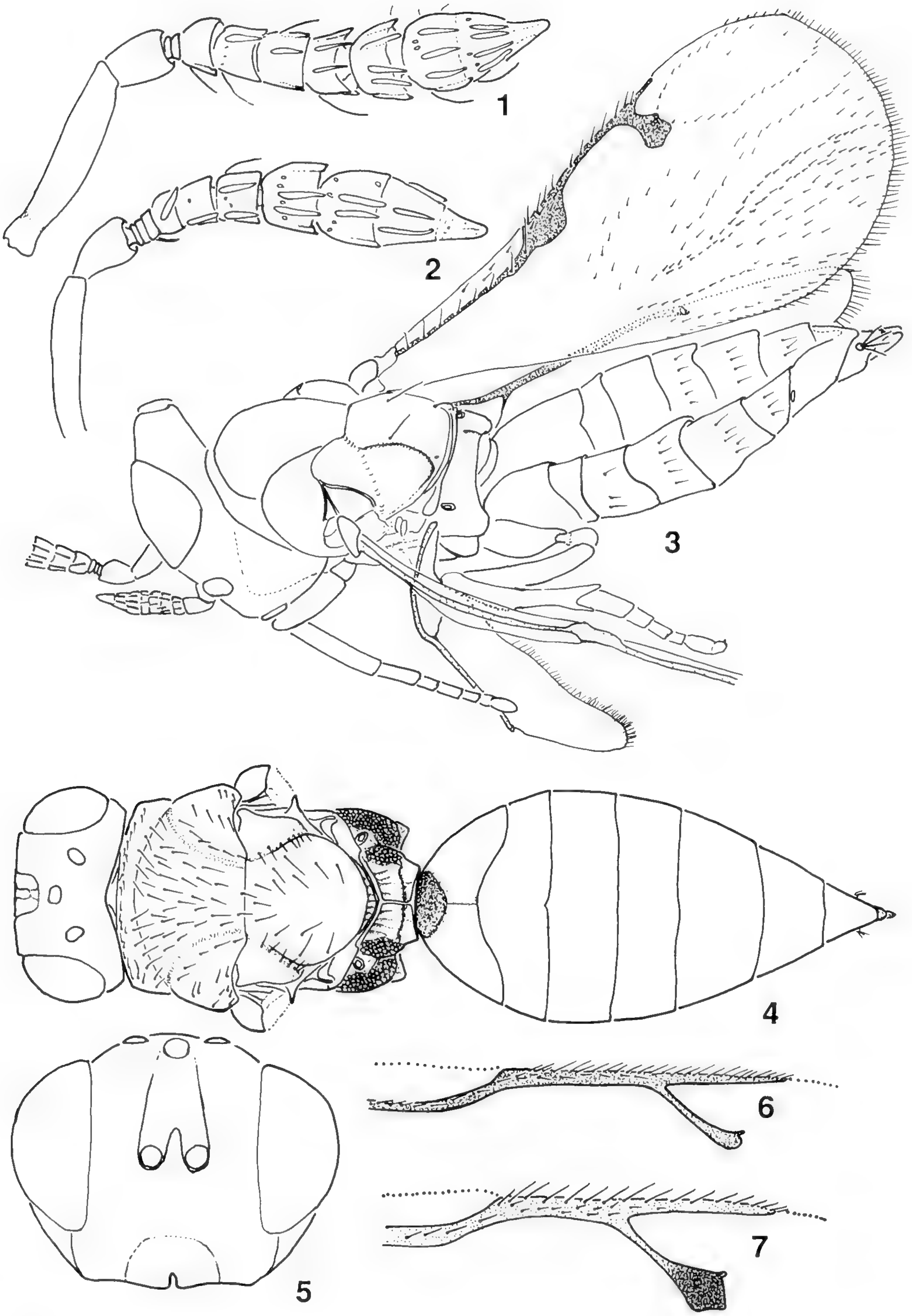
A study of the described species of Nearctic Pteromalidae by the authors for a key to the Nearctic genera has uncovered numerous taxonomic changes that need to be made before the key is published. Some of these, including new synonymies and corrections in the placement of genera and species of Nearctic Pteromalidae, are reviewed in the present text. In addition, five new species of Pteromalidae representing unusual species or species belonging to genera not yet recorded from the Nearctic region are described.

Terminology in this paper generally follows that of Graham (1969), except that genal concavity is used instead of genal hollow, the lower ocular line (abbreviated LOcL) is an imaginary line across the face between the most ventral point of the orbits, club is used instead of clava, the elongate raised sensilla on the antennal flagellar segments are called multiporous plate (abbreviated MPP) sensilla, the middle body tagma including the thorax and propodeum is called the mesosoma, and the gastral terga are numbered T1–7 beginning with the first tergite after the petiole. The following abbreviations are used: median ocellar diameter is MOD, ocel-ocular distance is OOL, posterior ocellar distance is POL, lateral ocellar distance is LOL, antennal funicular segments basally to distally are F1 through F6 and the gastral terga are T1 through T7. Sculpturing is defined according to Harris (1979). The units of measurement given in the descriptions can be converted to millimeters by multiplying by 0.02.

1. *Ptinobius* Ashmead was created for *Charitopus magnificus* Ashmead, 1888 without description (Ashmead 1896). *Ptinobius* was characterized in Ashmead (1904), and separated from *Cleonymus* Latreille and *Micradelus* Walker by differences in the visibility of the labrum. This character is of no validity as the labrum is more or less exposed in all species of this group, and since the species assigned to *Ptinobius* agree otherwise with those in *Cleonymus, Ptinobius* was synonymized with *Cleonymus* by Bouček (1988). He examined the types of all Nearctic species but formally transferred only *P. magnificus* to *Cleonymus.* The authors now transfer the four other Nearctic *Ptinobius* species to *Cleonymus* as *C. agrili* (Rohwer) **n. comb.**, *C. amabilis* (Cockerell) **n. comb.**, *C. californicus* (Crawford) **n. comb.** and *C. texanus* (Crawford) **n. comb.**

2. *Dipachystigma* Crawford was originally placed in the Tetracampini (Crawford 1911), then moved to the Pirenini (Peck 1951), but we place it in the Colotrechninae. The type species, *D. cushmani,* has five-segmented tarsi and both of the character states defining the Colotrechninae (Grissell 1985)—the axillae project cephalad well beyond the front of the scutellum and the scutellum with a pair of lateral longitudinal grooves produced by its swollen lateral portions (Fig. 3). *Dipachystigma* will not run out in the key to the genera of the Dvalliniinae (= Colotrechninae) by Hedqvist (1978) because the two known species are minute; consequently their antennal segmentation is reduced relative to other genera in the Colotrechninae. *Dipachystigma* is phenetically close to *Elachertodomyia* Girault; both genera having furrowlike notauli, five or fewer funicular segments, and slender femora. *Dipachystigma* can be separated from *Elachertodomyia* by the enlarged basal area of the marginal vein and by the spinelike terminal club segment.

Dipachystigma was described for *D. cushmani* Crawford, 1911 (Fig. 3); *D. secundum* Girault, 1917 was described shortly thereafter. These species are very similar except for differences in size and in the antennal segmentation. The type of *D. secundum,* with a wing length of 0.56 mm, is much larger than any specimens of the type series of *D. cushmani.* The six specimens of the type series of *D. cushmani* have wing lengths between 0.36 and 0.42 mm ($\bar{x} = 0.38$ mm). The funiculus of the type of *D. secundum* has two minute annelliform segments visible only in microscopic preparations, five quadrate funicular segments, and a three-segmented club (Fig. 1). The funiculus of the type of *D. cushmani* has two minute annelliform segments, one very short transverse almost annelliform funicular segment, four terete funicular segments each wider and longer than the one preceding, and a three segment club (Fig. 2). Two of the five paratypes of *D. cushmani* still retaining their antennae have the second funicular segment transverse also, so that only three funicular segments are quadrate and have MPP sensilla. A series of five females in the collection at Texas A&M that were collected on the same day from Benston-Rio Grande State Park, Texas, have four funicular segments with MPP sensilla except the smallest specimen, which has only three. The variation in the number of funicular segments with MPP sensilla may be attributed to the size of the individual—large individuals may have four or five such segments, smaller individuals three. However, until a series is found which contains individuals with both four and five segments with MPP sensilla, we prefer to keep *D. cushmani* and *D. secundum* separate.



Figs. 1–7. 1, *Dipachystigma secundum,* female, antenna. 2–3, *D. cushmani,* female. 2, antenna; 3, habitus. 4–7, *Ficicola flora.* 4, female, body (dorsal view); 5, female, head (anterior view); 6, female, fore wing venation; 7, male, fore wing venation.

3. Examination of many specimens of Diparinae, especially in the CNC (Ottawa) and the USNM (Washington, D.C.), led us to affirm that *Apterolelaps* Ashmead, 1904 is a junior synonym of *Dipara* Walker, 1833 (as *Tricoryphus* Förster, 1856) as first proposed by Delucchi (1959). Subsequent revisions of the Diparinae by Hedqvist (1969) and Yoshimoto (1977) maintained *Apterolaelaps* as a valid genus. These latter researchers based their conclusions on the fact that the annellus is almost fused with the first funicular segment in the single type specimen of the type species, *A. nigriceps* Ashmead. However, in all other characters this specimen agrees with the species characterized by Yoshimoto as *Dipara pedunculata* (pp. 1040–1042, and figs. 2A–D, 26). Yoshimoto further confused the matter by designating a holotype female for *D. pedunculata* that disagrees with his own description, and is in fact a specimen of *D. canadensis* Hedqvist. The synonymy of the two described Nearctic species of *Dipara* should be as follows:

Dipara nigriceps (Ashmead) **n. comb.**
  Apterolelaps nigriceps Ashmead, 1904: 279.
  Apterolaelaps nigriscutum Girault, 1916: 264.
Dipara canadensis Hedqvist
  Dipara canadensis Hedqvist, 1969: 193.
  Dipara pedunculata Yoshimoto, 1977: 1040–1042, **n. syn.**

4. Ashmead (1904) regarded the Lelapinae and Diparinae as separate subfamilies in the Miscogasteridae and Pteromalidae respectively, so separated mainly because of the presence or absence of a median tooth on the clypeus. After Lelapinae was placed in synonymy under Diparinae by Bouček (1954: 54), Delucchi (1962: 380) retained the two former groups as two different tribes of the Diparinae. Later Hedqvist (1969) apparently followed Delucchi in regarding the two tribes as valid subdivisions of the Diparinae, but did not refer to Delucchi's paper. From his key, however, it is possible to assume that he disregarded the clypeal character used by Ashmead, and placed the genera with brachypterous females in the Diparini; *Laelaps* Haliday, with fully winged females, was placed in the Lelapini. Yoshimoto (1977), following Hedqvist (1969), also used this subdivision, again in a vague way, without knowing about Delucchi's proposal.

We do not see any reason why the Diparinae of America should be divided into three tribes (the Diparini, Lelapini, and Netomocerini) as proposed by Hedqvist (1971). We feel they should be regarded as synonyms as treated by Bouček (1988) since intermediates between these "tribes" are known. Although morphologically very close to *Lelaps* Haliday, both Hedqvist (1969) and Yoshimoto (1977) placed *Spalangiolaelaps* Girault, 1916 in the Diparini because only the brachypterous females of its type species, *S. argenticoxa* Girault, are known, and did not compare it with *Lelaps* (of the Lelapini) whose species, described or undescribed, are fully winged. *Spalangiolaelaps* Girault is maintained herein as a valid genus, but when the male of *S. argenticoxa* is known, *Spalangiolaelaps* may prove to be a *Lelaps* species with brachypterous females.

5. Palearctic *Gastrancistrus* Westwood species are known to belong to several species groups, but the genus exhibits such a variety of form in the Nearctic region that a precise definition of the genus is difficult. Certain species are so divergent from the basic morphology that they were given generic names. The authors believe *Gastrancistrus* should be treated rather broadly to prevent its fragmentation into biologically or cladistically meaningless units. After examination of the appropriate types by the authors, the following genera are newly synonymized with *Gastrancistrus* Westwood: *Parasyntomocera* Girault, 1917, **n. syn.**; *Stigmatocrepis* Ashmead, 1904, **n. syn.**; *Parecrizotes* Girault, 1916, **n. syn.**; and *Mesecrizotes* De Santis, 1968, **n. syn.**

6. The genus *Bairamlia* Waterston should

be deleted from the North American catalog (Burks 1979) because that record is based on the misidentification of *Pirene marylandensis* Girault by Gahan (in Waterston 1929). Our examination of the holotype of *P. marylandensis* revealed that the species belongs in *Gastrancistrus,* and should be known as *G. marylandensis* (Girault), **n. comb.**

7. The generic name *Pirene* Haliday, 1833 was replaced by *Macroglenes* Westwood, 1832 by Bouček (1988) and the two species under the genus in Burks (1979) are now regarded as *Macroglenes.* This includes *P. penetrans* as *M. penetrans* (Kirby), **comb. revocata**, and the species *P. marylandica,* as *M. marylandicus* (Girault), **n. comb.**, despite a remark by Burks that "placement of this sp. in *Pirene* may be erroneous." We have examined the holotype fragment on a slide and have no doubt that the species belongs to *Macroglenes.*

8. *Systasis diplosidis* Eckel was described in 1903. In 1969 Graham described a new genus, *Melancistrus,* for species similar to *Systasis* but with a more hirsute callus, the propodeum with a distinct median carina usually crossed by a transverse elevation or crest, the hind coxa more crested and hirsute, and the female gaster with the hypopygium longer and with a terminal membranous projection (mucro). *Systasis diplosidis* fits the definition of *Melancistrus,* and so is transferred to *Melancistrus* as *M. diplosidis* (Eckel), **n. comb.** This is the first record of *Melancistrus* from the Nearctic region.

9. *Ormocerus flora* Girault, 1920 is not an *Ormocerus* species. We place it, as the type species, in a new genus, *Ficicola* Heydon, that is characterized as follows:

Ficicola Heydon, New Genus
Figs. 4–7

Type species.—*Ormocerus flora* Girault, 1920.

Female: Body copper-colored; head and dorsum of mesosoma with distinct white setae. Head, dorsum of mesosoma finely punctate. Head having clypeus with anterior margin more or less produced, deeply emarginate mesally (Fig. 5); gena convex; toruli located well above LOcL, separated by dorsally projecting spur (Figs. 4, 5); antennal scrobes deep; occiput immarginate. Antenna with 2 annelli, 6 funicular segments; club 3-segmented, without apical spicula or ventral patch of micropilosity. Mesosoma with short horizontal pronotal collar, its anterior edge abrupt but acarinate; notauli extending to hind margin of pronotum as narrow and shallow groove (Fig. 4); scutellum broadly abutting mesoscutum; upper epimeron with a pair of pits, smooth only along anterior margin; dorsellum cariniform; propodeum with complete median carina, with straight costula meeting median carina at right angles; plicae as wide as spiracles and minutely alveolate dorsally, callus finely alveolate and moderately setose, nucha short and smooth crescent. Gaster sessile; terga inflated even in air-dried specimens; hind margin of T1 concave mesally, with median longitudinal line of weakness so in some lights the tergum appears divided in two (Fig. 4); succeeding terga unremarkable. Fore wing with costal cell bare over mesal ⅓; basal cell and basal vein bare; speculum well developed, open posteriorly; marginal vein slender, longer than postmarginal vein; stigmal vein shorter than postmarginal vein; stigma not noticeably enlarged, concolorous with stigmal vein (Fig. 6). Legs, especially fore and hind femora enlarged; hind coxa without dorsobasal setae; hind tibia with one apical spur.

Males similar to females except: Body color yellowish green except gaster brown with basal circular yellow patch. Antenna with one row of MPP sensilla on each funicular segment, with short semierect setae. Fore wing with marginal vein somewhat thickened; stigma enlarged, much darker than remainder of venation (Fig. 7).

Ficicola flora is known from the holotype female, paratype male and female and an additional 2 males all reared from fig, 16 May 1887 at Coconut Grove, Florida (United States) (all USNM). An additional 16 specimens were collected from the following Florida localities (all USNM): Biscayne, 2 ♀; Cutler, 10.II.1909 (on *Ficus aurea*), 2 ♀; Miami, V.1989 (ex *Ficus aurea* fruit galls), 7 ♀, 5 ♂.

Etymology.—The genus name is derived from *Ficus,* the generic name of figs, and the suffix *-cola,* meaning resident. The gender is masculine.

10. *Terobia vulgaris* Ashmead, 1902 was described from St. Paul Island, Alaska from "many specimens." A total of 42 specimens of what must be the type series are housed under this name in the USNM collection. These must be regarded as syntypes since their data labels record them from the type locality, they all have identical type labels, and both the original description and the Smithsonian type log book record there being many type specimens. These syntypes include at least four different species, but only two of these species are represented by unbroken specimens of both sexes. Ashmead's description is contradictory at times, and neither of these species agrees perfectly with his description. A lectotype female has been chosen from the series most likely to be unambiguously distinguishable, labelled, and is deposited in the USNM collection. *Terobia vulgaris* was moved to *Ormocerus* Walker by Burks (1979) after *Terobia* was synonymized with *Ormocerus* by Delucchi (1955). The lectotype of *T. vulgaris* (as well as the other three "species" in the type series) belongs in *Seladerma* Walker, so *Terobia vulgaris* Ashmead is herein transferred to *Seladerma* as *S. vulgaris* (Ashmead), **n. comb.**

11. Burks (1979) lists eight Nearctic species of *Miscogaster* Walker. *Miscogaster aurata* (Ashmead), 1896 is herein transferred to *Sphaeripalpus* Förster as *S. auratus* (Ashmead) **n. comb.** *Miscogaster abnormicolor* Girault, 1917; *M. biguttata* Girault, 1917; *M. discoloripes* Girault, 1917; *M. flora* Girault, 1917; *M. keatsi* Girault, 1917; *M. marylandica* Girault, 1916; and *M. ungutta* Girault, 1916 are all transferred to *Gastrancistrus* Westwood as *G. abnormicolor* (Girault) **n. comb.**, *G. biguttatus* (Girault) **n. comb.**, *G. discoloripes* (Girault) **n. comb.**, *G. flora* (Girault) **n. comb.**, *G. keatsi* (Girault) **n. comb.**, *G. marylandicus* (Girault) **n. comb.** and *G. ungutta* (Girault) **n. comb.** True undescribed *Miscogaster* species do occur in North America (authors' unpublished information). Furthermore, the European *M. hortensis* Walker and *M. maculata* Walker were introduced to control the Alfalfa blotch leafminer, *Agromyza frontella* (Rondani), and may be established since *M. hortensis* was recovered a year after release (Hendrickson and Barth 1979).

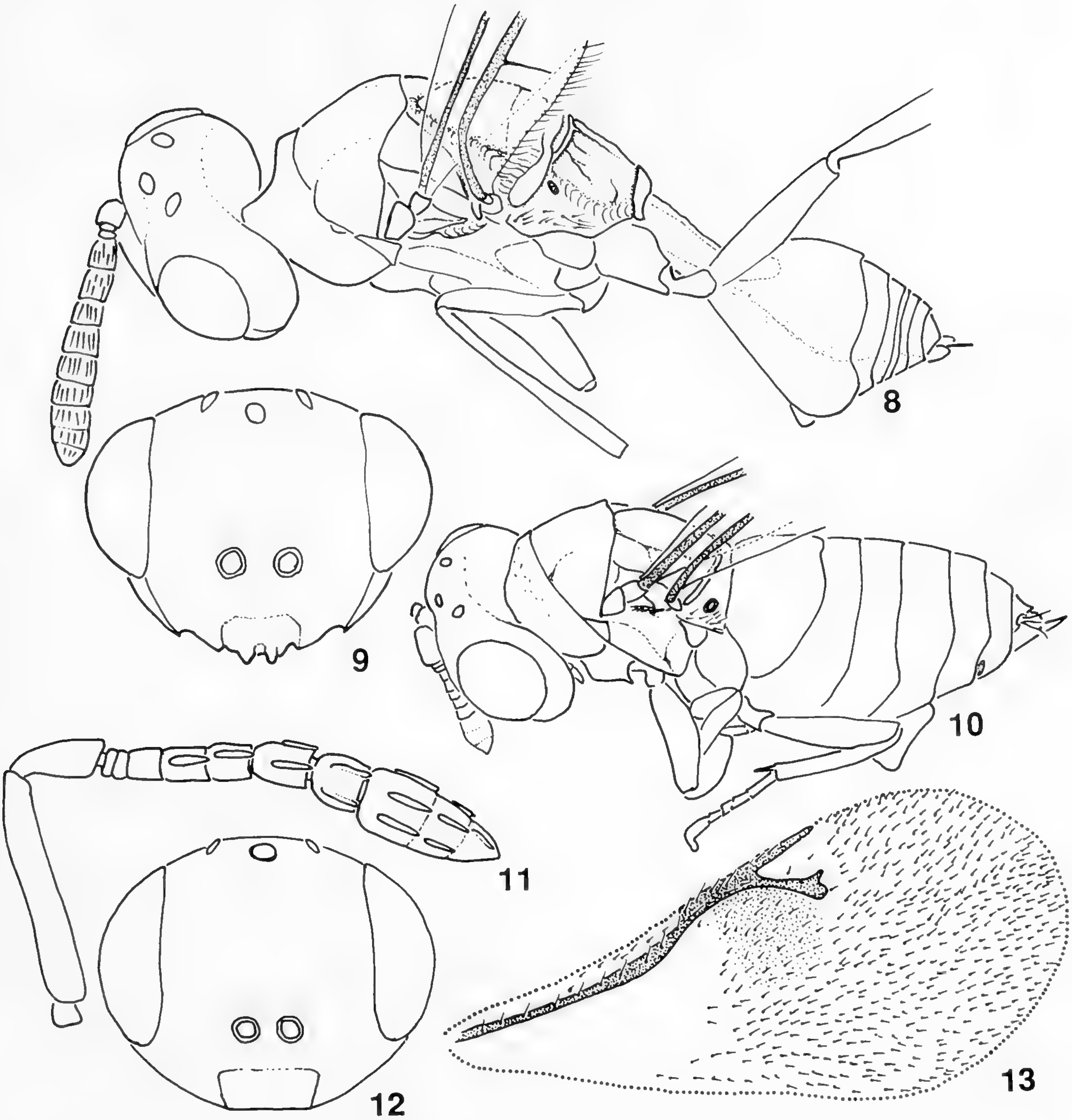
12. *Dipara latipennis* Ashmead, 1890 was transferred to *Callimerismus* Graham by Hedqvist (1969). The reasons why *D. latipennis* is not a species of *Callimerismus* are outlined in Heydon (1989). The following new genus is described for this species.

Collentis Heydon, New Genus

Figs. 8–9

Type species.—*Dipara latipennis* Ashmead, 1890.

Body dark green metallic. Clypeus with three asymmetrically arranged apical denticles (the left two teeth more or less fused but the separation still indicated by a distinct groove) (Fig. 9); with shallow genal hollows extending ⅓ malar distance; toruli 1 × own diameter above LOcL; vertex with weak crest behind posterior ocelli. Antenna with two annelli and six funicular segments; club with small patch of MPP sensilla on apical club segment, without terminal spicula. Mesosoma with pronotal collar smooth over posterior ½, rounded anteriorly; notauli very shallow, traceable to hind margin of mesoscutum as strip of distinct sculpture; scutellum highly convex (Fig. 8), longer than wide, without anterior median groove; frenal sulcus distinct, frenum alveolate; prepectus alveolate, without carina delimiting dorsoposterior corner; upper epimeron al-



Figs. 8–13. 8–9, *Collentis latipennis,* female. 8, habitus; 9, head (anterior view). 10–13, *Amphidocius schickae,* female. 10, habitus; 11, antenna; 12, head (anterior view); 13, fore wing.

veolate ventrally; propodeum alveolate with some weak rugae, extending posteriorly between hind coxae, median carina not well developed, plicae weakly developed but smoothly and regularly converging posteriorly, nucha smooth raised crescent. Petiole elongate, tapering anteriorly and lacking anterior ventral basal flange, with pairs of anteriorly directed setae extending halfway down its length. Gaster shortly ovate; T1 extending ½ gastral length, hind margin sinuous laterally and weakly convex mesally (Fig. 8). Fore wing with postmarginal vein longer than marginal vein; stigma hardly wider than stigmal vein; speculum present and not bordered by setae posteriorly; basal vein unpigmented. Hind wing lacking any setae basad of basal cross vein. Legs with two spurs on hind tibia.

Males similar but also with maxillary

palps not enlarged; all funicular segments elongate; scape with convex shiny brown smooth boss.

Collentis belongs in the Miscogasterini, and is similar to *Rhicnocoelia* Graham but has a reticulate, elongate petiole; *Rhicnocoelia* has a smooth, transverse petiole. *Collentis* is also similar to *Miscogaster* but lacks a darkly pigmented basal vein, enlarged stigma, setae basad of basal cross vein in hind wing, and a median emargination in T1. *Collentis* also has the body sculpture alveolate not coriaceous as in *Miscogaster* species.

Etymology.—The generic name, from the Latin words *collis,* meaning hill or high ground, and *entis,* meaning being, refers to the montane places where *C. latipennis* exists. The gender of *Collentis* is feminine.

Material examined.—The holotype male was collected at West Cliff, Colorado (USNM Type No. 41231, examined). An additional female and male seen were collected as follows (USNM): United States. Colorado: Chambers Lake, Larimer Co., 18.VII.1895, 1 ♂; Rist Canyon, Teller Co., 6.V.1895, 1 ♀.

Biology.—The host(s) of *Collentis* species are unknown, but are likely to be leaf or stem mining Diptera as are other related genera.

13. The genus *Lophocomodia* was established by Ashmead (1888), who based it on the single species *L. americana* Ashmead, 1888. The original type material is lost, but it seems to us that the description clearly suggests that it was based on a male of *Psilocera* (also G. E. Wallace, pers. comm.). Hence, *Lophocomodia* becomes a new junior synonym of *Psilocera* Walker, 1833 and the species should be known as *P. americana* (Ashmead) **n. comb.** The species may be recognizable from the description when *Psilocera* is revised for North America.

14. Girault based the description of the genotype of *Acaenacis* Girault, 1917 on a comparison with that of *Megatrydymus* Girault, 1917. He cited three differences between the two genera: *Megatrydymus* had complete notauli, spatulate body setae, and a more slender gaster; *Acaenacis* had incomplete notauli, its body setae slender, and a broader gaster (Girault 1917). However, *Megatrydymus* has incomplete notauli; although the notauli in *Megatrydymus,* as indicated by a strip of distinctive sculpture, do extend further posteriorly than in most other Pteromalinae, they do not extend to the scutoscutellar sulcus as a furrow, groove, or line of punctures. The other two differences, while accurate, we feel are of no more than specific value. Since *Acaenacis* and *Megatrydymus* share a similar distinct gestalt and similar biologies (as parasitoids of cynipids), the authors synonymize *Megatrydymus* Girault (**n. syn.**) with *Acaenacis* Girault. The two species of *Megatrydymus, M. agrili* (Rohwer), 1919 and *M. tacti* Girault, 1917, thus become *Acaenacis agrili* (Rohwer) **n. comb.** and *A. tacti* (Girault) **n. comb.**

Acaenacis can be briefly characterized as follows: Head with clypeus rectangular, as high or higher than wide, its anterior margin nearly straight, anterior tentorial pits deep; toruli high on head (½ way up LOcL). Antenna 13-segmented, with 3 annelli and five funicular segments; scape extending well above vertex; all funicular segments elongate, with more than one row of MPP sensilla. Mesosoma with pronotal collar rounded anteriorly; notauli sometimes indicated far posteriorly by band of distinctive sculpturing; propodeum short in females (median length ⅓ or less scutellar length), longer in males (median length around ½ scutellar length), plicae indicated by convex folds; nucha a transverse smooth strip along hind margin of propodeum. Legs with hind coxa crested, bare dorsally; hind tibia with two apical spurs. Fore wings with postmarginal vein only about as long as stigmal vein; stigma greatly enlarged. Gaster with hind margin of T1 often sinuous sublaterally but roundly produced medially. *Acaenacis* is represented by three described Nearctic species and by other undescribed species in Central and South America.

15. Burks (1979) lists two Nearctic species of *Caenacis* Förster. *Caenacis asinus* Girault has the sharply carinate collar, the elongate reticulate propodeum with low straight transverse costula, and other characteristics of *Ablaxia* Delucchi. *Caenacis asinus* Girault, 1917 is herein transferred to *Ablaxia* Delucchi as *A. asinus* (Girault) **n. comb.** This is the first Nearctic record of *Ablaxia.*

Semiotellus cupraeus (Provancher), 1881 was transferred to *Caenacis* by Burks (1964). The type was not seen by the authors, but the brief description in Burks (1964) suggests that it may be an *Ablaxia* as well, possibly the same species as *A. asinus.*

16. *Epipteromalus* Ashmead was described for the species *E. algonquinensis* Ashmead (Ashmead 1904), but was subsequently synonymized with *Trichomalus* Thomson by Kurdjumov (1913). This synonymy was missed by "Zoological Record" and apparently by almost all Nearctic chalcidoid researchers since *Epipteromalus* appears without mention of its synonymy in Peck (1963) and Burks (1979) (but see *Epipteromalus* in Gahan and Fagan 1923). The authors believe *Epipteromalus* is a valid genus of Pteromalinae (*sensu* Graham 1969). It can be briefly characterized as follows: Species with body color dark, only weakly metallic. Head usually rather large; clypeus with anterior margin weakly truncate or weakly concave; lateral mouth margin emarginate but gena without well developed concavity above mandible; face with striae extending from clypeus to toruli or beyond; occiput immarginate. Antenna with 2 annelli and six funicular segments, these latter short and sometimes strongly transverse. Mesosoma compact; pronotal collar at most weakly margined; scutellum strongly convex, narrowed anteriorly, axillar grooves very broad and deep; upper mesepimeron smooth. Fore wing with postmarginal vein about as long as marginal vein, much longer than stigmal vein. Gaster of female ovate, blunt apically. In addition to the unusual facial striae and the convex, narrow scutellum, *Epipteromalus* species lack the dorsal hairs on the hind coxa characteristic of *Trichomalus* species. *Epipteromalus algonquinensis* Ashmead, 1904 is the only described Nearctic species, but there are at least four undescribed Nearctic species of the genus.

17. *Eulonchetron* Graham, 1956 was missed in the North American catalog (Burks 1979), although Graham (1969: 600) listed specimens of *E. scalprum* (Askew) from Manitoba, Canada. The valid name and synonymy of the species, as examination of the relevant types revealed, is as follows:

Eulonchetron giraulti (Peck) Bouček, 1991: 202.
  Habrocytus canadensis Girault, 1917: 178, 181, 182 (preoccupied by Ashmead, 1887).
  Habrocytus giraulti Peck, 1951: 562 (n. n. for *canadensis* Girault, 1917).
  Lonchetron scalprum Askew, 1962: 1–3.
  Eulonchetron scalprum (Askew) Graham, 1966: 261.
  Lonchetron giraulti (Peck) Burks, 1979: 814.

18. *Merisus harmolitae* Gahan, 1928 was moved to *Homoporus* Thomson by Burks (1979). Herein, *M. harmolitae* is restored to its original status as a species of *Merisus* Walker. *Merisus harmolitae* females have the convex gaster and elongate 4th and 5th gastral terga characteristic of female *Merisus*; males have the flagellum distinctly paler ventrally, and the funicular segments with numerous MPP sensilla and short setae as do other male *Merisus.* Female *Homoporus* have the dorsum of the gaster collapsed in air-dried specimens and the 4th and 5th gastral terga not so long (generally shorter than tergum 3); males have the flagellum of a nearly uniform color, and the funicular segments with only one or two sparse rows of MPP sensilla and usually with long, semierect setae.

Nonetheless, there is some difficulty with the generic placement of *M. harmolitae* since it lacks one of the primary characteristics by which *Merisus, Homoporus,* and related genera are recognized—the apical spicula on the female club. However, *M. harmolitae* does have another of the unique characteristics of this group—the uniformly reticulate, featureless propodeum. Some *Chlorocytus* species are phenetically similar to *M. harmolitae* and lack an apical spicula on the club, a distinct median carina, and plicae. But *Chlorocytus* species usually have a more or less carinate pronotal collar, nearly always have deep basal foveae that are margined medially and/or laterally by fine carinae, and the female gaster collapses in air-dried specimens. *Merisus harmolitae* lacks these latter features, so it is thought best to retain *M. harmolitae* in *Merisus,* though its status may need review once the generic limits of *Homoporus, Merisus,* and *Chlorocytus* are better understood.

19. Burks (1979) transferred *Eutelus betulae* Girault, 1917 to *Mesopolobus* Westwood. From the type material, it is obvious that the species belongs to *Psilonotus* Walker, as suggested by Graham (1969). Hence the species should be known as (*Psilonotus betulae* Girault), **n. comb.** A lectotype female was selected by the authors, labelled, and placed in the type collection of the USNM.

20. *Karpinskiella* Bouček was recently synonymized with *Tomicobia* Ashmead (Bouček 1991). *Karpinskiella paratomicobia* Hagen and Caltagirone, 1968 is herein transferred to *Tomicobia* as *T. paratomicobia* (Hagen and Caltagirone) **n. comb.**

21. *Zatropis* Crawford, 1908 is one of the most species-rich genera of Nearctic Pteromalidae. *Zatropis* species can be recognized as follows: Body color generally very dark, but often with flattened white setae. Head with clypeus truncate, usually weakly concave mesally; gena sometimes flattened but usually not concave (weakly so in *Z. albiclava*); toruli located just above to well above LOcL; occiput immarginate. Antenna with three annelli and five funicular segments; female club lacking apical spicula or large ventral patch of MPP sensilla. Pronotal collar crested anteriorly but acarinate; propodeum relatively short, with plicae usually strongly developed, median carina usually well developed and broadening into relatively large triangular nucha, this nucha convex but flattened posteriordorsally and usually alveolately sculptured. Fore wing with postmarginal vein longer than stigmal vein; dorsally with speculum extending to stigmal vein along anterior margin of wing; ventrally usually with only one (rarely with more than one) row of well developed admarginal setae. Gaster of females ovate acuminate.

Despite its species sharing a similar gestalt, there are few autapomorphic characters defining *Zatropis* as a whole. The three most distinctive characteristics of *Zatropis* species are: 1. A distinct ventral row of admarginal setae on the fore wing (a similar distinct ventral row of admarginal setae is also found in *Callitula* Spinola, *Systasis* Walker, and *Eurydinoteloides* Girault). 2. Many *Zatropis* species have distinct flattened white setae on the head and mesosoma (similar setae are found in a few other pteromaline genera such as *Acaenacis*). 3. *Zatropis* species have the propodeum relatively short, the median carina usually well developed, and the nucha convex but flattened dorsoposteriorly. More study is needed on the relationship between *Zatropis* and other similar Pteromalinae genera such as *Mesopolobus* Westwood and *Eurydinoteloides* and many similar forms found in the Neotropics, but a few preliminary synonymies can be made.

Trimeromicrus Gahan, 1914, **n. syn.**, with its only included species, *T. maculatus* Gahan, 1914 is herein synonymized under *Zatropis,* with the species now known as *Z. maculatus* (Gahan) **n. comb.** Females of this common species are unique among other *Zatropis* species in having metallic blue-green patches on the otherwise dark dorsum of the mesosoma: two pairs along the anterior margin of the mesoscutum, one on the anterior corner of each axilla, and one anteriomedially on the scutellum.

Mesopolobus justicia (Girault), 1917 is herein transferred to *Zatropis,* as *Z. justicia* (Girault) **n. comb.**, on the basis of its possession of a well developed row of admarginal setae and the small, but convex nucha which lacks an anterior transverse carina. *Mesopolobus* species lack admarginal setae on the fore wing and their nucha is a smooth crescent demarcated anteriorly by a more or less well developed carina.

New Taxa

Descriptions follow of two unusual *Sphegigaster* Spinola species with flattened bodies, and species representing new Nearctic records for *Amphidocius* Dzhanokmen, *Tricyclomischus* Graham and the first true Nearctic species of *Panstenon* Walker.

Amphidocius schickae **Heydon & Bouček, New Species**

Figs. 10–13

Holotype, female.—*Color:* Head and mesosoma dark green except pleural region and scutellum anterior to frenal sulcus which are purplish black, propodeum green; gaster purplish black except T1 and anteriolateral corners of succeeding terga green. Antenna yellow-brown with basal ½ of pedicel, anelli, and club slightly darker. Legs with coxae and femora bluish black; remainder yellow-brown but hind femur slightly darker in basal ½. Fore wing with veins pale brown, membrane with brown macula extending from marginal and stigmal vein to middle of wing (Fig. 13).

Sculpture: Body sculpture very weak, especially propodeum; reticulations of scutellum much smaller than those of mesoscutum; upper epimeron smooth.

Structure: Body length 1.0 mm. Head ovate in anterior view (Fig. 12), width 1.4× height (23:17), 2.2× length (23.0:10.5); clypeus with anterior margin nearly straight (Fig. 12); eye height 1.2× length (11:9), 2.0× malar distance (11.0:5.5), length 9.0× temple length (9:1); torulus located just above LOcL; ratio of MOD, OOL, POL, LOL as 1.5:2.0:7.0:3.5. Antenna (Fig. 11) with length of pedicel plus flagellum 0.78× head width (18:23); relative lengths of scape, pedicel, annelli 1 & 2, annellus 3, F1–4, club as 9.0: 3.5:0.5:1.0:1.5:1.5:2.0:1.0:6.0; relative widths of F1, F4, club as 1.0, 2.0, 3.0; F1–2 appearing elongate, F3–4 appearing about as long as wide; MPP sensilla sparse, only 1–2 visible per side, setalike; no visible micropilosity on club. Mesosoma length 1.3× width (23:18); collar quite short, with anterior edge crested; frenal sulcus distinct; dorsellum short, <½ frenal length; propodeum nearly featureless (Fig. 10), plicae completely effaced medially; petiolar foramen carinate with carinae converging medially and extending forward as sharp median carina. Fore wing (Fig. 13) length 2.8× width (66.0:23.5); apical wing fringe absent; relative lengths of submarginal, marginal, postmarginal, stigmal veins as 28:6:5:6; costal cell with single ventral setal row in apical ⅖; basal vein and cell bare; speculum open posteriorly. Gaster ovate, blunt apically, length 1.1× width (25:22); hind margin of T1 with weak median emargination; hypopygium extending ⅔ gaster length.

Allotype, male.—Similar to holotype except generally paler, predominant color on head and dorsum of mesosoma green, scape and legs pale yellow, T2 yellow-brown, macula on wing more yellow and diffuse (covering entire center of wing). Body length 0.96 mm. Antenna with length of pedicel plus flagellum 0.91× head width (20:22); relative lengths of scape, pedicel, annelli 1 & 2, annellus 3, F1–4; club as 9.0:3.5:1.0: 1.0:2.0:2.0:2.0:2.0:6.5; relative widths of F1, F4, club as 1.0, 1.5, 2.5; F1–4 appearing elongate; MPP sensilla sparse, 2–3 visible per face, setalike; funicular setae reclinate. Gaster ovate, length 1.2× width (23.0:19.5).

Variation.—Specimens examined display little morphological variation and generally closely resemble the holotype and allotype.

Type material.—The holotype (UCD), allotype (UCD) and 3 female and 7 male paratypes emerged in the laboratory around 22 August 1990 from leaf galls of *Neuroterus saltatorius* collected from *Quercus douglassi* in the Stebbins Cold Canyon Reserve, 11 km w. Winters, California (United States) by S. L. Heydon. An additional 105 paratypes were collected as follows (BMNH, CNC, UCD, USNM): Canada. British Columbia: Victoria, 16.VIII.1990 (ex *Neuroterus saltatorius*), 76 ♀, 44 ♂. United States. California: Clearlake Oaks, ex *Neuroterus saltatorius* galls, 1 ♀, 14 ♂; Caswell State Park (Ripon), 15.VIII.1980, ex *Neuroterus ?saltatorius,* 2 ♀, 6 ♂; Roseville, em. IX.1967, ex *N. saltatorius* asexual generation on *Q. lobata,* 7 ♀, 5 ♂; Sacramento, 24.VIII.1961, gall *Neuroterus saltatorius,* 1 ♂; Stebbins Cold Canyon Reserve, 13–24.IX.1990 (Malaise trap), 2 ♀, 18.VIII.1990, 9 ♀, 2 ♂.

Etymology.—It is our pleasure to name this species in honor of a friend of the senior author, Kathy Schick, who introduced him to the complexity and fascination of the cynipid and parasitoid faunas of California oaks.

Biology.—*Amphidocius schickae* is one of a number of parasitoids that can be reared from the mustard seed-sized leaf galls of the summer agamic generation of the cynipid *Neuroterus saltatorius* H. Edwards. Since at least one other pteromalid species as well as eulophids and eupelmids can also be reared from these galls, the exact trophic relationship of *A. schickae* to the other species living in these galls needs clarification. It is interesting to note that the galls of *N. saltatorius* occur in great numbers on both the blue oak and the valley oak which are two of the most common trees in California. Nearly every one of these galls is parasitized and *A. schickae* is one of the most common parasitoids. It is therefore likely that *A. schickae* is one of the most common species of Pteromalidae in California and it is surprising that it has remained undiscovered until now.

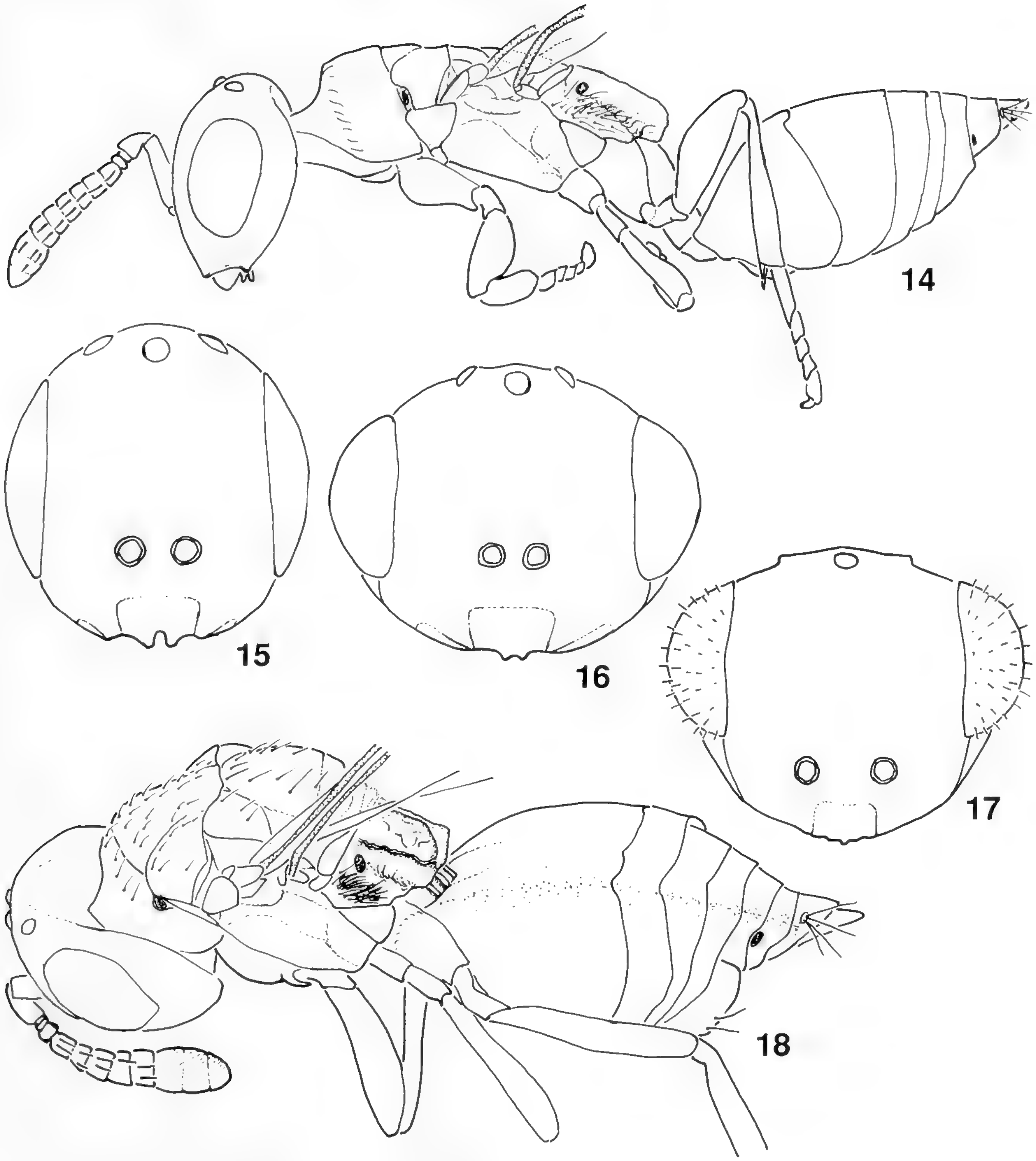
***Sphegigaster grisselli* Heydon,**
New Species

Figs. 14–15

Color: Body greenish black except dorsum of mesosoma excluding propodeum dark green. Antenna brown, scape with weak green metallic reflections, base of scape and apex of pedicel paler. Legs with coxae dark green; pretarsi brown; hind femora brown with weak metallic reflections; remainder yellow-brown. Wings clear with veins pale yellow-brown.

Sculpture: Clypeus striate; vertex coriaceous laterad and posterior to ocelli; pronotum with posterior ⅓–½ smooth; scutellum with smooth strip along hind margin, dorsellum smooth; upper epimeron alveolate; propodeum evenly alveolate.

Structure: Body length 1.9 mm. Head circular (appearing long-ovate) (Fig. 15); width 0.96× height (22:23), 1.7× length (22:13); eye height 1.6× length (13:8), 2.9× malar distance (13.0:4.5), length 2.0× temple length (8:4); genal hollow extending almost halfway to eye; torulus located ½ own diameter above LOcL; ratio of MOD, OOL, POL, LOL as 2.0:4.5:6.0:3.0; occiput deeply concave. Antenna with length of pedicel plus flagellum 1.0× head width (23:22); only scape and pedicel together reaching median ocellus; relative lengths of scape, pedicel, annellus, F1–6, club as 9.0:4.0:1.0:1.5:2.0:2.0:2.0:2.0:2.0:6.0; relative widths of F1, F6, club as 2.0:3.0:3.0; MPP sensilla in single sparse row; club with no visible patch of micropilosity. Mesosoma length 2.3× width (43.0:18.5), flattened with majority of mesoscutum and scutellum in same plane (Fig. 14); collar rounded, without any trace of teeth anteriorly, humeral angles rounded rectangular; propodeum with a very low median crest, posteriolateral corners of me-



Figs. 14–18. 14–15, *Sphegigaster grisselli,* female. 14, habitus; 15, head (anterior view). 16, *S. schauffi,* female, head (anterior view). 17–18, *Tricyclomischus nearcticus,* female. 17, head (anterior view); 18, habitus.

dian panels rounded, nuchal region smooth, propodeum longer than scutellum. Fore wing length 2.7× width (67:25); speculum open posteriorly; relative lengths of submarginal, marginal, postmarginal, stigmal veins as 24:25:11:5; costal cell setose in apical ⅓, more or less bare basally; basal cell bare; basal vein with single seta on right wing, stigma hardly wider than stigmal vein. Petiole length 1.8× width (10.0:5.5), maximum width 1.2× minimum width (5.5:4.5); with 2 basal setal pairs. Gaster length 1.5× width (33:22); hind margin of T1 weakly sinuous, broadly produced mesally; terminal gastral terga projecting beyond apex of T2.

Allotype, male.—Similar to female except generally paler, head and mesosoma dark green, vertex and dorsum of mesosoma with yellowish reflections; scape dark green; pretarsi and hind femur nearly concolorous with remainder of legs. Body length 2.0 mm. Antenna with length of pedicel plus flagellum 1.9× head width (55.0:29.5); relative lengths of scape, pedicel, annellus, F1–6, club as 10.0:4.0:1.0:7.5:7.0:6.5:6.5:6.0:5.5:11.0; relative widths of F1, F6, club as 3.0:3.0:3.0; funicular segments elongate, pedunculate; MPP sensilla very sparse; setae straight, semierect, on minute papillae giving flagellum a granulate appearance. Pronotal collar with anterior margin lacking any trace of teeth. Petiole length 2.1 × width (15:7). Gaster length 1.6× width (35:22).

Diagnosis.—*Sphegigaster grisselli* differs from other Nearctic *Sphegigaster* species (see Heydon and LaBerge 1989) in having the head as high as wide; the scape not nearly reaching the median ocellus; the vertex smooth; the segments of the male flagellum more elongate (2× as long as wide), pedunculate, and granulately sculptured; the dorsum of the mesosoma flattened; a broad smooth strip along the hind margin of the pronotal collar and scutellum; and the upper epimeron alveolate. Other *Sphegigaster* species have the head distinctly wider than high; the scape reaching or nearly reaching the median ocellus; the vertex alveolate; the segments of the male flagellum shorter, not pedunculate, and smooth; the dorsum of the mesosoma arched anterioposteriorly; the pronotal collar almost completely alveolate; and the upper epimeron smooth to coriaceous. *Sphegigaster grisselli* and *S. schauffi* described below are similar to species in *Ploskana* Bouček because of their flattened bodies and bidentate clypeus, but they share four characters with other *Sphegigaster* species that are not found in *Ploskana* species: 1. Distinct genal hollows. 2. Incomplete notauli. 3. Lack of a median carina or plicae on the propodeum. 4. Absence of a pair of sublateral emarginations in the hind margin of T1.

Etymology.—It is my pleasure to name this species in honor of my good friend and colleague Dr. E. E. Grissell.

Type material.—The holotype, allotype (both CNC), and 3 female and 12 male paratypes (CNC, UCD) emerged from the pith of *Urtica dioica* stems collected in Ancaster, Ontario (Canada) by J. E. Martin. An additional 13 paratypes were collected as follows (AMNH, CNC, CSU): Canada. Ontario: Ancaster, IV.1963 (reared from Agromyzidae, ex pith of *Urtica dioica* stems), 2 ♀, 3 ♂, 19.XII.1966 (ex *Phytomyza flavicornis* Fallen), 1 ♀, 3 ♂, 21.XII.1966 (ex *Melanagromyza martini* Spencer), 1 ♀. Quebec: Lac Mondor, Ste. Flore, 6.VII.1951, 1 ♂. United States. Wisconsin: Ashland, Dingdong Creek, 3 mi e. Clam Lake, 1.VIII.1978, 1 ♀. Wyoming: 4 mi wnw. Moran P.O., Teton Co., 20.VII.1977, 1 ♂.

Biology.—Known host(s) of *Sphegigaster grisselli* include *Phytomyza flavicornis* Fallen and *Melanagromyza martini* Spencer (both Diptera: Agromyzidae). The type series was reared from the stems of *Urtica dioica* L. (Urticaceae). Spencer and Steyskal (1986) list *Melanagromyza urticella* Spencer as a stem borer in *U. dioica* and this fly may be its insect host.

***Sphegigaster schauffi* Heydon,**
NEW SPECIES

Fig. 16

Holotype, female.—*Color:* Body black except for khaki metallic reflections on smooth strip along posterior margin of pronotal collar and lateral lobes of mesoscutum. Antenna brown. Legs with coxae black; remainder brown except knees, apical tip of tibiae, basal tarsi yellow-brown. Wings clear; veins pale brown, stigma brown.

Sculpture: Vertex laterad and posterior to ocelli alveolate; clypeus alveolate; pronotal collar with posterior ½ smooth; scutellum with only narrow smooth strip along hind margin; dorsellum smooth; propodeum uniformly reticulate; upper epimeron smooth.

Structure: Body length 1.9 mm. Head

transversely ovate in anterior view (Fig. 16); width 1.3× height (26.0:20.5), 2.2× length (26:12); eye height 1.4× length (12.0:8.5), 2.0× malar distance (12:6), length 2.8× temple length (8.5:3.0); genal hollow extending ⅓ malar distance; torulus located 1× own diameter above LOcL; ratio of MOD, OOL, POL, LOL as 2.0:5.0:6.0:2.5; occiput moderately concave. Antenna with length of pedicel plus flagellum 0.88× head width (23:26); relative lengths of scape, pedicel, annelli, funiculus, club as 10.0:3.5:1.0:1.5:2.0:2.0:2.0:2.0:2.5:6.5; relative widths of F1, F6, club as 2.0:3.0:3.5; each funicular segment wider than preceding, F1–3 quadrate, F4–6 transverse; scape not quite reaching median ocellus; MPP sensilla sparse, 1–3 visible per face. Mesosoma length 2.3× width (41:18), dorsally flattened side to side, very weakly arched front to back; pronotal collar with anterior edge rounded and lacking any trace of angular teeth, humeral angles not prominent; frenal sulcus indistinct; propodeum just shorter than scutellum; without median crest; posteriolateral corners of median panels rounded; nuchal region with only a short smooth strip. Fore wing length 2.3× width (70:31); speculum open behind; relative lengths of submarginal, marginal, postmarginal, stigmal veins as 28:15:12:7; costal cell with single ventral setal row; basal cell and vein bare dorsally; stigma width 1.5× length (3:2). Petiole length 2.0× width (9.0:4.5), maximum width 1.1× minimum width (4.5:4.0). Gaster length 2.7× width (43:16); hind margin of T1 shallowly concave, weakly convex mesally; hypopygium extending 0.33× length of gaster (14:43); terminal gastral terga extending well beyond hind edge of T2.

Allotype, male.—Similar to holotype except generally paler; face blue-green, frons yellowish green; smooth portion of pronotal collar, lateral portions of mesoscutum, epimeron dark yellowish green. Antenna with scape and pedicel pale brown, remainder brownish yellow. Leg color pattern similar to females except coxae dark blue-green and brown parts much paler. Body length 1.8 mm. Antenna with length of pedicel plus flagellum 0.96× head width (23.5:24.5); relative lengths of scape, pedicel, F1–6, club as 10.0:3.5:1.0:1.5:2.0:2.0:2.0:2.5:2.0:7.0; relative widths of F1, F6, club as 1.5:2.0:2.5; funicular segments elongate, broadly contiguous (not pedunculate), MPP sensilla sparse, setae reclinate. Petiole length 2.5× maximum width (10:4), maximum width 1.1× minimum width (4.0:3.5). Gaster length 1.5× width (27.0:17.5).

Diagnosis.—*Sphegigaster schauffi* is similar to *S. grisselli* in having a flattened mesosoma and a broad smooth strip along the hind margin of the pronotal collar. It differs from other Nearctic *Sphegigaster* species (see Heydon and LaBerge 1989) in having the body black and the gaster more slender (its length almost three times its width) and T1 very shallowly emarginate. Other Nearctic *Sphegigaster* species are metallic green or blue and have the gaster broader and the hind margin of T1 distinctly emarginate.

Etymology.—It is my pleasure to name this species in honor of my good friend and colleague Dr. M. E. Schauff.

Type material.—The holotype (USNM) was collected "west of mine" at Kemmererbottom in Lincoln County, Wyoming (United States) on 12 July 1983 by G. Bohart and E. Coomis. The allotype (USNM) was collected at Kemmerer, Lincoln County, Wyoming on 13 July 1983 by G. Bohart and E. Coomis.

Biology.—Host(s) of *Sphegigaster schauffi* are unknown, but the allotype has a label reading "ex. Art. trident." [*Artemisia tridentata* Nutt. (Compositae)].

***Tricyclomischus algonquinus* Heydon, NEW SPECIES**

Figs. 17–18

Holotype, female.—*Color:* Head, scape, mesosoma, coxae dark olive green except frons more green; pedicel, flagellum, legs beyond coxae, gaster dark brown; wings with veins brown; membrane with yellowish tint.

Sculpture: Clypeus smooth; head, mesosoma coriaceous; scutellum weakly colliculate; frenum coriaceous; dorsellum, propodeum rugose alveolate; prepectus alveolate; T1–3 smooth, remainder coriaceous.

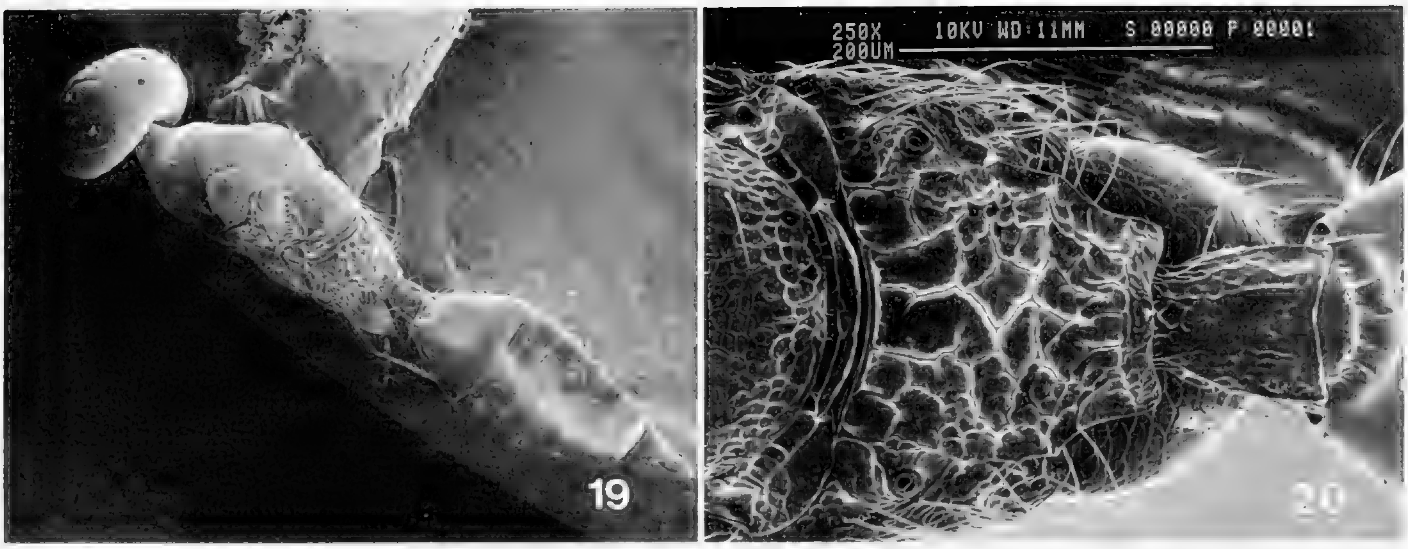
Structure: Body length 1.7 mm. Head pentagonal in anterior view (Fig. 17); width 1.2× height (26.5:23.0), 2.1× length (26.5:12.5); torulus located just below LOcL; eye height 1.2× length (12.5:10.0), 1.6× malar distance (12.5:8.0), length 5.0× temple length (10:2); ratio of MOD, OOL, POL, LOL as 2.0:4.0:8.0:3.5. Antenna with length of pedicel plus flagellum 0.87× head width (23.0:26.5); relative lengths of scape, pedicel, annelli, F1–6, club as 13.0:4.0:1.0:1.5:2.0:2.0:2.5:2.5:3.0:8.0; widths of F1, F6, club as 2.0:4.0:4.0; F1 small; F2–5 with MPP sensilla in single row, 2–3 visible per face; F6, club granulately textured, with MPP sensilla less distinct; club hemispherical apically (Fig. 18). Mesosoma length 1.6× width (37.5:24.0); dorsellum longer mesally than laterally, anterior edge carinate; propodeum with complete median carina, plicae distinct and meeting carina along anterior margin of nucha, spiracle circular and 1× own diameter from anterior margin of propodeum. Fore wing length 2.1× width (74:35); relative length of submarginal, marginal, postmarginal, stigmal veins as 27.0:14.0:14.5:9.0; stigma length about ½ its width; costal cell with 1 complete row of ventral setae, with partial second row on apical ⅓; basal cell completely setose; basal vein visible; speculum reduced. Petiole transverse, length 0.38× width (3:8). Gaster length 1.4× width (37:27), 0.73× combined length of head and mesosoma (37:47); T1 with hind margin sinuous laterally, straight mesally; hypopygium extending 0.70× gastral length (26:37).

Allotype, male.—Similar to female except body length 1.6 mm. Antenna with length of pedicel plus flagellum 1.2× head width (28:24); relative lengths of scape, pedicel, annelli, F1–6, club as 12.0:4.0:1.0:2.0:2.5:2.5:2.5:2.5:3.0:9.0; relative widths of F1, F6, club as 2.0:3.0:3.0; scape with shiny boss extending from basal ⅓ to apex; funicular segments with MPP sensilla in single row, 2–3 visible per face, setae reclinate (length about equal to funicular segment length). Gaster length 1.6× width (35:22).

Diagnosis.—Specimens of *Tricyclomischus algonquinus* were compared with a pair of the Palearctic species *T. celticus* Graham, and the following differences were noted: *T. algonquinus* has the F1 of the female antenna smaller than F2, but still quadrate in profile; the female flagellum strongly clavate; the female club blunt apically and strongly sclerotized so it does not collapse in air-dried specimens; and the scutellum generally setose over at least the anterior ¼–⅓, these scutellar setae not or only slightly longer and thicker than the setae of the mesoscutum and axilla. *Tricyclomischus celticus* has the female F1 much smaller than F2, annelliform in profile; the female flagellum weakly clavate; the female club moderately pointed apically, collapsed in air-dried specimens; and the scutellar setae limited to four lateral setal pairs, these setae distinctly longer and thicker than the setae of the mesoscutum and axilla.

Etymology.—The species name refers to the Nearctic distribution of this species.

Type material.—The holotype and allotype (both CNC) were collected between 24 and 30 June, 1952 at Churchill, Manitoba (Canada) by J. G. Chillcott. A total of 57 paratypes seen were collected as follows (CNC, UCD): Canada. Manitoba: Chesterfield, 11.VII.1950, 1 ♀; Churchill, 17.VI.1952, 6 ♀, 22 ♂, 20.VI.1952 (on willow catkins), 2 ♀, 4 ♂, 29.VII.1949, 1 ♀, 21.VIII.1952, 2 ♂; Eastern Creek (near Churchill), 10.VII.1952, 1 ♀, 13.VIII.1952, 1 ♀; Farnworth Lake (near Churchill), 26.VI.1952, 1 ♀; Fort Churchill, 3.VI.1952, 2 ♂; Mile 505, Hudson Bay River, 13.VI.1952, 1 ♀, 1 ♂, 13.VI.1952, 2 ♀, 1 ♂, 16.VII.1952, 1 ♀; Warkworth Creek (near Churchill), 21.VI.1952, 3 ♂. 7.VII.1952, 1



Figs. 19–20. 19–20, *Panstenon poaphilum*, female. 19, habitus; 20, propodeum and petiole.

