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SPATIAL PROPERTIES OF NICHE SEPARATION AMONG  
*EUEIDES* AND *DRYAS* BUTTERFLIES (LEPIDOPTERA:  
NYMPHALIDAE: HELICONIINAE) IN COSTA RICA

Allen M. Young

*Abstract.*—Young, Allen M., Invertebrate Division, Milwaukee Public Museum, Milwaukee, Wisconsin 53233.—Habitat and larval food plant associations of heliconiine butterflies (Lepidoptera: Nymphalidae), *Dryas iulia* (Fabricius), *Eueides lybia* (Fabricius), *E. aliphera* (Godart), and *E. isabella* (Cramer) were examined briefly in three regions of northern Costa Rica. The following patterns were found: (1) although *E. lybia* and *E. aliphera* are sympatric and utilize the same larval food plant, *Passiflora vitifolia* H.B.K. (Passifloraceae) in tropical wet forest, they are not micro-sympatric since the former occurs along shaded forest edges and forest light gaps, while the latter occurs in open secondary habitats; (2) *Dryas iulia* is sympatric with both species (1) and it is microsympatric with *E. aliphera* but uses a different larval food plant, *P. auriculata* H.B.K.; (3) both *D. iulia* and *E. isabella* are microsympatric in the Mcseta Central and use both the same larval food plant (*P. adenopoda* D.C.) and nectar source (*Serjania* cf. *atrolineata* Saw. & Wright—Sapindaceae) during the dry season; (4) in a patch of semi-deciduous forest in the lowland tropical dry forest zone, *D. iulia* shares a larval food plant, *P. capsularis* L., with *E. isabella*, but also uses *P. platyloba* Killip and *P. suberosa* Juss. The widespread occurrence of *D. iulia* may be due to a high tolerance for heat and low humidity, and the use of *Plectostemma* subgenus of *Passiflora* as food plants. Other factors, such as oviposition behavior and larval habits, are also discussed.

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The heliconiine butterfly *Dryas iulia* (Fabricius) (Lepidoptera: Nymphalidae: Heliconiinae) is widespread in tropical wet and dry forest regions of Costa Rica. Emsley (1963) points out that it is very widespread throughout much of subtropical and tropical America. In some regions of Costa Rica, it is sympatric with at least two or three species of another heliconiine genus, *Eueides*. Adults of one of these, *E. aliphera* (Godart), are strikingly similar to *D. iulia*, and the two heliconiines often occur together (Emsley, 1963). *Eueides aliphera* is also often sympatric with *E. lybia* (Fabricius) and *E. isabella* (Cramer) in the tropical wet forests of northeastern Costa Rica. Although the life cycles and larval food plant associations of these butterflies (Figs. 1 and 2) are known from various regions of tropical America (Beebe et al., 1960; Alexander, 1961a, b; Brown and Mielke, 1972;

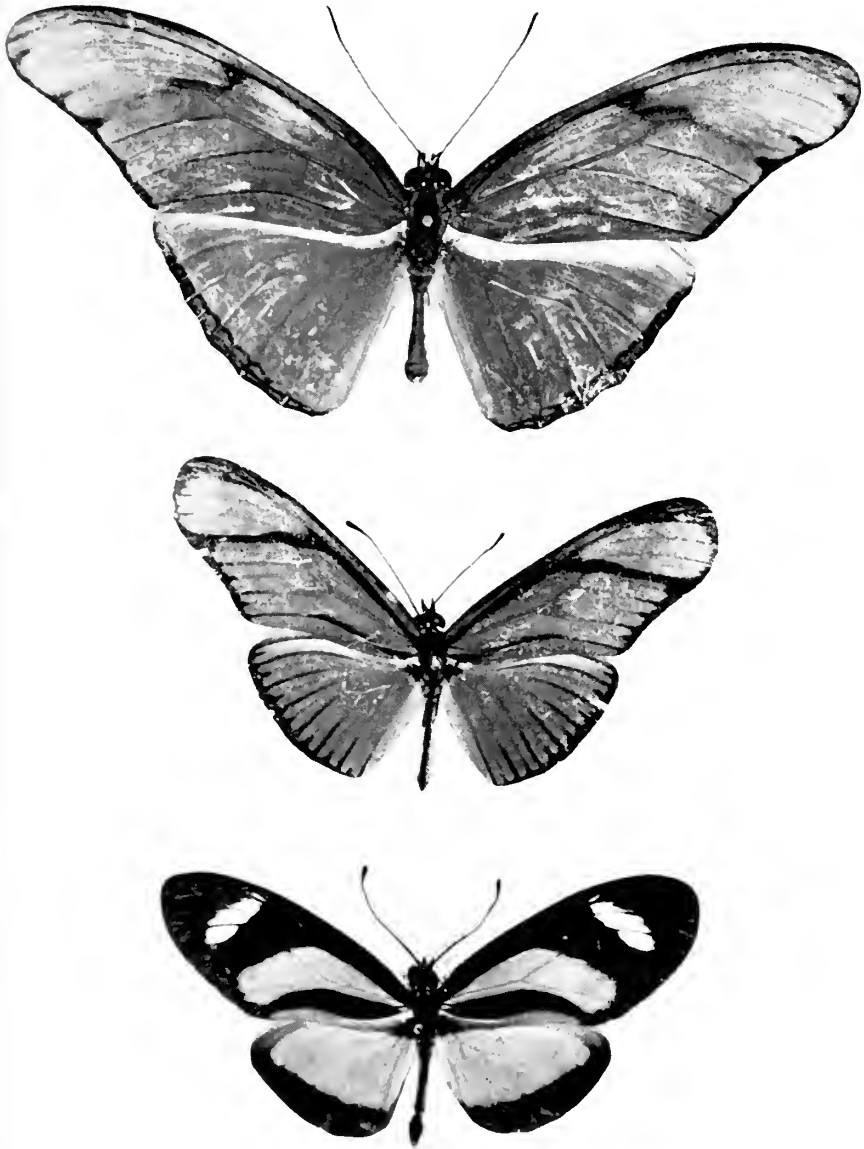


Fig. 1. *Dryas iulia* (Fabricius), *Eucides aliphera* (Fabricius), and *E. lybia* (Fabricius) from "Tirimbina," near La Virgen de Sarapiquí, Heredia Province, Costa Rica. These individuals were reared from the egg stage.

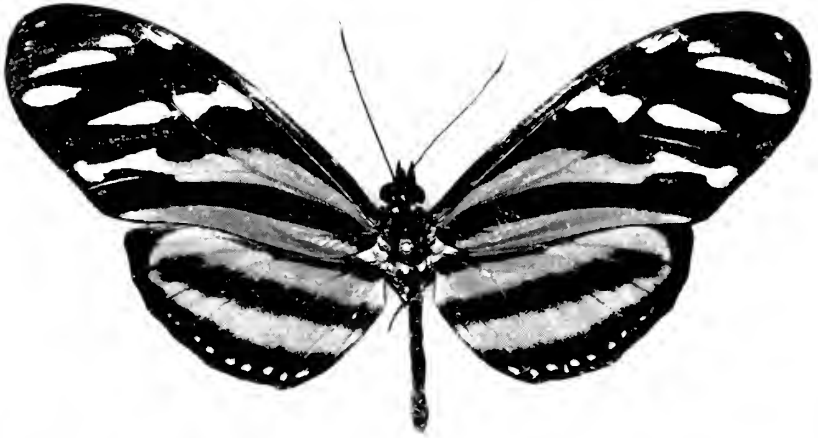


Fig. 2. *Eucides isabella* (Cramer) from San Rafael de Ojo de Agua, Alajuela Province, Costa Rica. *Eucides aliphera* trapped in spider web at "Tirimbina" (February 1977).



Benson et al., 1976), this paper reports some aspects of niche separation in three regions of northern Costa Rica: (1) Meseta Central, where *D. iulia* occurs with *E. isabella*, (2) northeastern premontane tropical wet forest where *D. iulia* occurs with *E. lybia* and *E. aliphera*, and (3) a patch of semi-deciduous forest in the tropical dry forest zone, Puntarenas Province, where *D. iulia* occurs with *E. isabella*. The general thesis explored by these descriptive field observations is that co-occurring heliconiines may exhibit niche differences, and these patterns may vary regionally.

### Methods

During the period of 25 July–27 August 1976, the habitat, life cycle, and larval food plants of *E. lybia* were studied at “Tirimбина,” La Virgen, Heredia Province, a region of Premontane Tropical Wet Forest (Holdridge, 1967), and *E. isabella* was similarly studied at the “Barranea Site,” a small semi-deciduous forest in Puntarenas Province (see Orians, 1969 for description of this locality). *Eueides isabella* was again studied from 15 January–23 February 1977 but at San Rafael de Ojo de Agua, Alajuela Province, in Tropical Moist Forest (Holdridge, 1967) of the Meseta Central. *Eueides aliphera* was studied at “Tirimбина,” 12 January–18 February 1977. *Dryas iulia* was studied as follows: (1) 3 February–14 March 1977—“Tirimбина,” with rearing continuing in Milwaukee, Wisconsin (3–14 March); (2) 15 January–23 February 1977—San Rafael de Ojo de Agua; (3) 25 January and 24 February 1977—Barranea Site. Observations were made on: nectar sources, larval food plants (including oviposition), and behavior of immature stages. Occasionally, a few individuals of each species were reared, using previously developed techniques (Young, 1975, 1976).

### Results

Although *E. isabella* occurs in northeastern Costa Rica (e.g., at “Finca La Selva,” Puerto Viejo, pers. obs.), it was not seen at “Tirimбина” during the study periods, but habitat differences were seen here for *E. lybia* and *E. aliphera*. *Eueides lybia* adults are most commonly seen along the edges of shaded primary forest and forest light gaps (tree fall areas). The life cycle (Fig. 3) takes place on *Passiflora vitifolia* H.B.K. (Passifloraceae), a large forest vine. Population numbers of *E. lybia* are generally low, and adults are concentrated near certain individuals of *P. vitifolia*. A fresh female *E. lybia* shows up several times daily to lay eggs. Within a 10-minute period, as many as 12 eggs can be deposited on a vine, usually one per leaf. The white egg is deposited on the under side of an old leaf after considerable inspection of the vine. Daily observations indicate that adult populations are confined to small areas of preferred habitats.

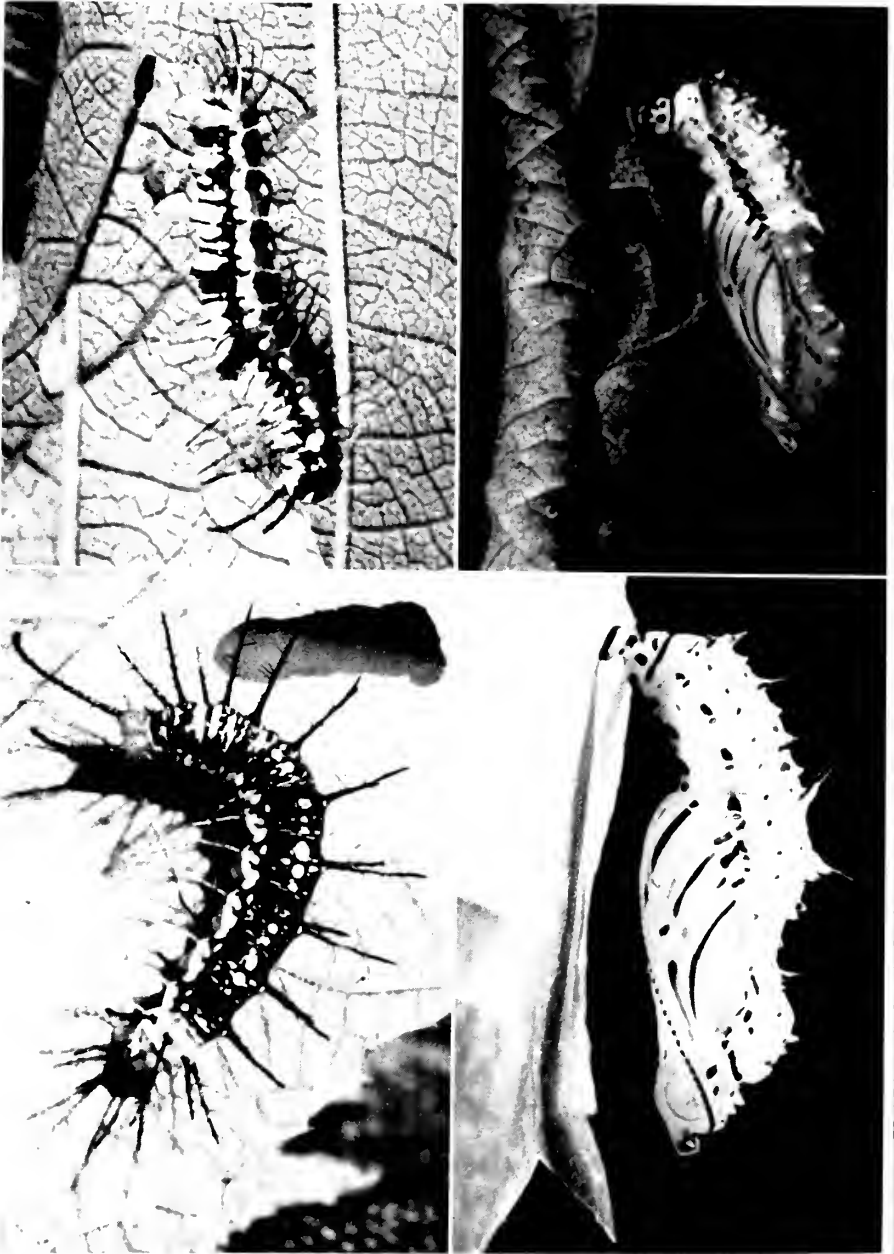


Fig. 3. Top: fifth instar larva and pupa of *E. aliphera*; bottom: same for *E. lybia*. Both series from "Tirimina."



Fig. 4. Cut-over forest habitat at "Tirimбина" where young vines of *P. vitifolia* are abundant in direct sunlight and used for oviposition by *E. aliphera* (February 1977).

In open secondary vegetation, *E. aliphera* is very abundant and adults generally stay closer to the ground than seen for *E. lybia*. Oviposition takes place on small, tender *P. vitifolia* vines. A major habitat of *E. aliphera* at "Tirimбина" is recently cut-over forest, where young *P. vitifolia* grow over logs and branches of fallen trees (Fig. 4). The larva and pupa of *E. aliphera* and *E. lybia* are strikingly similar in appearance (Fig. 3) and size. The major distinction between the two species is the habitat: *E. aliphera* prefers low vegetation exposed to direct sunlight while *E. lybia* prefers shaded forest edges and light gaps (where indirect sunlight is filtered down from the canopy). Oviposition by *E. aliphera* is similar to *E. lybia* but egg production might be higher in the former: one fresh female on 12 January 1977 deposited 27 eggs on an isolated small vine of *P. vitifolia* within a 10-minute period at 11:00 AM. This vine was then inspected on three dates before the end of the month, and within 15 days only three larvae (third instars) were left. Unlike *E. lybia*, several eggs were deposited on a single leaf, although other leaves were also used the same day. Adult populations of *E. aliphera* are large and fluid, being distributed over a large area. Small clumps of *P. vitifolia* occur over small areas.

During the intense dry season of the Meseta Central, flowering shrubs



Fig. 5. Stream-edge forest remnant at San Rafael de Ojo de Agua where *E. isabella* and *D. iulia* are abundant during the pronounced dry season of this region, and where a nectar source, *Serjania* cf. *atrolineata* (Sapindaceae) and larval food plant, *Passiflora adenopoda* attract the butterflies at this time.

and trees along streams attract many butterflies, and *E. isabella* shows up at flowering bushes of *Serjania* cf. *atrolineata* Saw. & Wright (Sapindaceae) (Fig. 5). An example is San Rafael de Ojo de Agua, where *E. isabella* visits the inflorescences (Fig. 6) along with *D. iulia* and several other butterflies (mostly Nymphalidae and Pieridae). One particular bush that was frequently visited by *E. isabella* and *D. iulia* was situated about three meters from a large vine of *Passiflora adenopoda* H.B.K. (Fig. 7), where oviposition by both was observed. Inspection of the vine on several dates (January–February 1977) turned up many eggs and larvae of *E. isabella* and a few of *D. iulia*. The egg of *E. isabella* is deposited singly on the under side of an old leaf, and occasionally eggs were deposited on branches of bamboo that intertwined with the food plant. Oviposition by *E. isabella* is a very time-consuming process with a lot of time spent in “false” oviposition acts at the food plant. The larva bears a very close general resemblance to those of the other *Eueides* studied, but the pupa is distinct (Fig. 8). In comparison to *E. lybia* and *E. aliphera*, *E. isabella* exhibits several differences: (1) different strategy of wing color pattern; (2) different larval



Fig. 6. *Eueides isabella* visiting inflorescence of *S. cf. atrolincata* at 1:00 PM 15 January 1977 at San Rafael de Ojo de Agua.



Fig. 7. *Passiflora adenopoda*, a larval food plant of *D. iulia* and *E. isabella* at San Rafael de Ojo de Agua. Note large woody tendrils.

food plant; (3) more pronounced divergence of the pupa stage. Like *E. aliphera* the preferred habitat of this species during the dry season is the open stream-edge exposed to direct sunlight. At this time of the year, adults are concentrated near a nectar source and breeding takes place nearby. During the wet season at the Barranca Site near the Pacific coast, *E. isabella* is abundant in the drier areas of the forest where *P. platyloba* Killip is found; eggs and larvae have been found on this vine. During the dry season this butterfly is scarce or absent here.

*Dryas iulia* is abundant at "Tirimbina" in open secondary vegetation where a larval food plant, *P. auriculata* H.B.K. (Fig. 9) grows in small patches heavily intertwined with, and shaded by, other vines. Unlike *P. vitifolia*, this vine has very smooth leaves and woody tendrils. A second food plant species of *D. iulia* here, *P. biflora* D.C., also has smooth leaves and woody tendrils. Both vines grow in the same habitat as *P. vitifolia*. Here, *E. aliphera* and *D. iulia* fly together. The egg is deposited on a woody tendril, which also functions as a perch for the first instar larva; older larvae rest on leaves and pupation sometimes occurs on the food plant (Fig. 10). Like *E. aliphera*, *D. iulia* is very abundant and the adults are dispersed over large areas. When a female shows up at a vine, she may deposit 2 or 3 eggs on different tendrils within two minutes; the large bright yellow egg is very conspicuous against the shaded back-



Fig. 8. Life stages of *E. isabella* from San Rafael de Ojo de Agua: egg, third instar larva, fifth instar larva and pupa.

ground of the surrounding vegetation. On two days (3 and 8 February 1977) a very frayed female (probably the same individual) showed up at a young vine of *P. biflora* at about 1:00 PM depositing two eggs on the first date and one on the second date. The eggs are invariably deposited

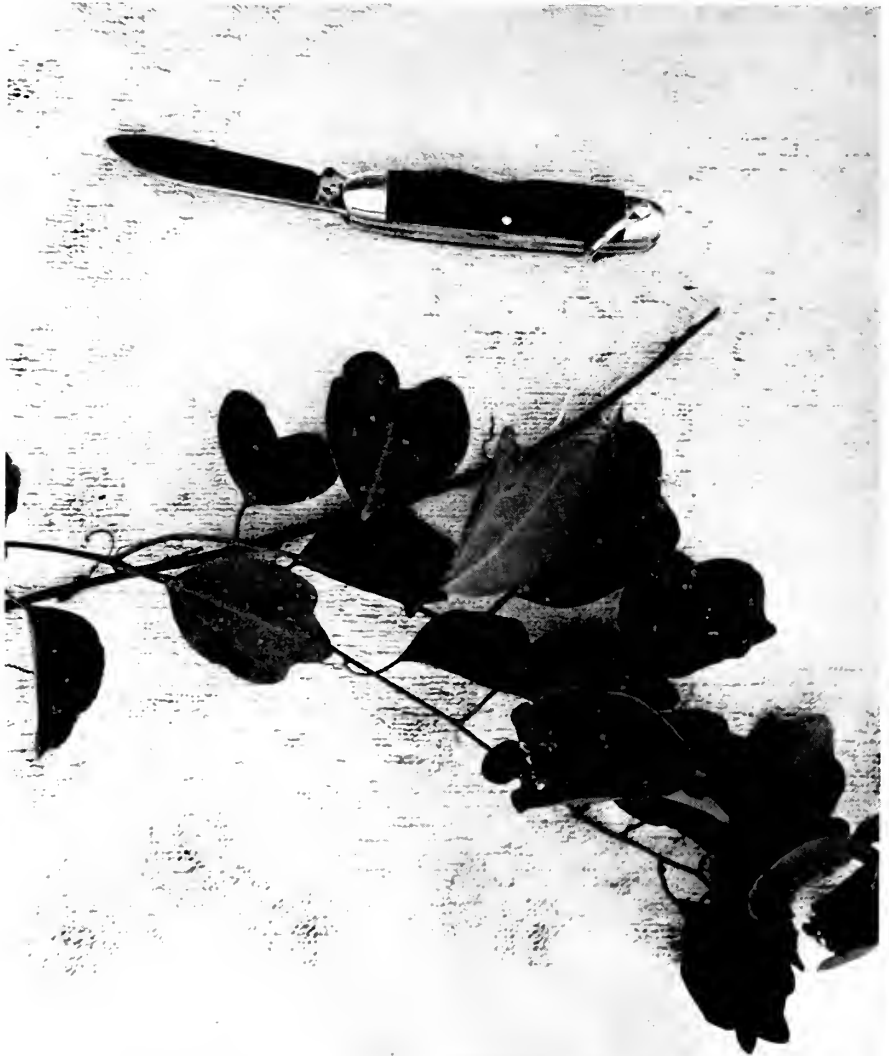


Fig. 9. *Passiflora auriculata*, a larval food plant of *D. iulia* at "Tirimbina."

on vines in very shady conditions; when a larva is placed in sunlight, it becomes very agitated and starts to move very rapidly.

Like the food plants of *D. iulia* at "Tirimbina," the food plant at San Rafael de Ojo de Agua, *P. adenopoda*, possesses woody tendrils. At the Barranca Site, at least three species of *Passiflora*, all with woody tendrils and smooth leaves, are used as food plants by *D. iulia*: *P. aff. capsularis*



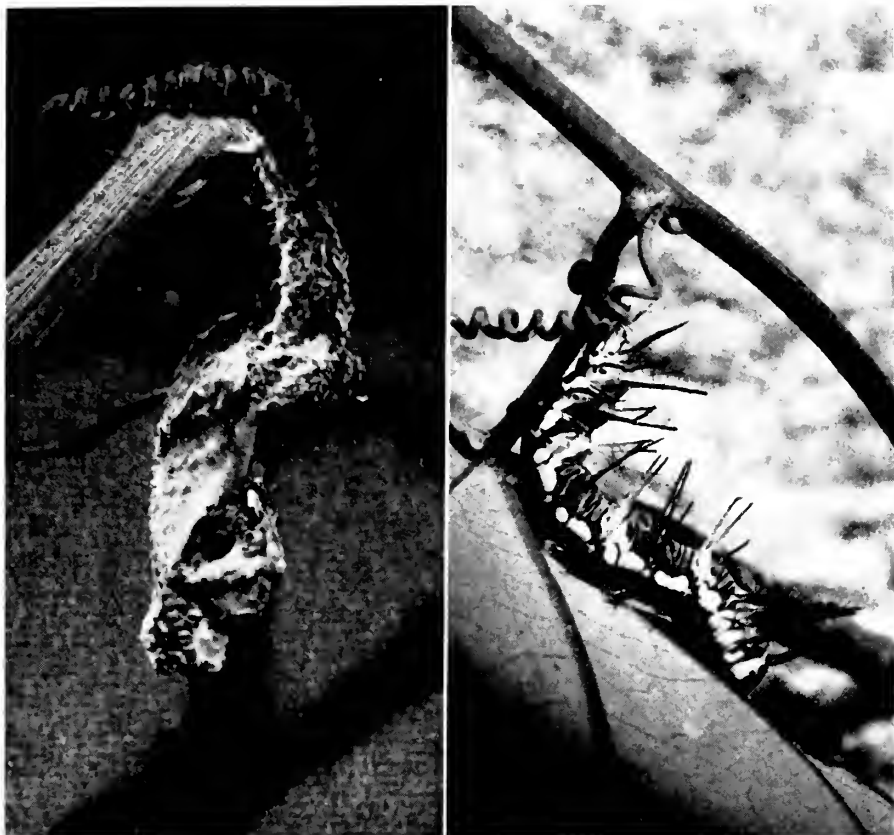


Fig. 10. Pupa and fifth instar larva of *D. iulia* (see also excellent diagrams in Beebe et al., 1960). Note woody tendril of *P. auriculata* in both photographs.

*L.*, *P. platyloba* Killip, and *P. suberosa* Juss. (Fig. 11). These vines have fresh leaves during the intense dry season, and two lines of evidence indicate breeding at this time: One pair of freshly-eclosed mating adults was seen (Fig. 12), and the easily-recognizable larval resting perches are common (Fig. 11). Adults are not abundant here at this time. Within a 2 hour period on 24 February 1977, one fresh and three very worn adults of *D. iulia* were seen (1-4 PM). While the *Passiflora* "sub-community" remains lush at this time, *D. iulia*, and perhaps to the exclusion of other sympatric heliconiines, is the only species breeding, perhaps at greatly reduced numbers. Even though some of the vines are very small, they show signs of larval damage from *D. iulia* (Fig. 11). Estimates of developmental times are given in Table 1 and, as expected, they are similar.



Fig. 11. Three larval food plants of *D. iulia* at the "Barranca Site," Puntarenas, Puntarenas Province, Costa Rica, February 1977. Photographs taken in the wild. Top to bottom: *P. platyloba*, *P. aff. capsularis*, and *P. suberosa*. Leaf damage of *P. suberosa* shows larval perching site and pattern of feeding, very characteristic of *D. iulia* (see also Alexander, 1961a). All three vines less than one meter long.



Fig. 12. Mating pair of freshly-eclosed *D. iulia* at the "Barranca Site," 25 January 1977, 11:00 AM. Resting near ground on woody plant.

Table 1. Developmental time\* for the heliconiine butterflies *Dryas iulia*, *Eucides aliphra*, *E. lybia*, and *E. isabella*.\*\*

Duration of Life Stages (Days):				
Egg	Larva	Pupa	Total	Larval Food Plant
				<i>Dryas iulia</i>
5	20-21	13-14	38-40	<i>Passiflora auriculata</i> H.B.K.
				<i>Eucides aliphra</i>
5	18-19	10-11	33-35	<i>P. vitifolia</i>
				<i>E. lybia</i>
5	20-21	8	33-34	<i>P. vitifolia</i>
				<i>E. isabella</i>
5	21-22	9-10	35-36	<i>P. adenopoda</i> D.C.

\* Range of individuals reared was 3-11 and all species were reared in same manner and under similar conditions.

\*\* *D. iulia*, *E. aliphra* and *E. lybia* reared from "Tirimina" and *E. isabella* from San Rafael de Ojo de Agua (see text).

## Discussion

The phylogenetic affinities of *Eueides* and *Dryas* within heliconiine evolution have been discussed (Emsley, 1965) and their life stages described (Beebe et al., 1960; Alexander, 1961a, b). Unlike some *Heliconius*, which are noted for pollen-feeding (Gilbert, 1972), heliconiines such as *Eueides* and *Dryas*, are nectar-feeders and the distributions of adult populations in space and time must be regulated in part by the availability of the appropriate inflorescences. For example, although many adults of *E. isabella* were found on or near the blooming *Serjania* bush on 15 and 16 January 1977, the blooms were gone by 25 January and no adults were seen in the vicinity, despite an abundance of larval food plant nearby. The persistence and predictability of preferred nectar sources may be a major factor in determining the spatial aspects of adult population structure in heliconiines, perhaps for reasons similar to those discovered for *Heliconius* populations (Ehrlich and Gilbert, 1973; Gilbert, 1975; Cook et al., 1976). In strongly seasonal regions of the tropics, the phenology of flowering might result in a greater mobility of heliconiine populations annually in response to changing distributions of nectar sources. At less seasonal regions such as "Tirimbina," such patterns may be very different.

Different responses and tolerances of butterfly species to environmental parameters such as air temperature may determine where most of the eggs are deposited. Thus although *E. lybia* and *E. alipha* both use *P. vitifolia* as a larval food plant at "Tirimbina," one species does so most often in one habitat and the other in a different habitat. Perhaps this is a differential response to air temperature and humidity, with one species (*lybia*) being less tolerant of the higher temperatures and lower humidity one presumably finds in open secondary habitats. Such a divergence in niche could lower the probability of local extinctions resulting from interspecific competitive interactions, if larval food plants and nectar sources are limited resources. Selection favors the co-occurrence of *D. iulia* and *E. alipha* perhaps as a mimicry relationship, although this has not been studied. Brown and Mielke (1972) report that both *E. alipha* and *E. isabella* have strongly localized populations and that adults tend to stay near the food plants. Cohesiveness of *Eueides* populations is, therefore, predicted to be a result of the distribution of larval food plants and nectar sources, and selection for mimicry with *D. iulia*. The general morphological and color similarity of the larva and pupa between these species suggests another form of mimicry operative in the juvenile stages.

The scarcity or absence of *E. isabella* at "Tirimbina" is surprising since it does occur at other nearby localities. However, as Brown and Mielke (1972) point out, this species is never very abundant locally.

It is generally expected that different heliconiines will have similar de-

developmental times and Beebe et al. (1960) report a generalized heliconiine larval developmental time of about 12 days. The estimates given here are considerably higher. It is likely that food plant differences and other environmental factors will greatly influence this statistic.

Although mortality of eggs and larvae of *D. iulia* is unknown, the observed disappearance of eggs and larvae of *E. aliphera* at "Tirimbina," although limited data, suggest high mortality. Emsley (1963) states that *D. iulia* and *E. aliphera* often share the same habitats. Gilbert (1975) predicts that in general, heliconiine immature stages are killed by ants and other predators. Young (1978) found that eggs and young larvae of *Heliconius hecale* (Fabricius) and *H. cydno* (Bates) disappear at high rates at "Tirimbina," suggesting predation and parasitism. The sophisticated egg-positioning and larval behavior of *D. iulia* (Alexander, 1961a, b; Benson et al., 1976) may offset some mortality. *Eueides* larvae do not exhibit such behavior. *Dryas iulia* sometimes places eggs on plants adjacent to the food plant (Benson et al., 1976) and this may be an effective way of hiding eggs from potential predators (assuming that the larvae can successfully locate the food plant).

Benson et al. (1976) predict that the widespread abundance of *D. iulia* is dependent upon the diversity and abundance of *Plectostemma*, a subgenus of *Passiflora*. *Passiflora adenopoda* is in this subgenus, but at least one other, *P. platyloba*, is in the subgenus *Granadilla* (Benson et al., 1976). Brown and Mielke (1972) report several regional larval food plants of *D. iulia* in Brazil. Of the 42 known larval food plants of about a dozen species of *Eueides*, 34 are in *Granadilla*, and two in *Plectostemma* (Benson et al., 1976). *Passiflora vitifolia* is in the subgenus *Distephana* (Benson et al., 1976). To these considerations it is added that *P. vitifolia* is also used by *Heliconius hecale* and *H. cydno* at "Tirimbina" (Young, 1978). Benson et al. (1976) mention that silvaniform and melpomeniform *Heliconius* radiated mainly onto *Granadilla* and *Distephana*.

The predilection of *D. iulia* for open habitats exposed to direct sunlight and the evergreen condition of the larval food plants are properties that account for the presence of adults during the dry season in lowland Puntarenas Province, a period when other adult heliconiines are noticeably less abundant or absent (pers. obs.). Perhaps *Heliconius* and other heliconiines are less tolerant of dry season conditions here. Another important factor is the availability of preferred nectar sources during the dry season.

The data and above discussion suggest some definite patterns of niche separation for *Eueides* species and *Dryas iulia* in northern Costa Rica that warrant further study. Although *E. lybia* and *E. aliphera* are sympatric in northeastern Costa Rica and utilize the same larval food plant, the former species prefers forest edge habitats and the latter open secondary habi-

tats. The flexibility of the larval food plant for thriving in both types of habitats may be a major factor accounting for this pattern of niche separation between *E. lybia* and *E. aliphera*. *Dryas iulia* occurs in the same habitat as *E. aliphera* but utilizes a different larval food plant species that thrives in shaded undergrowth. At a more seasonal locality, both *E. isabella* and *D. iulia* occur in the same habitat and utilize the same larval food plant and nectar source. In an even more seasonal region, *D. iulia* is sympatric with *E. isabella* and they use the same larval food plant in the same habitat, but at least *D. iulia* has two other food plants there. The widespread occurrence of *D. iulia* over several regions of Costa Rica may be due in part to (1) its ability to use both *Plectostemma* and *Granadilla* larval food plants, and (2) unusually high flexibility in thermal-moisture tolerances.

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A REVISION OF THE GENUS *ODMALEA* BERGROTH  
(HEMIPTERA: PENTATOMIDAE)

L. H. Rolston

*Abstract.*—Rolston, L. H., Department of Entomology, Louisiana State University, Baton Rouge, Louisiana 70803.—The genus *Odmalea* is re-described and a key provided to distinguish among the closely related genera *Brepholoxa*, *Dendrocoris*, *Odmalea*, and *Thoreyella*. *Odmalea norda* n. sp. from Venezuela and *O. vega* n. sp. from Colombia are added to the genus, the other four members are re-described, and a key is provided for the separation of the species. NEW COMBINATIONS are *Odmalea basalis* (Walker) from *Euschistus*, *Odmalea concolor* (Walker) from *Thoreyella*, and *Odmalea pallida* (Jensen-Haarup) from *Thoreyella*. NEW SYNONYMY recognized is *Thoreyella pulchra* Jensen-Haarup as a junior synonym of *Odmalea basalis* (Walker), *Odmalea quadripunctula* Bergroth and *Odmalea quadripunctula modesta* Ruckes as junior synonyms of *Odmalea concolor* (Walker), and *Odmalea olivacea* Ruckes as a junior synonym of *Thoreyella brasiliensis* Spinola.

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When Bergroth (1914) erected *Odmalea* he took care to distinguish between this genus and *Dendrocoris* Bergroth, enumerating seven characters which seemed to differentiate the two genera. Most of these apparent differences disappear into intraspecific or intrageneric variability, emphasizing the similarity of these genera. Nelson (1955) observed that *Brepholoxa* Van Duzee is much like these geminate genera, chose felicitous characters to separate the three and discussed their position in the classification of pentatomids. *Thoreyella* Spinola also belongs to this group of genera and, indeed, is less readily separated from *Odmalea* than are *Brepholoxa* and *Dendrocoris*.

All of these genera have a median ventral spine at the base of the abdomen, and in none does this spine fit into the posterior margin of the metasternum; the sterna are not produced save, at most, for a mild tumescence on each side of the mesosternum; the bucculae continue to or past the distal end of the first rostral segment, terminating as a lobe at the base of the head (Fig. 5). The pygophoral form is peculiar to these four genera and varies only in detail among species (Figs. 6 and 7). The following key separates the four genera.

Key to Genus Group

1. Ostiolar canal extending less than halfway from ostiole to lateral margin of metapleuron; second segment of antennae longer than each succeeding segment *Brepholoxa* Van Duzee



- Ostiolar canal extending more than halfway from ostiole to lateral margin of metapleuron; second segment of antennae much shorter than each succeeding segment 2
- 2. Superior surface of femora prolonged at apex as spine (Fig. 30). 3
- Femora unarmed *Dendrocoris* Bergroth
- 3. Ostiolar canal curved (Fig. 23); juga contiguous before tylus *Thoreyella* Spinola
- Ostiolar canal straight or slightly curved (Figs. 4, 15, 27, 44 and 48); juga usually separated at apex, rarely contiguous, in which case coria are decidedly bicolored, stramineous and castaneous *Odmalea* Bergroth

*Odmalea* Bergroth, 1914

*Odmalea* Bergroth, 1914, pp. 436-437

Head wider across eyes than long, lateral margins sigmoid, tapering to apex; antenniferous tubercles exposed from above; juga separated (with rare exceptions) at apex of head (Figs. 1, 24, and 45). First antennal segment not surpassing apex of head; two basal segments each much shorter than each of three distal segments. Bucculae toothed near anterior limit, prolonged as lobe at base of head, reaching to or slightly past distal end of first rostral segment (Fig. 5); apex of rostrum attaining metacoxae.

Humeral angles acutely produced; anterolateral angles strongly toothed (Figs. 2, 13, 25, 36, and 46). Anterolateral margin obtusely rounded, usually with a few small denticles widely spaced at irregular intervals.

Basal width of scutellum subequal to length; frena extending past middle. Costal angle of coria extending considerably beyond apex of scutellum (Figs. 3, 14, 26, 37, and 47).

Prosternum and metasternum flat or nearly so; mesosternum weakly tumescent behind procoxae on each side of depression along midline. Ostiolar sulcus nearly straight, extending about two-thirds distance from mesial margin of ostiole to lateral margin of metapleuron (Figs. 4, 15, 27, 44, and 48). Superior surface of femora prolonged apically as spine (Fig. 30); anterior tibiae flattened toward apex on superior surface, asymmetrically widened; middle and posterior tibiae sulcate or not.

Abdominal spine terminating between metacoxae or longer and reaching mesocoxae.

Pygophoral opening narrowing posteriorly on dorsal surface, continuing onto ventral surface (Figs. 6-7, 16-17, 28-29, 38-39 and 49-50). Lateral thecal lobes prominent to exceptionally large, thecal processes absent (Figs. 11, 21, 31, 41 and 51); penisfilum lying entirely on median vertical plane.

First gonocoxae almost or entirely concealed (Figs. 8, 22, 33 and 53). Spermathecal bulb elongate, bearing few to many diverticula or bulbous enlargement distad of distal flange (Figs. 9, 35 and 55).

*Comment.*—Bergroth (1914), in his description of the genus and of the type species, the latter under the junior synonym *O. quadripunctula*, attributed to sexual dimorphism differences between the sexes that he observed in the proportional length of antennal segments and in the relative length of the coria and scutellum. His examples apparently did not represent the variability of these proportions fairly, and his conclusion is not supported by the specimens examined in this study.

The boundary between the theca and conjunctiva is unclear in *Odmalea* species, and the division made here is therefore somewhat arbitrary. Full inflation of the conjunctiva seemed to have been attained in some specimens of *O. basalis*, and in these examples the lateral theca lobes became perceptibly more turgid. These structures therefore appear intermediate between typical thecal lobes and conjunctival appendages.

This American genus is represented by one or more species from Arizona into northern Argentina, but nowhere is any species common if collections are reliable indicators of abundance.

#### The Species of *Odmalea*

At the time Bergroth (1914) erected *Odmalea* he described *O. quadripunctula*, designating this species as the type species, and transferred *Dendrocoris schaefferi* Barber to *Odmalea*. Ruekes (1959a, b) added *O. olivacea* from Brazil and *O. quadripunctula modesta* from Panama.

Six species are recognized here. The type species is *Odmalea concolor* (Walker), transferred from *Thoreyella*. This name is a senior synonym of *O. quadripunctula* Bergroth and *O. quadripunctula modesta* Ruekes. The latter refers to a form that is not geographically limited within the species range. *O. schaefferi* (Barber) remains as a member of the genus, but *O. olivacea* Ruekes is placed in the synonymy of *Thoreyella brasiliensis*, the type species of *Thoreyella*. *Odmalea pallida* (Jensen-Haarup) is transferred from *Thoreyella* and *Odmalea basalis* (Walker) from *Euschistus*. Two new species, one from Venezuela and one from Colombia, are added to the genus. The six species are separated by the following key.

#### Key to Males of Species

1. Propleura bicolored, broad border ventrad of denticles dark, remainder of propleura much paler 3
  - Propleura almost uniformly colored, pale 2
2. Parameres with digitiform production at apex only (Figs. 6 and 12). (S. Amer., Trinidad, Panama) *O. concolor* (Walker)
  - Parameres with two digitiform productions, one apical and one lateral (Figs. 16, 18 and 19). (Southern S. Amer.) *O. pallida* (J-H)
3. Parameres terminating distally in simple hook (Figs. 54 and 57); pale

- area on basal half of each corium continuing as narrow percurrent costal border to costal angle of corium (Fig. 47) 5
- Parameres expanded distally (Figs. 28, 34, 38, 42 and 43); a large pale area on basal half of each corium and smaller pale area at costal angle (Figs. 26 and 37) 4
4. Parameres unilaterally expanded at apex (Fig. 34); pale areas at base and apex of each corium separated (Fig. 26). (Southern S. Amcr.) *O. basalis* (Walker)
- Parameres bilaterally expanded at apex (Fig. 42); pale areas at base and apex of each corium narrowly connected along costal margin (Fig. 37) (Venezuela) *O. norda* n. sp.
5. Margin of genital cup incised directly caudad of parameres, pygophore continuing beyond this point as digitiform projection from dorsal view (Fig. 49). (Southwestern U.S., Mexico) *O. schaefferi* (Barber)
- Margin of genital cup depressed directly caudad of parameres, pygophore beyond depression knobbed (Fig. 56). (Colombia) *O. vega* n. sp.

*Odmalea concolor* (Walker, 1867) new combination

*Mormidea concolor* Walker, 1867:256-257; Lethierry and Severin, 1893:123 (listed).

*Thoreyella concolor*: Distant, 1900:421 (listed); Kirkaldy, 1909:137 (listed); Jensen-Haarup, 1931:320 (keyed).