♀. Newfoundland: Portland Creek, VI.1974 (Malaise trap), 1 ♂. Northwest Territories: Yellowknife, 20.V.1953, 1 ♀. United States. Alaska: Keni Peninsula, Sidlak Rd., 28.VI.1984, 1 ♀; Naknek, 8.VII.1952 (on tundra), 1 ♀.

Biology.—The host(s) of *Tricyclomischus nearcticus* are unknown. Many specimens from Churchill, Manitoba were collected on willow catkins.

Panstenon poaphilum **Heydon,**
NEW SPECIES
Figs. 19–20

Holotype, female.—*Color:* Head, neck weakly metallic green; remainder of mesosoma with bluish tint; petiole, gaster pale brown with weak metallic reflections. Antenna with scape yellow-brown, apical ⅓ darker; pedicel and flagellum brown. Legs (including coxae) pale yellow-brown except pretarsi brown. Fore wing with veins pale brown; membrane clear.

Sculpture: Head coriaceous except occiput weakly alveolate; mesosoma with neck coriaceous; collar anteriorly and laterally imbricate, posteriomedially alveolate; scutellum alveolate; propodeum alveolate-rugulose. Petiole weakly costulate. Gaster smooth except TIV–VI coriaceous in part.

Structure: Body length 2.1 mm. Head width 1.3× height (33:26), 1.7× length (33:19); clypeus with anterior margin truncate, as wide as high; eye height 1.1× length (16:15), 2.3× malar distance (16:7), length 5.0× temple length (15:3); toruli located ⅔ the distance between clypeus and vertex; ratio of OOL, POL, LOL as 5:10:5. Antenna with combined length of pedicel and flagellum 1.3× head width (40:33); relative lengths of scape, pedicel, annelli, F1–6, club as 14:5:2:4:4:4:4:4:4:9; widths of F1, F6, club as 3:4:5. Mesosoma length 2.1× width (55:27); collar with very weak anterior transverse carina (Fig. 19); propodeum with plicae distinct (Fig. 20). Fore wing length 3.1× width (105:34); relative lengths of submarginal, marginal, postmarginal, stigmal veins as 36:27:34:8; costal cell with single ventral row of setae; remainder of fore wing setose dorsally except for basal anterior half of basal cell. Petiole terete, length 1.0× maximum width (7.5:7.5); with a pair of seta midway down its length that extend perpendicularly (Fig. 20). Gaster fusiform (Fig. 19), length 2.0× width (55:27).

Males similar but with antenna more slender, each segment twice as long as wide and petiole distinctly longer than wide.

Variation.—The body length of females examined varied from 1.9–2.7 mm. The metallic coloration is more intense in larger specimens. The legs may be more intense yellow-brown. There is also considerable variation in the amount of rugosity on the propodeum.

Diagnosis.—*Panstenon poaphilum* differs from the European species *P. agylla* (Walker) in having the malar distance only 0.44 × the eye height, the pronotal collar only weakly carinate, the frenal sulcus weakly impressed and in lacking a red band on the gaster. *Panstenon poaphilum* closely resembles *P. oxylus* (Walker) but has a pair of lateral setae on the petiole and the propodeum with distinct rugae in the region between the plicae.

Etymology.—The species name is derived from the Greek words *poa,* meaning grass, and *philia,* meaning love.

Type material.—The holotype (UCD) was collected 24 June 1982 on the South Farms of the University of Illinois (near Champaign), Illinois (USA) by the senior author. Thirty-five female and 6 male paratypes were collected as follows (CNC, UCD, USNM); Canada. Alberta: Slave Lake, 17.VIII.1924, 1 ♀. Manitoba: Ridge Mountain National Park, east scarp, 30.VI.1979 (aspen-maple forest), 1 ♂. United States. Georgia: Sapelo Island (McIntosh Co.), 29.IV.1987 (savanna, flight intercept trap), 3 ♂. Illinois: South Farms of the University of Illinois (near Champaign), 25.VI.1982, 1 ♀; Forest Glen State Preserve, 6 mi ne. Georgetown, 26.V.1984, 1 ♀; 1 mi n. Pomona, 5.IX.1982, 1 ♀. Indiana: Richmond, 2 ♀. Minnesota: Olmstead Co., 15.V.1905 (from oat stubble), 1 ♀, 24.V.1905, 1 ♀, 25.V.1905, 1 ♂, 3.VI.1905 (from oat stubble), 2 ♀. Missouri: Columbia, 6.IX.1967, 1 ♀; Williamsville, 20.IV–1.V.1987, 2 ♀, V.1987, 1 ♀, VI.1987, 1 ♀, VII.1987, 2 ♀, VIII.1987, 5 ♀, 10–26.IX.1987, 3 ♀, X.1987, 1 ♀. Virginia: Fairfax Co., near Annandale), 1–12.VII.1988, 1 ♀; 4 mi s. Cuckoo, 25.IV–13.V.1988, 1 ♀; 27.V.1986, 2 ♀, 26.VI–5.VII.1987, 2 ♀, 6–16.VII.1987, 1 ♀, 13–27.VII.1988, 1 ♀; 2 mi w. Dawn, 12.V.1973, 1 ♀; Shenandoah National Park (915 m), 19.IX.1980, 1 ♂.

Biology.—The exact host(s) of *P. poaphilum* are unknown, but it has been reared in association with oat stubble.

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NEW SPECIES OF *LEPIDOSTOMA* FROM MEXICO AND CENTRAL AMERICA (TRICHOPTERA: LEPIDOSTOMATIDAE)

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Abstract.—Five new species of *Lepidostoma* (Trichoptera: Lepidostomatidae) are described and illustrated: ***L. chiriquiensis***, from Panama, ***L. ectopium***, from Costa Rica and Panama, ***L. polylepidum***, from Costa Rica, ***L. tapanti***, from Costa Rica and Panama, and ***L. xolotl***, from Mexico. All are included in the *Lepidostoma* (*Nosopus*) *Mexicanum* Group as defined by Weaver (1988).

Key Words: Trichoptera, *Lepidostoma,* new species, Mexico, Central America

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Recent collecting in Costa Rica, western Panama, and northwestern Mexico has revealed five species of *Lepidostoma* previously unknown to science. Dr. O. S. Flint, Jr., Smithsonian Institution, Washington, D.C., kindly forwarded to us the two Mexican specimens (through Mr. David Faulkner) as well as the Panamanian material (through Dr. Henk Wolda). The Costa Rican material was collected mainly by us during an ongoing survey of the Trichoptera of Costa Rica. The descriptions of these new species bring to 21 the number of species now known in Weaver's (1988) *Lepidostoma* (*Nosopus*) *Mexicanum* Group, a group entirely confined to the southwestern United States, Mexico, and Central America. The distributions of these species are indicated in Table 1 and complete citations to works containing original descriptions are included in the Literature Cited. Weaver (1988) placed all of the Neotropical species in the *Mexicanum* Group and his revision should be consulted for keys, descriptions, and illustrations of these species. The new species are all associated with middle to upper elevation streams flowing through forested areas.

Types of species described herein are deposited in the collections of the Instituto Nacional de Biodiversidad, Santo Domingo de Heredia, Costa Rica (INBIO), the National Museum of Natural History, Smithsonian Institution, Washington, D.C. (NMNH), the San Diego Natural History Museum, San Diego, California (SDMNH), and the University of Minnesota Insect Collection, St. Paul, Minnesota (UMSP).

Lepidostoma chiriquiensis, NEW SPECIES

Fig. 1A–E

This species is similar to *L. delongi* Ross, but differs from it in characteristics of tergum X and the inferior appendages as described below.

Male: Length of forewing 8 mm. Color brown. All specimens preserved in alcohol, badly rubbed, vestiture lacking, except for spatulate scales on the mesal surfaces of the one-segmented maxillary palpi. Tibial spur

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Table 1. *Lepidostoma Mexicanum* Group species and distributions.

Species	Distribution
Lepidostoma acarolum Denning 1962	USA: Arizona, New Mexico
Lepidostoma aztecum Flint and Bueno 1977	MEXICO: Morelos, Veracruz
Lepidostoma chiriquiensis, new species	PANAMA
Lepidostoma dafila Bueno and Contreras 1986	MEXICO: Oaxaca
Lepidostoma delongi Ross 1946	MEXICO: Chiapas, Michoacan, Morelos
Lepidostoma denningi Weaver 1988	MEXICO: Chiapas
Lepidostoma ectopium, new species	COSTA RICA; PANAMA
Lepidostoma frontale (Banks) 1901	MEXICO: Hidalgo, Veracruz
Lepidostoma heveli Flint and Bueno 1977	GUATEMALA
Lepidostoma lacinatum Flint 1967	MEXICO: Durango, Sinaloa; USA: Arizona
Lepidostoma leonilae Bueno and Contreras 1986	MEXICO: Nuevo León
Lepidostoma mexicanum (Banks) 1901	USA: Arizona, Colorado; MEXICO; GUATEMALA, COSTA RICA, PANAMA
Lepidostoma oaxacense Bueno and Contreras 1986	MEXICO: Oaxaca
Lepidostoma polylepidum, new species	COSTA RICA
Lepidostoma quila Bueno and Padilla 1981	MEXICO: México, Morelos
Lepidostoma rectangulare Flint 1967	MEXICO: Durango
Lepidostoma reimoseri Flint and Bueno 1977	COSTA RICA
Lepidostoma steinhauseri Flint and Bueno 1977	EL SALVADOR
Lepidostoma talamancense Flint and Bueno 1977	COSTA RICA; PANAMA
Lepidostoma tapanti, new species	COSTA RICA; PANAMA
Lepidostoma xolotl, new species	MEXICO: Durango, Nayarit

formula 2–4–4. *Genitalia:* Segment IX annular. In lateral view, segment X broadly rounded apically with scattered setae and small spinose projections; ventral edge of X with lobe-like extension mesally; in dorsal view, with V-shaped cleft. Inferior appendage broad, with terete basodorsal process, slightly sinuate middorsal process, and shorter apicodorsal process; apical edge of inferior appendage with sharp sclerotized flange. Phallobase short; phalicata tubular, curved; parameres long, apical halves covered with short, spinose setae; phallotremal sclerite present.

Holotype: ♂, PANAMA: Chiriquí: Guadalupe Arriba, 8°52′26″N, 82°33′13″W, 26.vi.–2.vii.1985, H. Wolda (NMNH). *Paratypes:* Same data as holotype, except 21–27.xii.1983, 1 ♂ (UMSP); same, except 1–7.viii.1984, 1 ♂ (INBIO); same, except 12–18.vi.1985, 2 ♂ (one specimen with phallus and inferior appendages missing) (NMNH).

Etymology: Named for the type locality, the province of Chiriquí, Panama.

Lepidostoma ectopium, New Species

Figs. 2A–E, 3

Based on male genitalic features, *Lepidostoma ectopium* seems to be most closely related to *L. oaxacense* Bueno and Contreras. In lateral view, segment X of the new species is excavated less deeply than that of *L. oaxacense,* but otherwise the two structures are similarly shaped. The unusual nature of the inferior appendage, with its long, heavily spinose basodorsal process and its curved pointed subapicodorsal process, strikingly differentiates *L. ectopium* from *L. oaxacense.*

Male: Length of forewing 7 mm. Head setal warts bearing long, filiform, brown scales. Antennal scape cylindrical, long, about equal to intraocular distance, irregularly dispersed with short to long, brown and yellow setae; pedicel with short brown setae; mesal surfaces of antennal flagellomeres basally with linear yellowish-white

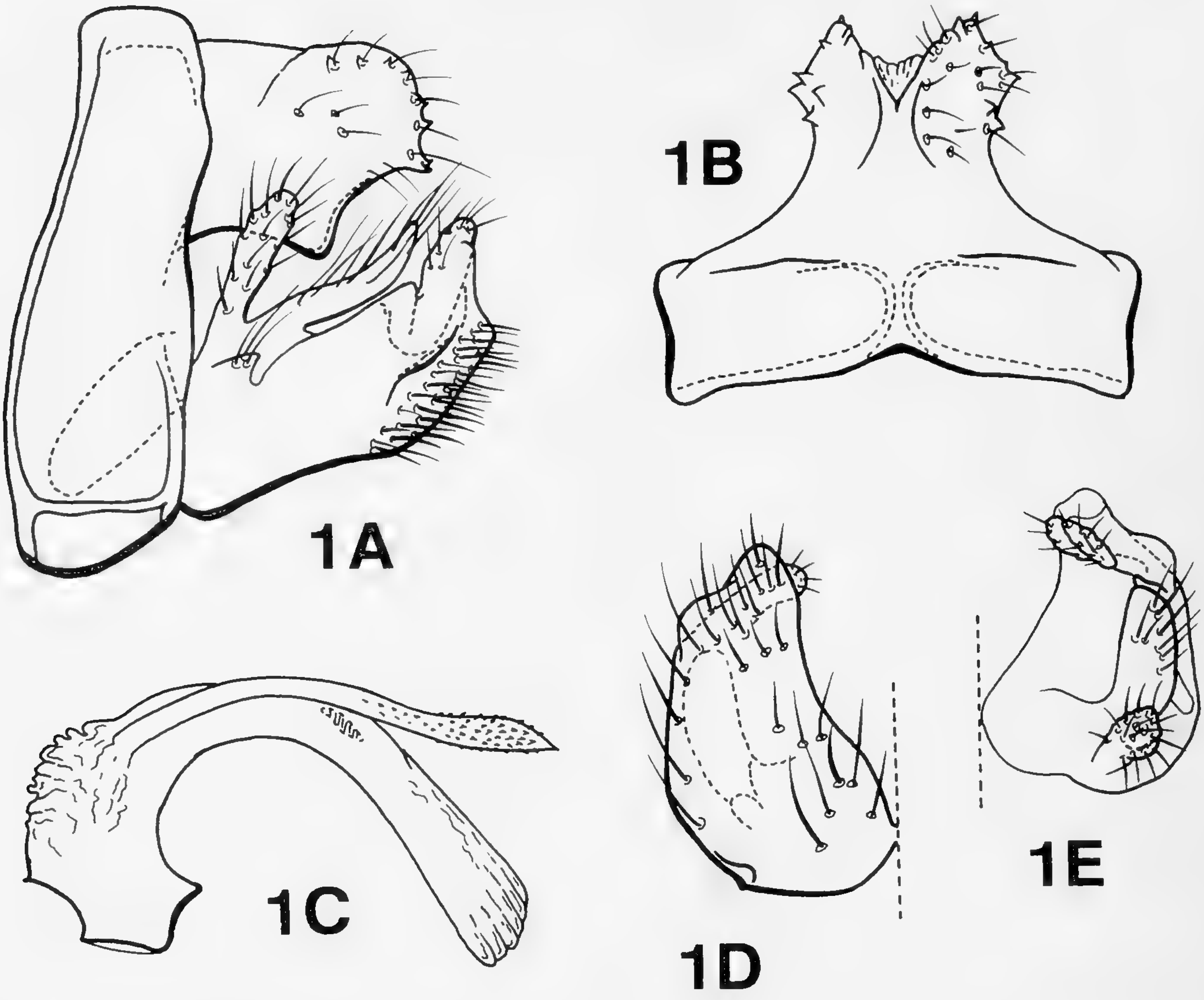
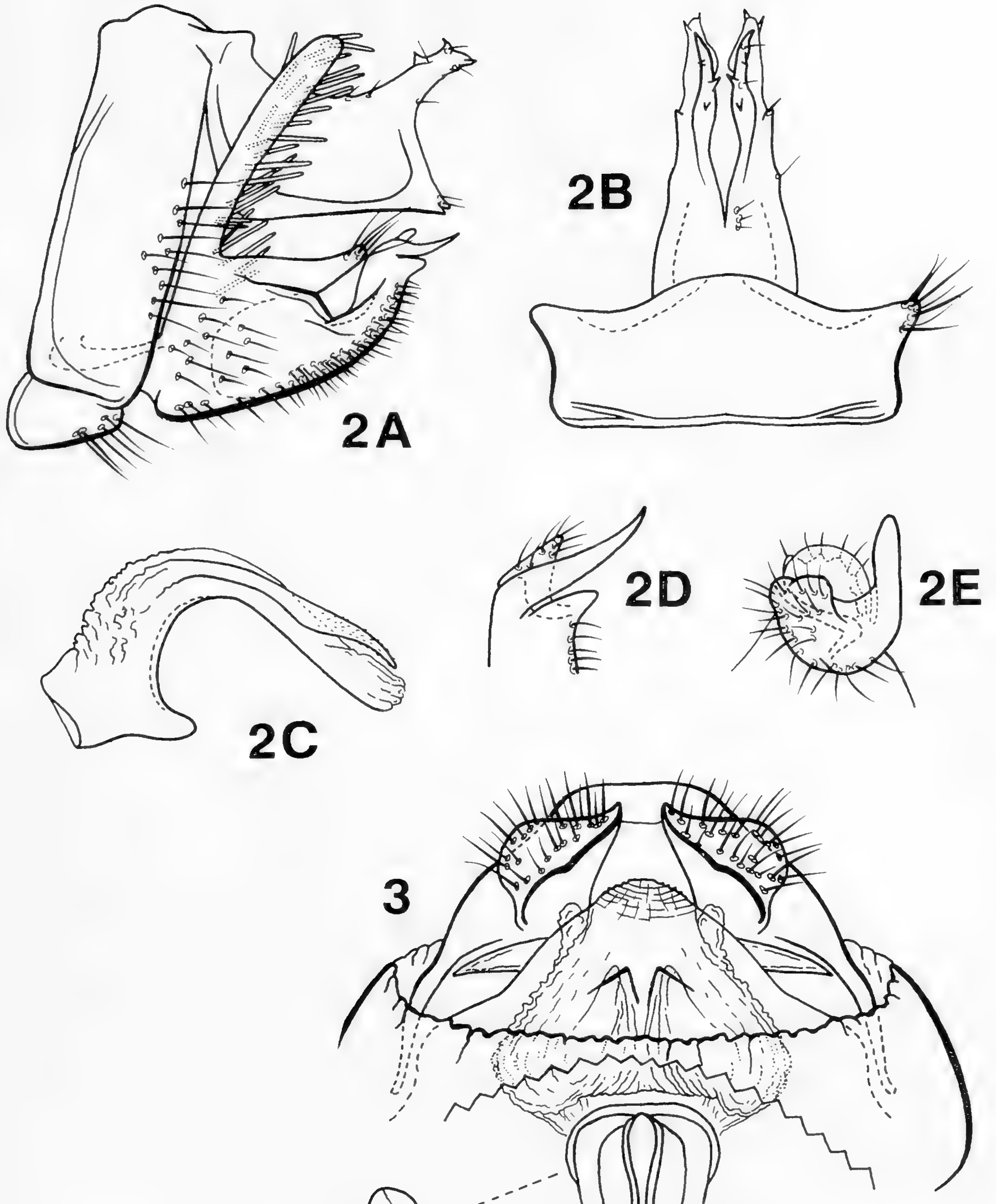


Fig. 1. *Lepidostoma chiriquiensis*, new species, male genitalia: A, segments IX, X, inferior appendage, lateral; B, segments IX, X, dorsal; C, phallus, lateral; D, inferior appendage, ventral; E, same, dorsal.

scales, apically with linear, brown scales, lateral surfaces of flagellomeres densely clothed with fine, apically hooked, brown hairs. Maxillary palpi apparently one-segmented, short, ovate, their apices rounded, covered with long brown and yellow setae; maxillary palpi held against each other apically and together against frons, appressed surfaces concave and bearing long, spatulate, brown scales. Thoracic sclerites brown with scattered long, brown hairs. Legs yellow, sparsely covered with brown and yellow setae. Tibial spur formula 2–4–4. Forewing covered with brown and yellow setae and linear scales; hindwing with light brown setae. *Genitalia:* Segment IX annular. In lateral view, segment X saddle-shaped, mesally cleft; with apicodorsal and apicoventral spinose projections. Inferior appendage broad basally, basodorsal process very long bearing long spine-like setae (these blunt apically and originating from inner surface of basodorsal process); middorsal process narrow, apically setose; apex of inferior appendage with curved, pointed process and pair of blunt processes; ventral surface of inferior appendage covered with short, stout setae. Phallobase short; phalicata tubular; parameres as long as phalicata, abruptly attenuated, and with very small, faint, apical setae; phallotremal sclerite may be present but difficult to discern.

Female: Structure and color similar to male. Sternum VIII broad, sclerotized, slightly concave. Tergum IX saddle-shaped in lateral view, with anterolateral apo-



Figs. 2, 3. *Lepidostoma ectopium,* new species: 2, male genitalia: A, segments IX, X, inferior appendage, lateral; B, segments IX, X, dorsal; C, phallus, lateral; D, apex of inferior appendage, lateral; E, same, dorsal. 3, female genitalia (drawn to same scale as male), ventral; inset, spermathecal sclerite, lateral.

demes. Segment X small, rounded, fused to segment IX. Segments IX+X bearing pair of prominent, apicoventral, setose, appendage-like lobes. Sternum IX with apex striated, bluntly acute, and with pair of small, triangular pockets midventrally. Spermathecal sclerite as illustrated in Fig. 3 and inset; oval in ventral view, saddle-shaped in lateral view with long axis of sclerite horizontally oriented; keyhole shaped area subequal to length of spermathecal sclerite.

Holotype: ♂, COSTA RICA: Puntarenas: Río Bellavista, ca. 1.5 km NW Las Alturas, 8.951°N, 82.846°W, 1400 m, 8–9.iv.1987, Holzenthal, Hamilton, Heyn (NMNH). *Paratypes:* PANAMA: Chiriquí: Guadalupe Arriba, 8°52′26″N, 82°33′13″W, 11–17.i.1984, H. Wolda, 1 ♂ (NMNH); same, except 18–24.i.1984, 1 ♂ (NMNH); same, except 28.ii.–6.iii.1984, 1 ♀ (NMNH); same, except 14–20.iii.1984, 1 ♂ (UMSP); same, except 21–27.iii.1984, 1 ♂ (UMSP); same, except 28.iii.–3.iv.1984, 1 ♀ (UMSP); same, except 4–10.iv.1984, 1 ♂ (INBIO); same, except 18–24.iv.1984, 1 ♂ (NMNH); same, except 16–22.v.1984, 1 ♂ (NMNH); same, except 22–28.viii.1984, 1 ♀ (INBIO); same, except 8–14.v.1985, 1 ♂ (NMNH).

Etymology: From the Greek *ektopius* meaning out of place, odd, strange, or unnatural; in reference to the unusual male genitalia of the species.

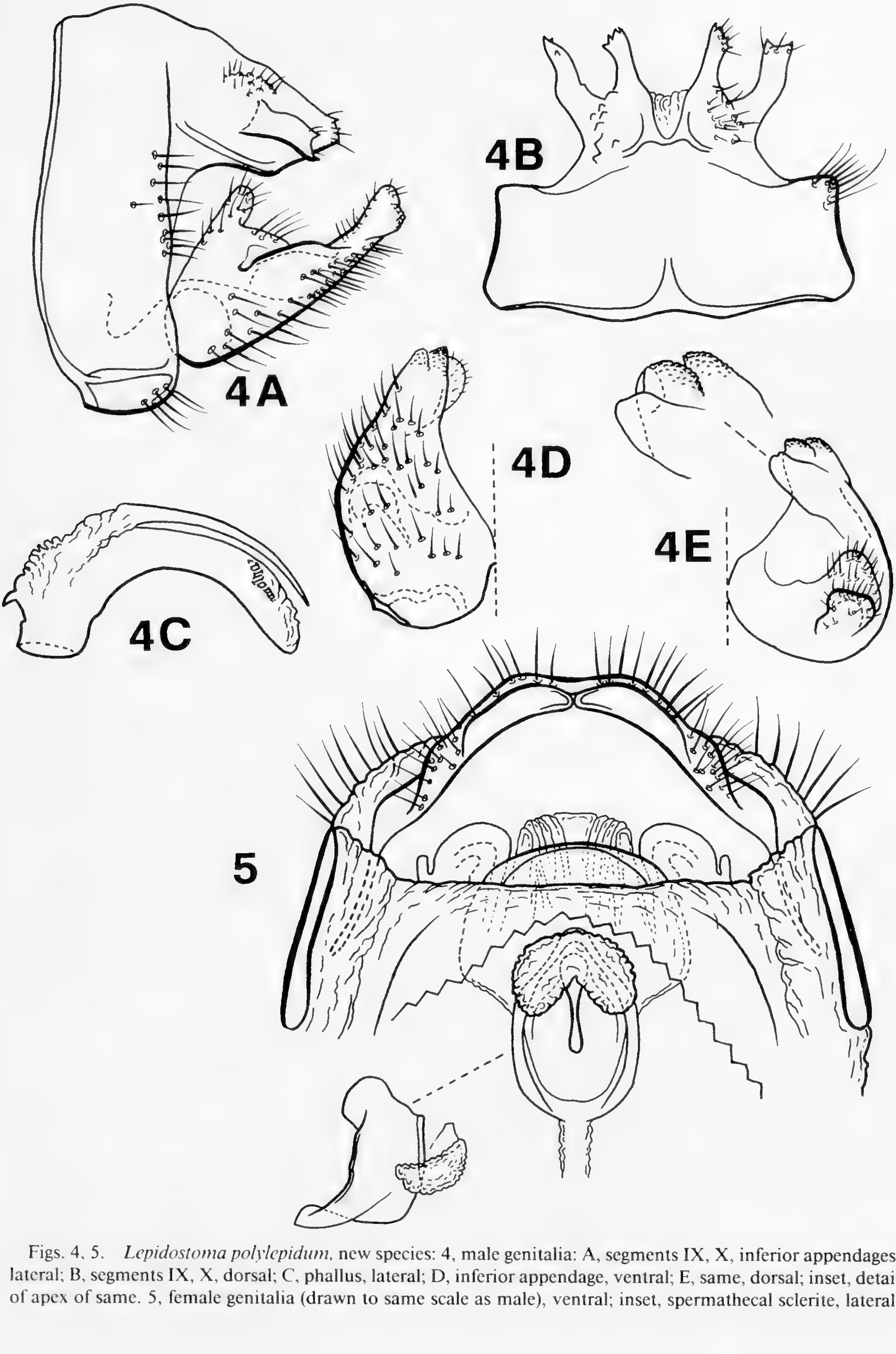
Lepidostoma polylepidum, New Species

Figs. 4A–E, 5

Males of *Lepidostoma polylepidum* are unique among the Neotropical species in the possession of heavily scaled head, maxillary palpi, antennae, and wings. The male genitalia, especially the inferior appendages, are similar to those of *Lepidostoma talamancense* Flint, but the presence of midlateral processes on segment X of the new species serves to separate it from *L. talamancense.*

Male: Length of forewing 10 mm. Head with frontal setal warts bearing oblong spatulate brown scales, anterior setal warts with oblong yellowish-white scales, posterior setal warts with long, filiform yellowish-white scales. Antennal scape cylindrical, long, about 1½ times intraocular distance, mesal ⅔ of its surface covered with oblong to spatulate brown scales, lateral ⅓ of surface with more scattered linear yellowish-white scales; pedicel with short spatulate brown scales; mesal surfaces of antennal flagellomeres covered with spatulate brown scales, lateral surfaces densely clothed with fine, silky, apically hooked yellow setae. Maxillary palpi one-segmented, short, ovate, their apices attenuated, covered with oblong yellowish-white scales; maxillary palpi held appressed against frons. Thoracic sclerites yellowish-brown, with scattered long, narrow hairs. Legs yellow, dorsal surfaces covered with short brown setae, ventral surfaces covered with short yellow setae. Tibial spur formula 2–4–4. Forewings completely covered with oblong brown scales, intermixed with patches of yellow scales, with scaleless, concave furrow between Sc and R1; hindwings slightly less densely covered with brown scales and fewer yellow scales. *Genitalia:* Segment IX annular. Segment X triangular in lateral view with short basodorsal setae; in dorsal view, deeply cleft mesally; X bearing pair of sclerotized midlateral projections, these projections varying in length from about ½ length of X to much shorter, their apices with 1–3 sharp points. Inferior appendage broad basally, narrow apically; basodorsal process narrow, round, apically setose; middorsal process short, bearing long setae; apex of inferior appendage narrow, extending beyond tergum X, with subapical serrate ectal flange; in ventral view inferior appendage with two serrate apical processes and subapical mesal thumblike process. Phallobase short, with basal spur; phalicata tubular; parameres as long as phalicata; phallotremal sclerite present.

Female: Length of forewing 11 mm. Antennal scape cylindrical, long, with long, gold and brown setae; flagellomeres apically with brown hairs forming band around segment, basally with yellow hairs. Maxillary palpi 5-segmented. Forewing covered with patch-



Figs. 4, 5. *Lepidostoma polylepidum*, new species: 4, male genitalia: A, segments IX, X, inferior appendages, lateral; B, segments IX, X, dorsal; C, phallus, lateral; D, inferior appendage, ventral; E, same, dorsal; inset, detail of apex of same. 5, female genitalia (drawn to same scale as male), ventral; inset, spermathecal sclerite, lateral.

es of brown and yellowish setae creating mottled pattern similar to that created by patches of scales on male forewings; some hairs along major longitudinal veins very long and erect; hindwing brown, with brown setae. Remaining nongenitalic structure and color similar to male. Genitalia: Sternum VIII broad, sclerotized, slightly concave. Tergum IX saddle-shaped in lateral view, with anterolateral apodemes. Segment X small, fused to segment IX. Segment IX+X bearing pair of apicoventral, setose, appendage-like lobes. Sternum IX broad, rounded, sclerotized, bounded laterally by pair of globose semimembranous lobes; membranous lobe protruding from above sternum IX. Spermathecal sclerite as illustrated in Fig. 5 and inset; oval in ventral view, saddle-shaped in lateral view with long axis of sclerite vertically oriented; keyhole shaped area about ½ length of sclerite; reniform membranous structure present at posterior end of spermathecal sclerite.

Holotype: ♂, COSTA RICA: San José: Río Parrita Chiquito, rt 12, 6.5 km SW jct rt 2, 9.703°N, 83.970°W, 1990 m, 10.iv.1987, Holzenthal, Hamilton, Heyn (NMNH). *Paratypes:* Same data as holotype, 16 ♂, 4 ♀ (UMSP), 2 ♂, 2 ♀ (INBIO), 2 ♂, 2 ♀ (NMNH); COSTA RICA: Puntarenas: Río Bellavista, ca. 1.5 km NW Las Alturas, 8.951°N, 82.846°W, 1400 m, 8–9.iv.1987, Holzenthal, Hamilton, Heyn, 12 ♂, 14 ♀ (pinned), 3 ♂, 7 ♀ (alcohol) (UMSP).

Etymology: Named for the heavily scaled appearance of the male.

Lepidostoma tapanti, New Species

Fig. 6A–D

This new species is most similar to *L. reimoseri* Flint and Bueno, but differs from it in having a more acute and less spinose segment X.

Male: Length of forewing 7.5 mm. Head setal warts bearing long, filiform, brown setae. Antennal scape cylindrical, long, about equal to intraocular distance, mesal surface with long, brown setae, lateral surface with shorter, yellow setae; pedicel with short brown setae; antennal flagellomeres unicolorous, densely clothed with fine, apically hooked, yellowish-white setae. Maxillary palpi apparently one-segmented, with long, filiform brown and yellow setae. Thoracic sclerites yellow, with scattered long yellow setae. Legs yellow, sparsely covered with narrow brown and yellow setae. Tibial spur formula 2–4–4. Forewings covered with long brown and yellow setae, with concave furrow between Sc and R1; hindwing with light brown setae. *Genitalia:* Segment IX annular. In lateral view, segment X roughly ovoid, apex bluntly acute; in dorsal view, deeply cleft mesally. Inferior appendage broad basally, with long, rounded, apically setose, basodorsal process and short, middorsal, setose process; apex narrow, rounded, with small, serrate, subapical flange; in ventral view, apex with thin apicomesal flange. Phallobase with basodorsal spur; phalicata tubular, narrow; parameres as long as phalicata; phallotremal sclerite present.

Holotype: ♂, COSTA RICA: Cartago: Reserva Tapantí, Río Dos Amigos and falls, ca. 6 km (rd) NW tunnel, 9.704°N, 83.783°W, el. 1500 m, 4–5.viii.1990, Holzenthal, Blahnik, Muñoz (NMNH). *Paratypes:* COSTA RICA: Cartago: Reserva Tapantí, Río Grande de Orosi, 9.686°N, 83.756°W, 1650 m, 8–9.vii.1986, Holzenthal, Heyn, Armitage, 1 ♂ (UMSP). PANAMA: Chiriquí: Guadalupe Arriba, 8°52′26″N, 82°33′13″W, 21–27.xii.1983, H. Wolda, 2 ♂ (NMNH); same, except 15–21.ii.1984, 2 ♂ (INBIO); same, except 4–10.iv.1984, 1 ♂ (NMNH); same, except 11–17.iv.1984, 1 ♂ (NMNH); same, except 25.iv.–1.v.1984, 2 ♂ (UMSP); same, except 16–22.v.1984, 1 ♂ (UMSP); same, except 6–12.vi.1984, 2 ♂ (INBIO); same, except 20–26.vi.1984, 1 ♂ (NMNH); same, except 19–25.ix.1984, 1 ♂ (NMNH); same, except 17–23.x.1984, 1 ♂ (NMNH); same, except 24–30.x.1984, 1 ♂ (NMNH); same, except 7–13.xi.1984, 1 ♂ (NMNH); same except 13–

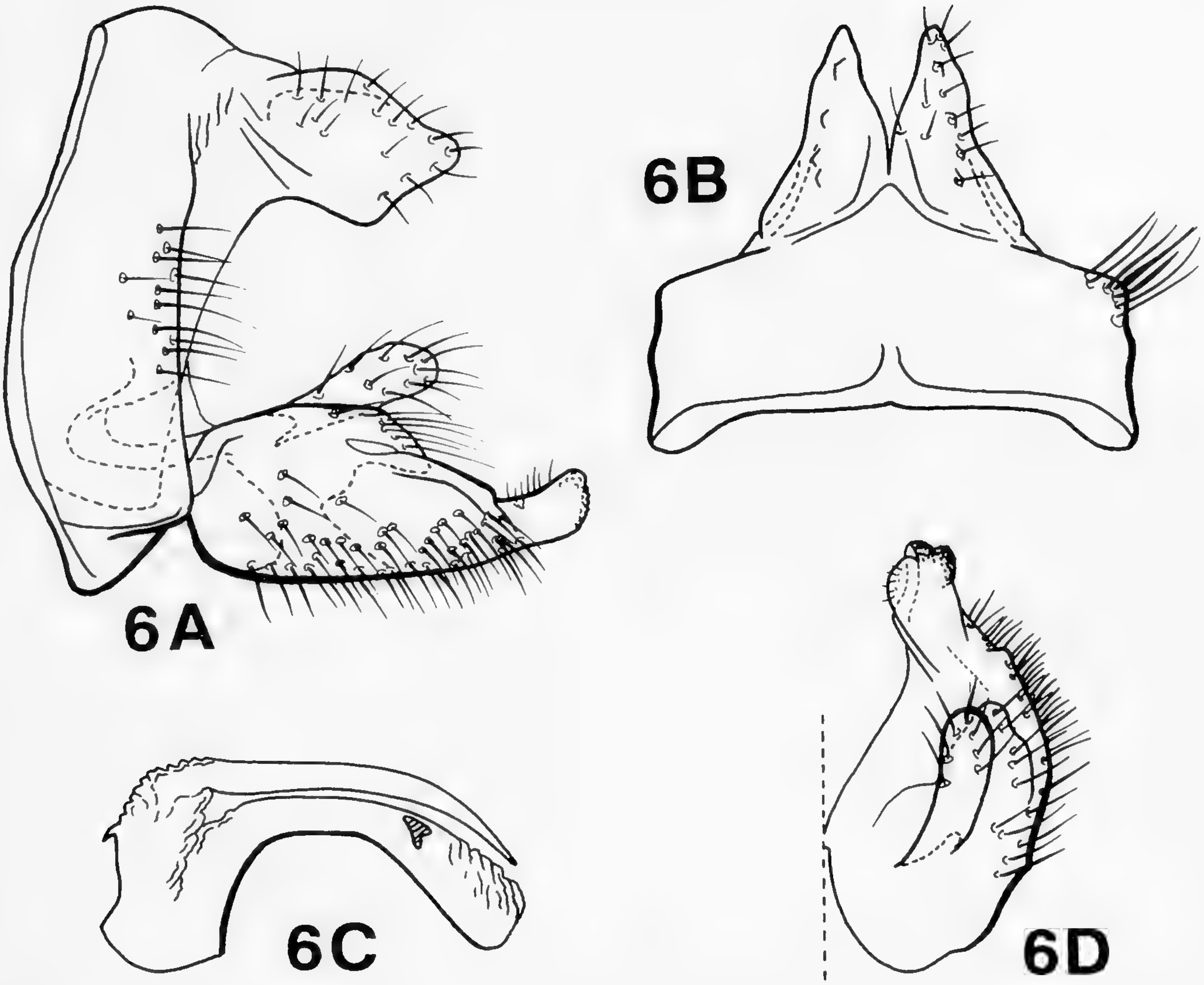


Fig. 6. *Lepidostoma tapanti,* new species, male genitalia: A, segments IX, X, inferior appendage, lateral; B, segments IX, X, dorsal; C, phallus, lateral; D, inferior appendage, dorsal.

19.ii.1985, 1 ♂ (UMSP); same, except 15–21.v.1985, 1 ♂ (INBIO); same, except 5–11.vi.1985, 1 ♂ (NMNH); same, except 28.viii.–3.ix.1985, 1 ♂ (NMNH); same, except 24–30.iv.1986, 2 ♂ (UMSP).

Etymology: Named for the type locality, Tapantí National Wildlife Reserve, Costa Rica.

Lepidostoma xolotl,
New Species
Fig. 7A–E

Lepidostoma xolotl is a typical member of the *Mexicanum* Group and appears most similar to *L. delongi* Ross. It differs from that species in having glabrous parameres and a different morphology of the apex of the inferior appendage.

Male: Length of forewing 8 mm. Head setal warts bearing long, filiform, brown setae, many with base and apex yellow. Antennal scape cylindrical, long, about equal to intraocular distance, mesal surface with long setae colored as those on head, lateral surface with shorter, thinner yellow setae and patch of long yellow setae basally; pedicel with short yellow setae; lateral surfaces of flagellomeres densely clothed with fine, silky, apically hooked, yellowish-white setae; mesal surfaces covered with short yellow setae, more apical flagellomeres with brown apical setae giving banded appearance. Maxillary palpi one-segmented, long, cylindrical, held straight out from frons, covered with long, narrow, spatulate, dark brown setae, with yellow setae mesally. Thoracic sclerites brownish-yellow, with scattered long yellow setae. Legs yellow,

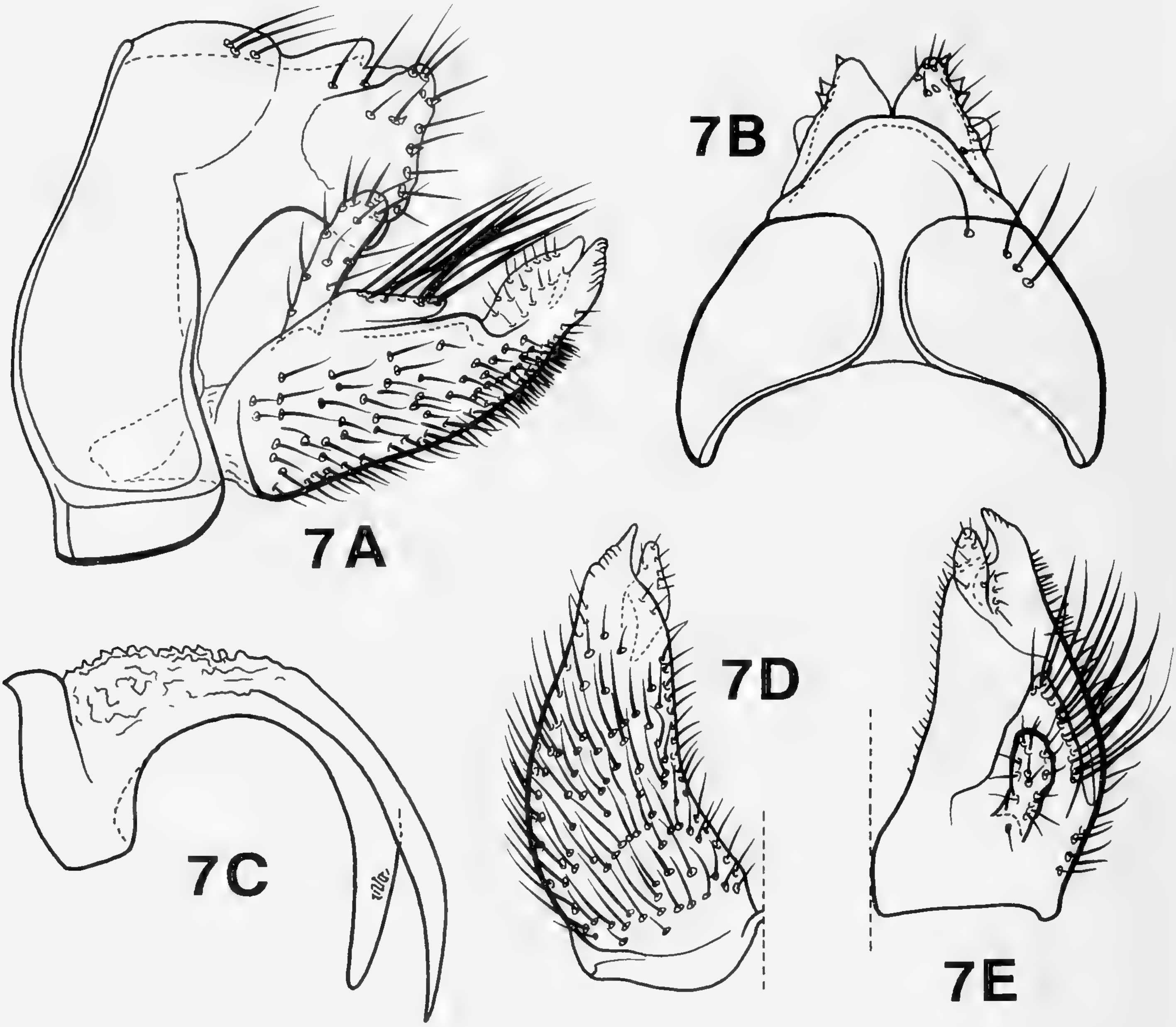


Fig. 7. *Lepidostoma xolotl,* new species, male genitalia: A, segments IX, X, inferior appendage, lateral; B, segments IX, X, dorsal; C, phallus, lateral; D, inferior appendage, ventral; E, same, dorsal.

brown setae on dorsal surfaces, yellow setae on ventral surfaces. Tibial spur formula 2–4–4. Forewings covered with short and long brown and golden setae, with shallow concave furrow between Sc and R1; hindwing with light brown setae. *Genitalia:* Segment IX annular. In lateral view, segment X roughly quadrate, about as long as wide, with small, scattered, spinose projections and long setae; in dorsal view cleft mesally. Inferior appendage very heavily setose, broad basally, with long, terete, basodorsal process and subequal, thumb-like middorsal process bearing many long, thick dorsal setae; apex of inferior appendage bifid, with terete, setose, apicomesal process and heavily sclerotized, ridged, pointed apicolateral process. Phallobase with basodorsal spur; phalicata tubular, narrow; parameres longer than phalicata, glabrous; phallotremal sclerite small.

Holotype: ♂, MEXICO: Nayarit: 49.4 mi E Venado, 18–21.v.1988, N. Bloomfield (NMNH). *Paratype:* MEXICO: Durango: El Salto, Rcho. Nuevo, 11–15.v.1988, Bloomfield, 1 ♂ (SDMNH).

Etymology: Named for *Xólotl,* Aztec god of the evening twilight; in reference to the crepuscular flight of adult Trichoptera.

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IBALIID PARASITOIDS OF SIRICID WOODWASPS IN NORTH AMERICA: TWO NEW *IBALIA* SPECIES AND A KEY TO SPECIES (HYMENOPTERA: CYNIPOIDEA)

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Abstract.—Two new parasitic wasp species, ***Ibalia kirki*** and ***Ibalia arizonica*** (Ibaliidae), are described from the northern Arizona-New Mexico region. Both species were found among preserved specimens reared from woodwasp-infested coniferous trees in 1971–72 during a search for natural enemies of Siricidae for introduction to Australia. The two new species belong to a monophyletic group of four species within *Ibalia* (*Ibalia*). Three of these species are known only from southwestern North America, whereas the fourth, *I. leucospoides* (Hochenwarth), is widely distributed throughout the Holarctic region. The phylogeny and the historical biogeography of this group of species is discussed briefly. North American distribution records of all six *I.* (*Ibalia*) species known from the region are mapped. A key to the North American *Ibalia* species is presented, including a representative of the subgenus *Tremibalia.*

Key Words: Hymenoptera, Cynipoidea, Ibaliidae, *Ibalia,* key, new species, Arizona, distribution N. America, Siricinae hosts

To control the accidentally introduced woodwasp *Sirex noctilio* F. on *Pinus radiata* D. Don in Australia, CSIRO made a worldwide search for natural enemies during 1962–1973 (Spradbery 1970, Kirk 1974, 1975, Taylor 1976, 1978, 1980, Spradbery and Kirk 1978, Madden 1988). Among the preserved woodwasp parasitoids collected by A. A. Kirk in northern Arizona-New Mexico (see Kirk 1975) we found two previously undescribed *Ibalia* species closely related to *Ibalia leucospoides* (Hochenwarth). Because these three species are similar in appearance, specimens of the two new species were previously assigned to belong to *I. leucospoides* by Kerrich (1973).

Ibalia leucospoides is widely distributed throughout Eurasia, northern Africa and North America (Kerrich 1973, Spradbery and Kirk 1978), whereas the two new species are known only from material labelled Arizona or Arizona-New Mexico. A fourth close relative, *I. ruficollis,* appears to be restricted to Arizona, New Mexico and northern Mexico. In total, we examined about 400 specimens of these four species. The specimens of *I. leucospoides* came from throughout the Holarctic region, including the southwestern United States. A number of morphometric measurements were collected, some of which were found useful in separating the species (Figs. 1–3). Surface sculpture and color also provided a number of distinguishing characters.

The family Ibaliidae includes the East Asian genus *Heteribalia* Sakagami and the

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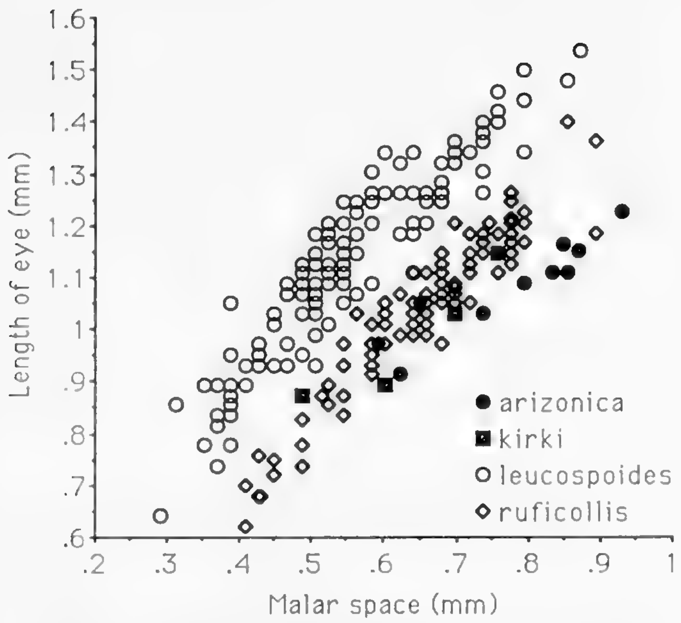

Fig. 1. Correlation between the length of the eye and the malar space in specimens of both sexes.

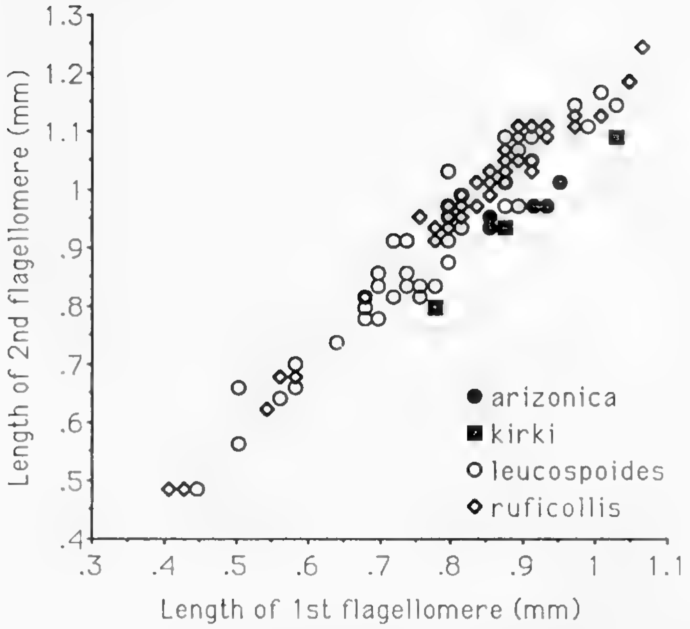

Fig. 3. Correlation between the lengths of the 2nd and the 1st flagellomere of the female antenna.

mainly Holarctic genus *Ibalia* Latreille, which is divided into the subgenera *Ibalia* and *Tremibalia* Kierych (Kierych 1973, Ronquist and Nordlander 1989). Species of *I.* (*Ibalia*) are all parasitoids of Siricinae in coniferous trees whereas species of *I.* (*Tremibalia*) appear to be restricted to Tremicinae hosts in hardwoods. In North America, as well as in the southwestern USA, there are now six known species of the subgenus *Ibalia.* These include *I. montana* Cresson, *I. rufipes* Cresson, and the four species mentioned above. In addition, there is one North American representative of the subgenus *Tremibalia, I.* (*T.*) *anceps* Say (see Ronquist and Nordlander 1989: 22), which is widely distributed east of the Rocky Mountains. The North American *Ibalia* species can be distinguished with the aid of the key presented below.

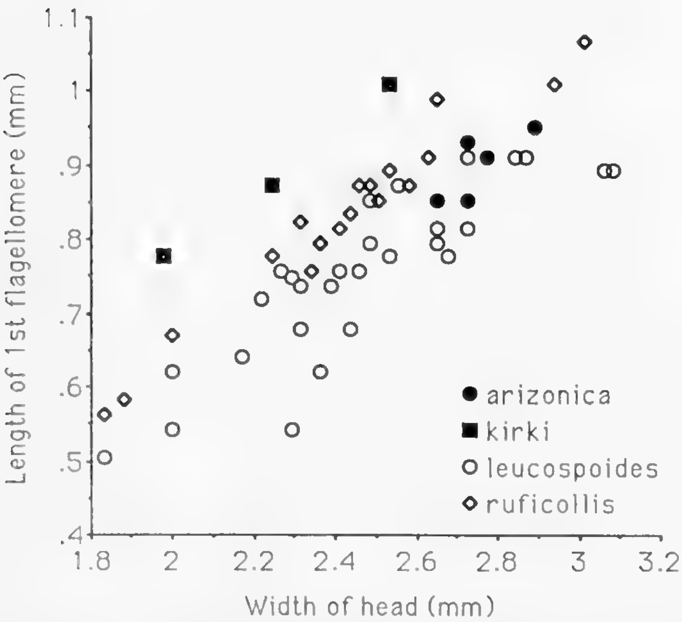

Fig. 2. Correlation between the length of the 1st flagellomere of the female antenna and the width of the head.

Structural terminology in the key and the species descriptions follow Ronquist and Nordlander (1989). Terms for wing cells are in accordance with Gauld and Bolton (1988). The characters mentioned in the species descriptions were selected among those that exhibit different states within the genus *Ibalia.* Illustrated and more detailed descriptions of other *Ibalia* species are presented in Kerrich (1973), Kierych (1973), and Ronquist and Nordlander (1989).

KEY TO THE *IBALIA* SPECIES FROM NORTH AMERICA

1. Eye length more than 3.0 times length of malar space. Male antenna with 12 flagellomeres. Hind wing with two hamuli. Anterior lateral crest of metacoxa rounded. Parasitoid of *Tremex columba* (L.) in hardwoods . . . *I. anceps* Say
– Eye length less than 2.7 times length of malar space (Fig. 1). Male antenna with 13 or (in *I. montana*) 12 flagellomeres. Three hamuli. An-

terior lateral crest of metacoxa triangular. Parasitoids of Siricinae in coniferous trees 2

2. Vertex, lower part of antennal scrobes, and sides of pronotum almost smooth 3
– Vertical and antennal scrobes costate. Sides of pronotum costate, with or without a smooth area in the center 4
3. Head yellow to brown. Male antenna with 12 flagellomeres. Scutellum scabrous, without distinct transverse costae. Metasoma of female about twice as long as head and mesosoma combined, extending much beyond apex of fore wing .... *I. montana* Cresson
– Head black. Male antenna with 13 flagellomeres. Scutellum dorsally with distinct transverse costae, at least on anterior half. Female metasoma less than 1.4 times combined length of head and mesosoma, not extending beyond apex of fore wing .... *I. rufipes* Cresson (In North America: subspecies *I. r. rufipes* (Cresson*)
4. Antennal scrobes with sparse oblique costae; carinae laterally delimiting antennal scrobes almost parallel. Width of head about 2.5 times length of 1st flagellomere in female (Fig. 2). Scutellum laterally without a distinct, smoothly curved marginal ridge. Posterior scutellar processes not distinctly depressed anterodorsally. Metasoma elongate (Fig. 4), its length in female more than 2.8 times its height and about 1.5 times combined length of head and mesosoma .... **I. kirki**, new species
– Antennal scrobes with many transverse or irregular costae; lateral carinae at least slightly curved. Width of head at least 2.7 times the length of 1st flagellomere in female (Fig. 2). Scutellum laterally with a complete, smoothly curved ridge. Posterior scutellar processes distinctly depressed anterodorsally. Length of female metasoma less than 2.5 times its height and less than 1.4 times combined length of head and mesosoma (Fig. 5) 5
5. Pronotum largely reddish yellow (in extremely small specimens sometimes black with only a dark brown dot laterally). Fore wing smoky without contrasting clear areas (Fig. 6). Hind wing smoky except at base ... *I. ruficollis* Cameron
– Pronotum entirely black. Fore wing partly tinted, with costal, basal and subbasal cells clear and contrasting (Figs. 7, 8). Hind wing largely clear, tinted only along margin 6
6. Eye length at least 1.7 (in average 2.1) times length of malar space (Fig. 1). Antennal scrobes with many transverse costae. 2nd flagellomere generally distinctly longer than 1st in female (Fig. 3). Pronotum laterally with a large smooth area .... *I. leucospoides* (Hochenwarth) (In North America: subspecies *I. leucospoides ensiger* Norton*)
– Eye length about 1.3–1.5 times length of malar space (Fig. 1). Antennal scrobes costate-rugose. 2nd flagellomere only slightly longer than 1st in female (Fig. 3). Pronotum laterally almost entirely costate .... ***I. arizonica***, new species

Ibalia kirki Liu and Nordlander, NEW SPECIES

Figs. 1–4, 9

Head, antennae, mesosoma and legs black; metasoma reddish brown, without light patches.

Head: Vertex with many distinct costae, which diverge posteriorly. Antennal scrobes with sparse oblique costae; lateral carinae parallel. Genae strongly costate. Ratio of eye length to length of malar space about 1.5–1.8 (Fig. 1).

Antennae: Female antenna slender; width of head about 2.5 times the length of 1st flagellomere (Fig. 2). 2nd flagellomere in female only slightly longer than 1st flagellomere (Fig. 3). Male antenna with 13 flagellomeres; 1st flagellomere with a sinuate excavation along its entire length.

Mesosoma: Pronotal crest abruptly raised and incised medially. Pronotum laterally almost entirely costate. Propleuron not strongly protruding downwards. Scutellar foveae smooth. Scutellum scabrous; without well-defined lateral margin. Posterior scutellar processes not distinctly depressed in front of the raised foliaceous process behind. Femoral groove longitudinally strigate; speculum smooth. Metepisternum rugose. Posterolateral propodeal process high.

Wings: Fore wing partly tinted, with costal, basal and subbasal cells clear and contrasting. Areolet present. Hind wing largely tinted, clear at base. Three hamuli.

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* The Nearctic and Palearctic subspecies of both *I. rufipes* and *I. leucospoides* were recognized by Kerrich (1973) on the basis of differences in the coloration of the metasoma.

Legs: Anterior lateral crest of metacoxa triangular. Anterior apical process of 2nd metatarsomere reaching almost to the middle of 4th tarsomere. Anterior mesotibial spur absent.

Metasoma: Female metasoma elongate, reaching distinctly beyond apex of fore wing; its length about 3.1 times its width and about 1.5 times the length of head and mesosoma combined (Fig. 4).

Material examined.—Holotype ♀: Arizona-New Mexico (no further data), emerged 1971, A. A. Kirk, in National Museum of Natural History, Washington, D.C. Paratypes 2 ♀ 1 ♂: same data as holotype.

All specimens reared from siricid-infested coniferous material (Kirk 1975). (This may have been wood from dead, mature trees of *Picea engelmannii* Parry felled at an altitude above 2500 m on Mount Humphreys, Arizona, and containing *Sirex cyaneus* F. and *Xeris spectrum* L. [A. A. Kirk in litt.]).

Ibalia arizonica Liu and Nordlander, New Species

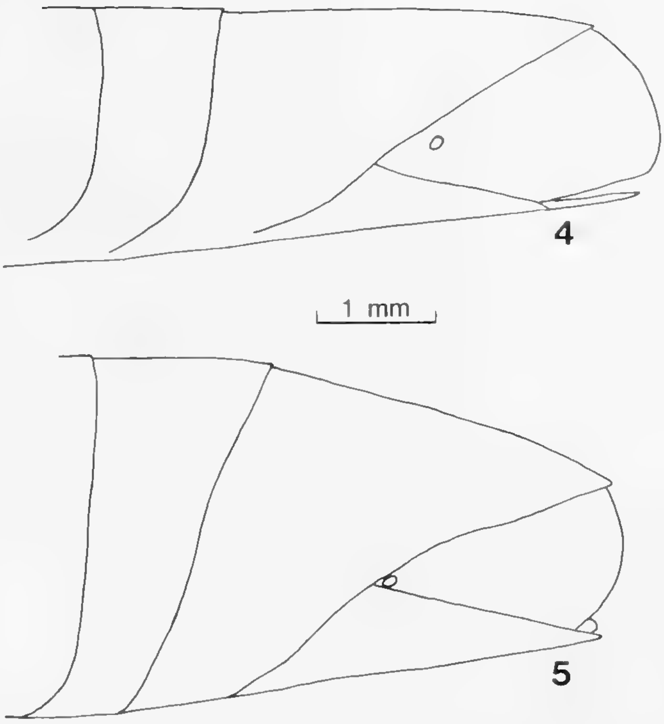
Figs. 1–3, 5, 7, 9

Head, antennae, mesosoma and legs black; metasoma reddish brown, without light patches.

Head: Vertex with many distinct costae, which diverge posteriorly. Antennal scrobes transversely costate-rugose; lateral carinae curved. Genae strongly costate. Eyes short; ratio of eye length to length of malar space about 1.3–1.5 (Fig. 1).

Antennae: Female antenna not particularly slender; width of head about 3 times the length of 1st flagellomere (Fig. 2). 2nd flagellomere in female only slightly longer than 1st flagellomere (Fig. 3). Male antenna with 13 flagellomeres; 1st flagellomere with a sinuate excavation along its entire length.

Mesosoma: Pronotal crest abruptly raised and incised medially. Pronotum laterally almost entirely costate. Propleuron not strongly protruding downwards. Scutellar foveae smooth. Scutellum scabrous; lateral margin distinct and smoothly curved. Posterior scutellar processes distinctly depressed in front of the raised foliaceous process behind. Femoral groove longitudinally strigate; speculum smooth. Metepisternum rugose. Posterolateral propodeal process high.



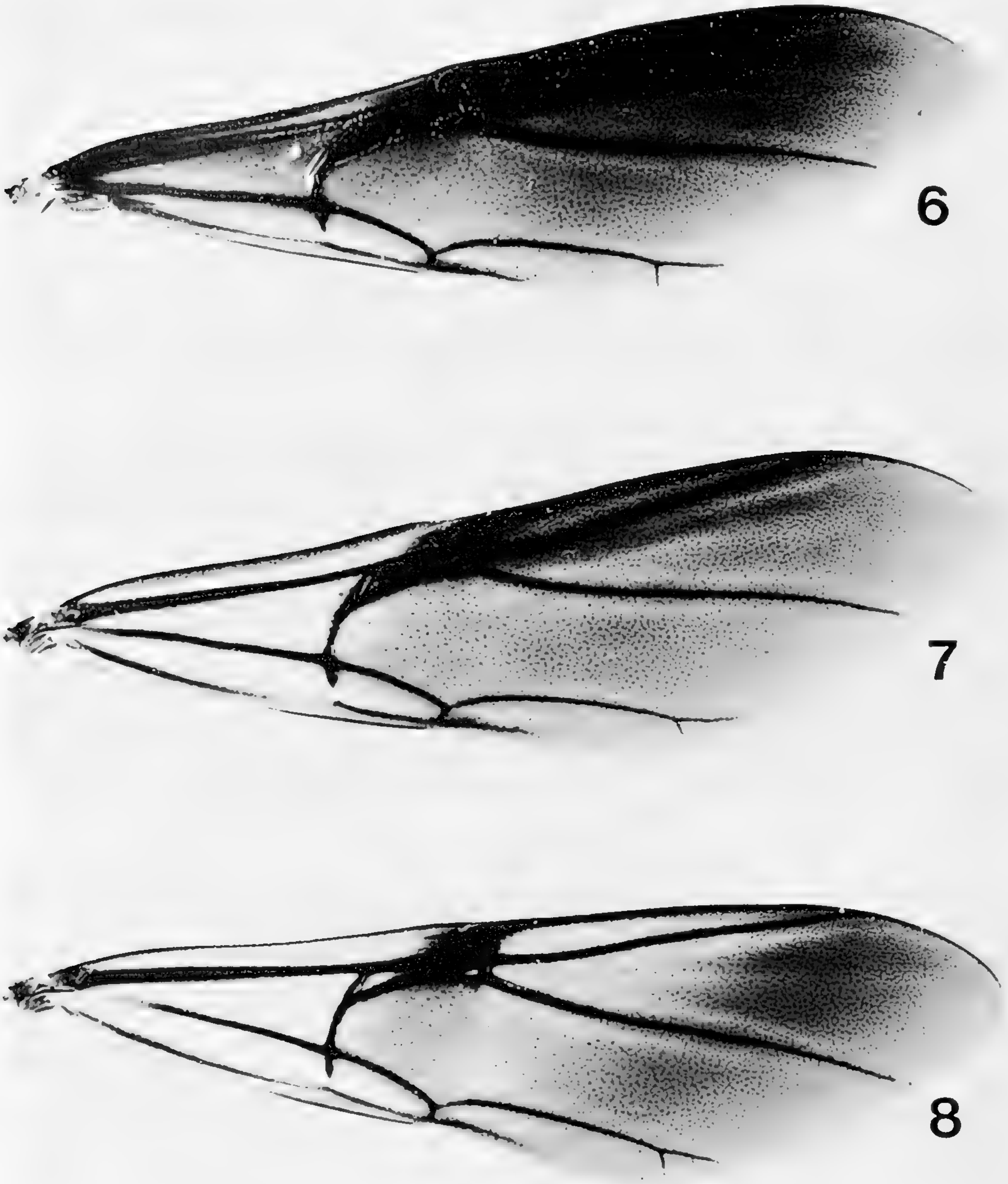
Figs. 4–5. Posterior part of the female metasoma in lateral view. 4, *I. kirki*. 5, *I. arizonica*.