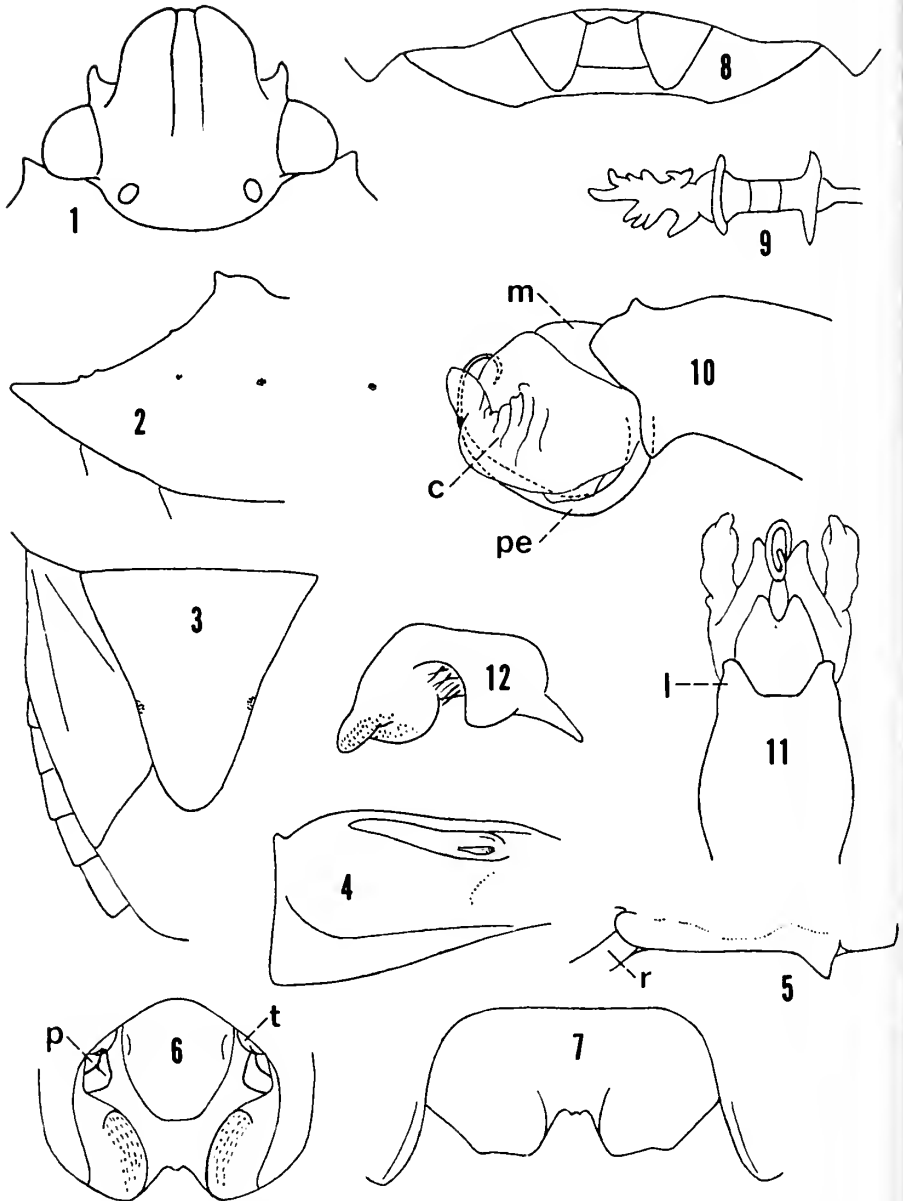
*Odmalea quadripunctula* Bergroth, 1914:437-438, 439, fig. 5 (*O. schaefferi* compared); Pirán, 1968:21 (record). NEW SYNONYMY.

*Odmalea quadripunctula modesta* Ruckes, 1959:17-18. NEW SYNONYMY.

*Odmalea quadripunctata* (sic): Buckup, 1961:12 (record).

Dull sordid yellow, green when living, with dark markings; punctation concolorous, usually excepting patch or band of dark punctures on pronotum before each corium, closer and stronger on head than generally prevailing on dorsum. Jugs little or no longer than tylus, usually with castaneous to fuscous lateral border (Fig. 1). Denticles occasionally lacking on anterolateral margins of pronotum. Margins of humeral angles black. Four small dark spots on anterior disk of pronotum arranged in straight transverse line or in shallow posteriorly directed arc, these almost equidistant or middle pair farther from each other than each from nearest lateral spot; lateral or all spots rarely obscure (Fig. 2). Scutellum usually with dark marginal spot at distal end of each frenum (Fig. 3). Connexiva broadly exposed.

Postcrolateral angle of mesopleura usually bearing dark dot. Appendages



Figs. 1-12. *O. concolor*. Fig. 1. Head. Fig. 2. Pronotum. Fig. 3. Corium and scutellum. Fig. 4. Metapleuron. Fig. 5. Right buccula; second rostral segment (r). Fig. 6. Genital cup, dorsal view; paramere (p); tumescence (t). Fig. 7. Pygophore, ventral view. Fig. 8. Genital plates. Fig. 9. Distal part of spermatheca. Fig. 10. Theca and related structures, lateral view; conjunctiva (c), median penal lobe (m), penisfilum (pe). Fig. 11. Same, dorsal view; lateral thecal lobe (l). Fig. 12. Right paramere.

nearly color of body. Middle tibiae barely flattened to weakly sulcate; posterior tibiae obviously sulcate. Abdominal spine reaching between metacoxae, sometimes longer and just attaining mesocoxae.

Length of body without membranes 7.0–8.1 mm. Head 1.8–2.0 mm wide across eyes, 1.3–1.5 mm long; antennal segments 0.3–0.4; 0.3–0.6; 0.8–1.0; 0.9–1.0; 0.9–1.0 mm in length. Pronotum 5.5–7.0 mm wide at humeri, 1.9–2.3 mm long at meson. Scutellum 3.2–3.8 mm wide at base, 3.1–3.6 mm long.

Opening into genital cup narrowing posteriorly on dorsal surface, passing between broadly depressed surfaces with wide mesial border of dense setae, continuing onto ventral surface as deep concave emargination with small median tooth (Figs. 6 and 7). A finely shagreened tumescence of irregular form located anterolaterad of each paramere. Paramere deeply cupped, much expanded before apex, with transverse base (Fig. 12). Lateral thecal lobes extending posteriorly, their length subequal to distance separating them at base (Fig. 11); distal margin of theca reflexed between lateral lobes and along ventral margin (Fig. 10).

Spermathecal bulb with numerous diverticula (Fig. 9).

*Type*.—Female, in British Museum (Natural History). Type examined.

*Synonymy*.—Although the syntypes of *Odmalea quadripunctula* were not located, Bergroth's detailed description leaves little room for doubt as to the identity of the specimens. Discrepancies between his description and the specimens examined concern the color of some of the punctation, the lower range of size (6–7 vs. 7–8 mm), and the presence of two rather than four dark spots across the pronotum. The differences in coloration, size and markings noted are not inconsistent with the assumption of conspecificity in a species as variable as this one.

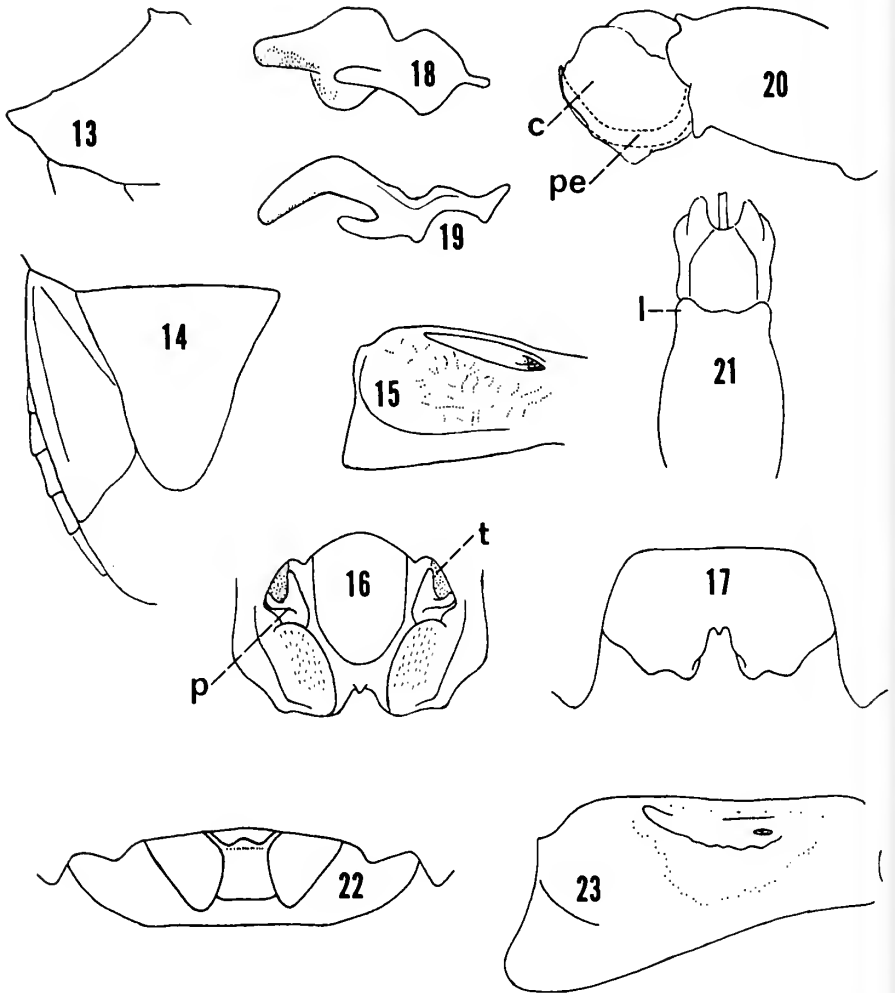
*Odmalea quadripunctula modesta*, described from Barro Colorado in the Panama Canal Zone, represents the common form of this species throughout its range except that most specimens, including those from the Panama Canal Zone, have a few denticles on the anterolateral margins of the pronotum. The type, in the American Museum of Natural History, was examined.

*Distribution*.—Specimens examined were from the Amazon region of Brazil (type locality of *Mormidea concolor*), Trinidad and Panama. Other records are from French Guiana (Bergroth, 1914), Rio Grande do Sul, Brazil (Buckup, 1961) and Rio de Janeiro, Brazil (Pirán, 1968).

*Odmalea pallida* (Jensen-Haarup, 1931) new combination

*Thoreyella pallida* Jensen-Haarup, 1931:320, 322.

Light stramineous, often pinkish dorsally on humeri and much of head excepting broad area around ocelli. Punctures concolorous or nearly so,



Figs. 13–22. *O. pallida*. Fig. 13. Pronotum. Fig. 14. Corium and scutellum. Fig. 15. Metapleuron. Fig. 16. Genital cup, dorsal view; paramere (p); tumescence (t). Fig. 17. Pygophore, ventral view. Fig. 18. Right paramere. Fig. 19. Same, rotated 90° toward observer. Fig. 20. Theca and related structures, lateral view; conjunctiva (c), penisfilum (pe). Fig. 21. Same, dorsal view; lateral thecal lobe (l). Fig. 22. Genital plates.

Fig. 23. *Thoreyella brasiliensis*, metapleuron.

sometimes those along lateral margins of head and scattered punctures on disk black; punctation on head and on pronotum before cicatrices coarser than elsewhere on dorsum. Juga slightly longer than tylus, convergent distally, each jugum narrowly rounded at apex. A submarginal line along head above antenniferous tubercles and margins of humeri black. Pro-

notum sometimes marked with transverse line of four dark spots, the inner pair farther from each other than each from nearest lateral spot. Humeral angles acute but not spinose (Fig. 13). Connexiva not or narrowly exposed (Fig. 14).

Distal half of middle tibiae flattened on superior surface; posterior tibiae flattened or weakly sulcate. Abdominal spine scarcely reaching middle of metacoxae or longer and attaining mesocoxae.

Length of body without membrane 6.5–7.5 mm. Head 1.5–1.8 mm wide across eyes, 1.2–1.3 mm long; antennal segments 0.3; 0.3–0.5; 0.7–0.8; 0.7; 0.8 mm long. Pronotum 4.9–6.1 mm wide at humeri, 1.6–2.0 mm long at meson. Scutellum 2.9–3.4 mm wide at base, 2.9–3.3 mm long.

Opening into genital cup trilobed anteriorly on dorsal surface, narrowing posteriorly between large flattened setose lobes, continuing onto ventral surface as deep emargination with a small mesial tooth projecting from anterior margin (Figs. 16 and 17). Digitiform apex and lateral production of parameres resting against and largely obscuring irregular tumescence on each side of genital cup; parameres much expanded distad and again basad of production located near point of articulation (Figs. 18 and 19). Lateral lobes of theca projecting posteriorly little past median lobe (Fig. 21). Distal margin of theca reflexed between lateral lobes and also along ventral margin (Fig. 20).

*Type*.—Female, in Universitetets Zoologiske Museum, Copenhagen. Type examined.

*Distribution*.—Argentina: Misiones, Formosa; Brazil: The notation following “Brazil” on the holotype appears to read “Maroim (Hygom) Benzon.” The meaning of this notation is obscure.

*Comment*.—Only four specimens of *O. pallida* were available for study, but it seems that this species varies as does *O. concolor* in the intensity and number of pronotal spots. The males of the two species are easily distinguished by the genitalia. The females are less readily separated. The humeral angles among these examples of *O. pallida* are less produced and more obtuse than is usual in *O. concolor*, and none of the specimens bore scutellar spots as most examples of *O. concolor* do.

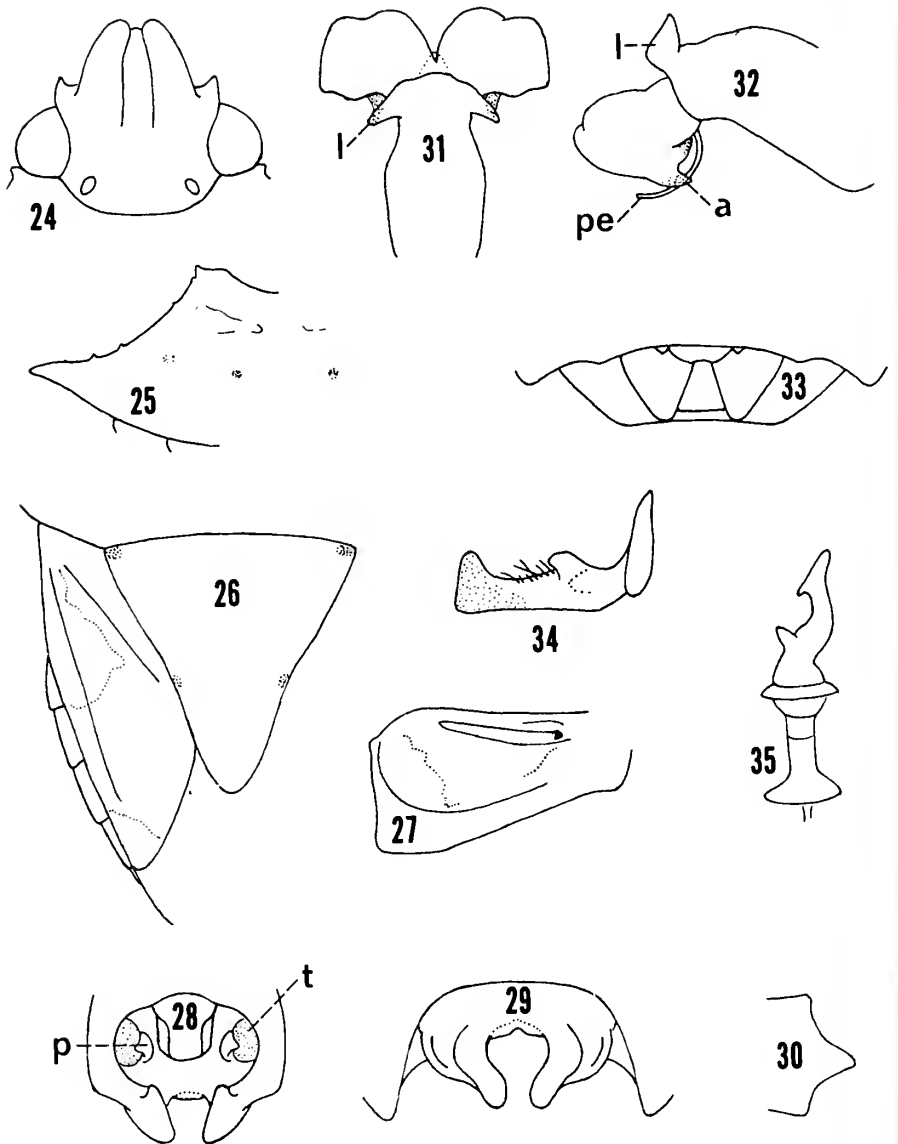
#### *Odmalea basalis* (Walker, 1867) new combination

*Mormidea basalis* Walker, 1867:257 (not Walker, 1868:553) Lethierry and Severin, 1893:123 (listed).

*Euschistus basalis*: Distant, 1899:437 (listed); Kirkaldy, 1909:63 (listed).

*Thoreyella pulchra* Jensen-Haarup, 1931:319, 320; Pirán, 1956:32 (record); Pirán, 1962:10, fig. 8 (record, ♀ genital plates); Becker and Grazia-Vieira, 1971:20 (record). NEW SYNONYMY.

Dorsum mostly dark stramineous. Head becoming rufous toward apex;



Figs. 24-35. *O. basalis*. Fig. 24. Head. Fig. 25. Pronotum. Fig. 26. Corium and scutellum. Fig. 27. Metapleuron. Fig. 28. Genital cup, dorsal view; paramere (p); tumescence (t). Fig. 29. Pygophore, ventral view. Fig. 30. Spine at apex of posterior femur. Fig. 31. Theca and related structures, dorsal view; lateral thecal lobe (l). Fig. 32. Same, lateral view; conjunctival appendage (a), lateral thecal lobe (l), penisfilum (pe). Fig. 33. Genital plates. Fig. 34. Right paramere. Fig. 35. Distal part of spermatheca.



punctuation concolorous to fuscous on disk, rufous to dark castaneous toward apex; lateral margins of head often black. Antennae rufous, sometimes with third or third and fourth segments almost entirely light stramineous. Juga surpassing tylus, usually leaving quadrate incision at apex of head, convergent, rarely contiguous, individually and narrowly rounded distally (Fig. 24).

Pronotum turning to light castaneous on humeri; punctuation sometimes entirely dark but usually light castaneous with darker punctures about cicatrices, in broad basal band and along lateral borders. Disk with narrow impunctate median line and 4 blackish spots arranged in shallow posteriorly directed arc; middle spots somewhat farther from each other than from nearest lateral spot (Fig. 25).

Scutellum bearing 4 small dark spots, one in each basal angle and marginal spot at distal end of each frenum (Fig. 26). Pale stramineous wedge near base of each corium extending from costal margin mesad, separated from clavical vein by two rows of dark punctures, impunctate mesad of radial vein, with obscure concolorous punctuation on exocorium; a much smaller subtriangular area of similar or somewhat darker color and with concolorous punctuation usually present at apex of each corium; punctuation on remainder of corium fuscous along veins, elsewhere castaneous to fuscous. Moderately exposed connexiva pale stramineous, immaculate.

Ventral surfaces stramineous, immaculate, concolorously punctate, excepting broad lateral border of pronotum and head colored and punctate similar to adjacent dorsal surfaces. Tibiae not sulcate. Abdominal spine extending between but not surpassing metacoxae.

Length of body without membranes 6.1–7.0 mm. Head 1.6–1.7 mm wide at eyes, 1.3–1.5 mm long; antennal segments 0.3–0.4; 0.2–0.4; 0.9–1.1; 0.7–0.9; 0.8–1.0 mm in length. Pronotum 5.0–6.0 mm wide at humeri, 1.5–1.8 mm long at meson. Scutellum 2.6–3.0 mm wide at base, 2.5–3.0 mm long.

Genital cup bearing large finely shagreened tumescence anterolaterad of each paramere (Fig. 28); opening into genital cup narrowing posteriorly on dorsal surface, then expanding on ventral surface to obovate form truncated anteriorly by membrane, this sometimes missing (Fig. 29), bordered on both dorsal and ventral surfaces by broad sulcus of uneven depth, this usually traversed near anterior limit on dorsal surface by a thin dark ridge. Apex of parameres curved from dorsal view, with concave lateral surface appressed to tumescence of lateral pygophoral wall; parameres unequally expanded at apex, with a tubercle located adjacent to point of articulation (Fig. 34). Lateral lobes of theca elongate, divergent (Figs. 31 and 32). Bifid appendage on each lateral conjunctival lobe pigmented at apices.

Spermathecal bulb sinuous, with diverticulum toward base and another subapically (Fig. 35).

*Types*.—The following specimen is designated as LECTOTYPE: male, with pygophore dissected, labeled (a) Santarem (b) *Mormidea basilis*, Walkers catal. PARALECTOTYPES: male, 2 females with same data. One female bears in addition to a "type" label next to the specimen and a fourth label "Brit. Mus. Type No. Hcm. 1027." However, Walker did not designate a holotype and no lectotype has been designated previously.

*Synonymy*.—The type of *Thoreyella pulchra* is unusual only in having the jugs contiguous rather than convergent before the tylus.

*Distribution*.—Specimens examined came from Brazil: Santarem (type locality), Minas Gerais; Argentina: Corrientes; Uruguay: Salto. The type locality of *Thoreyella pulchra*, "Riacho del Oro," was not identified.

Pirán (1956, 1962) listed this species from the department of Artigas, Uruguay, and Entre Rios, Argentina. Becker and Grazia-Vieira (1971) recorded three female specimens of this species among pentatomids which they examined from Venezuela. This record needs verification since it may apply to the closely related species which follows.

*Odmalea norda* n. sp.

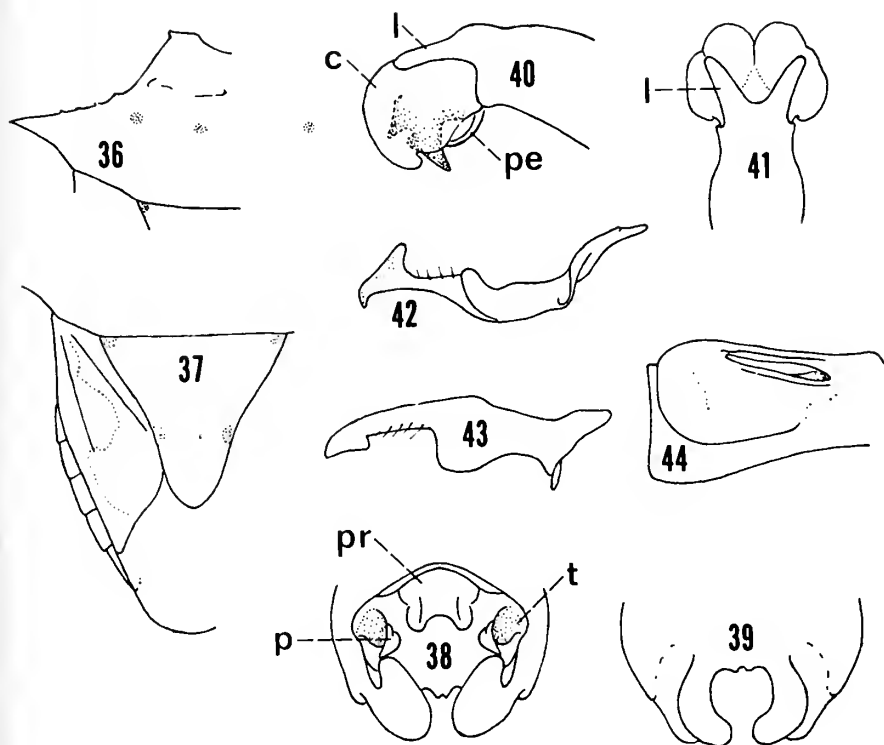
Dorsum mostly dark stramineous. Punctuation on head concolorous to fuscous on disk, black along lateral margins of jugs; antennae brownish yellow. Jugs surpassing tylus, convergent, each jugum narrowly rounded distally.

Pronotum divided along meson by narrow earinate impunctate callous. Four black spots on disk arranged in shallow posteriorly directed arc with middle pair farther from each other than each from nearest lateral spot (Fig. 36). Punctuation fuscous to black in broad basal border, on humeri and along anterolateral margin, elsewhere castaneous. Humeri spinose.

Scutellum with 4 small dark spots, one in each basal angle and marginal spot at distal end of each frenum (Fig. 37). A pale wedge covers basal half of each corium from costal margin mesad, reaching costal vein at base but distally separated from vein by 2 or 3 rows of castaneous punctures; pale area continuing along exocorium, expanding into subtriangular area at costal angle; pale areas concolorously punctate excepting impunctate ivory region between radial and clavical veins occupying distal half of basal wedge; punctuation on remainder of corium dark castaneous. Connexiva moderately exposed, immaculate, concolorous with exocoria.

Ventral surfaces stramineous, thorax a little darker than abdomen, concolorously punctate, excepting broad lateral border of pronotum and head colored and punctate similar to adjacent dorsal surfaces. Tibiae not sulcate. Abdominal spine reaching between but not surpassing metacoxae.

Length of body without membranes 5.8 mm. Head 1.7 mm wide across



Figs. 36–44. *O. norda*. Fig. 36. Pronotum. Fig. 37. Corium and scutellum. Fig. 38. Genital cup, dorsal view; paramere (p), proctiger (pr), tumescence (t). Fig. 39. Pygophore, ventral view. Fig. 40. Theca and related structures, lateral view; conjunctiva (c), lateral thecal lobe (l), penisfilum (pe). Fig. 41. Same, dorsal view; lateral thecal lobes (l). Fig. 42. Right paramere. Fig. 43. Same, rotated 90° toward observer. Fig. 44. Metapleuron.

eyes, 1.3 mm long; antennal segments 0.3; 0.3; 1.0; 0.9; 1.0 mm long. Pronotum 5.0 mm wide at humeri, 1.5 mm long at meson. Scutellum 2.6 mm wide at base, 2.4 mm long.

A large finely shagreened tumescence in genital cup located anterolaterad of paramere and cephalad of deep blind sulcus in margin of genital cup (Fig. 38). Dorsal opening into genital cup narrowing posteriorly to slot; ventral opening expanding from slot, subquadrate with membranous anterior border notched mesially, embraced on each side by broad submarginal depression (Fig. 39). Parameres bilaterally but asymmetrically expanded at apex (Figs. 42 and 43), their concave lateral surface appressed to tumescence on lateral walls of genital cup; parameres much expanded

near point of articulation and at base. Proctiger strongly carinate on each side toward base. Lateral lobes of theca greatly prolonged, divergent (Figs. 40 and 41). Median penal lobes forming cone with curved spur above penisfilum; spur about half as long as penisfilum. Heavily pigmented structure located along mesial surface of conjunction on each side, trifurcate distally with apices acute, the middle one curved mesad.

*Type*.—Holotype, male, labeled: Museum Paris, Venezuela, Coll. E Seguy, 1919. Deposited in the American Museum of Natural History. No paratypes.

*Comment*.—This species closely resembles *O. basalis* and *O. schaefferi* but differs most obviously in the form of the parameres and theca.

*Odmalea schaefferi* (Barber, 1906)

*Dendrocoris (Liotropis) schaefferi* Barber, 1906:262.

*Dendrocoris schaefferi*: Kirkaldy, 1909:151; Banks, 1910:84.

*Odmalea schaefferi*: Bergroth, 1914:438, 439.

Yellowish brown above with faint rufous suffusion on head, humeri and sometimes coria; connexiva and costal border of coria pale stramineous with concolorous punctation; elsewhere on dorsum punctation castaneous to black, a subbasal impunctate arca located mesad of radial vein. Apex of head subquadrately incised between narrowly rounded distal ends of juga (Fig. 45). Pronotum divided along midline by narrow impunctate line; 4 small blackish spots on pronotum arranged in shallow posteriorly directed arc, middle pair about half again farther from each other than each from closest lateral spot (Fig. 46). Scutellum with 4 blackish spots, one in each basal angle, one at distal end of each frenum (Fig. 47). Connexiva moderately exposed.

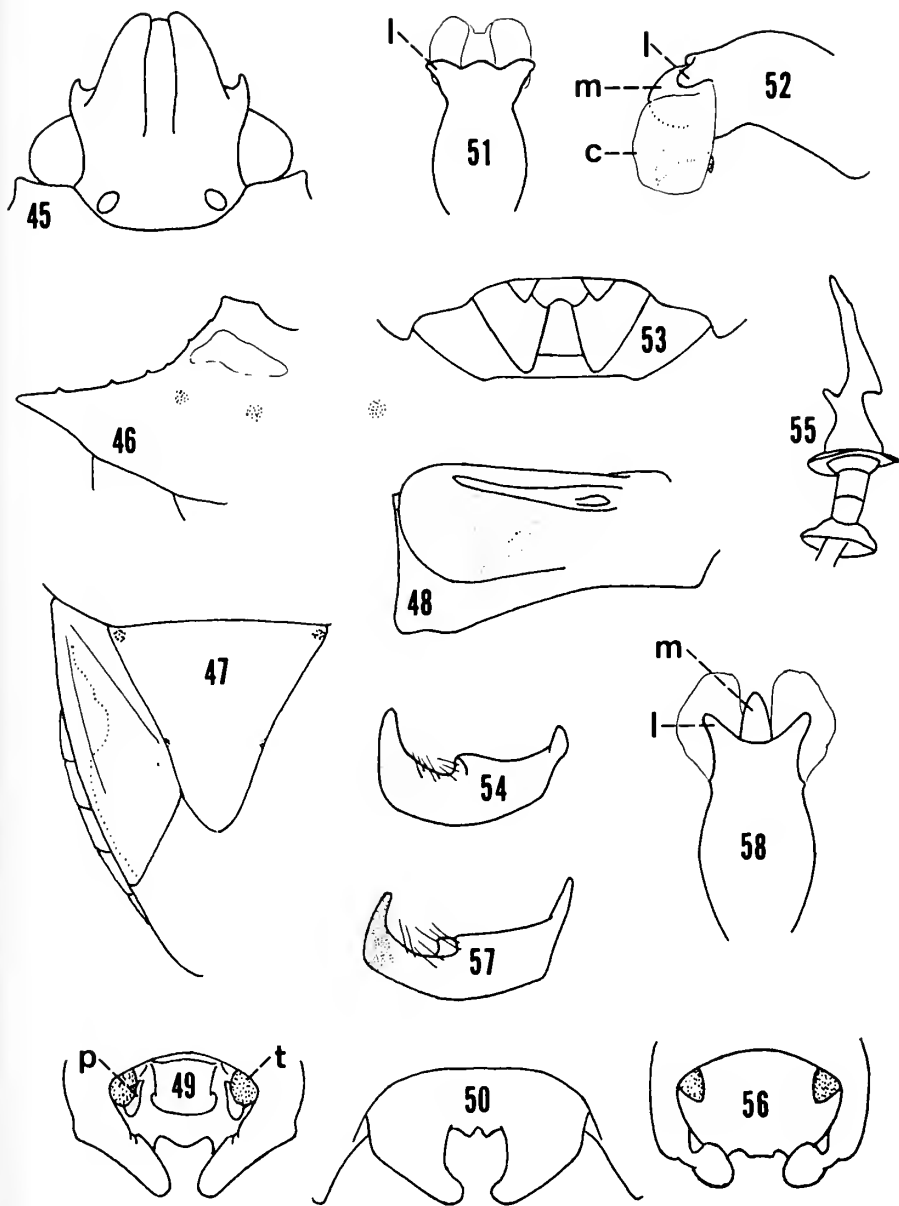
Ventral surfaces pale stramineous with concolorous punctation, excepting broad lateral border of pronotum and head colored and punctured similar to adjacent dorsal surfaces. Legs pale stramineous, none of tibiae sulcate; antennae usually darker. Abdominal spine not surpassing metacoxae.

Length of body without membrane 6.9–7.1 mm. Head 1.7–1.9 mm wide

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Figs. 45–55. *O. schaefferi*. Fig. 45. Head. Fig. 46. Pronotum. Fig. 47. Corium and scutellum. Fig. 48. Metapleuron. Fig. 49. Genital cup, dorsal view; paramere (p), tumescence (t). Fig. 50. Pygophore, ventral view. Fig. 51. Theca and related structures, dorsal view; lateral thecal lobe (l). Fig. 52. Same, lateral view; conjunctiva (c), lateral thecal lobe (l), median penal lobe (m). Fig. 53. Genital plates. Fig. 54. Right paramere. Fig. 55. Distal part of spermatheca.



Figs. 56-58. *O. vega*. Fig. 56. Genital cup, dorsal view, parameres and proctiger removed. Fig. 57. Right paramere. Fig. 58. Theca and related structures, dorsal view; lateral thecal lobe (l); median penal lobe (m).

across eyes, 1.4–1.5 mm long; antennal segments 0.4; 0.2–0.4; 1.2–1.5; 1.0–1.3; 1.1 mm long. Pronotum 5.4–6.2 mm wide at humeri, 1.6–2.0 mm long at meson. Scutellum 2.8–3.2 mm wide at base, 2.7–3.3 mm long.

Dorsal opening into genital cup concavely arcuate anteriorly, narrowing rather uniformly to posterior margin, notched midway along lateral margins (Fig. 49). Outer pygophoral walls before this notch broadly depressed. On ventral surface opening into genital cup subquadrate, trisinate basally, enclosed parenthetically by broad depression (Fig. 50). Genital cup bearing large finely reticulated tumescence anterolaterad of parameres. Parameres bent into acute hook distally, moderately expanded near point of articulation, little expanded at base (Fig. 54). Distal margin of theca trisinate from dorsal view (Fig. 51), reflexed ventrally but not dorsally from lateral view (Fig. 52); lateral lobes extending obliquely laterad and a little farther posteriorly than median lobe. Conjunctiva bearing heavily pigmented bifid appendage on mesal surface of each lobe.

Spermatheca with two opposed diverticula toward base (Fig. 55).

*Types*.—Described from 3 males and 5 females, 7 of these identifiable and in the U.S. National Museum. The following specimen is designated LECTOTYPE: male, labeled (a) Brownsville, Tex., V-03, Cat. No. 97 (b) Cotype 42717 (c) type 61089 (d) Type (c) *Dendrocoris schaefferi* Barber, Type. PARALECTOTYPES: male, labels (a) and (b) as on lectotype; male, label (a) as on lectotype, (b) Cotype (c) *Dendrocoris schaefferi* Barb., ♂, Cotype; female, labeled (a) Brownsville, Tex., VI-03, Cat. No. 97, Brooklyn Museum Coll. 1929 (b) Type (c) *Dendrocoris schaefferi* Barber, ♀, Type; female, labeled (a) Brownsville, Tex., V-03 (b) Cotype 42717 (c) *Dendrocoris schaefferi* Barber, Cotype; female, labeled (a) Brownsville, Tex., V-03 (b) Cotype (c) *Dendrocoris schaefferi* Barb., ♀, Cotype; female, labeled (a) Brownsville, Tex., V-03, Cat. No. 97, Brooklyn Museum Coll. 1929 (b) Cotype No. 42717.

*Distribution*.—From southwest Texas to Chiapas, Mexico.

#### *Odmalea vega* n. sp.

Form, size and color of *O. schaefferi* but male genitalia differing in several respects.

Length of body without membranes 6.7 mm. Head 1.7 mm wide across eyes, 1.5 mm long; antennal segments 0.4; 0.2; 1.2; 1.0; 1.0 mm long. Pronotum 5.7 mm wide at humeri, 1.8 mm long at meson. Scutellum 3.1 mm wide at base, 2.8 mm long.

Margin of genital cup directly caudad of parameres depressed, projecting beyond this point as knob, not incised and continued as digitiform projection as in *O. schaefferi* (Fig. 56). Two small tubercles on parameres near point of articulation (Fig. 57).

*Type*.—Holotype, male, labeled: Colombia, Bolivar, 10 mi S Cartagena, 15-XI-1973, D. Engleman, Coll. Deposited in U.S. Nat. Museum, Type no. 72133. No paratypes.

*Distribution*.—Colombia.

*Comment*.—A single female collected near Bogota, Colombia, may be this species. The spermatheca has a bulbous enlargement distad of distal flange, but it lacks the diverticula found in *O. basalis* and *O. schaefferi*.

#### Acknowledgments

I am indebted to Mssrs. N. Møller Anderson of the Universitetets Zoologiske Museum (Copenhagen), P. van Doesburg of the Rijksmuseum van Natuurlijke Historie (Leiden), W. R. Dolling of the British Museum (Natural History) (London), H. D. Engleman, M.D., R. C. Froesehner of the U.S. National Museum (Washington), Luis de Santis of the Universidad Nacional de La Plata, Facultad de Ciencias Naturales y Museo (La Plata) and P. Wygodzinsky of the American Museum of Natural History (New York) for their contributions toward this revision.

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### BOOK REVIEW

Insects that feed on trees and shrubs. An illustrated practical guide. Warren T. Johnson and Howard H. Lyon. 464 pp., 212 color illustrations. Comstock Publishing Associates—Cornell University Press, Ithaca and London. 1976. \$35.00.

This book was prepared with the collaboration of Carl S. Koehler of the University of California, Berkeley, of N. E. Johnson of Weyerhaeuser Company, and of J. A. Weidhaas of Virginia Polytechnic Institute. It is an unusual reference work, which combines authoritative descriptions of pests with beautiful full-page color plates. The text is authoritative, readable, concise, and well organized. The book is divided into two parts— insects that feed on conifers, and those that feed on leafed evergreens and deciduous plants. Not only professional entomologists and extension workers, but laymen interested in indoor and outdoor plants will find this treatise very useful. In numerous instances natural enemies of pests that exert biological control have been mentioned. Life cycles, seasonal histories, diagrammatic drawings explaining morphological features, and distribution maps are among the important features of this work. A good subject index is provided. The illustrations are perhaps the most remarkable feature and they enhance the value of this volume. The color photographs have been prepared by Prof. Johnson as well as by Howard H. Lyon, whose professional skill was responsible for many of the striking pictures of living insects. These illustrations are crisp and sharp and the color rendition of high quality. This practical guide belongs into every college and university library as well as every public library. It will also be of considerable interest to home garden owners everywhere. Those who will examine this book will wish to own their personal copies, because of the lasting value of this publication.

Karl Maramorosch, *Waksman Institute of Microbiology, Rutgers University.*



A ROTARY FLIGHT TRAP USED FOR SAMPLING  
*HAPLAXIUS CRUDUS* (HOMOPTERA: CIXIIDAE)  
IN COCONUT GROVES<sup>1, 2</sup>

Neil L. Woodiel and James H. Tsai

*Abstract.*—Woodiel, Neil L., and Tsai, James H., Postdoctoral Research Associate and Asst. Professor of Entomology, respectively, Agric. Res. Ctr., University of Florida, 3205 SW 70th Ave., Fort Lauderdale, Florida 33315. Present address of senior author: Arrowhead Drive, Box 422, McMinnville, Tenn. 37110.—A rotary flight trap was successfully devised to sample flying insects associated with the palm community in south Florida. This machine consisted of a triangular support unit, and a boom and net assembly powered by an electric motor. Traps were operated three weeks per month for 12 months during 1974-1975. Although over 50 species of insects were periodically collected, *Haplaxius crudus* (Van Duzee) was trapped throughout the year. The flight activities of this insect appeared to be high in March, May, September and November. While in operation, the nets sampled 4,741 cu m of air per hour for insects. A list of materials necessary to construct this sampling unit is presented.

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### Introduction

Bonnet (1911) conceived the idea of a constantly moving aerial net to sample airborne insects in France by attaching a net to his car. Later Byers (1928) collected dragonflies and McClure (1938) collected general insect populations by this method. Similar aerial nets were used in the leafhopper and mosquito studies by Chamberlin and Lawson (1940, 1945) and Stage and Chamberlin (1945). Airplanes were used to sample the wind dispersion of gypsy moth by Collins and Baker (1934). Davies (1935) used water power as energy for his nets, and Williams and Milne (1935) used electricity as the power source for their nets. Small gasoline engines were adapted for use by Barnes et al. (1939) and Chamberlin and Lawson (1940, 1945). The rotary nets employed in this study were a combination of previously used systems best suited for the studies conducted.

This study was conducted to test the utility of the aerial net for determining which insects most commonly fly in and around coconut palms in southeast Florida in hopes of determining which of these insects might be vectors of the lethal yellowing (LY) disease agent of coconut palms. Because *Haplaxius crudus* (Van Duzee) was reported by Schuiling and

Johnson (1973) to be abundant in coconut plantings in Jamaica, special emphasis was given to this insect and observations on trapping this planthopper are reported here.

### Materials and Methods

This machine consists of three sections: (1) the support system; (2) the power unit; and (3) the boom and net assembly (Fig. 1). The total number and type of items required to construct each section are listed in Table 1.

The machines were mounted at three heights (1.5, 4 and 8 m) around the groves of coconut palms. Traps were operated Monday through Friday, three weeks per month, over a 12-month period.

With a net opening of 35.6 cm diameter and a boom length of 3.65 m, the two nets sampled a volume of 4,741 cu m of air per hour for insects, or approximately 114,000 cu m of air in 24 h, when spinning at 30 revolutions per minute. At the end of each collecting period, the small collecting bags attached to the rear openings of the trap were removed and emptied into a killing jar.

Sample areas were located in Broward and Dade counties, Florida. In Dade County, the Doral Country Club was chosen for sampling since it had a very high incidence of LY. In Broward County, the Agricultural Research Center (ARC) in Fort Lauderdale was chosen since the disease was not present in the immediate vicinity at the start of this study. At each site the nets were placed near and under coconut palms.

### Results and Discussions

The rotary flight trap is an excellent quantitative sampling method for flying insects and can be varied to fit many situations. Since it is non-selective, it offers a means of determining the population density of any flying insects at different elevations and at different times of the year. The traps were occasionally blown over by the wind but this was later prevented by securely anchoring them in the ground. When blowdowns occurred some type of safeguard was required to stop the machine from rolling due to the power of the motor. A pin of soft metal was inserted through the motor shaft and base of the boom assembly which would shear if the machine were to tip over. This avoided stress to the gears of the reduction assembly. The motor shaft was threaded so the base of the boom assembly could be screwed onto it. When the pin which held the two together was sheared, the boom would unscrew and fall to the ground rather than continue to tighten. This also reduced the stress on the power assembly.

Speed of operation definitely affected the efficiency of the machine. The  $\frac{1}{4}$  hp motor produced  $4.5 \times 10^8$  Dyne-cm of torque at the shaft, more

Table 1. Materials required to construct a rotary net with the materials listed by units.

Units	Total materials required
Support unit	
Angle Aluminum (3.81 cm angle for frame)	7 m
Sheet Aluminum (38 mm sheet for top)	52 sq cm
Sheet Aluminum (8 mm sheet for sides)	3 sq m
Plywood (2.5 cm for motor support)	116 sq cm
Plywood (2.5 cm for bearing support)	65 sq cm
Power unit	
Geared electric motor ( $\frac{1}{4}$ hp) (Dayton® Model 5K939)	1
Universal Joint Assm. (19 mm)	1
Shaft (19 mm in cold rolled steel)	60 cm
Steel Sheet (13 mm thick, $49.5 \times 22.7$ cm wide)	1,045 sq cm
Self-aligning Bearings (19 mm)	2
Electrical Cord	3 m
Electric Plug (Male)	1
Bolts $6.3 \times 76$ mm (for shaft pin)	1
Bolts $6.3 \times 32$ mm (motor support)	12
Boom assembly	
Rigid conduit, 13 mm	6 m
Cross coupling, 13 mm	2
Short nipple (13 mm)	1
Cable 3 mm (plastic coated)	12 m
Eye bolts 13 mm	9
Turnbuckle 13 mm	3
U-clamp 13 mm	6
L-coupling 13 mm	2
Cotterpin (heavy duty)	4
Nets	
Steel rod 6.3 mm (for hoops)	18 m
Aluminum $13 \times 3$ mm	3 m
Reinforcing rod 2.5 cm	5 m
Net materials	2 sq cm
Saran 52 mesh	452 sq cm

The total cost for the above materials is estimated to be \$60.00.

® The use of a trademark name should not be interpreted as an endorsement of one product over another that would provide equal effectiveness.

of power than required to do the desired work. The rpm could be increased from 30 to 60 with the same motor and the torque reduced to  $2.3 \times 10^8$  Dyne-cm. This would still be sufficient to operate a 3.66 m boom and at a more efficient rate. Higher rpm prevents insects from dodging the moving nets and from flying out of the nets after being caught.

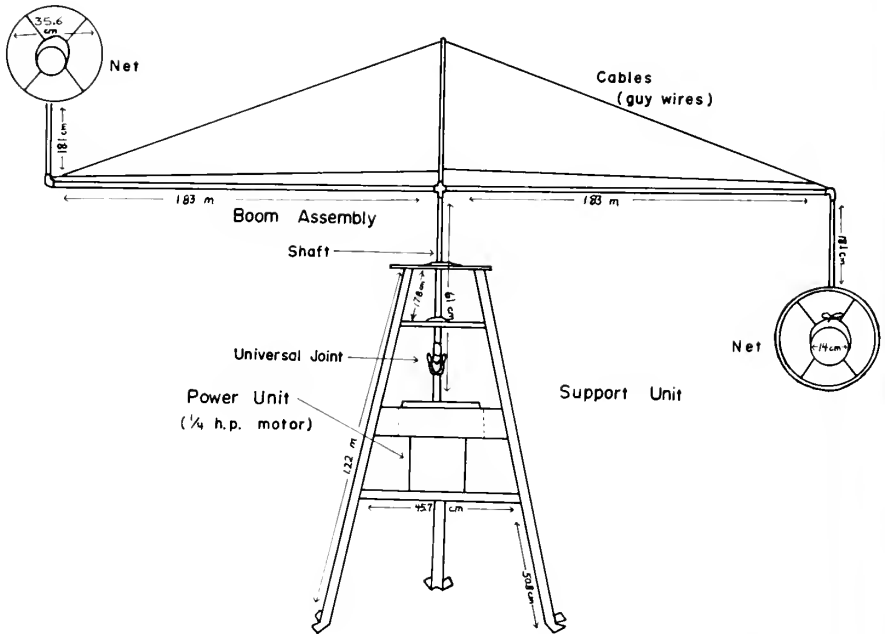


Fig. 1. Diagram of rotary flight trap and the specifications of assembly.

The electric motor requires less attention and appears to be more reliable than other power sources.

One feature of the system which can be adjusted is the length of the boom. The boom in our study was 3.66 m in length as it had been in earlier studies (Chamberlin and Lawson, 1945; Barnes et al., 1939); however, a 3.05 m length boom was used by McClure (1938). Diameter of nets in our study was 35.6 cm while those used in previous studies had varied from 48 cm (Chamberlin and Lawson, 1945; Barnes et al., 1939), to 25.4 cm (McClure, 1938). Various sizes of the nets and booms used in previously mentioned studies give some indication of the flexibility of this system.

The nets can be modified to operate at any angle from the vertical to the horizontal. The machine used in this coconut study was operated with the boom spinning on a horizontal plane with one net suspended below the boom and one placed above the boom (Fig. 1).

In our studies with the aerial net, over 50 species of insects were collected. Nearly 90% of the total leafhoppers and planthoppers trapped in the nets at each sampling site was *H. crudus*. This confirmed the observations made in Jamaica by Schuling and Johnson (1973). Therefore, this insect was considered as a prime suspect as a vector of LY (Tsai, 1975, 1977).

Populations of *H. crudus* vary not only from area to area but also at

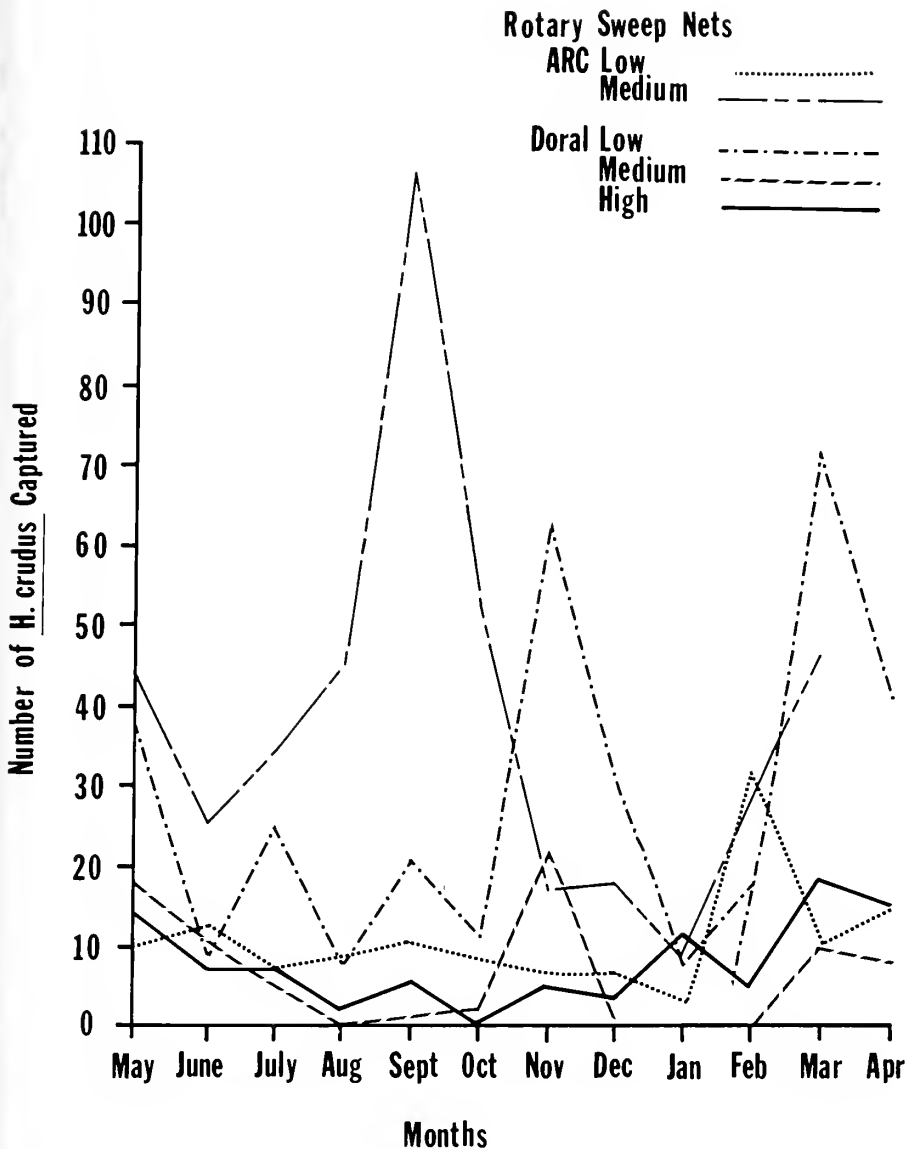


Fig. 2. Monthly average numbers of *H. crudus* captured in the rotary flight traps at the Agricultural Research Center and Doral Country Club (Low = 1.5 m; Medium = 4 m; High = 8 m).

different heights above the ground (Fig. 2 and 3). The nets which collected the highest number of *H. crudus* were the 4 m nets at the ARC. They were located near several mature coconut palms and a large coconut seed bed. The 1.5 m nets at the ARC were located under the same trees

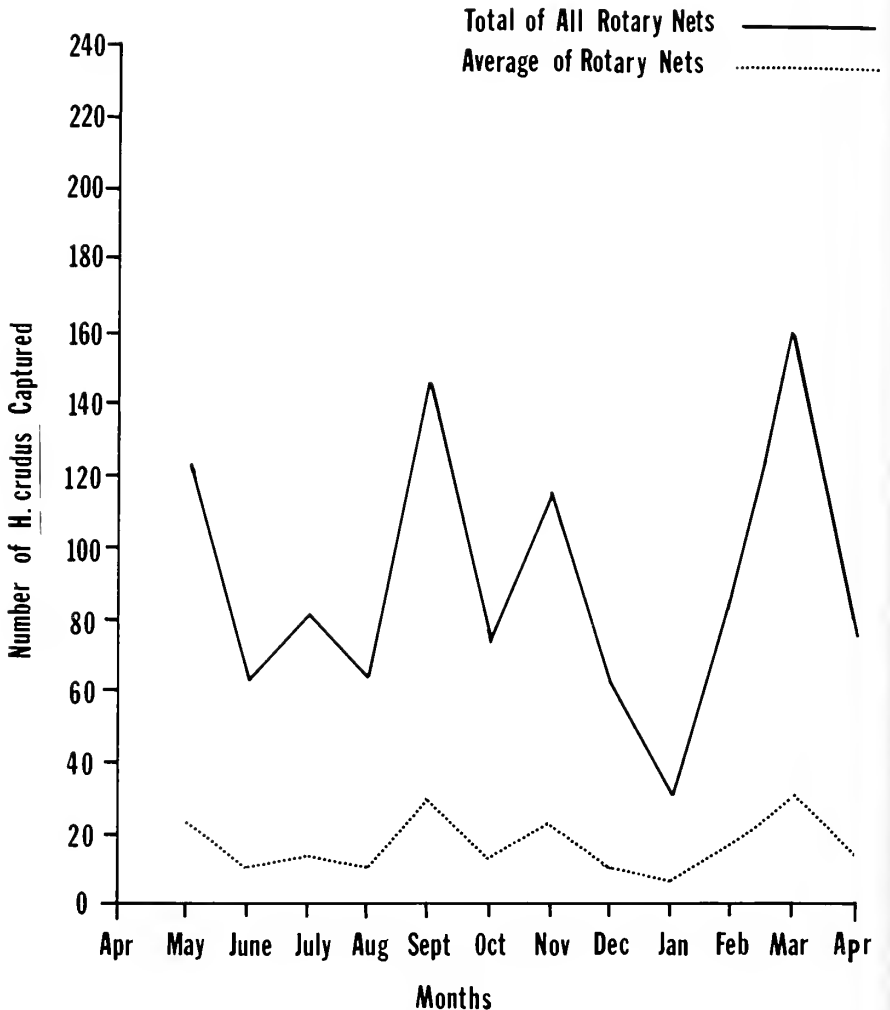


Fig. 3. Monthly total and average numbers of *H. crudus* captured in all rotary nets from the Agricultural Research Center and Doral Country Club.

almost within the seed bed, caught considerably fewer insects than the 4 m nets. In contrast, the traps at Doral captured considerably more *H. crudus* in the 1.5 m than the 4 m or 8 m nets, because more St. Augustinegrass (*Stenotaphrum secundatum* (Walt.) Kuntze), bermudagrass (*Cynodon dactylon* (L.) Pers.), and bahiagrass (*Paspalum notatum* Flugge) were planted on the Doral golf course than on the site of ARC. It is conceivable that more *H. crudus* migrated from their breeding hosts to their feeding

hosts. All nets at Doral were located in close proximity to mature palm trees which were healthy when the study began. By the end of the study, one year later, 90% of coconut palms had succumbed to LY and were removed from the Doral study area. Samples in the nets did not differ before or after removal of the palms. This indicated that *H. crudus* may feed on other plants still on the golf course and is not really affected by the loss of the palms. This would indicate also that plants other than coconut palms could serve as alternate hosts of *H. crudus* and possibly the LY causal agent. The current research efforts are directed at the search for alternate hosts. The average numbers of *H. crudus* did not fluctuate greatly during the entire year. The maximum difference in monthly average was seven fold. In the rain months (mid May to late September), the average numbers of *H. crudus* samples were relatively less. The flight activities of this insect appeared to be high in March, May, September and November (Figs. 2 and 3). Since this insect was found throughout the year it could help explain why the infection rate of LY remains constant throughout the year (McCoy, 1976). This study of flight patterns of *H. crudus*, therefore, becomes an important aspect of LY research in view of experimentation as well as control.

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#### Footnotes

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<sup>2</sup> Florida Agricultural Experiment Station Journal Series No. 721.



THE LIFE HISTORY OF *RELIQUIA SANTAMARTA*,  
A NEOTROPICAL ALPINE PIERINE BUTTERFLY  
(LEPIDOPTERA: PIERIDAE)

Arthur M. Shapiro

*Abstract.*—Shapiro, Arthur M., Department of Zoology, University of California, Davis, California 95616.—The egg, larva, and pupa of *Reliquia santamarta* from the alpine zone of the Sierra Nevada de Santa Marta, Colombia are described. Resemblances to and differences from the early stages of the Nearctic *Pieris callidice* group are noted. Overall *R. santamarta* shows considerable differentiation from its alleged Nearctic relatives, but the hypothesis that it represents a relict of the stock which initially invaded South America from the north and subsequently underwent great adaptive radiation remains tenable.

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*Reliquia santamarta* Ackery is an unusual Pierine butterfly of uncertain affinities. It is known only from above 3,500 m in the Sierra Nevada de Santa Marta of northeastern Colombia, an isolated non-Andean range on the Caribbean margin. Discovered by Michael Adams in 1971, *R. santamarta* has been seen alive by only a handful of biologists. In January 1977 I was able to obtain fertile ova from 8 wild females collected at the type locality, the headwaters of the Rio Cambirumeina at 3,900–4,400 m. This material was reared at Cali, Colombia for use in photoperiod experiments which are being reported elsewhere (Shapiro, 1977a). Like the entire montane and alpine Neotropical Pierine fauna, *R. santamarta* has never been reported as reared in captivity.

The adult of *R. santamarta* is morphologically and phenotypically very similar to the Holarctic *Pieris callidice* Hubner group, which includes the familiar Nearctic *P. protodice* Bdv. & LeC. and *P. occidentalis* Reak. It is less similar to the widespread high Andean taxa of the genera *Tatochila*, *Phulia*, *Piercolias*, etc. and differs strikingly from them in having the submarginal lozenge-markings pointed basad in the interspaces, in this regard resembling true *Pieris*. The affinities of *R. santamarta* pose a critical problem for the interpretation of Pierine phylogeny and biogeography. It is generally assumed (Klots, 1933; Forster, 1958; Mani, 1968; Field and Herrera, 1977) that the entire Andean Pierine fauna evolved from a *Pieris*-type ancestor which invaded South America from the north in the Pliocene or Pleistocene, more or less in tandem with Andean orogeny. The same history is postulated for the Cruciferae, the plant family with which Pierini are predominantly associated globally (Raven and Axelrod, 1974:629). The

Sierra Nevada de Santa Marta is the northernmost mountain mass on the continent, and is characterized by an unusually high floral and faunal endemism (Adams, 1973, 1975). One of its oddest residents is the Pierid (Coliadini) *Nathalis iole* Bdv., which occurs in the high montane and alpine zones but is otherwise unknown in South America. It is a common "weedy" butterfly of dry, open sites in the southern and southwestern United States, in Mexico and northern Central America, and in parts of the West Indies. Because *N. iole* is so morphologically odd, possessing several characters normally associated with boreo-alpine Pierids, it has seemed "out of place" in its North American range. These traits, along with its oddly-shaped pupa, do not seem aberrant in its Colombian range and suggest daring new biogeographic hypotheses. The occurrence of *R. santamarta* in this range is exceptionally interesting in that this seems the logical place to look for a relict population of a northern invader, and the adult looks to "fill the bill." Neither Ackery (1975) nor Shapiro (1977a, b) was, however, able to pronounce on the relationships of *R. santamarta* with great confidence, given the lack of information on its early stages. These are now available for study.

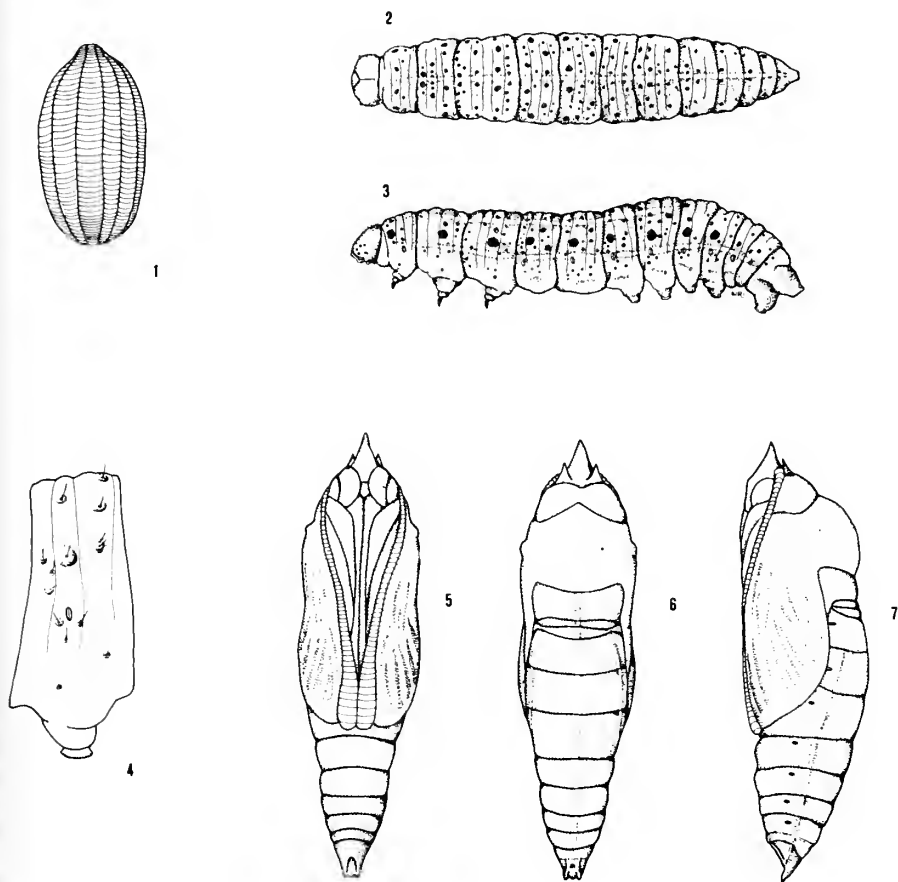
#### Rearing Procedures

These are described in more detail in Shapiro (1977a). Rearing was carried out at  $26.5^{\circ}\text{C} \pm 2^{\circ}$  on continuous light on fresh cuttings of the Cruciferous weed *Lepidium virginicum* L. from a vacant lot in Cali. This regime is very different from the conditions in which this species develops afield (Shapiro, 1977b). Since the adult phenotype was not modified (Shapiro, 1977a) it seems likely the early stages were also normal. The growth rate was certainly tremendously increased, very closely matching those of other high-altitude and -latitude Pierines reared at temperatures of  $20^{\circ}\text{C}$  or higher.

The descriptions which follow were prepared from live material and (fifth-instar larva, pupa, and egg) preserved specimens. Alcoholic material will be deposited with the British Museum (Natural History), the United States National Museum, and the Allyn Museum of Entomology, all of which have substantial adult series.

#### Descriptions

*Egg* (Fig. 1).—Size and form of the egg of *Pieris protodice*,  $0.85 \times 0.25$  mm, erect, spindle-shaped, the chorion sculptured as figured, with about 12 vertical ribs; laid singly (in captivity—none were found afield) on leaves of various wild Crucifers. When laid dull yellow, changing within a few hours to orange-yellow and within two days to brick red; becoming blackish and translucent about 12 h before hatching. Time to hatch 6 days.



Figs. 1-7. *Reliquia santamarta* from northeastern Colombia. 1, egg,  $\times 22.5$ . 2, mature larva, dorsal view. 3, mature larva, lateral view. 4, lateral view of seventh segment, showing major tubercles. 5, pupa, ventral view. 6, pupa, dorsal view. 7, pupa, lateral view. All  $\times 3$  except 4,  $\times 15$ .

*Larva: first instar.*—At hatch 1 mm long; pale unmarked yellow with a dark head; usually eating the eggshell. After feeding on the leaf becoming grayish green, unmarked, finely downy; head black. Begins as a pit feeder on leaves, soon switching to strip feeding. Length of instar  $1\frac{1}{2}$  days.

*Second instar.*—After molt 3.5 mm long at rest. Yellowish green, unmarked, finely downy, head black. By the end of the instar faint stigmatal yellow lines are visible, and a trace of a mid-dorsal one. Length of instar  $1\frac{1}{2}$  days.

*Third instar.*—After molt 7.5 mm long at rest. Gray-green; a faint yellow

mid-dorsal and stronger yellow stigmatal lines, these lines all bordered by conspicuous black tubercles of two sizes, with many very small less conspicuous tubercles scattered over the body at large; head at first gray-green, turning to dull brownish, mottled with black; ocelli black. Length of instar 2-3 days.

*Fourth instar.*—After molt 11 mm long. Ground color olivaceous gray-green; dorsal stripe pale yellow; stigmatal lines vaguely reddish yellow; black tubercles in three sizes, mostly bearing short black hairs. True legs black; venter and prolegs pale gray-green. Length of instar 2-3 days.

*Fifth instar.*—After molt 15 mm long at rest. Maximum resting size before prepupal period, 22 mm. Color as in fourth instar; by the Korerup and Wanscher system (1967) ground color 3E6 ("olive"). Tuberculation as in Figs. 2-4. The last one or two fecal pellets produced before pupation are red, as in the *Pieris callidice* group. Before pupation the larva is very active and wanders for several hours prior to selecting a final site. Length of instar 3½-4 days.

*Prepupa.*—Similar to the *P. callidice* group. Attached by the anal legs and by a girdle around the thorax. Generally vertical, head up. Length of prepupal period, 8-12 hours. The prepupa does not become very pale in color, as occurs in *Euchloe ausonides* Lucas of the Nearctic which has a somewhat similar larva.

*Pupa* (Figs. 5-7).—Length 18 mm, width at girdle 4.7 mm. After pupation bright green (27A6), usually but not always changing within 24 h to light buff (4A2, "yellowish white"), pattern as shown, with indistinct dark markings between the wing-veins (5D4, "light brown"); in color very similar to dormant pupae of *Pieris napi* L. rather than to members of the *callidice* group, which are characteristically grayish. Frontal prominence short, as in the *callidice* group, much shorter than in any *napi* population. The two supraocular prominences larger than in the *callidice* group or any Holarctic *Pieris*, approaching the frontal one in size. Most strikingly, the flaring dorsolateral prominences (near the outer angles of the wing cases), which are moderately developed in the *callidice* group and greatly so in *P. rapae* L. and *P. napi*, are entirely absent. The shape of the pupa suggests a *Colias*, but with uninflated wing cases. Before emergence the eyes, wings, and body are pigmented in that order, with white pigment laid down in the wings several hours before black. Meconium red, as in the *P. callidice* group. Length of pupal period, 6-7 days.

#### Discussion

The early stages of *Reliquia santamarta* are perplexing. There are strong hints of relationship to the *Pieris callidice* group in all stages. The egg is virtually identical, the larval striping and tuberculation are somewhat

similar, the pupa has a similar facies except for the lack of dorsolateral prominences, and—perhaps most significantly—the larval wastes before pupation and the meconium are both red, a trait shared only with the *callidice* group among the Nearctic Pierines. There are, however, so many aberrant traits that one must hesitate before accepting a close kinship. The ground color of the mature larva is unlike any Nearctic Pierine; it most closely approaches *Pieris beckeri* Edwards. However, it is identical to the color of larvae of *Pieris brassicae* L. of Palaearctic, and it shares with that species the three-stripe pattern, along with a pronounced but hard-to-define “oily” look. Unlike *P. brassicae* the larvae are not gregarious and do not stink. The pupa also somewhat resembles *P. brassicae* in having a small frontal prominence, but the enlargement of the supraoculars is similar to the condition in the Andean genus *Tatochila* (Shapiro, 1977c) and points to a connection there—otherwise resemblances in the early stages are minimal. The first and second instar larvae are reminiscent of *Pieris sisymbrii* Bdv., but the later instars are not. *P. sisymbrii* has a blue-green egg of an unusual shape and an aposematically-colored fifth-instar larva which loses all its tubercles, and despite its facies does not seem to be closely related to the *callidice* group.

In culture *R. santamarta* behaved as a leaf, rather than an inflorescence, feeder when presented with *Lepidium* tops. In the Nearctic, leaf-feeding Pierines tend to have cryptic green larvae with faint dorsal and stigmal yellow stripes, while inflorescence feeders are striped lengthwise in purplish-gray and yellow. These patterns have evolved independently in closely related species pairs in *Pieris* (Pierini) and also in *Euchloe* (Euchloini). This suggests that although the larva of *R. santamarta* has not been found in the wild, it is probably a foliage feeder on the perennial rosette Crucifers (many gray-green) which abound in its rocky alpine habitat.

The geologic interpretation of the Caribbean margin, including the Sierra Nevada de Santa Marta, is in flux and in any case exceedingly complex (Tschanz et al., 1974). Several hypotheses can be advanced to account for the range of *R. santamarta*, but given the various resemblances to the *P. callidice* group (including such “offbeat” characters as egg and meconium color) and the link to *Tatochila* in pupal shape, the most persuasive hypothesis is the traditional one which makes the Andean Pierines derivative from Nearctic invaders and assigns to *Reliquia* a truly relict status. *R. santamarta*, it should be noted in passing, has well-developed androconia while these have been lost by *P. protodice*, *callidice*, and *occidentalis*. It also has the long antennae characteristic of the Andean *Hypsochila* and *Pierphulia* and some lowland Neotropical genera, e.g. *Itabalia*. There are definite hints that if the Nearctic-invasion hypothesis is correct, the ancestor of *R. santamarta* was a more primitive Pierine than

the present-day *callidice* group, whose distribution demonstrates a pre-Pleistocene origin.

### Acknowledgments

This work was made possible by grants from the National Science Foundation and the National Geographic Society and with the help of Colombian friends too numerous to mention. Special thanks are due Mrs. Adrienne R. Shapiro and Dr. Arthur S. Weston for their help in the Sierra Nevada de Santa Marta. The illustrations are by Ms. Lynn Siri.

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THE LIFE HISTORY OF AN EQUATORIAL MONTANE  
BUTTERFLY, *TATOCHILA XANTHODICE*  
(LEPIDOPTERA: PIERIDAE)

Arthur M. Shapiro

*Abstract.*—Shapiro, Arthur M., Department of Zoology, University of California, Davis, California 95616.—The egg, larva, and pupa of *Tatochila xanthodice* from moderate elevations in the Cordillera Central of the Colombian Andes are described. There are numerous suggestions of affinity to the Holarctic *Pieris callidice* group. The pupa is unusual in the reduction of the frontal prominence and concomitant enlargement of the supraocular oncs, and in the reduction of the dorsolateral prominences.

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The white butterflies of the tribe Pierini have undergone an adaptive radiation in the Andean region unparalleled elsewhere in the world: there are seven endemic genera and about 40 species from northeastern Colombia to Tierra del Fuego. The origins and affinities of this fauna are difficult to interpret. The butterflies occur in alpine, montane, subantarctic, temperate and Mediterranean climates, but avoid the lowland tropics. This distribution closely follows that of the Cruciferae, with which Pierines are usually associated. Traditionally the Andean taxa have been considered descendants of a Nearctic invader which penetrated South America about the time of the Andean orogeny (Klots, 1933; Forster, 1958; Mani, 1968; Field and Herrera, 1977). Evidence from recent studies of the biology of Colombian Pierines is contradictory and confusing (Shapiro, 1977a, b). There are biogeographic and physiological hints of at least older, and perhaps multiple, invasions.

The early stages of the Andean Pierines are unpublished. Several common Chilean and Peruvian species have been reared (J. Herrera, M. Etcheverry, G. Lamas M., personal communications). Any data bearing on the early stages may be useful in phylogenetic and biographic inference about these animals; as a minimum they permit comparisons with the Nearctic Pierini, which have nearly all been described thoroughly.

*Tatochila xanthodice* is a common Pierine of montane, subalpine, and (occasionally) alpine northern South America, from northeastern Colombia (Sierra Nevada de Santa Marta, 10°54'N, 3,650-4,000 m) (Ackery, 1975) south to Cajamarca, Peru (7°10'S, 2,700 m) (Herrera and Field, 1959). In south-central Colombia it is multiple-brooded with 3 or 4 generations a year at Tenerife, Department of Valle del Cauca (3°30'N, 2,700-3,000 m).

There it is a colonizing insect, breeding on European Cruciferous weeds (*Raphanus sativus* L., *Brassica campestris* L., *Lepidium ruderales* L.) in onion fields and on cultivated cabbage (*Brassica oleracea* L.) in gardens. Tenerife stock was collected in 1977 for photoperiod experiments (Shapiro, 1977a), affording the opportunity for a description of the early stages. Additional material was subsequently collected for me by Rodrigo Torres N. of Buga, Valle. Several rearing regimes were used; these are described in Shapiro, 1977a. No phenotypic variation in the adult was induced by these treatments. The descriptions which follow, including developmental rates, are for animals reared at 25°C on continuous light on fresh cuttings of *Lepidium strictum* (Wats.) Rattan.

Alcoholic material of the early stages is being deposited at the United States National Museum, Washington, D.C.

### Descriptions

*Egg* (Fig. 1).—Similar to the egg of *Pieris protodice* Bdv. & LeC. but larger, 1.2 × 0.33 mm. Erect, spindle-shaped, the chorion sculptured as figured, with 9–11 vertical ribs connected by about 40 horizontal ones. Laid singly afield on leaves and stems, less often on inflorescences; usually on the upper surfaces of leaves but frequently below; commonly found on young rosettes of wild radish with only 2–5 leaves, less often on large plants. Light orange when laid, darkening to deep orange after 12–18 h, translucent blackish 12 h before hatching. Time to hatch, 4 days.

*Larva: first instar*.—At hatch 1.5 mm long at rest. Dull orange, apparently unmarked except for minute dark tubercles bearing short setae; head black. Begins as a pit feeder on leaves. Length of instar, 2 days.

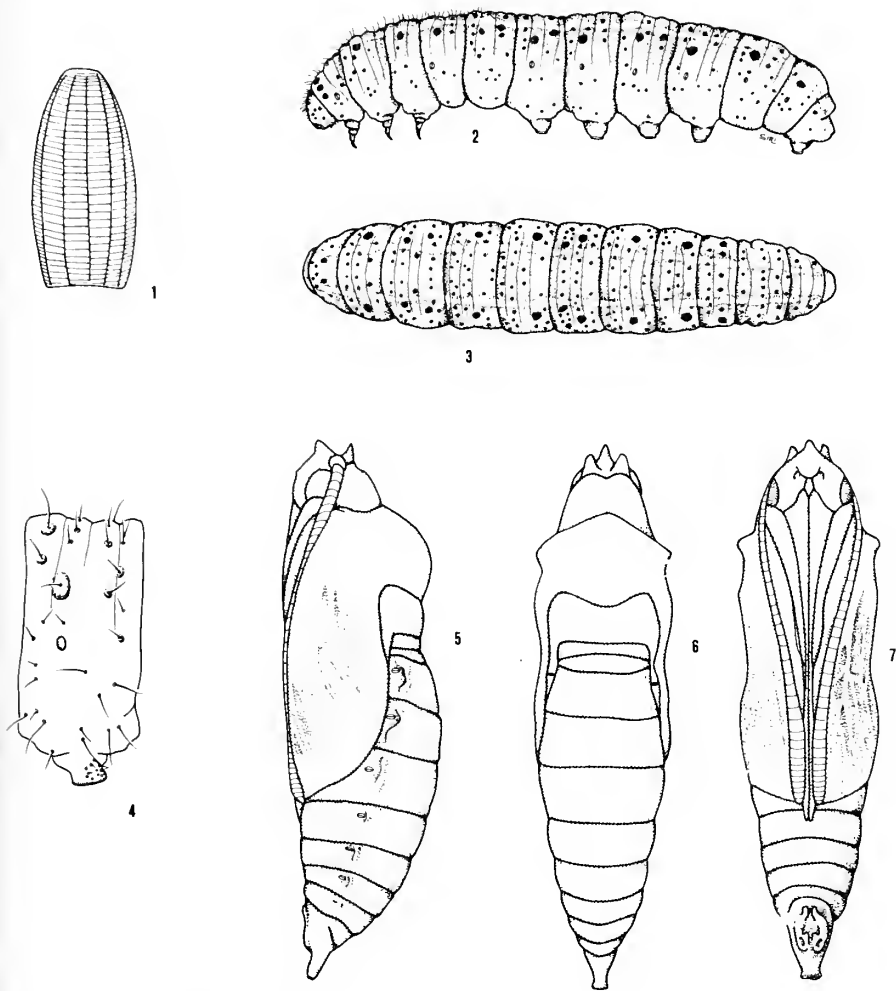
*Second instar*.—After molt 5 mm long. Olive green, with two subdorsal stripes, stigmatal stripes, and a very faint mid-dorsal one all yellow. Head gray-green, ocelli black. Head and body covered with many black tubercles of 3 sizes. Length of instar 2–3 days.

*Third instar*.—After molt 9 mm long at rest. Velvety black, pattern as before, the dorsal stripe very faint to obsolete. Head plain dull black. At this stage the larva will feed indiscriminately on any aerial part of the plant, growing very rapidly. Length of instar 3 days.

*Fourth instar*.—After molt 13 mm at rest. Pattern as before, the stigmatal stripes poorly defined and dull orange, the dorsal stripe often disappearing altogether. Length of instar 3–4 days. (Very rarely the black color is replaced by a dull gray-green throughout.)

*Fifth instar*.—After molt 18 mm long, reaching 28 mm before ceasing feeding. Body with many black tubercles in 3 sizes (Figs. 2–4), each bearing a short hair. By the Kornerup and Wanscher (1967) method the two subdorsal stripes are 2A5 (“light yellow”); just before the intersegmental





Figs. 1-7. *Tatochila xanthodice* from southern Colombia. 1, egg,  $\times 20$ . 2, mature larva, lateral view. 3, mature larva, dorsal view. 4, lateral view of seventh segment, showing major tubercles. 5, pupa, lateral view. 6, pupa, dorsal view. 7, pupa, ventral view. All  $\times 25$  except 4,  $\times 65$ .

membrane at the anterior end of each segment the yellow stripes contain squarish orange (7A8, "reddish orange") spots. Stigmatal stripes weak, orange, often obsolescent. The dorsal stripe is almost always absent. (Very rarely the black color is replaced by dull gray-green throughout.) Mature larvae eat a tremendous amount, and one can strip a small *Brassica campestris* plant of its foliage and siliques. As in the *Pieris callidice* Hbn.

group, the last one or two fecal pellets produced before pupation are red. Length of instar, 5 days.

*Prepupa*.—Similar to the *P. callidice* group; attached by the anal legs and a girdle around the thorax. Usually vertical, head up. Prior to spinning a silken mat the larva wanders for 5–8 hours. Length of prepupal period, 12–30 hours.

*Pupa* (Figs. 5–7).—Length 22 mm; width at girdle 5 mm. Initially colored like the larva/prepupa, assuming its final coloration in 4–6 h. Ground color 24A2 (“turquoise white”) with numerous black dots corresponding to the larger larval tubercles, and two rows of orange spots dorsally corresponding to those in the larval subdorsal lines, which may be faintly indicated. The pattern of the anterior portion, including the wing cases, is extremely variable. Some have this entire area unmarked 5A3 (“pale orange”). Others have it concolorous with the body, with or without heavy black filling on the wings. A few have the head, prothorax, and appendages including wings mostly black. The commonest form, with dark filling between the wing veins, is illustrated. The overall color scheme is reminiscent of pupae of *Chlosyne* and *Euphydryas* (Nymphalidae). The variation is completely uncorrelated with temperature of photoperiod. After eclosion the pupal case is pale dull brown, with all the markings preserved.

Frontal prominence greatly reduced, the two supraocular prominences of equal size; flaring prominences at the outer angles of the wing cases reduced, only very faintly indicated above the spiracles. Before eclosion the eyes, wings, and body are pigmented in that order. White is laid down 15–20 hours before black pigment in the wings. In females the outer half of the wing appears solid black in the pharate adult, and the ground color changes from white to yellow. Meconium red, as in the *P. callidice* group. Length of instar 7–10 days. The pupa is exceptionally active and wriggles if disturbed.

### Discussion

The larva of *Tatochila xanthodice* is reminiscent in facies of the *Pieris callidice* group. It differs in the reduction of the stigmatal stripes and in having fewer large tubercles. In habits it resembles *P. rapae* L., eating high-water-content Crucifers, consuming great amounts of foliage, producing very copious frass. The pupa is unlike anything found in the Nearctic, and has only a very vague and unconvincing resemblance to the similar-sized *Pieris brassicae* L. of the Palaearctic. The configuration of the various prominences is strikingly similar to the pupa of *Reliquia santamarta* Ackery (Shapiro, 1977b) although that species is more of a “normal” Pierine and looks much less odd. The larva and adult are extremely constant, contrasting with the variable markings of the pupa. Three of about 70 larvae reared were gray-green rather than black; they produced unexceptional pupae and adults.

The coloration of the larva and pupa of *T. xanthodice* recall the Nymphalid genus *Euphydryas* of north temperate latitudes. In that genus the behavior of the larva and adult suggests distastefulness, and the coloration may be aposematic. No information is available as to the palatability of *Tatochila*, but the larvae are fully exposed and conspicuous on their host plants. The adult female of *T. xanthodice* is the most heavily melanized Andean Pierine; its behavior suggests a thermoregulatory function for the pigmentation. The same may be true for the larva.

In general the morphology of the early stages of *T. xanthodice* supports the inferred derivation of the group from a Nearetic invader akin to the present *P. callidice* group. The recently studied *R. santamarta* from north-eastern Colombia is a feasible intermediate. The tendency toward reduction of the frontal prominence occurs also in the very unusual Nearetic Coliadine, *Nathalis iole* Bdy., which may be of South American origin. The adaptive significance of this character in those species which do not resemble thorns or twigs requires investigation.

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THE GLYCOPROTEINS OF INSECT CELLS IN CULTURE

Neil I. Goldstein and Arthur H. McIntosh

*Abstract.*—Goldstein, Neil I., and McIntosh, Arthur H., Waksman Institute of Microbiology, Rutgers University, The State University of New Jersey, P.O. Box 759, Piscataway, N.J. 08854. Present address of senior author: The Wistar Institute, 36th Street at Spruce, Philadelphia, Pa. 19104.—Insect cells in culture synthesize glycopeptides and shed these molecules into the medium. The profiles of  $^{14}\text{C}$ -glucosamine labelled proteins, as determined by sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE), show both quantitative as well as qualitative differences between the insect lines studied.

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Introduction

Glycoproteins are important macromolecular constituents of cells, occurring in both intra- and extracellular membranes (Yamada and Weston, 1974; Chiarugi and Urbano, 1973). The glycoproteins of the cell's plasma membrane play important biological roles, being involved in active transport, cell to cell recognition, and as viral and hormonal receptor sites (Singer, 1974; Marchesi et al., 1976). The membrane has been shown by histochemical techniques to contain or be closely associated with glycoprotein material (Gasic and Gasic, 1963). Of further interest are the qualitative and quantitative changes which have been reported for glycoproteins of cells transformed by viruses and chemical carcinogens (Perduc et al., 1972; Warren et al., 1973). Recent work by Hynes (1976) has shown that a large molecular weight membrane glycoprotein (called LETS protein or large external transforming sensitive protein) is greatly reduced in transformed fibroblasts when compared to the normal parents and may be involved in the adhesion of these cells to the substratum (Hynes, 1976).

Although glycoproteins occur in such diverse cell types as sponge, yeast, plant, and vertebrate cells, most of the glycoprotein studies have involved the latter cell type. In view of the rapid developments and interest in the field of insect cell culture (Maramorosch, 1976), and the limited utilization of insect cell lines, these studies were undertaken to determine whether glycoproteins are normal components of insect cells. In addition, the cellular glycoproteins were separated by polyacrylamide gel electrophoresis (PAGE) in order to differentiate the different species of glycoproteins.

Table 1. Acid precipitable material from insect cells.<sup>a</sup>

Cell line	CPM/MG protein		
	In medium	Trypsinate	Trypsin-extracted cells
AE	31,990 ± 4,499 <sup>b</sup>	81,828 ± 19,022	185,771 ± 32,613
SF	32,277 ± 5,145	37,595 ± 8,688	81,281 ± 22,755
CP	23,230 ± 5,525	28,241 ± 8,973	68,107 ± 11,682

<sup>a</sup> Aliquots of the medium, trypsin, and trypsin-extracted cells isolated from cells grown in radioactive medium were treated for 15 minutes with cold TCA (final concentration = 20% TCA). The precipitated material was collected on filter pads using vacuum filtration. The pads were dried overnight at room temperature and counted by liquid scintillation spectrometry.

<sup>b</sup> Mean ± S.D. based on at least 2 experiments using replicate samples.

### Materials and Methods

*Cell lines and medium.*—The lepidopteran insect cell lines *Spodoptera frugiperda* (SF, IPLB-21), *Laspeyresia pomouella* (CP-169) and the dipteran cell line *Aedes aegypti* (AE) were grown at 28°C in monolayer culture using TC199-MK medium (for SF and CP) (McIntosh et al., 1972) and M & M medium (for AE) (Mitsubishi and Maramorosch, 1964).

*Metabolic labelling of glycoproteins.*—Cells from confluent 75 cm<sup>2</sup> T-flasks were removed with trypsin (0.25%), pelleted at 1,000 × g, and 5 × 10<sup>5</sup> cells resuspended in growth medium containing either 2.8 μ Ci/ml of 3H glucosamine (sp. act. 7.5 ci/m mole) (for plating experiments) or 1.5 μ Ci of <sup>14</sup>C glucosamine (sp. act. > 200 m Ci/m mole) (for PAGE). The cells, in 4 ml of medium, were dispensed into several 25 cm<sup>2</sup> T-flasks and incubated at 28°C for 72 hours. At the end of this time period, all of the cells were observed to be in late log phase (non-confluent).

*TCA plating procedures.*—The medium was aspirated, removed from those flasks which were to be used in these experiments and the monolayer washed three times with Hanks' balanced salt solution (HBSS). Four ml of fresh, unlabelled medium were added to each flask and the cells incubated for an additional 24 hours at 28°C. The medium was then removed from each T-flask and the floating cells pelleted by centrifugation. The cells remaining in monolayer were treated with 2 ml of 0.25% trypsin for 30 minutes to remove the exposed surface proteins (trypsin). The trypsin-extracted cells were pelleted and washed 3× with HBSS. To dissolve the pelleted cells, 0.1 NaOH was added. An aliquot was then removed for protein determination by the method of Lowry et al. (1951).