Wings: Fore wing partly tinted, with costal, basal and subbasal cells clear and contrasting (Fig. 7). Areolet present. Hind wing largely clear, tinted along margin. Three hamuli.

Legs: Anterior lateral crest of metacoxa triangular. Anterior apical process of 2nd metatarsomere reaching almost to the middle of 4th tarsomere. Anterior mesotibial spur absent.

Metasoma: Female metasoma not elongated; its length about 2.3 times its width and about 1.2 times the length of head and mesosoma combined (Fig. 5).

Material examined.—Holotype ♀: USA, Arizona-New Mexico (no further data), emerged 1972, A. A. Kirk, in National Museum of Natural History, Washington, D.C.



Figs. 6–8. Fore wing. 6, *I. ruficollis*. 7, *I. arizonica*. 8, *I. leucospoides ensiger*.

Paratypes 4 ♀ 3 ♂: 1 ♀ 3 ♂, same data as holotype; 2 ♀, Arizona, 1972, A. A. Kirk, in Natural History Museum, London; 1 ♀, Arizona, 1972, A. A. Kirk, in Australian National Insect Collection, Canberra.

All specimens reared from siricid-infested coniferous material (Kirk 1975); tree species and exact localities unknown.

BIOGEOGRAPHY AND PHYLOGENETIC RELATIONSHIPS

Including the two species described here, the genus *Ibalia* comprises 12 species in the world, seven of which belong in the subgenus *Ibalia* (Ronquist and Nordlander 1989). Only one of the *I.* (*Ibalia*) species

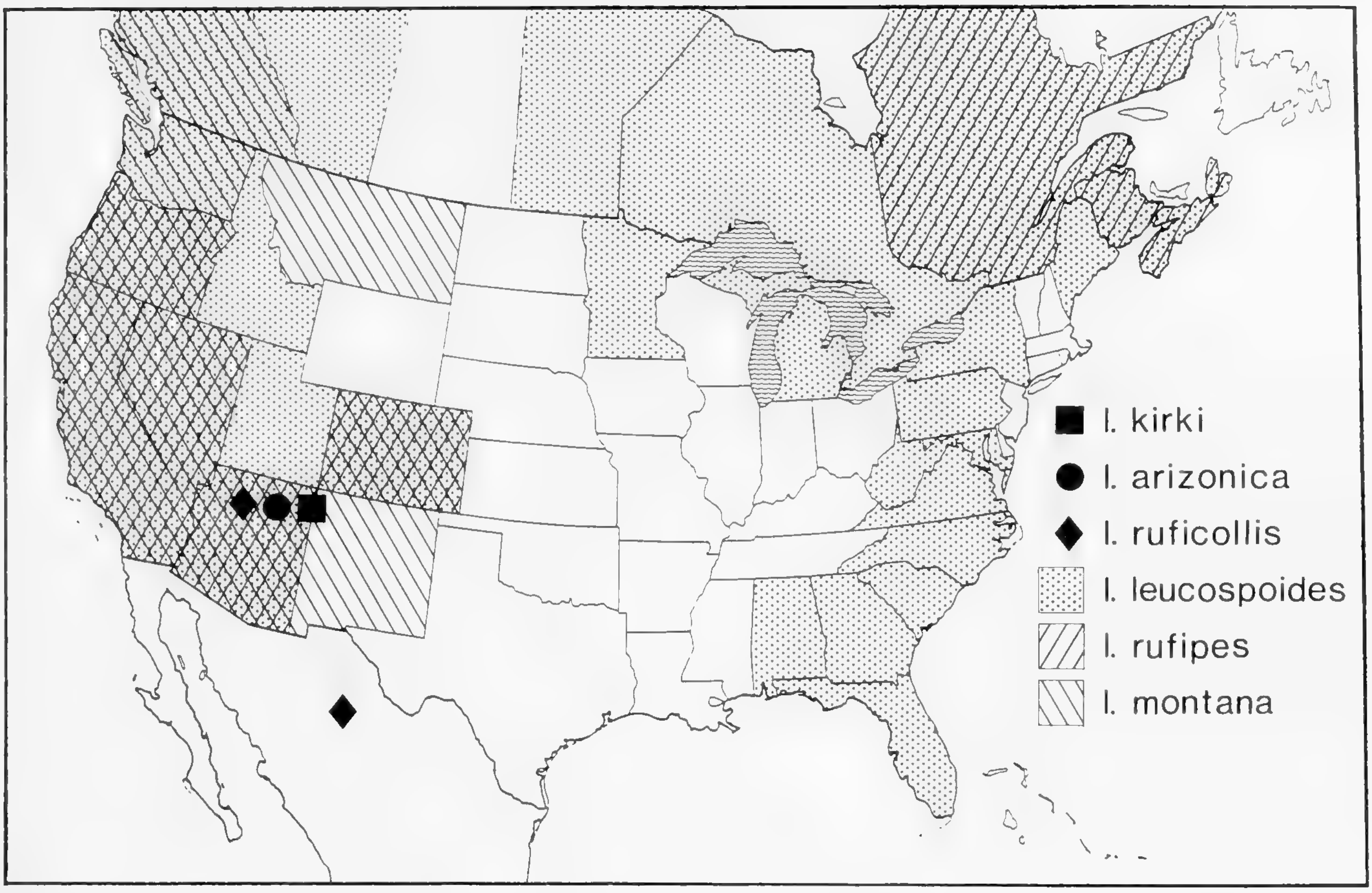


Fig. 9. Distributions of *Ibalia* (*Ibalia*) species in North America. The various types of hatching and the symbols indicate at least one record from a state or province. The map is based on examined material in the Australian National Collection, Canberra, the California Academy of Sciences, San Francisco, the Canadian National Collection, Ottawa, the Natural History Museum, London, and the U.S. National Museum, Washington, D.C. In addition, the following records from the literature are included: *I. leucospoides* from Alabama and South Carolina (Kirk 1974), *I. montana* from New Mexico (Kirk 1975), Montana and Oregon (Weld 1952) (Weld's record from Labrador needs confirmation and is therefore omitted), and *I. rufipes* from Colorado (Kirk 1975). Krombein et al. (1979) reported *I. rufipes* from Alberta, Manitoba, and Ontario, but these records probably refer to *I. gigantea* Yoshimoto, which they erroneously listed as a synonym of *I. rufipes* (Kerrich [1973] demonstrated that *I. gigantea* is a synonym of *I. leucospoides ensiger*). In addition to the records indicated on the map, one specimen of *I. leucospoides* was recorded from Northwestern Territories, Canada.

does not occur in North America; *I. aprilina* Kerrich from Japan. Figure 9 shows the known distributions of *I.* (*Ibalia*) species in North America. *Ibalia leucospoides* and *I. rufipes* are widely distributed throughout the Holarctic region. *Ibalia montana* occurs in mountainous areas in western North America, including the Rocky Mountains, Pacific Mountain System and Colorado Plateau, ranging from Arizona in the south to British Columbia in the north. The two new species *I. arizonica* and *I. kirki* are both known only from Arizona-New Mexico and the closely related *I. ruficollis* only from that area and the adjacent Chihuahua province in Mexico. *Ibalia leucospoides* appears to be infrequent in Arizona-New Mexico; only one male, from Happy Jack, Arizona, was found in the material we studied.

The quite restricted distributions of *I. arizonica, I. kirki* and *I. ruficollis* in southwestern North America suggest that they have speciated in this region. According to a forthcoming cladistic study of the family Ibaliidae (Nordlander, Liu, and Ronquist, manuscript), these species form together with *I. leucospoides* a monophyletic group within the subgenus *Ibalia.* In the single shortest cladogram, which includes all known ibaliid species, these four species are nested: (*kirki* (*arizonica* (*ruficollis, leucospoides*))). However, several alternative branching sequences for these very similar species are just one step shorter, and none of the putative synapomorphies appear to be particularly reliable. It is thus possible that *I. leucospoides* differs from the other species only in that it possesses a number of plesiomorphic character states. This last pattern would be expected if *I. arizonica, I. kirki,* and *I. ruficollis* have split off through peripheral isolation from an already widely distributed *I. leucospoides,* in which none of the studied characters transformed between the speciation events (cf. Wiley 1981: 48–51; Brooks and McLennan 1991: 94–98). We consider such a scenario plausible with regard to the present distributions of these species, although supporting evidence from the cladistic study is lacking. If, in fact, *I. leucospoides* shares some true synapomorphies with only one or two of the other species, as implied in the shortest cladogram, character transformations must have occurred in their stem species. In that case *I. leucospoides* should either have spread over the world from southwestern North America after these speciation events, or the new character states must have had time between speciations to become established in the populations throughout the range of a widely distributed ancestor.

Acknowledgments

We are indebted to Rune Axelsson for photographic assistance, to Nigel Fergusson (London), Arnold Menke (Washington, D.C.), Ian Naumann (Canberra) and Jennifer Read (Ottawa) for loaning us *Ibalia* specimens, and to Henri Goulet, Arnold Menke, and Fredrik Ronquist for comments on the manuscript. This work was jointly carried out during a visit by ZL to Uppsala in 1990–1991, hosted by Christine Dahl (Uppsala University) and GN and supported by a scholarship from the Chinese National Council of Education.

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A NEW SPECIES OF THE NEOTROPICAL GENUS *SPHAERIDOPS* AMYOT & SERVILLE, 1843 (SPHAERIDOPINAE: REDUVIIDAE)

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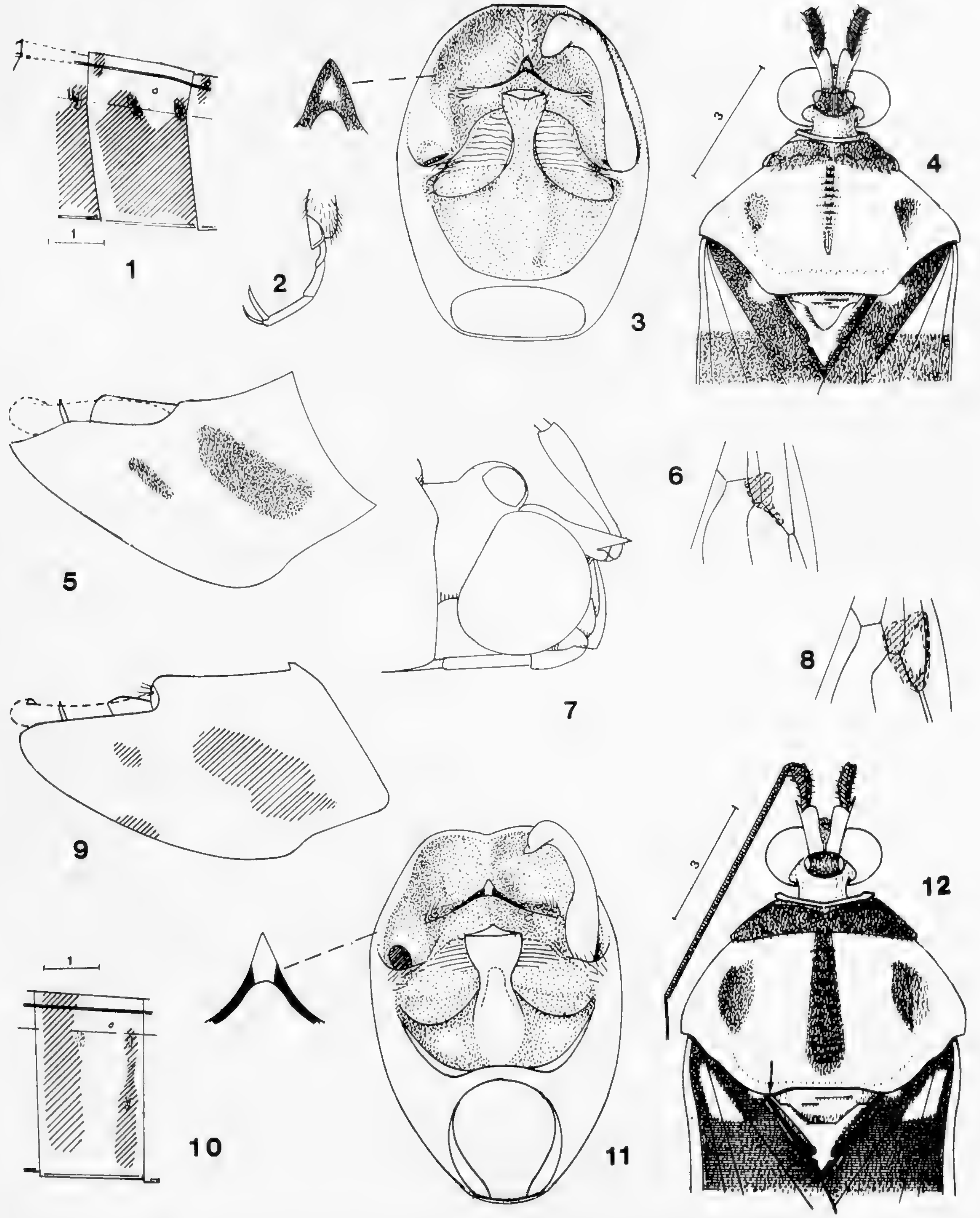
Abstract.—***Sphaeridops eulus*** n. sp. is described from specimens from Paraguay and Brazil. It is compared with its congener and illustrated with line drawings and SEM photos. The possible use of the dorsal surface of the hypopygium as a new taxonomic tool is discussed.

Key Words: Reduviidae, Sphaeridopinae, *Sphaeridops eulus* n. sp., new genitalic characters, Brazil, Paraguay

The Sphaeridopinae are characterized by two unique characters, namely, the head mostly occupied by the very large eyes and the antennophores raised on the vertex, close together, between the eyes. The subfamily contains four genera with one species in each. A second species of *Sphaeridops* is described below.

The members of this subfamily have a few other unusual characters. On the anterior lobe of the pronotum there are sensory organs, of unknown function, as can be seen from SEM photos 13, 14 and 15. We have observed corresponding organs in the other two genera known to us. Another unusual character is the organization of the connexival margin. The dorsal and ventral components of the connexivum, are well separated by a vertical sclerite (Figs. 1, 10). The margin of the dorsal component is thickened and that of the sternal carinate. The suture separating the connexival segments from their corresponding sterna is obsolete, poorly defined. A somewhat similar condition is found in the triatomine *Dipetalogaster,* in which the urotergites are connected to the connexivum by an expandable membrane. In the sphaeridopines the corresponding areas are sclerotized. The prosterna are strikingly different in each of the three genera that we know in the subfamily, as will be demonstrated in a future paper.

Figures 3 and 11 show, for the first time, the male genital capsule on dorsal view. The anatomical details of this surface present several characters that are, at least, of specific value. In the two species considered in this paper, a common pattern is evident and the differences between both species are numerous. We have compared these with the corresponding parts of other genera in other reduviid subfamilies. We call posterior upper surface the area from behind the apical border to the anal opening. It is membranous in the emesines and sclerotized in the sphaeridopines studied. The anal opening also serves as the exit for the phallus. The opening may be hidden or not by the proctiger as they may be close together or somewhat apart. The hypopygial caudal spine can be marginal or inside the surface. We call anterior upper surface the area from behind



Figs. 1–12. Figs. 1–6, *Sphaeridops amoenus* (L. & S.), male. 1, abdominal sterna, apodemal depressions spotted, lateral view. 2, spongy fossa and fore tarsus. 3, genital capsule, dorsal and detail of spine. 4, anterior half of body. 5, hypopygium, lateral. 6, spot at apical angle of corium (colors inverted). *Sphaeridops eulus* n. sp. Figs. 7–12, male holotype. 7, head, lateral. 8, spot at apical angle of corium (colors inverted). 9, hypopygium, lateral. 10, abdominal sterna, apodemal depressions spotted. 11, hypopygium, dorsal and detail of spine. 12, anterior half of body.

the anal opening to the base of the hypopygium. The proctiger is found here. In the emesines and sphaeridopines studied, the posterior surface is sclerotized. In both groups of species, where the two surfaces meet, a variety of spines, smooth surfaces, corrugations, depressions, pilosity (length, location, extension), etc., are found. In summary: the dorsal surface of the hypopygium, in the Reduviidae at least, seems to present good specific and generic characters. A systematic survey of the Reduviidae and other heteropterous families should be carried out to study the possible use of this surface as one more taxonomic tool.

SEM photos were made with an IDS-DS 130 microscope, in the Electron Microscope Laboratory, at the University of California at Berkeley. The holotype is deposited in the National Museum of Natural History, Washington, D.C., the paratype in the senior author's collection. Measurements are in mm.

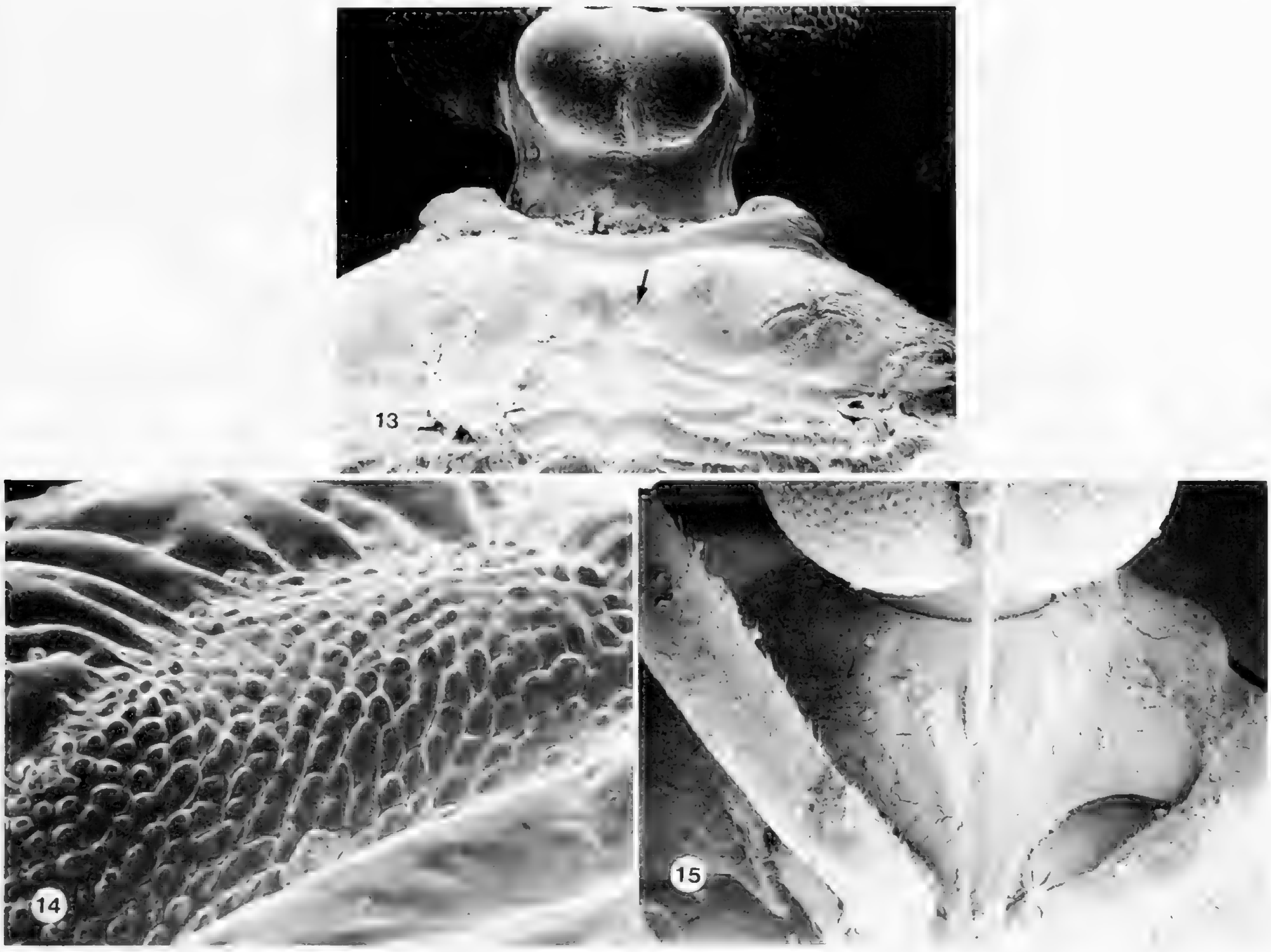
DESCRIPTION

Sphaeridops eulus
Maldonado and Santiago-Blay
NEW SPECIES

Figs. 7–15

Male.—Red and black; two orange areas on each hemelytron. The following parts black: head, ocellar elevation, eyes, antennae, base of antennophores; anterior lobe of the pronotum, median line and two suboval spots on posterior lobe of the pronotum (Fig. 12), upper halves of pleurae, lateral margins of scutellum, legs, most of fore wings, center of orange spot at apex of corium, lateral thirds of mesosternum, anterior half of metasternum, caudal fourth of connexival segments, two transverse stripes on sterna, base of genital capsule and three oval spots on apical half (Fig. 9). First two rostral segments gray, last segment pale gray. Ocelli crystalline.

Head.—Length 1.87, width across eyes 2.50, interocular space before ocellar elevation 0.75, width of ocellar elevation 1.12, ocelli apart at 1.3× their width (0.47:0.36); width of eyes 0.87, length of eyes 1.25, eyes surpassing ventral level of head by ⅖ their height (0.62:1.62), eyes ventrally 0.25 apart; frons below antennophores 0.68 wide; neck 0.47. *Antennal segments:* I, 1.43; II, 6.37; III, 1.25; I, 0.68; I as in Fig. 12; II slender, straight, half as thick as I apically (0.18: 0.37), III and IV filiform, half as thick as II; I semidecumbent setose, setae shorter than apical diameter of segment; II to IV with moderately abundant semivertical setae, subequal in length to diameter of II and slightly longer than diameter of III and IV. Antennophore spined on lateroapical margin (Fig. 12), surpassing anterior margin of head (Fig. 7). Neck cylindrical, narrowing to base. *Pronotum:* collar angularly concave, lateral angles slightly swollen; anterior lobe slightly elevated, shallowly sculptured into three main areas; median sulcus shallow, short; sensory organ present (arrow, SEM photo 13), median length 0.31, length below margins of collar 0.75; width 3.75; posterior lobe—length 4.37, width 7.25, scutellar lobes slightly developed (arrow, Fig. 12), posterior margin very shallowly concave, humeral angles sharp, unspined; surface irregularly corrugate, transversely corrugate along median black stripe and at humeral depressions. Pleurae vertically corrugate; osteole opening above on mesopleura, a simple conical depression, three canaliculi converging into it along its polished surface; the metapleura has what could be another stink gland opening: its surface is rough, has an oval, polished, slightly raised structure on its disc, and a slit-like opening above. Protibia with a small apical spongy fossa (as in Fig. 2 of *amoenus*). Fore wing with costal margin folded down at humeral angle, resting on a well developed pleural carina. Scutellum triangular, width 2.75, length 2.12; apical spine thick, on each side with a basal, small granule, slightly bent upward; disc depressed, with a few transverse corrugations. Prosternum as in SEM photo 15. Total length 22.20–22.50 mm.



Figs. 13–15. *Sphaeridops eulus* n. sp. 13, anterior lobe of pronotum, sensory organ, arrow. 14, sensory organ, detail. 15, prosternum.

Holotype.—Male, Horqueta, PARAGUAY, 57-10 W 23-24 N, collector unknown, in the National Museum of Natural History. *Paratype:* male, BRAZIL, Bahia, Encrusilhada, 960 m, Nov 1972, M. Alvarenga collector, in JMC collection.

Etymology.—The trivial name *eulus* (Gr. *eulus* = owl) refers to the two large, ocellate spots at apex of corium that remind one of a pair of owl's eyes.

This new species is closely related to the Brazilian *Sphaeridops amoenus* (Lepeletier and Serville, 1825), the type species. The longitudinal, median, corrugate, black stripe on the posterior lobe of the pronotum, narrow in *amoenus* and broad in *eulus,* the sculpturing of both stripes is different (Figs. 4, 12). The black ornamentation of their abdominal sterna is and the coloration of the humeral angle of the fore wings are different (Figs. 1, 10). They differ in many details of the dorsal genitalia (Figs. 3, 5, 9, 11). In the paratype, the lateral margin of the posterior lobe of the pronotum is slightly concave on the middle third instead of uniformly convex as in the holotype.

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A NEW SPECIES OF *ACANTHOCOCCUS* (HOMOPTERA; COCCOIDEA; ERIOCOCCIDAE) FROM SUNDEW (*DROSERA*) WITH A KEY TO THE INSTARS OF *ACANTHOCOCCUS*

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Abstract.—This paper describes the first U.S. species of *Acanthococcus* that possesses dome-shaped setae and lacks a denticle on the claw. The adult male also is unusual in that it has clear areas on the scutum, a character that occurs in the Coccidae and Margarodidae.

Key Words: Scale insect, eriococcin, felt scale, systematics

The Eriococcidae (felt scales or eriococcins) comprises about 54 species in the United States and 450 species in the World (Miller 1991a). Predominant hosts in the U.S. include woody shrubs, trees, and grasses. Several species are serious pests of ornamentals and grass crops.

The purpose of this research is to provide information on the separation of the immature stages of eriococcids and to describe a new species that occurs in boggy situations in Georgia and Florida. Although specimens of this species have been collected on several plants in this habitat, the predominant host is *Drosera,* sundew. This insectivorous group of plants has never been reported as a host of an eriococcid, and plays an unlikely role in this regard because most eriococcids occur in dry habitats. The new eriococcid species is described to make a name available for inclusion in a larger publication on the Eriococcidae of the eastern United States.

Methods

Terminology follows that of Miller (1984, 1991b) for the adult female and immatures, and that of Afifi (1968) for the adult male. Abdominal segmentation designations have been changed so that the first visible ventral segment is I. Measurements and numbers are from 10 specimens, when available, and are given as a range with an average in parentheses.

Depositories of specimens are: The Natural History Museum, London (BM); California Department of Food and Agriculture, Sacramento (CDA); Florida State Collection of Arthropods, Gainesville (FSCA); University of California, Davis (UCD); University of Georgia, Griffin (UG); National Museum of Natural History, Washington, D.C. (USNM); Virginia Polytechnic Institute and State University, Blacksburg (VPI).

Results

The composite illustration given in Fig. 1 provides a graphic representation of the first and second instars of *Acanthococcus eriogoni* (Ehrhorn). Although the first instar, second-instar male, and second-instar female are consistently distinct within *Acanthococcus,* the differences have not been

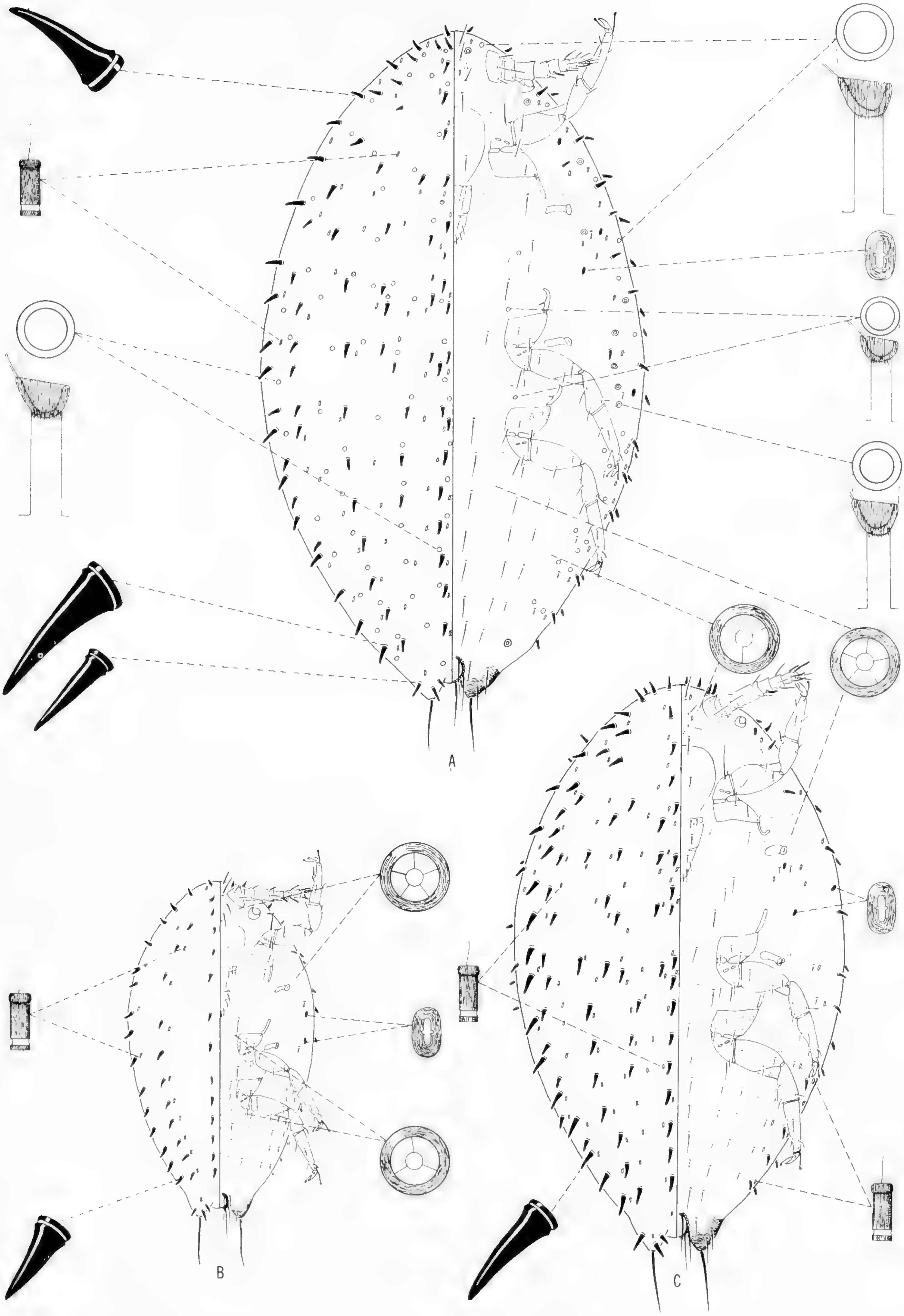

Fig. 1. *Acanthococcus eriogoni* (Ehrhorn). 35 mi. S. Tucson, Santa Rita Range, Pima Co., Arizona, on *Eriogonum wrightii*, H. S. Haskell: A) Second instar male; B) First instar (sexes indistinguishable); C) Second instar female.

clarified in any detail previously. In order to facilitate recognition of the various immature instars, a key is provided.

Key to Instars of *Acanthococcus* and Most Eriococcidae

1. Meso- and metathorax without wings or wing pads 2
– Meso- and metathorax with wings or wing pads 5
2(1). Macrotubular ducts present 3
– Macrotubular ducts absent 4
3(2). Vulva present; abdominal segment V usually with 15 or more dorsal setae (fig. 2) . . . . third-instar female (adult)
– Vulva absent; abdominal segment V with less than 15 dorsal setae (figs. 1a & 5) . . . . second-instar male
4(2). With at least 8 dorsal setae on abdominal segment V (figs. 1c & 3) . . . second-instar female
– With less than 8 dorsal setae on abdominal segment V (figs. 1b & 6) . . . . first instar (sexes indistinguishable)
5(1). Wings well developed; genital capsule heavily sclerotized, with aedeagus (fig. 4) . . . . fifth-instar male (adult)
– Wings in form of pads; genital capsule unsclerotized and without aedeagus 6
6(5). Wing pads less than 30 μ long; ocular sclerites absent, unsclerotized (not illustrated) . . . . third-instar male
– Wing pads more than 40 μ long; ocular sclerites lightly sclerotized (not illustrated) . . . . fourth-instar male

Treatment of Species

Acanthococcus droserae
Miller, Liu, and Howell
New Species
Sundew eriococcin

Type material.—Adult female holotype (1 specimen on slide). Right label "HHT-382-72/On Drosera sp./Ware Co., Ga./VIII-16-72/Coll. R. Beshear," left label "Acanthococcus/droserae/Miller Liu & Howell / HOLOTYPE" (USNM). In addition there are 52 paratypes listed in the "Specimens Examined" section.

Field characteristics.—Occurring at the base of leaves near the main stem of the plant. The body is pink; adult females form white ovisacs.

Adult female (Fig. 2).—*Recognition characters:* Adult female holotype. Mounted 1.1 mm long (paratypes 1.0–1.6(1.2) mm), 0.7 mm wide (paratypes 0.6–0.8(0.7) mm). Anal lobes weakly sclerotized on venter and dorsum; each lobe dorsally with 3 enlarged setae, conical, apices rounded (lateral longest, posteromedial shortest), with 1 or 2 microtubular ducts (paratypes with 1–2(1) duct); each lobe ventrally with 2 slender body setae and 3 sessile pores (paratypes with 3–5(4) pores).

Dorsum with enlarged setae of 2 sizes: Larger size present along body margin, usually with 2 present on margin of each abdominal segment, and on medial areas of abdominal segment IV through head; smaller size restricted to medial and sublateral areas except on posterior abdominal segment where present medially. Largest lateral seta 27 μ long (paratypes 27–30(29) μ), largest medial seta 22 μ long (paratypes 22–24(22) μ); on abdominal segments II to VIII longest lateral seta 1.2 times longer than longest medial seta (paratypes 1.2–1.4(1.3) times). Lateral enlarged setae straight with rounded apices, medial setae with blunt apices dome shaped; small setae cylindrical with blunt or truncate apices. Enlarged setae few, e.g. abdominal segment V with 13 setae (paratypes 11–14(13) setae), with large-sized setae arranged in 2 pairs of longitudinal lines (medial, lateral). Macrotubular ducts of large size, scattered over surface. Microtubular ducts 5 μ long (paratypes 4–5(5) μ), with area farthest from dermal orifice sclerotized and divided into 2 parts, apical portion rounded, about equal to remaining sclerotized portion; total sclerotized area about 2 times as long as unsclerotized area; dermal orifice sclerotized. Microtubular ducts scattered over surface. Multilocular pores absent.

Anal ring dorsal, with 4 pairs of setae.

Venter with longest seta on abdominal segment VIII 27 μ long (paratypes 27–37(33) μ), on segment III 15 μ long (paratypes 9–15(14) μ); longest posterior anal-lobe seta 110 μ long (paratypes 109–116(111) μ). Enlarged setae present on submargin from segment VI forward to head, with setae on head

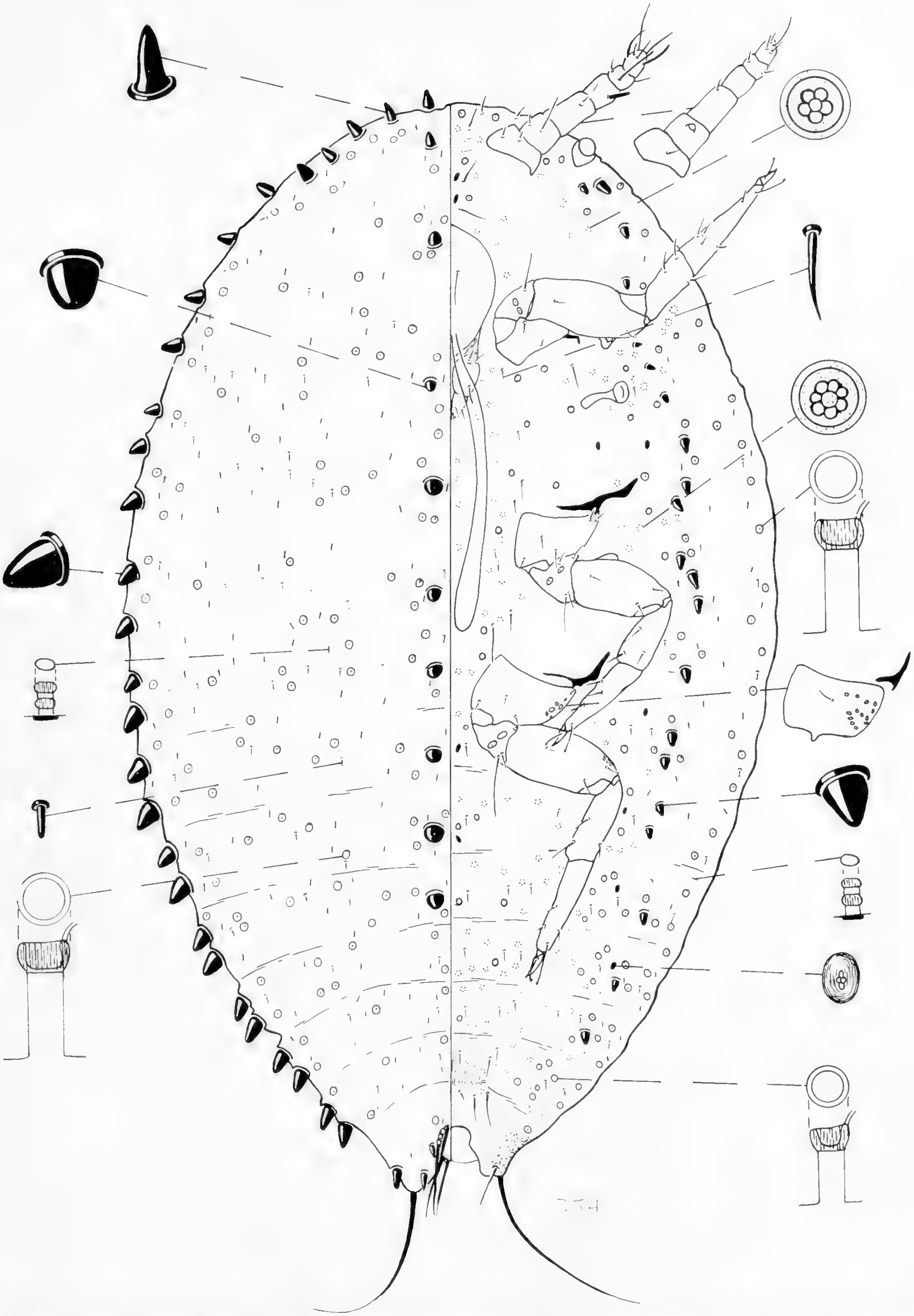

Fig. 2. Adult female (third instar)—*Acanthococcus droserae* Miller, Liu, and Howell. East of Fargo on Highway 177, Ware Co., Georgia, VIII-5-72, on mixture of hosts, R. J. Beshear.

slightly smaller than those on abdomen. Macrotubular ducts of 2 kinds: Larger size same as on dorsum, present along lateral margins; smaller size present on sublateral and medial areas. Microtubular ducts present near body margin. Multilocular pores of 4 kinds: Quinqueloculars present over surface, most abundant on posterior abdominal segments; triloculars, septeloculars, and noneloculars uncommon. Cruciform pores present on sublateral areas of abdominal segment V through head; with 4 pores between antennae and anterior margin of clypeolabral shield (paratypes with 2–5(4) pores).

Legs with translucent pores about 2 μ long; hind coxae dorsally with 21 and 18 pores (paratypes with 7–32(18) pores), ventrally with 5 (paratypes with 2–5(4) pores); hind femora dorsally with 6 pores (paratypes with 4–8(6) pores) in a cluster near distal apex, ventrally without pores; femora with 5 setae; tibiae with 5 setae; middle seta on front tibia located on inner margin of tibia, about same size as outer apical setae; inner, apical tibial setae slightly more robust than other leg setae; tarsi longer than tibiae (hind tibia/tarsus 0.77 (paratype 0.75–0.77(0.76)); claws without denticle. Antennae 6-segmented, third segment longest. Segment 6 with 4 or 5 sensory setae; segment 5 with 1 larger than single sensory seta on segment 4.

Variation: Some specimens have large-sized enlarged setae medially on segment V. The relative sizes of the setae on the anal lobes may vary from lateral longest and posteriomedial shortest to lateral longest and anteromedial shortest.

Specimens examined: The above description is based on 49 specimens from 7 localities.

Second-instar female (Fig. 3).—*Recognition characters:* mounted, 0.6–0.7(0.7) mm long, 0.4 mm wide. Anal lobes distinctly sclerotized ventrally; each lobe dorsally with 3 enlarged setae, conical, apices rounded (lateral longest, anteromedial shortest), with 1 microtubular duct; each lobe ventrally with 2 slender body setae, without sessile pores.

Dorsum with enlarged setae of 2 sizes: Larger size present along body margin, usually with 2 present on margin of each abdominal segment, and on medial areas of abdominal segment IV or III through head; smaller size restricted to medial and sublateral areas except on posterior abdominal segment where present medially. Largest lateral seta 25–30(27) μ long, largest medial seta 17–20(18) μ long; on abdominal segment II to VIII longest lateral seta 1.2–1.8(1.5) times longer than longest medial seta. Lateral setae straight with rounded apices, medial large-sized setae with blunt apices; small setae cylindrical with blunt apices. Enlarged setae few, e.g. abdominal segment V with 8 setae, large-sized setae arranged in 2 pairs of longitudinal lines (medial, lateral). Macrotubular ducts absent. Microtubular ducts 4–5(4) μ long, with area farthest from dermal orifice sclerotized and divided into 2 parts, apical portion rounded, about equal to remaining sclerotized portion; total sclerotized area about 2 times as long as unsclerotized area; dermal orifice sclerotized. Microtubular ducts loosely associated with both sizes of enlarged setae. Sessile pores absent.

Anal ring dorsal, with 3 pairs of setae.

Venter with longest seta on abdominal segment VIII 27–32(30) μ long, on segment III 7–10(9) μ long; longest posterior anal-lobe seta 104–106(105) μ long. Enlarged setae present on submargin from segment II or mesothorax forward to prothorax, absent from head. Macrotubular ducts absent. Microtubular ducts present near body margin.

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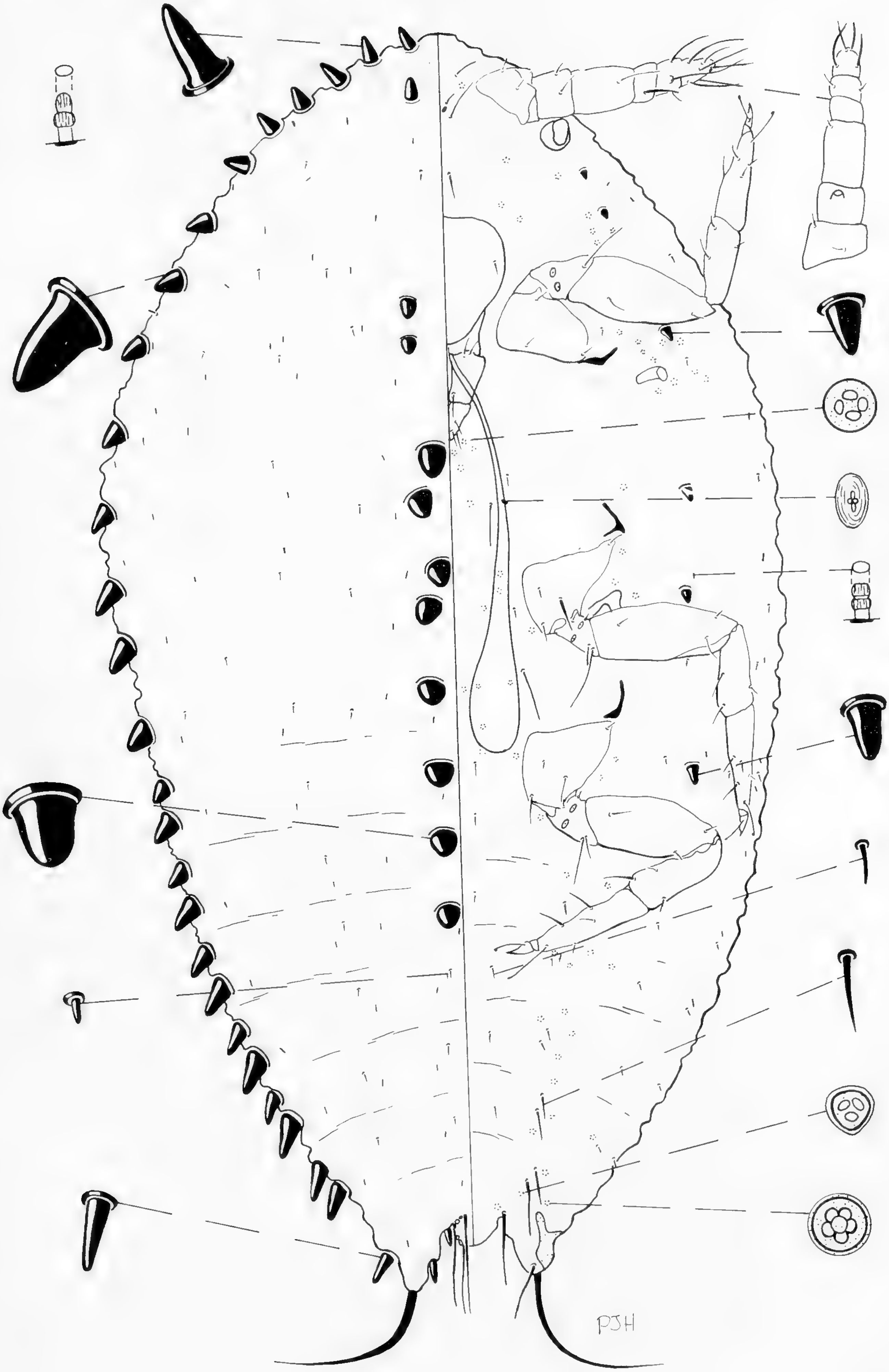
Fig. 3. Second-instar female—*Acanthococcus droserae* Miller, Liu, and Howell. On county road off of Highway 94 between Fargo and Statenville (Bethel Primitive Baptist Church), Echols Co., Georgia, V-18-68, on *Aletris lutea* (?), R. J. Beshear (HHT-170-68).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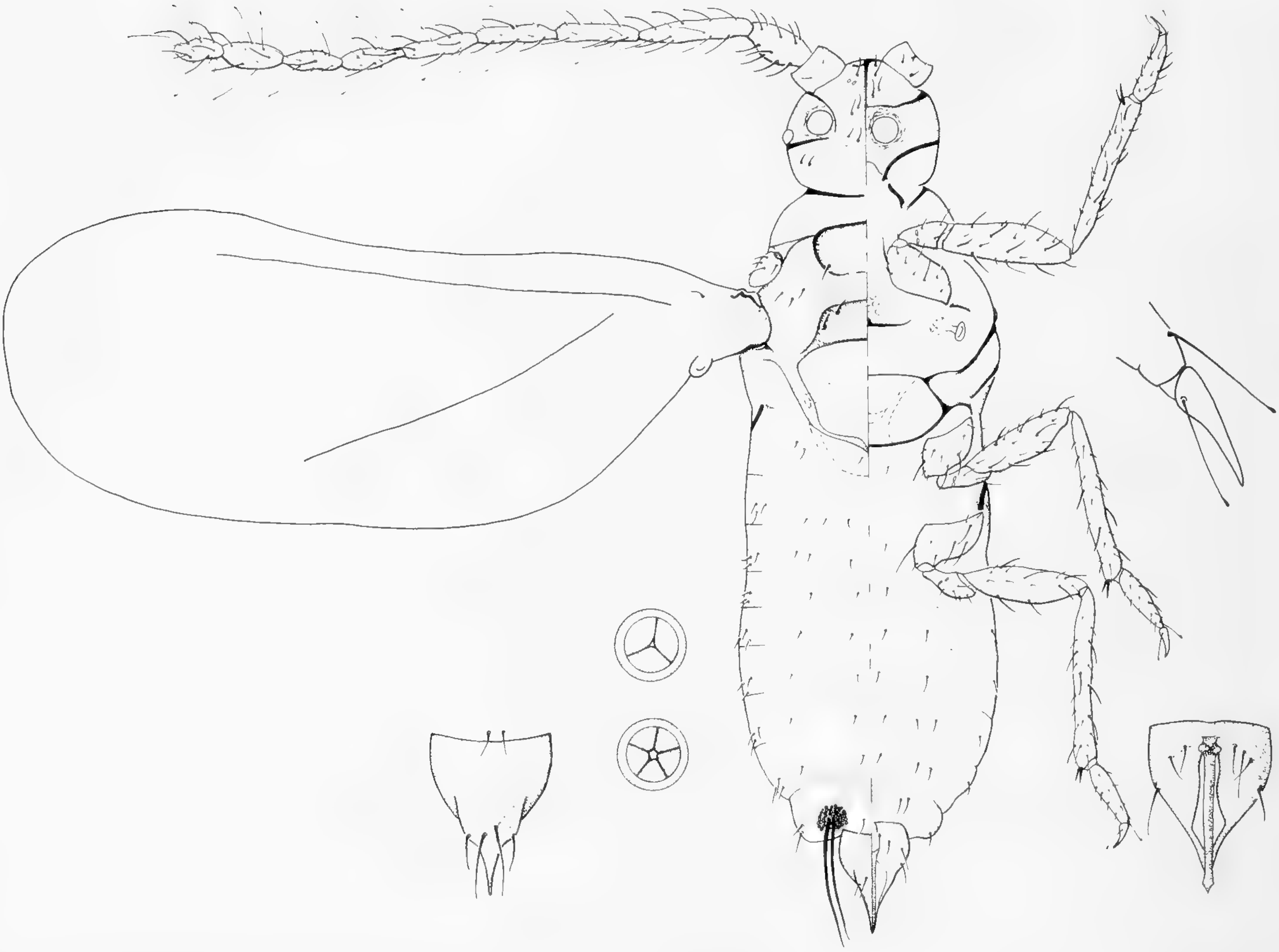


Fig. 4. Adult male (fifth instar)—*Acanthococcus droserae* Miller, Liu, and Howell. East of Fargo on Highway 94, Clinch Co., Georgia, X-13-87, mixture of hosts, R. J. Beshear.

Multilocular pores of 2 kinds: Quinqueloculars present medially and sublaterally on thorax and head, restricted to sublateral areas on abdomen; trilocular pores rare. Cruciform pores uncommon, usually present on head and on metathorax; with 1–2(2) pores between antennae and anterior margin of clypeolabral shield.

Legs without translucent pores; femora with 5 setae; tibiae with 5 setae; tarsi longer than tibiae (hind tibia/tarsus 0.69–0.75(72)); claws without denticle or with very small denticle in 1 specimen. Antennae 6-segmented.

Specimens examined: The description is based on 4 specimens from 2 localities.

Fifth-instar male (adult) (Fig. 4).—*Recognition characters:* Mounted, 0.9–1.1(1.0) mm long, 0.3–0.4(0.3) mm wide. Abdominal segment VIII slightly produced laterally, giving weak lobular appearance.

Dorsum with 1 pair of tail-forming pore clusters; each cluster with 2 elongate, capitate setae, longest seta 141–153(149) μ long; with 33–43(37) multilocular pores in cluster. Multilocular pores in tail-forming pore clusters only, with 3–7 loculi, quinqueloculars most common. X type dermal pores present near dorsal arm of midcranial ridge. Body setae apically acute, slightly shorter than those on venter, in clusters of 3 near each margin of abdominal segment VIII to I, also in transverse rows on abdominal segments VII to II, with 1 seta in medial area and 1 or 2 setae in mediolateral areas, 1 seta medially on segment VIII; setae present on meta- and mesothorax, absent from prothorax; head setae posterior of postocular ridge and posterior and lateral of dorsal arm of midcranial ridge. Abdominal sclerotization restricted to basal areas surrounding marginal clusters of setae, abdominal tergites unsclerotized. Metapostnotal ridge absent. Scutellar ridge present, not heavily sclerotized. Scutum with oval clear areas anterior of scutellum. Prescutum rectangular, prescutal suture weakly developed. Pronotal ridges well developed; pronotal sclerites absent. Hamolohalterae absent. Mesothoracic wings 862–942(889) μ long, each with 1 seta near base. Postoccipital ridge weakly sclerotized, lateral end bifurcate. Dorsal arm of midcranial ridge thin, extending toward postoccipital ridge. Dorsomedial sclerite unsclerotized. Dorsal eye 20–30(28) μ in diameter. Lateral ocellus 12–15(14) μ in diameter, touching postocular ridge. Ocular sclerite sclerotized near eyes.

Penial sheath 124–140(128) μ long, 86–99(91) μ wide; length/width ratio 1.3–1.5(1.4). Style in lateral view straight, apically acute. Anal opening 17–30(23) μ in diameter. Aedeagus 79–91(87) μ long; apex inflated. Dorsally 2 setae on each side of style; ventrally 3–5(4) setae.

Venter with setae present medially, mediolaterally, and laterally on segments VII to IV, with 1 or 2 setae present on segments VIII, III, and II. Thoracic setae absent; head setae near anterior portion of ventral arm of midcranial ridge. Abdominal sclerotization restricted to sternite VIII. Metathoracic precoxal ridge lightly sclerotized. Prosternum with distinctive pattern of sclerotization, oval or triangular. Mouth tubercle inconspicuous. Preoral ridge heavily sclerotized. Cranial apophysis inconspicuous, or absent. Ocular sclerite unsclerotized except near ventral eye. Ventral eye 27–30(28) μ in diameter.

Pro- and mesothoracic legs about equal in size, metathoracic legs longest. Hind tibia 178–217(202) μ long; hind tarsus 77–89(84) μ long; tibia/tarsus 2.3–2.5(2.4). Slender fleshy setae present on legs and antennae; capitate setae present on antennal segments 4 to 10. Antennae 10-segmented, 651–787(740) μ long; segment 3 longest, 116–133(124) μ long; segment 10, 52–62(57) μ long, barrel shaped; segment 3/10 1.9–2.5(2.2).

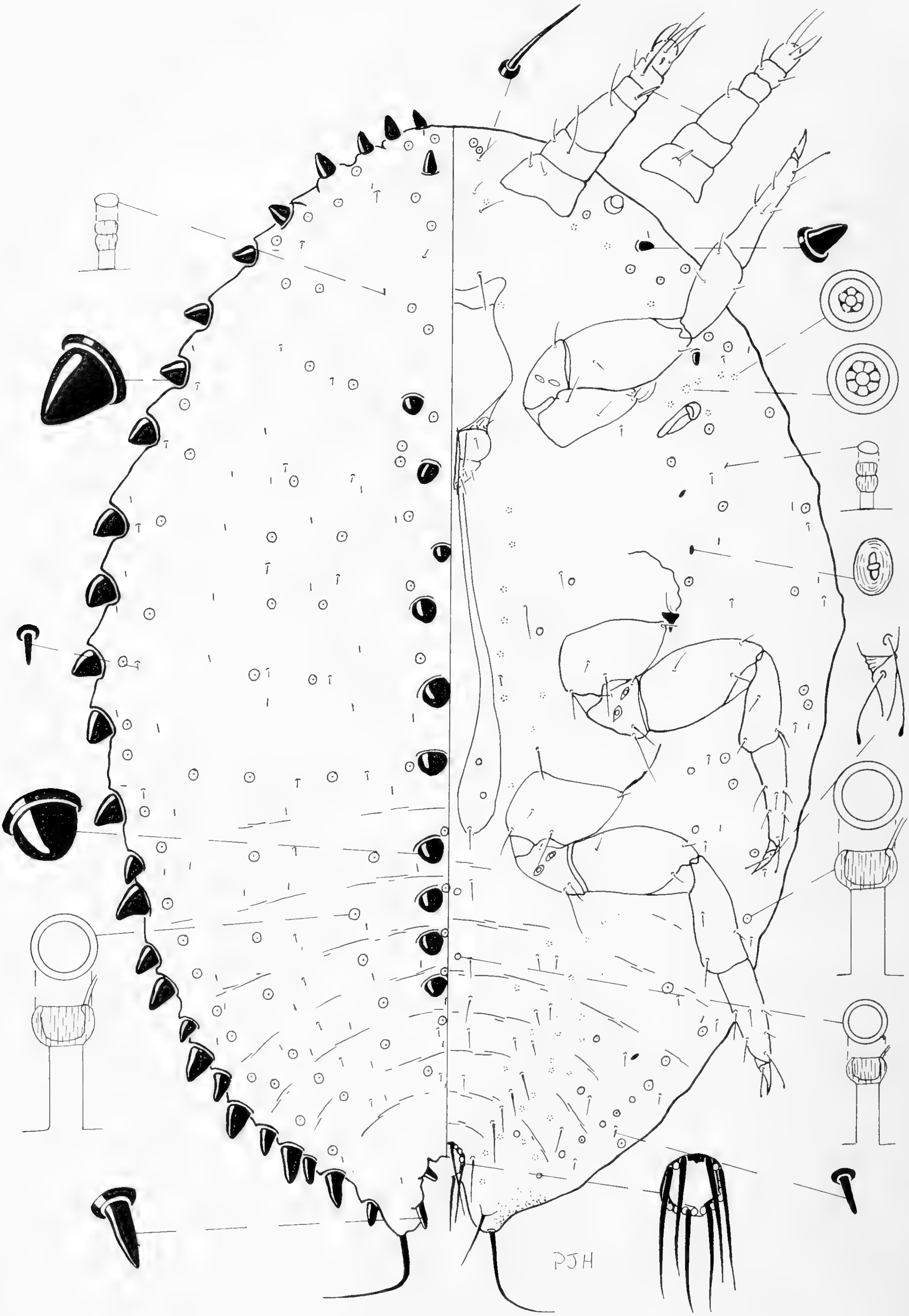
Specimens examined: The above description is based on 7 specimens from 1 locality.

Second-instar male (Fig. 5).—*Recognition characters:* Mounted 0.7–0.8(0.8) mm long, 0.4–0.5(0.5) mm wide. Anal lobes sclerotized ventrally, unsclerotized dorsally; each lobe dorsally with 3 enlarged setae, about same shape, conical, with rounded apices (seta on outer margin longest, anteromedial seta shortest), with 1 microtubular duct; each lobe ventrally with 2 body setae and 1 or 2 sessile pores.

Dorsum with enlarged setae of 2 sizes: Larger size along body margin, usually with 2 on margin of each abdominal segment, and in medial areas of abdominal segment V or IV to head; smaller size in sublateral line and in medial areas of abdominal segments VII to VI or V. Largest lateral seta 22–23(22) μ long, largest medial seta 17 μ long; on abdominal segments II to VIII, longest lateral seta 1.3–1.4(1.4) times longer than longest medial seta. Lateral setae straight or slightly curved, conical, with slightly rounded apices; medial setae of larger size straight, dome shaped, smaller size cylindrical with truncate or blunt apex. Enlarged setae few, e.g. abdominal segment V with 7–8(8) setae, with 2 pair of longitudinal lines of large-sized setae on lateral and medial areas. Macrotubular ducts of large size, scattered over surface. Microtubular ducts 4 μ long, with area farthest from dermal orifice sclerotized and divided into 2 parts, apical portion rounded, about equal to length of remaining sclerotized portion; total sclerotized area about equal to unsclerotized area. Multilocular pores absent.

Anal ring dorsal, with 3 setae.

Venter with longest seta on segment VIII 32 μ long, on segment III 12–14(13) μ long;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longest posterior anal-lobe seta 101–104(102) μ long. Enlarged setae restricted to margin of anterior thorax and sometimes head. Macrotubular ducts of 2 kinds: Larger size same as on dorsum, present along lateral margins; smaller size restricted to posterior 2 or 3 abdominal segments or sublateral areas. Microtubular ducts present along body margin. Multilocular pores of 3 kinds: Quinqueloculars scattered over thorax and head, restricted to sublateral band on abdomen; triloculars and septeloculars rare. Cruciform pores on sublateral areas of head and thorax, 1 specimen with 1 pore present on each side of abdominal segments VII to II; with 1–3(2) pores between antennae and anterior margin of clypeolabral shield.

Legs without translucent pores; femora and tibiae each with 5 setae; inner apical tibial seta more robust than other leg setae; tarsi longer than tibiae (hind tibia/tarsus 0.73–0.76(0.74); claws without denticle. Antennae 6-segmented, third segment longest. Segment 6 with 5 sensory setae; segment 5 with 1 seta conspicuously longer than single sensory seta on segment 4.

Specimens examined: The description is based on 2 specimens from 1 locality.

First instar (Fig. 6).—*Recognition characters:* Mounted 0.1 mm long, 0.1 mm wide. Anal lobes without sclerotization; each lobe dorsally with 3 enlarged setae, about same shape, conical, with acute apices (seta on outer margin longest, anteromedial seta shortest), without macrotubular ducts; each lobe ventrally with 1 body seta, without sessile pores.

Dorsum with enlarged setae of 2 sizes: Larger size along body margin, with 1 seta on margin of each abdominal segment; smaller size in sublateral and medial lines. Largest lateral seta 17 μ long, largest medial seta 5 μ long; on abdominal segments II to VIII, longest lateral seta 3.4 times as long as longest medial seta. Lateral setae straight or slightly curved, conical, with acute or slightly rounded apices; medial setae cylindrical, with blunt apices. Enlarged setae few, e.g. abdominal segment V with 6 setae, with no longitudinal pattern of larger setae except on margin. Macrotubular ducts absent. Microtubular ducts 4 μ long, with area farthest from derm sclerotized and divided into 2 parts, apical portion rounded, about equal to length of remaining sclerotized portion; total sclerotized area about equal to unsclerotized area. Multilocular pores absent.

Anal ring dorsal, with 3 setae.