To a 0.5 ml aliquot of medium were added 2 ml of cold 20% trichloroacetic acid (TCA). To the trypsin and the trypsin-extracted cells, enough cold 100% TCA was added to bring the concentration to 20%. The sam-

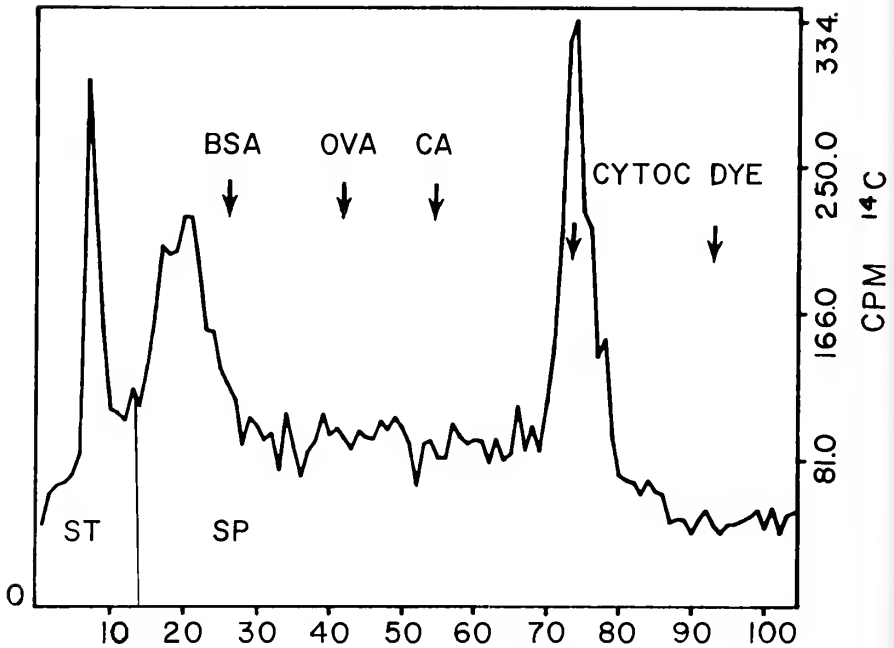


Fig. 1. Electrophoresis of  $^{14}\text{C}$ -glucosamine labelled glycoproteins from AE cells. The glycoproteins were labelled, isolated, and electrophoresed as described in the text. Bovine Serum Albumen (BSA), Ovalbumen (OVA), Carbonic Anhydrase (CA), and Cytochrome C (CYTO C) were run as standards. The tracking dye (DYE) was noted.

ples were vortexed and kept at  $4^{\circ}\text{C}$  in an ice bath for 15 minutes. The TCA precipitable material was collected on filter pads using vacuum filtration, washed  $5\times$  with cold 5% TCA, dried overnight at room temperature, and counted by liquid scintillation procedures using Aquasol as the cocktail. The amount of glucosamine-labelled material was expressed as counts per minute per mg of protein.

*Polyacrylamide gel electrophoresis.*—The cells to be isolated for PAGE were washed in monolayer  $3\times$  with HBSS, scraped with a rubber policeman, and pelleted at  $1,000\times g$ . To the pellet was added  $300\ \lambda$  of PAGE sample buffer containing 2% sodium dodecyl sulfate (SDS) and 5% 2-mercaptoethanol. Before electrophoresis, the samples were heated for 3 minutes in a boiling water bath. About 25,000 cpm per sample were layered on the gel. The following proteins were run as standards: bovine serum albumen (MW = 66,000); ovalbumen (MW = 46,000); carbonic anhydrase (MW = 31,000); cytochrome C (MW = 12,000). Electrophoresis was carried out in a slab gel system consisting of a 5% stacking gel (pH 6.8) and a 10% separating gel (pH 8.8) (Laemmli, 1970). The samples were allowed to migrate 9.5

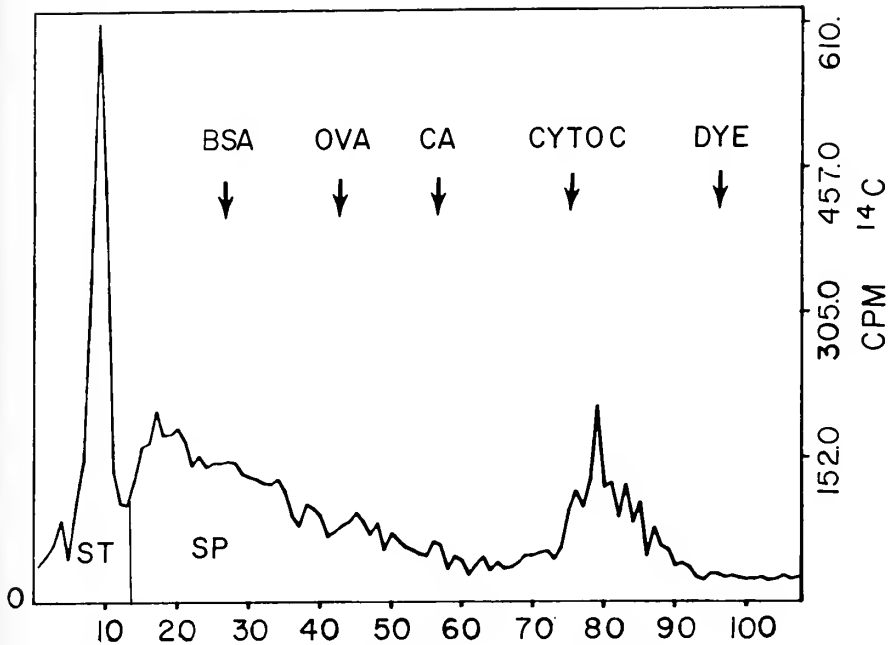


Fig. 2. Electrophoresis of <sup>14</sup>C-glucosamine labelled glycoproteins from SF cells. See Fig. 1 for legend description.

cm. The gel was stained with 0.05% Coomassie brilliant blue dye in H<sub>2</sub>O, glacial acetic acid and isopropyl alcohol (13:2:5, v/v), and destained in 10% acetic acid. The gel was photographed and each sample slot cut and sectioned into 1 mm slices using a Joyce Loebel Gel slicer. Slices were placed in glass mini vials, solubilized with a homemade cocktail (5% Protosol; 1% H<sub>2</sub>O; 4 g PPO; 50 mg POPOP per liter of toluene) and counted by liquid scintillation spectrometry.

### Results and Discussion

The results of our experiments show that the three insect cell lines can synthesize glucosamine-labelled proteins which are found in the plasma membrane and are shed into the medium (Table 1). Among the three lines, AE synthesized the greatest quantity of cellular and membrane APM when compared to SF and CP (Table 1). This is probably related to the different growth properties of the cell lines. AE grows to the highest maximum cell density ( $36 \times 10^6$ ) compared to either SF ( $17 \times 10^6$ ) or CP ( $16 \times 10^6$ ) in 25 cm<sup>2</sup> T-flasks (McIntosh, 1976). In addition, it is interesting to note that the amount of APM released into the medium was constant among the three cell lines. This "shed" material probably results from the rapid

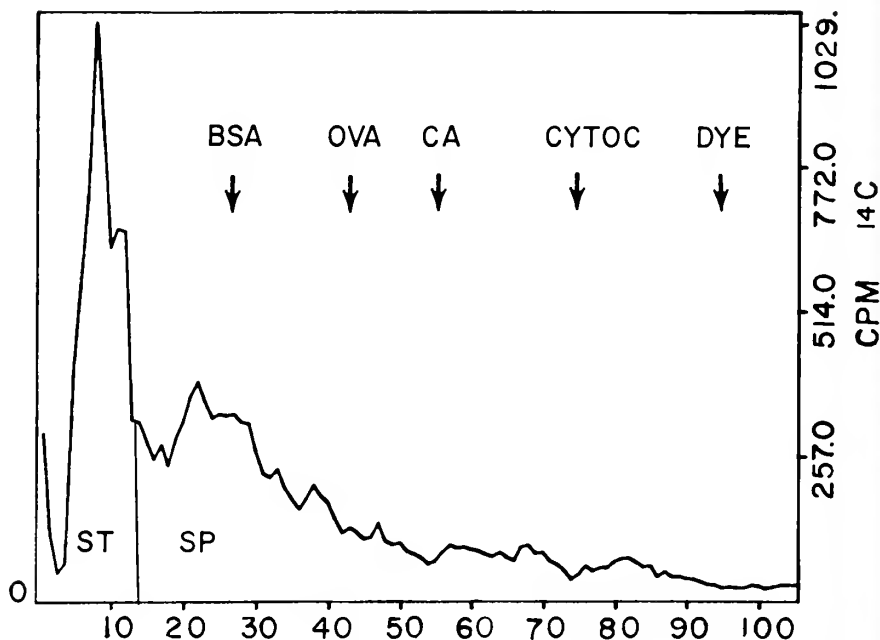


Fig. 3. Electrophoresis of  $^{14}\text{C}$ -glucosamine labelled glycoproteins from CP cells. See Fig. 1 for legend description.

turnover of cell surface membrane proteins (Gahmberg and Hakomori, 1974). It would appear that the rate of membrane turnover is the same for the three insect cell lines.

The possibility that these insect glycopeptides might represent non-specifically absorbed, labelled serum proteins (Angello and Hauschka, 1974) was tested. Medium to which  $2 \mu\text{Ci}$  of  $^3\text{H}$ -glucosamine had been added and incubated for 72 hours at room temperature was extensively dialyzed in distilled water and  $>1 \times 10^5$  cpm added to replicate flasks of each cell line for 72 hours. The medium was changed, cold medium added and the cells processed as described in the Materials and Methods section. It was observed that the amount of radioactivity in samples treated in this manner was no higher than background values. Therefore, it seems unlikely that serum proteins are responsible for any counts observed.

Whole cell proteins and glycoproteins were characterized by SDS-PAGE. Proteins separated by electrophoresis can be visualized by staining with Coomassie blue dye. The profiles of the  $^{14}\text{C}$ -glucosamine-labelled proteins are shown in Figs. 1-3. In all 3 cell lines, there is a major peak in the stacking gel and a region of peaks in the BSA molecular weight area of the separating gel; in AE and SF, a major peak near the cytochrome C



marker was also observed. Several major conclusions from the data can be summarized: 1) A major peak in the stacking gel region quantitatively different between the 3 cell lines; 2) an area of peaks in the molecular weight range 125,000–50,000; 3) a qualitative difference between CP, on the one hand and AE and SF, on the other in the 12,000–20,000 molecular weight area. It must be noted that molecular weight determinations of glycoproteins by SDS-PAGE are not accurate (Segrest and Jackson, 1972).

The function of insect glycopeptides is unknown. It seems probable that they play a role similar to that in mammalian cells; for example, cell-cell interaction (Spiro, 1970). In addition, there is some evidence that glycoproteins are responsible for the ability of tissue culture cells to attach to a substratum. In general, most insect cells do not attach firmly to culture vessel surfaces and are easily removed from T-flasks by simple shaking. We are presently investigating this phenomenon in relation to insect glycopeptides. In addition electrophoresis of glycopeptides may serve as a useful technique in aiding in the identification of insect cell lines.

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## BOOK REVIEW

*Virus and Mycoplasma Diseases of Plants in India.* S. P. Rauchaudhuri and T. K. Nariani. 102 pp. 1977. Mohan Primplani, Oxford & IBH Publishing Co., New Delhi. 32 rupees (\$4.00).

This hard cover volume is a real bargain at current book prices. The well illustrated text provides information not only for the beginner, but also for more experienced entomologists and plant pathologists interested in the vectors and diseases of cultivated plants in India. To write a treatise of this kind required a balance between jamming too much and too detailed information on the one hand, and omitting some useful data for the sake of brevity and clarity on the other. The authors have been successful in keeping the text to an essential minimum. The chapters deal with virus diseases of cereal crops, legumes, fruit trees, vegetables, plantation crops, industrial plants, and ornamentals. A separate chapter is devoted to wall-free microbial disease agents that resemble mycoplasmas. An index of hosts and of vectors is provided. The vector index will be of special interest to entomologists. It lists eryophyid mites, aphids, leafhoppers, plant-hoppers and whiteflies as well as the respective disease agents in India. A list of pertinent references follows each chapter.

The book is authoritative and up-to-date. The two authors have worked for many years at the Indian Agricultural Research Institute in New Delhi, and have published numerous research papers on this subject, but this is the first handbook that brought together the information pertaining to vectors and plant diseases in the subcontinent of India. The book will be a welcome addition to departmental libraries and, thanks to its low cost, also to individual workers.

Karl Maramoroseh, *Waksman Institute of Microbiology, Rutgers University.*

## BOOK REVIEW

*Biochemical Interaction Between Plants and Insects.* James W. Wallace and Richard L. Mansell, Eds. 425 pp. 1976. Plenum Press, New York and London. \$35.00.

The chemical relationships between plants and insects are presented by 21 authors of 8 chapters. The compilation was the result of a symposium held at Tampa, Florida in the summer of 1975. The chemical defenses of plants and their effectiveness, primarily that of tannins and glucosinolates are discussed by P. Fenny. Nutrition and host specificity in insect-plant interactions are described by S. D. Beck and J. C. Reese. These authors

cited more than 200 references in their comprehensive review of plant allelochemicals that affect insect growth, development, reproduction, and metabolism. C. N. Roeske et al. described the cardenolite metabolism in the monarch butterfly. D. F. Rhoades and R. G. Gates presented a general theory of plant antiherbivore chemistry. Repellents and attractants in arthropods and plants were reviewed by E. Rodriguez and D. A. Levin. The chemical and biochemical aspects of the control of boll weevil in the United States, and especially the work at the USDA Laboratory at Mississippi State were reviewed in great detail by P. A. Hedin et al. Chemical messengers in insects and plants, particularly plant pheromones, kairomones, and allomones, were described by L. B. Hendry et al. The concluding chapter by Kurt Mothes, past president of the Leopoldina Academy in Halle, German Democratic Republic, gives a scholarly and stimulating presentation of his findings of a red poppy, earlier confused with the ordinary oriental opium poppy *Papaver orientale*, but found to be a different species, *P. bracteatum*. This plant produces 100% thebaine, but no morphine, and it could serve as a non-narcotic source of commercial codeine.

The amount of information in this book is impressive and the compilation should be of great assistance to those interested in interactions between insects and plants. The material is not readily accessible elsewhere, making this book a valuable addition to the literature. The references are especially useful since they include the complete titles. There is an index but I found it far from complete. The book is produced by photocopy from a typed manuscript without justified margin. This inexpensive production process contrasts with the fairly high price of this No. 10 volume in the series of Recent Advances in Phytochemistry. Despite a few shortcomings, the thorough review of the subject in the 8 self-contained chapters will be of considerable interest to insect physiologists, general entomologists, plant physiologists, teachers and graduate students.

Karl Maramorosch, *Waksman Institute of Microbiology, Rutgers University.*

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TERRESTRIAL MITES OF NEW YORK—VI. FURTHER  
NOTES ON TARSONEMIDAE (ACARINA)<sup>1</sup>

Mercedes D. Delfinado

*Abstract.*—Twenty-one species of *Tarsonemus* known from New York are keyed. Five new species are described and illustrated: *Tarsonemus acerbilis* and *T. edwardi* found associated with eriophyid mites in galls, and *T. blakemorei*, *T. socius* and *T. vulgaris* taken from bird nests and stored grain. Five tarsonemid mites previously reported from nest habitat are newly recorded from stored grain; these are: *T. ascitus* Delfinado, *T. confusus* Ewing, *T. granarius* Lindquist, *T. imitatus* Delfinado and *T. waitei* Banks.

---

This paper describes five new species of tarsonemid mites belonging to the genus *Tarsonemus* Canestrini & Fanzago as defined by Scharschmidt (1959). Two of the species were found associated with eriophyid mites in galls on leaves of *Populus* sp. and *Acer saccharinum* L., and three species were collected from bird nests and stored grain. Also included in this report are five tarsonemids newly found in stored grain; these mites were previously described and reported by Delfinado (1976) from nests in New York. A key for the identification of the females of *Tarsonemus* from New York is given.

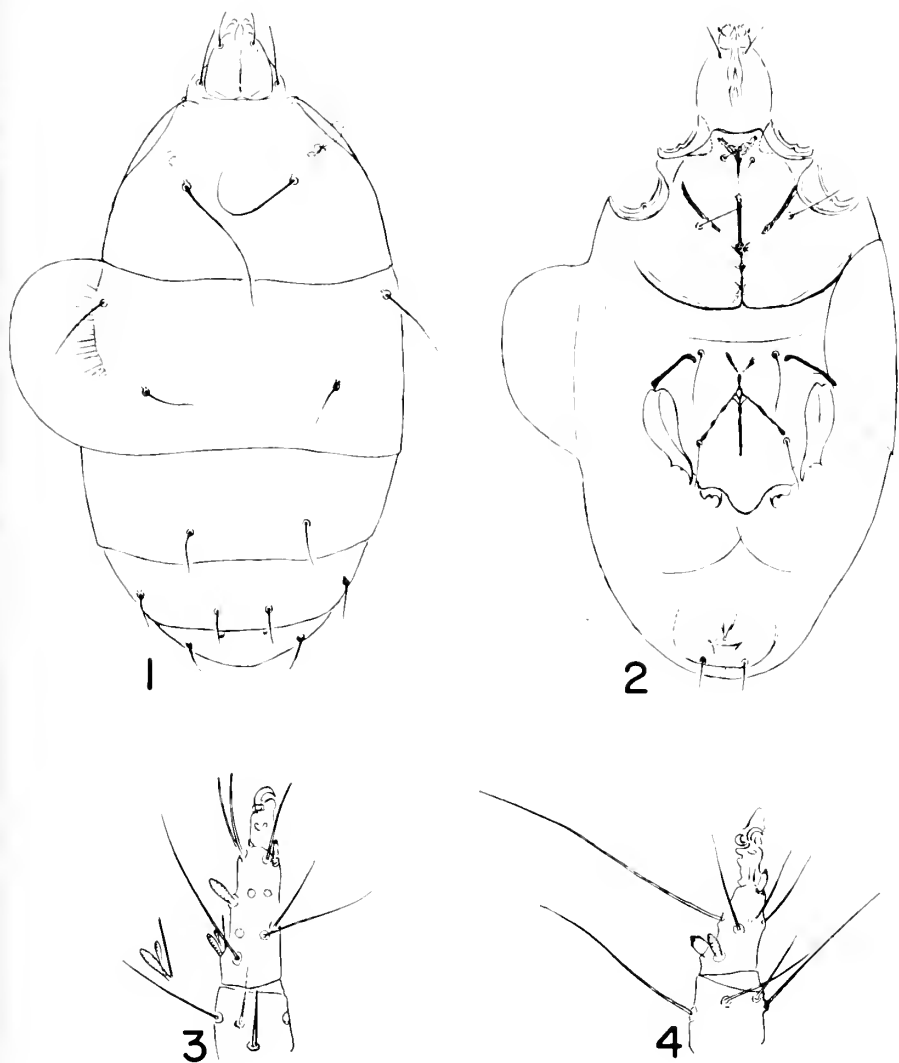
I wish to thank E. W. Baker for making the illustrations and reviewing the manuscript.

*Tarsonemus acerbilis*, n. sp.  
(Figs. 1-13)

*Female.*—Length of idiosoma 230  $\mu$ , width 109  $\mu$  (holotype). Gnathosoma about as wide as long or slightly longer than wide, almost conical; dorsal and ventral setae similar in length and size; external setae lacking. Palpal external setae minute. Pharynx slender, tubular and not enlarged.

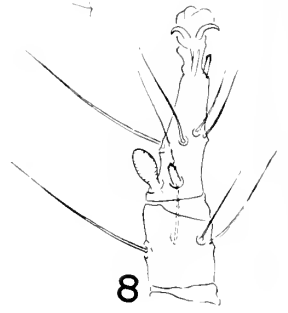
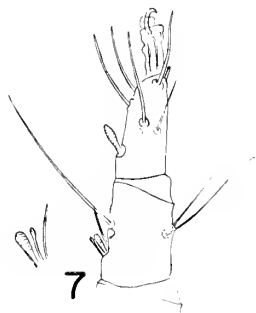
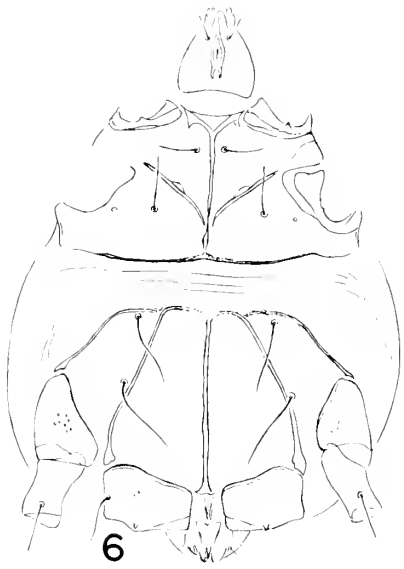
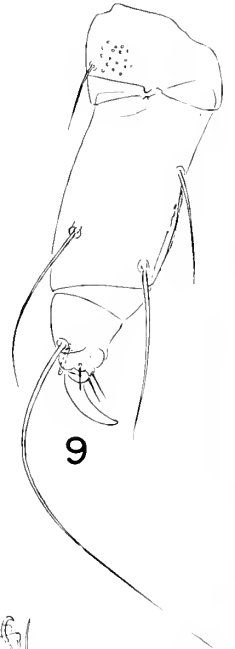
Dorsum (Fig. 1): Dorsal plates of idiosoma minutely punctate. Pseudostigmatic organs capitate, elongate oval, spiculate. Vertical setae slender and smooth, about  $\frac{2}{3}$  as long as scapular setae. Scapular setae about as long as distance between their insertions. Setae of tergite I slender, with lateral pair slightly longer than dorsal pair. Setae of tergite II and dorsal setae of tergite III slender, about equal in length. Lateral setae of tergite III longer than setae of tergite IV, both pairs heavier than other setae.

Venter (Fig. 2): Apodemes well developed. Anterior median apodeme interrupted or weakened between apodemes I and II, posteriorly weakened

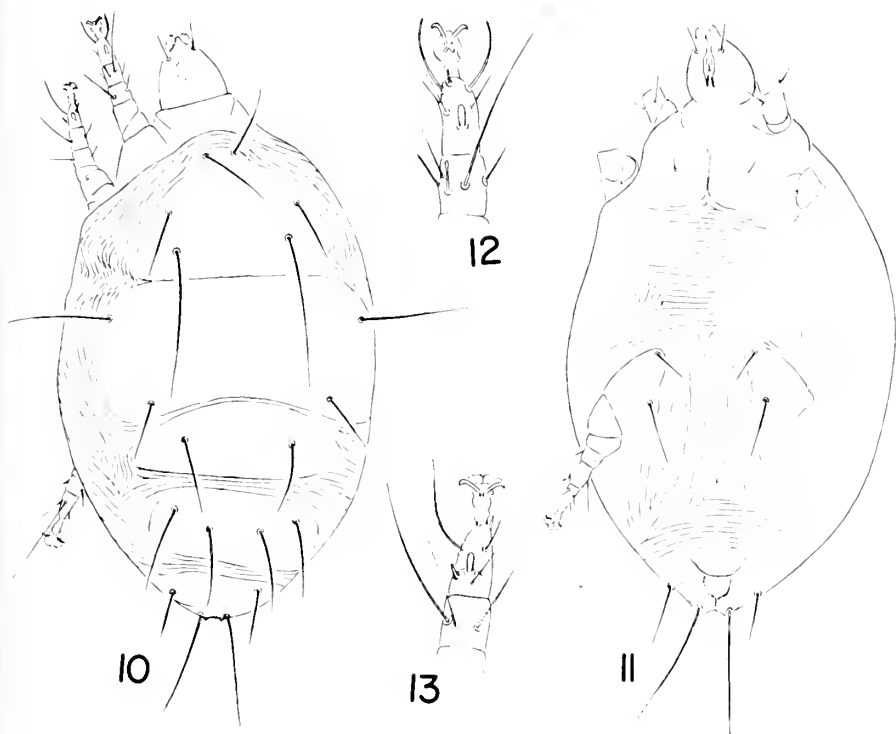


Figs. 1-13. *Tarsonemus acerbilis*, n. sp., female, 1. Dorsum; 2. Venter; 3. Tibio-tarsus I; 4. Tibia and tarsus II; male, 5. Dorsum; 6. Venter; 7. Tibia and tarsus I; 8. Tibia and tarsus II; 9. Leg IV; larva, 10. Dorsum; 11. Venter; 12. Tibia and tarsus I; 13. Tibia and tarsus II.

before reaching transverse apodeme. Apodemes II slightly curved, not uniting with anterior median apodeme. Transverse apodeme strong, arcuate, not interrupted or weakened. Apodemes III extending medially near coxal setae III. Anterior end of posterior median apodeme weak, bifurcate, but







strong and straight posteriorly. Apodemes IV almost straight, weakened at junction of posterior median apodeme. All coxal setae similarly long and slender. Coxal setae I and II immediately posterior to apodemes I and II respectively. Caudal setae short, slender. Metapodosomal lobe rounded, slightly produced posteriorly.

Legs (Figs. 3, 4): Femora I and II with 4 and 2 setae respectively. Tibiotarsus I group of sensilla consisting of 1 small, clavate and 1 slender stalked capitate solenidia, and 1 long, stout pointed seta; tibiotarsal solenidion arising at distal  $\frac{1}{2}$  of tibiotarsus, clavate. Tarsus II solenidion clavate, smaller than spinelike seta; spinelike seta unusually large and hyaline, with black pointed tip, laterad of solenidion. Leg IV slightly longer than combined length of femur-genu and tibia of leg III. Tarsus III shorter than tibia III. Distal ventral spine of tarsus II stout, with pointed black tip; that of tarsi I and III slender, with blunt black tips.

*Male*.—Length of idiosoma 179  $\mu$ , width 121  $\mu$ . Smaller than female, somewhat globular. Gnathosomal characters as in female.

Dorsum (Fig. 5): Dorsal plates minutely punctate. Propodosoma with anterior and posterior pairs of vertical setae slender, equal in length, about  $\frac{1}{2}$  as long as 2 pairs of scapular setae. Both pairs of scapular setae very long, whiplike. Anterior lateral setae of metapodosoma twice as long as 2 pairs of stout posterior setae.

Venter (Fig. 6): Apodemes strongly developed. Anterior median apodeme extending posteriorly to and uniting with transverse apodeme. Apodemes II straight, uniting with anterior median apodeme near its junction with transverse apodeme. Transverse apodeme almost straight. Apodemes III and IV and posterior median apodeme united anteriorly, sometimes with weakened or interrupted areas between apodemal junctions. Posterior median apodeme straight, not bifurcate posteriorly. Coxal setae I shorter than coxal setae II-IV. Coxal setae III and IV inside coxal plates III.

Legs (Figs. 7, 8, 9): Femora I and II with 4 and 2 setae respectively. Tibia I group of sensilla consisting of 1 clavate and 1 slender stalked capitate solenidia, and 1 stout, pointed seta; distal solenidion large, clavate. Tarsus II solenidion very large, spherical; spinelike seta smaller than and laterad of solenidion. Femur IV robust, with small, rounded flange or ridge extending between 2 ventral setae; ventral setae stout and stiff, with distal seta slightly longer than proximal seta. Tibia IV with short, slender, somewhat clavate solenidion. Ventral distal spine of tarsi I-III similarly slender; tip of tarsus II spine blunt, others almost pointed.

*Larva*.—Idiosoma ovoid, with poorly sclerotized plates. Membranous integument striate.

Dorsum (Fig. 10): Propodosomal vertical setae as long as medial setae. Scapular setae longest of idiosomal setae. Lateral setae of tergite I about  $2\frac{1}{2}$  times as long as dorsal setae, slender. Dorsal setae of tergite I and all setae of tergites II-IV fairly stout and barbed. Setae of tergite II about as long as setae of tergite III. Posterior medial pair of setae on tergite IV about  $2\frac{1}{2}$  times as long as lateral pair.

Venter (Fig. 11): Propodosomal apodemes weakly developed. Hysterosomal apodemes lacking. Coxal setae I and II inside coxal plates I and II respectively; coxal setae III and IV inside coxal plates III; all setae similarly short and slender.

Legs (Figs. 12, 13): Tibia I group of sensilla consisting of 1 slender stalked solenidion and 1 stout, pointed seta; clavate solenidion lacking. Tarsi I and II solenidia slender, clavate. Spinelike seta on tarsus II small and dark tipped, laterad of solenidion.

*Holotype*.—Female, Schenectady, New York, 7 July 1976, in eriophyid galls on leaves of *Acer saccharinum* L., collected by E. W. Baker & M. D. Delfinado.

*Paratypes*.—Twenty-two females, 6 males, 3 molting larvae, with same data as holotype. The holotype and 15 paratypes are deposited in the

New York State Museum & Science Service collection at Albany; other paratypes are in the U.S. National Museum collection, and the Acarology Laboratory, Ohio State University, Columbus, Ohio.

*Remarks.*—*T. acerbilis*, n. sp. is readily distinguished from other gall-inhabiting tarsonemids by the following: In the female the spinelike seta of tarsus II is unusually large and hyaline with black pointed tip. In the male the solenidion of tarsus II is very large and globular, and femur IV has a small, rounded flange or ridge. The femora I and II of both sexes have 4 and 2 setae respectively. The larva differs from that of *T. edwardi*, n. sp., the other described larva, by the number of solenidia in tibia I group of sensilla: *acerbilis* has 1 solenidion and 1 seta, while *edwardi* lacks solenidia.

*Tarsonemus blakemorei*, n. sp.

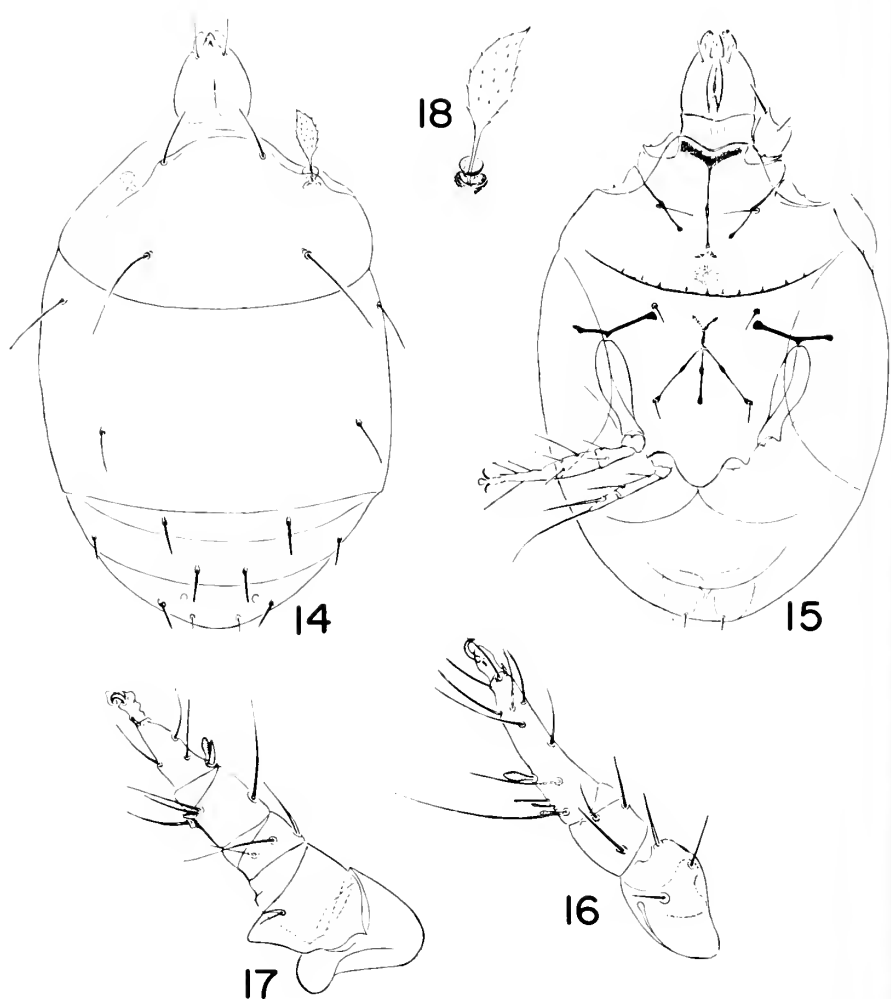
(Figs. 14–18)

*Female.*—Length of idiosoma 134  $\mu$ , width 77  $\mu$  (holotype). Gnathosoma longer than wide, with ventral setae shorter and more slender than dorsal setae; lacking external setae. Palpal external setae minute. Pharynx slender but slightly swollen at mid portion.

*Dorsum* (Fig. 14): Dorsal plates of idiosoma with faint minute punctuations. Pseudostigmatic organs capitate, long and slender, attenuate with 1–2 larger spines at apex, generally covered with large spines. Vertical setae short and slender, smooth about  $\frac{2}{3}$  as long as scapulars, in some specimens appearing heavier than scapulars. Scapular setae slender, fairly weak, shorter than distance between their insertions. Setae of tergite I slender, lateral pair longer than dorsal pair. Setae of tergites II–IV short and stiff, barbed, with dorsal setae of tergite III slightly longer and heavier than other setae; lateral setae of tergite III appearing shortest.

*Venter* (Fig. 15): Apodemes complete but somewhat fragile. Anterior median apodeme uninterrupted, disappearing posteriorly before reaching transverse apodeme. Apodemes II straight, medially widely separated from anterior median apodeme. Transverse apodeme arcuate. Apodemes III with long, slender lateral extensions. Posterior median apodeme with bifurcate and weak anterior end, straight and uninterrupted posteriorly. Apodemes IV straight, anteriorly uniting with posterior median apodeme, posteriorly extending to coxal setae IV. Coxal setae I, III and IV similarly short and slender. Coxal setae II longer and slightly heavier than other setae, on apodemes II. Caudal setae short and stiff, slender. Metapodosomal lobe broadly rounded.

*Legs* (Figs. 16, 17): Femora I and II with 3 and 2 setae respectively, each with large ventral triangular flange; dorsal distal seta of femur I conspicuously stout. Tibiotarsus I group of sensilla consisting of 1 clavate and 1 slender stalked capitate solenidia and 1 stout seta; tibiotarsal soleni-



Figs. 14-18. *Tarsonemus blakemorei*, n. sp., female, 14. Dorsum; 15. Venter; 16. Leg I; 17. Leg II; 18. Pseudostigmatic organ.

dion clavate, arising at proximal  $\frac{1}{2}$  of tibiotarsus. Tarsus II spinelike seta just laterad of and as long as solenidion. Tibia II with spinelike protuberance distally. Leg IV shorter than combined length of femur-genu and tibia of leg III. Tarsus III shorter than tibia III. Ventral distal spine of tarsi II and III similarly large; that of tarsus I small and slender.

*Male and larva.*—Unknown.

*Holotype.*—Female, Middle Grove, Saratoga Co., New York, 29 October 1976, taken from blackbird nest, by E. Blakemore.

*Paratypes*.—Ten females, with same data as holotype; 10 females, Saratoga, New York, 27 October 1976, taken from flycatcher nest, by E. Blakemore. The holotype and 10 paratypes are deposited in the New York State Museum & Science Service collection at Albany; other paratypes are in the U.S. National Museum in the Acarology Laboratory, Ohio State University, Columbus, Ohio.

*Remarks*.—*T. blakemorei*, n. sp. is a very small species with a very short leg IV, and a strong ventral flange on femora I and II. It is distinguished from other nest-inhabiting tarsonemids by the presence of the long, lateral extensions of the ventral apodemes III; by the strong and conspicuously stout dorsal distal seta of femur I, by the presence of a spinelike protuberance distally on tibia II, and by the proximal location of the tibiotarsal solenidion. This species is named for its collector, E. Blakemore, of the New York State Museum & Science Service, Albany.

*Tarsonemus edwardi*, n. sp.

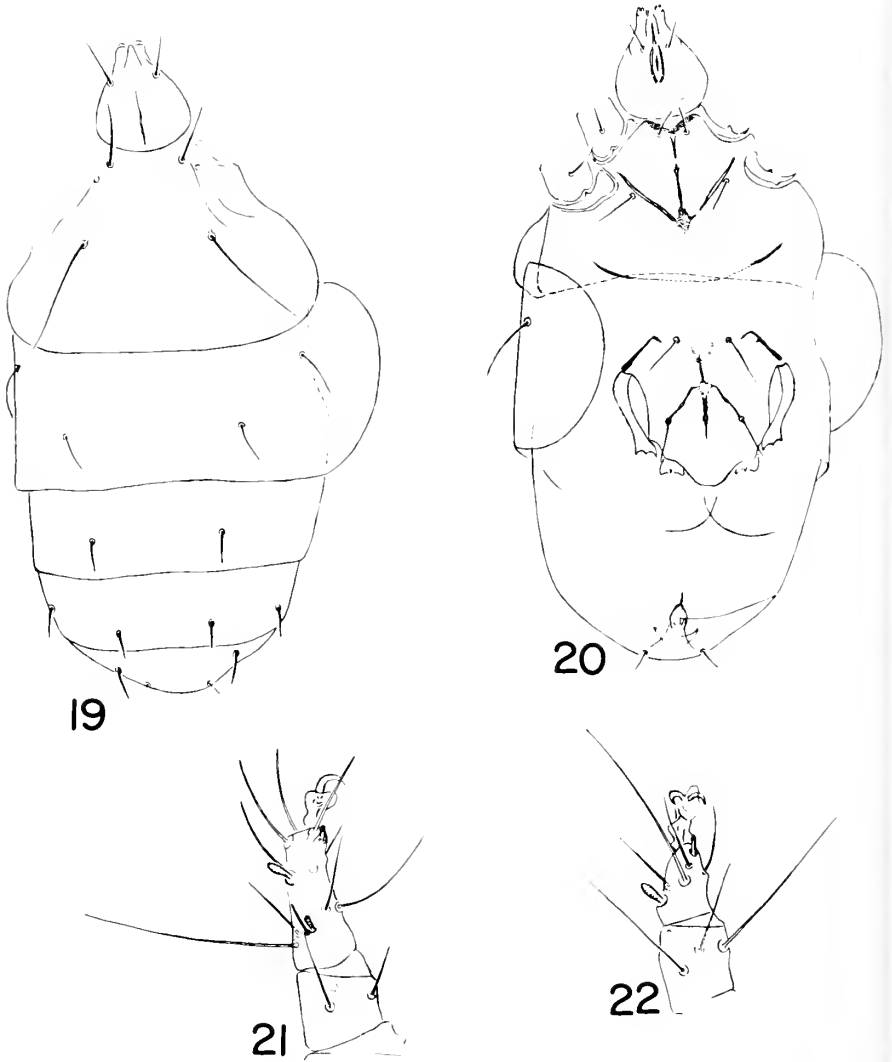
(Figs. 19–31)

*Female*.—Length of idiosoma 230  $\mu$ , width 115  $\mu$  (holotype). Gnathosoma longer than wide, almost conical; dorsal setae stouter than ventral setae, equally long; external setae lacking. Palpal external setae minute, spinelike. Pharynx slender, not enlarged.

Dorsum (Fig. 19): Dorsal plates of idiosoma finely punctate. Pseudostigmatic organs capitate, ellipsoidal, spiculate. Vertical setae stout, about  $\frac{1}{2}$  as long as scapular setae, finely barbed. Scapular setae slender, slightly longer than distance between their insertions. Setae of tergite I slender, dorsal pair shorter than lateral pair. All setae of tergites II–IV similarly short and stiff.

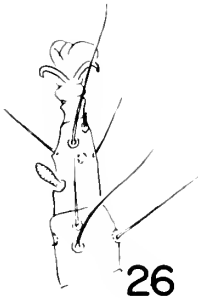
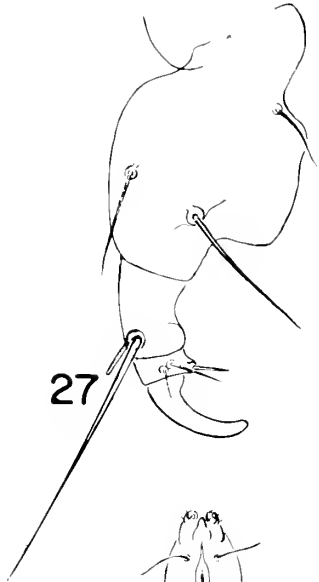
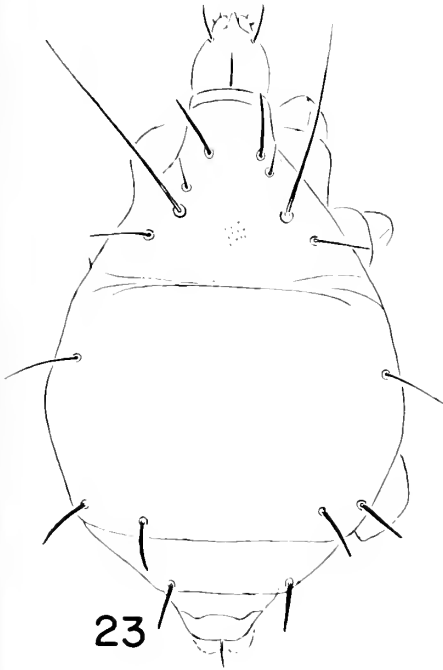
Venter (Fig. 20): Apodemes well developed. Anterior median apodeme interrupted between apodemes I and II, posteriorly weakened at junction of apodemes II, not reaching transverse apodeme. Apodemes II straight, tapering towards and weakening near anterior median apodeme, and not strongly united with it. Transverse apodeme weak, faintly visible except lateral extremities. Apodemes III extending medially near coxal setae III. Anterior end of posterior median apodeme weak, but clearly bifurcate, posteriorly straight and tapering. (In some specimens the bifurcate extremity is lacking.) Apodemes IV crooked, weakly united anteriorly with posterior median apodeme. All coxal setae similarly slender. Coxal setae I posterior to apodemes I, shorter than coxal setae II–IV. Coxal setae II immediately posterior to or on apodemes II. Caudal setae similar to or slightly heavier than coxal setae. Metapodosomal lobe broadly rounded.

Legs (Figs. 21, 22): Femora I and II each with 3 setae, lacking ridge or flange. Tibiotarsus I group of sensilla consisting of 1 small, clavate



Figs. 19-31. *Tarsonemus edwardi*, n. sp., female, 19. Dorsum; 20. Venter; 21. Tibiotarsus I; 22. Tarsus and tibia II; male, 23. Dorsum; 24. Venter; 25. Tibia and tarsus I; 26. Tibia and tarsus II; 27. Leg IV; larva, 28. Dorsum; 29. Venter; 30. Tibia and tarsus I; 31. Tibia and tarsus II.

solenidion and 1 stout pointed seta; accompanying capitate solenidion lacking, tibiotarsal solenidion arising at distal  $\frac{1}{3}$  of tibiotarsus. Tarsus II solenidion slender, clavate, similar to distal solenidion of tibiotarsus I; accompanying seta not spinelike and located distad of solenidion. Leg IV longer than



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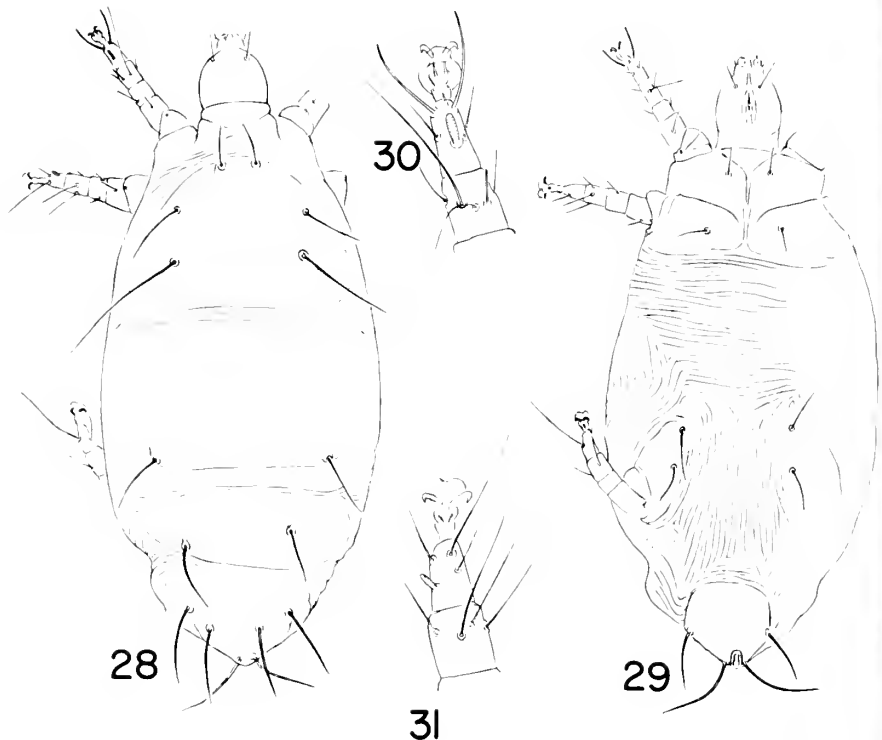
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Figs. 19-31. Continued.



Figs. 19-31. Continued.

combined length of femur-genu and tibia of leg III. Tarsus III about as long as tibia III. Distal ventral spines of tarsi I-III similarly slender.

*Male*.—Length of idiosoma 204  $\mu$ , width 115  $\mu$ . Smaller than female, somewhat ellipsoidal. Gnathosomal characters as in female.

Dorsum (Fig. 23).—Dorsal plates of idiosoma finely punctate. Propodosoma with anterior vertical setae stout and stiff, twice as long as posterior vertical pair; posterior vertical setae slender, shortest of setae. Anterior scapular setae stout, longest of setae; posterior scapulars short, slightly longer and heavier than posterior verticals. Three pairs of metapodosomal setae as follows: Anterior lateral setae always longer and more slender than 2 pairs of posterior setae; posterior lateral and dorsal pairs stout, almost equal in length.

Venter (Fig. 24): Apodemes strongly developed. Anterior median apodeme extending posteriorly to transverse apodeme, may be weakened or interrupted at or near junction of apodemes II. Apodemes II curved posteriorly, weakly uniting with anterior median apodeme near its junc-



tion with transverse apodeme. Transverse apodeme with 2 weakened areas. Apodemes III and IV and posterior median apodeme united anteriorly with one another. Posterior median apodeme straight, not bifurcate. Coxal setae I shorter than coxal setae II-IV. Coxal setae III and IV inside coxal plates III.

Legs (Figs. 25, 26, 27): Femora I and III each with 3 setae and ventral ridge. Tibia I group of sensilla lacking capitate solenidion as in female, with 1 fairly large clavate solenidion and 1 stout, pointed seta. Tarsus II solenidion similar in size and shape to corresponding solenidion of tarsus I; accompanying seta not spinelike, distad of solenidion as in female. Femur IV robust, with large flange as figured, inner proximal margin of flange usually straight, distal portion rounded and produced posteriorly; ventral proximal seta shorter than distal seta. Tibia IV with long, rodlike solenidion, about as long as or slightly longer than width of tibia. Ventral distal spine of tarsi I-III similarly small.

*Larva*.—Idiosoma elongate oval, with weakly sclerotized and poorly defined idiosomal plates. Membranous integument striate.

Dorsum (Fig. 28): Propodosomal vertical setae shorter than medial pair. Scapular setae very long, longest of idiosomal setae. Lateral setae of tergite I slender, as long as dorsal setae. Dorsal setae of tergite I, and all setae of tergites II-IV similarly stout and barbed. Setae of tergite II as long as setae of tergite III. Posterior dorsal pair of tergite IV about twice as long as lateral pair.

Venter (Fig. 29): Apodemes of propodosoma distinct but not well developed. Hysterosomal apodemes lacking. Integument striate. Coxal setae I and II inside coxal plates I and II respectively; coxal setae III and IV inside coxal plates III; all setae smooth and slender.

Legs (Figs. 30, 31): Tibia I group of sensilla consisting of 1 pointed seta, lacking solenidia. Tarsi I and II solenidia clavate. Tarsus II dorsal seta distad of solenidion not spinelike as in female and male. Ventral distal spine of tarsi I-III very small.

*Holotype*.—Female, Schenectady, New York, 7 July 1976, collected by E. W. Baker & M. Delfinado, in eriophyid galls on leaves of *Acer saccharinum* L.

*Paratypes*.—Eighteen females, 6 males, Rensselaerville, New York, 7 July, collected by E. W. Baker & M. Delfinado, in eriophyid galls on leaves of *Populus* sp. The holotype and 10 paratypes are deposited in the New York State Museum & Science Service collection at Albany; other paratypes are in the U.S. National Museum collection, and the Acarology Laboratory, Ohio State University, Columbus, Ohio.

*Remarks*.—The female and male of *T. edwardi*, n. sp. differ from those of *T. acerbilis*, n. sp. in that the leg I group of sensilla consists of only 1 solenidion and 1 seta; the tarsus II seta distad of solenidion is not spine-

like, and femora I and II each have 3 setae. The male has a large flange on femur IV, and a considerably long rodlike solenidion on tibia IV. Other differences can be found in the structure of the ventral apodemes. The larval propodosomal vertical setae are shorter than medial pair, and the tibia I group of sensilla lacks solenidia in *edwardi*.

This species is named for Edward W. Baker, with warmest affection.

*Tarsonemus socius*, n. sp.

(Figs. 32-34)

*Female*.—Length of idiosoma 262  $\mu$ , width 128  $\mu$  (paratype). Gnathosoma longer than wide, with equally strong dorsal and ventral setae, dorsal setae barbed and longer than short smooth ventral setae. Palpal external setae stout, spinelike. Pharynx slender, tubular.

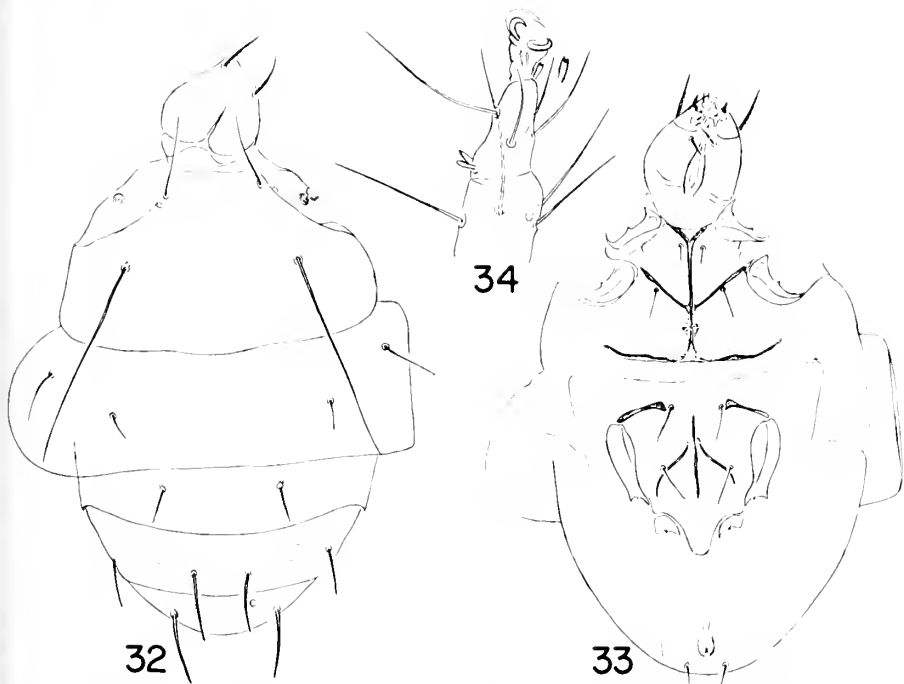
Dorsum (Fig. 32): Dorsal plates of idiosoma minutely punctate. Pseudostigmatic organs capitate, ellipsoidal, spiculate. Vertical setae slender, about  $\frac{1}{4}$  as long as scapular setae. Scapular setae longer than distance between their insertions. Lateral setae of tergite I longer than dorsal pair. Setae of tergite II shortest. Dorsal setae of tergite III longer than lateral pair. Setae of tergite IV conspicuously longer and heavier than other setae.

Venter (Fig. 33): Apodemes well developed. Anterior median apodeme uninterrupted, uniting posteriorly with transverse apodeme. Apodemes II straight, tapering near junction of anterior median apodeme and clearly uniting with it. Transverse apodeme straight, with curved lateral extremities, weakened or interrupted medially at junction of anterior median apodeme. Apodemes III extending to coxal setae III. Posterior median apodeme straight, anterior end not bifurcate. Apodemes IV uniting anteriorly with posterior median apodeme, curved posteriorly and extending beyond coxal setae IV. Coxal setae I posterior to apodemes I, shorter than coxal setae II. Coxal setae II on apodemes II, shorter than coxal setae III and IV. Coxal setae III and IV equally long. Caudal setae short and stiff. Metapodosomal lobe narrowly rounded and protruding.

Legs (Fig. 34): Femora I and II with 4 and 3 setae respectively; femur II with ventral ridge. Tibiotarsus I group of sensilla consisting of 1 small clavate and 1 slender stalked capitate solenidia, and 1 stout rodlike seta; distal solenidion slender, clavate. Tarsus II solenidion clavate; spinelike seta large, longer than and slightly distad of solenidion. Leg IV about as long as combined length of femur-genu and tibia of leg IV. Distal ventral spine of tarsi I-III with blunt, dentate tip; spine of tarsus I considerably smaller than others.

*Male and larva*.—Unknown.

*Holotype*.—Female, Beltsville, Maryland, 1 June 1976, from milled oats, collected by E. W. Baker & M. Delfinado.



Figs. 32-34. *Tarsonemus socius*, n. sp., female, 32. Dorsum; 33. Venter; 34. Tibia and tarsus II.

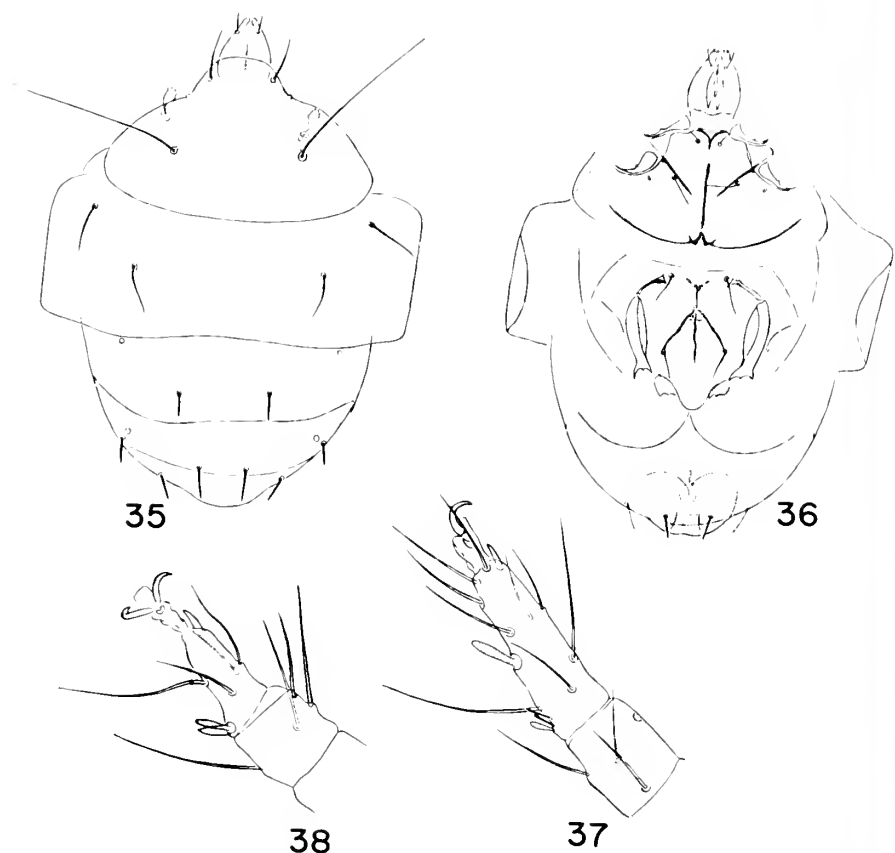
*Paratypes*.—Two females, with same data as holotype; 1 female, One-squethaw Creek, Albany, New York, 11 April 1976, from bird nest, collected by E. Blakemore. The holotype and 1 paratype are deposited in the New York State Museum & Science Service collection at Albany; 2 paratypes are in the U.S. National Museum collection.

*Remarks*.—*T. socius*, n. sp. differs from other known stored product and nest inhabiting species by the structure of the ventral apodemes, by the long body setae of tergites III and IV, by the strong gnathosomal and palpal setae, and by the dentate ventral distal spine of tarsi I-III.

*Tarsonemus vulgaris*, n. sp.  
(Figs. 35-38)

*Female*.—Length of idiosoma 223  $\mu$ , width 134  $\mu$  (holotype). Gnathosoma longer than wide, with ventral setae shorter than dorsal setae, both pairs slender; lacking external setae. Palpal external setae very small and spinelike. Pharynx swollen at posterior half.

Dorsum (Fig. 35): Dorsal plates of idiosoma uniformly minutely punctate. Pseudostigmatic organs capitate, ellipsoidal, spiculate. Vertical setae



Figs. 35-38. *Tarsonemus vulgaris*, n. sp., female, 35. Dorsum; 36. Venter; 37. Tibiotarsus I; 38. Tibia and tarsus II.

slender, minutely barbed, about  $\frac{1}{3}$  as long as scapular setae. Scapular setae longer than distance between their insertions. Setae of tergite I slender, with lateral pair longer than dorsal pair. Setae of tergites II-IV stiff and barbed, with blunt tips. Setae of tergite II shortest. Dorsal and lateral setae of tergite III nearly equal in length, shorter than stout setae of tergite IV.

Venter (Fig. 36): Apodemes well developed. Anterior median apodeme widely interrupted between apodemes I and II, continuing posteriorly to transverse apodeme, with short medial spurs at junction with transverse apodeme. Apodemes II straight, tapering medially but not uniting with anterior median apodeme. Transverse apodeme arcuate, indented medially at junction of anterior median apodeme. Apodemes III medially

extending near coxal setae III. Posterior median apodeme with bifurcate anterior end, weakened or interrupted portion immediately posterior to junction of apodemes IV. Apodemes IV anteriorly uniting with posterior median apodeme, crooked, posteriorly extending to coxal setae IV. All coxal setae slender. Coxal setae I posterior to apodemes I, shorter than coxal setae II. Coxal setae on apodemes II, shorter than coxal setae III. Coxal setae III longest. Coxal setae IV shortest. Caudal setae stiff and barbed, similar in size to setae of tergite III. Metapodosomal lobe small, rounded posteriorly.

Legs (Figs. 37, 38): Femora I and II with 3 and 4 setae respectively. Femur II with ventral flange; femur I lacking flange but with ridge, ventral seta on ridge stout and long, barbed. Tibiotarsus I group of sensilla consisting of 1 clavate and 1 slender capitate solenidia, and 1 stout seta; distal tibiotarsal solenidion arising at distal  $\frac{1}{2}$  of tibiotarsus, long and slender, clavate. Tarsus II spinelike seta very large, laterad of clavate solenidion. Leg IV shorter than combined length of femur-genu and tibia of leg III. Ventral distal spine of tarsus II larger than that of tarsi I and III.

*Male and larva.*—Unknown.

*Holotype.*—Female, Shaker Road, Albany, New York, 27 May 1975, taken from robin nest, by E. Blakemore.

*Paratypes.*—One female, with same data as holotype; 9 females, Saratoga and Middle Grove, New York, 26 April, 18 October 1975, taken from Phoebe and blackbird nests, by E. Blakemore; 8 females, Beltsville, Maryland, 1 June 1976, from milled oats, collected by E. W. Baker & M. Delfinado. The holotype and 6 paratypes are deposited in the New York State Museum & Science Service collection at Albany; other paratypes are deposited in the U.S. National Museum collection, and the Acarology Laboratory, Ohio State University, Columbus, Ohio.

*Remarks.*—The female of this species has many characters in common with that of *T. insignis* Delfinado, including the strong, barbed setae on the ventral ridge of femur I. *T. vulgaris*, n. sp., however, may be readily distinguished by the presence of short medial spurs at the junction of the anterior median and transverse apodemes, the transverse apodeme being indented at its junction with the anterior median apodeme.

The following species listed below are additional records from stored grain material; they have been previously found in nest habitat from New York (Delfinado, 1976).

*Tarsonemus ascitus* Delfinado, 1976

*Additional records.*—Two females, Onesquethaw Creek and Shaker Road, Albany, New York, 11 April, 27 May 1976, from robin nests; 1 female, Green Co., New York, 14 August 1976, from bracket fungi, all collected by E. Blakemore. Three females, Beltsville, Maryland, 1 June 1976, from milled oats, collected by E. W. Baker & M. Delfinado.

*Tarsonemus confusus* Ewing, 1939

*Additional records.*—Two females, Cambridge, and 5 females, Rensselaerville, New York, 24, 26 August 1976, from corn feed, collected by R. Means; 15 females, Shaker Road, Albany and Middle Grove, Saratoga, New York, 26 April, 27 May, 18 October 1976, from robin and Phoebe nests, collected by E. Blakemore. Five females, Beltsville, Maryland, 1 June 1976, from milled oats, collected by E. W. Baker & M. Delfinado.

*Tarsonemus granarius* Lindquist, 1972

*Additional records.*—Three females, Shaker Road, Albany, New York, 27 May 1976, from robin nests, collected by E. Blakemore; 2 females, Cambridge, New York, 21 April 1976, from nest in bird house, collected by M. Delfinado; 2 females, Rensselaerville, New York, 26 August 1976, from corn feed, collected by R. Means; 3 females, Huntington, Long Island, New York, September 1975, from wild oats packing material, collected by M. Delfinado.

*Tarsonemus imitatus* Delfinado, 1976

*Additional records.*—Three females, Beltsville, Maryland, 2 June 1976, from milled oats, collected by E. W. Baker & M. Delfinado.

*Tarsonemus waitei* Banks, 1904

*Additional records.*—Two females, Shaker Road, Albany, New York, 27 May 1976, from robin nests, collected by E. Blakemore; 2 females, Cambridge, New York, 8 August 1976, from corn feed, collected by R. Means.

Key to Female *Tarsonemus* from New York

1. Apodemes III extending laterally beyond trochanters III (Fig. 15); scapular setae shorter than distance between their insertions 2
  - Apodemes III not extending laterally beyond trochanters III (Figs. 2, 20, 33, 36); scapular setae longer than or as long as distance between their insertions 4
2. Lateral extensions of apodemes III with characteristic scalloped or uneven posterior edges; body surfaces heavily and conspicuously punctate *ascitus* Delfinado
  - Lateral extensions of apodemes III simple; body punctations minute and inconspicuous 3
3. Femora I and II each with prominent ventral flange (Fig. 17); tibia II with spinelike protuberance distally; anterior median apodeme uninterrupted between apodemes I and II; lateral extensions of apodemes III long, peglike *blakemorei*, n. sp.

- Only femur II with ventral flange; tibia II without protuberance; anterior median apodeme interrupted between apodemes I and II; lateral extensions of apodemes III short, spurlike  
*praesignis* Delfinado
- 4. Gnathosoma with ventral apodemes  
*fusarii* Cooreman 5
- Gnathosoma without ventral apodemes 5
- 5. Tarsus II spinelike seta absent or not developed (Fig. 22) 6
- Tarsus II with large spinelike seta usually laterad of solenidion (Figs. 4, 17, 34, 38) 9
- 6. Tibiotarsus I group of sensilla consisting of 1 solenidion and 1 rodlike seta (Fig. 21) 7
- Tibiotarsus I group of sensilla consisting of 2 solenidia and 1 rodlike seta  
*granarius* Lindquist
- 7. Metapodosomal lobe elongate, produced posteriorly; anterior median apodeme diffused immediately posterior to apodemes II; apodemes II curved medially, clearly not uniting with anterior median apodeme  
*cryptocephalus* (Ewing)
- Metapodosomal lobe broadly rounded; anterior median apodeme diffused before or at posterior level of apodemes II; apodemes II straight, ending at diffused area of anterior median apodeme, not strongly uniting with it 8
- 8. Anterior median apodeme interrupted between apodemes I and II; transverse apodeme weak except lateral extremities; posterior median apodeme extending posteriorly beyond junction of apodemes IV; found in eriophyid galls  
*edwardi*, n. sp.
- Anterior median apodeme not interrupted; transverse apodeme strong, with 2 short weakened or interrupted areas at middle; posterior median apodeme weak, not extending anteriorly; found in large numbers in bird nests  
*waitei* Banks
- 9. Transverse apodeme strong and well defined 11
- Transverse apodeme weak and indistinct at middle, strong at lateral extremities 10
- 10. Setae of tergite IV unusually long, 2-3 times as long as other hysterosomal setae; posterior median apodemes short, not bifurcate anteriorly  
*dubius* Delfinado
- Setae of tergite IV as long as lateral setae of tergite III, slightly longer and stronger than other setae; posterior median apodeme weak anteriorly but clearly bifurcate  
*imitatus* Delfinado
- 11. Transverse apodeme wavy or with 2 indentations at middle; anterior median apodeme diffused at posterior level of apodemes II  
*confusus* Ewing
- Transverse apodeme arcuate or with a notch at middle where it joins anterior median apodeme; anterior median apodeme well defined or diffused shortly before reaching transverse apodeme 12

12. Anterior median apodeme interrupted or weakened between apodemes I and II 13  
 - Anterior median apodeme continuous, not interrupted 18
13. Spinelike seta of tarsus II very large, hyaline and with black pointed tip, considerably larger than solenidion (Fig. 4); found in eriophyid galls *acerbilis*, n. sp. 14  
 - Spinelike seta of tarsus II as normal spine (Figs. 17, 34, 38); mostly found in nests and stored grain 14
14. Femur II with ventral flange; anterior median apodeme broadly interrupted between apodemes I and II 15  
 - Femur II without ventral flange; anterior median apodeme narrowly interrupted or weakened between apodemes I and II 17
15. Ventral seta on ridge of femur I slender, inconspicuously barbed; flange of femur II small and not as developed as in related species *smileyi* Delfinado 16  
 - Ventral seta on ridge of femur I stout and barbed 16
16. Transverse apodeme medially indented and with short spurs at junction with anterior median apodeme *vulgaris*, n. sp. 16  
 - Transverse apodeme simple *insignis* Delfinado<sup>2</sup>
17. Anterior median apodeme strong and well defined posteriorly; posterior median apodeme normally bifurcate anteriorly; metapodosomal lobe small, attenuate posteriorly; bursa copulatrix globular *talpae* Schaarschmidt 17  
 - Anterior median apodeme posteriorly weakened or diffused between apodemes II and transverse apodeme; posterior median apodeme with broad cellular neck between anterior fork and junction of posterior median apodemes; metapodosomal lobe small, narrowed posteriorly; bursa copulatrix elongate *neotalpae* Delfinado
18. Femur II with ventral flange 19  
 - Femur II without flange 20
19. Femur I with prominent ventral flange similar to that of femur II; setae of tergites II-IV similarly stout, with blunt tips *nidicolus* Delfinado  
 - Femur I with small flange appearing as ventral ridge; all setae of tergites I-IV similarly slender and short *similis* Delfinado
20. Setae of tergite II shorter and more slender than setae of tergites III and IV; dorsal setae of tergite III longer than lateral pair; distal ventral spine of tarsi I-III with blunt, dentate tip; palpal external setae stout and spinelike *socius*, n. sp. 20  
 - Setae of tergite II similar to other hysterosomal setae; dorsal setae of tergite III shorter than lateral pair; palpal external setae minute; ventral distal spine of tarsi I-III not dentate *irregularis* Delfinado



## A checklist of tarsonemid mites presently known from New York:

1. *Steneotarsonemus chionaspivorus* (Ewing), 1911
2. *S. friedmani* Smiley, 1967
3. *S. oconnori* Delfinado, 1976<sup>3</sup>
4. *S. pallidus* (Banks), 1899
5. *Tarsonemus acerbilis*, n. sp.
6. *T. ascitus* Delfinado, 1976
7. *T. blakemorei*, n. sp.
8. *T. confusus* Ewing, 1939
9. *T. cryptocephalus* (Ewing), 1939
10. *T. dubius* Delfinado, 1976<sup>3</sup>
11. *T. edwardi*, n. sp.
12. *T. fusarii* Cooreman, 1941
13. *T. granarius* Lindquist, 1972
14. *T. imitatus* Delfinado, 1976<sup>3</sup>
15. *T. insignis* Delfinado, 1976
16. *T. irregularis* Delfinado, 1976
17. *T. neotalpae* Delfinado, 1976
18. *T. nidicolus* Delfinado, 1976
19. *T. praesignis* Delfinado, 1976
20. *T. similis* Delfinado, 1976
21. *T. smileyi* Delfinado, 1976<sup>3</sup>
22. *T. socius*, n. sp.
23. *T. talpae* Schaarschmidt, 1959
24. *T. waitei* Banks, 1904
25. *T. vulgaris*, n. sp.
26. *Xenotarsonemus viridis* (Ewing), 1939
27. *Iponemus confusus oriens* Lindquist, 1969.

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#### Footnotes

<sup>1</sup>Published by Permission of the Director, New York State Science Service, Journal Series No. 233.

<sup>2</sup>This species has no spurlike lateral extensions of apodemes III as inadvertently mentioned on p. 267 (Delfinado, 1976).

<sup>3</sup>Additional paratypes are deposited in the Cornell University Insect Collection, Ithaca, New York.

TERRESTRIAL MITES OF NEW YORK—VII. KEY TO  
THE SPECIES OF SCUTACARIDAE AND  
DESCRIPTIONS OF NEW SPECIES<sup>1</sup>

M. D. Delfinado and E. W. Baker

*Abstract.*—Thirty-five species and three subspecies of Scutacaridae are listed from New York. An identification key to the species is given. In addition, three new species and 1 new subspecies are described and figured; these are: *Imparipes cupes*, *Scutacarus* (S.) *meansi*, *S.* (S.) *unicus indefinitus*, and *S.* (S.) *(Variatipes) subaffinis*. The specimens were collected from bird nests, dog food, and from a cupedid beetle. *Scutacarus* (S.) *subellipticus* Delfinado & Baker, 1976 (Dec.) is a synonym of *S.* (S.) *curtus* Delfinado, Baker & Abbatiello, 1976 (June). The following are transferred from *Imparipes* Berlese to *Archidispus* Karafiat: *insulanus* (Delfinado, Baker & Abbatiello), *longitarsus* (Delfinado, Baker & Abbatiello), *similis* (Delfinado, Baker & Abbatiello) and *tarsalis* (Delfinado, Baker & Abbatiello).

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This series summarizes our knowledge of the scutacarid fauna of New York in the New York State Museum & Science Service collection at Albany. It contains 24 species and one subspecies of *Scutacarus* Gros, four species of *Archidispus* Karafiat, and seven species and two subspecies of *Imparipes* Berlese (Delfinado, Baker & Abbatiello, 1976; Delfinado & Baker, 1976). A key for the identification of the species based on females is given. An additional three new species and one subspecies are described and figured from specimens collected from bird nests, dog food, and from a cupedid beetle in New York. These are: *Imparipes cupes*, *Scutacarus* (S.) *meansi*, *S.* (S.) *unicus indefinitus*, and *S.* (S.) *(Variatipes) subaffinis*. *Scutacarus* (S.) *subellipticus* Delfinado & Baker, 1976 (Dec.) is conspecific with *S.* (S.) *curtus* Delfinado, Baker & Abbatiello, 1976 (June); we find no characters to separate the females.

In a previous paper (Delfinado & Baker, 1976), an attempt was made to key the subgenera of *Imparipes* following Karafiat (1959). In that key (1976:265) we erred in recognizing *Heterodispus* Paoli and *Archidispus* Karafiat based on the characters of leg IV. We hope the present key will clarify these errors; we do not recognize *Heterodispus*. The setal nomenclature is that of Delfinado, Baker & Abbatiello (1976).

The following is a list of species of Scutacaridae known from New York:

Genus *Scutacarus* Gros  
Subgenus *Scutacarus* Gros

- acarorum* (Goeze), 1780: Delfinado, Baker & Abbatiello, 1976:117.  
*bakeri* Mahunka & Rack, 1977, new name for *pectinatus* Delfinado, Baker & Abbatiello, 1976:120, preocc. by *Scutacarus pectinatus* Mahunka, 1968.  
*communis* Delfinado, Baker & Abbatiello, 1976:122.  
*curtus* Delfinado, Baker & Abbatiello, 1976:129 = *subellipticus* Delfinado & Baker, 1976:300, *new synonym*.  
*eickworti* Delfinado & Baker, 1976:298.  
*fimetarius* Delfinado, Baker & Abbatiello, 1976:115.  
*formosus* Delfinado, Baker & Abbatiello, 1976:120.  
*grosi* Delfinado, Baker & Abbatiello, 1976:126.  
*imitans* Delfinado & Baker, 1976:296.  
*impar* Delfinado & Baker, 1976:288.  
*mahunkai* Delfinado, Baker & Abbatiello, 1976:115.  
*meansi*, n. sp.  
*nearcticus* Delfinado, Baker & Abbatiello, 1976:128.  
*notabilis* Delfinado, Baker & Abbatiello, 1976:125.  
*pedestris* Delfinado, Baker & Abbatiello, 1976:125.  
*spinus* Storkan, 1936: Delfinado & Baker, 1976:292.  
*subspinus* Delfinado & Baker, 1976:290.  
*terrenus* Delfinado & Baker, 1976:293.  
*unicus* Delfinado & Baker, 1976:295.  
*unicus indefinitus*, n. ssp.

Subgenus *Variatipes* Jacot

- affinis* Delfinado, Baker & Abbatiello, 1976:107.  
*contiguus* Delfinado, Baker & Abbatiello, 1976:109.  
*jacoti* Delfinado, Baker & Abbatiello, 1976:112.  
*subaffinis*, n. sp.  
*uniformis* Delfinado, Baker & Abbatiello, 1976:112.

Genus *Archidispus* Karafiat

- insulanus* (Delfinado, Baker & Abbatiello), 1976:137, *new combination*.  
*longitarsus* (Delfinado, Baker & Abbatiello), 1976:129, *new combination*.  
*similis* (Delfinado, Baker & Abbatiello), 1976:133, *new combination*.  
*tarsalis* (Delfinado, Baker & Abbatiello), 1976:133, *new combination*.

Genus *Imparipes* Berlese

- apicola* (Banks), 1914: Delfinado & Baker, 1976:269.  
*cupes*, n. sp.

- degenerans italicus* Berlese, 1904: Delfinado, Baker & Abbatiello, 1976: 135.
- d. nearcticus* Delfinado, Baker & Abbatiello, 1976:137.
- humilis* Delfinado, Baker & Abbatiello, 1976:140.
- ithacensis* Delfinado & Baker, 1976:279.
- obsoletus* Rack, 1965: Delfinado, Baker & Abbatiello, 1976:143.
- parapicola* Delfinado, Baker & Abbatiello, 1976:140.
- vulgaris* Delfinado & Baker, 1976:286.

## Key to Species (Females)

1. Leg IV 4-segmented, tibia and tarsus fused, without pretarsus, claws and empodium (*Scutacarus* Gros) 2
  - Leg IV 5-segmented, tibia and tarsus distinct, usually with pretarsus, claws and empodium 26
2. Tibiotarsus I with claw (subg. *Scutacarus* Gros) 3
  - Tibiotarsus I without claw (subg. *Variatipes* Jacot) 22
3. Tibiotarsus IV elongate, 5-6 times as long as basal width 4
  - Tibiotarsus IV short, at most twice as long as basal width 5
4. Epimeral setae 4b extending beyond posterior margin of hysterosoma; caudal setae  $h_2$  shorter than  $h_1$ , sparsely barbed
  - malunkai* Delfinado, Baker & Abbatiello
  - Epimeral setae 4b not reaching posterior margin of hysterosoma;  $h_2$  and  $h_1$  equal in length, plumose
    - finetarius* Delfinado, Baker & Abbatiello
5. Empodium of tarsi II and III slender, spatulate, and not disclike; tarsus II solenidion  $W_1$  very long, rodlike *meansi*, n. sp.
  - Empodium of tarsi II and III rounded, disclike; tarsus II solenidion  $W_1$  short, usually clavate 6
6. Epimeral setae 4b absent 7
  - Epimeral setae 4b present 9
7. Dorsal setae  $c_2$  and  $f_2$  similar in form to and almost as long as other dorsal setae *grosi* Delfinado, Baker & Abbatiello
  - Dorsal setae  $e_2$  and  $f_2$  minute or small, spinelike and well differentiated from other dorsal setae 8
8. Dorsal setae  $e_2$  and  $f_2$  minute, simple *spinus* Storkan
  - Dorsal setae  $e_2$  and  $f_2$  not as small, spinelike and sparsely barbed *subspinus* Delfinado & Baker
9. Epimeral setae 4a anterior to 4b
  - notabilis* Delfinado, Baker & Abbatiello
  - Epimeral setae 4a in transverse line with 4b 10
10. Dorsal setae  $d$ ,  $e_1$ ,  $f_1$  and  $f_2$  conspicuously long,  $\frac{1}{2}$ - $\frac{3}{4}$  as long as length of idiosoma;  $c_2$  minute 11

- Dorsal setae  $d$ ,  $e_1$  and  $f_1$  shorter than idiosoma;  $e_2$  and  $f_2$  varied in size 13
- 11. Caudal setae  $h_1$ ,  $h_2$  and  $h_3$  much shorter than dorsal setae  $d$ ,  $e_1$ ,  $f_1$  and  $f_2$ ;  $h_1$  and  $h_2$  finely plumose  
*communis* Delfinado, Baker & Abbatiello
- Caudal setae  $h_1$ ,  $h_2$  and  $h_3$  very long, nearly as long as dorsal setae;  $h_1$  and  $h_2$  pectinate 12
- 12. Epimeral setae 4a very short, smooth; 3a and 3b both short, extending posteriorly to apodemes 4  
*formosus* Delfinado, Baker & Abbatiello
- Epimeral setae 4a long, barbed, approaching posterior margin of hysterosoma; 3a and 3b long, extending beyond apodemes 4 to bases of 4a and 4b *bakeri* Mahunka & Rack
- 13. Tibiotarsus IV with 7 setae 14
- Tibiotarsus IV with 6 setae 20
- 14. Seta  $s$  of tibiotarsus IV short and slender; seta  $d$  of femur I serrate distally *acarorum* (Goeze)
- Seta  $s$  of tibiotarsus IV usually long and robust; seta  $d$  of femur I simple 15
- 15. Dorsal setae  $e_2$ ,  $f_1$  and  $f_2$  strongly developed, large and well differentiated from other dorsal setae  
*nearcticus* Delfinado, Baker & Abbatiello
- Dorsal setae  $e_2$ ,  $f_1$  and  $f_2$  normal type, or  $e_2$  may be minute 16
- 16. Dorsal setae  $e_2$  minute *terrenus* Delfinado & Baker
- Dorsal setae  $e_2$  not minute, short and slender, or may be spine-like 17
- 17. Epimeral setae 4b long, extending to posterior margin of hysterosoma; 4a short, weak; caudal setae  $h_1$  densely plumose  
*pedestris* Delfinado, Baker & Abbatiello
- Epimeral setae 4b short, not reaching posterior margin of hysterosoma; 4a short but not weak; caudal setae  $h_1$  barbed or pectinate 18
- 18. Dorsal setae  $e_2$  and  $f_2$  similar to other dorsal setae except shorter; caudal setae  $h_3$  small, lanceolate *impar* Delfinado & Baker
- Dorsal setae  $e_2$  and  $f_2$  almost spinelike, well differentiated from other dorsal setae;  $h_3$  hairlike 19
- 19. Seta  $s$  of tibiotarsus IV long and slender, sparsely barbed  
*unicus indefinitus*, n. subsp.
- Seta  $s$  of tibiotarsus IV short, robust, daggerlike and smooth  
*unicus unicus* Delfinado & Baker
- 20. Tibia II dorsal seta distad of solenidion  $\phi$  spinelike, large and stout *eickworti* Delfinado & Baker
- Tibia II dorsal seta distad of solenidion  $\phi$  not spinelike, slender 21

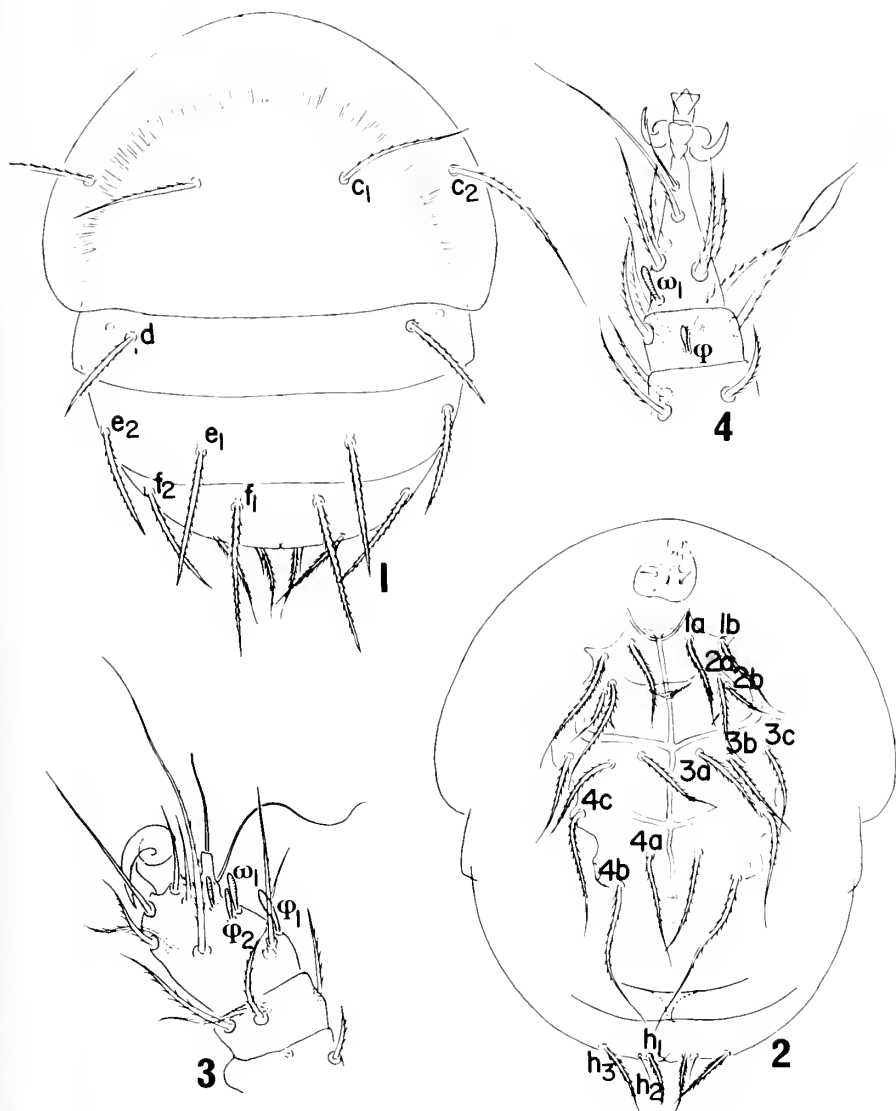
21. Tibiotarsus I solenidion  $W_2$  short and small, elavate, considerably shorter than  $W_1$  *imitans* Delfinado & Baker  
 – Tibiotarsus I solenidion  $W_2$  long and slender, much longer than  $W_1$  *curtus* Delfinado, Baker & Abbatiello
22. Epimeral setae 4a anterior to 4b; dorsal setae  $e_2$  and  $f_2$  strongly developed, especially  $f_2$  and pressed against posterior margin of hysterosoma; caudal setae  $h_1$  broad, leaflike, with hairy fringe *jacoti* Delfinado, Baker & Abbatiello<sup>2</sup>  
 – Epimeral setae 4a in transverse line with 4b; setae  $e_2$  and  $f_2$  normal type and not appressed to margin of hysterosoma; caudal setae  $h_1$  not leaflike 23
23. Dorsal setae  $d$ ,  $e_1$ ,  $e_2$ ,  $f_1$  and  $f_2$  similar in length, with  $e_1$  and  $f_1$  as long as  $e_2$  and  $f_2$ ; caudal setae  $h_1$  barbed,  $h_2$  simple *uniformis* Delfinado, Baker & Abbatiello  
 – Dorsal setae  $d$ ,  $e_1$ ,  $e_2$ ,  $f_1$  and  $f_2$  of various lengths,  $f_1$  or both  $e_1$  and  $f_1$  longer than  $e_2$  and  $f_2$ ;  $h_1$  and  $h_2$  of various forms 24
24. Only dorsal setae  $f_1$  longer than  $e_1$ ,  $e_2$  and  $f_2$ ; caudal setae  $h_1$  and  $h_2$  finely serrate *contiguus* Delfinado, Baker & Abbatiello  
 – Dorsal setae  $f_1$  and  $e_1$  longer than  $e_2$  and  $f_2$ ;  $h_1$  and  $h_2$  not as above 25
25. Tibiotarsus I solenidion  $W_2$  long, as long as  $W_1$ ; caudal setae  $h_1$  sparsely barbed,  $h_2$  simple *affinis* Delfinado, Baker & Abbatiello  
 – Tibiotarsus I solenidion  $W_2$  shorter than  $W_1$ ;  $h_1$  and  $h_2$  serrate *subaffinis*, n. sp.
26. Tarsus IV elongate, gradually narrowing distally; pretarsus always shorter than tarsus (*Archidispus* Karafiat) 27  
 – Tarsus IV broad basally, abruptly narrowed distally; pretarsus usually as long as tarsus (*Imparipes* Berlese) 30
27. Tibiotarsus I with small elaw as figured in Delfinado, Baker & Abbatiello, 1976; 139, epimeral setae 3b, 4a and 4b characteristically lanceolate; tibia IV with rodlike solenidion *insulanus* (Delfinado, Baker & Abbatiello), n. comb.  
 – Tibiotarsus I without elaw; epimeral setae 3b, 4a and 4b not lanceolate; tibia IV without solenidion 28
28. Epimeral setae 2b daggerlike, smooth; seta  $p$  of tarsus IV large, immensely developed *tarsalis* (Delfinado, Baker & Abbatiello), n. comb.  
 – Epimeral setae 2b slender, barbed; seta  $p$  slender 29
29. Tibiotarsus I solenidion  $W_2$  as long as  $W_1$ , rodlike; caudal setae  $h_2$  simple *similis* (Delfinado, Baker & Abbatiello), n. comb.  
 – Tibiotarsus I solenidion  $W_2$  very short, peglike, much shorter than  $W_1$ ; setae  $h_2$  barbed *longitarsus* (Delfinado, Baker & Abbatiello), n. comb.