Venter with longest seta on segment VIII 22 μ long, on segment III 5 μ long; longest posterior anal-lobe seta 82 μ long. Enlarged setae, macrotubular ducts and microtubular ducts absent. Multilocular pores of 2 kinds: Quinqueloculars present on each side of body on sublateral areas of each segment from VII to II, on submedial areas of each thoracic segment and on head near posterior margin of clypeolabral shield; septelocular pores present laterad of each spiracle. Cruciform pores on sublateral area of mesothorax; without pores on head.

Legs without translucent pores; femora and tibiae each 5 setae; inner apical tibial seta more robust than other leg setae; tarsi considerably longer than tibiae (hind tibia/tarsus 0.49); claws with small denticle. Antennae 6-segmented, third segment longest. Segment 6 with 4 sensory setae; segment 5 with 1 conspicuously longer than single sensory seta on segment 4.

Specimens examined: This description is based on 1 specimen.

Material studied.—FLORIDA, Clay Co.:

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Fig. 5. Second-instar male—*Acanthococcus droserae* Miller, Liu, and Howell. On county road off of Highway 94 between Fargo and Statenville (Bethel Primitive Baptist Church), Echols Co., Georgia, V-18-68, on *Aletris lutea* (?), R. J. Beshear (HHT-170-68).

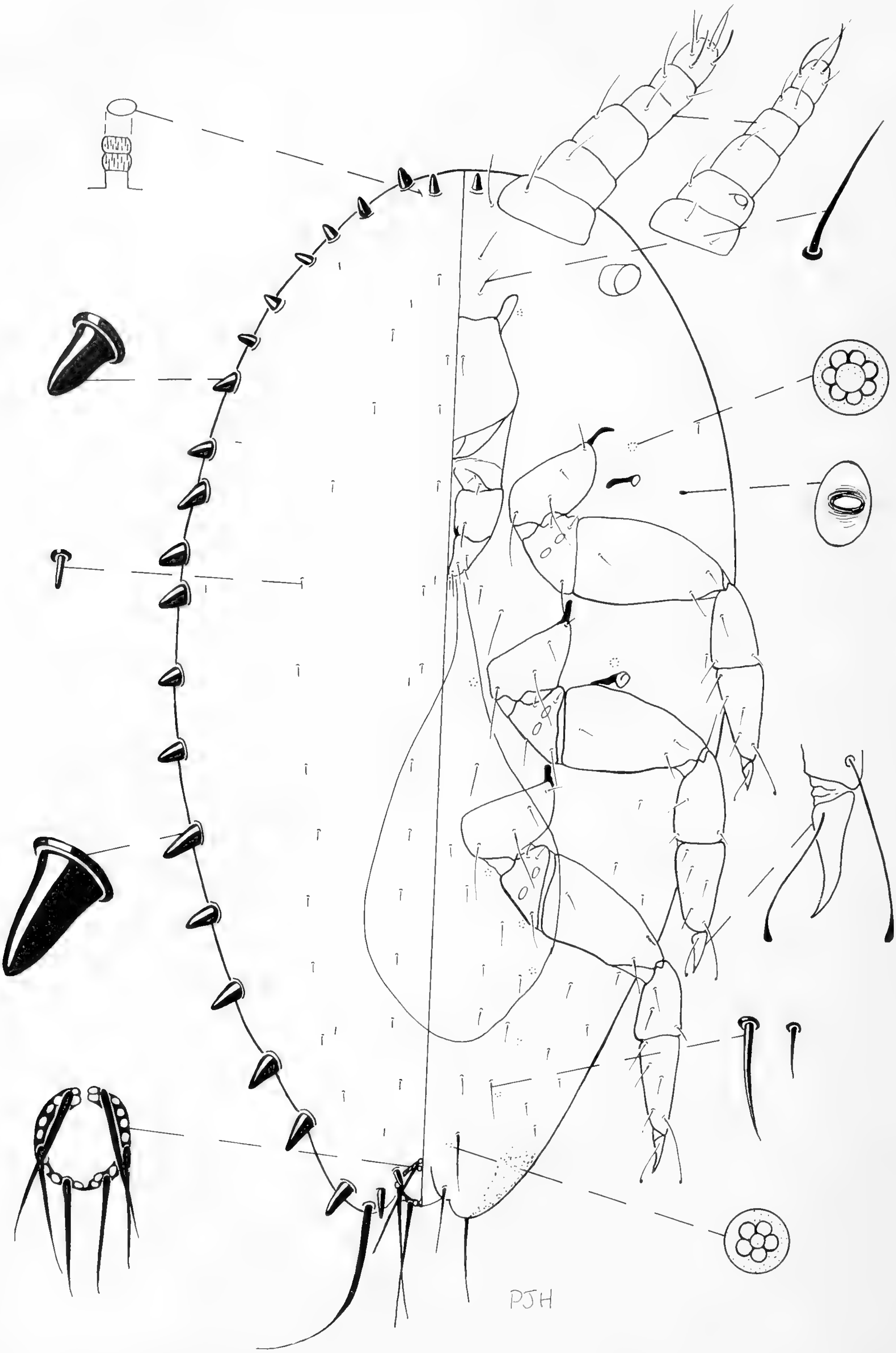

Fig. 6. First instar (sexes indistinguishable)—*Acanthococcus droserae* Miller, Liu, and Howell. East of Fargo on Highway 177, Ware Co., Georgia, VIII-5-72, on mixture of hosts, R. J. Beshear.

Near Green Cove Springs on Highway 17, V-28-76, host unknown, R. J. Beshear (HHT-131-76) (1 ad female) UG. Levy Co.: West of Otter Creek on Highway 24, IV-4-74, VI-4-74, on *Aletris farinosa,* R. J. Beshear (HHT-111-74 and HHT-94-74) (2 ad female on 2 sl) UG.

GEORGIA, Charlton Co.: East of Fargo on Highway 177, II-9-83, II-14-84, on *Drosera* sp., R. J. Beshear (HHT-8-83 and HHT-24-83) (19 ad female on 19 sl) UG, USNM; East of Fargo on Highway 177, II-14-84, on mixed plants including *Drosera* sp., R. J. Beshear (HHT-4-84) (3 ad female on 3 sl) UG. Clinch Co.: East of Fargo on Highway 94, X-13-87, mixture of hosts, R. J. Beshear (HHT-4-87) (4 ad female, 7 ad male, 2 second-instar female on 7 sl) UG. Echols Co.: On county road off of Highway 94 between Fargo and Statenville (Bethel Primitive Baptist Church), V-18-68, on *Aletris lutea* (?), R. J. Beshear (HHT-170-68) (2 second-instar males and 2 second-instar females on 2 sl) USNM. Ware Co.: East of Fargo on Highway 177, III-4-72, VIII-5-72, VIII-16-72, XI-11-72, IX-17-73, mixture of hosts, R. J. Beshear (HHT-111-72, HHT-379-72, HHT-382-72, HHT-462-72, HHT-225-73) (20 ad females, 4 ad males, 1 first instar on 25 sl) USNM, UG.

This species has been collected primarily by bringing bog samples into the Laboratory and placing them in a Berlese Funnel. In all instances, *Drosera* plants were present, but a mixture of other potential hosts also was included in the samples. Ms. Ramona J. Beshear examined *Drosera* specimens in bogs and found specimens of this species at the base of the leaves. She has collected a small number of specimens on *Aletris,* but believes that these were individuals that moved from the *Drosera* host to molt or lay eggs and were incidental.

Comparison with other species.—The adult female of *Acanthococcus droserae* is unique among the North American eriococcid fauna in possessing a medial row of dome-shaped enlarged setae and in lacking a denticle on the claw. The adult male also is unique by possessing small clear areas on the scutum reminiscent of the well-developed, clear scutal area on soft scale males (Giliomee 1967). This structure has not been reported for any other eriococcid including those described by Afifi (1968) and Miller and González (1975).

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SCAPTERISCUS BORELLII GIGLIO-TOS: THE CORRECT SPECIES NAME FOR THE SOUTHERN MOLE CRICKET IN SOUTHEASTERN UNITED STATES (ORTHOPTERA: GRYLLOTALPIDAE)

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Abstract.—*Scapteriscus acletus* Rehn and Hebard, 1916, the Southern Mole Cricket, is made a synonym of *S. borellii* Giglio-Tos, 1891, based on examination of types and fieldwork in the United States and Argentina.

Key Words: mole cricket, *Scapteriscus,* Gryllotalpidae

The mole cricket genus *Scapteriscus* Scudder, 1869 includes 13 described species (Chopard 1968, Nickle and Castner 1984), all but one of them occurring naturally in the Western Hemisphere. Giglio-Tos (1894) described the species *S. borellii* from specimens collected in Argentina; it was last reported in taxonomic literature by Hebard (1924). It is a common, widespread species, ranging across Bolivia, Paraguay, Uruguay, southern Brazil, and northern Argentina. In 1916 Rehn and Hebard described a mole cricket from Georgia, *S. acletus,* and indicated that it was the only endemic species of two-clawed mole cricket in the United States. The following information indicates that *S. borellii* and *S. acletus* are actually the same species.

In addition to *S. acletus,* two other *Scapteriscus* mole cricket species, *abbreviatus* Scudder, 1869 and *vicinus* Scudder, 1869, are known to occur in southeastern U.S., both introduced accidently into the U.S. late in the nineteenth or early in the twentieth century (Chittenden 1903, Rehn and Hebard 1912). Walker and Nickle (1981) demonstrated that in fact all three species were accidental introductions, and they mapped the spread of each species into their present distributions in the southeastern states. They also indicated that *acletus* occurs in the United States in two morphologically distinct forms, a mottled form and a four-dot form (based on patterns of color on the pronotum). They indicated that the mottled form of *acletus* was introduced into Brunswick, Georgia (type locality), about 1904, and into Mobile, Alabama, about 1919, and that the four-dot form of *acletus* was introduced into Charleston, South Carolina, about 1919 and into Port Arthur, Texas, about 1925. In their discussion, they cited the speculation by Worsham and Reed (1912) that *S. vicinus* (reported incorrectly as *didactylus*) was transported probably in soil ballast used in commercial shipping of the nineteenth century.

Nickle and Castner (1984) traced the probable avenues of transport of each of the introduced mole crickets found in the U.S. and suggested that *abbreviatus, acletus,* and *vicinus* probably all came from Argentina or southern Brazil, since all three species are found in that region. Today the sharp geographic boundaries delineating mottled and four-dot populations of *S. acletus* are not as distinct as previously supposed, although four-dot populations are nearly uniform in Texas, Louisiana, peninsular Florida, and South Carolina, and mottled individuals are more likely to be found in Alabama, Mississippi, and southern Georgia. The mottled population in the vicinity of Brunswick, Georgia, upon which Rehn and Hebard based their original description of *acletus,* seems to have been replaced or assimilated by four-dot forms spreading either from South Carolina or from yet another possible site of introduction near Jacksonville, Florida, where two juvenile four-dot specimens were collected in 1924 (see Walker and Nickle 1981, fig. 1).

Although the two forms are somewhat different in color patterns and overall robustness, there are no clear-cut differences to suggest that they are different species. I consider them to be conspecific, representing variants in color patterns of the widespread South American species. Each form probably was introduced as small samples of individuals from different localities in South America early in the twentieth century. Based on analysis of museum specimens of South American *Scapteriscus* (Nickle and Castner 1984), the mottled form of *S. acletus* was probably descended from specimens from southern Brazil, whereas the four-dot forms probably came from Argentina.

Because researchers in Florida are developing a biocontrol program for the economic control of mole crickets in southeastern U.S., it has become important to correctly delimit the pest species and to find their native homelands. In a field trip to northern Argentina in 1981, I found that mole crickets morphologically identical to *S. acletus* from peninsular Florida were attracted to an artificially produced calling song of *acletus,* a trill of 55 p/s with a carrier frequency of 2.6 kHz. The attraction of individuals to the pair-forming calling sound is generally a strong indication of conspecificity. The holotype and paratype of *S. borellii* loaned to me from the Museo Anatomie Comp., Universita di Torino, in Turin, Italy, are identical to the four-dot form of *acletus,* and I conclude that *acletus* is a junior synonym of *borellii,* NEW SYNONYMY.

ACKNOWLEDGMENTS

I wish to thank Dr. T. J. Walker for the use of the artificial cricket signal box used in field studies in Argentina and southeastern U.S. and for his help in bringing this paper to completion. Thanks are also extended to the curators of the Museo Zool. Anat. Comp., Univ. Torino, Turin, Italy, and to Daniel Otte of the Academy of Natural Sciences of Philadelphia, Pennsylvania, for loaning the types of *Scapteriscus.* Finally I thank Drs. Walker and Howard Frank, of the Department of Entomology & Nematology, University of Florida, and Drs. Alma Solis, Arnold Menke, and Eric Grissell, of the Systematic Entomology Laboratory, U.S. National Museum of Natural History, Washington, D.C., for reviewing the manuscript.

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A REVISION OF THE NEARCTIC GENUS *GYMNOCARENA* HERING (DIPTERA: TEPHRITIDAE)

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Abstract.—The genus *Gymnocarena* Hering is revised to include 13 Nearctic species: **angusta,** n. sp., *apicata* (Thomas), n. comb., *bicolor* Foote, **carinata,** n. sp., *diffusa* (Snow), **fusca,** n. sp., **hernandezi,** n. sp., *lichtensteinii* (Wiedemann), n. comb., **magna,** n. sp., *mexicana* (Aczél), **mississippiensis,** n. sp., **serrata,** n. sp., and *tricolor* (Doane). *Mylogymnocarena* Foote is a new synonym of *Gymnocarena,* and *flava* Foote is a new synonym of *tricolor.* A lectotype is designated for *lichtensteinii.* New host data are presented for *carinata* and *mexicana,* and it is noted that all known hosts of *Gymnocarena* belong to the tribe Heliantheae (Asteraceae). Cladistic relationships among the species are analyzed, and descriptions, illustrations, and distribution maps for all species, as well as a key, are provided.

Resumen.—El género *Gymnocarena* Hering se revisa para incluir 13 especies nearcticas: **angusta,** sp. n., *apicata* (Thomas), comb. n., *bicolor* Foote, **carinata,** sp. n., *diffusa* (Snow), **fusca,** sp. n., **hernandezi,** sp. n., *lichtensteinii* (Wiedemann), comb. n., **magna,** sp. n., *mexicana* (Aczél), **mississippiensis,** sp. n., **serrata,** sp. n., and *tricolor* (Doane). *Mylogymnocarena* Foote es un sinonimo nuevo de *Gymnocarena,* y *flava* Foote es un sinonimo nuevo de *tricolor.* Un lectotipo se designa para *lichtensteinii.* Datos huespedes nuevos se presentan para *carinata* y *mexicana,* y se reporta que todos huespedes conocidos de *Gymnocarena* pertenecen al tribu Heliantheae (Asteraceae). Relaciones cladisticas entre las especies se analizan, y descripciones, ilustraciones, mapas de distribución por todos las especies, y una clave, se proveen.

Key Words: Fruit flies, *Helianthus, Dahlia, Verbesina,* taxonomy

The genus *Gymnocarena* Hering includes 13 species, seven of which are newly described in this paper. They are relatively large fruit flies, 4.0–7.5 mm long, with wing patterns of solid brown and/or yellow with large hyaline or whitish marks. *Gymnocarena* is endemic to North America, occurring from the central and western United States and Canada to central Mexico. Host data are limited, but the species whose biologies are known breed in flower heads of plants in the tribe Heliantheae of the Asteraceae. The type species, *G. diffusa* (Snow), is sometimes a pest of commercial sunflowers.

Materials and Methods

Acronyms for the depositories of specimens listed in the text are as follows: ANSP—Academy of Natural Sciences; AMNH—American Museum of Natural History; BMNH—Natural History Museum (formerly British Museum); CAS—California Academy of Sciences; CDA—California Department of Agriculture; CNC—

Canadian National Collection; CSUFC—Colorado State University; FLBPC—F. L. Blanc personal collection; FMNH—Field Museum of Natural History; FSCA—Florida State Collection of Arthopods; JJPC—J. Jenkins personal collection; INHS—Illinois Natural History Survey; KSU—Kansas State University; MCZ—Museum of Comparative Zoology, Harvard University; MSUEL—Michigan State University; NMW—Naturhistorisches Museum Wien; SDNHM—San Diego Natural History Museum; TAMU—Texas A&M University; UAE—University of Alberta, Edmonton; UAT—University of Arizona; UCB—University of California, Berkeley; UCR—University of California, Riverside; UKaL—Snow Entomological Museum, University of Kansas; UMMZ—University of Michigan, Museum of Zoology; UNAM—Instituto de Biología, Universidad National Autonoma de México; UNL—University of Nebraska; USNM—National Museum of Natural History, Smithsonian Institution; USU—Utah State University; WSU—Washington State University; ZMHU—Zoologisches Museum der Humboldt Universität.

I follow the morphological terminology of McAlpine (1981), except as noted in Norrbom and Kim (1988). The length of female syntergosternite 7 was measured dorsally, to the ridge at the base, and does not include the apodemes. The size and shape of the facial carina is a useful character in *Gymnocarena,* although it varies subtly among some species. Its size refers in this paper to how much it is produced from the plane of the face. The height of the ventral, laterally expanded part was measured in comparison to that of the face, which was measured to the ventral margin of the antennal sockets. Within the light areas of the wing in most species there are distinctive patterns of white spots within slightly darker grayish or light brown areas. These patterns, apparently due to microtrichia color, may be difficult to see, especially in teneral specimens. The term "light" is used in this paper to refer collectively to hyaline, white, or grayish areas, as they are often difficult to differentiate.

RELATIONSHIPS

Norrbom (1987) transferred *Gymnocarena* to the subfamily Tephritinae because it does not have distinctly differentiated scapular setae and because of its Asteraceae hosts. Further supporting this hypothesis is the shape of the epandrium and outer surstyli, which is almost oval (Fig. 1C, E), with the margin of the surstylus usually projected to form a dorsal lobe (Fig. 1B, D). This shape is common within the Tephritinae and may be the groundplan condition for the subfamily. It does not occur in the Trypetinae.

Within the Tephritinae, the relationship of *Gymnocarena* is unclear. It shares a number of plesiomorphic character states with the Terelliini and a group of mainly neotropical genera including *Acrotaenia* and *Polionota* (see Norrbom 1987), but I have discovered no synapomorphies indicating its relationship to any other taxon. The following are character states of *Gymnocarena* that are probably plesiomorphic for the Tephritinae: frons non-setulose medially; postocular setae and scutal setulae slender to slightly swollen; 3 or more pairs of frontal setae; dorsocentral seta usually more or less aligned with postsutural supra-alar seta; vein R_1 without gap in dorsal setulae near apex of vein sc; vein R_{4+5} setose dorsally to beyond dm-cu; cell bcu with apical lobe large, one-third to one-half width of cell.

The monophyly of *Gymnocarena* is indicated by a synapomorphy of the male genitalia—the distiphallus has spines on the membranous apical part (Fig. 1A). This type of distiphallus is unique within the Tephritidae to my knowledge. The lack of microtrichia on most of the arista except basally (Fig. 2) may also be a synapomorphy. In most Tephritinae there are at least minute microtrichia. In addition, most other characters that are important at the generic level

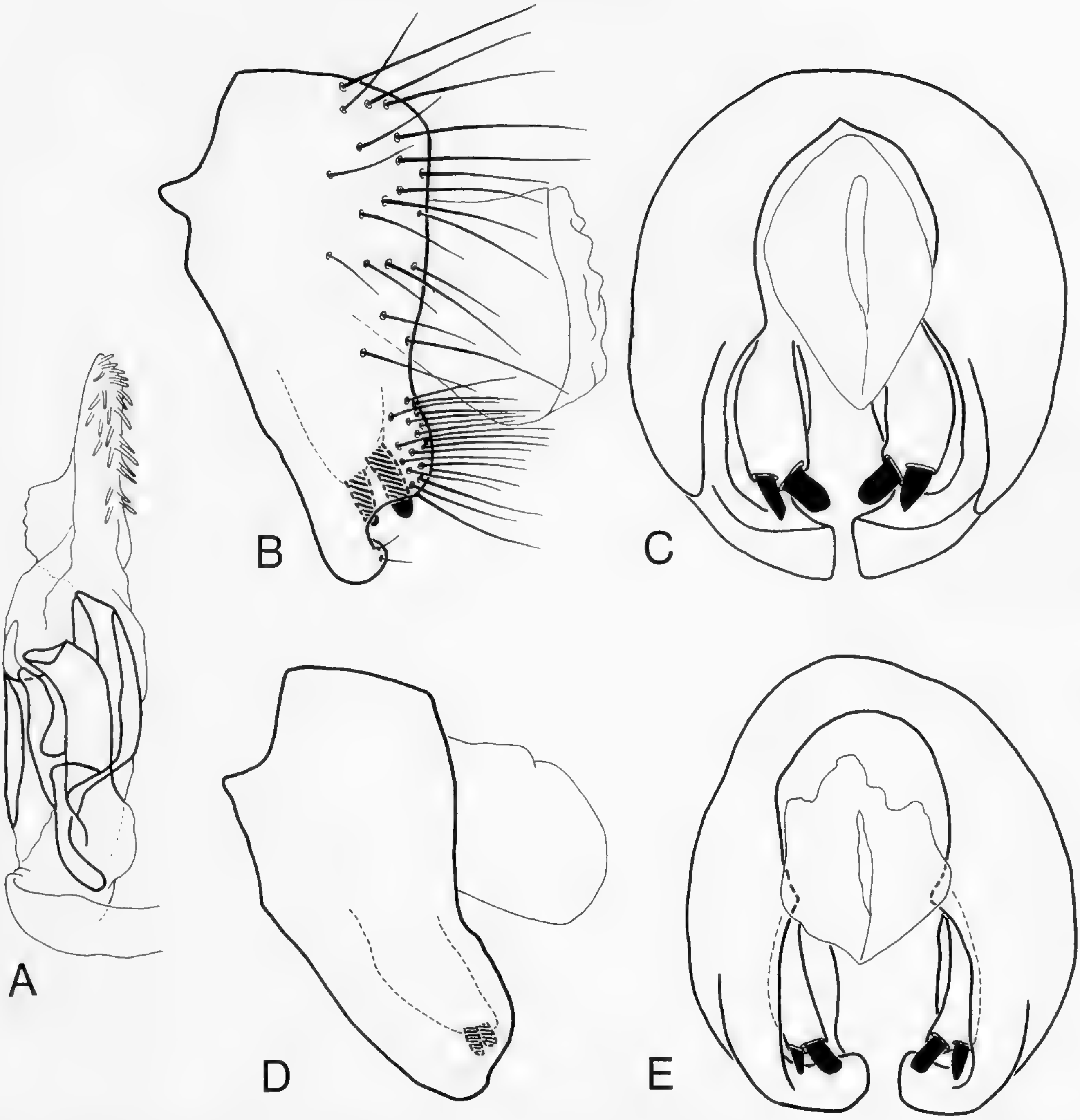


Fig. 1. Male terminalia: A–C, *diffusa* (Snow); D–E, *mexicana* (Aczél); A, distiphallus; B, D, epandrium and outer surstyli, lateral view; C, E, same, posterior view.

in the Tephritidae, such as chaetotaxy, head shape, outer surstylus shape, and wing venation, are consistent within *Gymnocarena*. Some of these characters could also be apomorphies for the genus, but cannot be evaluated because its sister group is unknown. Their consistency at least does not contradict a hypothesis of monophyly.

As delimited here, *Gymnocarena* includes the genera *Tomoplagiodes* Aczél and *Mylogymnocarena* Foote. The latter is a new synonym. Blanc and Foote (1987) recognized its similarity with *Gymnocarena* and admitted that it may be congeneric, but they proposed several characters to separate the two taxa. When other characters and the new species described in this paper are considered, however, this classification does not seem valid. Of the characters used by Blanc and Foote, I found the angle between the crossveins to be highly variable intraspecifically when I examined larger series of specimens. The swollen femora appear to be an apomorphic character state of *diffusa*

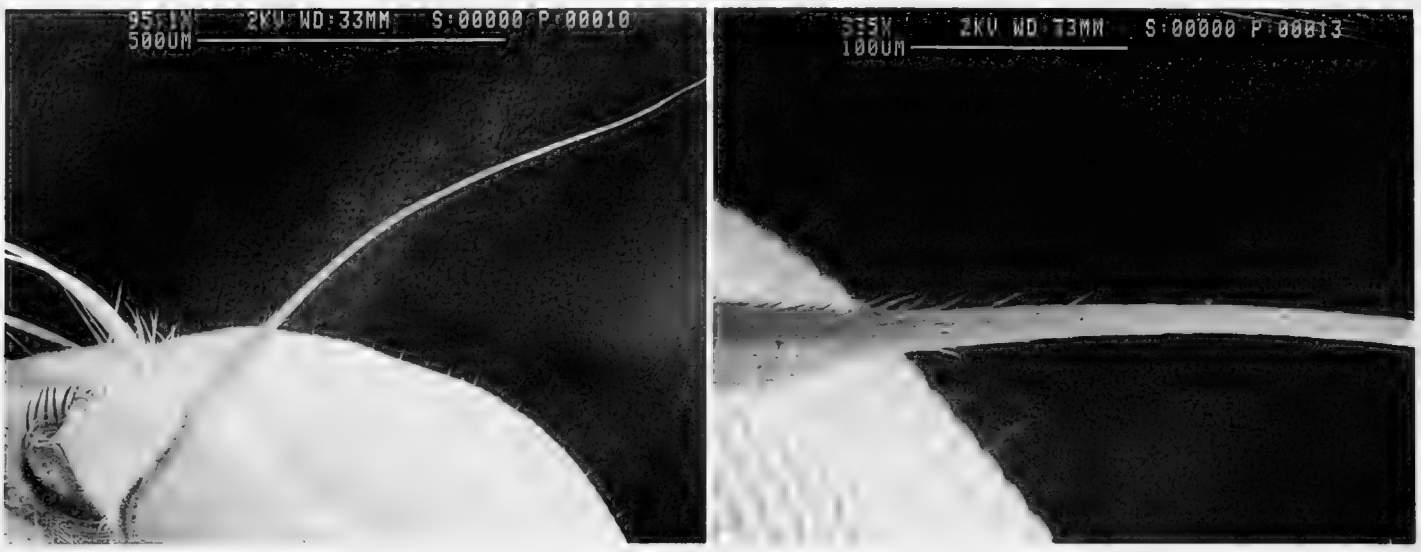


Fig. 2. Antenna of *mexicana*: A, arista; B, base of arista, enlarged.

and *tricolor,* but wing pattern color, the number of hyaline areas in cell r_1, and a number of other characters (see Tables 1 and 2) exhibit considerable homoplasy and do not consistently divide the species into distinct subgroups. I see no reason, therefore, to continue to recognize *Mylogymnocarena.*

Relationships within *Gymnocarena* are poorly resolved. I was able to recognize only 7 characters that are useful for cladistic analysis of the included species. These and their states are listed in Tables 1 and 2. Other characters that are somewhat useful taxonomically, such as genal height and syntergosternite 7 length, are so variable that I was unable to interpret them for phylogenetic analysis. Another potentially useful character, the size of the dorsal lobe of the outer surstylus, is unknown for too many taxa. The diverse wing patterns of *Gymnocarena* contain considerable phylogenetic information, but they are very difficult to divide into states and to order into transformation series. I tried dividing the pattern into several characters based on certain areas of the wing, but as this seemed to result in additional homoplasy in early analyses, I eventually recognized just one character (i.e. general wing pattern) with five states.

The characters were analyzed using Hennig86 (J. S. Farris, copyrighted; see Farris 1988, Fitzhugh 1989). The implicit enumeration option (ie*) was used in all runs. Determination of character polarity was hindered by the fact that the sister group of *Gymnocarena* is unknown. For most characters, one state is found in most or all other Tephritinae, and this state was considered plesiomorphic and was assigned to the hypothetical outgroup used in the analysis. This was not possible for characters 2 and 5, as the abdominal setulae color and wing pattern vary considerably in other Tephritinae. For these characters, I ran several analyses varying the states assigned to the outgroup. Only states 1 and 2 were used for character 2, as I guessed these to be the more likely plesiomorphic states. Nonredundant coding (O'Grady and Deets 1987) was used to transform character 2 for analysis by Hennig86 which does not accept nonlinear multistate characters. The types of *G. carinata* were reared after this paper was submitted for publication and after the illustrations of the phylogenetic hypotheses had been prepared. This species is not included in the analysis, although it has the same character states as *G. serrata* and *fusca,* and appears to be most closely related to them.

Some examples of trees resulting from the analyses are shown in Figs. 3–4, but there are many other trees of equal length that represent equally parsimonious hypotheses

Table 1. Characters and states used in phylogenetic analysis of *Gymnocarena*. Unless otherwise noted, state 0 is hypothesized as plesiomorphic.

1. Femora—0) not swollen; 1) swollen.
2. Wing pattern—0) highly reduced, not dark basal to dm-cu, but dark area with light spots; 1) extensive, with many light spots, yellow at least basally, light area in radial cells small and distinctly divided; 2) extensive, with few light spots, dark areas entirely brown, light area in radial cells large and partially divided; 3) extensive, with few light spots, dark areas entirely brown, light area in radial cells small and undivided or absent; 4) reduced, dark areas entirely brown, light area in radial cells large, only partially or not divided. This character is hypothesized as a linear transformation series, except that states 3 and 4 are considered independently derived from state 2. The plesiomorphic state is also uncertain, although states 1 or 2 seem most likely.
3. Facial carina size—0) weakly to moderately developed; 1) moderately to well developed.
4. Cuticle—0) never with tiny dark spots; 1) with tiny dark spots in at least some specimens.
5. Abdominal setulae—0) brownish except on syntergite 1+2; 1) entirely yellowish. The polarity of this character is uncertain.
6. Aculeus tip shape—0) moderately broad, strongly tapered; 1) very slender basally and apically; 2) broad apically. States 1 and 2 are hypothesized as independently derived from state 0.
7. Aculeus tip margin—0) non-serrate; 1) serrate.

Table 2. Character state distributions in species of *Gymnocarena* and four hypothetical outgroups.

Character No.	1234567
hypoth. outgr. A	0100100
hypoth. outgr. B	0200100
hypoth. outgr. C	0100000
hypoth. outgr. D	0200000
diffusa	1110120
tricolor	1110120
bicolor	0301020
hernandezi	0311020
manga	0411020
lichtensteinii	04110??
mexicana	0411020
angusta	0211010
apicata	0001010
mississippiensis	0101010
serrata	0301001
fusca	0301001

of the relationships among the species of *Gymnocarena*. The only consistent results of all of the analyses are the following groups of species: *diffusa* + *tricolor*; *serrata* + *fusca*; and *magna* + *lichtensteinii* + *mexicana*. The first pair is the most strongly supported clade, with 2–4 synapomorphies. These always include character 1 (swollen femora), but the others vary, depending upon the hypotheses of polarity used in the analyses (e.g. state 1 of character 5 is a synapomorphy if state 0 is assigned to the outgroup; or, in trees where *diffusa* + *tricolor* is not the basal clade, character 4, state 1 (cuticle with tiny dark spots) occurs as a synapomorphy for the genus, with the reversal to state 0 (cuticle without spots) a synapomorphy for *diffusa* and *tricolor* (see Fig. 4)). The *serrata* + *fusca* clade is supported by a unique synapomorphy in character 7 (aculeus tip serrate), and *magna* + *lichtensteinii* + *mexicana* are grouped consistently by character 2, state 4 (wing pattern reduced). Another common clade is *apicata* + *mississippiensis,* which is frequently the sister group to *angusta*. These 3 species are grouped by character 6, state 1 (aculeus slender), but *angusta* often runs elsewhere because of differences in characters 2 (wing pattern) and 3 (facial carina size). Usually, *bicolor* and *hernandezi* are found in clades including *serrata* + *fusca* and/or *magna* + *lichtensteinii* + *mexicana*.

The polarity of character 5 (abdominal setulae color) has considerable effect on the analyses. When the hypothetical outgroup is assigned state 1 for this character (i.e. state 1 plesiomorphic), the usual results are trees with *diffusa* + *tricolor* as the sister group of the remaining species. With this polarity, state 0 of character 5 and state 1 of character 4 are synapomorphies for the remaining species. With this polarity for character 5 and with state 1 in the outgroup for character 2 (Table 2, outgroup A), 14 trees of length 16 (ci = 68, ri = 81) result, all with *diffusa* + *tricolor* as the basal clade. Two of

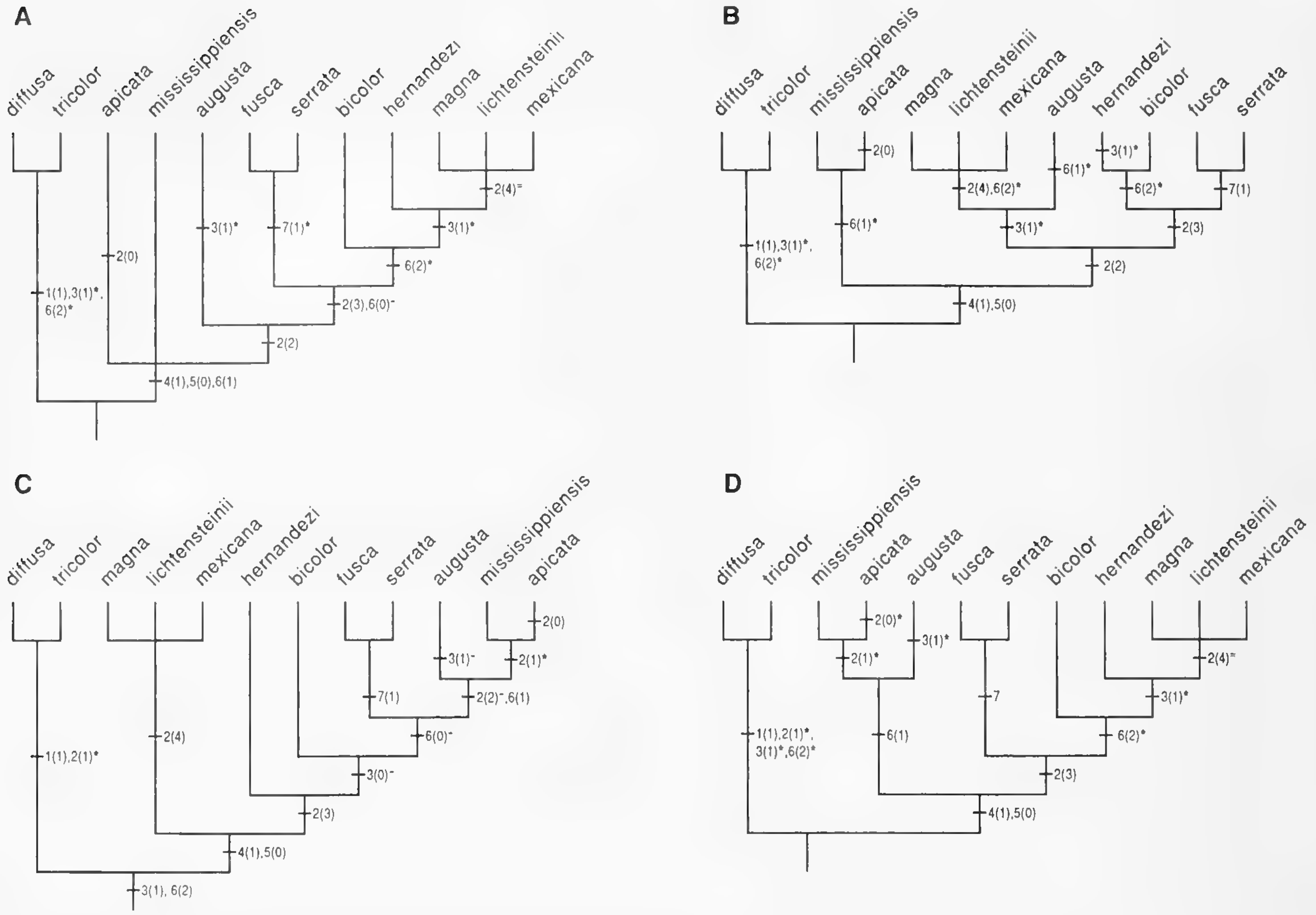


Fig. 3. Examples of hypotheses of phylogenetic relationships among the species of *Gymnocarena* if state 1 of character 5 is assigned to outgroup. A, B, 2 of 16 trees resulting if state 1 is assigned for character 2 (Table 2, outgroup A); C, D, 2 of 5 trees resulting if state 2 is assigned for character 2 (Table 2, outgroup B). Numbers refer to characters, those in parentheses to states, listed in tables 1 and 2. "*" indicates homoplasy, "−" indicates reversal.

these are shown in Fig. 3A–B. With state 2 in the outgroup for character 2 (Table 2, outgroup B), 5 trees of length 16 (ci = 68, ri = 80) result, in 4 of which *diffusa* + *tricolor* is the basal clade (e.g. Fig. 3C–D). The remaining tree has the same topology as Fig. 4A, with *apicata* + *mississippiensis* + *angusta* as the basal lineage, and with *diffusa* + *tricolor* closest to *magna* + *lichtensteinii* + *mexicana.* It differs from the tree of Fig. 4A only in having an additional step at the base because character 5 state 1 was assigned to the outgroup.

Assigning state 0 to the outgroup for character 5 changes the tree morphology considerably. With state 1 in the outgroup for character 2 (Table 2, outgroup C) the results are ambiguous; 30 trees of length 16 (ci = 68, ri = 80) result, some with *diffusa* + *tricolor* the basal clade (e.g. Fig. 4B), some with *apicata* + *mississippiensis* (sometimes also + *angusta*) as the basal lineage (e.g. Fig. 4C), and some with a basal trichotomy of *apicata, mississippiensis,* and the remaining species (e.g. Fig. 4D). With state 2 in the outgroup for character 2 (Table 2, outgroup D), only 1 tree results, of length 15 (ci = 73, ri = 84). In this tree (Fig. 4A), *apicata* + *mississippiensis* + *angusta* are the sister group to the remaining species. The latter interpretation of polarities may be slightly preferable over the others given the slightly shorter length and higher consistency and retention indices of the tree.

HOST DATA

Species of *Helianthus, Verbesina,* and *Dahlia* are the only confirmed host plants of *Gymnocarena.* All three plant genera belong to the tribe Heliantheae of the Aster-

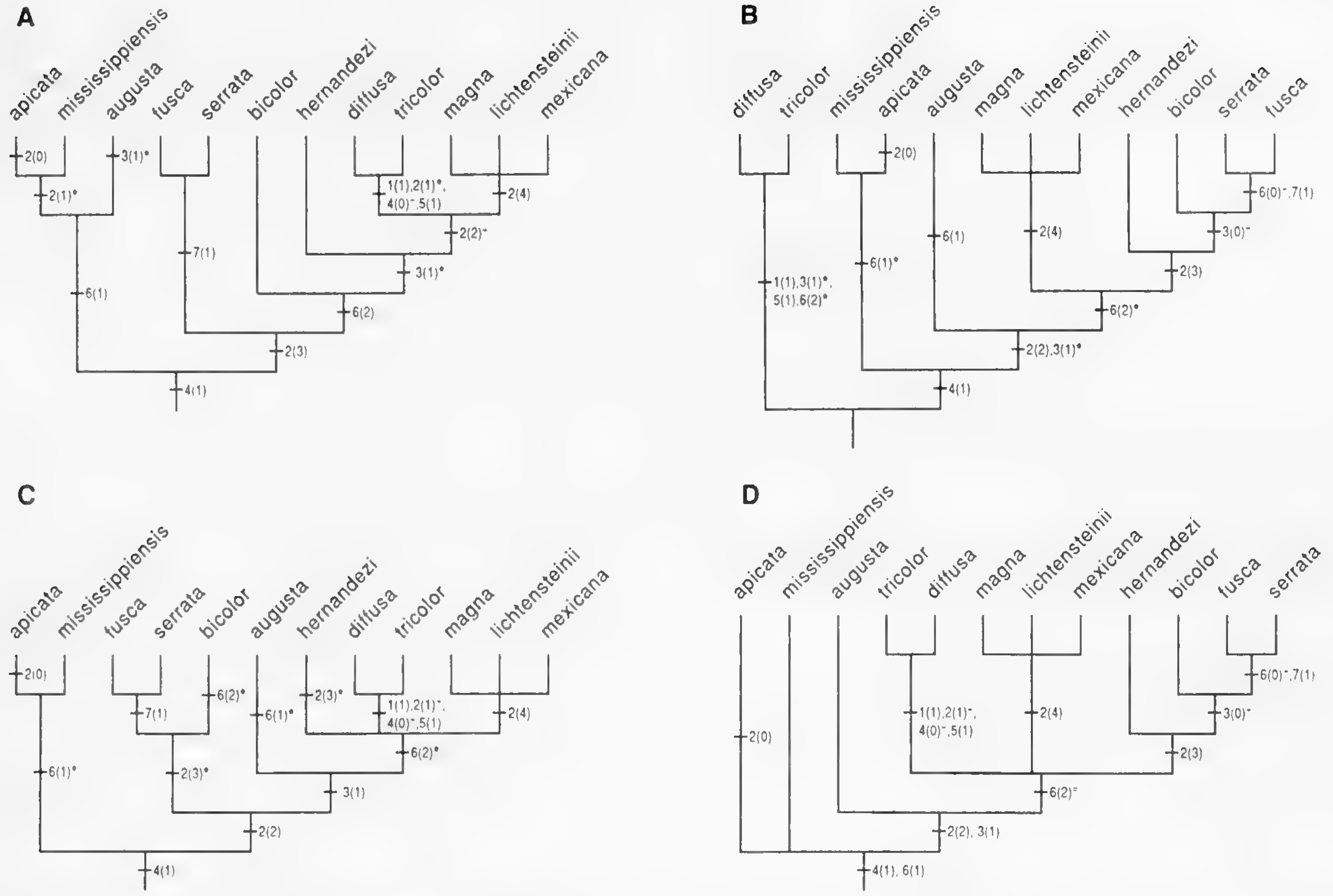
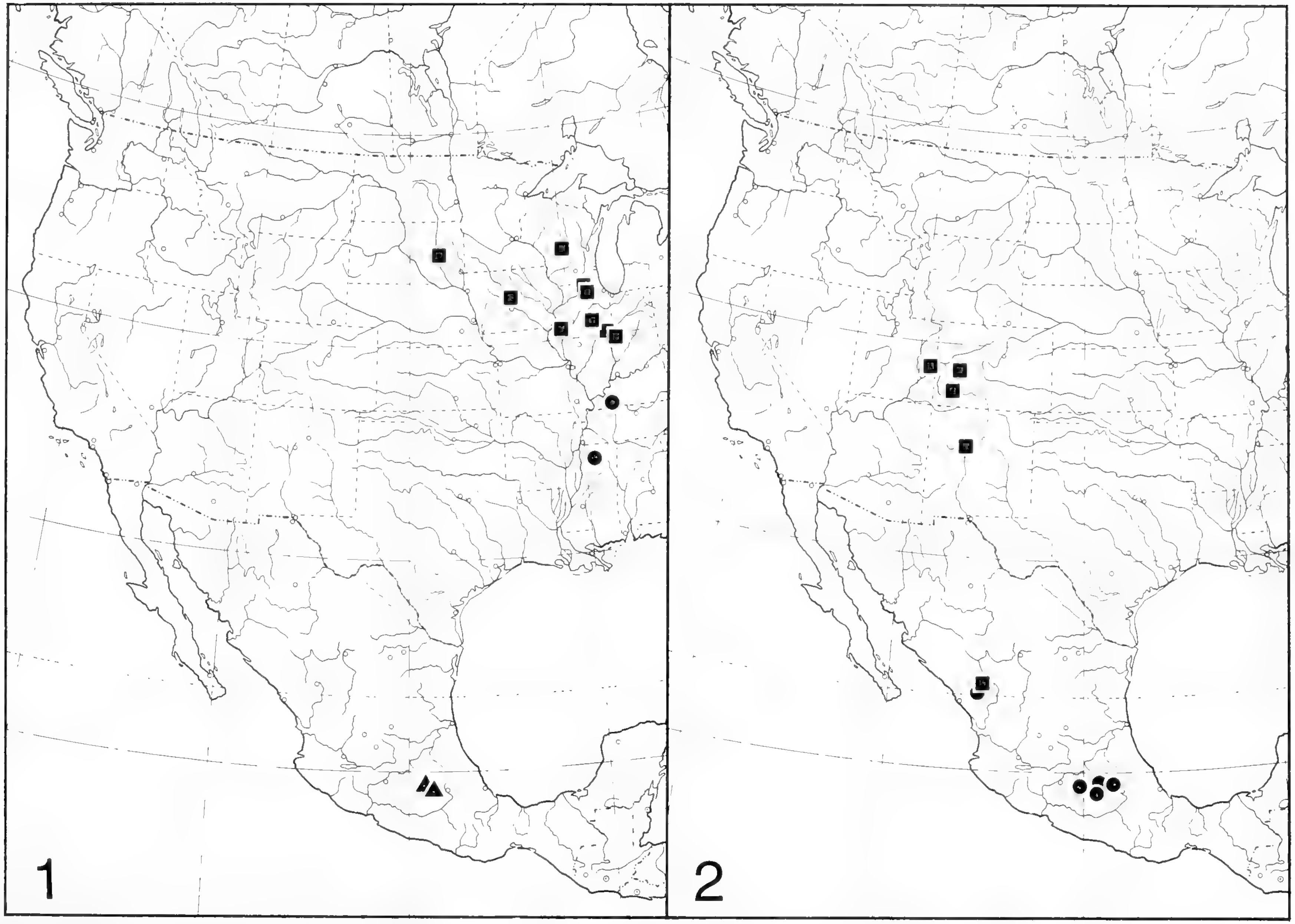


Fig. 4. Examples of hypotheses of phylogenetic relationships among the species of *Gymnocarena* if state 0 of character 5 is assigned to outgroup. A, single tree resulting if state 2 is assigned for character 2 (Table 2, outgroup C); B–D, 3 of 30 trees resulting if state 1 is assigned for character 2 (Table 2, outgroup D). Numbers and symbols are as in Fig. 1.

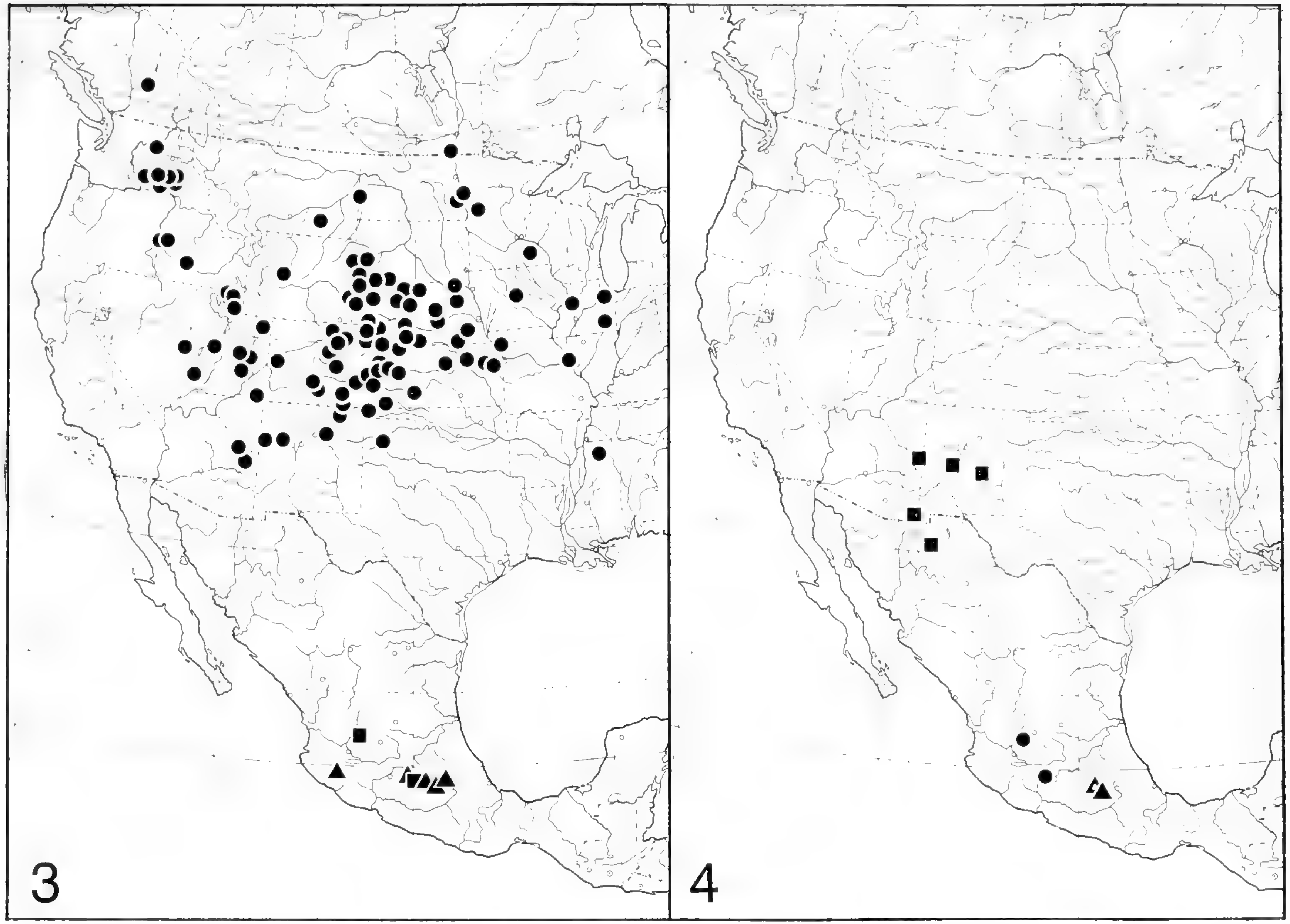
aceae, suggesting that *Gymnocarena* species may be restricted to this group. *Gymnocarena tricolor* (Doane) breeds in flower heads of *Helianthus tuberosus* and *H. grosseserratus* (W. B. Stoltzfus, pers. comm.), and *G. diffusa* has been reared from flower heads of *H. annuus* (wild and cultivated varieties), *H. maximiliani,* and *H. tuberosus.* Adults of *G. diffusa* also have been collected on *H. petiolaris,* but this plant is unconfirmed as a host. *Helianthus* species may be hosts of other *Gymnocarena* species; adults of *G. apicata* have also been collected on *H. annuus.* Other plants must be used by the *Gymnocarena* species occurring in central Mexico, however, as no *Helianthus* are known to occur there (except for *H. annuus* introduced for cultivation), and only a few extend into northern Mexico (Heiser et al. 1969). *Verbesina oncophora* is a host of *G. carinata,* and *Dahlia imperialis, D. merckii,* and possibly other *Dahlia* species are hosts of *G. mexicana* (see "Biology" under those species).

According to Kamali and Schulz (1973, 1974) females of *G. diffusa* lay their eggs between involucral bracts of unopened sunflower capitula, and the larvae feed on the spongy tissue of the receptacle. They leave the flower to pupariate in the soil and overwinter in this stage. The larvae of *G. carinata* and *G. mexicana* also leave the capitulae of their hosts to pupariate. I made only casual observations of their feeding. The larvae of *G. carinata* consumed some developing seed tissues and most of the receptacle of *V. oncophora* capitulae. There is little receptacle tissue in *Dahlia* flowers, and the larvae of *G. mexicana* seem to consume mainly developing achenes and surrounding tissues in the basal half of the capitulum.

The pest status of *G. diffusa* is unclear, because the effect on seed production of the larval receptacle feeding, although obvious-



Maps 1–2. Localities of specimens examined. 1: *angusta* Norrbom (triangles), *mississippiensis* Norrbom (circles), and *tricolor* (Doane) (squares). 2: *apicata* (Thomas) (squares) and *mexicana* (Aczél) (circles).



Maps 3–4. Localities of specimens examined. 3: *diffusa* (Snow) (circles), *magna* Norrbom (squares), and *serrata* Norrbom (triangles). 4: *bicolor* Foote (squares), *carinata* Norrbom (hollow triangle), *fusca* Norrbom (solid triangle), and *hernandezi* Norrbom (circles).

ly deleterious, has not been well studied. Kamali and Schulz (1974) reported that infestation levels in sunflower cultivars averaged 56% in 1971–72 in North Dakota, but McBride et al. (1985) considered the damage to be negligible. In eastern Colorado, however, B.C. Kondratieff (pers. comm.) found that damage (less than 50% seed development) in cultivated sunflowers averaged between 26% and 49% in 1987–89.

DISTRIBUTION

The species of *Gymnocarena* occur from the central Nearctic Region to its southern extent in central Mexico (Maps 1–4). *Gymnocarena mississippiensis* is known only from the Mississippi Valley, and *G. tricolor* from the midwestern United States. *Gymnocarena diffusa* has the broadest range, from Illinois, southern Manitoba and British Columbia to Mississippi and Arizona. Its distribution and abundance probably have been increased by human cultivation of one of its hosts, *Helianthus annuus*. The remaining nine species of *Gymnocarena* are montane. *Gymnocarena apicata* occurs in the Rockies in Utah, Colorado, and New Mexico, with another population, possibly disjunct, in the Sierra Madre Occidental in Durango, whereas *G. bicolor* is known only from the mountains of Arizona, New Mexico, and Chihuahua. *Gymnocarena hernandezi, G. magna,* and *G. mexicana* are known from the Sierra Madre Occidental and the transverse volcanic belt of central Mexico, whereas *G. angusta, G. carinata, G. fusca,* and *G. serrata* have been collected only in the latter area. The type locality of *G. lichtensteinii* is not precisely known, but it is also probably from the volcanic belt. I have examined no *Gymnocarena* adults from the Sierra Madre Oriental or the Sierra Madre del Sur, although I have seen a puparium from *Dahlia* flowers in Oaxaca that may be *G. mexicana* or another *Gymnocarena* species (see *G. mexicana,* "Biology").

The distribution of *Gymnocarena* indicates that its evolution has been recent. Its absence from California suggests that it arose after the Middle Pliocene, and its distribution in Mexico fits the pattern of nearctic groups of recent (Pliocene-Pleistocene) penetration (Halffter 1987).

Genus *Gymnocarena* Hering

Gymnocarena Hering 1940: 4 (Type species: *Oedicarena diffusa* Snow, by original designation); Foote 1960: 112 [review], 1965: 675 [catalog], 1980: 30 [review, in key]; Wasbauer 1972: 117 [hosts]; Blanc and Foote 1987: 428 [review].

Tomoplagiodes Aczél 1954: 91 (Type species: *T. mexicana* Aczél, by original designation); Foote 1967: 48 [catalog], 1980: 30 [synonymy].

Mylogymnocarena Foote 1960: 111 (Type species: *Urellia apicata* Thomas, by original designation); Foote 1965: 669 [catalog]; Blanc and Foote 1987: 430 [review]. **NEW SYNONYMY.**

Description.—Body length 4.0–7.5 mm, not including female ovipositor. Cuticle yellow to orangebrown. Setae yellow to brown, never whitish or strongly expanded. Setulae yellow to brown, acuminate. *Head:* more or less quadrate in lateral view, frons and face usually meeting at angle of 90–105°, rarely as much as 120°; lunule wider than high; frons non-setulose medially; usually 3 pairs of frontal setae, 4–5 on one or both sides occasionally in *mexicana,* rarely in other species; 2 pairs of reclinate, unicolorous orbital setae; postocular setae slender to slightly swollen; genal height 0.23–0.50 times eye height; arista (Fig. 2) bare except for minute microtrichia on swollen basal part, usually with slight but distinct subapical bend. *Thorax:* entirely microtrichose, but not densely so; anepisternal cleft (internal sulcus) distinct; scapular setae undifferentiated or varied in number and location; typical setae present, including following pairs: 1 postpronotal, 2 unicolorous notopleurals, 1 presutural and 1 postsutural supra-alar, 1 intra-alar, 1 postalar, 1 dorsocentral, 1 acrostichal, 2 anepisternal, 1 katepisternal, 1 anepimeral; dorsocentral setae usually aligned with supra-alars or slightly anterior or posterior to them, sometimes distinctly posterior in *mexicana,* but always closer to supra-alars than to postalars or transverse suture; scutellum with 2 pairs of marginal setae, apical pair subequal to basal pair. *Legs:* hind femur with 1–3 anterodorsal and 1 posterodorsal preapical setae. *Wing:* light areas with faint pattern of gray and white microtrichia, or entirely with white microtrichia; vein R_1 entirely setulose dorsally, without gap near level of apex of sc; vein R_{4+5} setulose dorsally to beyond dm-cu, ventrally with at least 1–2 setulae basal to r-m, sometimes setulose to beyond r-m; cell bcu with distinct lobe, ⅓–½ as long as width of cell; r-m well beyond middle of cell dm. *Abdomen:* preabdominal terga and sterna entirely microtrichose. *Male genitalia:* epandrium and outer surstyli (Fig. 1C, E), in posterior view, nearly oval, in lateral view, margin of surstylus usually projected as dorsal lobe (Fig. 1B, D); hypandrial apodeme broad and flattened; lateral sclerite fused to hypandrium near level of arms of aedeagal apodeme, on left side less than ⅕ as long as distance from anterior fusion point to base of hypandrium, on right side, ½ to 1 times that distance; distiphallus (Fig. 1A) with numerous spinelike or scalelike projections on membranous apical part; endophallus short, stout, slightly curved. *Female terminalia:* 2 spermathecae (Fig. 7I); apical part of spermathecal duct (2–4 times length of spermatheca) dilated.

Key to Species of *Gymnocarena*

1. Cell r_{2+3} with basal ⅔ light or with only very faint gray markings, without band between pterostigma and r-m (Fig. 5A–B) 2

– Cell r_{2+3} with basal ⅔ largely yellow or brown, or at least with broad band between pterostigma and r-m (Fig. 5C–H) 3

2. Wing (Fig. 5A) with dark markings confined to apical third except for yellowish pterostigma; crossvein dm-cu narrowly bordered with dark brown; aculeus tip (Fig. 7B) slender, sharply acute (Durango to Utah and Colorado) .... *apicata* (Thomas)

– Wing (Fig. 5B) with dark brown mark extended from pterostigma into cell r_1; veins bm-cu, Cu_2, and r-m narrowly bordered with brown, dm-cu broadly bordered with brown; aculeus tip (Fig. 8F) broader, blunt (Puebla to Durango) .... *mexicana* (Aczél)

3. Cell r_{4+5} with large basal or medial light area filling almost half or more of cell (Fig. 5C–D) 4

Cell r_{4+5} more extensively dark, with or without several smaller medial light spots (Fig. 5E–H, 6A–F) 6

4. Cell r_{4+5} with large light area extended apical to midlength of cell, at most with tiny light spots apical to this (Fig. 5C–D); aculeus tip (at least in *magna*) blunt, broad, with sides concave 5

– Cell r_{4+5} with large light area not extended to midlength of cell, with round light spot half as wide as cell apical to its midlength; aculeus tip (Fig. 7A) acute, slender, with sides evenly tapered (Distrito Federal and Morelos) (see also couplet 7) .... **angusta**, n. sp.

5. Cell m with 4 white spots within faint gray area, usually arranged in rectangle, also with white spot within apical dark brown part of cell (Fig. 5C); aedeagus more than 3.0 mm long; female syntergosternite 7, measured dorsally, 1.87–2.41 mm long, 0.70–0.75 times as long as mesonotum (Mexico to Jalisco) ... . **magna**, n. sp.

– Cell m with 3 white spots within faint gray area, arranged in triangle, apical dark brown part of cell without white spot (Fig. 5D); aedeagus less than 3.0 mm long; female unknown, but syntergosternite 7 probably shorter (Mexico) .... *lichtensteinii* (Wiedemann)

6. Cell r_1, apical to pterostigma, with 2 light areas (Fig. 5F–H) or with 1 area with medial brown spot within it (Fig. 5E) 7

– Cell r_1, apical to pterostigma, entirely dark or with 1 uninterrupted light area (Fig. 6) 10

7. Wing pattern (Fig. 5E) entirely brown; medial brown spot in cell r_1 small, not extended to vein R_{2+3}; cell dm with basal half light; aculeus tip (Fig. 7A) slender, sharply acute (Distrito Federal and Morelos) (see also couplet 4) .. .. **angusta**, n. sp.