30. Tarsus and pretarsus IV very short, atrophied, lacking claws and empodium *obsoletus* Rack  
 – Tarsus and pretarsus IV normally developed, with claws and empodium 31
31. Epimeral setae 2b not daggerlike, sparsely barbed; seta *t* of tarsus IV minute *cupes*, n. sp.  
 – Epimeral setae 2b daggerlike; seta *t* of tarsus IV minute to long 32
32. Seta *t* of tarsus IV long, extending to or beyond tarsal claws; seta *r* of tarsus IV weak, bristlelike 33  
 – Seta *t* minute or very short; seta *r* short but not weak 35
33. Dorsal setae *d*, *e*<sub>1</sub>, *e*<sub>2</sub>, *f*<sub>1</sub> and *f*<sub>2</sub> longer than *c*<sub>1</sub> and *c*<sub>2</sub>; epimeral setae 2b stout, barbed; 4a long and barbed, about as long as 4b or 4c *humilis* Delfinado, Baker & Abbatiello  
 – Dorsal setae *d*, *c*<sub>1</sub>, *e*<sub>2</sub>, *f*<sub>1</sub> and *f*<sub>2</sub> shorter than or about as long as *c*<sub>1</sub> and *c*<sub>2</sub>; epimeral setae 2b daggerlike, smooth; 4a short, simple, about ½ as long as 4b or 4c 34
34. Caudal setae *h*<sub>1</sub> and *h*<sub>2</sub> shorter than *h*<sub>3</sub>, sparsely barbed *degenerans italicus* Berlese  
 – Caudal setae *h*<sub>1</sub> and *h*<sub>2</sub> as long as *h*<sub>3</sub> densely short plumose *degenerans nearcticus* Delfinado, Baker & Abbatiello
35. Dorsal setae *d*, *e*<sub>1</sub>, *e*<sub>2</sub>, *f*<sub>1</sub> and *f*<sub>2</sub> similarly long and slender, tapered to fine points, uniformly barbed 36  
 – Dorsal setae *d*, *e*<sub>1</sub>, *e*<sub>2</sub>, *f*<sub>1</sub> and *f*<sub>2</sub> robust, varying in thickness and length, densely barbed distally 37
36. Dorsal setae *c*<sub>1</sub> and *c*<sub>2</sub> longer and stronger than *d*, *e*<sub>1</sub>, *f*<sub>1</sub> and *f*<sub>2</sub>; *e*<sub>2</sub> short, ½ as long as other dorsal setae; tibiotarsus I solenidion *W*<sub>2</sub> short, clavate *vulgaris* Delfinado & Baker  
 – Dorsal setae *c*<sub>1</sub> and *c*<sub>2</sub> shorter and more slender than *d*, *e*<sub>1</sub>, *f*<sub>1</sub> and *f*<sub>2</sub>; *e*<sub>2</sub> as long as other dorsal setae; tibiotarsus I solenidion *W*<sub>2</sub> long, slender and rodlike *parapicola* Delfinado, Baker & Abbatiello
37. Epimeral setae 4a, 4b and 4c similarly strong; 4b extending beyond posterior margin of hysterosoma; only solenidion *W*<sub>2</sub> of tibiotarsus I slender, others clavate *ithacensis* Delfinado & Baker  
 – Epimeral setae 4a shorter and more slender than 4b and 4c; 4b approaching posterior margin of hysterosoma; tibiotarsus I solenidia *W*<sub>2</sub> and  $\phi$ <sub>2</sub> both slender, *W*<sub>1</sub> and  $\phi$ <sub>1</sub> large, clavate *apicola* (Banks)

*Imparipes (I.) cupes*, n. sp.  
 (Figs. 1–4)

*Female*.—Idiosoma 268 microns long, 229 microns wide (holotype), ellipsoidal.





Figs. 1-4. *Imparipes cupes*, n. sp. 1. Female dorsum; 2. Venter; 3. Tibiotarsus I; 4. Tibia and tarsus II.

Dorsum (Fig. 1): Dorsal plates uniformly, finely punctate, well sclerotized. Sensillus capitate, spiculate. Prodorsal setae spinelike,  $pd_1$  more robust than  $pd_2$ . Setae  $c_1$  shorter than  $c_2$ , both slender, attenuate distally and sparsely barbed;  $d$  more robust and shorter than other setae;  $e_2$ ,  $f_2$  equal

in length, more slender than and about as long as  $e_1$ ,  $f_1$ ;  $e_1$ ,  $f_1$  both stout but  $e_1$  appearing shorter and stouter than  $f_1$ ; all setae moderately barbed.

Venter (Fig. 2): Coxisternal plates well sclerotized, finely punctate. Apodemes 1, 3 and anterior (apsa) and posterior sternal (apsp) apodemes strongly developed. Apodemes 4 and posterior end of posterior sternal apodeme (apsp) free and incomplete. Epimeral setae 1a, 1b long and stout, densely pectinate; 2a sparsely barbed; 2b about  $\frac{1}{2}$  as long as 2a, not daggerlike, sparsely barbed; 3a, 3b, 3c similarly short, densely barbed; 4a shorter and more slender than 4b; sparsely barbed; 4b almost reaching posterior margin of hysterosoma, sparsely barbed; 4c more robust than 4b, densely barbed; 4a arising anterior to 4b. Caudal setae  $h_1$ ,  $h_3$  nearly as strong as dorsal setae, densely pectinate;  $h_2$  setiform, short and smooth, origin approximate to  $h_1$ .

Legs (Figs. 3, 4): Tibiotarsus I with claw; solenidia  $W_2$ ,  $\phi_2$  similarly short and slender, shorter than clavate  $W_1$ ;  $\phi_1$  conspicuously large, clavate. Tarsus II solenidion  $W_1$  small, clavate, smaller than that of tibiotarsus I. Tibial solenidion  $\phi$  of legs II & III small, slender clavate and in sclerotized depression; seta laterodistad of solenidion, not spinelike but robust. Leg IV pretarsus about as long as tarsus; tarsus with 6 setae including hair-like seta q, seta t minute.

*Male*.—Unknown.

*Holotype*.—Female, Ithaca, New York, 16 July 1975, from *Cupes concolor* (Coleoptera: Cupedidae) (T. McCabe), collected by B. M. OConnor.

*Paratypes*.—Four females, with same data as holotype. The holotype and 1 paratype are deposited in the U.S. National Museum of Natural History collection (Washington, D.C.); other paratypes are in the New York State Museum & Science Service collection at Albany, and Cornell University collection at Ithaca, New York.

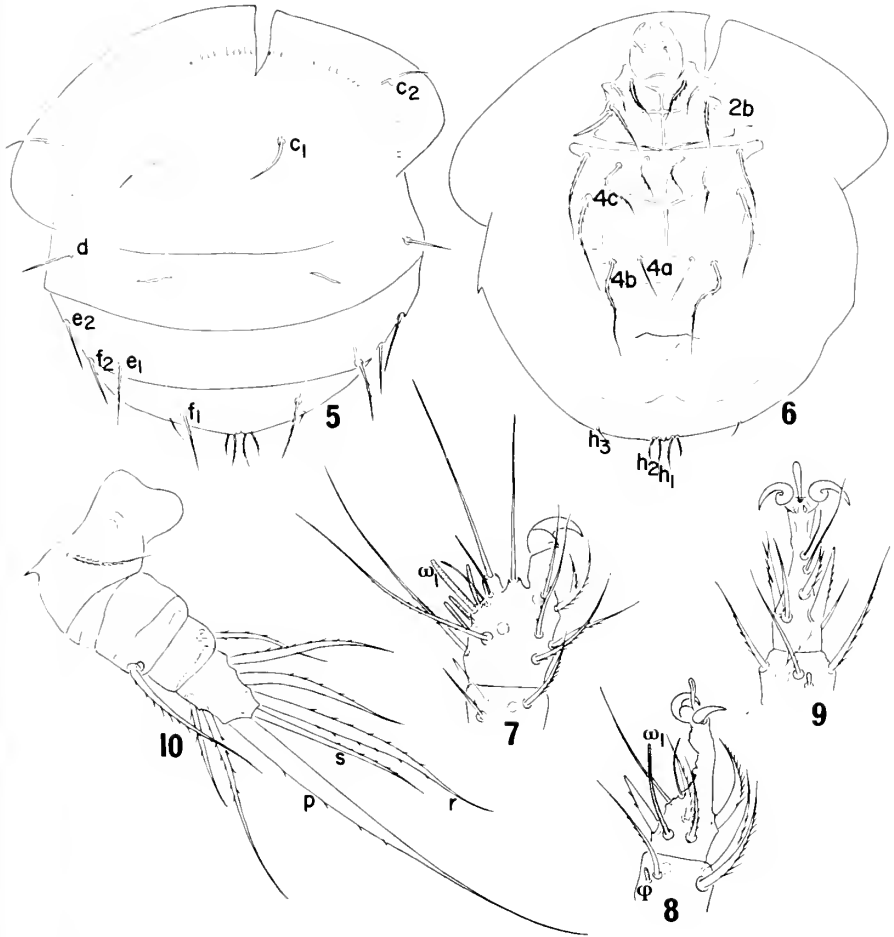
*Remarks*.—This species is similar to *Imparipes vulgaris* Delfinado & Baker, a scutacarid commonly found infesting bees. *I. cupes* differs as follows: Dorsal setae  $c_1$  are shorter than  $c_2$ ;  $e_2$  are as long as  $f_2$ ; epimeral setae 2b are not daggerlike, slender and sparsely barbed, and tibiotarsus I solenidion  $\phi_1$  is conspicuously large; in *vulgaris* setae  $c_1$  and  $c_2$  are equal in length;  $e_2$  are considerably shorter than  $f_2$ ; 2b are small, daggerlike and smooth, and solenidion  $\phi_1$  is not as large.

*Scutacarus* (*S.*) *meansi*, n. sp.

(Figs. 5-10)

*Female*.—Idiosoma 223 microns long, 191 microns wide (holotype), broadly ellipsoidal.

Dorsum (Fig. 5): Dorsal plates well sclerotized, uniformly, finely punctate. Sensillus capitate, sparsely spiculate. Prodorsal setae ( $pd_1$ ,  $pd_2$ )



Figs. 5-10. *Scutacarus (S.) meansi*, n. sp. 5. Female dorsum; 6. Venter; 7. Tibio-tarsus I; 8. Tibia and tarsus II showing empodium; 9. Tibia and tarsus III; 10. Leg IV.

minute and difficult to see. Setae  $c_1$ ,  $c_2$ ,  $d$  similarly short, stiff and smooth; setae  $e_1$ ,  $e_2$ ,  $f_1$ ,  $f_2$  similarly long and slender, finely attenuate distally;  $d$ ,  $e_1$ ,  $e_2$  smooth;  $f_2$  with 1-2 minute barbs;  $f_1$  finely barbed for most of its length.

Venter (Fig. 6): Coxisternal plates well sclerotized, uniformly, finely punctate. Apodemes 1, 2 strong, complete. Apodemes 4 and posterior sternal apodeme (apsp) incomplete, free. Epimeral setae 1a stout, densely pectinate; 1b slender, sparsely pectinate; 2a slightly heavier than 1b, sparsely pectinate; 2b daggerlike, smooth; 3a, 3b similar in thickness,

sparsely pectinate, 3a shorter than 3b; 3c heavier and longer than 3a, 3b, barbed; 4a short and slender, about  $\frac{1}{2}$  as long as 4b, smooth; 4b sparsely barbed; 4c robust, sparsely pectinate; 4a, 4b bases arranged in straight transverse line. Caudal setae  $h_1$ ,  $h_2$  barbed, approximate at their origins,  $h_1$  heavier and longer than  $h_2$ ;  $h_3$  small, slender and smooth.

Legs (Figs. 7-10): Tibiotarsus I with claw; solenidia  $W_2$ ,  $\phi_1$ ,  $\phi_2$  similarly slender clavate and much shorter than  $W_1$ ;  $W_1$  very long and slender, fingerlike. Tibial solenidion  $\phi$  of legs II & III very small, peglike, not in depression; seta distad of solenidion not spinelike, slender. Tarsus II solenidion  $W_1$  characteristically very long and slender, rodlike. Leg IV as figured; tibiotarsus short, about  $\frac{1}{3}$  as long as basal width, with 7 setae; seta p stouter than r; seta s slender. Trochanter IV with pointed spur dorsally. Empodium of tarsi II & III slender, spatulate and not disclike.

*Male*.—Unknown.

*Holotype*.—Female, Cambridge, New York, 21 April 1976, taken from bird nest, by M. Delfinado.

*Paratypes*.—Three females, with same data as holotype; 2 females, Cambridge, New York, 30 April 1976, from dog food, collected by R. Means. The holotype and 2 paratypes are deposited in the New York State Museum & Science Service collection at Albany; other paratypes are in the U.S. National Museum of Natural History, and the Acarology Laboratory, Ohio State University, Columbus, Ohio.

*Remarks*.—This species is unique in that the empodium of tarsi II & III is not disclike but slender and spatulate, and the tarsus II solenidion  $W_1$  is unusually long and slender; also the trochanter of leg IV has a pointed spur dorsally.

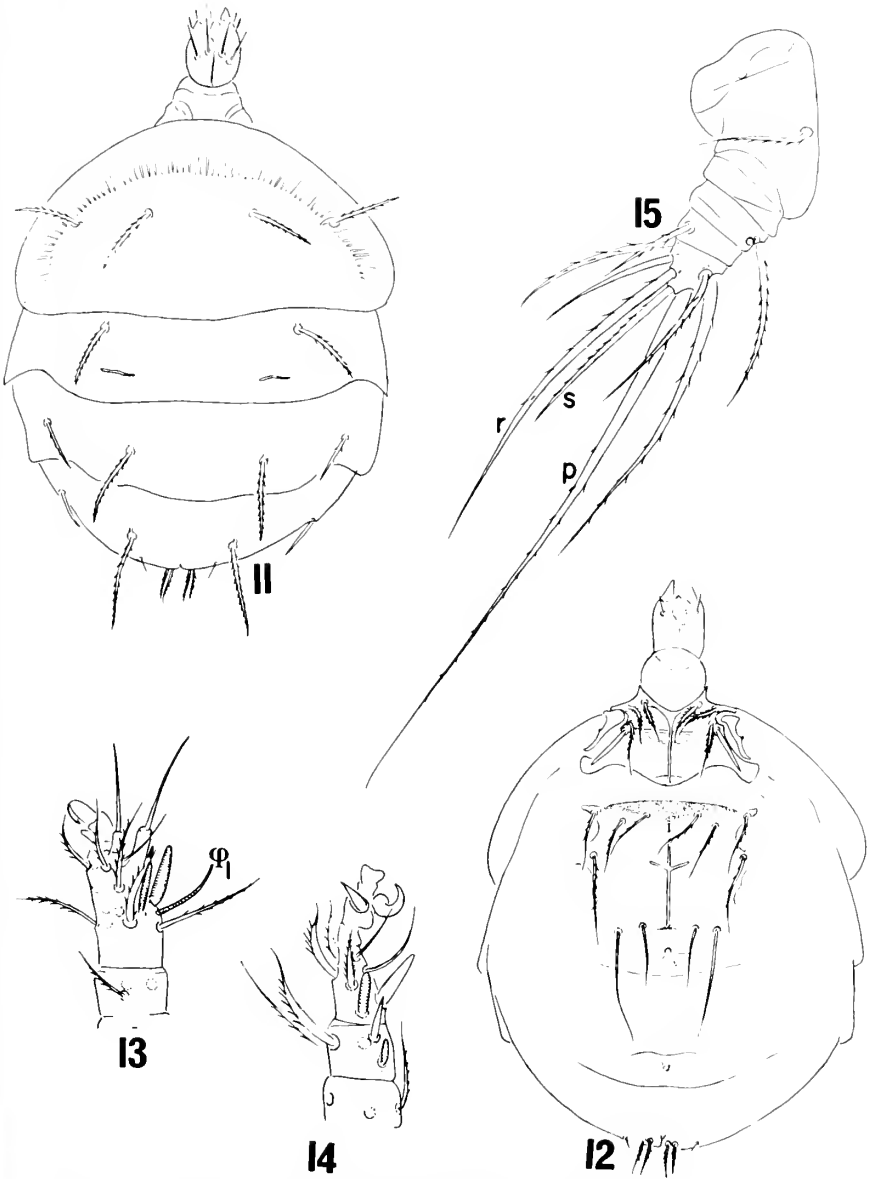
This mite is named for Robert E. Means, of the New York State Museum & Science Service, Albany, who has collected many specimens.

*Scutacarus (S.) unicus indefinitus*, n. subsp.  
(Figs. 11-15)

*Female*.—Idiosoma 190 microns long, 153 microns wide, excluding gnathosoma (paratype), ellipsoidal.

Dorsum (Fig. 11): Dorsal plate minutely punctate. Prodorsal setae  $pd_1$  as slender as  $pd_2$ . Sensillus capitate, spiculate. Type and size of dorsal hysterosomal setae essentially as in type form, *unicus* Delfinado & Baker, except  $e_1$ ,  $f_1$  noticeably longer than other setae;  $e_2$ ,  $f_2$  slender and short, with 2-3 sharp barbs as in type form. Setae  $c_1$ ,  $c_2$  equally short and stout, both shorter than  $e_1$ ,  $f_1$  and with sharp barbs.

Venter (Fig. 12): Apodemes and type of cpimeral setae as in type form. Caudal setae  $h_1$ ,  $h_2$  pectinate, equal in length and approximate at their origins;  $h_3$  very small.



Figs. 11-15. *Scutacarus (S.) unicus indefinitus*, n. subsp. 11. Female dorsum; 12. Venter; 13. Tibiotarsus I; 14. Tibia and tarsus II; 15. Leg IV.

Legs (Figs. 13–15): Tibiotarsus I with claw; solenidia  $W_2$ ,  $W_1$ ,  $\phi_1$ ,  $\phi_2$  as in type form, with  $\phi_1$  characteristically very long and slender. Tarsus II solenidion  $W_1$  as large as that of tibiotarsus I. Tibia III solenidion  $\phi$  much smaller than that of tibia II; seta laterodistad of solenidion spinelike, robust. Tibiotarsus IV slightly longer than basal width, with 7 setae; seta s slender, sparsely barbed distally.

*Male*.—Unknown.

*Holotype*.—Female, Cambridge, New York, 21 April 1976, taken from bird nest, by M. D. Delfinado.

*Paratypes*.—Six females, with same data as holotype. The holotype and 2 paratypes are deposited in the New York State Museum & Science Service collection at Albany; other paratypes are in the U.S. National Museum of Natural History, and the Acarology Laboratory, Ohio State University, Columbus, Ohio.

*Remarks*.—The female of the new subspecies, *indefinitus*, differs primarily from that of the type form, *unicus*, by having long, slender and sparsely barbed seta s of tibiotarsus IV; in the type form this seta is short, daggerlike and smooth. Also prodorsal setae ( $pd_1$ ,  $pd_2$ ) are similarly slender; in the type form  $pd_1$  are more robust than  $pd_2$ .

*Scutacarus (Variatipes) subaffinis*, n. sp.

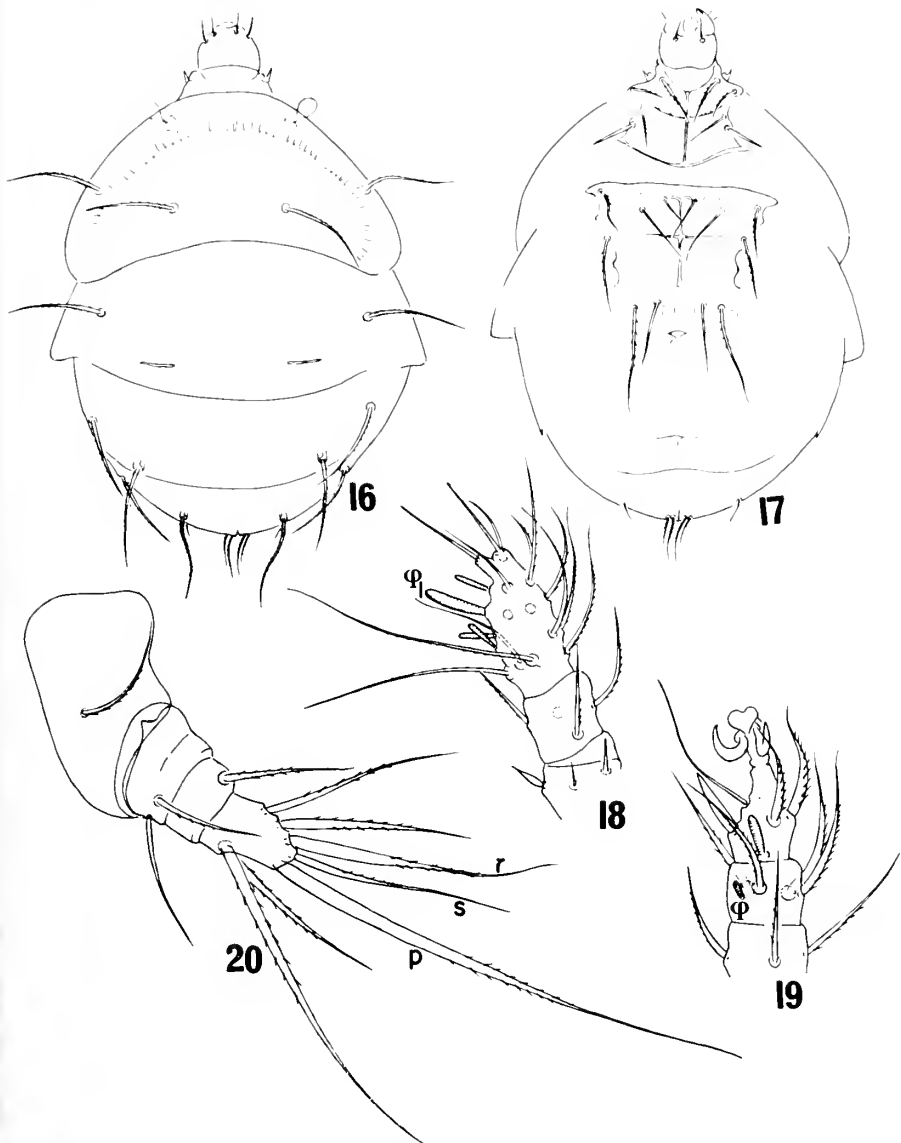
(Figs. 16–20)

*Female*.—Idiosoma 287 microns long, 191 microns wide (paratype), ellipsoidal.

Dorsum (Fig. 16): Dorsal plates uniformly punctate. Sensillus capitate, sparsely spiculate. Prodorsal setae  $pd_1$  stout, lanceolate and short,  $pd_2$  long and slender. All dorsal setae long and slender, finely attenuate distally;  $c_1$ ,  $c_2$  slender, about as long as  $d$ ,  $f_1$ ,  $e_1$ , sparsely barbed;  $d$ ,  $e_2$ ,  $f_2$  about equal in length, sparsely and minutely barbed, may appear smooth;  $e_1$ ,  $f_1$  stronger and longer than other setae.

Venter (Fig. 17): Coxisternal plates well sclerotized, finely punctate. Apodemes 1, 3 strong and complete. Apodemes 4 and posterior end of sternal apodeme (apsp) free, incomplete. Epimeral setae 1a stout, sharply serrate; 1b almost as slender as 2a, barbed; 2a slender, stiff, sparsely barbed; 2b daggerlike, smooth; 3a shorter and more slender than 3b, 3c, sparsely barbed; 4a short and slender, with minute barbs; 4c stouter than 4b, almost serrate; 4a, 4b bases arranged in straight transverse line. Caudal setae  $h_1$ ,  $h_2$  strong and serrate, approximate at their origins,  $h_1$  stronger and longer than  $h_2$ ;  $h_3$  tiny.

Legs (Figs. 18–20): Tibiotarsus I without claw; solenidia  $W_2$ ,  $\phi_2$ ,  $\phi_1$  similarly short;  $W_3$ ,  $\phi_2$  both slender, clavate;  $\phi_1$  clavate, swollen distally;  $W_1$  long and conspicuously large, clavate. Tibial solenidion  $\phi$  of legs II & III



Figs. 16–20. *Scutacarus* (V.) *subaffinis*, n. sp. 16, female dorsum; 17, venter; 18, tibiotarsus I; 19, tibia and tarsus II; 20, leg IV.

small, somewhat capitate, in sclerotized depression; seta laterodistad of solenidion not spinelike, slender. Tarsus II solenidion  $W_1$  short, clavate. Tibiotarsus IV short, about  $\frac{1}{3}$  as long as basal width, with 7 setae, all robust and sparsely serrate; seta r nearly as stout as seta p, seta s slender.

*Male*.—Unknown.

*Holotype*.—Female, Cambridge, New York, 21 April 1976, taken from bird nest, by M. D. Delfinado.

*Paratypes*.—Ten females, with same data as holotype. The holotype and 4 paratypes are deposited in the New York State Museum & Science Service collection at Albany; other paratypes are in the U.S. National Museum of Natural History, and the Acarology Laboratory, Ohio State University, Columbus, Ohio.

*Remarks*.—In general appearance the female of *subaffinis*, n. sp. may be confused with that of *affinis* Delfinado, Baker & Abbatiello, or that of *contiguus* Delfinado, Baker & Abbatiello. *S. subaffinis*, however, differs by having similarly long, slender and distally attenuate dorsal setae, and similarly short solenidia  $\phi_1$ ,  $\phi_2$ ,  $W_2$  of tibiotarsus I and  $W_2$  being shorter than  $W_1$ . In the related species  $W_2$  is conspicuously long and slender, as long as  $W_1$ ; dorsal setae  $e_2$  and  $f_2$  are much shorter than other setae. Caudal setae  $h_1$  and  $h_2$  are serrate in *subaffinis* and *contiguus*; in *affinis* these setae are sparsely barbed and simple respectively.

#### Acknowledgment

We thank Dr. Gisela Rack, of the Universität Hamburg, Zoologisches Institut und Zoologisches Museum, West Germany, for kindly reviewing the manuscript.

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#### Footnotes

<sup>1</sup>Published by Permission of the Director, New York State Science Service Journal Series No. 239.

<sup>2</sup>*S. jacoti* has 7 setae on tibiotarsus IV, not 6 as figured and stated in the original description (1976:111-112).

A NEW SUBGENUS OF *EUSCHISTUS*  
(HEMIPTERA: PENTATOMIDAE)

L. H. Rolston

*Abstract.*—*Mitripus*, new subgenus, is erected for seven South American species of *Euschistus* Dallas. The contained species previously recognized are: *E. acutus*, *E. anticus*, *E. convergens*, *E. latus*, *E. legionarius* and *E. tauricornis*. *Euschistus grandus*, new species, is added to this group. A key to species, and a description or diagnosis of each, are provided.

New synonymy recognized is *E. varicornis* Bergroth, 1914, as a junior synonym of *E. acutus* Dallas, 1951.

A lectotype and paralectotype are designated for *E. alaticollis* Stål, 1860, a junior synonym of *E. latus* Dallas, 1852.

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Among the species of *Euschistus* are seven from South America which warrant grouping into a new subgenus. The group includes *Euschistus acutus* Dallas, *E. anticus* Stål, *E. convergens* (Herrich-Schäffer), *E. latus* Stål, *E. legionarius* Breddin, *E. tauricornis* Stål and one new species. The six species previously recognized are transferred from the nominate subgenus.

*Mitripus* new subgenus

One pair of small tubercles located on proctiger about midway between base and apex of proctiger or nearer base (Fig. 12). Theca lacking lobes on distal margin. Thecal processes originating within theca (Fig. 6).

Inferior ridge of pygophore wanting or represented only on each side. Lateral walls of genital cup each bearing large carina or carinae (Fig. 5). Rim of genital cup interrupted on each side of superior ridge by diagonal depression (except *E. convergens*) (Fig. 12). Penisfilum lying on medial vertical plane. Jugal surpassing tylus (except *E. convergens*), convergent, rarely contiguous (Fig. 1).

*Type species.*—*Euschistus acutus* Dallas, 1851.

*Comments.*—In species of the nominate subgenus, the tubercles on the proctiger are located subapically, the distal margin of the theca is lobed, and the thecal processes are firmly attached to the dorsal, distal thecal margin. Characteristics enumerated for *Mitripus* other than those relating to the proctiger and theca also occur uncommonly in the nominate subgenus or are not universal among the species of *Mitripus*.

When the conjunctiva of some specimens of *E. acutus* inflates, part of the conjunctiva everts from the theca and carries with it the thecal processes, which are then individually movable (Fig. 7). Clearly these processes are

attached to the conjunctiva rather than to the rigid theca. This suggests that the thecal processes, which are common among pentatomid species, had their origin as appendages of the conjunctiva. A partial invagination of the conjunctiva would place the basal part of conjunctival appendages, if these arose near the distal margin of the theca, inside the theca. This condition is found elsewhere in the genera *Ladeaschistus* and *Sibaria* (Rolston, 1973 and 1975).

The spermathecal bulb among species of this subgenus also presents an interesting trend. In five species the bulb is elongate and digitiform, in *E. latus* it is short relative to the diameter, and in *E. grandis* the bulb is spherical (Figs. 39-45). As far as is known, all species in the nominate subgenus have a spherical spermathecal bulb.

The genital plates provide relatively weak taxonomic characters, but the form of the posterior margin of the basal plates does differ among species. It contrasts strongly in each of two pairs composed of species similar in general appearance, viz. *Euschistus anticus* and *E. convergens*, and *E. grandis* and *E. latus* (Figs. 46-52). The basal plates overlap along part of the mesial margin, and either plate may overlap the other.

#### Key to Species of Subgenus *Mitripus*

1. Pair of small subbasal scutellar patches of dense black punctation (Fig. 8) *E. anticus* Stål
- Scutellum lacking patches of black punctures, or punctation in such patches not especially dense 2
2. Humeral angles acute (Fig. 1) *E. acutus* Dallas
- Humeral angles narrowly rounded (Fig. 35), or broadly rounded at least anteriorly (Figs. 13, 18, 25, 31) 3
3. Humeral angles broadly rounded, little elevated (Fig. 13); tylus and juga subequal in length *E. convergens* (H-S)
- Humeral angles narrowly rounded (Fig. 35), or rounded anteriorly, angulate posteriorly, swept strongly upward (Figs. 18, 25, 31); juga surpassing tylus 4
4. Humeral angles narrowly rounded, little elevated (Fig. 35) *E. tauricornis* Stål
- Humeral angles broadly rounded anteriorly, angulate posteriorly, swept strongly upward (Figs. 18, 25, 31) 5
5. Thoracic pleura without conspicuous black spot above each coxa; length of body without membranes less than 11 mm *E. legionarius* Breddin
- Black spot present above some or all coxa; length of body without membrane more than 11 mm 6
6. Posterior angle of humeri pale; pronotum behind eyes black or fuscous *E. grandis* n. sp.

- Posterior angle of humeri dark brown; pronotum iridescent bluish-green behind eyes  
*E. latus* Dallas

*Euschistus acutus* Dallas, 1851

*Euschistus acutus* Dallas, 1851:202.—Walker, 1867:247 (listed).—Stål, 1872: 24 (keyed, records).—Lethierry & Severin, 1893:126 (listed).—Van Duzee, 1901:344 (record).—Kirkaldy, 1909:63.—Rolston, 1974:17-19, figs. 10-17 (keyed, description, distribution).

*Euschistus variicornis* Bergroth, 1914:429-430. NEW SYNONYMY.

Dorsum fuscous, grading to black on anterolateral pronotal margins, on humeri and at least basally on head; numerous yellowish brown subcalloused spots scattered on pronotum, scutellum and base of hemelytra; a lacuna of same color located near distal end of radial vein, and a small calloused yellow spot at posterior margin of each cicatrice near medial boundary; punctation rather dense, black, arranged in irregular transverse rows on base of pronotum. Length without membrane 7.6-9.0 mm.

Juga slightly surpassing tylus, inclined near apex from tylus to elevated outer margin; lateral margins not parallel (Fig. 1). Basal segment of antennae brownish yellow with fuscous longitudinal streak dorsolaterally, narrow incomplete apical ring, and elongated ventral spot; remaining segments fuscous excepting dorsal longitudinal streak on second, basal 2 tenths of third and fourth, and basal half of fifth yellowish.

Denticles on anterolateral pronotal margins small, acute or reduced to vertical rugae. Humeral angles strongly produced, acute to spinose, neither elevated nor turned forward. Membrane of hemelytra dark, veins simple or furcate. Connexivum narrowly exposed, black, interrupted in middle and narrowly at apex of each segment with yellow.

Venter orange yellow, punctation concolorous; thoracic pleura bearing 5 small black spots on each side. Evaporative area unicolorous. Spiracles and surrounding surface concolorous.

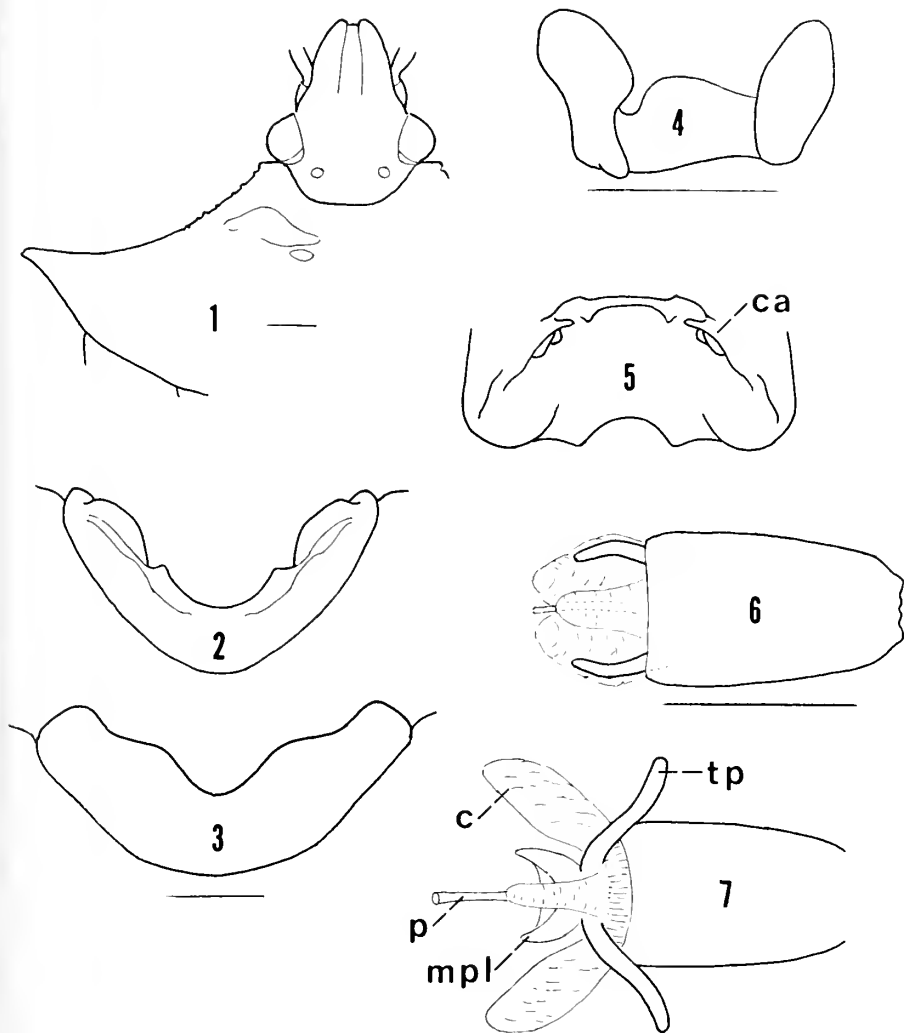
Broad emargination in posterior margin of pygophore deep and sinuous from both caudal and ventral views (Figs. 2, 3), with concave mesial notch from dorsal view (Fig. 5). Carina on each lateral wall of genital cup complex, anteriorly subvertical and bifid, posteriorly divided into two divergent rami.

Posterior margin of basal plates shallowly concave above 9th paratergite (Fig. 46). Spermathecal bulb digitiform; proximal part of spermathecal pump convolute (Fig. 39).

*Distribution*.—From Bolivia, Peru and northern Brazil northward in South America and Trinidad.

*Type*.—Female in British Museum (Natural History). Examined.

*Comment*.—The acute humeri are diagnostic within the subgenus.



Figs. 1-7. *E. acutus*. 1. Head and pronotum; 2. Posterior margin of pygophore, caudal aspect; 3. Pygophore, ventral aspect; 4. Right paramere; 5. Genital cup, dorsal aspect, with parameres and proctiger removed; carina (ca); 6. Theca and related structures, conjunctiva uninflated; 7. Same, conjunctiva inflated; conjunctiva (c); median penial lobes (mpl); penisfilum (p); thecal processes (tp). Dimensional lines equal 0.5 mm.

Bergroth applied the name *E. veriicornis* to specimens from French Guiana and compared them with *E. acutus*, writing: "Voisin de *E. acutus* Dall., mas plus petite et avec presque toute la face supérieure parsemée de petites taches calleuses pâles et les joues plus longues." The measure-

ments given for length without membrane of  $\delta$  7.8 mm and  $\eta$  8.3 mm, and for width at humeri of  $\delta$  5.8 mm and  $\eta$  6.8 mm, fall within the range observed in *E. acutus*. The dorsum of *E. acutus* is, indeed, sprinkled nearly all over with small, pale, calloused spots. Bergroth's detailed description also applies in other respects to *E. acutus*. The only apparently discordant statement concerns the pygophore, the apical margin of which he described as "—utrinque obliquato-subtruncato, medio sinuato, fundo sinus recto." The bottom of the emargination is concave, not straight, but if a male is inverted with the longitudinal axis of the body horizontal and the pygophore observed perpendicularly to this axis, then the bottom of the emargination does appear straight.

Although the specimens upon which Bergroth based the name *E. varicornis* were not located, I place this name in the synonymy of *E. acutus* on the basis of the description of these specimens.

*Euschistus anticus* Stål, 1860

*Euschistus anticus* Stål, 1860:20.—Walker, 1867:248 (listed).—Stål, 1872:24 (keyed, descriptive note).—Berg, 1878:306 (synonymy, variation, record).—Berg, 1879:45 (reprint 1878 paper).—Distant, 1887:61 (listed).—Berg, 1891:277 (descriptive note).—Bergroth, 1892:262 (synonymy).—Lethierry & Severin, 1893:126 (synonymy).—Kirkaldy, 1909:63 (synonymy).—Buckup, 1961:10 (record).—Grazia-Vieira & Casini, 1973:58 (record).

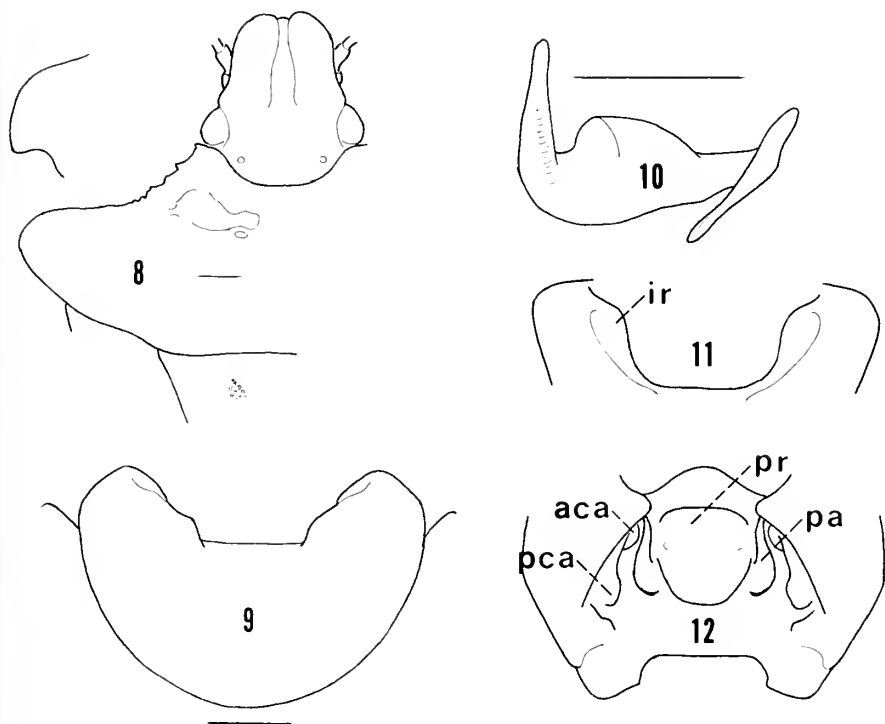
*Euschistus inermis* Mayr, 1864:910.—Mayr, 1868:62, fig. 11.—Walker, 1867:248 (listed).—Stål, 1872:24 (keyed, synonymy) (synonymized by Berg, 1878).

*Euschistus fallax* Mayr, 1864:910.—Mayr, 1868:63, fig. 12.—Walker 1867:248 (listed).—Stål, 1872:24 (keyed, synonymy) (synonymized by Berg, 1878).

*Euschistus planicornis* Fallou, 1889:36 (synonymized by Bergroth, 1892).

Head and anterior portion of pronotum fuscous to black with faint bronze tinge, remainder of dorsum yellowish brown, castaneously punctate, with vague dark reticulation on hemelytra; a small patch of dense usually black punctures on each side of scutellum near base about midway between lateral margin and meson; calloused spot at posterior border of each cicatrice near mesial limit usually pale; a small pale mesial spot usually present at base of scutellum. Length without membrane 8.4–10.1 mm (7–10.5 mm according to Berg, 1891).

Head rather flat, shallowly impressed anteromesad of eyes and submarginally at apex. Juga surpassing tylus, convergent or just contiguous at apex, their lateral margins subparallel for middle third of distance from



Figs. 8–12. *E. anticus*. 8. Head and pronotum, with variation in humeri; 9. Pygophore, ventral aspect; 10. Right paramere; 11. Posterior margin of pygophore, caudal aspect; inferior ridge (ir); 12. Genital cup, dorsal aspect; anterior carina (aca); posterior carina (pca); paramere (pa); proctiger (pr). Dimensional lines equal 0.5 mm.

eyes to apex (Fig. 8). Antennae light to dark brown with a few obscure darker dots on basal three segments.

Denticles on anterolateral margins of pronotum acute, black, inclined toward humeri. Humeri moderately produced, rounded; posterolateral margin sometimes emarginated; dorsal surface following contour of pronotal disk from cephalic view, or moderately elevated. Pale portion of pronotal disk less densely punctate than dark anterior portion, with many punctures arranged in transverse rows separated by rugose interstices. Membranes of hemelytra lightly fumose; veins simple or furcate. Connexivum rather narrowly exposed, castaneous to black, weakly to strongly alternated with paler spot in middle of each segment.

Venter orange yellow, concolorously punctate; thoracic pleura with four small black spots on each side, lacking spot at anterolateral angle of pro-

thorax, occasionally with spot only at base of each subcoxae. Evaporative area unicolorous. Peritremes of spiracles fuscous.

Emargination of pygophore deep, concave, exposing inferior ridge from caudal view (Fig. 11), mesially truncate from ventral and dorsal views (Figs. 9, 12). Inferior ridge obsolete mesially. Margins of genital cup interrupted by diagonal sulcus on each side of superior ridge. Large lobed carina located on each lateral wall of genital cup; a smaller carina on each side of first partially obscured by apex of parameres (Fig. 12). Parameres terminating in simple hook (Fig. 10).

Posterior margin of basal plates markedly concave above 9th paratergite (Fig. 47). Spermathecal bulb digitiform; basal part of spermathecal pump slightly sinuous (Fig. 40).

*Distribution*.—Argentina (Misiones), southern Brazil (Minas Gerais, Rio Grande do Sul, Santa Catarina) and Uruguay (Rivera).

*Type*.—Male, in Naturhistoriska Riksmuseet, Stockholm. Not seen.

*Comments*.—The small paired areas of dense, usually black punctation near the base of the scutellum is diagnostic.

I have accepted the synonymy given by Berg (1878) and Bergroth (1892). The figure published by Mayr (1868) of *E. inermis* (Fig. 11) is hard to reconcile with the one for *E. fallax* (Fig. 12) or specimens of *E. anticus*. It differs especially in the conspicuously sigmoid junction of the corium and membrane, and in the absence of subbasal scutellar spots. The distal margin of the corium actually varies in *E. anticus* from slightly convex to slightly sigmoid, and the illustrator may have exaggerated the difference between two specimens. With regard to the two subbasal spots, these are present in the 37 specimens which I have examined, but they do not always contrast strongly in color. Stål (1860) noted that these spots are sometimes obsolete. Presumably they were inconspicuous in the specimen to which Mayr applied the name *E. inermis* since the dark reticulation on the coria is also absent.

#### *Euschistus convergens* (Herrich-Schäffer, 1842)

*Cimex convergens* Herrich-Schäffer, 1842:94, fig. 665.

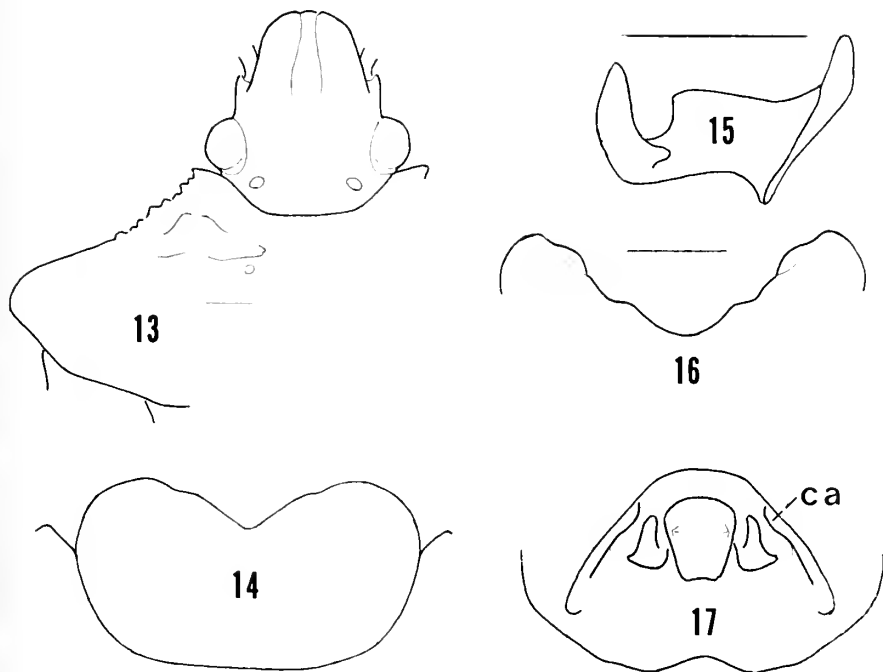
*Pentatoma convergens*: Herrich-Schäffer, 1844:95.

*Euschistus convergens*: Dallas, 1851:203 (synonymy).—Walker, 1867:247 (synonymy).—Stål, 1872:24 (keyed, synonymy, descriptive note).—Lethierry & Severin, 1893:127 (synonymy).—Kirkaldy, 1909:64 (synonymy).

*Euschistus roripes* Stål, 1860:20.—Walker, 1867:248 (listed) (synonymized by Stål, 1872).

Dorsum fuscous with head and anterior portion of pronotum black, or entirely black, relieved by small pale spot at posterior margin of each





Figs. 13-17. *E. convergens*. 13. Head and pronotum; 14. Pygophore, ventral aspect; 15. Right paramere; 16. Posterior margin of pygophore, caudal aspect; 17. Genital cup, dorsal aspect; carina (ca). Dimensional lines equal 0.5 mm.

cicatrice near mesial limit, another on disk of each corium, and often by one to five poorly delineated spots along base of scutellum; punctation dense, black. Length without membrane 8.5-10.4 mm.

Juga slightly converging over apex of tylus, their lateral margins tapering from eyes to evenly rounded apex of head (Fig. 13). Antennae black or fuscus with sordid yellow on little more than basal half of last segment, basal fourth of fourth, basal 2 tenths of third, and as streaks above and below on three basal segments.

Humeri moderately produced, broadly rounded, elevated little if any above pronotal disk. Anterolateral margins of pronotum concave; denticles few, obtuse, yellowish. Scutellar disk uneven. Membrane of hemelytra brown, veins simple or furcate. Connexivum black, alternated with brownish orange marginal spot in middle of each segment.

Venter orange yellow, concolorously punctate; five small black spots on each side of thoracic pleura. Evaporative areas unicolorous. Peritremes of spiracles fuscous.

Posterior margin of pygophore with sinuous V-shaped emargination

from both caudal and ventral views (Figs. 14, 16), convexly arcuate with mesial notch from dorsal view (Fig. 17). Inferior ridge reduced to subvertical ridge on each side. Small denticle on each lateral wall of genital cup located just entad of and obscured by diagonal carina (Fig. 17). Parameres unequally bifid (Fig. 15).

Posterior margin of each basal plate evenly convex (Fig. 48). Spermathecal bulb digitiform: proximal part of spermathecal pump convolute (Fig. 41).

*Distribution*.—Argentina (Misiones), Bolivia, Brazil (Minas Gerais, Rio de Janeiro, Santa Catarina), and Paraguay.

*Type*.—Type material of *Cimex convergens* was not located. The type of *Euschistus roripes* Stål, a male, in the Naturhistoriska Riksmuseet, Stockholm, was compared by Per Inge Persson with specimens of *Euschistus convergens* furnished to him and found to be conspecific with these specimens.

*Euschistus grandis* n. sp.

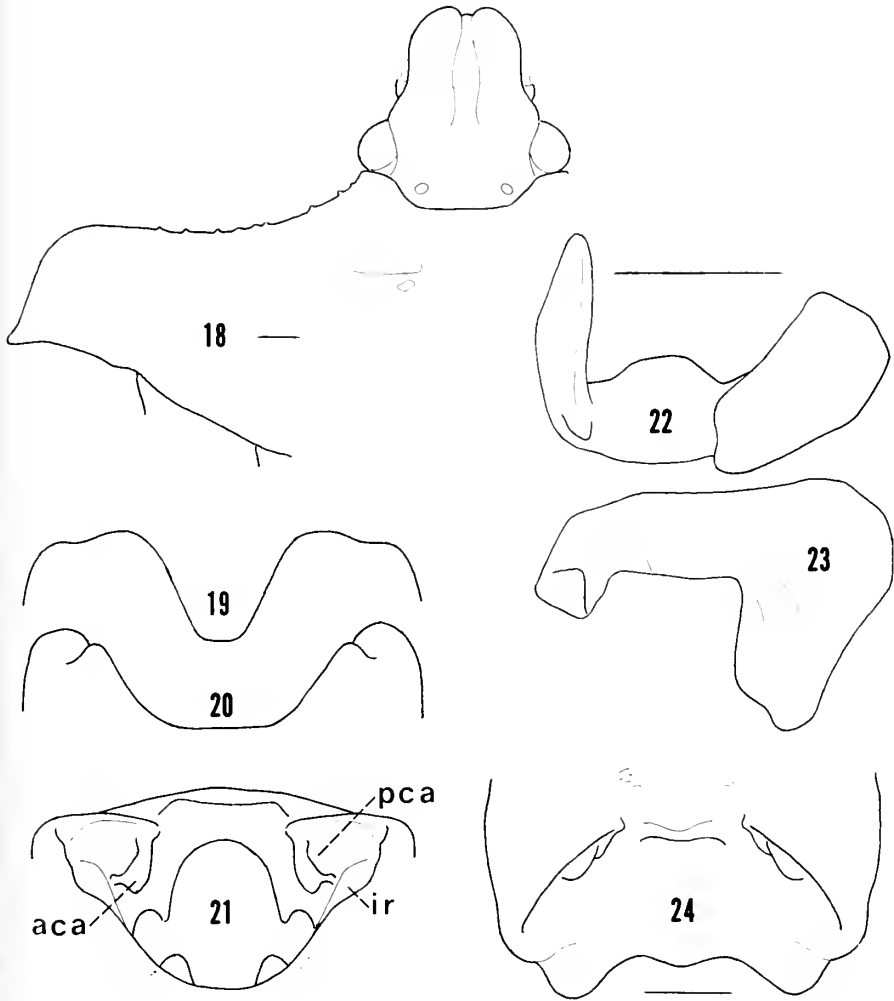
Dorsum yellowish brown to dark castaneous, becoming fuscous to black on anterior portion of pronotum and on head; small pale spot at posterior margin of each cicatrice near mesial limit, another mesially at base of scutellum; punctation dense, black, fine to moderate. Length of body without membrane 12.1–14.0 mm.

Juga longer than tylus, lateral margins briefly subparallel in concavity before eyes, inner margins toward apex converging slightly over tylus; incision at apex of head shallow (Fig. 18). Antennae ivory to sordid yellow marked with black as follows: lateral stripe and narrow apical ring on basal segment, lateral and mesial stripe widening and fusing toward apex on second and third segments, all of fourth except narrow irregular basal ring, and apical half of last segment.

Humeri strongly produced laterally, rising well above pronotal disk; truncate apex rounded anteriorly, angular posteriorly, slightly concave beneath from lateral view; posterior angle paler than rest of humeri. Anterolateral margins slightly concave, nearly right angular to axis of body; denticles small, acute, black.

Fovea in basal angles of scutellum small, obscure; scutellar disk often roughly uneven, uniformly punctate, often with scattered smooth spots, these pale or not. Corium of hemelytra with impunctate lacuna of variable size near end of radial vein; membrane brown, veins branching. Connexiva black, with short narrow pale marginal line in middle of each segment; punctation dense, black.

Venter yellowish brown; punctation mostly concolorous, sometimes castaneous, less dense but coarser than on dorsum. Basic pattern of 5 black spots on each side of thoracic pleura reduced: spot at anterolateral angle of propleura wanting, spot at base of metathoracic subcoxae



Figs. 18-24. *E. grandis*. 18. Head and pronotum; 19-20. Variation in emargination of posterior pygophoral margin, ventral aspect; 21. Genital cup, caudal aspect, with parameres and proctiger removed; inferior ridge (ir); posterior carina (pca); anterior carina (aca); 22. Right paramere; 23. Same, rotated 90 degrees toward observer; 24. Genital cup, dorsal aspect, with parameres and proctiger removed. Dimensional lines equal 0.5 mm.

often absent. Evaporative areas usually unicolorous, rarely minutely fuscous punctate. Most black dots on femora and tibiae moderately large. Spiracles black. Pygophore finely fuscous punctate.

Deep broad emargination in posterior margin of pygophore evenly arcuate

at bottom of concavity from caudal view, sinuous on each side near dorsal margin, there exposing remnant of inferior ridge (Fig. 21); from ventral view posterior margin usually broadly emarginated, prominently sinuous on each side of emargination (Fig. 20), but emargination sometimes narrowed to about one-third width of pygophore and remainder of margin weakly sinuous (Fig. 19); emargination much shallower from dorsal view (Fig. 24). Rim of genital cup interrupted on each side of superior ridge by diagonal sulcus; lateral wall of genital cup each bearing two large subparallel carinae rising diagonally cephalad from depth of cup to rim. Proctiger distad of tubercles rather uniformly setose. Base of parameres extremely large; apical hook subtriangular in cross section, almost imperceptibly roughened on lateral surface (Figs. 22, 23).

Posterior margin of each basal plate evenly convex (Fig. 51). Spermathecal bulb spherical; spermathecal pump cylindrical (Fig. 42).

*Distribution*.—Brazilian states of Rio de Janeiro, Santa Catarina and São Paulo. Presumably present in Minas Gerais since Mount Itatiaia, from whence some specimens came, is at the junction of Rio de Janeiro, São Paulo and Minas Gerais.

*Types*.—Holotype, male, labeled (a) Brazil, São Paulo, Serra Bocaina, S. J. Barreiro, 1,650 m (b) Oct-Nov 1969, Alvarenga & Seabra. Deposited in the American Museum of Natural History. Paratypes: 10♂♂, 11♀♀. *Brazil, Rio de Janeiro*: Itatiaia, 800 m, 12-933, S Lopes et R. Cunha (2♀♀ RNH, ♀ LHR); Itatiaia, IV 1932, D. Mendes (♀ RNH); Itatiaia, 816 m, 2-1-933, N. B. Pagondes (♀ RNH); Itatiaia (sic), 1,000 m Est. Biologica, 22-12-33, W. Zikan (♂ RNH); same data except 19-1-34 (♀ USNM); same data except 25-x1-942 (♂ LHR); Faz. Penedo, Itatiaia, III-942, P. Wygodzinski (♀ RNH); Parque Nacional de Serra dos Orgaos, Terresopolis (sic), 1,500-1,700 m, 18-22, 4, 1947, Wygod. col. (♂ RNH, ♂ LHR, ♀ UNLP) *Santa Catarina*: (a) Rio Vermelho, XII 1944 (b) A. Maller (♂♀ AMNH); same data except I 1944 (♂ AMNH). *São Paulo*: same data as holotype (♂ BMNH, ♀ AMNH).

#### *Euschistus latus* (Dallas, 1852)

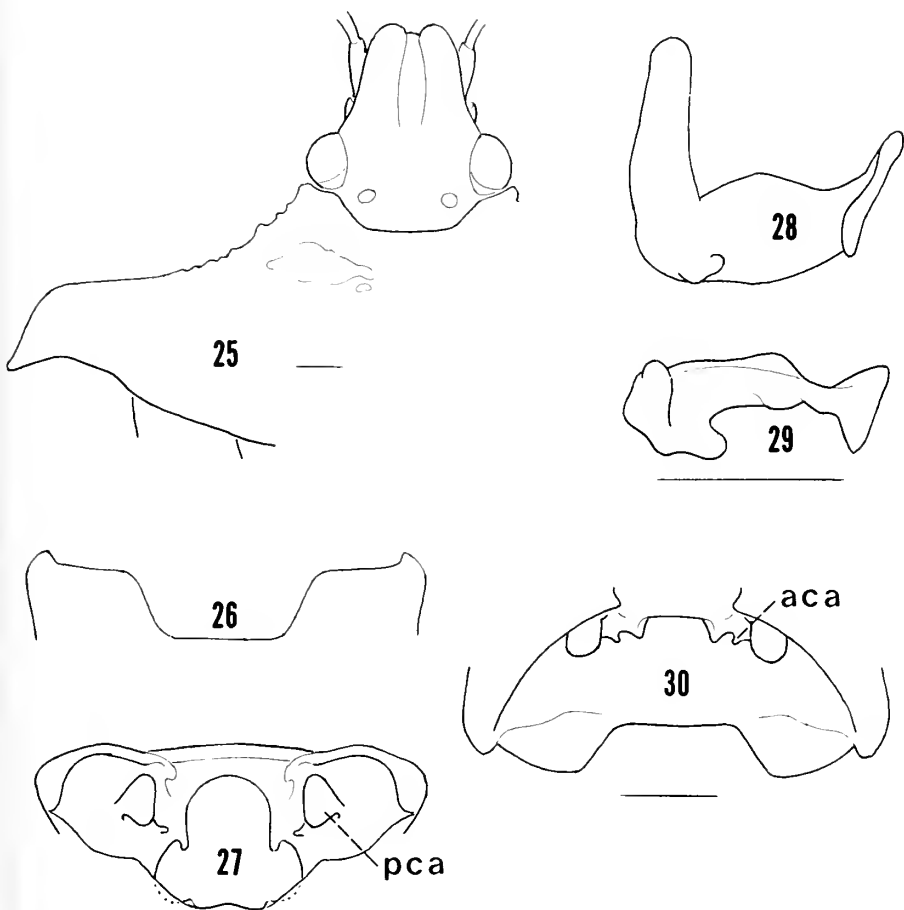
*Tropicoris latus* Dallas, 1852:12, fig. 5.

*Euschistus alaticollis* Stål, 1860:20.—Walker, 1867:248 (listed) (synonymized by Stål, 1872).

*Euschistus latus*: Stål, 1872:24 (keyed, synonymy, descriptive note).—Distant, 1887:61 (listed).—Lethierry & Severin, 1893:128 (synonymy).—Kirkaldy, 1909:65 (synonymy).—Costa Lima, 1940:58, fig. 252.

Differing principally from *E. grandus* as follows:

Metallic bluish-green border along anterolateral margins of pronotum



Figs. 25-30. *E. latus*. 25. Head and pronotum; 26. Posterior margin of pygophore, ventral aspect; 27. Genital cup, caudal aspect, with parameres and proctiger removed; posterior carina (pca); 28. Right paramere; 29. Same, rotated 90 degrees toward observer; 30. Genital cup, dorsal aspect, with parameres and proctiger removed; anterior carina (aca). Dimensional lines equal 0.5 mm.

broadest at eyes, evenescent before reaching humeri; exocoria usually colored similarly at base.

Lateral margins of juga tapering sinuously from eyes to apex, nowhere subparallel (Fig. 25).

Humeri clearly concave beneath from lateral view; posterior angle not differentially colored.

Posterior margin of pygophore sinuously concave from caudal view

(Fig. 27), with a small projection laterally and trapezoidal mesial emargination which narrows anteriorly from ventral view (Fig. 26); emargination from dorsal view truncate at bottom (Fig. 30). Anterior carina on each lateral wall of genital cup reduced to spur (Fig. 30). Prominent projection present where paramere sharply bent (Figs. 28, 29).

Posterior margin of each basal plate angulate, concave above 9th paratergite (Fig. 49). Spermathecal bulb somewhat elongate; spermathecal pump cylindrical (Fig. 43).

*Distribution*.—Brazil (Rio Grande do Sul, Rio de Janeiro); Uruguay (Montevideo).

*Types*.—The type of *Tropicoris latus* Dallas, a female, in the British Museum (Natural History) was examined. The syntypes of *Euschistus alaticollis* Stål, in the Naturhistoriska Riksmuseet, Stockholm, consist of a male and female. The male, labeled "Rio Jan" "Stal," is designated LECTOTYPE and the female, labeled "Brasil" "F. Sahlb." "♀" PARALECTOTYPE.

Per Inge Persson kindly compared the syntypes of *Euschistus alaticollis* with an example of *E. grandis* and *E. latus* and concluded that "it is quite evident—that *E. alaticollis* is conspecific with *E. latus* Dallas."

#### *Euschistus legionarius* Breddin, 1914

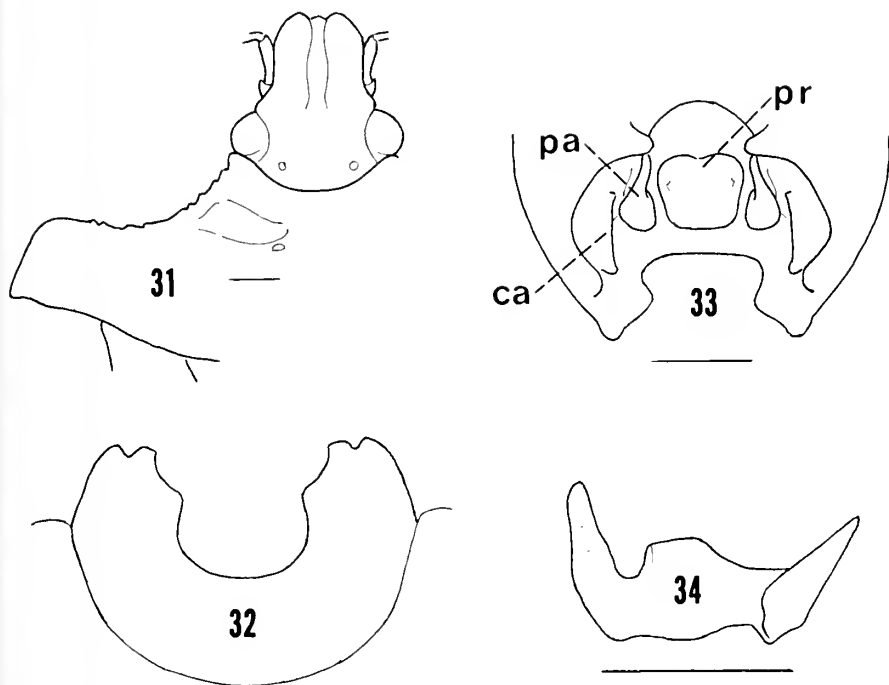
*Euschistus legionarius* Breddin, 1914:56—Schröder, 1964:62, 74, Pl. 1, fig. 4 (lectotype designated).

Dorsum yellowish brown grading to dark brown or fuscous on anterior half of pronotum and head; punctuation castaneous to black, denser where color is darkest. Length without membrane 7.2–9.2 mm (9¼–10 mm long according to Breddin, 1914).

Juga exceeding tylus, usually angular at apex, with lateral margins parallel for middle third of distance from eyes to apex (Fig. 31). Basal 2 tenths of fourth antennal segment and basal 3–5 tenths of fifth pale, remainder of these segments fuscous.

Anterolateral margins of pronotum concave, irregularly denticulate to humeri. Humeri explanately produced, rounded anteriorly, angulate posteriorly, sweeping upward. Cicatrices prominent, tumescent, with numerous strong punctures connecting with other pronotal punctures only near posterolateral boundary of cicatrices. Small elevated callous located near posteromesial margin of cicatrices usually pale. Basal disk of scutellum roughly elevated, bearing irregular patches of black punctures along base adjacent to small fovea in basal angles; apex not pale. Dark macule often present near end of radial vein; membrane slightly brown with few simple or branched veins and an occasional cell basally. Connexivum moderately exposed, with broad black border along sutures between segments.

Venter little paler than dorsum, punctuation mostly fuscous or castaneous;



Figs. 31–34. *E. legionarius*. 31. Head and pronotum; 32. Pygophore, ventral aspect; 33. Genital cup, dorsal aspect; carina (ca); paramere (pa); proctiger (pr); 34. Right paramere. Dimensional lines equal 0.5 mm.

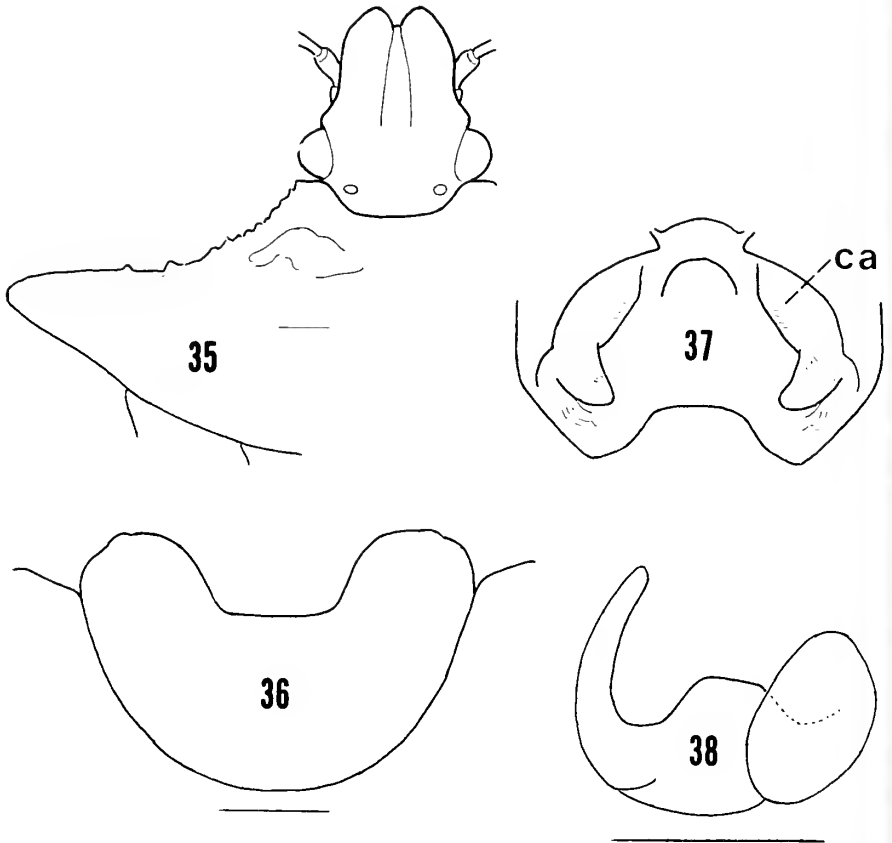
thoracic pleura lacking dark spots. Evaporative areas with fine dark punctation. Spiracles ringed with fuscous.

Posterior margin of pygophore deeply emarginate mesially; emargination truncate basally from dorsal and ventral views (Fig. 32, 33); a submarginal tumescence on pygophoral surface located below emargination. Inferior ridge lacking. Rim of genital cup broken on each side of superior ridge by diagonal sulcus. Carina on each lateral wall of genital cup tumescent, finely striate, produced posteriorly into tubercle. Parameres a simple hook (Fig. 34).

Posterior margin of each basal plate angulate, prominently concave above 2nd gonocoxae, diagonally linear above 9th paratergite (Fig. 50). Spermathecal bulb digitiform, twisted; spermathecal pump subcylindrical (Fig. 44).

*Distribution*.—Brazil (Minas Gerais, Santa Catarina, Rio de Janeiro).

*Type*.—Lectotype, male, in Natur-Museum Senckenberg, Frankfurt am Main. (Schröder, 1964). Not seen.



Figs. 35-38. *E. tauricornis*. 35. Head and pronotum; 36. Pygophore, ventral aspect; 37. Genital cup, dorsal aspect, with parameres and proctiger removed; carina (ca); 38. Right paramere. Dimensional lines equal 0.5 mm.

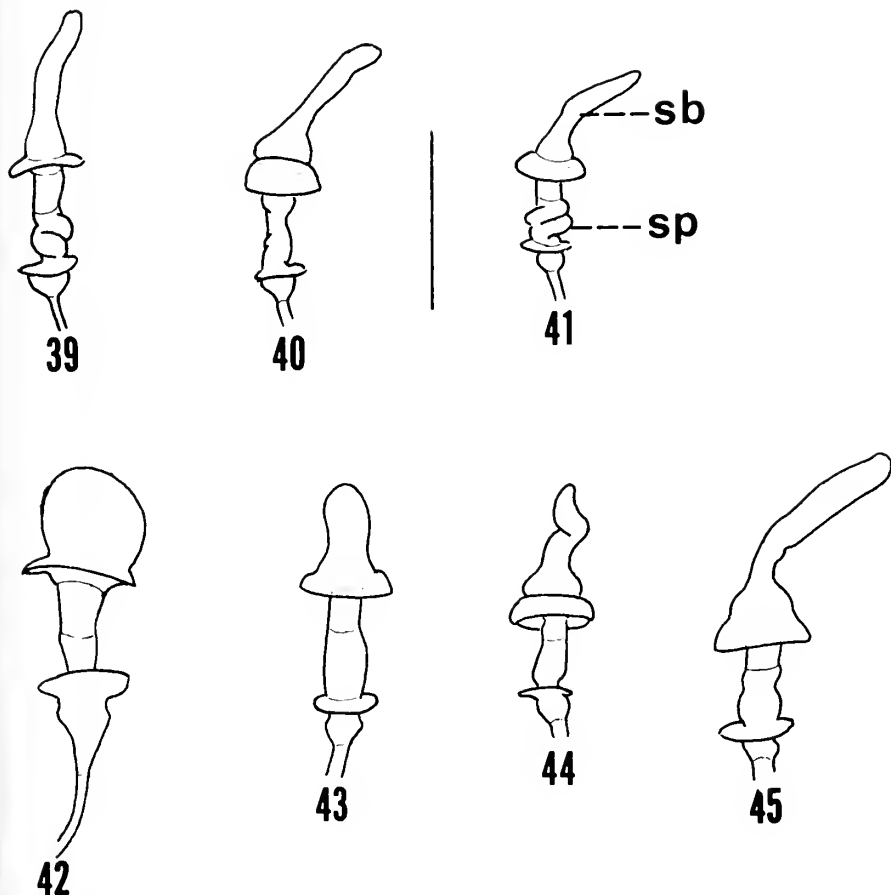
*Euschistus tauricornis* Stål, 1872

*Euschistus tauricornis* Stål, 1872:25 (keyed).—Berg, 1878:306 (listed).—Berg, 1879:45 (listed).—Lethierry and Severin, 1893:128 (listed).—Kirkaldy, 1909:66 (listed).—Pennington, 1922:317 (listed).

Dorsum yellowish brown with anterior portion of humeri black, densely punctate; these humeral areas connected by band of less dense black punctures. Length without membranes 8.0-9.5 mm.

Juga much exceeding tylus, convergent, each jugum rounded apically, their lateral margins parallel for middle third of distance from eyes to apex (Fig. 35). Second and third antennal segments streaked laterally

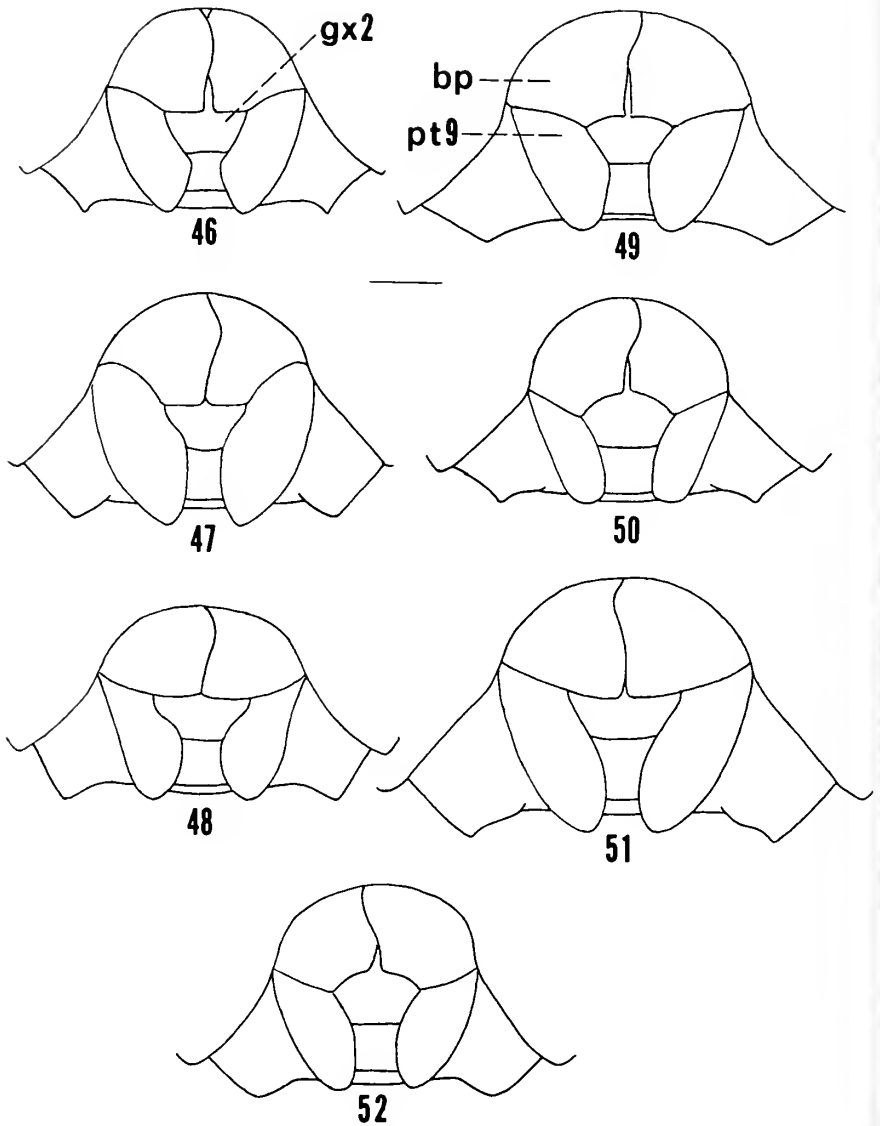




Figs. 39–45. Distal portion of spermatheca; spermathecal bulb (sb); spermathecal pump (sp); 39. *E. acutus*; 40. *E. anticus*; 41. *E. convergens*; 42. *E. grandus*; 43. *E. latus*; 44. *E. legionarius*; 45. *E. tauricornis*. Dimensional line equals 0.5 mm.

and mesially with fuscous; last two segments castaneous, basal 1–2 tenths pale.

Anterolateral margins of pronotum concave, irregularly denticulate to humeri. Humeri strongly produced laterally, narrowly rounded at apex, little elevated. Black punctures in irregular patches at base of scutellum not especially crowded; scutellar apex ivory, concolorously punctate. A dull fuscous macule located at end of radial vein; some punctures on coria connected by network of thin fuscous lines; membrane slightly brown, veins simple. Connexivum moderately exposed, sutures between segments broadly bordered with lustrous black.



Figs. 46–52. Genital plates, oriented with anterior and posterior margins of basal plates on same focal plane at meson; basal plates (bp); 2nd gonocoxae (gx 2); 9th paratergite (pt 9). 46. *E. acutus*; 47. *E. anticus*; 48. *E. convergens*; 49. *E. latus*; 50. *E. legionarius*; 51. *E. grandus*; 52. *E. tauricornis*. Dimensional line equals 0.5 mm.

Venter yellowish brown, punctation concolorous to light castaneous. Evaporative areas unicolorous. Thoracic pleura with 4 black spots, lacking spot at anterolateral angle of pronotum. Spiracles black.

Posterior margin of pygophore deeply and broadly emarginated mesially (Figs. 36, 37); an impression as large as emarginated area located on pygophoral surface below emargination. Inferior ridge lacking. Carina on each lateral wall of genital cup tumescent, with fine undulating striae, produced posteriorly into tubercle directed dorsomesad (Fig. 37). Rim of genital cup tripartite, divided by diagonal sulcus on each side of superior ridge. Unpigmented area on basal half of proctiger with pair of tubercles intruding from pigmented distal part of proctiger. Parameres bent into simple hook (Fig. 38).

Posterior margin of each basal plate angulate, decidedly concave above 2nd gonococae, slightly convex above 9th paratergites (Fig. 52). Spermathecal bulb digitiform; proximal part of spermathecal pump an irregular cylinder (Fig. 45).

*Distribution*.—Uruguay and Argentina (Buenos Aires).

*Type*.—Female, in Naturhistoriska Riksmuseet, Stockholm. Not seen.

*Comment*.—An apparently rare species. The humeral marking is diagnostic within the subgenus.

Deposition of paratypes is indicated as follows: American Museum of Natural History (AMNH); British Museum (Natural History) (BMNH); author's collection (LHR); Rijksmuseum van Natuurlijke Historie (RNH); Universidad Nacional de La Plata, Facultad de Ciencias Naturales y Museo (UNLP); U.S. National Museum (USNM).

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ACTIVITY AND DISPERSAL OF FIRST INSTAR  
LARVAE OF THE CITRUS BLACKFLY<sup>1</sup>

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*Abstract.*—We found that a small portion (0.2–0.3%) of first instar *Aleurocanthus woglumi* Ashby are mobile for 2–4 h and will crawl up to 25–30 mm. When leaves overlap these highly mobile individuals can crawl from one plant to another.

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The citrus blackfly (*Aleurocanthus woglumi* Ashby)<sup>2</sup> is a major pest of citrus that was discovered in the Ft. Lauderdale area of Florida in January, 1976. It is currently the target of an eradication effort by the Division of Plant Industries (Florida Department of Agriculture) and the Animal and Plant Health Inspection Service (USDA). A quarantine on the movement of all plants that have been shown to support full *A. woglumi* development is included in the eradication effort. However, there are many plants upon which females will oviposit, but which will not support complete development of the immature stages (e.g. orange jasmine, *Murraya paniculata* (L.) Jack) (Howard, F. W., and P. L. Neel, 1977. Host plant preferences of citrus blackfly (*Aleurocanthus woglumi* Ashby) (Homoptera: Aleyrodidae) in Florida. Proc. Int. Soc. Citriculture 1977 (in press)). This study was initiated to determine if first instar larvae of *A. woglumi* are capable of crawling from the leaves of one plant to those of another.

We field-infested 4 orange jasmine plants (*M. paniculata*) with *A. woglumi*. After 3–4 egg spirals were oviposited on each leaf, the plants were returned to the laboratory and uninfested citrus rootstock plants were put into contact with them. In addition, 5 uninfested citrus leaves were stapled to 5 of the infested orange jasmine leaves, harboring a total of 300 *A. woglumi* eggs, to provide a dispersal opportunity for first instar larvae. The length of time the first instar larvae are mobile after hatching was also observed.

After hatching, first instar larvae are mobile and seek feeding sites for up to 3–5 hours ( $n = 3$ ) before becoming immobile. Although no larvae were found on the citrus plants in contact with the orange jasmine, one larva was found on the citrus leaves stapled to the orange jasmine leaves. This individual represented  $\frac{1}{300}$  (0.3%) of the population and it had crawled a distance of 28 mm. It was previously observed that first instar *A. woglumi* are mobile for 2–4 hours and that 0.2% ( $\frac{1}{500}$ ) of the population are able to crawl up to 38 mm from the egg spiral (Dietz, H. F., and J. Zetek, 1920. The blackfly of citrus and other subtropical plants. USDA Agric. Bull. #885, 55 pp). The presence of these highly mobile individ-

uals in populations of *A. woglumi* presents the possibility that larvae may crawl from an unsuitable host to a suitable one if contact between the plants occurs.

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#### Footnotes

<sup>1</sup> Florida Agricultural Experiment Station Journal Series No. 520.

<sup>2</sup> Homoptera: Aleyrodidae.

A REDESCRIPTION OF *SPELEORODENS MICHIGENSIS*  
(FORD) N. COMB. (ACARI: EREYNETIDAE), A NASAL MITE  
OF MICROTINE RODENTS, WITH COMMENTS ON GENERIC  
RELATIONSHIPS IN THE SPELEOGNATHINAE

Barry M. OConnor

*Abstract.*—*Speleognathopsis michigensis* Ford is redescribed and placed in the genus *Speleorodens*. *Speleorodens clethrionomys* Fain and Lukoschus is placed in synonymy with *S. michigensis*. The characters used in delimiting genus group taxa within the Speleognathinae are discussed and the taxonomic system of Domrow is rejected in favor of that of Fain. A new genus, *Domrownetes*, is created for *Paraspeleognathopsis exul* Domrow.

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Mites of the family Ereynetidae, subfamily Speleognathinae, are cosmopolitan endoparasites of the upper respiratory passages of birds and mammals. In the latest reviews of the speleognathine parasites of mammals (Fain, 1970b; Fain & Lukoschus, 1971), 22 species in 7 genera were recognized. Of these species, only 2 were reported from the Nearctic region: *Speleorodens strandtmanni* (Fain, 1955) (= *Paraspeleognathopsis sciuri* Clark, 1961) from the Eastern gray squirrel, *Sciurus carolinensis*, and *Neospeleognathopsis bastini* (Fain, 1958) from the big brown bat, *Eptesicus fuscus*. Domrow (1975) described a new species, *Paraspeleognathopsis exul*, from Australia and synonymized *Speleorodens* Fain, 1962, and *Speleomys* Fain, 1970, with *Paraspeleognathopsis* Fain, 1958. He also pointed out several omissions in the review by Fain (1970b), notably the lack of reference to *Speleognathopsis michigensis* Ford, 1962, a parasite of the meadow vole, *Microtus pennsylvanicus*, in North America, and to the records by Drummond and Medley (1964) of *Speleognathus australis* Womersley, 1936, from North American bison, *Bison bison*.