– Wing pattern (Fig. 5F–H) yellow and brown or entirely yellow; brown or yellow mark in cell r_1 extended to vein R_{2+3}; cell dm with at

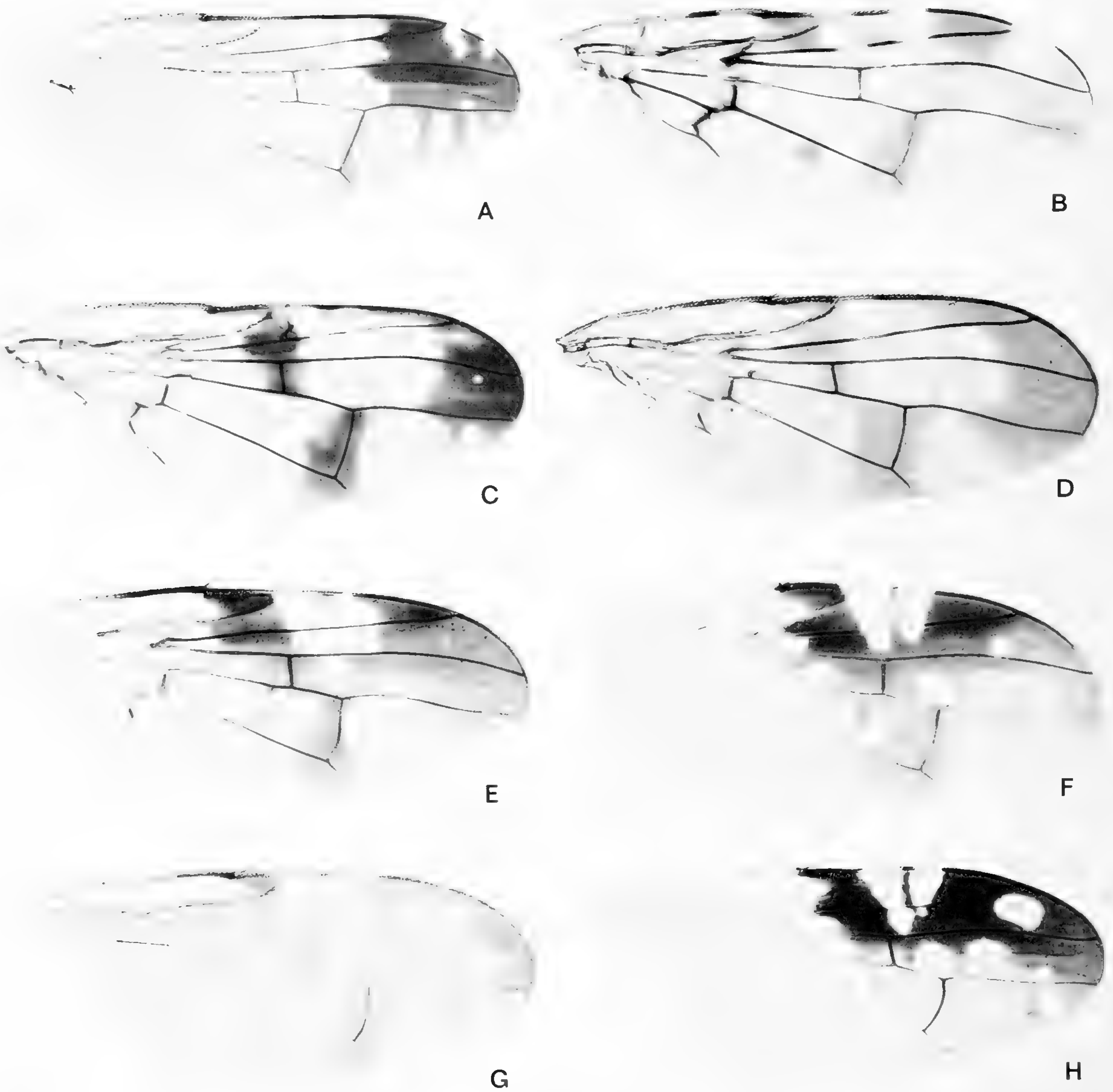


Fig. 5. Wings: A, *apicata* (Thomas), Durango: Tepalcates; B, *mexicana* (Aczél), Morelos: Lagunas de Zempoala; C, *magna* Norrbom, paratype, Jalisco: El Aguacate; D, *lichtensteinii* (Wiedemann), lectotype; E, *angusta* Norrbom, paratype; F, *mississippiensis* Norrbom, holotype; G, *diffusa* (Snow), Iowa: Little Wall Lake; H, *tricolor* (Doane), Iowa: Ames (*flava* paratype).

least basal one-sixth yellow; aculeus tip variable 8

8. Wing (Fig. 5G) with uninterrupted light band in cells r_{2+3}, br, and dm posterior to pterostigma, and with nearly complete light band between r-m and dm-cu, narrowly interrupted along vein M and sometimes along veins R_{2+3} and R_{4+5}; aculeus tip (Fig. 8A) blunt, sides strongly concave, 8th sternites easily visible in dorsal view (eastern Washington to Manitoba and Illinois, south to New Mexico and Arizona .... *diffusa* (Snow)

– Wing (Fig. 5F, H) with isolated light spots in cells r_{2+3}, br, and dm posterior to pterostigma; light spots between r-m and dm-cu broadly separated at least along vein R_{4+5} and in cell dm; aculeus tip variable, but sides less concave and 8th sternites not or only slightly visible in dorsal view 9

9. Basal marginal light spot in cells r_1 and r_{2+3} with apex more or less even with r-m (Fig. 5F); r-m and dm-cu entirely bordered on both sides by dark brown; apical light spot in cell m extended well into cell r_{4+5}; genal height

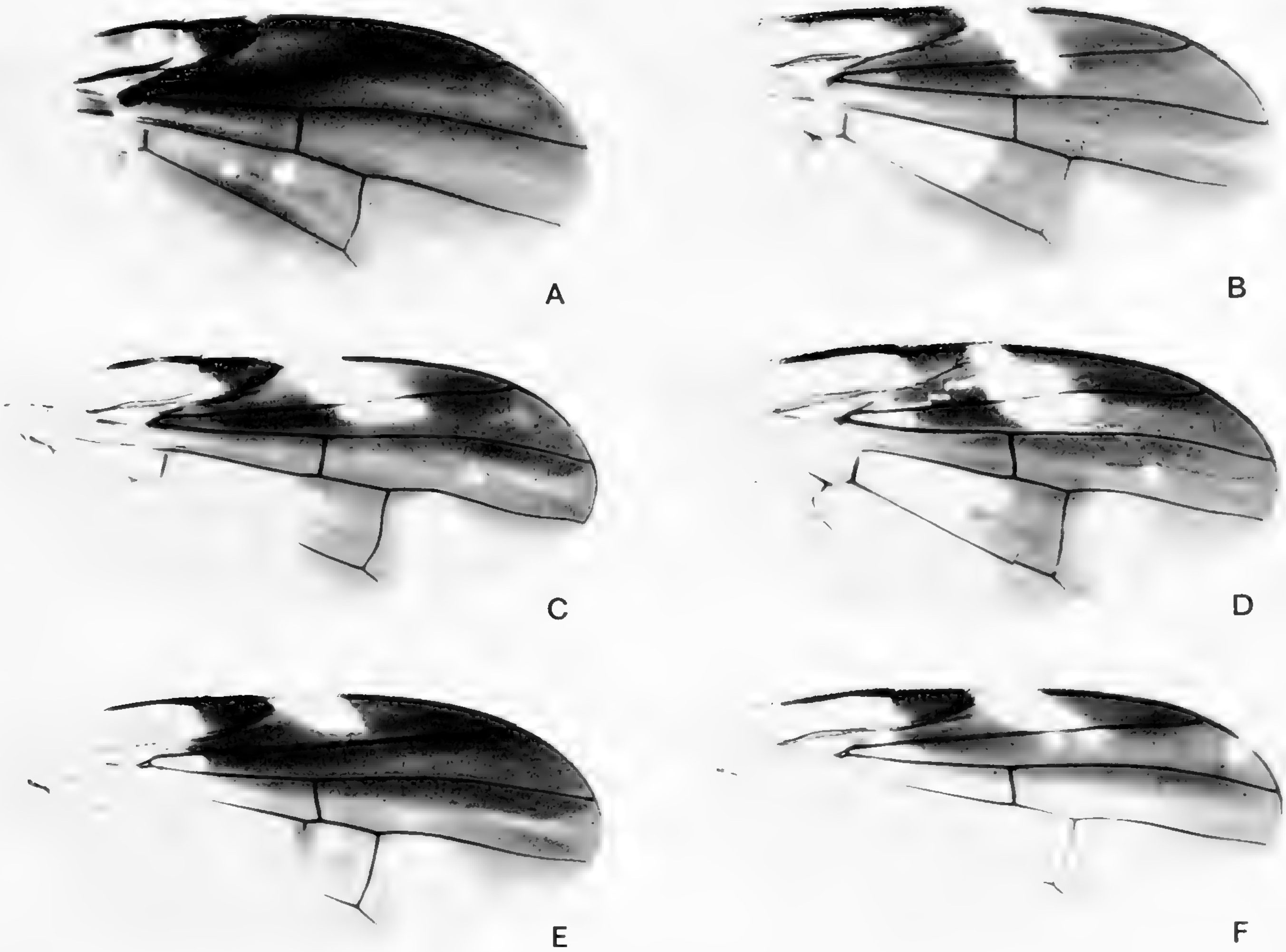


Fig. 6. Wings: A, *fusca* Norrbom, paratype; B, *bicolor* Foote, Chihuahua: Colonia Juarez; C, *hernandezi* Norrbom, paratype; D, sp. near *hernandezi,* Sinaloa: Potrerillos; E, *serrata* Norrbom, paratype, Morelos: Carretera Xochimilco-Oaxtepec; F same, paratype, Jalisco: Nevado de Colima.

less than 0.35 times eye height; scutellum usually with tiny dark spots; aculeus tip (Fig. 7C) acute, sides evenly tapered (Mississippi and Kentucky) .... **mississippiensis**, n. sp.

– Basal marginal light spot in cells r_1 and r_{2+3} with apex apical to r-m (Fig. 5H); posterior half of r-m and all of dm-cu bordered on both sides by yellow; light spot in cell m not extended into cell r_{4+5}, although r_{4+5} sometimes with small spot opposite it; scutellum without tiny dark spots; genal height at least 0.35 times eye height; aculeus tip (Fig. 8B) blunt, sides concave (South Dakota to Wisconsin and Indiana) .... *tricolor* (Doane)

10. Cell r_1 with large marginal light spot (Fig. 6B–F); cells r_{2+3} and r_{4+5} often with small light spots; cell m with large basal marginal light spot extended to or almost to vein M; aculeus tip variable, but not sagittate 11

– Cells r_1, r_{2+3}, and r_{4+5} entirely dark brown (Fig. 6A); cell m with 3 small marginal light spots, none extended more than halfway to vein M; aculeus tip (Fig. 7F) sagittate, weakly serrate (Morelos) .... **fusca**, n. sp.

11. Cell m with one large light spot with even margins, narrowly separated from vein M (Fig. 6B); vein Cu_1 bordered with brown in cell cu_1 along its entire length; cell r_{4+5} entirely brown; female syntergosternite 7 0.53 times as long as mesonotum; aculeus tip (Fig. 8C) blunt (Chihuahua, Arizona, New Mexico) .... *bicolor* Foote

– Cell m with one to several light spots, one of which touches vein M (Fig. 6C–F); vein Cu_1 bordered by light area in cell cu_1 along most of its length; cell r_{4+5} usually with 1–2 small light spots; female syntergosternite 7 more than 0.70 times as long as mesonotum or aculeus tip acute 12

12. Cell br entirely dark apical to bm-cu (Fig. 6C–D); cell r_{4+5} without basal light spot, but with medial light spot; base of cell r_{2+3} light or dark; aculeus tip, at least in *hernandezi* (Fig. 8D), nonserate, with extreme apex broad and blunt; female syntergosternite sometimes more than 2.00 mm long, 0.75 times length of mesonotum 13

– Cell br at least partially light apical to bm-cu

(Fig. 6E–F); cell r_{4+5} entirely dark, with only basal light spot, or with both basal and medial light spots; aculeus tip finely serrate, extreme apex slender; female syntergosternite 7 1.04–1.16 mm long, 0.40–0.57 times as long as mesonotum 14

13. Base of cell r_{2+3} entirely dark (Fig. 6C); aedeagus more than 3.0 mm long, more than 1.0 times as long as mesonotum; female syntergosternite 7 2.08 mm long, 0.75 times as long as mesonotum; aculeus tip (Fig. 8D) blunt (Michoacan and Jalisco) . . . . . **hernandezi**, n. sp.

– Base of cell r_{2+3} light (Fig. 6D); aedeagus less than 3.0 mm long, less than 1.0 times as long as mesonotum; female unknown, but syntergosternite 7 probably shorter; (Sinaloa) . . . . sp. near *hernandezi*

14. Base of cell r_{2+3} with light spot (Fig. 6E–F); aculeus tip (Fig. 7D–E) dorsally without medial ridge; 8th sternites nonserrate apicolaterally (Puebla to Jalisco) . . . . **serrata**, n. sp.

– Base of cell r_{2+3} entirely dark; aculeus tip (Fig. 7G–H) dorsally with medial ridge; 8th sternites serrate apicolaterally (Distrito Federal) . . . . **carinata**, n. sp.

Gymnocarena angusta **Norrbom, New Species**

Figs. 5E, 7A, Map 1

Holotype: ♀ (USNM), MEXICO: MORELOS: Km. 49.5 Rt. 142 (Xochimilco-Oaxtepec), 5 km. N El Vigia, 30.IX.1991, A. L. Norrbom.

Paratype: ♀ (UNAM), MEXICO: DISTRITO FEDERAL: Pedregal de San Angel, 20.VII.1968, C. Beutelspacher.

Diagnosis.—The wing pattern is intermediate between *G. magna* and *G. lichtensteinii,* which have a larger, more apically extended light area in the radial cells, and *G. hernandezi* and *G. serrata,* in which this light area is smaller and without a medial dark spot in cell r_1. The slender, non-serrate aculeus tip readily distinguishes *G. angusta* from all of these species.

Description.—Setae yellowish to light brown, those on frons darkest. Setulae yellowish except on abdomen. *Head:* genal height 0.34–0.35 times eye height; facial carina moderately to well developed, ventral expanded part medium sized, its height ⅓ that of face, in lateral view, margin of ventral part straight and more or less parallel with margin of facial ridge or concave and projected anteriorly. *Thorax:* with small dark spots (faint in paratype), at least on scutellum; mesonotum 2.12–2.70 mm long; dorsocentral setae aligned with supra-alar setae. *Legs:* femora not unusually stout. *Wing* (Fig. 5E): with dark brown mark from pterostigma to r-m, another covering dm-cu, and a third broad apical dark area, these narrowly connected or narrowly separated in cell r_{4+5}; largely light basal to these dark marks, with numerous white spots within gray areas (poorly differentiated in paratype); cell r_1 with broad light mark with irregular margin, extended into r_{2+3} or r_{4+5}, small brown spot within it along Costa; cell m with broad irregular light mark with 4–5 white spots and large faint medial brown spot within it; cell r_{4+5} with small light spot near its middle, largely light basally or mostly dark with large light spot anterior to dm-cu; cell r_{2+3} with small basal light area, apex entirely dark or with light spot at apex of R_{2+3}; cell br with light spot posterior to pterostigma; cell dm mostly light, except apex and narrow medial brown spot. *Abdomen:* setulae on syntergum 1+2 yellowish except posteriorly; setulae on terga 3–5 brown. *Female terminalia:* syntergosternite 7 1.01–1.08 mm long, 0.40–0.48 times as long as mesonotum; aculeus 0.84–0.95 mm long, tip (Fig. 7A) slender, sides nonserrate, nearly straight, evenly tapered to slender, acute extreme apex; 8th sternites with apices normally not visible in dorsal view, lateral margins evenly rounded; spermathecae relatively large.

Remarks.—The wing pattern of the paratype is more extensively dark than that of the holotype, but considering their very similar aculei and the range of wing variation in other species (e.g. *G. serrata*), a hypothesis that they are conspecific seems reasonable.

Distribution.—(Map 1). Known only from the Distrito Federal and Morelos.

Etymology.—The epithet is a Latin adjective meaning narrow, in reference to the slender aculeus.

Gymnocarena apicata (Thomas), NEW COMBINATION

Figs. 5A, 7B, Map 2

Urellia apicata Thomas 1914: 428 (Holotype ♀ (MCZ), USA: COLORADO; [with labels with "Colo. 2277," "Urellia apicata n. sp.," "Holotype no.," and "Type 7731"]).

Mylogymnocarena apicata: Foote 1960: 111 [taxonomy], 1965: 669 [catalog]; Wasbauer 1972: 118 [host catalog]; Dodson 1987: 614 [New Mexico]; Blanc and Foote 1987: 431 [review].

Diagnosis.—The highly reduced wing pattern, without dark markings basal to crossvein dm-cu, readily distinguishes this species. Only *G. angusta* and *G. mississippiensis* have a similarly slender aculeus.

Description.—Setae yellowish to light brown, those on frons typically darkest. Setulae yellowish except on abdomen and sometimes on scutellum. *Head:* genal height 0.37–0.41 times eye height; facial carina weakly to moderately developed, ventral part small or not expanded, in lateral view, margin of ventral part concave or projected anteriorly. *Thorax:* with or without small dark spots (present in 3 of 8 specimens, including type, but strong only in Durango male); mesonotum 2.41–2.62 mm long; dorsocentral setae aligned with supra-alar setae. *Legs:* femora not unusually stout. *Wing* (Fig. 5A): with dark brown apical spot, hyaline or faint gray basal to dm-cu, except pterostigma often yellowish or light brown; cell r_1 with apical ¼–⅓ dark brown, often with tiny circular subapical white spot basal to dark area; cell r_{2+3} with oval white spot basal to dark area and with 2 marginal white spots; cell r_{4+5} with basal ⅓ gray, with white spot basal to dark area, dark area with 1–2 tiny white spots within it; cell m with apex, 2 medial rays, and narrow ray over dm-cu and apex of vein Cu_1 dark brown, basal area mostly grayish with oval white spot bordering dark brown mark anteriorly, apical 2–3 light areas white. *Abdomen:* setulae on syntergum 1+2 yellowish except posteriorly; setulae on terga 3–5 brown. *Male terminalia:* outer surstylus without dorsal lobe; aedeagus 2.16 mm long, 0.82 times as long as mesonotum. *Female terminalia:* syntergosternite 7 1.08–1.16 mm long, 0.45–0.46 times as long as mesonotum; aculeus 0.92 mm long, tip (Fig. 7B) slender, sides nonserrate, nearly straight, evenly tapered to slender, acute extreme apex; 8th sternites normally not visible in dorsal view, lateral margins evenly rounded.

Remarks.—The holotype is the only specimen I examined with more than 3 pairs of frontal setae.

Biology.—This species has not been reared. Dodson (1987) collected adults on flowers of *Helianthus annuus.*

Distribution.—(Map 2). Utah and Colorado to Durango.

Specimens examined.—Holotype (see synonymy). MEXICO: DURANGO: Tepalcates, 30 mi W Durango, 8400 ft, 4–8.VIII.1972, J. Powell, D. Veirs & C.D. MacNeill, 1 ♂ (UCB). USA: COLORADO: San Juan Co.: S of Silverton, Molas-Elk Cr. Trails, 26–29.VII.1985, J. Jenkins, 1 ♀ (USNM); Gunnison Co.: Gothic, 9500 ft, 7.VIII.1972, C.L. Remington, 1 ♀ (MCZ). NEW MEXICO: Bernalillo Co.: VIII–IX.1981, G. Dodson, 2 ♀ (USNM). UTAH: Grand Co.: La Sal Mts., Warner Lake Campground, 10.VIII.1987, J. Jenkins, 1 ♀ (JJPC); San Juan Co.: La Sal Mts., nr. Warner Campground, 5–6.VIII.1985, J. Jenkins, 1 ♀ (USNM).

Gymnocarena bicolor Foote

Figs. 6B, 8C, Map 4

Gymnocarena bicolor Foote 1960: 113 (Holotype ♂ (USNM), USA: ARIZONA: Chiricahua Mountains, Indian Creek Canyon, 6100 ft); Foote 1965: 676 [catalog]; Wasbauer 1972: 117 [host catalog].

Mylogymnocarena bicolor: Blanc and Foote 1987: 431 [review].

Diagnosis.—*G. bicolor* is similar in wing pattern to *G. hernandezi* and *G. serrata,* which differ as indicated in the key. These

3 species are also distinguished by the shape of the aculeus tip, which in *G. bicolor* more closely resembles *G. tricolor* and *G. magna.*

Description.—Setae yellowish to brown, those on frons typically darkest. Setulae yellowish except on abdomen and sometimes on scutellum. *Head:* genal height 0.25–0.32 times eye height; facial carina weakly to moderately developed, ventral part small or not expanded, in lateral view, margin of ventral part concave or projected anteriorly. *Thorax:* usually with small dark spots, at least on scutellum (weak in N.M. ♂); mesonotum 1.87–2.25 mm long; dorsocentral setae slightly anterior to or aligned with supra-alar setae. *Legs:* femora not unusually stout. *Wing* (Fig. 6B): pattern mostly dark brown, faded in basal and anal cells and cell cu$_1$; largely infuscated apical to r-m; cell r$_1$ with 1 evenly margined, narrow white mark extended into cell r$_{2+3}$ apical to r-m; cell m with large white mark with well defined margin, sometimes with small brown marginal spot within it; cell r$_{2+3}$ without basal light area; cell br without light spot posterior to pterostigma; cell dm with large medial white spot, basal ⅓–⅕ faint gray or brown; cell cu$_1$ with small white spot near middle of vein Cu$_2$+A$_1$, larger medial marginal white spot. *Abdomen:* setulae on syntergum 1+2 yellowish except posteriorly; setulae on terga 3–5 brown. *Male terminalia:* outer surstylus with small dorsal lobe; aedeagus 1.74–2.20 mm long, 0.93–0.98 times as long as mesonotum. *Female terminalia:* syntergosternite 7 1.08 mm long, 0.53 times as long as mesonotum; aculeus 0.79 mm long, tip (Fig. 8C) with sides nonserrate, moderately concave, slightly more constricted near apices of 8th sternites than in *tricolor,* extreme apex broad and blunt but tapered more rapidly than in *hernandezi*; 8th sternites with apices usually slightly exposed in dorsal view, lateral margins evenly rounded.

Distribution.—(Map 4). Chihuahua to Arizona and New Mexico.

Specimens examined.—Holotype (see synonymy). MEXICO: CHIHUAHUA: Colonia Juarez, 5000 ft, 24.VIII.1979, G.S. Forbes, 1 ♂ (USNM). USA: ARIZONA: Apache Co.: St. Johns, 17.VIII.1935, I.J. Cantral, 1 ♀ (UMMZ). NEW MEXICO: Lincoln Co.: Lincoln, 24.VIII.1990, M.R. Perry, 1 ♂ (USNM). Socorro Co.: Magdalena Mts., 19.VIII.1951, E.L. Kessel, 1 ♂ (CAS).

***Gymnocarena carinata* Norrbom, NEW SPECIES**

Fig. 7G–H, Map 4

Holotype: ♀ (USNM), MEXICO: DISTRITO FEDERAL: La Cima, reared ex. flowers of *Verbesina oncophora* (91M21) coll. 26.IX.1991, emerged I.1992, A. L. Norrbom.

Paratype: 1 ♂ (USNM), same data as holotype.

Diagnosis.—*G. carinata* is similar in wing pattern to *G. serrata, G. hernandezi,* and *G. bicolor,* which differ as indicated in the key. The aculeus tip differs from all *Gymnocarena* species in having a strong dorsal ridge, and from all species except *G. serrata* and *G. fusca* in having fine serrations. The serrations on the 8th sternites also distinguish it from all other species.

Description.—Setae yellowish brown. Setulae yellowish except on abdomen and scutellum and posteriorly on scutum. *Head:* genal height 0.26 times eye height; facial carina weakly developed, ventral part small, in lateral view, margin of ventral part concave and projected anteriorly. *Thorax:* with small dark spots on scutellum; mesonotum 2.12–2.18 mm long; dorsocentral setae aligned with supra-alar setae. *Legs:* femora not unusually stout. *Wing:* pattern dark brown anteriorly, posterior half mostly grayish or yellowish; cell r$_1$ with narrow white mark with distinct margin, without medial gray mark, and not extended into r$_{2+3}$; cell r$_{2+3}$ with small white spot near apex of r$_1$ spot and with small subapical white spot, entirely dark basally; cell m with 3 white spots, grayish anterobasally; cell r$_{4+5}$ with posterior half of basal two-thirds grayish, with small white spot anterior to dm-cu and another near middle; cell br mostly grayish, with or without small white spot posterior to pterostigma; cell dm with 3–4 white spots, greyish except apically. *Abdomen:* setulae on syntergum 1+2 yellowish except posteriorly; setulae on terga 3–5 brown. *Male terminalia:* not dissected. *Female terminalia:* syntergosternite 7 1.04 mm long, 0.48 times as long as mesonotum; aculeus 0.85 mm long, tip dorsally with medial ridge, best seen in lateral view (Fig. 7H), in ventral view (Fig. 7G), distinctly constricted just basal to apices of 8th sternites, beyond constriction gradually tapered, sides slightly concave, serrate almost to extreme apex; 8th sternites with apices well exposed in dorsal view, apicolateral margins serrate.

Remarks.—The type specimens are slightly teneral; their wings are not entirely unfolded and the pattern is perhaps not fully developed. The paratype is partially covered with fungus.

Biology.—I collected flowers of *Verbesina oncophora* B.L. Robins. and Greenm. at only one site. More than 30 larvae emerged and pupariated and were placed in moist vermiculite, but only the two type specimens emerged as adults. The puparia are stouter than those of *G. mexicana* and *G. diffusa.* Their surface is more wrinkled than in *G. diffusa,* but less than in *G. mexicana.*

Distribution.—(Map 4). Known only from the type locality in the Distrito Federal near the Morelos border.

Etymology.—The epithet is a Latin adjective meaning keeled, in reference to the dorsal ridge on the aculeus tip.

Gymnocarena diffusa (Snow)
Figs. 1A–C, 5G, 7I, 8A, Map 3

Oedicarena diffusa Snow 1894: 161 (Lectotype (designated by Foote 1962: 174) ♀ (UKaL), USA: KANSAS, Snow); Doane 1899: 179 [taxonomy]; Snow 1903: 219 [list]; Curran 1934: 290 [head]; Knowlton and Harmston 1937: 145 [Utah]; Byers et al. 1962: 180 [type data]; MacNay 1952a: 128 [Manitoba], 1952b: 197 [host], 1952c: 315, 1954: 361, 1956: 313; Bird and Mitchener 1954: 129 [Manitoba]; Bird and Robinson 1956: 46; Bird et al. 1959: 50; Beirne 1971: 60 [Manitoba].

Straussia diffusa: Coquillett 1899: 261 [taxonomy]; Essig 1926: 602 [distribution].

Strauzia diffusia: Cresson 1907: 100 [New Mexico]. [misspelling].

Spilographa diffusa: Aldrich 1905: 604 [catalog]; Washburn 1905: 118 [Minnesota].

Gymnocarena diffusa: Hering 1940: 4; Foote 1960: 113 [taxonomy, distribution], 1965: 676 [catalog]; Lipp and Schulz 1970: 27 [host, pest status]; Kamali and Schulz 1971: 85 [artificial diet], 1973: 288 [immature stages; North Dakota], 1974: 695 [biology]; Wasbauer 1972: 117 [hosts]; Hilgendorf and Goeden 1981: 105 [host]; Lisowski 1985: 105 [taxonomy; Illinois]; McBride et al. 1985: 9 [pest status]; Blanc and Foote 1987: 429 [review]; Charlet et al. 1989: 5 [host].

Diagnosis.—The wing pattern of *G. diffusa* is distinctive in that both the light and dark areas are long bands, rather than spots. Only *G. tricolor* also has stout femora and all abdominal setulae yellow.

Description.—Setae and setulae yellowish. *Head:* genal height 0.40–0.50 times eye height; facial carina moderately to well developed, ventral expanded part large, its height approximately ½ that of face, in lateral view, margin of ventral part straight to convex, more or less parallel with margin of facial ridge. *Thorax:* without small dark spots; scutal microtrichia slightly more dense than in other species, producing light gray appearance; mesonotum 2.66–3.49 mm long; dorsocentral setae more or less aligned with supra-alar setae. *Legs:* femora stout. *Wing* (Fig. 5G): pattern yellow to light brown, with numerous white bands, including uninterrupted one through cells r_{2+3}, br, and dm posterior to pterostigma, and subapical one across cells r_{4+5} and m, often fused with spot in cell r_{2+3}; cell r_1 with 2 white

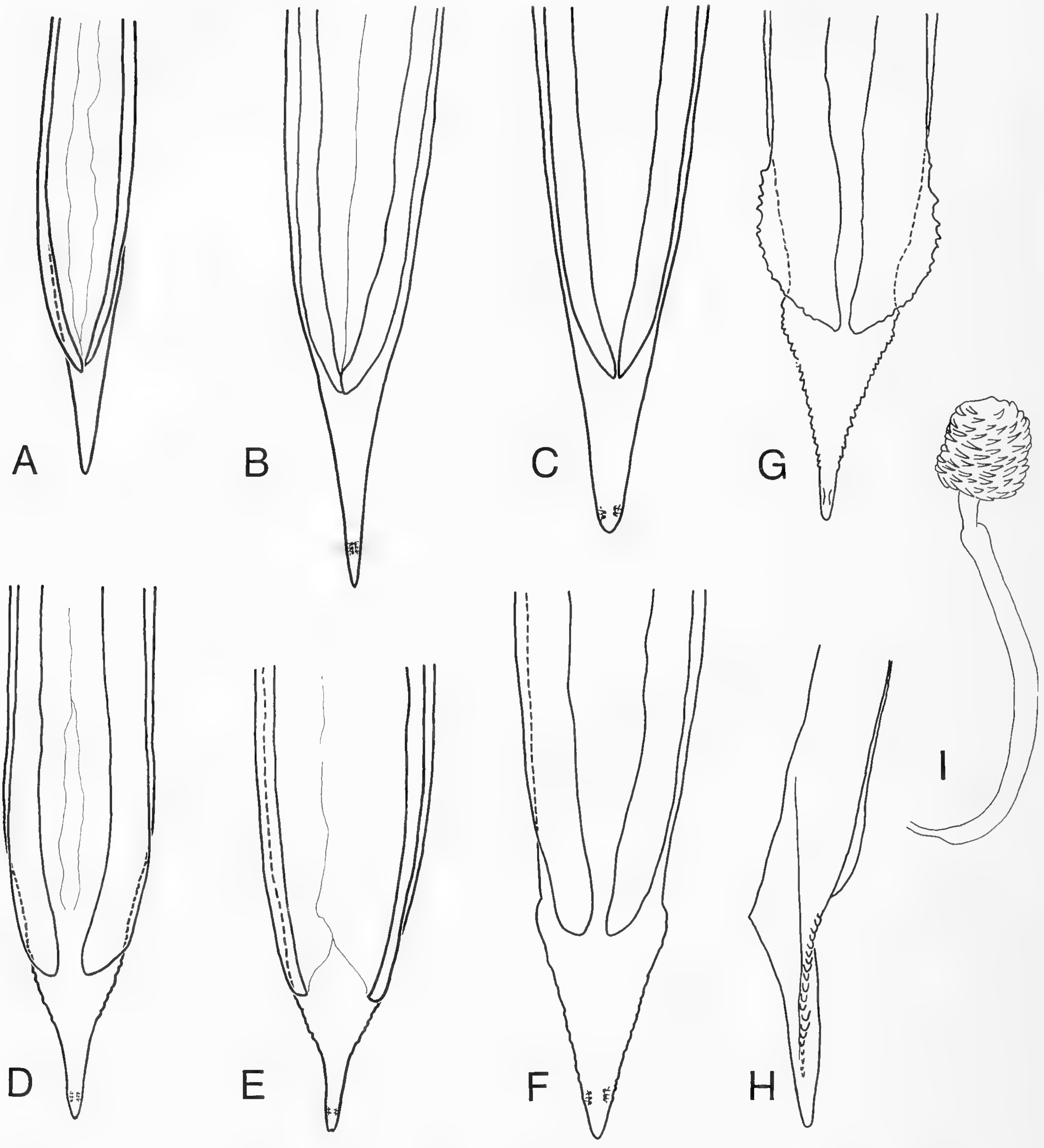


Fig. 7. Female terminalia: A, *angusta* Norrbom; B, *apicata* (Thomas); C, *mississippiensis* Norrbom; D–E, *serrata* Norrbom; F, *fusca* Norrbom; G–H, *carinata* Norrbom; I, *diffusa* (Snow); A–G, aculeus tip, ventral view; H, same, lateral view; I, spermatheca and apex of spermathecal duct.

marks, basal one extended into cell r_{2+3} basal to or even with r-m, apical one usually extended to vein M, occasionally narrowly interrupted along vein R_{2+3} or R_{4+5}; cell r_{2+3} with extreme base yellow. *Abdomen:* setulae on all terga yellowish. *Male terminalia:* outer surstylus with large dorsal lobe (Fig. 1B–C); aedeagus 3.62–3.95 mm long, 1.19–1.36 times as long as mesonotum. *Female terminalia:* syntergosternite 7 1.75–1.87 mm long, 0.52–0.61 times as long as mesonotum; aculeus 1.53–1.60 mm long, tip (Fig. 8A) with sides nonserrate, strongly concave, extreme apex broad and blunt; 8th sternites

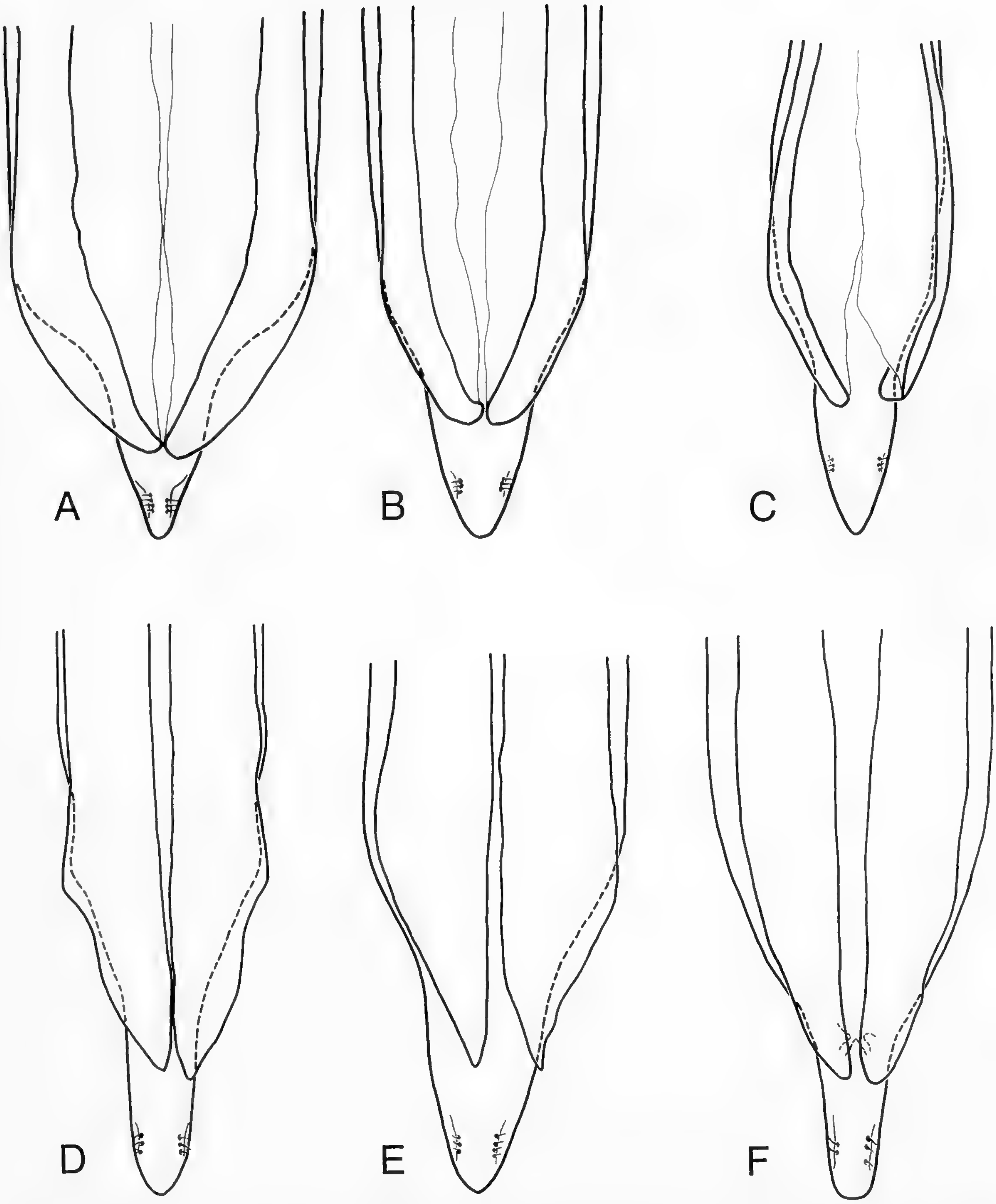


Fig. 8. Aculeus tip, ventral view: A, *diffusa* (Snow); B, *tricolor* (Doane); C, *bicolor* Foote; D, *hernandezi* Norrbom; E, *magna* Norrbom; F, *mexicana* (Aczél).

with apices broadly exposed in dorsal view, lateral margins evenly rounded.

Biology.—The known hosts are *Helianthus annuus* L., *H. maximiliani* Schrad. (MacNay 1952b, Kamali and Schulz 1973), and *H. tuberosus* L. (W. B. Stoltzfus, pers. comm.), although examined specimens were also collected on *H. petiolaris* Nutt. Kamali and Schulz (1973, 1974) thoroughly described the immature stages, life cycle, and biology of this species (see "Host data" section).

Distribution.—(Map 3). British Columbia, Manitoba and Illinois, south to Mississippi and Arizona. Not reported from California or the Pacific coast. Dots on map 4 are based on examined specimens except for several localities reported by Kamali and Schulz (1974): Fargo, Hunter, and Casselton, Cass Co., N. Dakota, and Hendrum, Norman Co., Minnesota.

Specimens examined.—A complete list of specimens examined is available from the author. Specimens were seen from the localities indicated on Map 4 in the following states and provinces: CANADA: British Columbia, Manitoba; USA: Arizona, Colorado, Idaho, Illinois, Iowa, Kansas, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Mexico, Nevada, Oklahoma, South Dakota, Texas, Utah, Washington, and Wyoming (ANSP, CAS, CDA, CNC, CSUFC, FLBPC, FMNH, FSCA, INSH, KSU, MSUEL, TAMU, UAE, UAT, UKaL, UNL, USNM, USU, WSU).

Gymnocarena fusca **Norrbom,** **New Species**

Figs. 6A, 7F, Map 4

Holotype: ♀ (USU), MEXICO: MORELOS: 6 mi E Cuernavaca, 1.IX.1974, G. Bohart & W. Hanson.

Paratype: same as holotype, 1 ♀ (USNM).

Diagnosis.—The entirely dark radial cells, particularly cell r_1, and the distinctively shaped aculeus tip distinguish *G. fusca* from all other *Gymnocarena* species.

Description.—Setae yellowish to brown, those on frons typically darkest. Setulae yellowish except on abdomen and scutellum. *Head:* genal height 0.23–0.25 times eye height; facial carina weakly to moderately developed, ventral part small or not expanded, in lateral view, margin of ventral part concave or projected anteriorly. *Thorax:* with small dark spots, at least on scutellum; mesonotum 2.58–2.70 mm long; dorsocentral setae slightly anterior to or aligned with supra-alar setae. *Legs:* femora not unusually stout. *Wing* (Fig. 6A): almost entirely dark brown, faded in basal and anal cells; cell c with 2 whitish spots separated by medial brown band; radial cells entirely brown; cell m with 3 marginal white spots; cell cu_1 with 2 marginal white spots; cell dm with 1–2 small medial white spots. *Abdomen:* setulae on syntergum 1+2 yellowish except posteriorly; setulae on terga 3–5 brown. *Female terminalia:* syntergosternite 7 0.91–1.12 mm long, 0.35–0.41 times as long as mesonotum; aculeus 1.00 mm long, tip (Fig. 7F) sagittate, constricted just basal to apices of 8th sternites, beyond constriction sides weakly serrate, nearly straight and evenly tapered to acute extreme apex; 8th sternites with apices normally not visible in dorsal view, lateral margins evenly rounded.

Distribution.—(Map 4). Known only from the type locality in Morelos.

Etymology.—The epithet is a Latin adjective meaning dark, in reference to the mostly brown wing.

Gymnocarena hernandezi **Norrbom,** **New Species**

Figs. 6C, 8D, Map 4

Mylogymnocarena sp.: Blanc and Foote 1987: 431.

Holotype: ♀ (UKaL), MEXICO: MICHOACAN: 5.3 mi SE Quiroga, 9.VIII.1963, G.W. Byers.

Paratype: MEXICO: JALISCO: El Aguacate, 14.7 mi SW Yahualica, 7700 ft, 12.IX.1986, D.K. Faulkner, 1 ♂ (SDNHM).

Diagnosis.—The wing pattern of *G. hernandezi* is similar to *G. bicolor, G. serrata,* and a probably undescribed species (see "Remarks"), which differ as indicated in the key. The shape of the aculeus tip is distinctive; it is broad, but not subapically constricted.

Description.—Setae yellowish to light brown, those on frons typically darkest. Setulae yellowish except on abdomen and sometimes on scutellum. *Head:* genal height 0.25–0.27 times eye height; facial carina moderately to well developed, ventral part small or not expanded, in lateral view, margin of ventral part concave or projected anteriorly. *Thorax:* with small dark spots, at least on scutellum; mesonotum 2.78–2.87 mm long; dorsocentral setae slightly anterior to or aligned with supra-alar setae. *Legs:* femora not unusually stout. *Wing* (Fig. 6C): pattern mostly dark brown, faded in basal and anal cells and cell cu_1 to faint gray; largely infuscated apical to r-m; r_1 with broad whitish area extended into cell r_{2+3} apical to r-m, with faint brownish medial spot; cell r_{4+5} with small whitish spot near its middle; cell m with large faint gray medial area with 3–4 white spots at its corners, apical dark brown part of cell with 1 white spot; cell r_{2+3} without small basal light area; cell br without light spot posterior to pterostigma; cell dm with basal third faint gray, medially with 3–4 white spots; cells a_1 and cu_1 with several white spots within grayish area. *Abdomen:* setulae on syntergum 1+2 yellowish except posteriorly; setulae on terga 3–5 brown. *Male terminalia:* outer surstylus with small dorsal lobe; aedeagus 3.33 mm long, 1.16 times as long as mesonotum. *Female terminalia:* syntergosternite 7 2.08 mm long, 0.75 times as long as mesonotum; aculeus 1.33 mm long, tip (Fig. 8D) slightly constricted before broadest part, with sides nonserrate, moderately concave, extreme apex broad and blunt, very gradually tapered; 8th sternites with apices usually slightly exposed in dorsal view, sides with distinct corner slightly apical to level of constriction in aculeus.

Remarks.—A male from Sinaloa (Hwy. 40, 6.5 mi E Potrerillos, 21.VIII.1964, E.I. Schlinger) in the collection of the UCR keys here, but probably represents another undescribed species. It differs from *G. hernandezi* as follows: the aedeagus is shorter (2.29 mm long, 0.89 times as long as mesonotum); the base of cell r_{2+3} is light (Fig. 6D); the light spot in r_1 is more irregular; and there is a subbasal white spot in cell dm. I am reluctant to formally describe it from only the male sex.

Distribution.—(Map 4). Jalisco and Michoacan.

Etymology.—I am pleased to name this species for my colleague Vicente Hernández Ortiz.

Gymnocarena lichtensteinii (Wiedemann), NEW COMBINATION
Fig. 5D

Trypeta Lichtensteinii Wiedemann 1830: 497 (Lectotype (here designated) ♂ (ZMHU), MEXICO [probably DISTRITO FEDERAL, MEXICO, MORELOS or PUEBLA] [with 2 green labels with "Lichtensteinii Wied. *" and "Mexico. Deppe." in handwriting that is not Wiedemann's but matching that on most other types of his species in ZMHU, an orange "Type" label, and a white label with "2457"]); Loew 1862: 92 [taxonomy], 1873: 289 [taxonomy].

Trypeta (*Icterica*) *Lichtensteinii*: Loew 1873: 330.

Icterica Lichtensteinii: Loew 1873: 290.

Icterica lichtensteinii: Hendel 1914: 61 [catalog]; Aczél 1950: 273 [catalog].

Ictericodes lichtensteinii: Aczél 1952: 120 [catalog]; Foote 1967: 29 [catalog].

Diagnosis.—This species and *G. magna* are very similar in wing pattern; possibly only terminalia length will reliably distinguish them. See "Remarks"; also see "Diagnosis" for *G. magna*.

Description.—Setae yellowish. Setulae yellowish except on abdomen and a few on scutellum. *Head:* genal height 0.28 times eye height; facial carina moderately developed, ventral expanded part medium sized, its height almost ¼ that of face, in lateral view, margin of ventral part straight, slightly projected. *Thorax:* with small dark spots on scutellum; mesonotum 2.38 mm long;

dorsocentral setae slightly anterior to supra-alar setae. *Legs:* femora not unusually stout. *Wing* (Fig. 5D): pattern largely faint gray with white spots; broad dark brown bands from pterostigma to r-m and from vein M to posterior margin along dm-cu, these narrowly connected along vein M; broad dark brown apical spot, without apical light spot in cell r_{2+3}; cell r_1 with narrow brown spot, fused with broad extension from apical brown spot along Costa, dividing large light area extended from cells r_{2+3} and r_{4+5}; the latter light area largely faint gray with 7 peripheral white spots; cell m with 3 white spots within faint gray area, arranged in triangle, apical dark brown part of cell without light markings; cells r_{2+3}, br, and dm light basal to band over r-m, br with 1 subapical, dm with 2 medial, and cu_1 with 2 white spots. *Abdomen:* setulae on syntergum 1+2 yellowish except posteriorly; setulae on terga 3–5 brown. *Male terminalia:* outer surstylus with small dorsal lobe; aedeagus 2.70 mm long, 1.13 times as long as mesonotum.

Remarks.—Wiedemann (1830) did not state the number of males he examined, so I regard the single specimen now in the ZMHU as a syntype, and designate it as a lectotype. This specimen is possibly conspecific with those I have recognized as *G. magna,* but the differences in wing pattern and especially aedeagus length suggest that they are distinct. As the female terminalia in *Gymnocarena* are more diagnostic than those of the male, corroboration of this hypothesis may depend upon the collection of females matching the lectotype in wing pattern. These presumably will have a shorter syntergosternite 7 than *G. magna* if there are two distinct species.

Distribution.—The type locality was not specified within Mexico, but it is probably within the Distrito Federal, or the states of Mexico, Puebla, or Morelos. According to Papavero (1971), Deppe collected during 1824–27 and 1829 in these states as well as Veracruz. He also made one trip to Oaxaca, but as no other *Gymnocarena* are known from the latter two states, it is unlikely that the lectotype of *lichtensteinii* came from them.

***Gymnocarena magna* Norrbom, New Species**

Figs. 5C, 8E, Map 3

Holotype: ♀ (SDNHM), MEXICO: JALISCO: El Aguacate, 14.7 mi SW Yahualica, 7700 ft, 14.IX.1986, D. K. Faulkner.

Paratypes: same as holotype, 2 ♀ (SDNHM) 1 ♂ 2 ♀ (USNM). MEXICO: MEXICO: El Yukon, 20 km W Toluca, 8800 ft, 8.VIII.1962, G. L. Bush, 1 ♂ (USNM) 1 ♀ (MSUEL).

Diagnosis.—This species and *G. lichtensteinii* are very similar in wing pattern and are recognized mainly by differences in terminalia length (see "Remarks" for *G. lichtensteinii*). Both differ from *G. mexicana* in having the dark pterostigmal band extended to r-m, and from *G. angusta* by the larger, more apically extended light area in the radial cells. In addition, *G. magna* differs from both of these species in the shape of its aculeus tip, which more closely resembles *G. tricolor* and *G. bicolor.*

Description.—Setae yellowish to light brown, those on frons typically darkest. Setulae yellowish except on abdomen and sometimes on scutellum. *Head:* genal height 0.31–0.39 times eye height; facial carina moderately to well developed, ventral expanded part medium sized, its height ¼–½ that of face, in lateral view, margin of ventral part straight, more or less parallel with margin of facial ridge or slightly projected. *Thorax:* usually with small dark spots, at least on scutellum; mesonotum 2.33–3.53 mm long; dorsocentral setae slightly anterior to slightly posterior to supra-alar setae. *Legs:* femora not unusually stout. *Wing* (Fig. 5C): pattern largely faint gray with white spots; broad dark brown bands from pterostigma to r-m and from vein M to posterior margin along dm-cu, these narrowly connected along vein M; broad dark brown apical spot, with at most 1 tiny apical light spot in cell r_{2+3}; cell r_1 with narrow brown spot, usually separate from narrow extension from dark apical spot along Costa, at least partially dividing light area extended from cells r_{2+3} and r_{4+5}; the latter light area largely grayish with 8–12 white spots; cell m with 4 or more white spots within faint gray area, usually arranged in rectangle, apical dark brown part of cell with 1–2 white spots; cells r_{2+3}, br, and dm light basal to band over r-m, br often with subapical, dm with 3–4 medial, and cu_1 with 3–6 white spots. *Abdomen:* setulae on syntergum 1+2 yellowish except posteriorly; setulae on terga 3–5 brown. *Male terminalia:* outer surstylus with medium sized dorsal lobe; aedeagus 3.41–3.95 mm long, 1.12–1.46 times as long as mesonotum. *Female terminalia:* syntergosternite 7 1.87–2.41 mm long, 0.71–0.75 times as long as mesonotum; aculeus 1.62 mm long, tip (Fig. 8E) similar to *tricolor,* with sides nonserrate, moderately concave, extreme apex broad and blunt; 8th sternites with apices at most slightly exposed in dorsal view, lateral margins evenly rounded.

Distribution.—(Map 3). Jalisco and the state of Mexico.

Etymology.—The epithet is a Latin adjective meaning large, in reference to the size of this species.

Gymnocarena mexicana (Aczél)
Figs. 1D–E, 2, 5B, 8F, Map 2

Tomoplagiodes mexicana Aczél 1954: 91 (Holotype ♂ (USNM), MEXICO: DISTRITO FEDERAL, VII–VIII.1910).

Tomoplagiodes mexicanus: Foote 1967: 48 [catalog].

Gymnocarena mexicana: Foote 1980: 30 [taxonomy].

Diagnosis.—The small size of the dark pterostigmal band is diagnostic for *G. mexicana.* This mark is absent (*G. apicata*) or extended to r-m in other species of *Gymnocarena* with reduced wing patterns. The dorsal teethlike structures on the aculeus are unique to this species.

Description.—Setae light to dark brown. Setulae generally brown except on postgena, parts of thoracic pleura and legs. *Head:* genal height 0.42–0.48 times eye height; facial carina moderately to well developed, ventral expanded part medium sized, its height ⅕–½ that of face, in lateral view, margin of ventral part straight, more or less parallel with margin of facial ridge or slightly projected. *Thorax:* usually with small dark spots, at least on scutellum; mesonotum 2.20–3.45 mm long; dorsocentral setae aligned with to distinctly posterior to supra-alar setae, but never more than ½ distance from them to postalar setae. *Legs:* femora not unusually stout. *Wing* (Fig. 5B): pattern largely hyaline or faint gray with white spots, except for following dark brown areas: pterostigma and cell r_1 posterior to it, narrow bands along bm-cu, Cu_2, and r-m, broad band along dm-cu, medial spot in r_1, spot on Cu_1, medial spot in r_{4+5}, and broad apical band extended from r_1 to m, interrupted by large apical white spot in r_{2+3} touching apex of R_{2+3}; r_{2+3} rarely with second marginal white spot; cell m with 2–3 white spots within medial grayish area. *Abdomen:* setulae on syntergum 1+2 yellowish except posteriorly; setulae on terga 3–5 brown. *Male terminalia:* outer surstylus with small dorsal lobe (Fig. 1D–E); aedeagus 2.91–3.33 mm long, 0.94–1.13 times as long as mesonotum. *Female terminalia:* syntergosternite 7 0.95–1.21 mm long, 0.32–0.44 times as long as mesonotum; aculeus 1.01–1.19 mm long, tip (Fig. 8F) with 3 teethlike projections on dorsal side near apices of 8th sternites, sides nonserrate, moderately concave, extreme apex broad and blunt, very gradually tapered; 8th sternites with apices at most slightly exposed in dorsal view, lateral margins evenly rounded.

Biology.—I collected more than 50 adults at Lagunas de Zempoala in mid August, 1989, only on or near plants of *Dahlia imperialis* Roezl ex. Ort., or to a lesser extent on *D. merckii* Lehm. Only a few plants were beginning to flower at that time, and no flies were reared from the samples collected. In late September and early October, 1991, numerous larvae were collected from flowers of both of the above species at this site. Other larvae were collected from flowers of *D. imperialis* near Angangueo, Michoacan and from flowers of *D. merckii* at Km. 42–43, Rt. 95 (libre), Distrito Federal. These are presumably *G. mexicana.* Like larvae of *G. diffusa,* they left the capitulae to pupariate. The puparia differ from those of *G. diffusa* in having more distinct segmentation and a more wrinkled, less punctate surface. They are very distinct from puparia of *Laksyetsa trinotata* Foote, which also attack *D. imperialis* at the Lagunas de Zempoala site; *L. trinotata* puparia are much broader posteriorly, being slightly egg or pear shaped, and they also usually remain inside the capitulum. I examined two puparia that may be *G. mexicana* from two other *Dahlia* species. No adults emerged from them, but they closely resemble the puparia of *G. mexicana* from Lagunas de Zempoala. One is from samples of *Dahlia coccinea* Cav. I collected from along Route 190 in the state of Mexico in August, 1989. The other was in the USNM collection with the type series of *Laksyetsa trinotata* and has the same label data, from Llano de las Flores, Oaxaca, from flower head of *Dahlia tenuicaulis.* As noted above, the puparia of *L. trinotata* from Lagunas de Zempoala are much different in appearance, and I doubt that the Oaxaca specimen is that species. These latter two *Dahlia* species may also be host plants of *G. mexicana* or at least of some *Gymnocarena* species. It is fitting that a species with the name *mexicana* breeds in *Dahlia,* the national flower of Mexico.

Distribution.—(Map 2). Durango to Morelos and Puebla. Possibly also in Oaxaca (see "Biology").

Specimens examined.—Holotype (see synonymy). MEXICO: DISTRITO FEDERAL: Pedregal de San Angel, 12.VII.1979, J. Butze, 1 ♂ (UNAM); La Cima, 18.VII.1984, G. Arzate, 1 ♂ (UNAM). DURANGO: 17 mi NE El Salto, 21.VII.1982, 1 ♂ (SDNHM). MICHOACAN: 3.5 km N of Angangueo, 4.X.1991, A.L.Norrbom, 1 ♀ (USNM). MORELOS: Parque Nacional Lagunas de Zempoala, 9200 ft, 11.VIII.1962, G.L. Bush, 1 ♂ 1 ♀ (MSUEL) 1 ♀ (USNM); same, 9400 ft, 22.VIII.1969, G. W. Byers, 1 ♀ (UKaL); same, clearing and ravine at entrance and path along Lago de Zempoala, on *Dahlia imperialis* or *D. merckii,* 9–11.VIII.1989, A.L. Norrbom, 37 ♂ 9 ♀ (USNM) 10 ♂ 2 ♀ (UNAM, IEXV). PUEBLA: 15 mi NW San Martin, 9000 ft, 26.VII.1963, G.W. Byers, 1♂ (UkaL).

Gymnocarena mississippiensis
Norrbom, New Species

Figs. 5F, 7C, Map 1

Gymnocarena tricolor: Blanc and Foote 1987: 429 [misidentification].

Holotype: ♀ (AMNH), USA: MISSISSIPPI: Lafayette Co.: Oxford, VI.1943.

Paratypes: KENTUCKY: Lyon Co.: Golden Pond, 25.V–25.VI.1964, M. Tidwell, 1 ♀ (FSCA). MISSISSIPPI: Lafayette Co., V–VI.1960, F.M. Hull, 1 ♂ (CNC); Oxford, VI.1943, 1 ♀ (USNM).

Diagnosis.—*G. mississippiensis* differs from other *Gymnocarena* species except *G. tricolor* in having a bicolored yellow and brown wing pattern with 2 distinct light triangles in cells r_1 and r_{2+3} (see key to distinguish these two species). It resembles *G. apicata* and *G. angusta* in aculeus shape.

Description.—Setae yellowish. Setulae yellowish except on abdomen. *Head:* genal height 0.25–0.34 times eye height; facial carina weakly to moderately developed, ventral part small or not expanded, in lateral view, margin of ventral part concave or projected anteriorly. *Thorax:* usually with small dark spots, at least on scutellum (3 of 4 specimens); mesonotum 2.16–2.41 mm long; dorsocentral setae slightly anterior to aligned with supra-alar setae. *Legs:* femora not unusually stout. *Wing* (Fig. 5F): pattern bicolored, mostly dark brown, but yellow in basal cells and parts of cells br, dm, and cu_1; r-m and dm-cu bordered only by dark brown; cell r_1 with 2 white marks, basal always and apical usually extended into r_{2+3}, apex of basal mark even with r-m; cell r_{2+3} with white spot along R_{4+5} opposite apex of R_1, sometimes (2 Mississippi paratypes) extended broadly to margin at apex of R_1; cell m with 3 white marks, at least apical one broadly extended into cell r_{4+5}; cell r_{4+5} with large white spot anterior to dm-cu; cell r_{2+3} with small basal white area; cell br with white spot posterior to pterostigma; cell dm with 2 medial white spots. *Abdomen:* setulae on syntergum 1+2 yellowish except sometimes posteriorly; setulae on terga 3–5 light brown. *Male terminalia:* outer surstylus with small dorsal lobe; aedeagus 2.50 mm long, 1.16 times as long as mesonotum. *Female terminalia:* syntergosternite 7 1.46 mm long, 0.61 times as long as mesonotum; aculeus 1.28 mm long, tip (Fig. 7C) slender, sides nonserrate, nearly straight, evenly tapered to acute extreme apex, slightly broader and blunter than in *angusta* and *apicata*; 8th sternites normally not visible in dorsal view, lateral margins evenly rounded.

Remarks.—The USNM paratype is missing its head. Also see "Remarks" for *G. tricolor.*

Distribution.—(Map 1). Mississippi and Kentucky.

Etymology.—The epithet is derived from the state of the type locality.

Gymnocarena serrata Norrbom, New Species

Figs. 6E–F, 7D–E, Map 3

Holotype: ♀ (UNAM), MEXICO: MORELOS: Km 49.5 Carretera Xochimilco-Oaxtepec [Rt. 142, 5 km. N El Vigia], 6.X.1984, A. Ibarra.

Paratypes: same as holotype, 9 ♀ (UNAM) 6 ♀ (USNM); same locality, 30.IX.1991, A. L. Norrbom, 1 ♂ 1 ♀ (USNM). MEXICO: DISTRITO FEDERAL: Ajusco, 1.X.1984, A. Ibarra, 1 ♀ (USNM). MICHOACAN: 3.5 km N of Angangueo, 4.X.1991, A.L.Norrbom, 1 ♂ (USNM). JALISCO: Parque Nacional Nevado de Colima, 10.7 mi N Hwy. 54, 8200 ft, 18.IX.1986, 1 ♀ (SDNHM). PUEBLA: 15 mi NW San Martin, 9000 ft, 26.VII.1963, G.W. Byers, 1 ♀ (UKaL).

Diagnosis.—*G. serrata* is similar in wing pattern to *G. hernandezi* and *G. bicolor,* which differ as indicated in the key. The shape of the aculeus tip, which is very finely serrate subbasally, is unique.

Description.—Setae yellowish to brown, those on frons typically darkest. Setulae yellowish except on abdomen and scutellum. *Head:* genal height 0.25–0.35 times eye height; facial carina weakly to moderately developed, ventral part small or not expanded, in lateral view, margin of ventral part concave or projected anteriorly. *Thorax:* usually with small dark spots, at least on scutellum (17 of 19 specimens); mesonotum 1.83–2.58 mm long; dorsocentral setae slightly anterior to aligned with supra-alar setae. *Legs:* femora not unusually stout. *Wing* (Fig. 6E–F): pattern mostly dark brown, faded in basal and posterior parts of wing; largely infuscated apical to r-m; cell r_1 with single broad white mark with distinct margin, without medial faint gray mark, often not extended into r_{2+3}; cell r_{2+3} sometimes with small medial apical white spot; cell m with 2–4 irregular white spots; cell r_{4+5} usually with small white spot anterior to dm-cu, sometimes also with small white spot near middle (no specimens had only the latter spot), sometimes entirely dark; cell r_{2+3} with small basal white area; cell br with white spot posterior to pterostigma, pattern faint in basal half; cell dm with 2–3 white spots in apical half, pattern faint in basal half. *Abdomen:* setulae on syntergum 1+2 yellowish except posteriorly; setulae on terga 3–5 brown. *Male terminalia:* outer surstylus with small dorsal lobe; aedeagus 1.72–2.27 mm long, 0.88–0.94 times as long as mesonotum. *Female terminalia:* syntergosternite 7 1.04–1.16 mm long, 0.45–

0.57 times as long as mesonotum; aculeus 0.83–0.96 mm long, tip (Fig. 7D–E) slightly constricted just basal to apices of 8th sternites, beyond constriction sides concave and weakly serrate to about midpoint, extreme apex slender, acute or with minute concavity; 8th sternites with apices usually slightly exposed in dorsal view, lateral margins evenly rounded.

Remarks.—The specimens from Morelos and the Distrito Federal have slightly more extensively dark wings than those from Jalisco, Michoacan, and Puebla, lacking the apical light spot in cell r_{2+3} and sometimes 1 or both spots in cell r_{4+5}. They are all assumed to be conspecific without further morphological or biological evidence to the contrary.

Distribution.—(Map 3). Jalisco to Morelos and Puebla.

Etymology.—The epithet is a Latin adjective meaning sawtoothed, in reference to the serrate aculeus.

Gymnocarena tricolor (Doane)
Figs. 5H, 8B, Map 1

Euaresta tricolor Doane 1899: 191 (Lectotype (designated by Foote 1966: 125) ♂ (WSU), USA: SOUTH DAKOTA [with labels with "S.D.," "Type 100" (red writing), "Euaresta tricolor Doane" (handwriting, probably Doane's, same as on label of wing slide (#31)), and red "Lectotype des. by Foote 1966 Proc. Ent. Soc. Wash. 68: 125 (Zack 1983)"]); Aldrich 1905: 613 [catalog].

Tephritis tricolor: Coquillett 1899: 264 [taxonomy].

Gymnocarena tricolor: Quisenberry 1950: 10 [taxonomy]; Foote 1960: 113 [taxonomy; Wisconsin], 1965: 676 [catalog]; Wasbauer 1972: 117 [host catalog]; Lisowski 1985: 111 [taxonomy; Indiana, Illinois].

Gymnocarena flava Foote, in Blanc and Foote 1987: 430 (Holotype ♀ (USNM), IOWA: Manson, Kalsow Prairie, 3.VIII.1973, W. B. Stoltzfus). NEW SYNONYMY.

[not] *Euaresta tricolor*: Huber 1927: 48 [misidentification of *Eutreta diana*].

[not] *Gymnocarena tricolor*: Grissell 1979: 753 [misidentification of *Eutreta diana*]; Blanc and Foote 1987: 429 [misidentification of *G. mississippiensis*].

Diagnosis.—*G. tricolor* differs from other *Gymnocarena* species except *G. mississippiensis* in having a bicolored yellow and brown wing pattern with 2 distinct light triangles in cells r_1 and r_{2+3} (see key to distinguish these two species). Only *G. diffusa* also has stout femora and all abdominal setulae yellow.

Description.—Setae and setulae yellowish. *Head:* genal height 0.36–0.45 times eye height; facial carina moderately to well developed, ventral expanded part large, its height ⅓–½ that of face, in lateral view, margin of ventral part straight to convex, more or less parallel with margin of facial ridge. *Thorax:* without small dark spots; mesonotum 2.62–3.09 mm long; dorsocentral setae more or less aligned with supra-alar setae. *Legs:* femora stout. *Wing* (Fig. 5H): pattern distinctly bicolored, dark brown from pterostigma and r-m to apex, at least basal third yellow; posterior half of r-m and all of dm-cu bordered by yellow; white areas are spots, not bands, including discreet spots in cells r_{2+3} (subbasal), br, and dm posterior to pterostigma; cell r_1 with 2 white marks, both extended into cell r_{2+3} apical to r-m, but neither extended beyond vein R_{4+5}; cell r_{2+3} with extreme base yellow, with large subapical white spot not extended to margin; cell r_{4+5} with 2 large white spots in basal half, sometimes with small spot in apical half; cell m with 4 white spots. *Abdomen:* setulae on all terga yellowish. *Male terminalia:* outer surstylus with medium sized dorsal lobe; aedeagus 3.20–3.33 mm long, 1.04–1.18 times as long as mesonotum. *Female terminalia:* syntergosternite 7 1.46–1.58 mm long, 0.49–0.52 times as long as mesonotum; aculeus 1.37 mm long, tip (Fig. 8B) with sides nonserrate, moderately concave, extreme apex broad and blunt; 8th sternites with apices at most slightly exposed in dorsal view, lateral margins evenly rounded.

Remarks.—Blanc and Foote (1987) misidentified as *G. tricolor* the species here described as *G. mississippiensis.* The species they called *G. flava* Foote is the true *G. tricolor.*

Huber (1927) reported that the types of *Callimome citripes* (currently *Torymus citripes* (Huber), Torymidae (Grissell 1979)) were reared from specimens of "*Euaresta tricolor* Doane on *Artemisia tridentata* Nuttall . . . recorded under Bureau of Entomology No. 3129." This record is an error, probably caused by confusion with the name *tricolor* Snow, a synonym of *Eutreta diana* (Osten Sacken). Two specimens in the USNM labeled with "3129" and dates matching those on card no. 3129 in the Bureau of Entomology file are *E. diana,* which is well known to breed in stem galls of *Artemisia tridentata* (Wasbauer 1972) and which has otherwise been reported as a host of *T. citripes* (Grissell 1979).

Biology.—W. B. Stoltzfus (pers. comm.) has reared this species from flowers of *Helianthus grosseserratus* M. Martens and *H. tuberosus* L. in Iowa.

Distribution.—(Map 1). South Dakota to Wisconsin and Indiana. I have not located the USNM specimen from Cranmoor [Wood Co.], Wisconsin reported by Foote (1960), but this locality is included on the distribution map. The square on South Dakota does not represent an exact locality; the specific type locality was not stated.

Specimens examined.—Lectotype of *tricolor*; holotype of *flava* (see synonymy). ILLINOIS: Boone Co.: 2.5 mi SW Cappon, 7.VIII.1980, E. A. Lisowski, 1 ♀ (INHS); Champaign Co.: Illini For. Plantation, 2.5 mi S Urbana, 21.VII.1979, E. A. Lisowski, 1 ♂ (INHS); DeKalb Co.: 1.5 mi E Fairdale, 7.VIII.1980, E. A. Lisowski, 1 ♂ (INHS); Livingston Co.: 2 mi W Fairbury, 22.VII.1980, E. A. Lisowski, 1 ♂ (INHS); McDunough Co.: 3 mi NE Bushnell, 29.VII.1980, E. A. Lisowski, 1 ♂ (INHS). INDIANA: Vermilion Co.: 0.5 mi N Eugene, 15.VII.1980, E. A. Lisowski, 1 ♂ (INHS). "N. Amer.," 1 ♂ (BMNH). IOWA: Story Co.: Ames, 7.VII.1973, W. B. Stoltzfus, 1 ♂ paratype of *flava* (USNM).

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A. Freidberg (Tel Aviv University), W. N. Mathis (Smithsonian Institution), J. Pakaluk and L. E. Carroll (Systematic Entomology Laboratory), and W. B. Stoltzfus (William Penn College) kindly reviewed the manuscript. The latter also very kindly allowed me to cite his unpublished host records for *G. diffusa* and *G. tricolor.* H. Robinson (Smithsonian Institution, Department of Botany) identified the *Dahlia* and *Verbesina* species. T. Griswald produced the illustrations of the wings and phylogenetic trees, and P. Malikul assisted with the SEM photographs.

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Note added in press. Two specimens were reared after acceptance of this paper: *G. mexicana*, MEXICO: MORELOS: Lagunas de Zempoala, emerged 1.VI.1992 ex. flowers of *Dahlia imperialis* (91M16) collected 23.IX.1991, A.L. Norrbom, 1♂ (USNM); *G. serrata*, MEXICO: MICHOACAN: road to Rincon de Curungueo, 5 km NE of Zitacuaro, emerged 4.VI.1992 ex. flowers of *Verbesina virgata* Cav. (91M35) collected 3.X.1991, A.L. Norrbom, 1♂ paratype (USNM). The larva of *G. serrata* left the capitulae to pupariate. Its puparium is very similar to that of *G. carinata*. The acronym IEXV, omitted from the list in Materials and Methods, represents the Institute de Ecología, Xalapa, Veracruz.

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EGG MORPHOLOGY OF *DRACONIA RUSINA* DRUCE FROM HONDURAS (LEPIDOPTERA: THYRIDIDAE)

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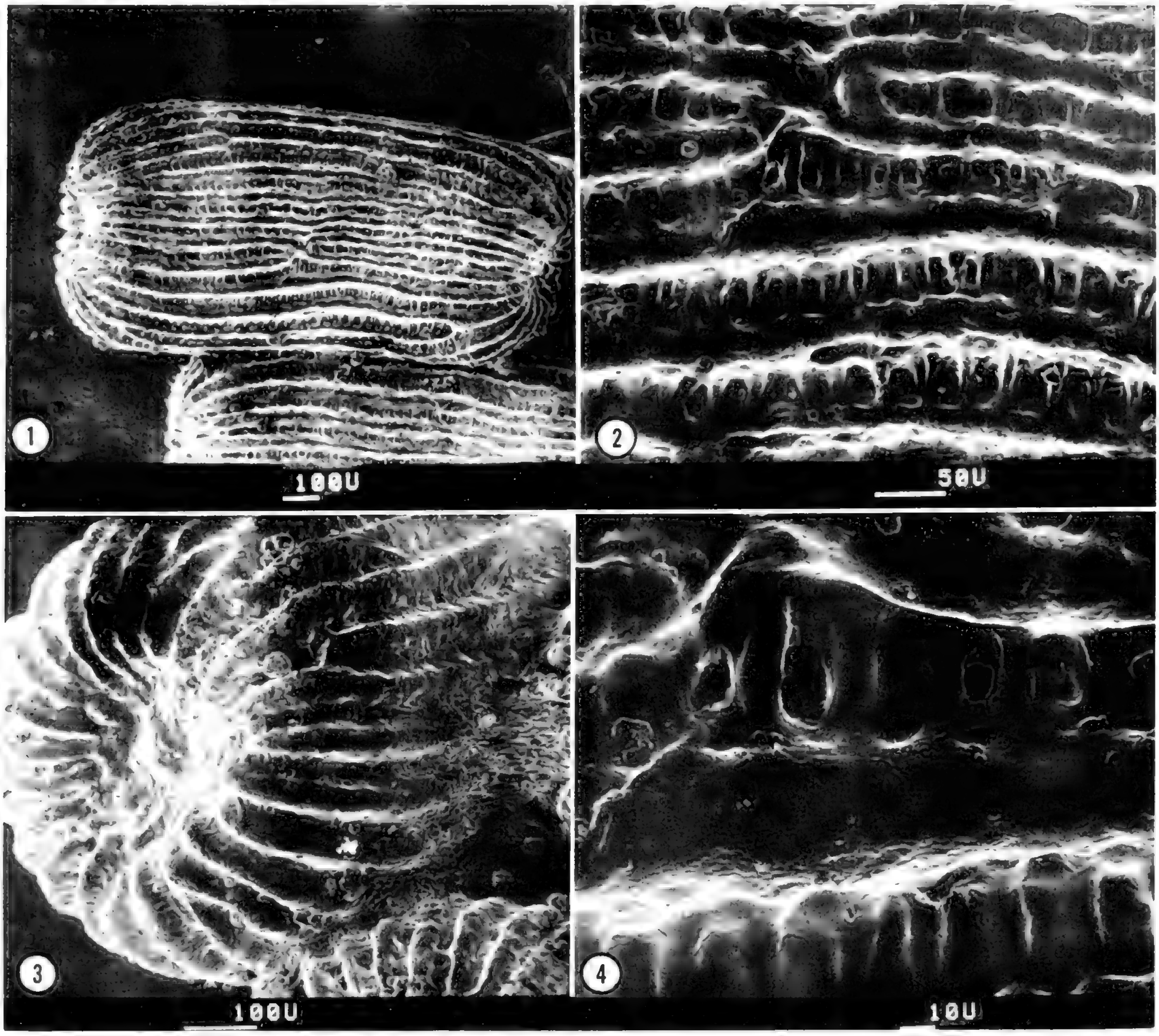
Abstract.—The egg and some first instar morphological features of *Draconia rusina* are given based on specimens collected in Honduras. This is the first record of *D. rusina* from Honduras and the second illustration of a Neotropical thyridid egg.

Key Words: *Draconia rusina,* Thyrididae, egg, first instar, Honduras

The systematic position of the Thyrididae is unclear. Munroe (1972) and Whalley (1976) tentatively united thyridids with other Pyraloidea. Common (1990) and Minet (1983) elevated this group to its own superfamily named Thyridoidea. Passoa (1985) suggested pupal pilifers as a synapomorphy of Pyralidae, Hyblaeidae, Pterophoridae, and Thyrididae. Although the presence of pilifers is apomorphic (by virtue of the outgroup comparison method where Monotrysia is a sister group to Ditrysia), this character is homoplastic because pupal pilifers also occur in the unrelated Papilionoidea (Mosher 1916). Very little is known about immature thyridids (Whalley 1976). Therefore, the egg and some first instar larval characteristics of *Draconia rusina* Druce are described here to aid in comparing the morphology of pyraloid families for systematic and identification purposes.

Draconia rusina is a large moth previously recorded from Guatemala, Panama and Venezuela (Gaede 1936). Several specimens of *D. rusina* were collected in Comayagua, Honduras (Department of Comayagua) at a blacklight during April, 1979, and again in March and May, 1980. Approximately 20 eggs were obtained in 1979 (parental female number 78, S. Passoa coll.) using cheesecloth as an oviposition substrate. They were either dried or preserved in 80% ethanol. After several years, a few dried eggs were mounted on aluminum stubs with Elmer's glue and sputter coated twice at different angles with gold-palladium for further study. These were examined with an information Scientific instrument DS-130 scanning electron microscope and photographed with Polaroid type 55 positive/negative film. Structural measurements, expressed in microns or millimeters, were made directly from the scale line on the photographs after dividing by the magnification. Egg terminology follows Downey and Allyn (1981).

The egg (Figs. 1–4) is cream-colored and subcylindrical with nearly parallel truncate ends (length 1.29–1.34 mm, mean = 1.30 mm, n = 4; width 0.61–0.68 mm, mean = 0.65 mm, n = 3). The chorion sculpturing is composed of approximately 21 ridges parallel to the long axis of the egg (Fig. 1) that converge and terminate at the micropylar shoulder (Fig. 3). Ridges across the long axis are usually straight and separated, although a few are crossed or bifurcate (Figs. 1, 2; inter-ridge distance 17.02–29.79 μm,



Figs. 1–4. Egg of *Draconia rusina* Druce. 1, lateral view (59 ×). 2, chorion ridges of the egg (235 ×). 3, oblique view of the micropyle (122 ×). 4, aeropyle apertures of chorion (580 ×). Scale lines marked in microns under each figure.

mean = 22.33 μm, n = 10). Aeropyle apertures occur on the chorion ridges (Figs. 2, 4) with one aperture per 21.28 to 28.40 μm (mean = 24.01 μm, n = 55). These apertures (Fig. 4) are irregularly shaped, with a width (opening parallel to the egg's long axis) of 6.38–19.15 μm (mean = 10.55 μm, n = 12) and a height of 10.34–20.69 μm (mean = 15.17 μm, n = 5). Micropylar end (Fig. 3) consists of a circular depression (diameter = 180.3 μm, n = 1) with a central raised tubercle (diameter = 77.87 μm, n = 1).

A review of published thyridid egg descriptions revealed some differences between taxa. Aniello (1980) mentioned a hexagonal pattern of cells on the chorion of *Dysodia sica* Druce but did not include longitudinal ridges in her illustration. In contrast, *Thyris fenestrella* (Scopoli) (Sarlet 1964), *Aglaopus pyrrhata* (Walker) (Common 1990) and *Draconia rusina* eggs all have chorionic ridges. All four genera (*Aglaopus, Draconia, Dysodia* and *Thyris*) share a rounded, truncate apex which may be a general characteristic of thyridid eggs. Common (1990), Aniello (1980) and Sarlet (1964) mention that thyridids have upright eggs. The location of the micropyle in *D. rusina* is consistent with this type of egg.

Although our *Draconia rusina* eggs never hatched, dissection revealed a fully developed larva within the egg shell. First instar larva of *D. rusina* have a short front, a bisetose SV group and apparently only one L seta on the thoracic segments, uniordinal crochets in a circle, and long setae on the anal shield. The latter character is shared with mature *Thyridopyralis* larvae which also have long setae on the anal shield. Aniello (1980) stated the crochets of first instar *Dysodia sica* larvae are in a biordinal circle, but this arrangement was not found in *Draconia rusina.*

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TWO NEW SPECIES OF NEOTROPICAL PARASITIC WASPS WITH HIGHLY MODIFIED OVIPOSITORS (HYMENOPTERA: BRACONIDAE: BRACONINAE AND DORYCTINAE)

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Abstract.—A new species of *Digonogastra* Viereck (Hymenoptera: Braconidae: Braconinae) from Argentina and a new species of *Heterospilus* Haliday (Hymenoptera: Braconidae: Doryctinae) from Venezuela and Brasil are described. Both new species have highly modified ovipositors with the apex formed into one or two arch-like regions. Ovipositor structure is interpreted functionally for both species.

Key Words: *Digonogastra, Heterospilus,* Braconidae, ovipositors, parasitic wasps, functional morphology

Digonogastra Viereck and *Heterospilus* Haliday are both large genera in the Neotropical Region, with over 500 species each, the majority of which are undescribed. Two new species, one in each genus, are described here because of their remarkable, apically arched or sickle-shaped ovipositors. These ovipositors are convergently similar to the arched ovipositors found in three Old World genera of Braconinae: *Zaglyptogastra* Ashmead (Quicke 1991), *Undabracon* Quicke, and *Cedilla* Quicke, as well as certain cremastine ichneumonids, e.g. *Pristomerus* Curtis (Quicke 1991). Nevertheless, there are also considerable differences among these ovipositors. For example, that of the new *Heterospilus* species is inverted in comparison with the otherwise similar ovipositor of *Cedilla* (Quicke and Tobias 1990), and that of the new *Digonogastra* species has a unique corrugated component and is mostly weakly sclerotized.

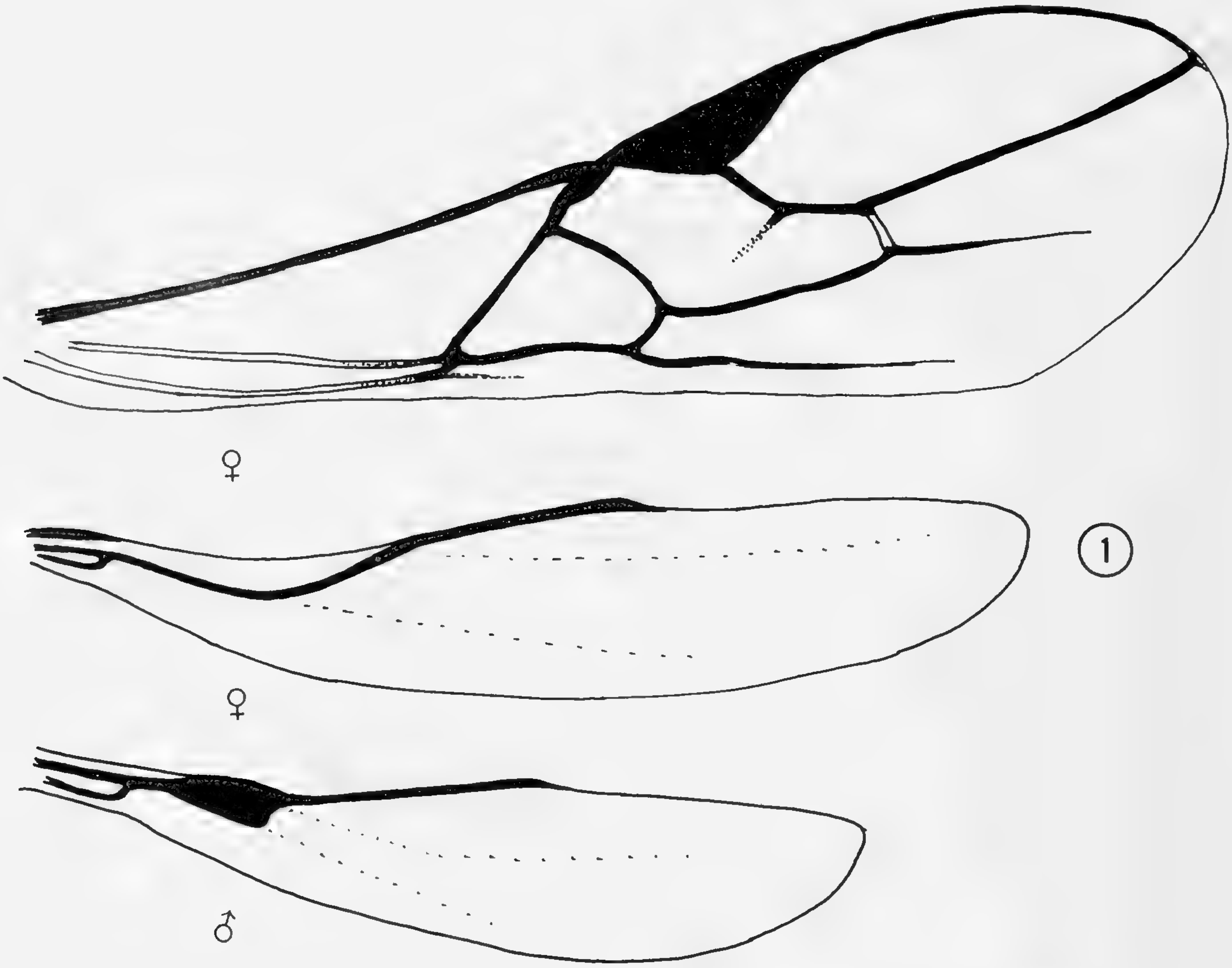
Authorship for each species is as indicated. Terminology for the descriptions follows that of van Achterberg (1979) and Quicke (1988). For consistency, van Achterberg's terminology is also employed here for the new species of *Heterospilus,* although previous works by the junior author on that genus have employed a different terminology (Marsh 1982a, b). A generic diagnosis for *Digonogastra* may be found in Quicke (1988) and for *Heterospilus* in Marsh (1965).

Depositories for specimens are listed by city as follows: Washington—National Museum of Natural History, Washington, D.C.; Ottawa—Biosystematics Research Centre, Ottawa, Canada; Sheffield—Department of Animal and Plant Sciences, University of Sheffield, Sheffield, England; London—The Natural History Museum, London, England.

Digonogastra zaglyptogastra Quicke, New Species

Figs. 2, 3–8, 20, 21

Female: Length of body, 6.0–8.5 mm; length of fore wing, 8.8–9.5 mm. Color. An-



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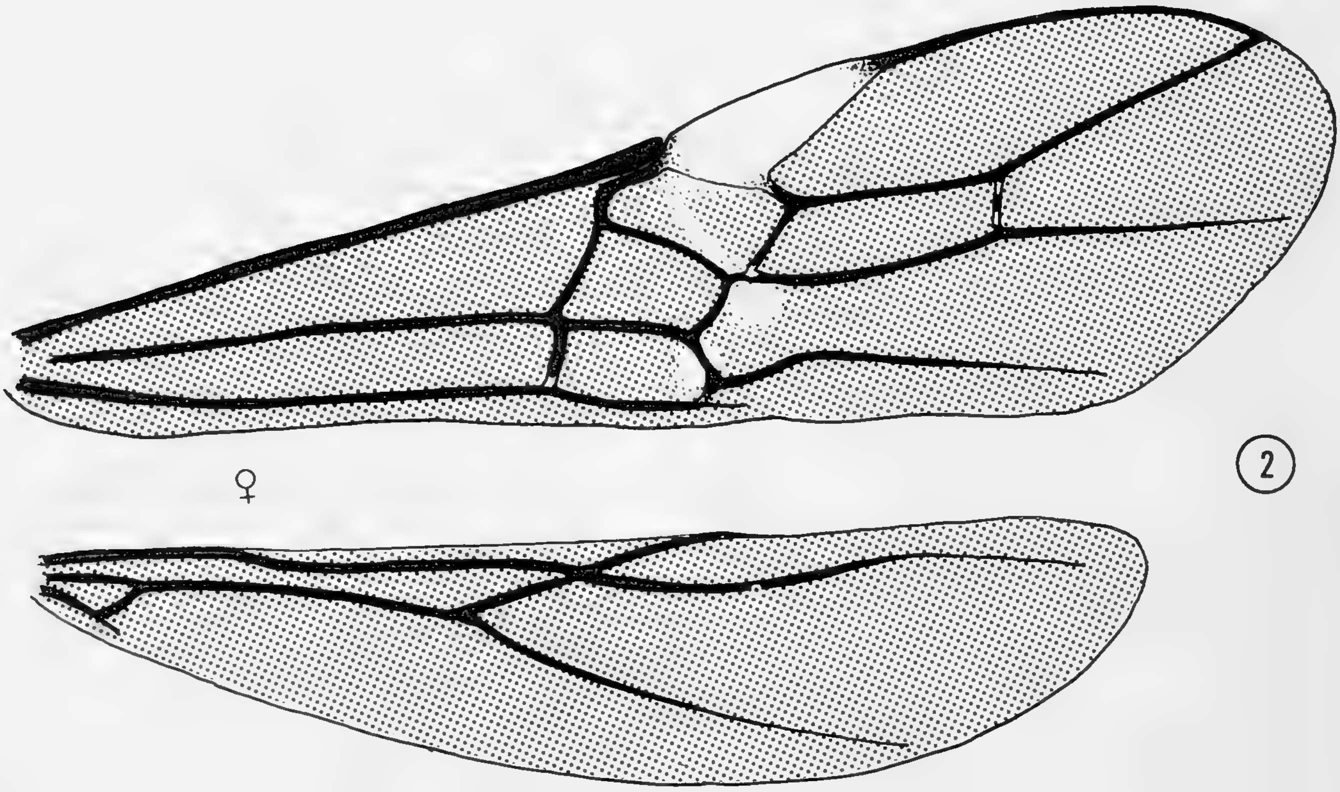

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Figs. 1, 2. Fore and hind wings. 1, *Heterospilus falcatus,* n. sp. 2, *Digonogastra zaglyptogastra,* n. sp.

tenna, head, propleuron, legs (except femora and sometimes hind tibia and tarsus), propodeum laterally and ovipositor sheaths black or piceous; remainder of body and legs "dirty" orange-brown; wings pale grey-brown, somewhat paler basally, with darker venation and largely pale yellow stigma.

Head (Figs. 3, 4): Antenna with 64 flagellomeres; terminal flagellomere acuminate, 2.5 times longer than maximally wide; penultimate flagellomere 1.7 times longer than wide; median flagellomeres 1.4 times longer than wide, first flagellomere 1.38 times and 1.5 times longer than the second and third flagellomeres respectively, the latter being 1.3 times longer than wide; scape elongate, longer ventrally than dorsally (Fig. 6); oral space (hypoclypeal depression) deep, dorsally rounded; transverse median clypeal carina poorly developed, not lamelliform; height of clypeus : inter-tentorial distance : tentorial-ocular distance = 1.0:2.9: 2.3; dorsal part of clypeus with rugulose sculpture; face with foveate-rugose sculpture, rather densely setose and with a distinct mid-longitudinal ridge medio-dorsally (Fig. 3); width of head : shortest distance between eyes : height of eye = 2.0:1.0:1.14; eyes with a few very short setae; frons moderately depressed with a well-developed mid-longitudinal sulcus, lateral half moderately setose; shortest distance between posterior ocelli : transverse diameter of posterior ocellus : shortest distance between posterior ocellus and eye = 1.3:1.0:2.9; length of head 2.6 times longer than horizontal length of eye.

Wings (Fig. 2): Forewing: lengths of veins SR1:3-SR:r = 8.0:5.1:1.0; lengths of veins 2-SR:3-SR:r-m = 1.8:3.9:1.0; vein cu-a interstitial to slightly postfurcal; vein 1-SR+M angled posteriorly shortly after arising from 1-SR. *Hindwing:* lengths of veins 1r-m: SC+R1 = 1.05:1.0; apex of vein C+SC+R with two or three thickened setae; base of wing evenly setose.

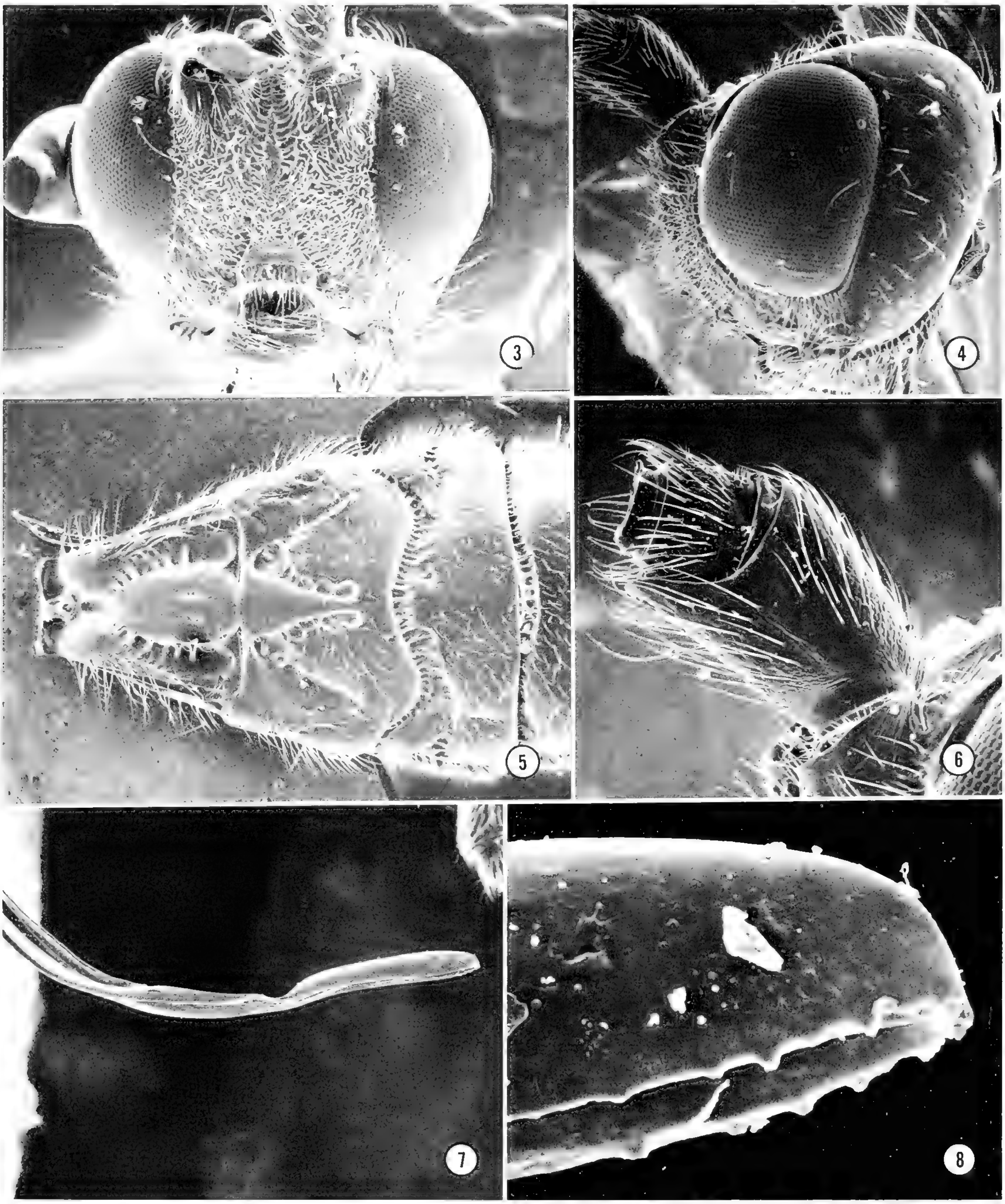
Legs: Lengths of fore femur : tibia : tarsus = 1.0:1.1:1.6; lengths of hind femur : tibia : basitarsus = 1.6:2.4:1.0; hindtibia slender with a well-developed longitudinal, lateral groove; hind basitarsus 6.85 times longer than deep.

Mesosoma: Smooth and shiny; 2.0 times longer than high; notauli absent except at extreme anterior margin of mesoscutum; scutellar sulcus narrow with approximately 12 transverse crenulae.

Metasoma (Figs. 5, 7, 8, 20, 21): Smooth and shiny, moderately setose; first tergum (Fig. 5) 1.22 times longer than wide, lateral carinae poorly developed, raised median area bordered laterally by crenulations, with pair of sub-medial pits shortly before posterior margin; second tergum (Fig. 5) 1.73 times wider than long medially, elongate mid-basal triangular area defined laterally by smooth or crenulate grooves, second suture sinuous and crenulate; third tergum (Fig. 5) with a more or less clearly defined, small mid-basal triangular area; terga 3–7 without transverse sub-posterior grooves; terga 4–6 with transverse peri-basal groove; ovipositor weakly sclerotized, markedly upcurved, approximately apical 0.25 formed into a pair of deep arch-like sections (Figs. 7, 20), both lower and upper valves similarly modified, sheaths with two pre-apical expanded sections (Fig. 21).

Type material.—*Holotype:* Female, ARGENTINA, Entre Rios Pronuciamento, October 1974. Deposited in Ottawa. Paratypes: 4 ♀, 2 ♂, same data as holotype; 5 ♀♀, topotypic but collected September 1964; 1 ♀, topotypic but collected December 1964. Deposited in Ottawa, Washington, and Sheffield.

Diagnosis.—This species is distinguished from all other known species of *Digonogastra* by the presence of two distinct, apical, arch-like regions of the ovipositor. The only other species of Braconinae with similar arched ovipositors belong to the exclusively Old World genera *Zaglyptogastra* and *Undabracon*, both of which have at least



Figs. 3–8. *Digonogastra zaglyptogastra,* n. sp. 3, face. 4, head, side view. 5, metasomal terga 1–3, dorsal view. 6, antennal scape, lateral view. 7, tip of ovipositor valves. 8, enlarged view of apex of dorsal valve of ovipositor.

three arch-like regions. Species of *Zaglyptogastra* seldom have a largely smooth metasoma (except for *Z. novaguinensis* Quicke and *Z. gaullei* Granger) and the two species which do lack the distinct mid-basal triangular area on the third metasomal tergum found in most *Digonogastra,* including *D. zaglyptogastra.* Species of *Undabracon,* as with other Aphrastobraconina, have the fore wing vein CU1b much wider anteriorly than vein 3CU1 posteriorly.

Heterospilus falcatus Marsh, New Species

Figs. 1, 9–19

Female: Length of body, 2.5–3.0 mm; length of fore wing, 1.5–1.75 mm. *Color:* Body brown; antenna with flagellum brown, pedicel brown or yellow, scape yellow; legs entirely yellow; wings hyaline, veins brown.

Head (Fig. 13): Antenna with 22–23 flagellomeres; length of malar space ⅓ eye height and about equal to basal width of mandible; temple narrow, about ½ eye width; oral space (hypoclypeal depression) wide and oval, width nearly twice length of malar space and equal to height of face (Fig. 13); ocelli small, ocellocular distance twice diameter of lateral ocellus; face granular; frons, vertex and temple finely granular, shining; malar space smooth, shining.

Mesosoma (Figs. 12, 14): Mesonotum and scutellum granular; notauli scrobiculate, meeting posteriorly in triangular rugose area; prescutellar furrow with 3–5 cross carinae; mesopleuron finely granular, nearly smooth dorsally, sternaulus deeply impressed and weakly scrobiculate, subalar groove rugose; propodeum rugose dorsally except for two large granular triangular areas at base bordered by strong carinae, granular laterally.

Wings (Fig. 1): Fore wing with first segment of radius (r) slightly longer than second segment (3-SR).

Legs: Hind femur swollen, about three times longer than wide.

Metasoma (Fig. 14): First tergum longitudinally striate, apical width twice basal width, length slightly longer than apical width; second tergum longitudinally striate on basal ¾; suture between second and third terga very weak or absent; remainder of terga smooth and shining; ovipositor (Fig. 9) nearly as long as body, usually curved upward, tip of valves expanded and sickle-shaped (Figs. 10, 15–18), tips of sheaths also expanded (Figs. 11, 19).

Male: Essentially as in female; hind wing with small stigma near base (Fig. 1), veins and stigma yellow.

Type material.—*Holotype:* Female, VENEZUELA, Edo. Aragua, Choroni, March 1952, P. Guagliumi, par. *Xyleborus confusus.* Deposited in Washington. Paratypes: 5 ♀, 4 ♂, VENEZUELA, same data as holotype; 1 ♀, 1 ♂, BRAZIL, Nova Teutonia, Fritz Plauman, 25-II-1937 and 9-X-1956. Deposited in London and Washington.

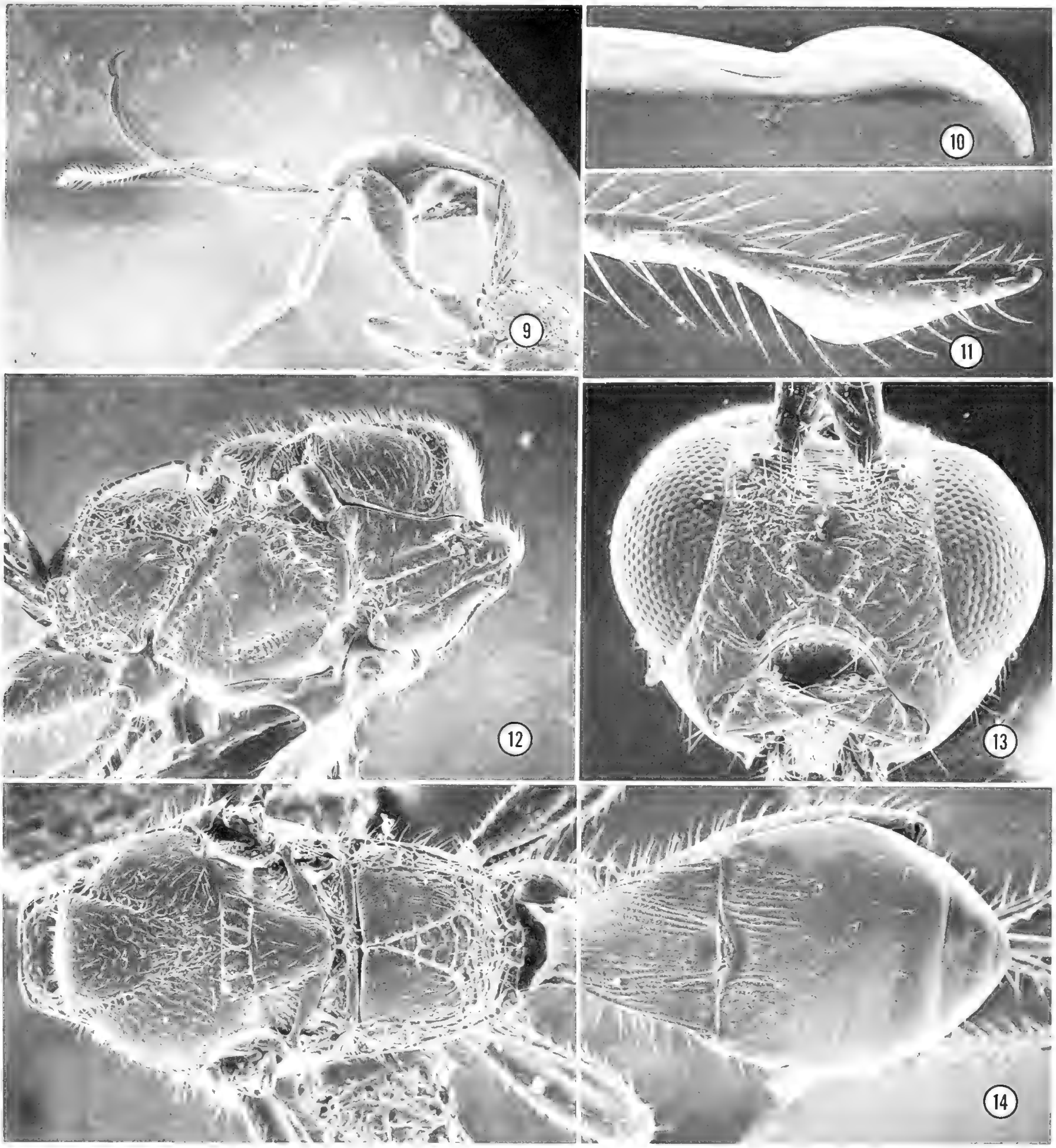
Etymology.—The specific name is from the Latin falcatus meaning sickle-shaped and refers to the unusual shape of the ovipositor.

Biology.—All of the type series from Venezuela were labeled as reared from *Xyleborus confusus* Eichhoff (Coleoptera: Scolytidae), which is a junior synonym of *X. ferrugineus* (F.).

Diagnosis.—This species can be distinguished from all other known species in the genus by the unusual shape of the tip of the ovipositor.

DISCUSSION

Very little is known about the function of the singly or multiply arched ovipositors found in a number of braconid and ichneumonid genera. Host records are available for only one species of the Old World braconine genus *Zaglyptogastra* (Quicke 1983, 1991) and for some species of the ichneumonid genus *Pristomerus.* There are no published accounts of oviposition in either genus being observed in enough detail to explain the role(s) of their specialized ovipositors. Following his examination of museum specimens of *Zaglyptogastra,* which had died with their ovipositors in a variety of degrees of curvature, Quicke (1991) proposed that the arched form enables the wasp to manipulate the ovipositor apex in a vertical plane by sliding the lower valves posteriorly relative to the upper ones, resulting in a ventral curving of the apical part. The



Figs. 9–14. *Heterospilus falcatus*, n. sp. 9, lateral view of metasoma and ovipositor. 10, apex of ovipositor valves. 11, apex of ovipositor sheath. 12, mesosoma, lateral view. 13, face. 14, mesosoma and metasoma, dorsal view.

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Figs. 15–21. Figs. 15–19, *Heterospilus falcatus*, n. sp. 15, dorsal ovipositor valve. 16, apex of dorsal ovipositor valve. 17, right ventral ovipositor valve, lateral view. 18, left ventral ovipositor valve, ventral view. 19, ovipositor sheath. Figs. 20–21, *Digonogastra zaglyptogastra*, n. sp. 20, dorsal ovipositor valve. 21, ovipositor sheath.


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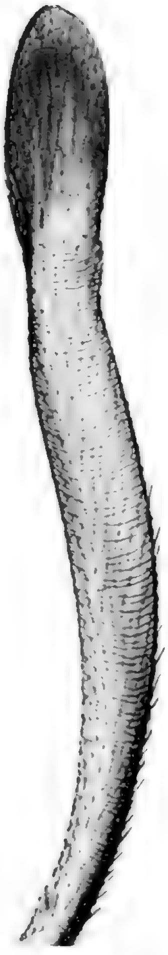
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only known host of *Zaglyptogastra* is the African coffee twig-boring cerambycid beetle, *Dirphya princeps* Jordan (Quicke 1983, 1991, El-Heneidy and Quicke 1991). Access to the *Dirphya* larva is almost certainly made via the row of frass holes the beetle makes at frequent intervals along the path of its excavation. The ability of *Zaglyptogastra* to manipulate its ovipositor through 180° probably greatly increases its ability to reach its host.

The multiply-arched ovipositor of *D. zaglyptogastra* probably functions in much the same way as that indicated above for *Zaglyptogastra* species. The biology of members of the genus *Digonogastra* is rather diverse and nothing is known of the hosts of the new species described here. Others, however, have been recorded from lamiine cerambycids (as for *Zaglyptogastra* above), Lepidoptera larvae in stems and seed pods (Quicke 1989, Wharton et al. 1989), and from bagworm moth larval cases (Psychidae). At least some of these hosts can be reached without the need to "drill" through a hard substrate. An ability to flex the ovipositor in some cases can easily be imagined as being useful. In approximately half of the known species of *Digonogastra,* the ovipositor has a pre-apical dorsal nodus and ventral serrations indicating a need to drill through a tough substrate. In the remainder of species, the ovipositor is robust and somewhat blade-like, lacking serrations; in these it seems likely that hosts are reached by pushing the ovipositor through a soft substrate. Thus, within *Digonogastra* there is considerable variation in ovipositor morphology, which is probably correlated with function.

The reasons underlying the similar but inverted ovipositor modification of *Cedilla* and *H. falcatus* are presumably based on a similar mechanical principle to that used by *Zaglyptogastra.* In the case of *H. falcatus,* protrusion of the ventral valves will result in an upwards rotation of the ovipositor apex which in turn may allow eggs or venom to be delivered to a part of the host that would not normally be reached by simple probing. Nevertheless, it is clear that in neither *H. falcatus* nor *D. zaglyptogastra* can the ovipositor be used to penetrate any hard substrate and, thus in both cases, access to the host is most probably via frass holes or similar easy routes.

ACKNOWLEDGMENTS

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NEST DISTRIBUTION OF THE SOLITARY BEE *ANDRENA MACRA* MITCHELL (HYMENOPTERA: ANDRENIDAE), WITH OBSERVATIONS ON NEST STRUCTURE

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Abstract.—The dispersion pattern of nests of the solitary bee *Andrena macra* was estimated, and the nest structure described within nesting sites at Quantico, Virginia. A χ^2 analysis indicated that nests had an aggregated or clumped distribution within each site. A nearest neighbor analysis, however, indicated that the spatial distribution of nests within most dense areas (aggregates) was random. A typical *A. macra* nest contained an entrance, tumulus, main vertical shaft, soil-filled lateral shafts, and 4–12 brood cells.

Key Words: *Andrena,* nest distribution, structure

Andrenid bees are a large group of pollen-gathering insects present on all continents except Australia, with approximately 1200 described species in North America north of Mexico (Hurd 1979). The family is split into the subfamilies Andreninae and Panurginae. In the Neartic region north of Mexico, the Andreninae contains the genera *Megandrena, Ancylandrena,* and *Andrena.* The genus *Andrena* contains 511 described species (Hurd 1979). Most *Andrena* are solitary, which means that each adult female constructs its own nest and mass provisions its brood cells, without any assistance from conspecifics (Michener 1974). Three species are communal, in which females share a common nest but continue to construct and provision their own brood cells. These include *Andrena accepta* Viereck (Rozen 1973), *Andrena crataeigi* Robertson (Osgood 1989), and *Andrena erythronii* Robertson (Michener and Rettenmeyer 1956). *Andrena* are typically vernal and univoltine, but *Andrena candida* Smith, *Andrena fulvipennis* Smith, and *Andrena mimetica* Cockerell have 2 generations in a season (Linsley 1937).

Andrena, as well as many other solitary bees, construct their nests in small to large restricted sites in roadbanks or other open areas. These sites sometimes contain hundreds, even thousands of nests in them (Michener 1974). No prior attempts have been made to determine nest dispersion patterns, for any of the solitary bees nesting in North America. I endeavored to determine whether the nests of the bee *Andrena macra* Mitchell were randomly distributed within several sites, and to describe nest structure. *Andrena macra* is known from West Virginia and Maryland southward to Florida and westward to Texas and Oklahoma (LaBerge 1986). They are vernal, solitary bees that construct their nests in the soil (Sivik 1954, Riddick 1988).

Materials and Methods

Nesting sites were found on the United States Marine Corps Reservation at Quantico, Virginia by walking alongside road-ways and observing bee flight activity, in May 1983. The dimensions of site I were 11 × 13 m; site II, 40 × 6 m; site III, 80 × 5 m; site IV, 20 × 4 m; and site V, 20 × 5 m. All sites were on sun-exposed roadsides, had soil of a clay-like consistency, and had sparse amounts of grasses in them. The approximate distance between nesting sites ranged from 1 mile, between sites I and III, to 5 miles, between sites I and IV. The distribution of *A. macra* nests within a site was determined in June and July 1983, at least 2 weeks after *A. macra* females had completed all nesting activities. Nesting site I was investigated from 24–29 June; site II from 6–15 July; site III from 21–27 July; site IV from 1–3 July 1983. Site V was not sampled in 1983. It was assumed that all nest entrances containing tumuli soil mounds represented active nests.

Four sites were artificially subdivided into 1 m^2 sections on graph paper, then a number was assigned to each section going from left to right across a row. Random digits (Rohlf and Sokal 1969) were used to select numbered sections to examine for nest entrances in the real sites. Quadrats (1 m^2) were used to investigate 38–40% of the random sections of sites I, II, and IV. Because of the great size of site III, 40% of the random sections in a 20 × 5 m portion of it was sampled. The nests found in each quadrat were counted, then observed and expected Poisson frequencies were generated for 5 frequency classes of nests. Frequency classes were 0–4, 5–9, 10–14, 15–19, and 20+ nests. A χ^2 analysis compared the observed and expected Poisson frequencies of nests confined to these classes.

The Coefficient of Dispersion (CD) indicated any deviation from a random distribution of nests within sites. CD represents the variance/mean ratio, which equals 1 in Poisson (random) distributions, is greater than 1 in clumped distributions and less than 1 in regular or even distributions (Sokal and Rohlf 1981).

A nearest neighbor analysis (Clark and Evans 1954) was used to estimate the spatial distribution of *A. macra* nests at sites III, IV, and V, in May 1985. A m^2 quadrat grid was used to record the precise position (in cm) of each nest entrance along the x, y axes of the quadrat on cm ruled graph paper. The distance to nearest neighbor was measured for each nest from the graph, and the mean observed distance determined. The ratio R equals the observed mean distance/expected mean distance, and measures any departure from random spacing of *A. macra* nests. R equals 1 in a random distribution, but equals 0 in a completely clumped distribution (Clark and Evans 1954). The standard variate of the normal curve, C (Clark and Evans 1954), was used to test the significance of the departure from random spacing of nests. The calculated C values were analogous to critical values in a normal distribution table, at infinite degrees of freedom.

Nest structure was observed at sites II–V on 19 July and 6–16 August in 1984, then 10–11 May and 14–22 June 1985. Approximately 20 excavations were made. A nest entrance that had a tumulus and was at least 20 cm away from any neighboring entrance was selected. The direction and depth of the nest were determined by injecting a mixture of powdered paint and water into the entrance, which then dried and outlined the nest.

RESULTS

Distribution.—*Andrena macra* nests were not randomly distributed in nesting sites. Figure 1 illustrates the observed and expected frequencies for classes of nests per m^2 quadrat. Quadrats containing 0–4 nests were more frequent than expected, those containing 5–9 nests were less frequent than expected and those containing 15 or more nests were more frequent than expected. The χ^2 values greatly exceeded those expected for random distributions (Table 1). A positive deviation from randomness (CD > 1.0) meant that *A. macra* nests were clumped

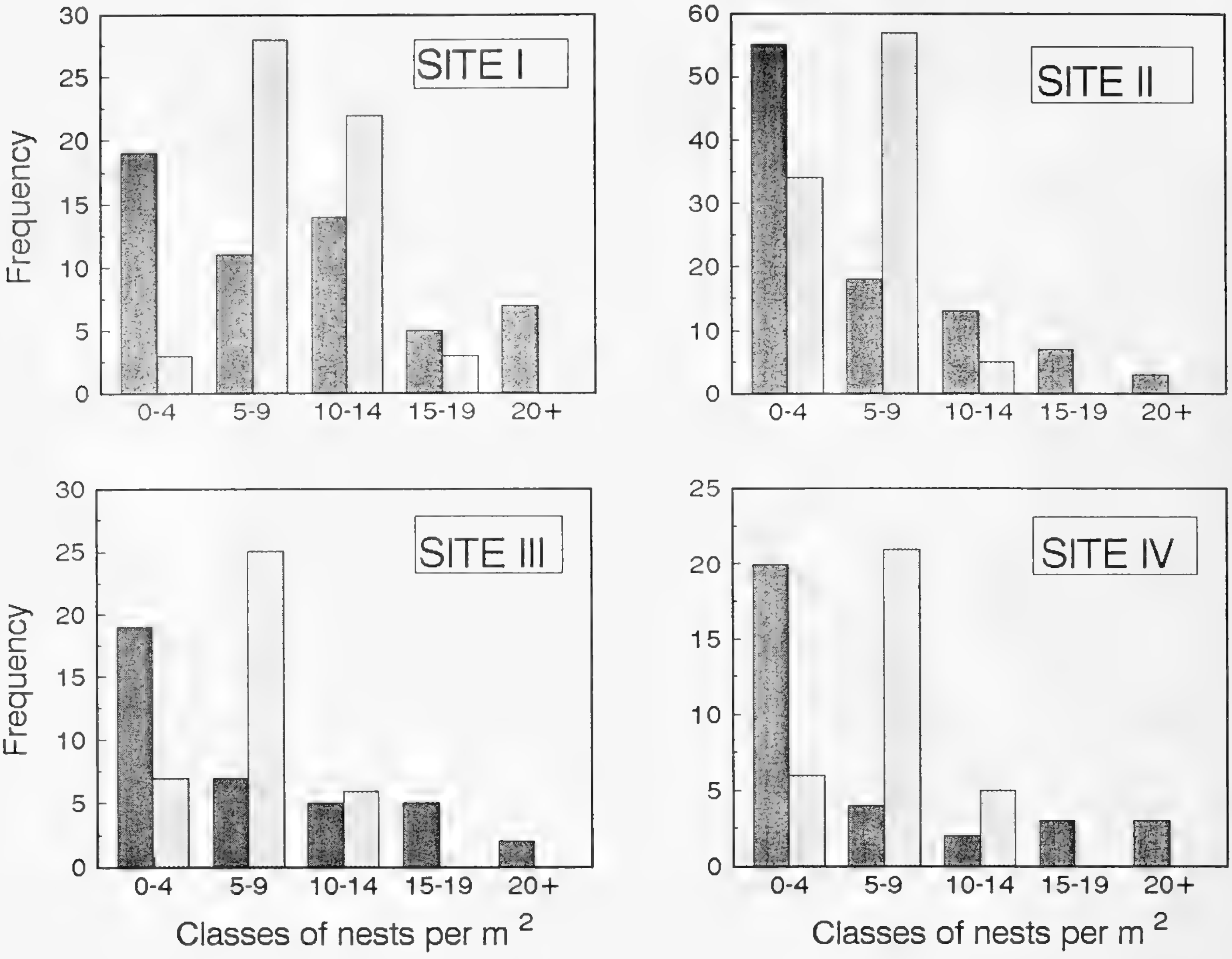

Fig. 1. Frequency diagrams of *A. macra* nest entrances, observed (dark bars) and expected (grey bars), per m^2 quadrat in nesting sites at Quantico, Virginia.

within nesting sites in 1983. The maximum number of nests found in a m^2 section ranged from 21, at site III, to 39, at site I. The estimated number of nests in an entire site was 1330 in site I (143 m^2 area), 1320 in site II (240 m^2 area), 2800 in site III (400 m^2 area), and 552 nests in site IV (80 m^2 area).

Table 2 provides the results of the nearest neighbor analysis for 4 samples, indicating mean distances, observed and expected, between neighboring nests. Distance to neighboring nests ranged from 1–16 cm in sample A, 2–20 cm in sample B, 5–26 cm in sample C, and 2–30 cm in sample D. The R ratio was very close to 1.0 in three of the samples, indicating that spacing between nests was at random within dense areas (aggregates) of sites IV and V, investigated in 1985. Sample A, however, indicated clumped spacing between nests ($P < 0.05$, site III).

Structure.—A typical *A. macra* nest consisted of an entrance, tumulus, main vertical shaft, one or more lateral shafts, and several brood cells. Nest entrances were positioned on clay textured soil. All entrances had a tumulus, defined as a loose pile of soil pellets removed by the female bee as it constructed its nest. Frequently the tumuli were concentric around the entrances, but on other occasions they were irregular piles on either side of them, on sloped surfaces. The mean nest entrance diameter at site III was 5.8 mm (SEM = 0.08, N = 59 entrances) in a 1 m^2 area; at site IV, 5.6 mm (SEM = 0.12, N = 17) in a 0.8 m^2 area, and 6.0 mm (SEM = 0.08, N = 58) in a 0.6 m^2 area. The mean nest entrance diameter at site V was

Table 1. Mean number of *Andrena macra* nests per m^2 in nesting sites at Quantico, Virginia in 1983.

Statistic	Nesting Sites			
	I	II	III	IV
Mean number	9.3	5.5	7.0	6.9
SEM	1.1	0.7	1.0	1.6
Sample χ^2	99	53	34	49
df	2	1	1	1
P	<0.001	<0.001	<0.001	<0.001
CD	7.3	7.9	5.6	11.9

5.8 mm (SEM = 0.07, N = 29) in a 1 m^2 area. Entrances were never blocked with loose soil during nest construction or while the female bee departed the nest to gather pollen-nectar provisions for the brood.

The main nest shaft was a continuation of the entrance and was approximately vertical to the horizontal plane of the roadbank. Shaft inner walls were not coated with any detectable secretion, but they appeared smooth along the entire length. Slight deviations (few cm) away from the vertical plane occurred when pebbles or twigs were avoided, or for no apparent reason. Vertical shaft diameters were approximately the same as entrance diameters along the entire length. Shaft lengths were recorded from complete nests, after the nesting season had ended. The average was 39 cm (SEM = 3.9, N = 8 shafts) at sites II and III combined. Maximum vertical shaft length was 65 cm, minimum was 25 cm. Vertical shafts remained open, or unfilled with loose soil, after the nests were completed and all brood were deposited.

A lateral shaft is simply a short, angled extension of the main vertical shaft. One back-filled lateral shaft was disclosed in a completed nest, and was found to angle at 30–40° downward, from the end of the vertical shaft. It began at 36 cm and was traced to a depth of 42 cm. Unfortunately, it did not clearly end at a brood cell, but cells were situated around it and 2–3 cm beneath it. A non-filled lateral shaft of a nest in an early stage of completion began at the end of the main vertical shaft (37 cm beneath the surface), and ended with an unprovisioned brood cell, 41 cm below the surface. A provisioned and sealed brood cell was 2 cm below the first. The lateral shaft leading to the second cell was not detected.

Brood cells were urn-shaped and composed of two walls, an outer wall of compacted soil and an inner wall of a thin shiny, waxy lining. Each slanted upwards, with the

Table 2. Nearest neighbor analysis of *A. macra* nests in dense areas of sites III, IV, and V at Quantico, Virginia in 1985.

Statistic	Samples			
	A	B	C	D
N (measurements)	59	58	17	29
Area (m^2)	1.0	0.6	0.8	1.0
Obs. mean distance (cm)	5.52	5.17	11.35	9.17
SEM	0.484	0.476	1.74	1.25
Exp. mean distance (cm)	6.51	5.08	10.85	9.28
R	0.848	1.02	1.046	0.988
P	<0.05	>0.5	>0.5	>0.9
Site	III	IV	IV	V

cell cap directed toward the surface at a 30–40° angle, from the vertical axis. Mean inner brood cell dimensions were 6.2 × 10.5 mm (N = 5 cells). The mean number of brood cells contained in a completed nest was 8.3 (SEM = 0.7, N = 9 nests), at sites II and III combined, with a maximum of 12 and a minimum of 4 per nest. Mean brood cell depth beneath the surface of site II was 44.4 cm (SEM = 1.8, N = 22 cells), with a maximum depth of 57 cm and minimum of 30 cm. The mean cell depth beneath site III was 59.8 cm (SEM = 3.3, N = 6 cells), with a maximum of 68 cm and minimum of 46 cm. Cells were positioned several cm beneath the end of the main vertical shaft, and all were clustered within a 5 cm radius of this shaft. Lateral shafts leading to the cells were not disclosed.

DISCUSSION

Distribution.—Hundreds of *A. macra* nests were found in well defined sites on sloping roadside shoulders in soil of mostly clay texture and sparse grass. Large nesting sites may benefit the offspring by increasing the opportunities for mating, as they emerge in early May. Mating occurred on the surface, where males were often seen pouncing on females, as they approached the entrances to their nests (Riddick 1988). Other *Andrena* are known to mate at nesting sites and at floral resources (Barrows 1978).

Large nesting sites have been reported previously for many species of solitary, soil nesting bees (Michener 1974), but the reasons why they persist in restricted areas remain equivocal (Michener et al. 1958, Cane 1991). Butler (1965) suggested that site odor restricts nest building to specific areas even when other suitable areas are close at hand. He transplanted a portion of an *Andrena flavipes* Panzer nesting site, while these bees were overwintering in brood cells, into an unused gravel pit. The following spring season, males and females emerged and many remained in the area around the pit. Mating was observed and female *A. flavipes* constructed new nests in this pit. This newly established site persisted for 5 years (Butler 1965). The chemical secretions released from the female bee's Dufour's gland are used in nest construction and nest marking (Hefetz 1987), but may also be the source of olfactory cues that induce males and females to remain at the nesting site (Duffield et al. 1984). The smell of emerging females or freshly excavated tumulus soil may attract other emerging *A. macra* to remain at the natal site then begin constructing their own nests, or maybe reusing natal nests. Nest reuse has been reported for *Andrena dunningi* Cockerell (Johnson 1981) and *Andrena viburnella* Graenicher (Stephen 1966). Philopatry, or the tendency of offspring to remain at the nesting site from which they were reared, is a possible means by which nest aggregations are initiated (Rosenheim 1990).

It is interesting to note that *A. macra* nests were not randomly distributed in the sites (Table 1), since many were found in a small proportion of the examined m^2 quadrats. The nest dispersion pattern found for this species may be common to all *Andrena,* but no comparable studies have been reported. However, the densities of nests in sample areas of nesting sites are reported for other species. For example, *Andrena alleghaniensis* Viereck nest density was as much as 43/m^2 (Batra 1990), *Andrena candida* Smith ranged from 1 to 5 nests/m^2 (Youssef and Bohart 1968), *Andrena erigeniae* Robertson ranged from 1 to 21 nests/m^2 (Davis and LaBerge 1975), and *Andrena viburnella* Graenicher ranged from 10 to 380 nests/m^2. Sivik (1954) reported 4.6 nests/yd^2 for an *A. macra* nesting site in North Carolina. The mean number of nests/m^2 quadrat ranged from 5.5 to 9.3 (Table 1) for *A. macra* nesting in Virginia, suggesting a moderate nest density, when compared to other species.

Andrena macra nesting sites persist for years. A site near Raleigh, North Carolina persisted for at least 19 years (Sivik 1954).

The sites in Quantico, Virginia were first discovered in May 1983 and were still active in May 1987, as females were observed entering nest entrances laden with pollen.

Structure.—The mean nest entrance diameter for *A. macra* nests ranged from 5.6–6.0 mm. Entrance diameters for other species range from 3.6 mm for *A. candida* nests (Youssef and Bohart 1968) to 7.5–9.0 mm for *Andrena carlini* Cockerell and *Andrena regularis* Malloch nests (Schrader and LaBerge 1978). Diameters are directly correlated with bee size; the larger the female bee, the larger its entrance diameter.

Andrena macra nest entrances were surrounded by tumuli. Each was composed of soil pellets removed during nest construction. Several species build their nests in sandy soil and, as a consequence, lack tumuli because of wind erosion. These include western species, *A. accepta* (Rozen 1973) and *Andrena placida* Smith (Thorp and Stage 1968), and an eastern species, *A. alleghaniensis* (Batra 1990). *Andrena macra* did not intentionally plug nest entrances with loose soil. However, some entrances were temporarily blocked while the females were excavating soil late in the day. *Andrena regularis* (Schrader and LaBerge 1978) and *A. viburnella* (Stephen 1966) nest entrances were similarly blocked with soil during excavations. *Andrena haynesi* Viereck and Cockerell plug their nest entrances with moist sand when not foraging (Parker and Griswold 1982).

One vertical shaft per nest is typical for *A. macra* and most other solitary *Andrena*. It is not filled with loose soil after nest completion. Species that back-fill their nest vertical shaft include *A. candida* (Youssef and Bohart 1968), *A. erythronii* (Michener and Rettenmeyer 1956), *A. regularis* (Schrader and LaBerge 1978), and *A. viburnella* (Stephen 1966).

Nest lateral shafts were back-filled with loose soil by *A. macra,* after nest completion. Many *Andrena* do the same. Some examples include: *A. accepta* (Rozen 1973), *A. alleghaniensis* (Batra 1990), *A. candida* (Youssef and Bohart 1968), *A. chalybaea* (Cresson) (Thorp 1969), *A. erigeniae* (Davis and LaBerge 1975), *A. erythrogaster* Ashmead (Miliczky 1988), *A. erythronii* (Michener and Rettenmeyer 1956), *A. foxii* Cockerell (Linsley et al. 1973), *A. helianthi* Robertson (Parker and Bohart 1982), *A. oenotherae* Timberlake (Linsley and MacSwain 1956), and *A. viburnella* (Stephen 1966). Back-filling lateral shafts is a means of protecting the brood from predators and parasites.

Andrena macra brood cells were urn-shaped, composed of an outer wall of compacted soil, and an inner wall or lining made from a wax-like substance. This cell shape and wall composition is typical for other *Andrena* nests. Inner linings are secreted from the female's Dufour's gland (Cane 1981). This secretion waterproofs the cell (Thorp 1969), maintains cell humidity and deters microbial growth (Duffield et al. 1984). Brood cell depth ranged from 30–68 cm beneath the surface at *A. macra* nesting sites II and III. Other *Andrena* nest cell depths range from 3–8 cm for *A. dunningi* (Johnson 1981), 15–60 cm for *A. placida* (Thorp and Stage 1968), to 270 cm for *A. haynesi* nesting on sand dunes in Utah (Parker and Griswold 1982). *Andrena* may position their brood cells at a certain depth, depending on the soil moisture content at the nesting site. This suggests that cell depth will vary from one locality to the next.

The average number of brood cells per nest was 8 (range 4–12), for *A. macra. Andrena alleghaniensis* nests contain 1–2 cells (Batra 1990), *A. candida* nests have 2–4 cells (Youssef and Bohart 1968), while each *A. viburnella* nest has 12–14 cells (Stephen 1966). The number of cells produced by each female *Andrena* may depend on the availability of floral resources.

Summary.—*Andrena macra* nests displayed a clumped dispersion pattern within 4 sites in Virginia. However, nests were randomly spaced from neighboring ones within

3 of 4 dense areas (aggregates) sampled. An *A. macra* nest contained a single entrance-exit opening, tumulus, single main vertical shaft, soil-filled lateral shafts, and an average of 8 brood cells. Cell number per nest and maximum cell depth beneath the surface were greater for *A. macra* nests than for the nests of many solitary species in North America. *Andrena* are pollinators of many wildflowers, agricultural crops and trees (Batra 1990, Miliczky et al. 1990). Transplanting portions of nesting sites, with the brood intact, into fruit tree orchards is a potential way of encouraging pollination by these indigenous bees. *Andrena* are efficient pollinators of apple in Ontario (Boyle-Makowski 1987).

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TWO NEW SPECIES OF *PELASTONEURUS* FROM ROOSEVELT ISLAND, DISTRICT OF COLUMBIA (DIPTERA: DOLICHOPODIDAE)

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Abstract.—The new species ***Pelastoneurus comatus*** and ***P. potomacus*** are described from the Potomac shore of Roosevelt Island, District of Columbia.

Key Words: *Pelastoneurus,* new species, Dolichopodidae, Potomac River, Roosevelt Island

A series of short collecting stops on Roosevelt Island, District of Columbia, during the Spring of 1991 were expected to be rather uneventful, but on the first attempt collections were obtained of two undescribed species of *Pelastoneurus.* One of the two species was recollected on subsequent visits to the island while the other is still known from only one specimen. The new species are particularly unexpected because previous collecting experience would indicate that *Pelastoneurus* is not a genus in which many novelties are likely in eastern North America.

The habitat of the two new species is along the muddy edges of the Potomac River where it is doubtful that either species could have occurred during the more polluted times of the river's recent history. Although presently known only from Roosevelt Island, both species obviously must have a wider range extending into some areas not affected by the past pollution. The specific localities on the island were also disturbed during the last few decades by construction of the Roosevelt bridge.

Other Dolichopodidae collected on the same muddy shore during the collecting trips in May and June 1991 include the widely distributed *Pelastoneurus vagans* Loew of the United States and Mexico, the local *Rhamphium brevilamellatum* Van Duzee known also from nearby northern Virginia, *Tachytrechus rotundipennis* Greene also of New Jersey and Delaware, and *Gymnopternus annulipes* H. Robinson previously known from Tennessee and Florida.

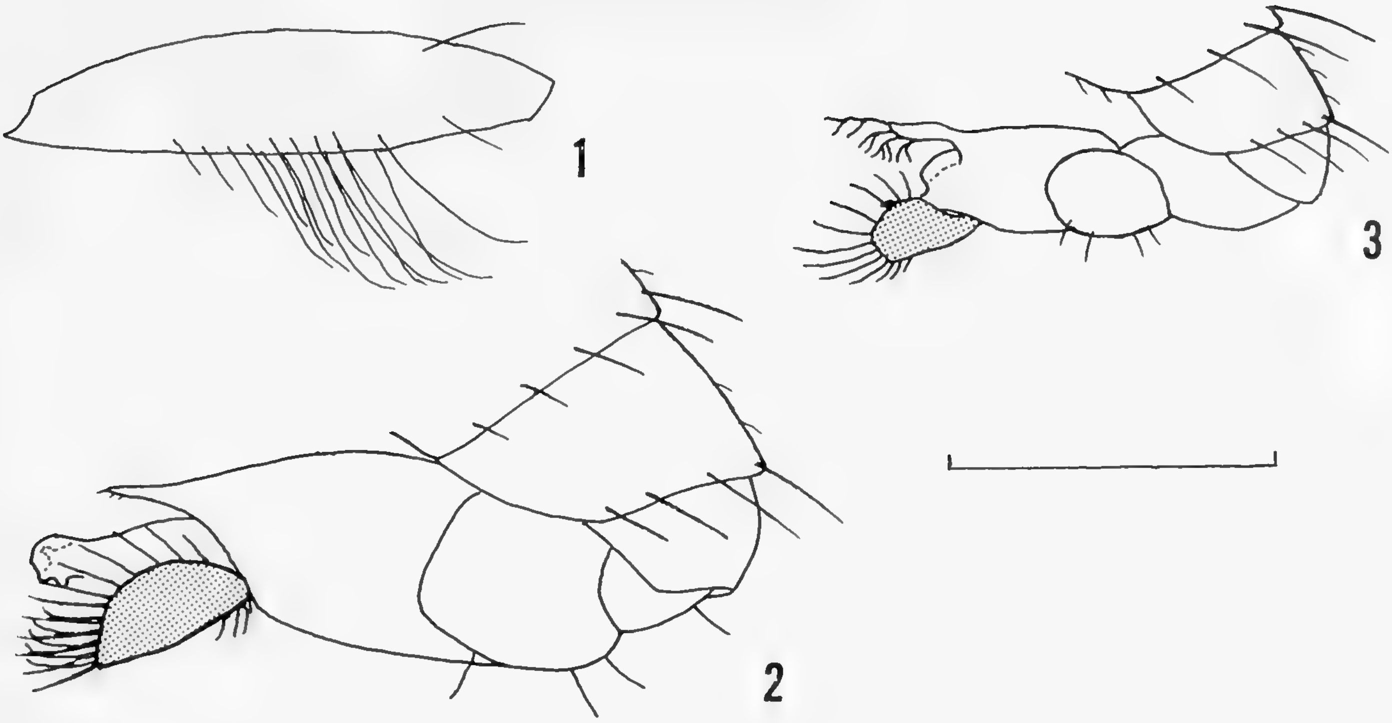
The new species are as follows.

Pelastoneurus comatus H. Robinson, NEW SPECIES
Figs. 1, 2

Male.—Length 4.3 mm; wing ca. 4 mm by 1.3 mm.

Face ¼ as wide as head, with lateral and lower margins nearly straight, strongly bulging and very slightly broader in lower ⅗, slightly yellowish-green above, mostly white-pollinose; front shining metallic blue-green with yellowish reflections near antennae. Palpi broad, grayish pollinose, with scattered short black setae; proboscis black. Antennal segments 1 and 2 blackish above, dark yellowish below; segment 3 blackish, shorter than high, rounded apically, arista from near base above, ca. ⅚ as long as face. Lower postocular setae black.

Thorax with mesonotum greenish brown



Figs. 1–3. *Pelastoneurus* sp., males. 1–2. *P. comatus*. 1. Hind femur. 2. Genitalia. 3. *P. potomacus*, genitalia. Line = 1 mm.

slightly dulled with yellowish pollen anteriorly, shining purplish posteriorly, scutellum greenish, margins above wings from notopleura to scutellum black, white pollinose on notopleura; pleura greenish, slightly dulled with pale yellowish pollen.

Legs mostly yellow; basal corner of coxa I, outside of coxae II & III, extreme tip of femur III, tip of tibia III, tarsi I from joint 3 or 4, and tarsi II & III from tip of basitarsus brown. Femora I & II with scarcely differentiated preapicals posteroventrally, II with sparse erect hairs ventrally near middle with longest as long as femur width, III (Fig. 1) with dense brush of hairs ventrally in 3–4 series, shorter before middle, many beyond middle much longer than femur width. Tibia I with 3 small anterodorsals in slightly stouter darker anterodorsal series; 2 posterodorsals, 1 smaller near 2/7 and larger near 4/7; 3 small subapicals and apicals anterodorsally, posterodorsally and posteroventrally. Tibia II with 3 large anterodorsals near 1/5, 2/5, 3/4, 1 small near 1/8; 2 larger posterodorsals near 1/3, 4/5, 1 smaller near 1/5; 1 large anterodorsal near 1/2; 5 subapicals or apicals. Tibia III with 4 large anterodorsals near 1/7, 3/8, 1/2, 5/7; 3 large posterodorsals near 1/6, 3/8, 4/7, 1 small near 1/7; 1 large anterodorsal near 2/3; 3 apicals, none posteriorly. Tarsi plain except very narrow felt line ventrally on I and small ventral setae on basitarsus III, lengths of tarsal joints from base as, I. 0.35, 0.25, 0.20, 0.10, 0.15 mm, II. 0.65, 0.35, 0.25, 0.20, 0.20 mm, III. 0.50, 0.61, 0.50, 0.40, 0.35 mm.

Wing elliptical with shallowly rounded anal lobe; surface grayish, veins brown. Costa not enlarged near base; R_{2+3} scarcely curved backward, R_{4+5} curving backward slightly more near tip; last of M_1 curving gradually forward beyond middle, ending close to tip of R_{4+5} well before wing apex; crossvein nearly perpendicular to base of M_1, scarcely longer than last of CuA_1. Calypter and halter yellow, former with black setae.

Abdomen with terga metallic yellowish green with slight white pollen on lateral surfaces except at margins. Genital capsule (Fig. 2) elongate, stout, blackish brown with slight whitish pollen on sternite 8; cerci blackish, oblong-elliptic with many black marginal setae on tip and outer margin about as long as lamella width, inner apical prongs with only 2 simple small black setae, inner appendages brown, projecting as small ear-like lobes and a short central peg.

Holotype: Male. District of Columbia: Roosevelt Island, shore by bridge, May 18, 1991, H. Robinson (USNM 104500).

The most distinctive feature of *Pelastoneurus comatus* is the dense fringe of ventral setae on the hind femur. The species would key in Robinson (1964) to *P. seticauda* Van Duzee of Missouri and Tennessee which has a similar type of broad and bulging male face. *Pelastoneurus seticauda* lacks the long hairs on the hind femur, has more pointed ovate cerci, and has inner genitalia with a stout curved spine instead of the large projecting mass bearing earlike apical lobes.

***Pelastoneurus potomacus* H. Robinson, New Species**

Fig. 3

Male.—Length 3.0–3.4 mm; wing 2.7–3.0 mm by 0.9–1.0 mm.

Face ⅕ as wide as head, lateral and lower margins straight, bulging in lower ½, slightly metallic bluish above, mostly silvery pollinose; front shining metallic blue. Palpus broad, blackish with slight whitish pollen, with scattered short black setae; proboscis black. Antennal segments 1 and 2 pale brownish; segment 3 blackish, shorter than high, rounded-truncate apically; arista from near base above, ca. ¾ as long as face. Lower postocular setae black.

Thorax with mesonotum greenish brown anteriorly scarcely dulled with pollen, shining purplish posteriorly, scutellum greenish with purple tinges, a black streak laterally above wing, whitish pollinose on notopleura; pleura greenish dulled with slight yellowish pollen.

Legs mostly yellow, basal ¼ of coxa I, outside of coxae II & III, and tarsi II & III from near tips of basitarsi brown. Femora I & II with scarcely noticeable preapicals posteroventrally, femur III with additional preapical anteroventrally, II & III with fine setulae more erect ventrally. Tibia I with 3 small anterodorsals; 2 posterodorsals 1 small near 1/4 and 1 larger near 4/7; 3 small subapicals and apicals anteriorly and ventrally. Tibia II with 3 large anterodorsals near 1/7, 3/7, 5/7. 1 small near 1/8; 2 large posterodorsals near 1/3, 3/4, 1 small near 1/5; 1 large anteroventral near 1/2; 5 apicals largest posteriorly. Tibia III with 3 large anterodorsals near 1/7, 3/7, 5/7; 3 large posterodorsals near 1/3, 3/7, 3/5, 1–2 small near 4/5; 3 large apicals with none posteriorly. Tarsi plain except ventral white felt on I and small ventral setae near base of basitarsus III, lengths of tarsal joints from base as, I. 0.20, 0.15, 0.10, 0.08, 0.10 mm, II. 0.40, 0.20, 0.15, 0.10, 0.10 mm, III. 0.30, 0.45, 0.30, 0.20, 0.20 mm.

Wing elliptical with shallowly rounded anal lobe; surface grayish, veins brown. Costa not enlarged near base; R_{2+3} nearly straight; R_{4+5} curving slightly backwards; last of M_1 curving gradually forward beyond middle, ending close to R_{4+5} well before wing apex. Crossvein at slightly obtuse angle from base of M_1, slightly shorter than last of CuA_1. Calypter and halter yellow, former with black setae.

Abdomen with terga dark metallic green with slight white pollen on lateral surfaces except near margins. Genital capsule (Fig. 3) elongate, rather narrow, with stout peduncle almost as broad as capsule, blackish brown with slight pale pollen near base; cerci blackish, oval with fan of black marginal setae somewhat longer than length of lamella, inner apical prongs with dense branching pale hairs dorsally, the apical branching hairs longer than setae of cerci.

Female.—Face ca. ¼ as wide as head, brownish pollinose below, paler near margins, strongly bulging in lower ⅗; palpi pale whitish; antennae blackish with segments 1 and 2 and base of 3 more yellow, 3 only ⅔ as long as high, more rounded apically.

Specimens: District of Columbia: Roosevelt Island, shore by bridge, all H. Robinson, 1991. Holotype male, June 2, 1991 (USNM 104501); allotype female, May 19; paratypes 2 males May 18, 1 male May 19, 5 males June 2.

Pelastoneurus potomacus seems well established on the western shore of Roosevelt Island near the bridge. The species keys in Robinson (1964) to the couplet with *P. lamellatus* Loew and *P. parvus* Aldrich, and it keys in Van Duzee (1923) to *P. parvus.* Of the two, *P. parvus* seems closest because of its comparatively narrow genital capsule and more rounded cerci. The new species differs from both the potential relatives by having branched hairs on the apical projection of the genital capsule. In addition, the reexamined type specimen of *P. parvus* has much shorter yellowish brown marginal hairs rather than long black setae on the cerci, a hind tibia with 4 large anterodorsals, and a more pointed third antennal segment about half again as long as high. The branched hairs on the tip of the genital capsule are not as long as those found in *P. laetus* Loew or *P. proximus* Aldrich. The latter two species differ more obviously from *P. potomacus* by having cerci nearly as long as their genital capsules. *Pelastoneurus proximus* to which the species keys in Aldrich (1904) differs further by having a brownish or yellowish face.

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STENELMIS LIGNICOLA AND *STENELMIS XYLONASTIS*, TWO NEW NORTH AMERICAN SPECIES OF WOOD-INHABITING RIFFLE BEETLES (COLEOPTERA: ELMIDAE)

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Abstract.—Adults of two new species of Nearctic *Stenelmis* are described. Both occur throughout much of the lower Midwest, Gulf Coast, and Atlantic Coast states. Adults of **S. lignicola** and **S. xylonastis** typically live in medium to large, warm, sandy rivers where they are found most often on submerged wood. Males of both species lack the spinous mesotibial ridge that occurs on males of nearly all other Nearctic *Stenelmis*. These species are structurally similar to each other and several described species, which has caused confusion in recent literature; emendations of literature records are provided when voucher specimens were available.

Key Words: Elmidae, *Stenelmis,* new species, Nearctic, riffle beetles

As part of a revisionary study of the riffle beetle genus *Stenelmis* in North America (Schmude and Hilsenhoff, in prep.), two new species are described herein. Both are broadly distributed throughout most of the southeastern United States, and are structurally similar to several described species, as well as to each other. Consequently, several publications have mentioned one or the other species (see below), often as misidentifications.

Adults of *S. lignicola* were identified as *S. convexula* Sanderson by Brown (1956), Sanderson and Brown (1959), and White (1980, in part, not all of the specimens were available for study), and as *S. markelii*(*sic*) Motschulsky by Finni and Skinner (1975, in part, not all of the specimens were available for study). Patrick (1961) and Patrick et al. (1967) identified *S. lignicola* as two and seven different species, respectively. Young (1954) identified some specimens of *S. xylonastis* as *S. convexula,* and Barr and Chapin (1988) identified them as *S. bicarinata* LeConte.

Males of both species lack a spinous ridge on the inner margin of the mesotibia, a secondary sexual character that is present on males of all other Nearctic species except *S. sinuata* LeConte; Brown's (1972: 34) statement that males of *S. convexula* lack this structure was in error. The absence of this character was first noticed by Burke (1963), who identified *S. xylonastis* as *Stenelmis* sp. Based primarily on the absence of a mesotibial ridge, adults of both new species were thought to be the "true" *S. bicarinata* by Brown (1987). Schmude and Hilsenhoff

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(1991) corrected this confusion and stated that the two new species would be described later; this article is the follow-up paper to their statement.

MATERIALS AND METHODS

The following institutions and individuals provided specimens for this study: AMNH—American Museum of Natural History, New York, L. H. Herman; ANSP—Academy of Natural Sciences of Philadelphia, D. Azuma; CASC—California Academy of Sciences, San Francisco, D. H. Kavanaugh, R. Brett; CDFA—California Dept. of Food and Agriculture, Sacramento, F. G. Andrews; CLEM—Clemson Univ., Clemson, M. C. Heyn, K. M. Hoffman; CMNH—Carnegie Museum of Natural History, Pittsburgh, J. E. Rawlins; CNCI—Canadian National Collections, Ottawa, L. LeSage; DPIC—Duke Power Company, Huntersville, NC, K. L. Manuel; FAMU—Florida A&M Univ., Tallahassee, R. W. Flowers; FSCA—Florida State Collection of Arthropods, Gainesville, M. C. Thomas; IMNH—College of Idaho Museum of Natural History, Caldwell, W. H. Clark; INHS—Illinois Natural History Survey, Champaign, K. C. McGiffen, K. R. Methven; LSUC—Louisiana State Univ., Baton Rouge, J. B. Chapin, C. B. Barr; MDEQ—Mississippi Dept. of Environmental Quality, Pearl, M. C. Beiser; MSEM—Mississippi Entomological Museum, Mississippi State, T. L. Schiefer; MSUC—Michigan State Univ., Lansing, R. L. Fischer; MCZC—Museum of Comparative Zoology, Harvard Univ., Cambridge, S. P. Shaw, D. Furth, S. Pratt; NCST—North Carolina State Univ., Raleigh, R. L. Blinn; NMNH—National Museum of Natural History, Smithsonian Institution, P. J. Spangler; PERC—Purdue Univ., West Lafayette, A. V. Provonsha, D. W. Bloodgood; RUIC—Rutgers Univ., New Brunswick; SEMC—Snow Entomological Museum, Univ. of Kansas, Lawrence, G. W. Byers, R. W. Brooks, J. Pakaluk, J. K. Gelhaus; TAMU—Texas A&M Univ., College Station, H. R. Burke, E. G. Riley; UAIC—Univ. of Alabama, Tuscaloosa, A. C. Benke; UDIC—Univ. of Delaware, Newark, R. W. Lake; UGAM—Univ. of Georgia Museum of Natural History, Athens, C. L. Smith; UKEC—Univ. of Kentucky, Lexington, P. H. Freytag; UMIC—Univ. of Mississippi, University, P. K. Lago; UMMZ—Univ. of Michigan, Ann Arbor, M. F. O'Brien; UMRM—Univ. of Missouri, Columbia, R. L. Blinn, K. B. Simpson; CBB—Cheryl B. Barr, California State Univ., Sacramento; HPB—Harley P. Brown, Oklahoma Museum of Natural History, Norman; MBG—Michael B. Griffith, West Virginia Univ., Morgantown; KLS—Kurt L. Schmude, Univ. of Wisconsin, Madison; WDS—William D. Shepard, California State Univ., Sacramento; DKY—Daniel K. Young, Univ. of Wisconsin, Madison.

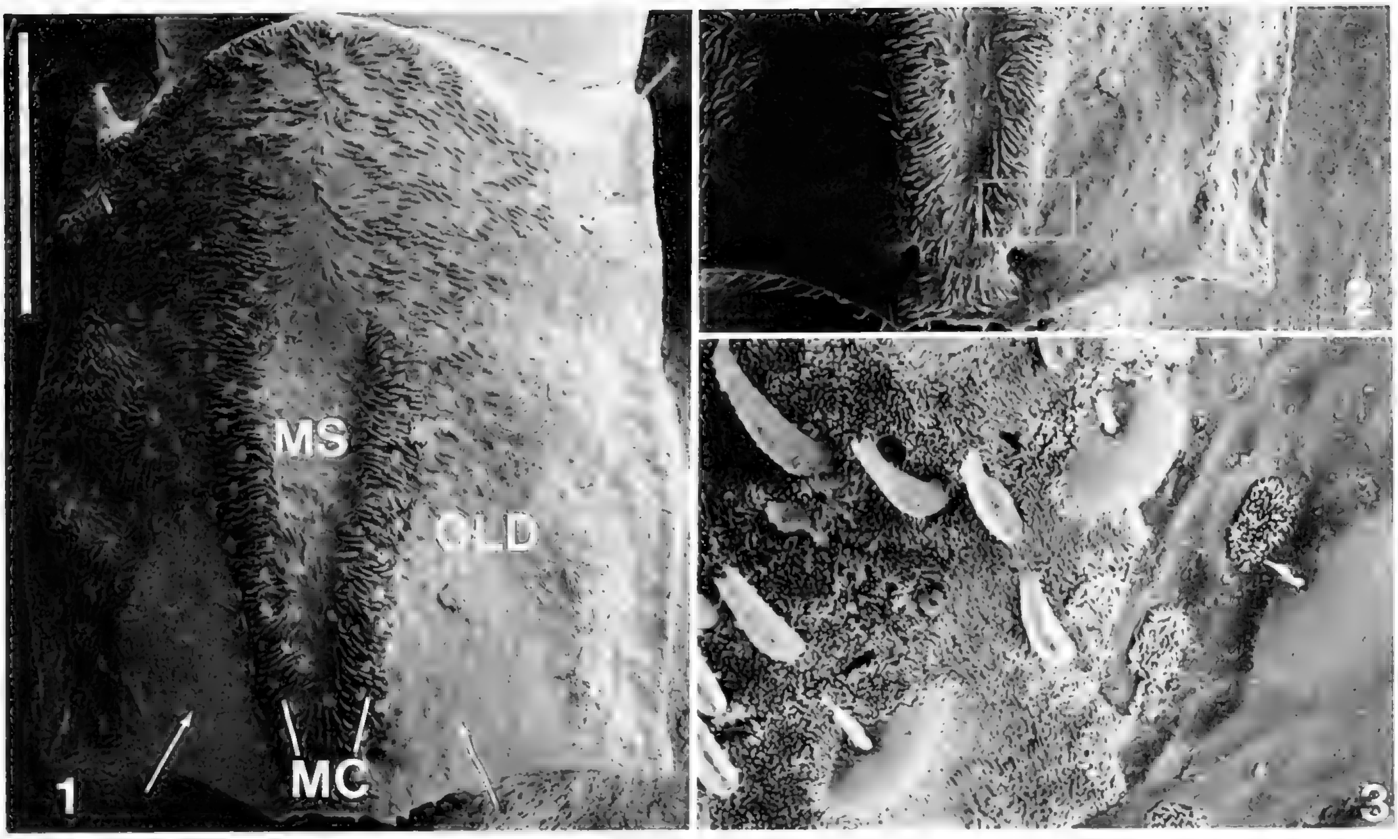
Scanning electron microscope (SEM) micrographs were made using an Hitachi S-570 SEM. Measurements were made at 72× or 144× (for comparative genitalic measurements) with an ocular micrometer on a Leitz dissecting microscope. The following abbreviations and explanations of pronotal structures and measurements are used in the text and Tables 1 and 2. Pronotal structures: **MS**—median sulcus, **MC**—median costae, **OLD**—oblique lateral depression. Measurements: **IOW**—minimum interocular width; **PL**—maximum length of pronotum measured along meson; **PW**—maximum width of pronotum; **PW/PL**—ratio of pronotal width vs. length; **EL**—maximum length of elytra measured from anterior margin to apex along elytral suture with beetle's venter resting on horizontal plane; **EW**—maximum width of elytra; **EL/EW**—ratio of elytral length vs. width; **PE Length**—length of pronotum and elytra, measured separately, and summed. U.S. Postal Service abbreviations for states are used in the Distribution and Habitat sections under each species.

Table 1. Variation of six mensural characters (in mm) and their ratios for adults of *Stenelmis lignicola* throughout its range. M = male, F = female; definitions for other abbreviations found in Methods section.

Locality	n	PL	PW	PW/PL	EL	EW	EL/EW	PE Length	IOW
OK pooled	M 21	0.83–1.00	0.73–0.84	0.83–0.92	2.00–2.31	1.04–1.15	1.84–2.01	2.83–3.24	0.33–0.36
	F 18	0.84–0.96	0.74–0.88	0.84–0.91	2.03–2.30	1.04–1.20	1.89–2.00	2.88–3.26	0.34–0.38
AL type series	M 12	0.84–0.91	0.74–0.84	0.84–0.92	1.98–2.25	1.05–1.16	1.79–1.94	2.81–3.16	0.34–0.38
	F 19	0.86–0.98	0.75–0.88	0.86–0.91	2.00–2.31	1.03–1.21	1.83–1.99	2.86–3.29	0.34–0.40
MS to NC pooled	M 58	0.76–0.98	0.68–0.88	0.83–0.93	1.83–2.31	0.98–1.28	1.80–1.95	2.59–3.29	0.31–0.40
	F 58	0.83–1.00	0.71–0.91	0.84–0.95	1.88–2.40	0.98–1.28	1.81–2.00	2.71–3.36	0.35–0.41
D.C., DE pooled	M 3	0.85–0.94	0.74–0.80	0.85–0.87	1.96–2.11	1.06–1.14	1.85–1.91	2.84–3.05	0.35–0.38
	F 12	0.85–0.98	0.76–0.85	0.85–0.90	1.96–2.33	1.04–1.20	1.85–1.98	2.81–3.29	0.34–0.39
KS to KY pooled	M 39	0.85–0.94	0.74–0.84	0.82–0.90	2.08–2.30	1.09–1.20	1.83–1.96	2.94–3.24	0.33–0.38
	F 48	0.89–0.99	0.76–0.89	0.85–0.92	2.08–2.35	1.10–1.24	1.86–2.01	2.96–3.33	0.35–0.40

Table 2. Variation of six mensural characters (in mm) and their ratios for adults of *Stenelmis xylonastis* throughout its range. Abbreviations as in Table 1.

Locality	n	PL	PW	PW/PL	EL	EW	EL/EW	PE Length	IOW
TX, type series	M 50	0.84–0.98	0.73–0.84	0.81–0.91	1.99–2.28	1.04–1.18	1.89–2.03	2.83–3.25	0.33–0.39
	F 50	0.89–1.01	0.76–0.88	0.81–0.89	2.04–2.35	1.04–1.21	1.86–2.04	2.94–3.36	0.35–0.40
OK, TX pooled	M 42	0.81–1.01	0.71–0.83	0.81–0.89	1.90–2.33	1.00–1.18	1.86–2.01	2.71–3.34	0.33–0.40
	F 49	0.88–1.04	0.74–0.89	0.81–0.88	2.04–2.44	1.03–1.26	1.87–2.04	2.91–3.48	0.34–0.43
LA to FL pooled	M 54	0.83–1.00	0.69–0.89	0.82–0.91	1.95–2.38	1.01–1.24	1.85–2.00	2.78–3.38	0.33–0.41
	F 59	0.91–1.05	0.74–0.93	0.80–0.88	2.14–2.51	1.08–1.30	1.83–2.09	3.08–3.54	0.35–0.43
GA to NC pooled	M 32	0.88–1.01	0.70–0.91	0.80–0.93	2.05–2.35	1.04–1.25	1.82–1.98	2.93–3.35	0.33–0.40
	F 17	0.95–1.09	0.80–0.96	0.83–0.91	2.23–2.48	1.13–1.30	1.88–2.01	3.20–3.56	0.38–0.44
VA to DE pooled	M 4	0.90–0.98	0.81–0.86	0.88–0.92	2.18–2.30	1.14–1.23	1.85–1.92	3.08–3.28	0.38
	F 18	0.91–1.08	0.79–0.95	0.83–0.89	2.09–2.49	1.08–1.30	1.88–1.99	3.00–3.56	0.36–0.45
IN, MO pooled	M 22	0.86–0.95	0.73–0.83	0.82–0.89	2.06–2.28	1.06–1.19	1.85–1.96	2.93–3.21	0.35–0.39
	F 29	0.90–1.01	0.75–0.89	0.80–0.89	2.11–2.34	1.10–1.26	1.84–1.98	3.04–3.34	0.35–0.41



Figs. 1–3. *Stenelmis lignicola* pronotum (dorsal view); bar = 0.30 mm; Alabama specimen. 1, MC—median costae; MS—median sulcus; OLD—oblique lateral depression; arrows point to dark basomesal triangles. 2, Rectangle delineates enlarged portion shown in Fig. 3. 3, Surface at 1000×, shows microtrichial layer and large setae on median costa (left) and absence of layer and large setae on basomesal triangle (right).

Stenelmis lignicola Schmude and Brown, New Species

Stenelmis convexula Brown 1956: 38; Sanderson and Brown, 1959: 67; White, 1980: 98 (in part).

Stenelmis markelii[*sic*] Finni and Skinner, 1975: 390 (Gibson Co., IN, record).

Stenelmis crenata, S. sulcata Patrick, 1961: 255.

Stenelmis bicarinata, S. convexula, S. crenata, S. decorata (in part), *S. hungerfordi* (in part), *S. sinuata* (in part), *S. sulcata* Patrick et al., 1967: 378–379.

Stenelmis spp. Benke et al., 1984: 40 (in part).

Holotype male.—*Head:* IOW: 0.38 mm. Median dark band between eyes uniform in width, equal in width to each light band at midlength. Antennae and palpi testaceous. Antennae shorter than pronotum.

Pronotum (Figs. 1–3): PL: 0.91 mm, PW: 0.83 mm. Widest slightly posterior to middle, sides gradually narrowed to base; more abruptly narrowed anterior to middle, gradually narrowed to apex. MS relatively short and shallow, posterior portion narrowed, obsolete in anterior 0.27 and posterior 0.15. MC distinct but not prominent, most elevated medially, convergent posteriorly, becoming obsolete at point between anterolateral tubercles, obsolete in anterior 0.42 and posterior 0.11. Lateral tubercles not prominent, separated by shallow OLD. Anterior tubercle round; posterior tubercle somewhat elongate, obsolete well before basal margin. Most pronotal granules large, as large as largest femoral granules (a few on posterior surface of MC slightly smaller), relatively dense and evenly distributed over entire surface, though obscured in dark areas. Color mostly gray, granules piceous; two basomesal triangular areas (see below) each bordered by MC, lateral tubercles, and posterior margin, and anterior portion of MS fuscorufous.

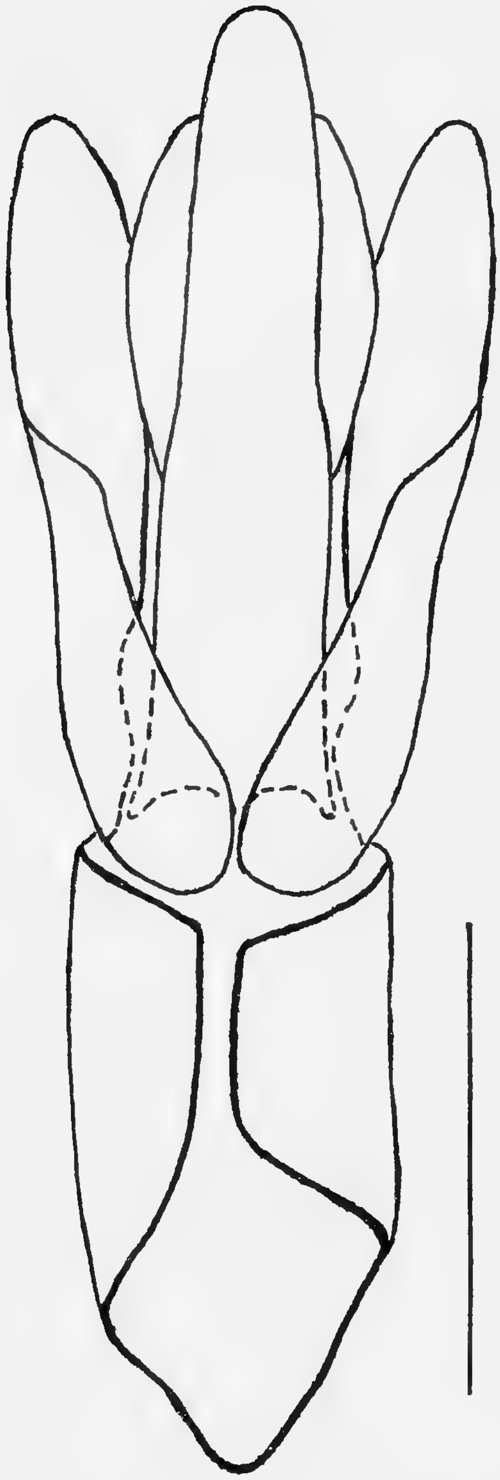


Fig. 4. *Stenelmis lignicola* male genitalia (dorsal view); bar = 0.25 mm; Indiana specimen.

Areas appearing gray when observed by light microscopy are covered with a sheet-like microtrichial layer that is similar to the microtrichial plastron (Spangler and Perkins 1989: 3) and porous plastron layer (Spangler 1990: 2) of the genera *Stenhelmoides* and *Stegoelmis*; structural details of the plastron can only be observed using the SEM. Fuscorufous areas lack the plastron. Figure 3 is an enlarged area of a median costa and a dark basomesal triangle showing the contrasting surfaces.

Scutellum: Six granules present, smaller than pronotal granules.

Elytra: EL: 2.19 mm, EW: 1.16 mm. Low costa on base of interval 3 for 0.15 elytral length, obsolete before reaching basal margin. Background color brown, each elytron bimaculate. Anterior macula not overlapping anterolateral angle (umbone), confined to striae 4–5, slightly longer than costa on interval 3; posterior macula slightly longer than anterior macula, expanded mesally to include stria 3 posteriorly, ending near apex of lateral carina; faint hint of vitta on interval 5 connecting maculae.

Venter: Apical emargination of last sternum relatively wide and deep, but narrower than apical width of metatarsomere 5.

Legs: Granules on femur dense, evenly scattered and of two disparate sizes, with smallest ones less than half size of largest granules. Femur and tibia gray, apex of femur and apex and base of tibia slightly testaceous, tarsus testaceous. Inner margin of meso- and metatibia without spinous ridge. Tarsomere 5 narrow in basal half with margins subparallel, next quarter dilated, apical quarter subparallel; apex 3.0× wider than base; longer than preceding four tarsomeres combined by 0.11 mm in protarsus, 0.13 mm in mesotarsus, 0.09 mm in metatarsus; apicoventral margin weakly convex.

Genitalia (Fig. 4): Penis: widest at base, gradually narrowed to middle, very slightly widened to near apex, then slightly narrowed to its broad and weakly pointed apex; lateral process narrow (0.30 width of narrowest medial point of penis) and arcuate, extending from just basal to narrowest portion of penis to point even with apices of parameres. Parameres: lengths of basodorsal and apicodorsal portions subequal; each inner dorsal margin progressively divergent from base toward outer margin with apical angle rounded and obtuse; outer margins subparallel, slightly convergent at their apices; apices evenly rounded; each inner ventral margin arcuate from apex to near base, then abruptly arcuato-emarginate.

Allotype.—IOW: 0.39 mm, PL: 0.93 mm, PW: 0.81 mm, EL: 2.19 mm, EW: 1.13 mm. Median dark band on head slightly wider than each light band; antennae and pronotum equal in length. Anterolateral margins of pronotum subparallel to apices; all pronotal and scutellar granules as large as largest femoral granules. Costa on interval 3 is 0.17 length of elytra; background color dark brown; posterior macula ending before apex of elytral carina.

Variation.—Within the type series, the antennae of many specimens are longer than the pronotum. The dark basomesal triangles on the pronotum are slightly reduced in some adults. Scutellar granules number 5 to 13. One male has vittate elytra with the medial portion of each vitta faint, narrow and confined to interval 5. Elytral maculae on other specimens are shorter than those on the holotype, being shorter than the costa on interval 3; on two specimens the anterior maculae include part of interval 4; the costae are slightly more pronounced and extend up to 0.20 length of elytra on a few beetles. Tarsomere 5 is longer than the preceding four tarsomeres by 0.10–0.13 mm in the pro- and mesotarsi and by 0.06–0.11 mm in the metatarsus.

Adults from other areas exhibit additional variation. The anterolateral margins of the pronotum are subparallel, convergent, or slightly divergent; the MC are less or more elevated, and obsolete in the anterior 0.37–0.42; the MS is obsolete in the posterior 0.11–0.15; the dark basomesal triangles are rufous to piceous and frequently reduced and crescent-shaped (infrequently absent), especially in specimens from southeastern areas. The elytral costa on interval 3 is quite low to moderately elevated and extends 0.20 the elytral length; the background color is light brown to black; the maculae are very faint to essentially absent. Specimens from Indiana have maculae that are frequently more extensive, expanding to interval 4 anteriorly and stria 3 posteriorly, or even narrowly vittate. In general, northern specimens have more extensive elytral markings and southern individuals are more frequently immaculate. Tarsomere 5 is longer than the preceding four tarsomeres by 0.04–0.11 mm in the metatarsus. The penis is infrequently evenly narrowed from its base to its apex, which is most commonly broad and round; the lateral process is as great as 0.44 the width of the penis; the outer anterior margins of the parameres are slightly arcuate.

Individuals from some populations in southeastern areas of North Carolina to northern Florida, exhibit even greater, but seemingly local, variation. Pronotal granules are smaller than the typically large granules on most individuals; they are as large as or slightly smaller than the largest femoral granules, which are themselves smaller than the typically large femoral granules; the two different sizes of femoral granules are much closer in size to each other. Elytral maculae are more difficult to discern and the elytra are commonly immaculate.

Type data.—*Holotype, allotype, 9 paratypes:* ALABAMA: *Jefferson Co.,* Vestavia Hills, 18 July 1981, T. King, black light trap (holotype with additional label: "mesotarsomere 5 on point, metatarsomere 5 in microvial"). Additional designated paratypes have the following label data: ALABAMA: *Jefferson Co.,* Birmingham, 16 July 1977, T. King, at light (n=15); ibid except 16 June 1978 (n=5). The holotype, allotype, and 4 paratypes will be deposited in the NMNH. Additional paratypes will be in the following collections: 3 INHS, 2 CASC, 2 CNCI, 2 FSCA, 2 SEMC, 2 TAMU, 1 LSUC, 1 MCZC, 1 NCST, 1 MSEM, 1 UGAM, 2 Instituto de Biologia, Universidad Nacional Autonoma de Mexico, Mexico, D.F. (UNAM), 3 HPB, 2 KLS.

Additional specimens examined.—An additional 3512 specimens were examined. Following each collection record, the numbers of individuals are in parentheses and immediately precede the depository institution or private collection, which are abbreviated as in the materials section. Dates and collectors are omitted. Counties or parishes for each state are in italics. **Alabama.** *Colbert* Sheffield (3 FSCA). *Hale* nr Payne Lake, S Duncanville (11 MSUC; 3 KLS). *Jefferson* Birmingham (2 HPB). *Lee* Auburn (2 NMNH). *Montgomery* Montgomery (2 NMNH). *Shelby* Montevallo (25 HPB). *St. Clair* (1 HPB). Springville (3 HPB). *Walker* Jasper (2 HPB). **Delaware.** *New Castle* West Creek, Newark (8 KLS). **District of Columbia.** (2 CMNH). **Florida.** *Calhoun* Chipola R., Scotts Ferry (28 FAMU). Torreya St. Pk. (4 MSEM; 1 KLS). *Gadsden* Chattahoochee (2 FSCA). Quincy (2 NMNH). *Jackson* bluff W Jim Woodruff Dam (42 UMMZ). FL Caverns St. Pk. (2 LSUC; 2 CBB). Spring Lake (158 MSEM; 33 KLS). *Liberty* Apalachicola R., Bristol (3 FAMU). *Okaloosa* Yellow R., Crestview (180 HPB; 21 KLS). *Santa Rosa* NW Holt (8 UGAM). Jay (1 FSCA). W. FL Exp. Sta. (2 FSCA). **Georgia.** *Bibb* GA For. Comm. Sta. (3 HPB). SE Macon (5 CDFA; 1 NMNH). *Brantley* Satilla R. (124 UAIC; 67 KLS). *Brooks* Little R. (3 RUIC). *Burke* Savannah R. (3 HPB), N Upper Three Runs Cr. & Hancock Land. (4 UGAM). *Calhoun* E Leary (1 FSCA). *Charlton* Okefenokee Natl. Widlf. Ref., Stephen Foster cmpgrd. (1 INHS). *Clarke* (1 UGAM). Athens & Whitehall For. (2 FSCA; 11 UGAM; 7 HPB; 4 KLS; 1 WDS). *Cook* Reed Bingham St. Pk. (1 UGAM). *Decatur* Mosquito Cr. (3 FSCA). *De Kalb* Dunwoody (9 FSCA; 2 HPB). *Dougherty* Flint R., Radium Springs (4 ANSP; 1 INHS). *Effingham* Ogeechee R. (145 UAIC; 125 KLS). Savannah R., nr Ebenezer Cr. (13 UGAM; 1 KLS). *Fulton* Bolton (1 UGAM). College Park (71 UKEC; 15 KLS). *Hart* Nuberg (2 FSCA). *Jackson* S Arcade (4 UGAM). *Lowndes* Valdosta (1 UMMZ). *Macon* Flint R. (5 HPB). *Monroe* N Forsyth (2 NMNH). *Montgomery* N Uvalda (10 UGAM; 2 KLS). *Morgan* S Rutledge (2 UGAM). *Pierce*/*Ware* Satilla R. (194 UAIC; 253 KLS). *Richmond* Savannah R., at Butler Cr., Fifth Str. Land. & N Rae Cr. (21 UGAM; 3 KLS). *Toombs* Altamaha R., Hwy 1 (21 HPB). *Ware* Satilla R., Waycross (6 SEMC). **Illinois.** (1 CMNH). *Adams* Quincy (2 INHS). *Champaign* Champaign (3 INHS). Mahomet, Nettie Hart Woodland Mem. (6 INHS). Urbana (1 INHS). **Indiana.** (3 CASC; 6 NMNH in Casey Coll.). *Gibson* White R., Cunningham's Ferry, NW Patoka (14 PERC; 4 KLS). *Howard* (4 LSUC). *La Porte* La Porte (1 CMNH). *Lawrence* E. Fk. White R. (1 HPB). *Marion* Indianapolis (1 FSCA). *Martin* Shoals (1 INHS). *Monroe* Bloomington (7 AMNH; 4 CASC; 1 CDFA; 4 CMNH; 78 FSCA; 8 IMNH; 5 LSUC; 2 MCZC; 12 MSEM; 2 MSUC; 4 PERC; 41 NMNH; 5 SEMC; 25 UMMZ; 50 HPB; 37 KLS). *Orange* W. Baden Springs (3 CASC; 1 KLS). *Pike* White R. (12 HPB). *Shelby* Shelbyville (3 CNCI). *Tippecanoe* Lafayette (1 CMNH). *Vanderburgh* Evansville (2 INHS; 4 NMNH; 4 UMRM). **Iowa.** (4 SEMC). *Des Moines* Burlington (2 MCZC; 4 RUIC). **Kansas.** *Douglas* (1 SEMC). Lawrence (2 CMNH). *Riley* (2 SEMC). **Kentucky.** *Fayette* Lexington (1 KLS). *Jefferson* Louisville (3 NMNH). *McLean* Green R., SE Calhoun (1 ANSP). **Michigan.** *Kalamazoo* Gull L. Biol. Sta. (1 MSUC). **Mississippi.** *Lafayette* Oxford (2 HPB). **Missouri.** St. Louis (1 MCZC). *Dunklin* Kennett (1 MSEM). *Wayne* Williamsville (8 INHS; 6 KLS). **North Carolina.** Fort Bragg (1 CASC). *Bladen* Cape Fear R., S Tolar Land. (2 ANSP). Turnbull Cr., S Ammon (2 NCST). *Catawba* Hog Hill (1 FSCA). *Cleveland* Shelby (2 NCST; 1 KLS). *Columbus* Waccamaw R. (77 KLS). *Craven* Neuse R., Streets Ferry (5 KLS). *Cumberland* Rockfish Cr. (12 KLS). *Durham* Durham, Duke Univ. For. (4 CDFA). Little R. (1 KLS). *Edgecombe* Tar R. (34 KLS). SW Tarboro (1 MSEM). *Granville* Oxford (3 NCST). *Lenoir* Neuse R., Kinston (99 KLS). *Montgomery* W. Fk. Little R., W Ether (1 INHS). *Moore* Southern Pines (2 NMNH). *Pitt* Tar R., Grimesland (2 KLS). *Robeson*

Lumber R., nr Maxton (83 KLS). Shoeheel Cr. (7 KLS). *Rutherford* Broad R. (9 KLS). *Sampson* Black R. (34 KLS). *Scotland* Lumber R., Wagram (27 KLS). *Wake* Raleigh (1 CNCI; 71 NCST; 1 NMNH; 16 HPB; 12 KLS). **Ohio.** (1 AMNH). **Oklahoma.** *Atoka* Clear Boggy Cr. (4 HPB). *Bryan* Blue R., Armstrong & nr Kenefic (233 HPB; 38 KLS), E Reagan (1 WDS). Bokchito Cr. (2 HPB). *Johnston* (2 HPB). Blue R., Wapanucka (17 HPB). Pennington Cr., Tishomingo & Devil's Den (75 HPB; 3 WDS). Reagan (4 HPB). **Pennsylvania.** *Westmoreland* Jeannette (5 CMNH). **South Carolina.** Savannah R. (345 ANSP; 98 INHS; 1 HPB; 9 KLS). *Aiken* (20 INHS). Savannah R., at Upper Three Runs Cr. & Stevens Cr. (236 UGAM; 21 KLS). Upper Three Runs Cr. (5 ANSP), Savannah R. Plant (2 CLEM; 3 KLS). *Allendale* Savannah R., N Lower Three Runs Cr. (20 UGAM; 3 KLS). *Anderson* Anderson (1 INHS). Portman Shoals (5 TAMU). *Calhoun* Congaree R., nr Lexington-Calhoun Co. line (144 ANSP). *Florence* Florence (2 CLEM). *Greenwood* Greenwood (1 SEMC). *Kershaw* Wateree R., nr Camden (20 ANSP). *Oconee* Whitewater R., Jocassee (1 INHS). *Orangeburg* Edisto R., nr Orangeburg (1 ANSP). S Fk. Edisto R., nr CSX railroad bridge & Roberts Swamp (29 DPIC; 10 KLS). *Pickens* Clemson (6 AMNH; 3 CLEM; 63 MSUC; 1 HPB; 8 KLS; 28 DKY). **Virginia.** James R., Sta. 1 (4 ANSP). **Mexico.** Tamaulipas, Punta Piedras (1 MSEM).

Distribution (Fig. 5).—*Stenelmis lignicola* is a common species in the Southeast from northern parts of MS and FL to NC; it is uncommon further north into DE. It is apparently absent from the western Gulf Coast states; Barr and Chapin (1988) did not collect any adults during their extensive study in LA. Besides being apparently locally abundant in OK, and the extensive light trap collections made by F. N. Young in IN, this species is uncommon but widespread in the lower Midwest states. Five specimens of this species and one of *S. xylonastis,* supposedly collected in Jeannette, PA by H. G. Klages (circa 1900), were initially believed to be doubtful range extensions. In later correspondence, J. E. Rawlins (CMNH—curator) stated that although the majority of specimens in the H. G. Klages Collection are correctly labeled, he knows for certain that some individuals are suspect. This fact further supports our doubts about the validity of the specimens' locality labels, although it is possible both species occur (or occurred) in the large rivers around Pittsburgh, PA. Also, one specimen of *S. lignicola,* light-trapped by the late W. H. Cross (MSEM) supposedly in Punta Piedras, Tamaulipas, Mexico, was examined. This record is a significant southwestern extension to the apparent distribution of *S. lignicola* and is considered questionable.

Habitat.—This species is apparently a strict inhabitant of wood, although it is occasionally collected on rocky substrates where it is probably a transient. It occurs chiefly in medium to large, warm, sandy, and often blackwater rivers. Benke et al. (1984) listed *Stenelmis* spp. in their study of the Satilla R., GA; adults were found exclusively on submerged wood, and *S. lignicola* was the most abundant species among their voucher specimens. Adults were found year around in rivers in SC (Patrick et al. 1967) and GA (Benke et al. 1984), and this is probably the case throughout its range. Adults are readily attracted to lights during their dispersal flights. Flight records for the Midwest (MO to KY) include 25 June–5 Sept., while records for the Southeast (AL to NC) are 19 May–9 Oct.

Etymology.—Latin, *ligni* (wood), and *cola* (inhabitant).

Stenelmis xylonastis Schmude and Barr, NEW SPECIES

Stenelmis sp. (*Sinuata-Humerosa* Group, apparently near *convexula* Sanderson and *märkelii* Motschulsky) Burke, 1963: 113.
Stenelmis bicarinata Barr and Chapin, 1988: 136.

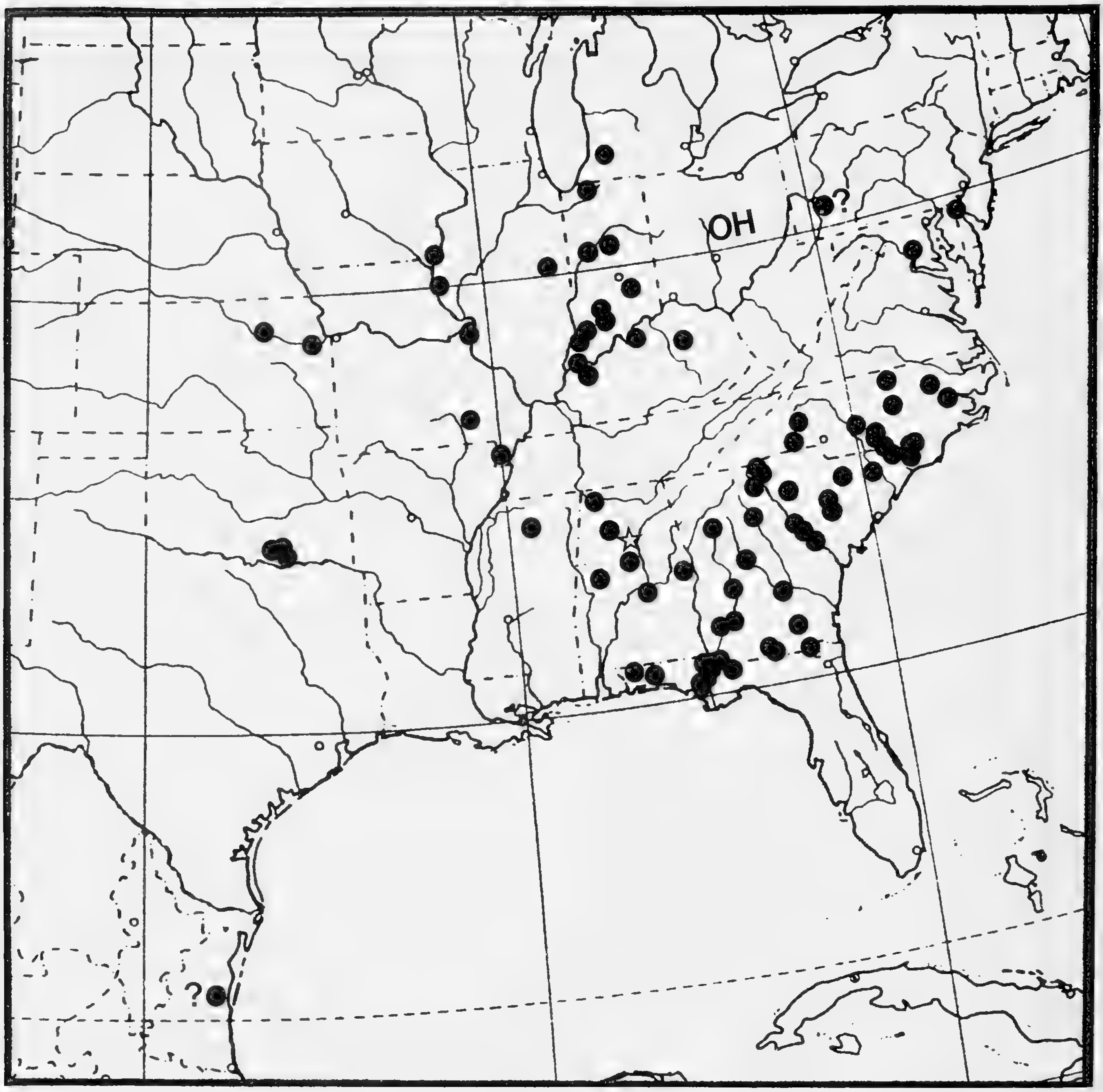


Fig. 5. Distribution of *Stenelmis lignicola.* Star: type locality. OH: a single Ohio record with no further locational details. Pennsylvania and Mexico records are questionable, see section on distribution.

Stenelmis convexula Young, 1954: 214 (in part).

Holotype male.—*Head:* IOW: 0.35 mm. Median dark band between eyes uniform in width, equal in width to each light band at midlength. Antennae and palpi testaceous. Antennae shorter than pronotum.

Pronotum (Fig. 6): PL: 0.91 mm, PW: 0.74 mm. Widest slightly posterior to middle, sides narrowed toward base with a slight sinuation before base; abruptly narrowed anterior to middle, feebly divergent and sinuate to apex. MS distinct, widest and deepest anteriorly, gradually narrowed and shallower toward base. MC low anteriorly, most elevated anterior to posterolateral tubercles, slightly less elevated toward base. MS and MC obsolete in anterior 0.27 and posterior 0.07. Lateral tubercles relatively prominent and separated by shallow OLD that is deepest mesad to posterior tubercle. Anterior tubercle small and round; posterior tubercle weakly and narrowly costate posteriorly, but obsolete well before basal margin. Granules small, slightly smaller than largest femoral granules, uniform in size, sparsely and uniformly scattered over surface, not readily visible in dark areas. Color mostly gray; MC, posterior half of MS, and area of pronotum between posterolateral tubercles lighter gray than remaining surface; granules, anterior half of MS, deepest portion of OLD, and narrow mediolateral band along basal margin fuscous.

Scutellum: Fourteen granules, smaller than pronotal granules, scattered over surface.

Elytra: EL: 2.09 mm, EW: 1.09 mm. Low costa on base of interval 3 for 0.18 elytral length, obsolete before reaching basal margin. Background color dark brown, each elytron very faintly bimaculate. Anterior macula not overlapping umbone, confined to striae 4–5, shorter than costa on interval 3; posterior macula about as long as anterior macula, expanded mesally to include interval 4 posteriorly, obsolete before reaching apex of lateral carina.

Venter: Apical emargination of last sternum relatively wide and deep, but narrower than apical width of metatarsomere 5.

Legs: Femur quite granular in appearance, granules uniformly scattered and of two sizes, with smallest ones about half size of largest ones. Femur and tibia light gray, apex of femur more testaceous, tarsus testaceous. Inner margin of meso- and metatibia without spinous ridge. Tarsomere 5 narrow in basal half with margins subparallel, next quarter dilated, apical quarter subparallel; apex 2.7 × wider than base; longer than preceding four tarsomeres combined by 0.11 mm in protarsus, 0.09–0.10 mm in mesotarsus, 0.08 mm in metatarsus; apicoventral margin weakly convex.

Genitalia (Figs. 7–10): Penis: widest at base, gradually narrowed to middle, slightly widened to near apex where it tapers to an acuminate tip; lateral process narrow (0.27 width of penis at its narrowest medial point), and evenly arcuate, extending from point where penis begins to narrow to point even with apices of parameres. Parameres: lengths of basodorsal and apicodorsal portions subequal; each inner dorsal margin progressively divergent from base toward outer margin with apical angle smooth and obtuse; outer margins subparallel in basal half, slightly arcuate in apical half; apices evenly rounded; each inner ventral margin arcuate from apex to near base, then abruptly arcuato-emarginate.

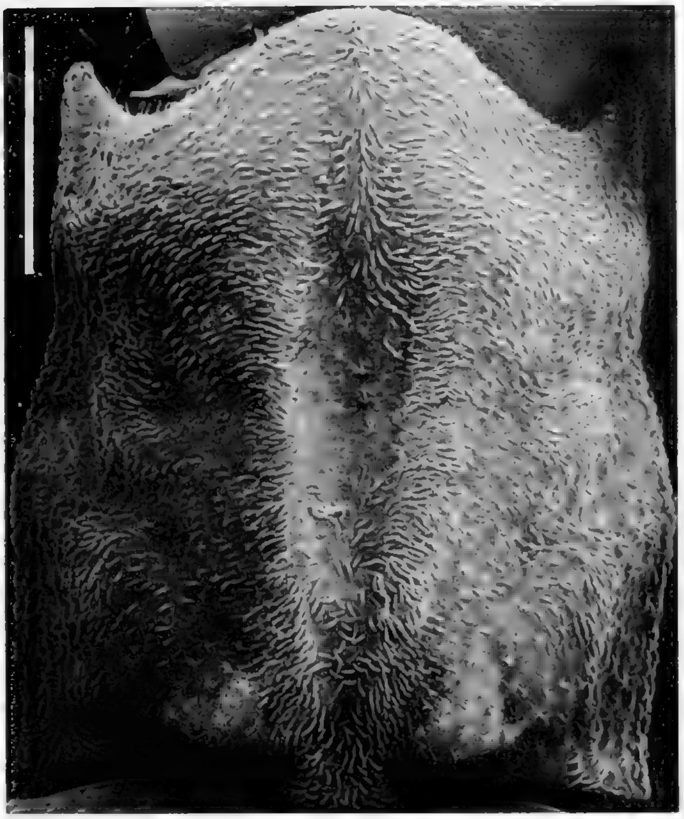
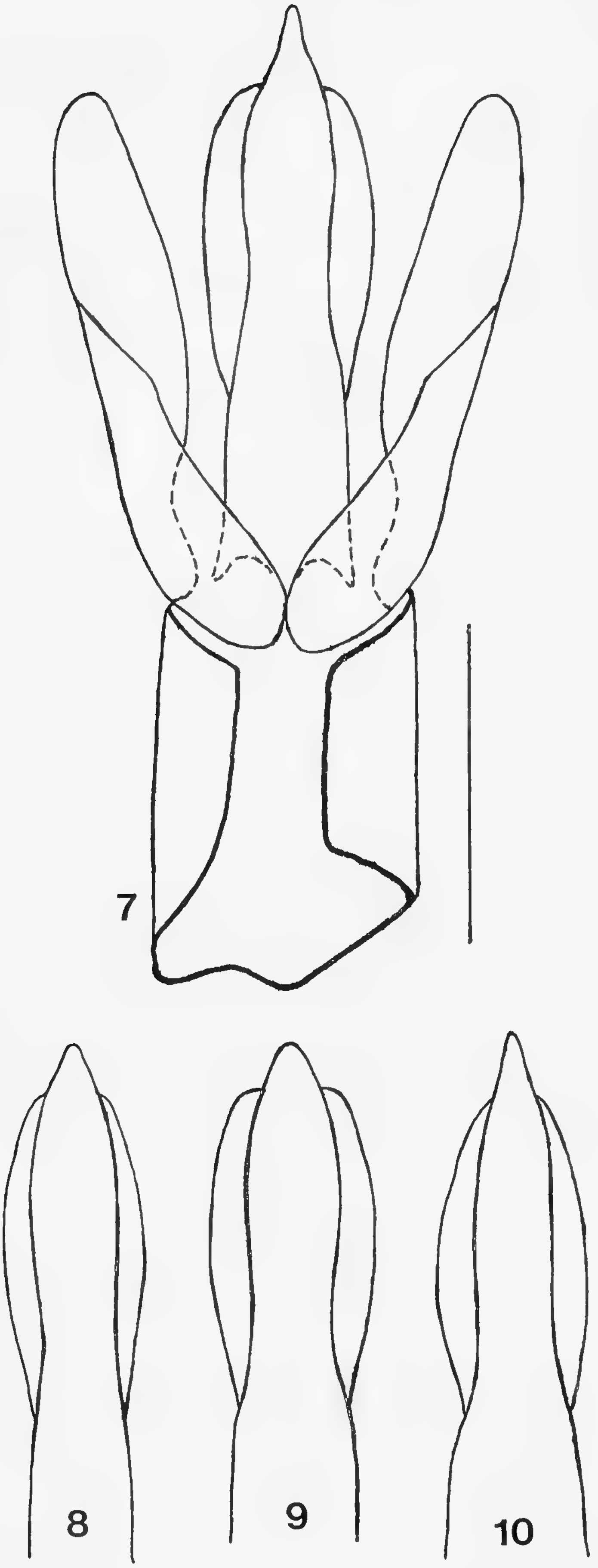


Fig. 6. *Stenelmis xylonastis* pronotum (dorsal view); bar = 0.27 mm; Mississippi specimen.

Allotype.—IOW: 0.36 mm, PL: 0.98 mm, PW: 0.84 mm, EL: 2.23 mm, EW: 1.13 mm. Essentially similar to holotype but larger. Apicolateral margin of pronotum sinuate but not divergent; MC most elevated nearer to base (between posterolateral tubercles); OLD shallower; fuscous areas nearly absent. Eight scutellar granules. Tarsomere 5 longer than combined lengths of preceding four tarsomeres by 0.10 mm in protarsus, 0.11 mm in mesotarsus, 0.06 mm in metatarsus; apex 3.0 × wider than base.

Variation.—Minor variation occurs within the type series. In some beetles the lateral margins of the pronotum are not sinuate basally, and the apical portions are subparallel or more divergent and not sinuate; MS and MC are less pronounced and obsolete



Figs. 7–10. *Stenelmis xylonastis* male genitalia showing variability of apex of penis (dorsal view); bar = 0.25 mm. 7, Parameres spread wider than natural; Mississippi specimen. 8, Holotype. 9, Paratype. 10, North Carolina specimen.

in the anterior 0.24–0.28 and posterior 0.08–0.11; fuscous areas are most commonly absent, but some paratypes have expanded fuscous areas that form basomesal triangles as in *S. lignicola.* The elytral maculae are infrequently brighter, and more frequently narrower or obscure with the elytra appearing immaculate. Pro- and mesotarsomere 5 of males and females are 0.08–0.11 mm and 0.06–0.11 mm longer, respectively, than the preceding four tarsomeres combined, while metatarsomere 5 is longer by 0.05–0.10 mm in males and 0.04–0.08 mm in females. The apex of the penis in some males is not as acuminate (Fig. 9).

Variation in individuals elsewhere is minimal. The median dark band on the head is narrower than the lateral light bands. The pronotal MS and MC are obsolete in the anterior 0.23 and posterior 0.05, and the posterolateral tubercle is weakly raised and obovate instead of costate. The scutellar granules are as few as 8. The elytral costa on interval 3 extends 0.14–0.22 the elytral length; the background color is pale brown to black; maculae are commonly bright and infrequently wider with the anterior macula confined to interval 4 to stria 5, and the posterior macula expanded mesally to include interval 3 posteriorly; the anterior macula is sometimes longer than the costa on interval 3; pale markings end at the apex of the lateral carina or slightly beyond. Some adults are vittate with the vittae similarly confined but narrowed to interval 5 medially. The margins of the penis are subparallel anteriorly in some males (Fig. 10); the acuminate apex is even more exaggerated in many males, especially those from Mississippi (Fig. 7).

Adults from populations in eastern North Carolina and South Carolina show greater, yet seemingly isolated, variation. Pronotal granules are larger and more densely distributed than the typically small and inconspicuous granules on most adults; they are as large as the largest femoral granules. The elytral costa on interval 3 nearly reaches the basal margin. Elytral markings may be brighter, maculate to vittate, wider (striae 3–5), and uniform in width. The lateral process is as great as 0.63 the width of the penis.

Type data.—*Holotype, allotype,* 217 *paratypes*: TEXAS: *Grimes Co.,* Navasota, Navasota River, 31 August 1967, H. P. Brown. The holotype, allotype, and 15 paratypes will be deposited in the NMNH. Additional paratypes will be in the following collections: 15 CASC, 15 INHS, 12 SEMC, 7 CNCI, 7 TAMU, 6 MCZC, 4 FSCA, 2 LSUC, 2 UNAM, 2 MSEM, 2 NCST, 2 PERC, 2 UGAM, 2 UMRM, 2 University of Wisconsin-Madison, 12 CBB, 84 HPB, 21 KLS, 3 WDS.

Additional specimens examined.—An additional 2412 specimens were examined. **Alabama.** *Baldwin* Fish R., SW Loxley (2 CBB). *Blount* Blount Springs (3 HPB). Mill Cr. (3 HPB). *Conecuh* Bushy Cr., SW Lenox (3 LSUC; 5 CBB). *Jefferson* Birmingham (2 HPB). Vestavia Hills (4 HPB; 1 KLS). *Mobile* Mobile (6 INHS; 5 MCZC; 5 SEMC, 1 HPB). *Pickens* Reform (1 INHS). *Shelby* Montevallo (48 HPB). *Walker* Jasper (16 HPB). **Arkansas.** *Cleveland* (1 HPB). *Little River* Red R., Ashdown (1 HPB). **Delaware.** *Kent* Tappahanna Ditch, Marydel (1 UDIC). **District of Columbia** (1 NMNH). **Florida.** *Bay* Pine Log Cr. (4 FAMU). *Jackson* bluff W Jim Woodruff Dam (1 UMMZ). *Okaloosa* (1 UMMZ). Blackwater R., NW Holt (1 FSCA; 1 UGAM). Yellow R., Crestview (1 HPB). Shoal R., at Cox Br. (6 FAMU). *Santa Rosa* Blackwater R., NW Holt (5 UGAM; 1 KLS). *Walton* De Funiak Springs (2 CNCI; 4 SEMC; 2 KLS). Turkey Cr., S Florala AL (1 CBB). **Georgia.** Atlanta (1 HPB). *Bibb* GA For. Comm. Sta. (1 HPB). *Clark* Whitehall For. (1 HPB). *Effingham* Ogeechee R. (3 UAIC). *Grady* Spence Mill Cr., NE Spence (16 MBG; 2 KLS). Tired Cr., E Cairo (1 UGAM). *De Kalb* Dunwoody (1 HPB). *Muscogee* Kendall Cr., E Columbus (1 LSUC; 1 CBB). *Richmond* Savannah R., N Rae Creek (3 UGAM). *Toombs* Ohoopee R., Lyons (1 INHS; 1 SEMC). **Indiana.** *Crawford* Grantsburg (1 AMNH; 1 KLS). *Monroe* Bloomington (1 HPB). **Kentucky.** *McLean* Green R., SE Calhoun (5 ANSP). **Louisiana.** Detailed data for the 54 localities listed for LA by Barr and Chapin (1988, under *S. bicarinata*) are all valid and not repeated here. *Allen* Calcasieu R., NW Oberlin (3 CNCI). *E. Baton Rouge* Greenwell Springs (1 CASC; 1 SEMC). *Winn* Winnfield (6 MCZC). **Maryland.** *Prince Georges* Bladensburg (11 NMNH; 1 KLS). Priest Bridge & Riverdale (2 NMNH). **Mississippi.** nr Hattiesburg (1 AMNH). *Adams* E Natchez (2 UMIC; 4 HPB; 2 KLS). *Covington* Lux (8 HPB). Okatoma Cr., Seminary (11 MDEQ). *Forrest* Black Cr., SE Hwy 59 (14 FAMU). Myers Cr. (2 LSUC; 2 CBB; 13 WDS). *George* Lucedale, Dog R. & Cedar Cr. (4 INHS). Pascagoula R., Merrill (2 MDEQ). Whiskey Cr. (1 INHS; 1 SEMC). *Greene* Gaines Cr. (4 INHS). Leaf R., McLain (7 HPB). nr State Line (9 MSEM; 2 UMIC; 3 HPB; 3 KLS). Whiskey Cr., Leaf (4 INHS; 1 SEMC). *Harrison* Biloxi (1 HPB). Gulfport (1 LSUC). Long Beach (1 FSCA). N Lyman (2 UMIC; 1 HPB). *Jackson* Pascagoula R., Big Creek (3 MDEQ). *Jefferson Davis* (18 MSEM; 1 KLS). *Lafayette* Oxford (6 UMIC; 3 HPB; 1 KLS). *Lamar* Black Cr. (23 HPB). Monroe Cr., S Sumrall (1 MDEQ). *Leflore* Greenwood (1 SEMC). *Lowndes* Camp Pratt (2 INHS). Columbus (1 SEMC). *Marshall* Chewalla Lake (1 UMIC). *Monroe* Hamilton (7 SEMC; 1 KLS). *Oktibbeha* Adaton (1 MSEM). Starkville (4 MSEM; 1 KLS). *Pearl River* Wolfe R., Hwy 26 (13 MDEQ). *Perry* Coleman Cr., New Augusta (1 WDS). W McLain (119 HPB; 20 KLS). *Pike* Tangipahoa R., Magnolia (33 HPB). *Pontotoc* SE Ecru (1 MSEM). *Simpson* Strong R., Mendenhall (5 HPB). *Smith* (1 RUIC). *Stone* Black Cr. (10 SEMC; 2 KLS). Red Cr. (1 UMIC; 1 HPB). *Warren* NE Bovina (2 UMIC; 2 HPB). *Wayne* Clara (6 INHS). **Missouri.** *Perry* Mississippi R., dike 100.1R (1 UMRM). *Ripley* Little Black R., W Glenn (3 UMRM; 2 KLS). *Wayne* Williamsville

(60 CNCI; 27 INHS; 57 KLS). **North Carolina.** *Bladen* Cape Fear R., S Tolar Land. (1 ANSP). *Columbus* Juniper Cr. (15 KLS). Waccamaw R. (1 KLS). *Cumberland* Rockfish Cr. (4 KLS). *Edgecombe* SW Tarboro (1 MSEM). *Granville* Oxford (2 NCST; 2 HPB; 1 KLS). *Moore* Lower Little R. (7 KLS). Mill Cr., Lakeview (1 FSCA). *Onslow* Gum Br. (8 KLS). New R. (7 KLS). *Robeson* Shoeheel Cr. (4 KLS). *Scotland* Big Shoeheel Cr. (2 KLS). *Wake* Raleigh (8 NCST; 1 NMNH; 1 HPB; 1 KLS). **Oklahoma.** *Atoka* Caney Cr. (3 HPB). Clear Boggy R. (221 HPB; 20 KLS). *Bryan* Blue R., NW Armstrong & nr Kenefic (40 HPB). Bokchito Cr. (1 HPB). *Cherokee* Terrapin Cr. (1 HPB). *Choctaw* Clear Cr., E Swink (3 HPB). *Coal* Clear Boggy Cr. (101 HPB; 23 KLS). *Johnston* Blue R. (1 HPB). Mill Cr., W Mill Creek (1 HPB). Pennington Cr., Tishomingo (3 HPB). *Latimer* W Red Oak (1 FSCA; 135 HPB; 67 KLS). *Le Flore* Poteau R. (11 HPB), SW Arkoma (1 WDS), Hodgen (25 HPB), E Panama (4 CBB; 9 KLS; 58 WDS). *McCurtain* Clear Cr. (1 HPB). Glover R., NW Broken Bow (3 WDS). Mountain Fk. R., nr mouth (2 HPB), Smithville (1 WDS). Yanubbee Cr., N Broken Bow (2 KLS). *Pontotoc Co.* Buck Cr. (7 HPB). *Pushmataha* Kiamichi R., SE Clayton (3 KLS; 15 WDS). **Pennsylvania.** *Westmoreland* Jeannette, (1 CMNH). **South Carolina.** *Aiken* Savannah R., at Stevens Cr. (1 UGAM). *Florence* Florence (5 CLEM; 4 NMNH). *Kershaw* Wateree R., nr Camden (3 ANSP). *Oconee* Seneca (1 CLEM). *Orangeburg* S Fk. Edisto R., at Roberts Swamp (1 DPIC). **Tennessee.** *Shelby* Loosahatchie R., nr Memphis (1 ANSP). **Texas.** Sabine R. (18 ANSP). *Anderson* Boxes Cr., SW Elkhart (3 INHS; 32 TAMU; 2 HPB). *Bexar* nr Schertz (1 CBB). *Brazos* Cedar Cr. (3 TAMU). College Station (2 TAMU). Navasota R., E Bryan (7 CASC; 6 TAMU). *Jefferson* Neches R., Beaumont (2 ANSP). *Grimes* Navasota R., N Navasota (19 TAMU). *Limestone* Navasota R., Groesbeck (2 HPB). *Montgomery* Sam Houston Natl. For., Stubblefield L. (2 TAMU). W Fk. San Jacinto R., Conroe (43 HPB; 11 KLS). The Woodlands (3 UGAM; 2 TAMU). *Nacogdoches* Angelino R., Douglass (30 HPB; 10 KLS). Lanana Cr. (1 WDS), Nacogdoches (10 WDS). *Polk* Long King Cr., Livingston (2 INHS; 5 TAMU; 4 HPB). *Robertson* Camp Cr. (2 TAMU; 1 HPB). *San Jacinto* Big Cr. Scenic Ar. (3 TAMU). *Walker* San Jacinto R., W New Waverly (31 TAMU; 2 HPB). **Virginia.** Fredericksburg (13 NMNH; 1 KLS). *Fairfax* (1 NMNH). mouth of Difficult Run (1 NMNH).

Distribution (Fig. 11).—*Stenelmis xylonastis* is relatively common across the western Gulf Coast states from western AL to eastern TX, including southeastern OK. It is widespread from northwestern FL to DE, but considerably less common. Its northern limit is in IN, where it is rare. There is one doubtful record from PA (see distribution under *S. lignicola*).

Habitat.—Burke (1963) reported finding this "common elmid . . . on submerged logs," and it appears that it is most often found on submerged wood, although adults were more frequently collected on rocks, debris, submerged tree roots, and aquatic plants than those of *S. lignicola.* In fact, slightly more collections of *S. xylonastis* were made from gravel than wood in LA (unpublished data). It is most prevalent in medium to large, warm, sandy, and often blackwater rivers, but Barr and Chapin (1988) found them in many small, cool, sandy, spring-fed streams. Adults have been found year around in rivers in the Southeast, and this is probably typical throughout its range. During their dispersal flights adults may be readily collected at lights. Our records indicate flight periods from 29 Apr. to 10 Sept. for areas in the Southeast, and from 2 July to 17 Aug. in MO to IN.

Etymology.—Greek, *xylo* (wood), and *nastis* (inhabitant).

Diagnoses.—The two species described in this paper cannot be inserted into the adult keys of Sanderson (1938) and Brown

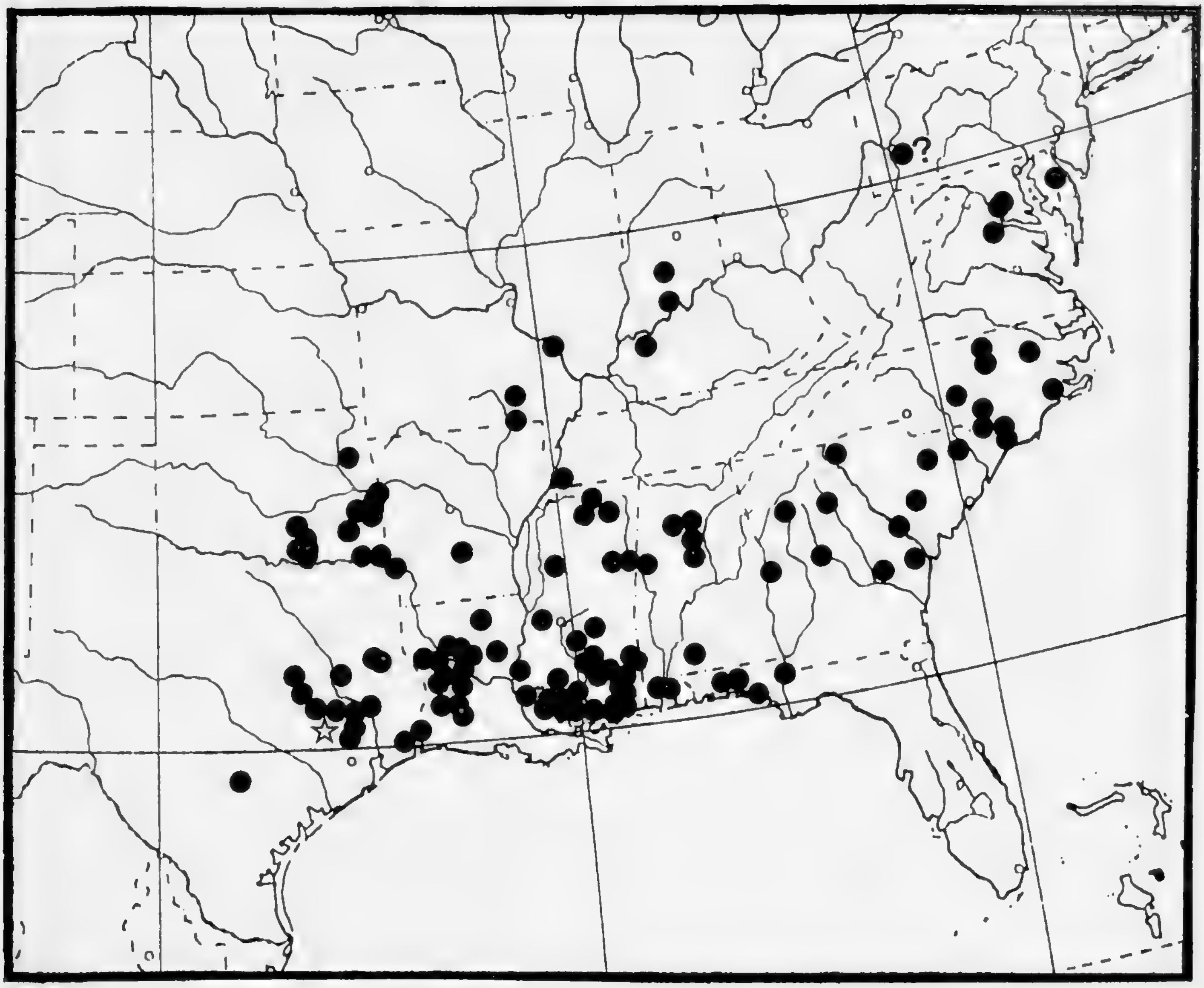


Fig. 11. Distribution of *Stenelmis xylonastis*. Star: type locality. Pennsylvania record is questionable, see section on distribution.

(1972) for the same reasons outlined in Schmude and Brown (1991). Instead, we provide a discussion on distinguishing characters. Both species would be placed in Sanderson's (1938) *sinuata/humerosa* group.

Males of both species can be distinguished from all other species, except *S. sinuata,* by the lack of a spinous mesotibial ridge. An accuminately tipped penis will separate males of *S. xylonastis*; the penes of *S. lignicola* and *S. sinuata* are more similar to each other, but in many *S. sinuata* the penis is wider with the margins straight and not medially sinuate. For *S. lignicola,* the pronotum has large granules, dark basomesal triangles (which may be crescent-shaped or otherwise reduced), and MC that are obsolete over a greater anterior portion. The femoral granules are typically of two disparate sizes with the largest subequal in size to the largest pronotal granules; the largest femoral and pronotal granules are distinctly larger and more numerous than those on adults of *S. sinuata* and *S. xylonastis.* The elytra most frequently have narrow maculae. For *S. xylonastis,* the combination of small pronotal and femoral granules, and very narrowly maculate or immaculate elytra (rarely vittate), are good characters; dark basomesal areas on the pronotum are not common. For *S. sinuata,* the pronotal and femoral granules are numerous, medium in size, and more raised, making the pronotal surface appear more rugged; there are no dark pronotal areas; the anterolateral margins are typically strongly divergent, more so than on the two new species. Elytral coloration is absent or consists of narrow, short maculae; strial punctures appear larger and deeper. These characters, along with the measurements listed in Tables 1 and 2, should easily identify most individuals of *S. lignicola* and *S. xylonastis.* Schmude and Hilsenhoff's revision will provide more detailed diagnoses.

Acknowledgments

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NOTE

First Distributional Records of *Ixodes dammini* Spielman, Clifford, Piesman, and Corwin in South Dakota (Acarina: Ixodidae)

Ixodes dammini Spielman, Clifford, Piesman, and Corwin was described by Spielman et al. (1979. J. Med. Entomol. 15: 218–234) to include ticks found to be vectors of lyme disease along the New England coast from Nantucket Island west to Shelter Island, New York. No records of *I. dammini* have been reported to date in South Dakota.

In 1969 McDaniel (unpublished data) collected *I. scapularis* (confirmed by personnel, Rocky Mountain Laboratory, Hamilton, Montana) from Brookings County, South Dakota from a deer. This record was not included by Easton (1983. Entomol. News 94: 191–195) in his checklist of the ticks of South Dakota. With the description of *I. dammini* and its importance as a cause of human babesiosis in the United States, *I. scapularis* became restricted to ticks collected in the southern United States and *I. dammini* to ticks collected from the northern United Sates.

On October 14, 1991 Kathy Asper of Watertown, South Dakota sent a single engorged female tick specimen to South Dakota State University for identification. It was tentatively identified as *I. scapularis* as it did not match the description of *I. dammini.* The specimen was sent to Dr. J. E. Keirans for confirmation and was identified as *I. dammini* by Dr. Keirans. The letter from Dr. Keirans had a postscript that stated "I think in the not too distant future *I. dammini* will become a synonym of *I. scapularis.*"

The specimens collected from a deer at Brookings in 1969 constitute the first record of *I. dammini* for South Dakota.

The 1991 collection of *I. dammini* was found indoors in a home on the top of a bedspread where it had dropped from a pet dog. The dog had been on the bed, stood up, shook itself and the tick was seen falling on the bedspread. The 1969 specimens were collected from a road killed doe a mile north of Brookings by the senior author.

The single female of *I. dammini* ex. dog Watertown, South Dakota, collected October 14, 1991 is deposited in the U.S. National Tick Collection (RML-120568), the specimens collected from the deer are in the South Dakota State H. C. Severin Insect Collection, Brookings, South Dakota.

The authors express their sincere appreciation to Dr. James E. Keirans, Research Professor and Curator, U.S. National Tick Collection, Georgia Southern University, for his identification of *I. dammini* and information regarding *I. scapularis.*

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NOTE

Pollen and Nectar Feeding by *Chilocorus kuwanae* (Silvestri) (Coleoptera: Coccinellidae)

Predaceous coccinellids are known to have a wide variety of accepted food. Even explicitly carnivorous lady beetles will supplement their diet with pollen and nectar from flowers and extrafloral nectaries (Hagen. 1962. Annual Review of Entomology 7: 289–326; Hodek. 1973. Biology of Coccinellidae. Junk, The Hague). There has, however, been relatively little work on the dietary habits of coccinellids that prey on scales of the family Diaspididae (Drea and Gordon. 1990. *In* The Armoured Scale Insects, Their Biology, Natural Enemies and Control. Vol. B. Elsevier, Amsterdam, pp. 19–40). This is a report on observations of adults of the imported diaspidid predator *Chilocorus kuwanae* (Silvestri) feeding on nectar and pollen of the host plant (*Euonymus* sp.) of one of its prey, the euonymus scale, *Unaspis euonymi* (Comstock) (Homoptera: Diaspididae).

Between April and September 1990, the Korean strain of *C. kuwanae* was released (n = 764) at a commercial location in Raleigh, N.C.; the site consisted of a low hedge (approx. 1 m) comprised of 8 bushes of *Euonymus japonicus aureo-variegatus* ("Gold Spot") severely infested with euonymus scale. On the morning of 4 June 1991, adult *C. kuwanae* (n = 27 by casual count) were observed on the flowers of these shrubs. The observed adults were the first generation of the year (matured from eggs produced by overwintering adults). Pupae and adults were the most abundant stages of *C. kuwanae* at the site, although a few late-instar larvae were also present. The bushes were largely free of live scale at the time of the observation.

On 6 June 1991 more detailed behavioral observations were conducted at the same site. We noted that adult *C. kuwanae* on flowers had their mouthparts in contact with the base of the ovary (Fig. 1). Because ants and honeybees were also observed in a similar position on the flowers, it is presumed that all these insects were feeding on floral nectar; floral nectaries in the family Celastraceae occur between the stamens and the ovary (Esau. 1965. Plant Anatomy. John Wiley & Sons, N.Y.). Adult *C. kuwanae* were observed similarly oriented on flowerheads of *Euonymus kiautschovicus* ("Manhattan") at a second site in Raleigh on 9 July 1991.

Eleven adults (6 males, 5 females) were collected from the flowerheads (6 June 1991) and brought back to the laboratory where they were dissected and their stomach contents inspected with phase contrast at 40×. All insects were positive for the presence of pollen in the gut. The prolate-spheroidal shape and the surface pattern of the pollen observed in the gut contents were consistent with that of published pictures of euonymus pollen (Lewis et al. 1983. Airborne and Allergenic Pollen of North America. The Johns Hopkins University Press, Baltimore), and with euonymus pollen collected from anthers and observed with a phase contrast microscope. Although thrips (*Frankliniella triticae* (Fitch)) were present on flowerheads at the site, no insect parts were obvious in the gut contents of the dissected coccinellids.

The reported observation of pollen and nectar feeding in *C. kuwanae* indicates that, when prey is scarce, this predator can supplement its diet with food of plant origin. Although nectar may be a source of energy for adults, it is probably nutritionally insufficient for egg or fat production (Hagen 1962). Pollen, however, is rich in protein (Levin and Haydak. 1958. Proceedings of the 10th International Congress of Ento-

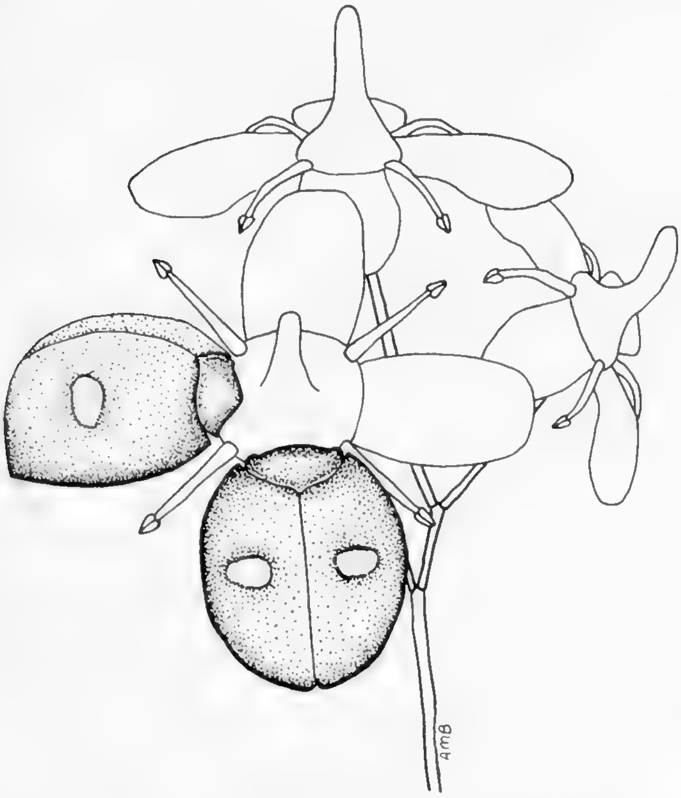

Fig. 1. Adults of *Chilocorus kuwanae* feeding at floral nectaries of *Euonymus* sp. Drawn from a photograph.

mology 4: 1079–1084), and may support oögenesis in the females. Unfortunately, we did not note the condition of ovaries in dissected females; the observed nectivory probably occurred during the pre-oviposition period of the newly emerged adults.

There is currently an extensive program for the release and distribution of *C. kuwanae* in the United States (Drea and Carlson. 1987. Proceedings of the Entomological Society of Washington 89: 821–824; Hendrickson et al. 1991. Proceedings of the Entomological Society of Washington 93: 197–200). These lady beetles can be reared in large numbers on scale infested bushes in outdoor insectaries, or on scale reared on squash in the laboratory (Tanaka and Kobayashi. 1970. Proceedings. Association for Plant Protection of Kyushu 16: 56–59; J. J. Drea, pers. comm.). Because of the need to synchronize the supply of scales to the needs of the beetles, however, periods of food shortage are a common problem in rearing these insects for biocontrol programs.

C. kuwanae has a wide host range within the Diaspididae and maintains itself on rotational prey over the course of the year (Kato. 1968. Kontyu 36: 29–38). Because of the reported observations, and because the ability to maintain a species of coccinellid on artificial diet may be related to broadness of host range (Hussein and Hagen. 1991. Entomologia Experimentalis et Applicata 59: 197–199), it may be possible to formulate a non-scale diet for laboratory maintenance or mass rearing of *C. kuwanae.* Artificial diet was a valuable alternative to natural prey for maintaining *C. nigritus* (Fabr.) adults. Artificial diets were, however, suboptimal for larval development and the maintenance of adults in *C. bipustulatus* L. and *C. infernalis* Muls. (Hattingh. 1989. 7th International Congress of the Entomological Society of South Africa, pp. 15–16).

We thank David L. Stephan (Entomology Department, North Carolina State University) for identifying the thrips, and John W. Scott (Plant Protection, North Carolina Department of Agriculture) for identifying the plants.

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Note

New Collections of Sexuales of *Diuraphis* (Homoptera: Aphididae) in North America

The 1986 discovery in the United States of *Diuraphis noxia* (Mordvilko), the Russian wheat aphid (Stoetzel. 1987. Journal of Economic Entomology 80: 696–704), brought renewed interest in the biological development of all species of *Diuraphis* occurring in North America. Aphids in this genus are pests of various grasses and small grains including wheat. The occurrence, or not, of sexuales and viable overwintering eggs impacts our efforts to control these pest species, and researchers are encouraged to look for these developmental stages.

On September 7, 1989, while working at the ARS European Parasite Laboratory, Behoust, France, one of us (MBS) discovered an apterous male of *D. noxia* in a laboratory colony originally collected on wheat and barley at Kishinev and vicinity, Moldavia, USSR (now Moldova), May 28–June 2, 1989. This represented the first contemporary collection of a sexuale of *D. noxia*. Subsequently, apterous oviparae and additional apterous males were reared from the same colony. In November 1989, apterous oviparae and apterous males were collected in fields in the Crimea; and apterous oviparae were collected in fields in the Ukraine (Kiriac et al. 1990. Proceedings of the Entomological Society of Washington 92: 544–547). Grossheim (1914. Memoirs of the Natural History Museum Zemstvo Governmental Taurida, Simferopol III: 35–78) reported that the sexuales of *D. noxia* were apterous.

Since the 1989 discovery of sexuales of *D. noxia* in the colony from Moldavia, a concerted effort has been made to determine if sexuales of *D. noxia* are being produced in North America. In November 1989, Susan Halbert (Kiriac et al. op. cit.) collected a few oviparae of *D. noxia* in Idaho and Oregon. One of us (MBS) has seen two oviparae of *D. noxia* collected January 5, 1990, by Keith A. Mirkes et al. in a laboratory colony originally collected in Bailey Co., Texas, and being maintained on a mixture of wheat and barley at the USDA/ARS Plant Science Laboratory, Stillwater, Oklahoma. To date, no males of *D. noxia* have been collected in North America.

In September 1990, Stoetzel collected *D. nodulus* (Richards) on downy brome in Sunderland, British Columbia, Canada, the type locality. This represented the first find of this species since Richards' original description in 1954 (Canadian Entomologist 91: 248–253). Specimens were sent to Cho-Kai Chan, Agriculture Canada, Vancouver, British Columbia, for establishment of a colony. Unfortunately, the colony developed into oviparae only and was lost. On September 12, 1991, one of us (RWH) collected and the other (MBS) identified one apterous male and more than 25 apterous oviparae of *D. nodulus* on mountain brome, *Bromus marginatus* Nees ex Steud., at the Upper Colorado Environmental Plant Center (UCEPC), Meeker, Colorado. More than 30 additional oviparae were collected at the same location on October 8, 1991. On March 26, 1992, on mountain brome at UCEPC, Meeker, Colorado, one of us (RWH) collected several overwintering eggs, some of which hatched after 4–5 days in the laboratory. This represents the first and only collection of sexuales and overwintering eggs of *D. nodulus*.

Gillette described *D.* (*H.*) *tritici,* the western wheat aphid, in 1911 (Entomological News 22: 440–442) from specimens collected on leaves of Colorado blue-stem, "*Agropyron glaucum,*" at Fort Collins, Colorado. Gillette reported that he had collected both apterous oviparous females and apterous males. Parker (1916. Journal of Economic Entomology 9: 182–187) reported that overwintering eggs of *D.* (*H.*) *tritici,* a major pest of wheat, *Triticum aestivum* L., hatched in early April in Montana and that stem mothers matured within two weeks. Parker reported that males and oviparae first appeared about October 15th and that egg-laying continued into December. On October 8, 10, 1991, one of us (RWH) collected and the other (MBS) identified 6 males and more than 50 oviparae of *D.* (*H.*) *tritici* on mountain brome at UCEPC, Meeker, Colorado. One of us (RWH) collected several overwintering eggs, some of which hatched after 4–5 days in the laboratory.

Walker (1848. The Zoologist 6: 2217–2221) described *D.* (*H.*) *frequens* from apterous oviparae and apterous males reportedly collected on *Artemisia maritima* near Fleetwood, England. On February 1, 1990, Susan Halbert (personal communication) collected one apterous male of *D.* (*H.*) *tritici* in a laboratory colony originally collected in Idaho and maintained on wheat at the University of Idaho facility in Parma.

A complete report of the morphology of these sexuales and the status of the species in *Diuraphis* will be given in a future article.

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BOOK REVIEW

Leafhoppers (Cicadellidae): A Bibliography, Generic Check-list and Index to the World Literature 1956–1985. P. W. Oman, W. J. Knight, and M. W. Nielson. 1990. CAB International, Wallingford, Oxon, U.K. 368 pp. $98.00 (hardcover).

The 30-year period from January 1956 to December 1985 witnessed a period of growth in leafhopper taxonomy unparalleled in the history of binomial nomenclature. This flurry of new taxa was precipitated by the publication of Metcalf and Wade's comprehensive *General Catalogue of the Homoptera,* which, ironically, hastened its own obsolescence by organizing the vast literature of the Auchenorrhyncha and providing a basis for further research. The number of leafhopper genera described since Metcalf and Wade (1084 new genera between 1956 and 1985) is rapidly approaching the number included in their catalogue, which covered the 200 years of taxonomy prior to 1956.

Oman and colleagues have not attempted to duplicate the detail of the *General Catalogue,* a daunting task that would have delayed publication for another decade. Instead, they have provided a concise and timely summary of post-Metcalf progress in the study of Cicadellidae. *Leafhoppers* will aid systematists and curators as well as non-taxonomists by organizing the plethora of family- and genus-group names, referencing identification aids, and providing access to the vast applied entomological literature on leafhoppers. The literature review and subject index refer the user to massive quantities of behavioral, biogeographical, ecological, and physiological data.

Following a brief introduction, in which the authors repeat the *raison d'être* of taxonomic catalogues and list summary statistics on the numbers of taxa described and papers published since Metcalf and Wade, a concise review summarizes the cicadellid literature for the years 1942–1955—papers included in Metcalf's catalogue but not in his bibliography and subject index.

The bibliography of over 6000 citations includes nearly all significant papers that discuss leafhoppers published from 1956 to 1985. Annotations indicate the content (including names of new family- and genus-group taxa) and language of each publication, when not obvious from the title. Journal titles are given in full.

The check-list follows and includes, in addition to the comprehensive and fully annotated list of family- and genus-group names, a list of family-group names proposed between 1956 and 1985, an alphabetical list of the 120 subfamilies and tribes recognized in the literature, a list of names erroneously listed as Cicadellidae in the *Zoological Record,* a list of references giving information on misidentified type species and other nomenclatural problems, and a list of names placed on the official lists of valid and rejected names in zoology. The section, "Use of Family-Group Names . . . ," illustrates the prevailing state of confusion regarding the higher classification of the Cicadellidae and provides a baseline of knowledge for a much needed revision of cicadellid family-group taxa. The check-list seems complete and well edited. I found no omissions and only minor typographical errors (e.g. *Adchunroides* Maldonado-Capriles is misspelled, p. 186).

Following the check-list, subject and taxonomic indices list papers published between 1956 and 1985. The subject index begins by listing general works, including reviews, bibliographies, and catalogues, followed by more specific subject areas (such as biology, ecology, pests, etc.) that are arranged alphabetically (except "Host Plant Resistance" follows "Insect Collections" and "Pathogen/Vector Interactions" comes after "Vectors of Plant Pathogens"). Plant pathologists and economic entomologists will welcome the latter section and the section on pest status, in which references are grouped by pathogen and crop name, respectively. Also valuable is the section on regional and local faunas, which lists faunal works for over 100 localities ranging in size from island to hemisphere, and the section on life histories, which lists nearly 100 species. Curators will find useful the list of references that discuss the holdings of various museums and locations of personal collections. Although excellent in its overall coverage, the usefulness of the subject index is diminished somewhat by the presence of overly inclusive subheadings, such as "Bionomics" and "Ecology," which comprise well over 300 citations each. Here the authors would have done well to follow Metcalf's *Bibliography of the Homoptera,* in which the "Morphology" heading comprises over 100 sub-headings, versus four under the equivalent heading "Structure" of Oman et al.

In the taxonomic index, citations for each genus are divided into "New species" and "Records." The latter category comprises annotated citations to works that include keys, phylogenies, redescriptions, nomenclatural changes, type designations, collection localities, or other information. Curiously, replacement names proposed for junior homonyms are not indexed separately (although cross-referenced in the check-list). Southern's (1982a) study of Peruvian *Empoasca,* in which 44 new species were described, is not listed in the index (although included in the bibliography).

Leafhoppers is a indispensable reference that should be on the shelf of every entomological library and on the desk of anyone with an interest in the auchenorrhynchous Homoptera. The type is a small but readable, laser-printed camera-ready copy and the binding seems adequate to withstand repeated use. Unfortunately, the poor-quality paper does not befit a work of such importance.

Too often the value of check-lists and bibliographies, for systematics and for biology in general, is not fully appreciated. Yet the basic role of such works in stimulating research and preventing needless repetition is undeniable. Paul Oman and his colleagues have produced a work of fundamental importance to the study of Cicadellidae.

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BOOK REVIEW

The Insects and Arachnids of Canada. Part 17. The Wolf Spiders, Nurseryweb Spiders, and Lynx Spiders of Canada and Alaska (Araneae: Lycosidae, Pisauridae, and Oxyopidae). Charles D. Dondale and James H. Redner. Agriculture Canada Publication No. 1856. 1990. 383 pp. Paperback ($20.00 in Canada, $24.00 elsewhere). Available from Canadian Government Publishing Centre, Supply and Services Canada, Ottawa K1A 0S9, Canada.

The spider superfamily Lycosoidea is characterized by the transformation of the tapetum of the posterior and lateral eyes into the so called "grate-shaped tapetum." Lycosoidea includes roughly ten families and about 235 genera and 3700 species (Coddington and Levi. 1991. Annual Review of Ecology and Systematics 22: 565–592). The present volume deals with the Canadian and Alaskan representatives of Lycosoidea, that is, the families Lycosidae, Pisauridae, and Oxyopidae. The same authors have also treated the Canadian fauna of the families Philodromidae, Thomisidae, Clubionidae, and Anyphaenidae, in parts 5 and 9, respectively, of the same series. This identification manual for lycosoids follows the same format as the mentioned preceding volumes.

The Introduction gives a short description of the classical lycosoid synapomorphy (the grate-shaped tapetum) and describes collecting techniques for these three spider families. The methods of study are presented at the end of this section. The Anatomy section presents a complete and concise description of the external morphology of the wolf, lynx, and nurseryweb spiders, and is particularly useful for the non-specialist.

The taxonomic section starts with the family Lycosidae, followed by Pisauridae, and concludes with the family Oxyopidae. Each family has an introductory section on the natural history of the group in which many of the works dealing with different aspects of their biology are cited. This part is followed by the morphological description of the family itself. Diagnoses are given under the "Comments" section. Keys for genera and species are provided in both English and French. The keys are explicit and clear, and profusely illustrated. The same format is used for the genus and species descriptions. The species descriptions are concise and include a section on the geographical range and another on relevant aspects of their biology. Species descriptions are profusely illustrated with drawings of the male and female genitalia, as well as a dorsal view of the body (there are a total of 592 drawings plus four photographs). In addition to these illustrations, 91 maps cover distributions in Alaska, Canada, and the bordering U.S. states. In total, the book treats 107 lycosid species (distributed in 14 genera), seven pisaurid species (in two genera), and two species of oxyopids (in a single genus). The bibliography section is exhaustive and contains more than 250 references. The book also contains a fairly extensive glossary (129 entries) of spider anatomical and morphological terms. Although some of the definitions in this section are given in a lycosoid context (e.g. haematodocha, median apophysis), the glossary will prove particularly useful for the readers not familiar with spider morphology. The book has been carefully edited and the illustrations are clearly labeled and numbered; I found almost no typographical errors.

As an identification manual for the lycosoids of Canada and Alaska this book is an excellent work, but there are a few points that deserve some comment because they clearly highlight the difference between taxonomy and systematics. Readers expecting a minimum of phylogenetic insight in this work, even within the geographical constraints imposed by the scope of the book, might be disappointed. For example, under the familial and generic descriptions, plesiomorphic and apomorphic characters could have been explicitly discriminated, so that each supraspecific taxon description would be accompanied by the list of putative synapomorphies. After all, we all (or at least a good number of systematists) would like to see that classifications are established as a reflection of the phylogenies underlying organic diversity. A few years prior to the publication of the present book the senior author published an excellent phylogenetic analysis of the subfamilial structure of Lycosidae (Dondale. 1986. Actas X Congreso Internacional de Aracnología, Jaca (España) 1: 327–332) in which the family was divided into five subfamilies. I was puzzled to see that Dondale's subfamilial classification was absent from the book. No explanation is offered in the text and one cannot help wondering why these subfamilies are not treated, since at least four out of the five subfamilies that Dondale considered as valid have representatives in Canada and Alaska. Also, some taxonomic decisions in Dondale and Redner's book need further explanation. *Dolomedes* is treated as a pisaurid genus, but in Platnick's catalog (Platnick. 1989: 398. Advances in Spider Taxonomy, 1981–1987 . . . . Manchester University Press) the family Dolomedidae is considered a valid taxon, although of "undemonstrated validity." If the reader wonders why the authors did not recognize the latter family, he or she will not find the answer to that question in the present book. Incidentally, Sierwald (1990:50. Nemouria 35: 1–59) has formally rejected the validity of Lehtinen's Dolomedidae in a recent work on pisaurid palp morphology. The genus *Hogna,* formerly considered a junior synonym of *Lycosa,* is resurrected without a formal discussion (p. 35), which results in a series of new combinations. A similar case involves *Varacosa* (p. 91), in which some revised combinations are established. Since the book does not have an abstract or a summary where these taxonomic decisions are highlighted, the reader will have to search carefully for them throughout the text, usually at the end of the "Comments" section. It seems that a more practical and "user-friendly" (especially if the user is a cataloger) way of flagging such taxonomic decisions (e.g. New Combination) would have been to include them after the taxon name and author at the heading of each description.

In the description of the family Lycosidae the authors point out that in lycosids the male palpal sclerite called the "conductor" might have four different origins (tegulum, base of the palea, median apophysis, or terminal apophysis), therefore recognizing, at least implicitly, the non-homology of some conductors. In a strict sense the term conductor should be used only for those structures of tegular origin, if homology is to be preserved in across-taxa comparisons. However, that is not always the case in this book, because in several instances a functional criterion is taken, which might be misleading (e.g. p. 97, figure 209; in this case the "conductor" is in fact an extension of the palea, as the authors point out). Once more, a phylogenetic approach, not incompatible with the goals of an identification manual, would have been very much desired.

Limiting the scope to arbitrary political boundaries might be the most serious criticism of this work, since it is obvious that some of the phylogenetic, taxonomic, and faunistic insight is likely to be lost in the process. It would be unfair to blame the authors for the extremely limited regional scope of the book, a decision that very likely is imposed by the research policies of Agriculture Canada. Such constraints and impositions on systematics are in clear opposition with the aims and nature of this science. I find such policies alarming, particularly in times in which documenting and preserving the remaining (and shrinking) biodiversity of the planet is a moral obligation of the scientific community, especially of the so called "industrialized countries." Dondale and Redner have already published numerous systematic studies on North American (and Central American) lycosids, which make some parts of the present volume somewhat repetitive (in fact many of the figures of the book are taken from the original revisionary work). Considering that resources are limited and that much revisionary work is still needed with North American spiders (linyphiids are a clear and painful example), such redundant treatment of some lycosoids might be interpreted as "overkill."

On the other hand, one cannot deny how practical it is to have the information on Canadian and Alaskan lycosoids condensed in a single volume. This is nonetheless a fine identification manual and I strongly recommend it to all spider systematists, as well as to those concerned with identifying North American spiders.

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SOCIETY MEETINGS

972nd Regular Meeting—January 9, 1992

The 972nd Regular Meeting of the Entomological Society of Washington was called to order by President Wayne N. Mathis in the Naturalists' Center of the Natural History Building at 8:00 p.m. on January 9, 1992. Twenty-one members and four guests were present. Minutes of the December meeting were read by President Elect Russell Stewart and approved as read.

President Mathis called for reports from officers. Membership Chairman Ralph Eckerlin read the names of two applicants for membership, Goran Noordlander, Department of Plant and Forest Protection, The Swedish University of Agricultural Science, Uppsala, Sweden, and James A. Slater II, Lawrence, Kansas. He also read a letter informing the society that Ted Tibbets, a member for many years, passed away on June 7, 1991. His special interest had been acarology and his family has established The Ted Tibbets Memorial Scholarship for students studying acarology at Utah State University in Logan, Utah.

Nathan Schiff brought in a live (or at least recently alive) grylloblattid he collected at Echo Summit, Nevada, during the recent ESA meeting in Reno. They are active at very low temperatures and can be found on snow fields or in ice caves. Ted Spilman announced an upcoming seminar about Harrison G. Dyar entitled "Digging for Dyar: The Man Behind the Myth" by Marc Epstein and Pamela Henson, January 22nd, 10:00 a.m. in Classroom B & C of the National Museum of Natural History. Wayne Mathis distributed a list of the officers and their phone numbers.

President Mathis introduced our immediate Past President, David R. Smith, Research Entomologist, Systematic Entomology Laboratory, PSI, ARS, USDA, Washington, whose talk was entitled "Those Amazing, Illusive, and Forgotten Hymenopterans." Dave Smith began his talk by pointing out that sawflies are not flies; they are really wasps, but they don't sting. Their name is attributed to the sawlike ovipositor that they use to insert eggs into plant tissue. The larvae are all phytophagous, caterpillarlike, and economically important. They damage agricultural crops, forests, and ornamental plants. They have a wide range of host plants from ferns, grasses, and mosses, to woody plants. Some are stem, twig, and wood borers and are morphologically modified for this habit as can be seen by the loss of legs and ornamentation. He then described the natural history of some representatives of the families of sawflies. For example, the argids are very diverse and several species from South America have unusual life histories. In one species the female attaches eggs to the surface of the leaf and sits over the eggs to protect them and the larvae for about three weeks. Most female sawflies die after egg-laying. The female of this species has been observed to exhibit various defensive stances to protect her eggs from intruders. The larvae line up and feed along the margin, the rows of larvae feed toward the center. After feeding the larvae go into the ground and form a tough cocoon for pupation. In another South American argid the female exhibits similar protective behavior of the eggs and the larvae are margin feeders. But instead of pupating in the ground, the larvae aggregate on the tree trunk and together spin a common protective covering and then each spin their individual cocoons perpendicular to the substrate forming a cocoon mass.

Dave Smith described several collecting methods used during a trip to the James Bay Region of Quebec, Canada and to various sites in Virginia. He has found that the Malaise trap is the best method for overall collecting and sampling and demonstrated one with the help of members in the audience. Sawflies are active early in the morning and so the trap should face the morning sun. The trap should be set up where there is a good flyway, and a diversity of vegetation that are known hosts for sawflies. The collecting jar is filled with 95% ethyl alcohol and can last 10–14 days. The traps are set up in early March and are taken down in early November in order to get the full seasonal picture. He has various sites including The University of Virginia's Blandy Experimental Farm in Clarke County in the northern Shenandoah Valley, and a more coastal site near Tappahanick in Essex County, Virginia. Up to 200 species of sawflies have been collected in the same area and up to 55 species in one trap. He has been able to glean information about distribution, flight periods, population peaks, variation within species, criteria for species separation, and sites for locating larvae. He also captures a wide variety of other interesting hymenopterans such as aulacids, evaniids, gasteruptiids, ibaliids, proproriids, trigonalyids, and vanhorniids, some of which are associated with sawflies.

Our visitors were introduced, President Wayne Mathis thanked Don Anderson for setting up for the meeting, and the meeting was adjourned. Refreshments were provided by Jill Swearingen and Warren Steiner.

M. Alma Solis, *Recording Secretary*

973rd Regular Meeting—February 6, 1992

The 973rd Regular Meeting of the Entomological Society of Washington was called to order by President Wayne N. Mathis in the Naturalists' Center of the Natural History Building at 8:00 p.m. on February 6, 1992. Twenty-nine members and five guests were present. Minutes of the January meeting were read by Recording Secretary M. Alma Solis and approved as read.

President Mathis called for reports from officers. Membership Chairman Ralph Eckerlin read the names of three applicants for membership, Luis M. Gomez Arias, Miami, Florida, Yue Ming, Department of Entomology, Michigan State University, East Lansing, Michigan, and William D. Sheppard, Department of Biological Sciences, California State University, Sacramento, California. He also announced that William B. Hull, a member whose interest was in Acarology, passed away on December 1, 1991. President Elect Russell Stewart announced that the banquet was tentatively being arranged for June 12, 1992 at the University of Maryland Adult Center. President Mathis announced the death of Ralph Crabill on January 16, 1992, a member who worked at the Smithsonian Institution and specialized in centipedes and spiders.

President Mathis called for notes or announcements from the members. Bill Bickley announced the death of Bob Nelson, a former President of the society, in December, 1991. J. H. Fales reported that the Eufala Skipper (*Lerodea eufala*) was found in good numbers at Point Lookout at the tip of St. Marys County in southern Maryland by Richard L. Waldrop on September 7, 1991. J. H. Fales also captured it there on October 2, 1991. This species is rare north of Virginia; and these records are the first for the Western Shore coastal plain in southern Maryland. Ed Barrows showed a slide illustrating how ants are used in Africa for suturing wounds. Manya Stoetzal reported on the whereabouts and health of the society's four Honarary Members, Curtis Sabrosky, Alan Stone, Ted Bissell, and Louise Russell. At the end of the meeting Manya read a bedtime story entitled "The Very Quiet Cricket" by Eric Carle. Breaking from tradition, visitors were introduced at this time.

Program Chairman Chris Dietrich introduced M. Alma Solis, Research Entomologist, Systematic Entomology Laboratory, PSI, ARS, USDA, Washington, DC, whose talk was entitled "INBio: Costa Rica's Biodiversity Inventory." Dr. Solis began her talk by describing how she first became involved with Costa Rica. In 1979 she went on a field course to Corcovado National Park on the Osa Peninsula while a student at the University of Texas at Austin with Larry Gilbert. Ten years later after finishing a Ph.D. with Charlie Mitter at the University of Maryland and upon becoming a Research Entomologist with the Systematic Entomology Laboratory, she pursued the project of the Pyraloidea of Costa Rica. Dan Janzen had by this time begun his "Moths of Costa Rica" project and INBio (Instituto Nacional de Biodiversidad) had already been established. INBio has a Director, Dr. Rodrigo Gamez, and a Director of Biodiversity, Dr. Alfio Piva. Dr. Piva is in charge of several departments including Arthropodology. There are seven curators, 8 technicians, and 26 parataxonomists in Entomology. The parataxonomists collect at their respective biodiversity offices in conservation areas or national parks in Costa Rica. They bring into INBio material estimated at about 3000–4000 specimens per month per parataxonomist. The curators at INBio serve as links between the parataxonomist and the taxonomists or specialists engaged in projects with INBio.

The pyraloid project is a collaborative effort with many pyraloid taxonomists worldwide and key among them is Eugene Munroe who is the world's expert and had begun working on the Costa Rica pyralids many years previous. The project was begun in 1990 with Alma Solis teaching a two-month, NSF-funded course on microlepidoptera with Jerry Powell, University of California at Berkeley, and Linda Pitkin of The Natural History Museum, London, England, to the parataxonomists. Parataxonomists are given various courses yearly by visiting scientists. Eugenia Phillips was also hired in 1990 to be curator of microlepidoptera at INBio and is specifically adding to the knowledge base in the Pyraloidea with studies in the Nymphulinae. The basic strategy of the project, with estimates of about 2000 species of pyraloids in Costa Rica, is to describe the new taxa to make the names available. This information will be incorporated into an identification handbook on the Pyraloidea that will provide information on various aspects of the species, including life history information. Preliminary work shows that most of the large moths in subfamilies, such as the Pyraustinae and Midilinae, are described. Most of the new species are in subfamilies, such as the Glaphyriinae, Nymphulinae, and Phycitinae, where the moths are small in size. Also it has become evident that there is great need to collect more at higher elevations, because preliminary collecting indicates endemic genera occur at high altitudes. This project is of importance for identification and quarantine purposes, as well as for ecological and phylogenetic studies on pyraloids. Pyraloid specimens and literature associated with INBio were presented. Finally, beautiful photos of neotropical pyraloids by Kjell Sandved were shown.

President Mathis thanked Don Anderson for setting up the meeting, and the meeting was adjourned. Refreshments were provided by Harold Harlan.

M. Alma Solis, *Recording Secretary*

974th Regular Meeting—March 5, 1992

The 974th Regular Meeting of the Entomological Society of Washington was called to order by President Wayne N. Mathis in the Naturalists' Center of the Natural History Building at 8:00 p.m. on March 5, 1992. Eighteen members and one guest were present. Minutes of the February meeting were read by Recording Secretary M. Alma Solis and approved as read.

President Mathis called for reports from officers. Membership Chairman Ralph Eckerlin read the names of two applicants for membership, David Baumgardner, Denton, Texas, and Ceibele Stramare Ribeiro-Costa, Department of Zoology, Federal University of Parana, Curitiba, Brazil. President Elect Russell Stewart announced that June 12 is a firm date for the annual banquet.

President Mathis called for notes or announcements from the members. J. H. Fales reported that a male Monarch butterfly that he had tagged (No. 30049) in southern Maryland at Plum Point in Calvert County on September 2, 1991 was recaptured by Dr. Lincoln Brower on February 11, 1992 at the El Rosario overwintering site near the town of Anganueo in the state of Michoacan, Mexico. He also had a map that showed the probable flight path of the butterfly from Maryland to Mexico and a photograph of the collecting locality (his backyard) in Maryland. Ed Barrows had a jar of silphids he brought in for identification. Ralph Eckerlin, who has a special interest in fleas, asked the members: "What is the difference between a coyote and a flea? A coyote howls in the prairie and a flea prowls in the hairy."

Program Chairman Chris Dietrich introduced Dr. Rowland W. Shelley, North Carolina Museum of Natural History, Raleigh, NC, whose talk was entitled "A Travelog of the Diplopoda." The Class Diplopoda, or millipedes, are slow-moving, primarily herbivorous arthropods. The distinguishing features of the class are two: one associated with the mouthparts and the other, the more obvious characteristic, the presence of diplosegments, each bearing two pairs of legs, formed by fusion of two originally separate somites. Millipedes lack a waxy cuticle, so they occur in moist areas with the exception of one species in the Sonoran desert. They range in size from microscopic to 10–12 inches and often occur in aggregates. They have three kinds of burrowing mechanisms: a head-on bulldozer type; a horizontal flattened type; and the wedge type that drag their body through the opening.

Millipedes are often confused with centipedes, but they belong to two different classes. Centipedes have poison claws and defensive glands; millipedes have no poison claws, but do emit a wide variety of chemicals, such as a northeastern species that emits a terpenoid, and members of the Order Polydesmia that secrete hydrogen cyanide. Centipedes have one pair of legs per segment that arise laterally and millipedes have 4 legs on most segments that arise ventrally. The spiracles of centipedes are lateral and valvular, whereas they are midventral and do not open in millipedes. He described the reproductive behavior and mode of movement of the major groups of millipedes. After the presentation, Dr. Shelley provided preserved and live specimens for observation.

Visitors were introduced and President Mathis thanked Don Anderson for setting up the meeting. The meeting was adjourned and refreshments were provided by Diane and Wayne Mathis.

M. Alma Solis, *Recording Secretary*

975th Regular Meeting—April 2, 1992

The 975th Regular Meting of the Entomological Society of Washington was called to order by President Wayne N. Mathis in the Naturalists' Center, National Museum of Natural History, at 8:00 p.m. on April 2, 1992. Fourteen members and seven visitors were present. Minutes of the March meeting were read by Manya Stoetzal and approved as read.

President Wayne Mathis called for reports from officers. Membership Chairman Ralph Eckerlin read the names of three applicants for membership: Boris C. Kondratieff, Department of Entomology, Colorado State University, David H. Hedrick, Department of Entomology, University of California, and R. E. Roughley, Department of Entomology, University of Manitoba.

President Mathis called for notes and/or exhibits. Ralph Eckerlin had a publication on Virginia's endangered species by Richard Hoffman and an article that appeared in the Washington Post on the Annual Insect Film Festival. Manya Stoetzal brought in and read a "tactile" children's book about arthropods. Nathan Schiff had a bottle of sawflies collected in Malaise traps from Beltsville for Dave Smith. Wayne Mathis pointed out that the place for the May meeting was not set and so members should pay close attention to the announcement card. Also, volunteers are needed to bring refreshments for the May meeting.

Program Chairman Chris Dietrich introduced Dr. Marty Condon, Department of Biological Sciences, University of Maryland, Baltimore County, Baltimore, MD, whose talk was entitled "Tephritids, Tropical Vines, and Tom Sawyer Trials." Dr. Condon described her work on the sex ratios of cucurbits in the genus *Gurania* and how the plant biology interacts with the tephritid flies in the genus *Blephanura.* In attempting to do an ecological study she soon realized that she needed to know what the flies were and the phylogenies of the associated plants and flies. As a result she has done much collaborative work with Allen Norrbom (SEL, USDA) on the morphology and Gary Steck (Florida Department of Agriculture) on the allozymes to show that different species of *Blephanura* utilize different parts of the plant at different times. She found the plants were not dioecious, had a male-biased sex ratio, and change their sex, with the first flowers appearing were male and then female. She also studied the morphology of plants and found that male stems are smaller than female stems. In the process she found that flies associated with fruits are different from the flies associated with flowers, and those that feed on the fruit are biologically very different. In one group the females lay eggs in the *Gurania* fruit and the larva develops in the calyx and does most of the feeding after the flower falls. In another group the females lay eggs directly into the seeds. They generally kill about half of the seeds, but do not affect the maturation of the fruit. Dr. Condon became interested in testing the theory that sympatric speciation occurs when a host shift occurs to different parts of the plant that are morphologically different and temporarily isolated.

She further went on to describe her present innovative work on the collaboration between public education, scientists, and students as a mechanism to solve problems in science, specifically taxonomy, and to get students excited about science. Dr. Condon found fly wing patterns, which are influenced by spider predatory behavior, difficult to score for analysis. She was approached by a junior high school teacher to talk to students and show them the wing patterns. The students were able to pick up on the repeating patterns or new characters. She was able to receive NSF funding to go out to schools and find new characters in conjunction with students. Students coded spots as present or absent and developed a character matrix for seven species. Dr. Condon passed around materials that are used in the classrooms for this study. School teachers Mary Beth Johnson and Mary Jo Eagen came to the meeting to explain what they are actually doing in the classrooms. They have found that students become really excited and interested when they know they are working on a real problem.

Visitors were introduced and the meeting was adjourned. Refreshments were provided by Holly Williams and Diane Mathis.

M. Alma Solis, *Recording Secretary*

976th Regular Meeting—May 7, 1992

The 976th Regular Meeting of the Entomological Society of Washington was called to order by President Wayne Mathis in the Log Lodge, Beltsville, Maryland, at 8:00 p.m. on May 2, 1991. Twenty-three members and six visitors were present. Minutes of the April meeting were read by Recording Secretary M. Alma Solis and approved as read.

President Elect Russell D. Stewart announced that tickets for the ESW annual banquet to be held Friday, June 12 are now being sold.

President Wayne Mathis called for notes or exhibits. J. H. Fales exhibited a poster on the Monarch butterfly, including a photograph taken by Dr. Lincoln Brower in Mexico on February 11 of a specimen that Fales had tagged at Plum Point, Maryland on September 2, 1991. Also, single migrating Monarch butterflies were seen in Calvert County on April 23rd and 24th. He also reported that the painted lady butterfly, *Vanessa cardui,* was reported to be migrating northward in swarms in California. The species was reported to occur this spring in much greater numbers in Calvert County, Maryland than in California. Warren Steiner brought a few slides of a trip he and Jill took to the island of Anguilla at the end of March. Wayne Mathis announced a book signing by Paul Opler, U.S. Fish and Wildlife Service, and Vichai Malikul, Smithsonian Institution, for the new book entitled "A Field Guide to the Eastern Butterflies" which is part of the Peterson Field Guide Series and published by Houghton Mifflin Co. (paperback $16.95).

Chris Dietrich, Program Chairman, introduced the speaker for the evening, Dr. James R. Ott, Dept. of Entomology, University of Maryland, whose talk was entitled "Life Within Seedbox Fruits: Prison or Paradise?" This was an ecological study of *Acanthoscelides alboscullatus* Horn (Bruchidae) and *Ludwigia alternifolia* L. (Onagraceae) in eastern North America. Adults visit the flowers in June and August in the early morning hours when nectar and pollen are produced. The females oviposit on the outside edges of the fruit and avoid fruits in proportion to the number of eggs already present and the age of the fruit. The larvae bore through the fruit walls which takes about 3 days and then feed on the individual ovules. This contrasts with most other bruchids that feed on a single seed. In the fall late-instar larvae form an overwintering cocoon with an operculum to be used as an exit later. There are about 8–10 beetles per fruit.

Dr. Ott tested a hypothesis that there is selection for small body size (diameter) of the individual beetles. In the fall the fruits become dehiscent and some of the beetles are cast out into the winter environment. When the fruit does not open they have to try to leave the fruit via the apical opening on top of the fruit. Some are able to get out by chewing the margins of the pore; many get stuck and do not get out. He found the females cannot distinguish a fruit of the appropriate size for emergence. Fitness is a function of body diameter since small animals can emerge and have an advantage over the larger animals.

Our visitors were introduced and the meeting was adjourned. After the meeting refreshments were provided by Manya Stoetzal.

M. Alma Solis, *Recording Secretary*

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MISCELLANEOUS PUBLICATIONS

Cynipid Galls of the Eastern United States, by Lewis H. Weld	$ 5.00
Cynipid Galls of the Southwest, by Lewis H. Weld	3.00
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Identification of Alaskan Black Fly Larvae, by Kathryn M. Sommerman	1.00
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A Short History of the Entomological Society of Washington, by Ashley B. Gurney	1.00
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Taxonomic Studies on Fruit Flies of the Genus *Urophora* (Diptera: Tephritidae), by George C. Steyskal	2.00
A Handbook of the Families of Nearctic Chalcidoidea (Hymenoptera), by E. Eric Grissell and Michael E. Schauff	10.00

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No. 1.	The North American Bees of the Genus *Osmia*, by Grace Sandhouse. 167 pp. 1939	$15.00
No. 2.	A Classification of Larvae and Adults of the Genus *Phyllophaga*, by Adam G. Boving. 95 pp. 1942	(out of print)
No. 3.	The Nearctic Leafhoppers, a Generic Classification and Check List, by Paul Wilson Oman. 253 pp. 1949	15.00
No. 4.	A Manual of the Chiggers, by G. W. Wharton and H. S. Fuller. 185 pp. 1952	15.00
No. 5.	A Classification of the Siphonaptera of South America, by Phyllis T. Johnson. 298 pp. 1957	15.00
No. 6.	The Female Tabanidae of Japan, Korea and Manchuria, by Wallace P. Murdoch and Hirosi Takahasi. 230 pp. 1969	15.00
No. 7.	Ant Larvae: Review and Synthesis, by George C. Wheeler and Jeanette Wheeler. 108 pp. 1976	11.00
No. 8.	The North American Predaceous Midges of the Genus *Palpomyia* Meigen (Diptera: Ceratopogonidae), by W. L. Grogan, Jr. and W. W. Wirth. 125 pp. 1979	12.00
No. 9.	The Flower Flies of the West Indies (Diptera: Syrphidae), by F. Christian Thompson. 200 pp. 1981	10.00
No. 10.	Recent Advances in Dipteran Systematics: Commemorative Volume in Honor of Curtis W. Sabrosky. Edited by Wayne N. Mathis and F. Christian Thompson. 227 pp. 1982	11.00
No. 11.	A Systematic Study of the Japanese Chloropidae (Diptera), by Kenkichi Kanmiya. 370 pp. 1983	18.00
No. 12.	The Holarctic Genera of Mymaridae (Hymenoptera: Chalcidoidae), by Michael E. Schauff. 67 pp. 1984	5.00
No. 13.	An Identification Manual for the North American Genera of the Family Braconidae (Hymenoptera), by Paul M. Marsh, Scott R. Shaw, and Robert A. Wharton. 98 pp. 1987	18.00

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