During my recent examinations of microtine rodents for acarine parasites, a single female of a speleognathine mite was collected from the nasal passages of a red-backed vole, *Clethrionomys gapperi*, collected at Arnot Forest, Schuyler County, New York, USA. In the key to species presented by Fain (1970b), this specimen keys to *Speleorodens clethrionomys* Fain and Lukoschus, 1968. However, comparison with the original description of *Speleognathopsis michigensis* showed no significant differences that would separate these two nominal taxa. I examined the holotype of *S. michigensis* in order to redescribe the female of this species and to note individual variations among the specimens at hand and those described in the literature. In the following description, all measurements

are in micrometers. Classification of setal types is based upon Fain (1963) and nomenclature for idiosomal setae follows that of Fain (1970a).

Family EREYNETIDAE Oudemans 1931

Subfamily SPELEOGNATHINAE Womersley 1936

Genus *Speleorodens* Fain 1962

*Speleorodens michigensis* (Ford, 1962) NEW COMBINATION

*Speleognathopsis michigensis* Ford 1962:104.

*Paraspeleognathopsis (Speleorodens) clethrionomys* Fain and Lukoschus 1968:86 NEW SYNONYMY.

*Speleorodens clethrionomys* Fain 1970a:516, 519.

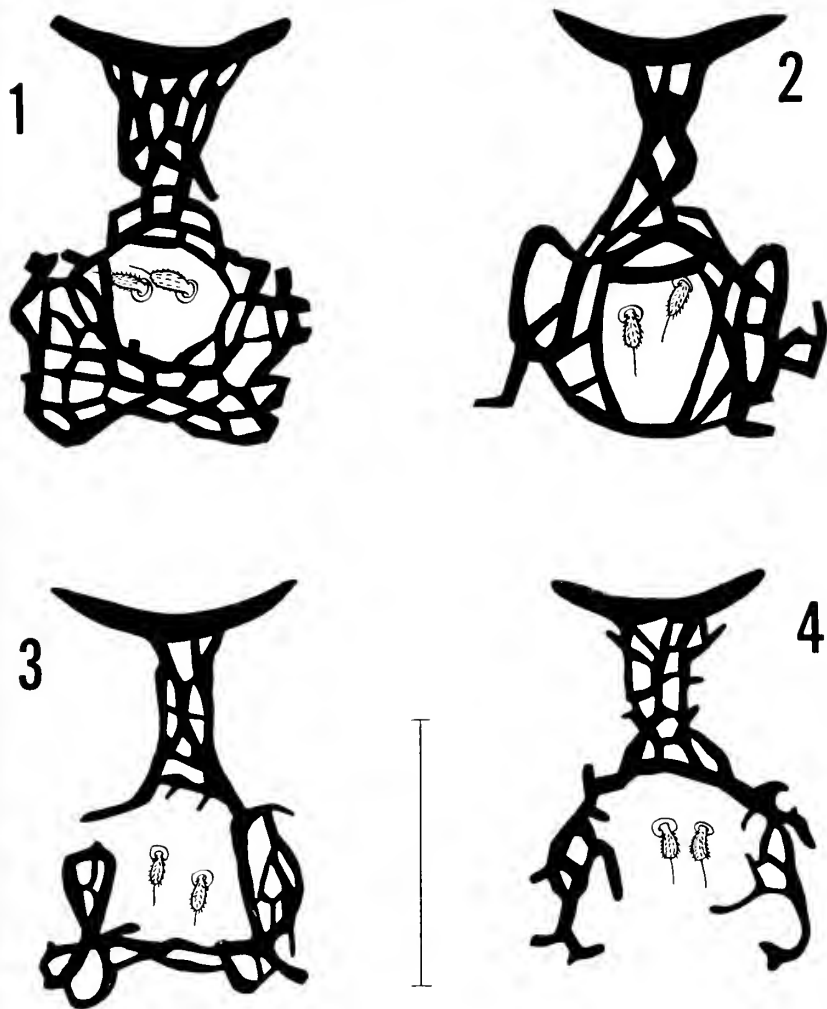
*Paraspeleognathopsis michigensis* Domrow 1975:98.

*Female*.—Length of idiosoma 264–350; width 150–255. Body cuticle finely striate with minute projections along striations. Cuticle completely hydrophobic. Network of subsurface sclerotizations well developed in the legs, coxal areas, gnathosoma and dorsal shield area. Dorsal shield composed of a network of wide lines interconnecting to form large open cells between them (Figs. 1–4). These cells larger and more irregular in shape than those of *S. strandtmanni*. Posterior margin of shield either open or closed by a few transverse lines. Interior portion of shield area containing setae *vi* without subsurface lines. Length of shield 90. Most dorsal setae cylindrical, rounded terminally, covered with short barbs and bearing an elongate terminal flagellum (Type BN). Length with flagellum 12–18; length of basal body of seta 6–8. Exceptions are setae *ve* which are shorter (4) and bear no flagellum (Type B), and setae *sci* (sensillae) which are elongate (22–28) and barbed along their entire length. Setae of the ventral idiosoma of the same form as dorsal setae but shorter, length 4–6 excluding flagellum which is difficult to observe. Genital opening in the form of an inverted Y, flanked by 3 pairs of setae (2 pairs *ge*; 1 pair *gm*). Anus small, indistinct, flanked by 1 pair of setae (*ai*). Setae *ae* displaced terminally or dorsally. Three pairs of intercoxal setae (*ic* 1–3) positioned mid-ventrally in a line between coxal areas.

*Gnathosoma*.—Hypostomal area with two pairs of short, barbed ventral setae. Palps consisting of two distinct segments; proximal segment bears a single modified seta (Type Fa); distal segment rounded, bearing 4 setae similar to body setae but very short (Type BN) and a single solenidion. Chelicerae reduced, details difficult to observe.

*Legs*.—Legs with pattern of lines well developed. Ereynetal organ of tibia I consisting of a basal bulb connecting to the surface via a long duct, in lateral view entire organ has the appearance of the letter J. Chaetotaxy: coxae 2-1-1-1; trochanters 1-1-0-0; femora 5(4)-5(4)-3-1; genua





Figs. 1-4. Variation in dorsal shield in *Speleorodens michigensis*. 1. Holotype from *Microtus pennsylvanicus*; 2. Specimen from *Clethrionomys gapperi*; 3 and 4. Specimens from *C. glareolus*. (Figures 3 and 4 redrawn from Fain and Lukoschus (1968).) Scale line is 50 micrometers.

4(5)-4-3-2(3); tibiae 4-2-2-2; tarsi 12-8-7-7. Certain leg setae greatly expanded, especially on femora, genua and tibiae (3 each); other setae similar to body setae or more elongate, especially on tarsi. A single solenidion is present on tarsi I and II. Two well developed claws present on each pretarsus. Accessory pulvillar pads absent.

*Male*.—Male specimens were not available for study. The male was described (as *P. (S.) clethrionomys*) by Fain and Lukoschus (1968), and differs from the female in the shape of the leg setae which are not expanded.

*Nymphs*.—Nymphal instars are unknown for this species.

*Larva*.—Larvae were not available for study, however, they were described both by Ford (1962) and by Fain and Lukoschus (1968). The larva of this species is characterized by a single claw which is angled at 90 degrees present on pretarsus III.

*Hosts and localities*.—*Speleorodens michigensis* has been reported from the following hosts, all rodents of the family Cricetidae, subfamily Microtinae: *Microtus pennsylvanicus* (Ord), Ingham County, Michigan, USA (Ford, 1962); *Microtus agrestis* (Linnaeus), Nijmegen, Holland (Fain and Lukoschus, 1968); *Clethrionomys glareolus* (Schreber), Holland (various localities) (Fain and Lukoschus, 1968); *Clethrionomys gapperi* (Vigors), Schuyler County, New York, USA (present study).

*Intraspecific variation in S. michigensis*.—Several characters of systematic importance are variable within this species, as indicated by examination of specimens and published descriptions from different hosts. However, the variations are not consistent with host differences and probably only reflect the inherently large genetic variability within the species. Such variability has been noted previously for the Ereyetidae (Fain, 1963) and for other endoparasitic groups of mites (Johnston and Manischewitz, 1973). The specific variations I have noted involve the shape of the dorsal shield, the position of seta  $l_1$  and the leg chaetotaxy. In the holotype specimen of *S. michigensis* from *M. pennsylvanicus*, the open area containing the *vi* setae in the center of the dorsal shield is closed posteriorly by 3 lines (Fig. 1). In the specimen from *C. gapperi*, the area is closed by a single line (Fig. 2). In two specimens from *C. glareolus*, Fain and Lukoschus (1968) illustrate this area being closed by 2 lines in one specimen (Fig. 3) and completely open in another (Fig. 4).

In the holotype of *S. michigensis*, both setae  $l_1$  are situated well posterior to a line drawn through the bases of setae  $d_1$ . In the specimen illustrated by Fain and Lukoschus (1968) and in the schematic drawing of *S. clethrionomys* by Fain (1970a), the  $l_1$  setae are slightly anterior to the  $d_1$ . In the specimen from *C. gapperi*, on the other hand, one seta of this pair is clearly posterior to the  $d_1$  while the other is slightly anterior.

The leg chaetotaxy of *S. michigensis* was not discussed in the original description by Ford (1962). Fain and Lukoschus (1968) noted the following variations within a series of specimens from *C. glareolus* and *M. agrestis*: coxa I, 2 or 1 seta; femur I, 4 or 5; genu I, 4 or 5; and genu IV, 2 or 3. The holotype of *S. michigensis* and the specimen from *C. gapperi* show identical leg chaetotaxy and show the following character states: coxa I, 2 setae;

femur I, 5 setae (3 inflated and 1 uninflated distal setae and 1 small uninflated proximal seta); femur II, 5 setae in the same pattern as on femur I except the inflated setae are not nearly as large; genu I, 4; and genu IV, 2.

### Discussion

Fain (1970b) recognized 9 genus-group taxa within the mammal-associated Speleognathinae. Domrow (1975), on the other hand, recognized only 3: *Speleognathus*, 1 species from Artiodactyla (Bovidae); *Paraspeleognathopsis* (including *Speleomys* and *Speleorodens*), 11 species from 3 orders of small mammals; and *Neospeleognathopsis* (including *Speleomyotis*, *Speleochir*, *Neospeleochir*, and *Hipposideroptes*), 8 species from Chiroptera. The characters which have been used to delimit these taxa are the presence or absence of eyes, the form of the idiosomal and leg setae, the degree of reduction of palpal segmentation and the structure of the pretarsus.

Based upon the relative values placed upon these morphological characteristics in the taxa involved, I find the system of Fain (1970b) preferable to that of Domrow (1975). The validity of these characters in defining taxa of various ranks is established in other prostigmatid taxa and in unrelated but ecologically similar endoparasitic groups. The characters are not as Domrow (1975) stated merely "an arbitrary selection from the range of characters useful as species-group level." (His emphases.) Furthermore, species subsequently described from bats (Fain and Lukoschus, 1971) but not mentioned by Domrow (1975) are easily accommodated within the more limited generic-level groups of Fain and do not show intermediate characteristics. In fact, the characters used by Fain in delimiting taxa at the subgeneric level in one group (bat parasites) appear to be valid at the generic level when applied to other groups (rodent parasites). It is probable that all the genus-group taxa of Fain represent valid genera which will in time be shown to be diverse. In this regard, I recognize the following genera among the bat-associated speleognathines: *Hipposideroptes*, *Neospeleognathopsis*, *Speleochir*, *Speleomyotis* and *Neospeleochir*, the latter two having been regarded as subgenera by Fain (1970b). On the other hand, the three groups recognized by Domrow (1975) at the generic level probably represent monophyletic evolutionary lines.

Finally, of all the described species, only *Paraspeleognathopsis exul* Domrow, 1975, from the Australian marsupial *Antechinus stuartii*, requires revision in systematic placement in order to be accommodated in the system of Fain (1970b). I consider this species to be the most primitive known species among the group parasitizing small terrestrial mammals (*Paraspeleognathopsis* s.l. of Domrow). It displays the most plesiomorphic character states, namely, 3-segmented palpi, least reduced leg chaetotaxy (except genu IV) and least reduction of genital setae. Apomorphic char-

acter states such as the loss of 1 pair of hypostomal setae, loss of 1 or 2 setae on genu IV and elongation of the dorsal shield as in the bat-associated genera indicate the distant relationship of this species to others. Within the taxonomic system of Fain, this combination of characters requires the erection of the following new genus.

*Domrownetes* NEW GENUS

Speleognathine mites with 3 free palpal segments; 1 pair of hypostomal setae; 12 setae present on tarsus I, 5 pairs of genital setae. Dorsal shield elongate with few open cells. Idiosomal and leg setae barbed (Type B) without terminal flagellum. Pretarsi without accessory pulvillar pads.

Type species: *Paraspeleognathopsis exul* Domrow 1975 by monotypy.

Derivation: This genus is named for Dr. Robert Domrow in recognition of his contributions to the knowledge of respiratory parasites of vertebrates. The name is formed by contracting the name Domrow with *Ereynetes*, the most primitive genus in the family, and is masculine in gender.

The following key to the speleognathine genera associated with mammals is modified from that of Fain (1970b). Keys to mammal-associated species are given in Fain (1970b) and Fain and Lukoschus (1971).

Key to Genera of Speleognathinae Associated with Mammals

- |   |   |
|---|---|
| 1. Idiosomal and leg setae barbed (Type B)  | 2 |
| – Some idiosomal or leg setae striate (Type S) or simple  | 5 |
| 2. Palp with 3 free segments; 1 pair of hypostomal setae  | 3 |
| – Palp with 1 or 2 free segments; 2 pairs of hypostomal setae; associates of Rodentia and Primates                                    | 4 |
| 3. Tarsus I with 12 setae; 5 pairs of genital setae; dorsal shield elongate with few small cells; associates of Marsupialia           |   |
| <i>Domrownetes</i> n. gen.  |   |
| – Tarsus I with 10 setae; 3 pairs of genital setae; dorsal shield expanded posteriorly with many larger cells; associates of Rodentia |   |
| <i>Speleomys</i> Fain, 1970   |   |
| 4. Palp with 1 free segment; dorsal shield without open central area bearing setae <i>vi</i>  | 6 |
| <i>Paraspeleognathopsis</i> Fain, 1958  |   |
| – Palp with 2 free segments; dorsal shield with setae <i>vi</i> situated in open central area   | 7 |
| <i>Speleorodens</i> Fain, 1962  |   |
| 5. Eyes present; associates of Artiodactyla   |   |
| <i>Speleognathus</i> Womersley, 1936  |   |
| – Eyes absent; associates of Chiroptera   | 6 |
| 6. Pretarsi with accessory pulvillar pads   | 7 |
| – Pretarsi without accessory pulvillar pads   | 8 |
| <i>Hipposideroptes</i> Fain, 1970   |   |
| 7. Accessory pulvillar pads small, median; setae <i>vi</i> present  | 8 |

- Accessory pulvillar pads large, striate, laterally positioned; setae *vi* absent 9
- 8. Palp with 3 free segments; 2 pairs of hypostomal setae; setae *l*<sub>5</sub> present; 7 pairs of genital setae *Speleomyotis* Fain, 1962
- Palp with 2 free segments; 1 pair of hypostomal setae; setae *l*<sub>5</sub> absent; 3-5 pairs of genital setae *Neospeleognathopsis* Fain, 1958
- 9. Palp with 2 free segments; sensillae not expanded *Speleochir* Fain, 1966
- Palp with 1 free segment; sensillae expanded *Neospeleochir* Fain, 1970

### Acknowledgments

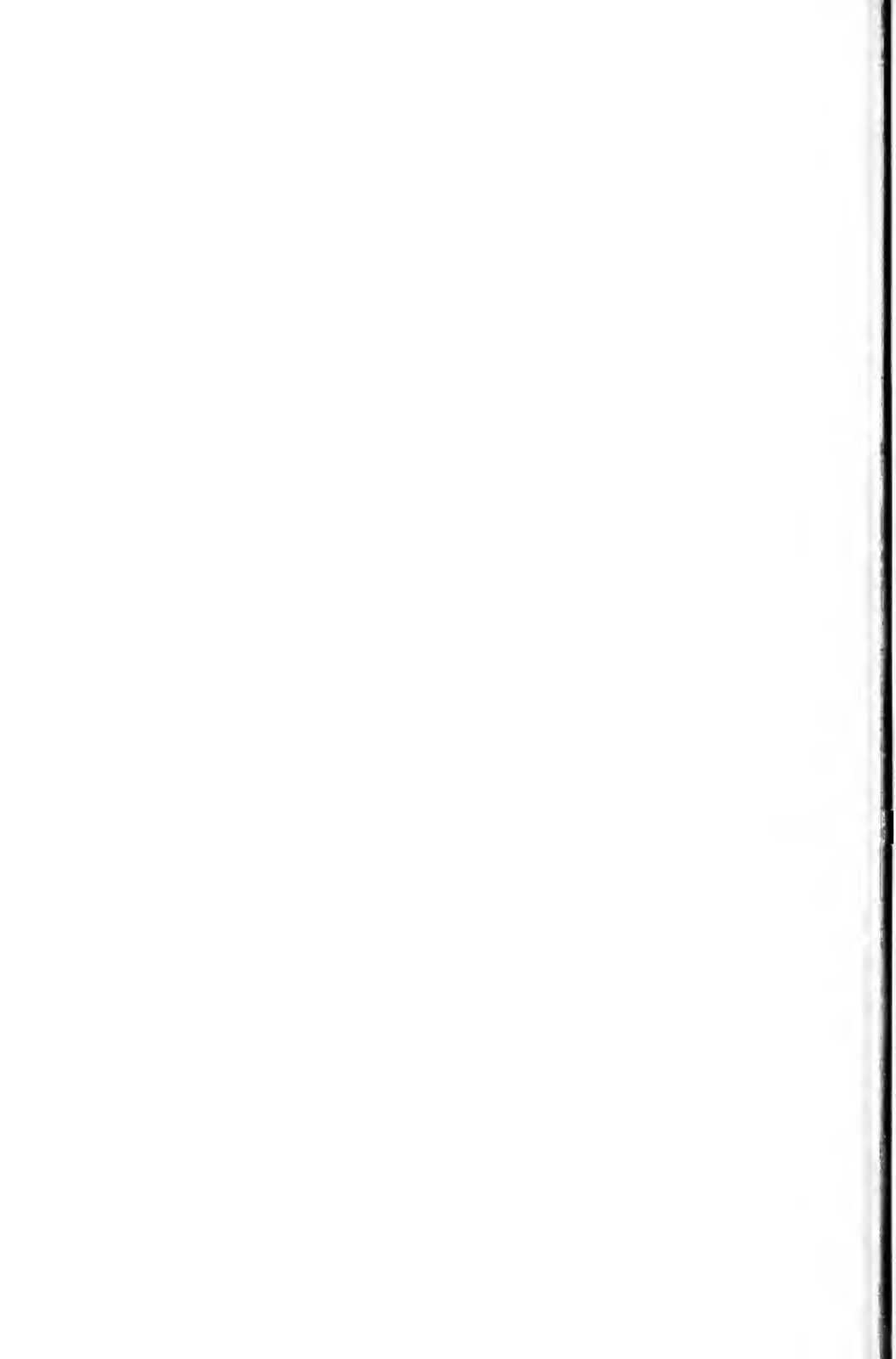
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## FORAGING TRAILS OF LEAF-CUTTING ANTS

Harold G. Fowler

*Abstract.*—Fowler, Harold G., Department of Entomology & Economic Zoology, Rutgers—The State University, New Brunswick, New Jersey 80903 U.S.A.—Leaf-cutters construct and maintain well defined foraging trails, which can be easily quantified. To examine the relationship between ant activity and trail measurements, colonies of eight species of *Atta* and *Acromyrmex* were examined. A significant correlation was found between leaf inputs per day and colony trail measurements (trail development). Also, the number of ants returning unladen was also correlated with the degree of trail development. Unladen ants have been postulated to comprise the trail maintenance force. However, no correlation was found between trail development and the proportion of ants returning unladen. This suggests that no predictions can be formulated concerning the proportion of foragers that must be diverted to trail maintenance.

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### Introduction

The Gardening Ants (tribe Attini) are among the dominant invertebrates of the Neotropics (Wheeler 1907). The higher attine genera *Atta* and *Acromyrmex* comprise the true leaf-cutting ants, harvesting vegetation to use as substrate in the cultivation of fungus. All species of *Atta* and many species of *Acromyrmex* construct and maintain conspicuous foraging trails, over which harvested vegetation is transported to the nest. Other species of *Acromyrmex* and the lesser genera of attines exhibit a much smaller degree of trail construction. Apparently all members of the Attini employ trail pheromones (Robinson et al. 1974) to recruit workers to suitable resource patches. Carroll and Janzen (1973) postulated that physically defined foraging trails would be expected for ants exploiting predictable resources, while pheromone trails would be employed to exploit low permanence resources. However, the integration of physical and chemical trails in the foraging strategies of leaf-cutting ants has not been elucidated.

The colony cost of foraging trail maintenance has been treated by Lugo et al. (1973) in a study of the energetics of an *Atta colombica* colony. These authors hypothesized that the trail maintenance force consisted of those ants which return to the nest unladen, and they further hypothesized that the size of the nest maintenance force ultimately determines colony size. Species characterized by a reduced or non-existent foraging trail system



were ignored by these authors. This report addresses this omission by testing an extension of the hypothesis of Lugo et al.: if those ants returning unladen constitute the trail maintenance force, the number of returning unladen workers should increase with increasing foraging trail development. This report also addresses an implicit assumption of the hypothesis by Carroll and Janzen (1973) that a high degree of physical trail development indicates a high predictability of resources and consequently should provide for a high input of resources into the colony, while the opposite should be expected for those species employing a reduced degree of trail development.

### Methods

Field observations were conducted in a mixed hardwood forest near Asuncion, Paraguay, and in a *Copernicia* sp. palm savanna in the lower Chaco, 40 km west of Asuncion, in January 1975. Mature colonies of leaf-cutting ants examined were two each of *Acromyrmex rugosus rugosus*, *Acromyrmex landolti fracticornis*, and *Acromyrmex lundii pubescens*, and one each of *Atta sexdens rubropilosa*, *Atta vollenweideri*, *Acromyrmex crassispinus*, *Acromyrmex laticeps* and *Acromyrmex heyeri*. The degree of trail development by each colony studied was quantified by measuring the length of all discernible physical trails (m), multiplying this value by the mean trail width (m), and then dividing by 100 to provide a 'trail index.' Mean trail width was calculated separately for each trail from measurements taken at 10 equidistant points along the trail from proximal to distal ends.

Foraging was monitored by hourly counts of the number of laden and unladen ants returning to the colony per 3 minutes. Census periods ranged from 24 to 240 hr. Due to rhythmic foraging cycles exhibited by the ants, foraging was monitored throughout the day. A 'trail maintenance ratio' was calculated using the index of Lugo et al. (1973), which is the ratio of unladen to laden ants.

### Results and Discussion

With the exception of *A. lundii pubescens*, species of *Atta* exhibited a greater degree of trail development than species of *Acromyrmex* (Table 1). Moreover, a significant correlation was found between trail development (trail index) and the input of substrate into the nest (number of incoming laden/day) ( $r = 0.940$ ,  $P < 0.01$ ), clearly suggesting the adaptive value of foraging trail development in resource exploitation. If trails develop in response to large or extremely profitable resource patches (Carroll and Janzen 1973), then trail development would allow for the exploitation of distant, predictable patches, and permit the ants to conservatively manage the resources within the foraging territory of the colony (Cherrett 1968; Rockwood 1976). At the other end of the scale, *A. rugosus rugosus*, which forages on

Table 1. Physical trail development and 'maintenance' indices of some mature, healthy colonies of Paraguayan leaf-cutting ants.

Species	Hours observed	No. of trails	Trail index <sup>a</sup>	Incoming ants/day <sup>b</sup>		'Maintenance' index <sup>c</sup>
				laden	unladen	
<i>Atta</i>						
<i>sexdens</i>	240	9	15.295	62,840	49,978	0.795
<i>vollenweideri</i>	24	14	9.450	27,552	11,418	0.414
<i>Acromyrmex</i>						
<i>crassispinus</i>	240	3	0.980	1,735	4,107	2.367
<i>heyeri</i>	24	4	0.780	3,228	2,089	0.647
<i>laticeps</i>	240	1	0.744	213	38	0.178
<i>landolti</i>	240	1	0.045	157	75	0.478
	240	1	0.060	151	101	0.669
<i>lundi</i>	24	5	2.950	4,673	3,342	0.715
	24	4	4.025	3,312	2,199	0.664
<i>rugosus</i>	240	1	0.092	58	18	0.310
	240	1	0.176	93	32	0.344

<sup>a</sup> Trail index = total length of trails  $\times$  mean trail width/100.

<sup>b</sup> From hourly 3 min counts. To obtain an estimate of the total incoming number of ants/day, multiply these figures by 20.

<sup>c</sup> Maintenance index = ratio of unladen to laden ants, after Lugo et al. (1973).

leaf and flower fall (unpublished), possesses only short trunk trails to direct foragers toward likely sites, much as in *Pogonomyrmex* spp. (Hölldobler 1976). Likewise, *A. landolti fracticornis*, a grass cutter, does not construct extensive foraging trails, but rather utilizes the discontinuities of the clonal growth pattern of the grass to reach cutting sites.

The construction and maintenance of foraging trails would present the colony with an added contingency to be met in order to maximize fitness (Wilson 1968). To examine trail maintenance further, an examination of Table 1 reveals a strong correlation between the number of ants returning unladen and the trail index ( $r = 0.918$ ,  $P < 0.01$ ). However, do the proportion of ants returning unladen constitute the trail maintenance force?, and if so, should we expect that as trail development increases the proportion of workers diverted to maintenance should also increase? This was disproven by a weak correlation ( $r = 0.004$ ) between the trail index and the maintenance index. Thus, we may assume that the total number of ants that might be diverted to trail maintenance increases linearly with trail development, but the proportion available for maintenance does not.

Although these results are based on one or two colonies per species, the results indicate that there is a linear relationship between trail development and ant activity, even across generic lines. Obviously, the proportion of

ants returning unladen cannot be used as a gauge of trail maintenance. It is possible that to maximize input of energy into the nest, there may be an optimum ratio of maintenance workers to foraging workers. Likewise, there is probably a maximum distance after which it is energetically too costly to forage, due to maintenance and travel time, and thus might explain the linear relationships found here. Exactly why so many ants return unladen is unclear, but it is improbable that all of these comprise the trail maintenance force. Littleddyke and Cherrett (1976) have shown that workers of *Atta cephalotes* and *Acromyrmex octospinosus* directly imbibe plant sap, and a large portion of the ants returning unladen to the nest may be transporting plant sap. Also, as older workers tend to do the foraging in many species of ants (Rosengren 1971), a portion of those ants seen unladen on the trail may be young foragers just learning their way around the colony's foraging territory. During this study, maintenance indices on the order reported by Lugo et al. (1973) were not observed, but it may be that tropical species must divert more workers into 'maintenance' than their subtropical counterparts.

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MIRID FAUNA ASSOCIATED WITH OLD-FIELD  
GOLDENRODS (*SOLIDAGO*: COMPOSITAE)  
IN ITHACA, N.Y.

Frank J. Messina

*Abstract.*—Messina, Frank J., Section of Ecology and Systematics, Cornell University, Ithaca, N.Y. 14853.—The mirid fauna associated with old-field goldenrods (*Solidago* spp.) was sampled from May 10 to October 25, 1977 in Ithaca, N.Y. Twenty-three species belonging to 16 genera were recorded; 97% of all individuals (1,099) belong to 6 genera (*Lygus*, *Slaterocoris*, *Lopidea*, *Plagiognathus*, *Adelphocoris* and *Polymerus*). The tarnished plant bug, *Lygus lineolaris*, was the most common species. The dominant mirids can be divided into 2 fairly distinct guilds, *Lygus lineolaris*, 2 *Plagiognathus* spp. and *Adelphocoris rapidus* feeding primarily on goldenrod flowers, and 3 *Slaterocoris* spp., *Lopidea media* and *Polymerus venaticus* feeding on the immature foliage. The phenological pattern exhibited by these species can be broadly explained by this difference in resource utilization. Observations on the biology of certain species are presented.

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Introduction

The genus *Solidago* contains over 100 species in North America (Fernald 1950). Recent studies have been directed toward the niche relationships of co-occurring species (Abrahamson and Gadgil, 1973; Werner and Platt, 1976), but little is known about the phytophagous insect loads of *Solidago* spp. This paper, as part of a larger study examining certain herbivores of old-field goldenrods, describes the mirid fauna found on *Solidago* spp. in Ithaca, N.Y.

The mirid faunas associated with several host plants have been described (e.g. Waloff and Southwood 1960, Dempster 1964, Wheeler 1974). Reid et al. (1976) collected 46 species of Miridae in sweep samples of *Solidago canadensis* at 4 sites in southeastern Ontario. Only 7 "resident" species, however, accounted for 90% of all individuals sampled; these species occurred in a "rigid phenological order" with little temporal overlap among the dominants. An example of geographic variation in the goldenrod-mirid association is presented here; results from the two locations can be compared in terms of species composition, abundance, and seasonality.

*Description of the Study Site.* The area sampled is an abandoned hay field

on the Whipple Farm near Ithaca, N.Y. The field is rectangular (70 m  $\times$  150 m), bordered on the east and west by tree hedgerows, on the north by a field of dense shrubs (predominantly *Viburnum* sp.), and on the south by a paved road. Recently it has been mowed on a 3-year cycle. The entire field is strongly dominated by *Solidago* spp., which form a near monoculture. *Solidago* density and species composition was estimated by taking a random series of 20 0.25 m<sup>2</sup> quadrats. The mean density of goldenrod stems was 65 stems/m<sup>2</sup>; the relative abundance was 64% *S. altissima*, 23% *S. rugosa*, 9% *S. graminifolia* and 3% *S. gigantea*. *S. juncea* was present but occurred in an overall density of less than 1%. The remainder of the vegetation consisted of grasses and sparsely distributed forbs including *Aster* spp., *Erigeron* spp., *Hieracium* spp., *Daucus carota*, *Plantago* sp. and *Dipsacus sylvestris*.

### Materials and Methods

Sweep samples were taken at approximately weekly intervals from 10 May to 23 October 1977. Fifty sweeps were taken along 4 permanent transects on each sampling day (200 sw/day). The transects were chosen to represent all major portions of the field; 2 of the transects were located in N-S direction and 2 ran E-W. Sweeps were made with a 43 cm diameter net along the tops of the goldenrod stands. Once the plants were in bloom the sweeps were made just below the panicles. Samples at each transect were placed in a 3.8 l jar with a small amount of chloroform. Samples were sorted in the laboratory and stored in 70% alcohol. Mirid specimens were identified to species except for 2 groups which were identified to genus. Selected specimens of these 2 genera were later identified to species. Voucher specimens of the dominant mirid species were placed in the Cornell University Collection under Lot. No. 1068.

### Results and Discussion

A total of 1,099 individuals representing 23 species (Table 1) of mirids were taken in sweep samples. This total was divided rather evenly among the 4 transects (SS1 = 227, SS2 = 288, SS3 = 259, SS4 = 275), suggesting that mirid abundance was similar in each portion of the field. Most of the species discovered were relatively rare, and many are probably not associated with goldenrods during any part of their life cycles. Of all mirids collected, 97% belong to six genera: *Lygus*, *Slaterocoris*, *Lopidea*, *Plagiognathus*, *Adelphocoris* and *Polymerus*. These mirids were observed on all goldenrod species, but were rarely found on the foliage of *S. graminifolia*. Biological notes on the dominant species follow.

*Lygus lineolaris* (Palisot de Beauvois), the tarnished plant bug, was the most common species. This mirid is a well-known economic pest and feeds

Table 1. Species of Miridae collected from sweep samples in an old field from 10 May to 23 October 1977. Nymphs of *Slaterocoris* and *Lopidea* were recorded separately.

Species	No. of Individuals
<i>Lygus lineolaris</i> (Palisot de Beauvois)	176
<i>Slaterocoris</i> Wagner	
<i>S. breviatus</i> (Knight)	144
<i>S. atritibialis</i> (Knight)	109
<i>S. stygicus</i> (Say)	77
<i>Slaterocoris</i> nymphs	100
* <i>Lopidea</i> Uhler (Adults)	132
<i>Lopidea</i> nymphs	59
<i>L. media</i> (Say)	
<i>L. marginalis</i> (Reuter)	
<i>L. heidemanni</i> Knight	
* <i>Plagiognathus</i> Fieber	111
<i>P. cuneatus</i> Knight	
<i>P. politus</i> Uhler	
<i>Adlephocoris rapidus</i> (Say)	86
<i>Polymerus venaticus</i> (Uhler)	52
<i>Adelphocoris lineolatus</i> (Goeze)	14
<i>Plagiognathus chrysanthemi</i> (Wolff)	8
<i>Leptoterna dolobratus</i> (F.)	6
<i>Prepops nigricollis</i> (Reuter)	6
<i>Capsus ater</i> (L.)	4
<i>Megalocerea recticornis</i> (Geoffroy)	4
<i>Orthocephalus coriaceus</i> (F.)	3
<i>Phytocoris</i> sp.	2
<i>Horcias dislocatus</i> (Say)	2
<i>Collaris meilleurii</i> Provancher	2
<i>Poecilocapsus lineatus</i> (F.)	1
<i>Stenotus binotatus</i> (F.)	1
TOTAL	1,099

\* Individuals of these genera (except for specimens of *Plagiognathus chrysanthemi*) were not determined to species for each sample. Subsequent determinations indicated the species listed here under the generic name. See text for further discussion.

on many different plant species (Taksdal 1963, Kelton 1975). Unlike the other common mirids, this species overwinters as an adult and 3 full generations occur in Ithaca (see also Ridgway and Gyrisco 1960, Wheeler 1974). Adults were found flying in Ithaca as early as 10 March 1977 and individuals of this species persisted beyond the last sampling date on 23 October 1977. This species was most abundant in the old field from mid-August until late September (Fig. 1). The peak in abundance corresponded with the apparent availability of composite flowers. Tarnished plant bugs were observed in

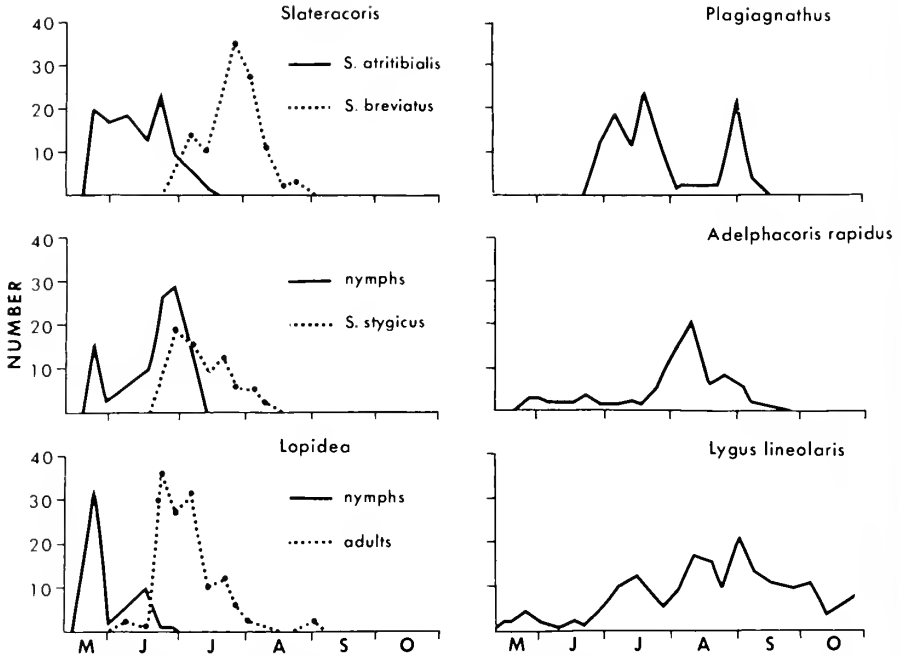


Fig. 1. Seasonal abundance of common mirids collected from sweep samples in 1977. Nymphs of *Slaterocoris* and *Lopidea* were recorded separately.

July on the earlier blossoms of *Erigeron* and were subsequently common on *Solidago* spp. and *Aster* spp. Doubtless more specimens would have been collected if sweeps had been made through the *Solidago* inflorescences where the bugs were most often found. Large numbers of nymphs may be collected by shaking goldenrod panicles in alcohol (up to 30/panicle, unpublished data), suggesting that females commonly oviposit on or near the fall flowers. The phenological pattern is similar to that found by Reid et al. (1976), where large numbers of individuals seem to disperse onto goldenrod plants upon flowering. These results support their statement that attempts to control this bug may be thwarted by continual replenishing of *L. lineolaris* populations on non-crop plants such as the ubiquitous goldenrods.

*Lygus vanduzeei* (Knight), which is listed as being restricted to or primarily feeding on goldenrod (Knight 1941, Kelton 1975), was not sampled in the study area. Yet this species, a "resident" component of the fauna (Reid et al. 1976), was fairly abundant in a similar old field located less than 400 m from the study site (the 2 fields are separated by an area of dense shrubs). At that site as many as 40 individuals were collected in 200 sweeps. Such spotty distribution was also noted for the nymphs by Reid et al. (1976) and contrasts sharply with the more even distribution of the tarnished plant



bug. Observations suggest that the patchy distribution of *L. vanduzeei* could result from a relatively low dispersal tendency or more restricted overwintering sites.

The 3 species of *Slaterocoris* recorded from the study area are all known to feed primarily on goldenrod (Leonard 1919, Knight 1941, Reid et al. 1976). Nymphs of the genus show a somewhat bimodal distribution (Fig. 1) which corresponds to the abundance of the adults. *S. breviatus* (Knight) was the most common adult, followed in order of abundance by *S. atritibialis* (Knight) and *S. stygicus* (Say). This order was also found by Reid et al. (1976) but in Canada *S. breviatus* was relatively more common; it was 25 × as abundant as *S. atritibialis*, and *S. stygicus* was virtually absent. In Ithaca the differences in abundance were not very large (Table 1) and more significantly, the phenology of *S. stygicus* overlapped considerably with *S. breviatus* (Fig. 1). On 2 occasions, individuals of *S. atritibialis* on laboratory plants were found feeding on the eggs of a goldenrod chrysomelid, *Ophraella sexvittata* (Leconte). This is apparently the first report of predation by this genus. "Facultative predation" has been recorded in the field and laboratory for several "phytophagous mirids" (Wheeler 1974, 1976) and may be an important component of their feeding niche.

*Lopidea* spp. were common but individuals could not be determined to species for each sample. Subsequent determination indicated that individuals sampled before 27 July (and thus the majority of specimens collected, Fig. 1), are *Lopidea media* (Say). These bugs are known to feed on *Solidago rugosa* (Knight 1941) and were observed on other goldenrods. This species was apparently absent from the 4 sites sampled by Reid et al. (1976). Two other *Lopidea* spp. were found in August and September, *L. marginalis* Reuter and *L. heidemanni* Knight. These are listed as feeding on non-goldenrods (Knight 1941, Wheeler 1974) and were rare. Nymphs of this genus (Fig. 1) were collected early in the season and were probably *L. media*.

Except for the distinctive *Plagiognathus chrysanthemi* (Wolff), which was rare, specimens of *Plagiognathus* were determined only to genus on each sampling date. Later determinations made on a subsample of the collection revealed that approximately 85% of the individuals were *P. cuneatus* Knight, with the remaining specimens belonging to *P. politus* Uhler. *P. cuneatus* was collected from late June to September and is apparently bivoltine in Ithaca (Fig. 1). It was observed almost exclusively on the composite flowers with the first generation predominantly on *Erigeron* spp. and the second on *Solidago* spp. and *Aster* spp. *P. politus* was also found in late June and exhibits a similar seasonal abundance in Ithaca (Wheeler 1974). Neither species was reported to have 2 full generations in southeastern Ontario (Reid et al. 1976) where *P. cuneatus* was also the more abundant species.

The rapid plant bug, *Adelphocoris rapidus* (Say), was present throughout

the season (Fig. 1), but was most numerous in August and September. This species feeds on a variety of herbaceous plants and was found most often on the goldenrod flowers. Nymphs were rarely sampled by the sweep method.

*Polymerus venaticus* (Uhler) was present in relatively low numbers from early June until late August. This bug is known to feed on goldenrod (Knight 1941, Reid et al. 1976) and was found on the unfolding leaves at the tops of the plants. It is apparently univoltine in Ithaca.

The actual phenological order of the common mirids in this study is similar to that found by Reid et al. (1976). *S. atritibialis* adults appear first followed by *P. venaticus*, *S. stygicus*, *S. breviatus*, *P. politus*, *P. cuneatus* and *L. lineolaris*. *L. vanduzeei* and *L. media* were not found at both study sites and, interestingly, they occupy the same phenological position (with a peak abundance between those of *P. venaticus* and *S. breviatus*). There is, however, considerable overlap among the seasonal abundances of the species in Ithaca, unlike the general condition reported by Reid et al. (1976). The example of *S. breviatus* and *S. stygicus* has been previously mentioned. Other instances of substantial overlap in adult populations would include the appearances of *L. lineolaris*, *A. rapidus* and *P. cuneatus* (Fig. 1). Reid et al. (1976) suggest some sort of "diffuse competition" (not food competition, because goldenrod resources do not appear limiting) to explain the degree of overlap and the predictable phenological order. While this concept is worth considering, it would be misleading to interpret the broad phenological pattern without reference to the particular resource the species utilize. Adults of *L. lineolaris*, *Plagiognathus* spp., and *A. rapidus* seem to feed primarily in the inflorescences of goldenrod and other late-blooming composites. The competition regime among these species, resource based or not, should be considered separately from the regime faced by mirids that feed on vegetative tissue (*P. venaticus*, *Slaterocoris* spp., and *L. media*). It would then be more useful to attempt to explain the phenological pattern within one of these resource guilds, given the constraints of the seasonal appearance of the resource.

#### Acknowledgments

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SEASONAL SUCCESSION AND DIVERSITY OF STONEFLIES  
(PLECOPTERA) IN FACTORY BROOK, MASSACHUSETTS<sup>1</sup>

Richard J. Neves

*Abstract.*—Neves, Richard J., Massachusetts Cooperative Fishery Research Unit, Department of Forestry and Wildlife Management, University of Massachusetts, Amherst, Massachusetts 01003. Present address of author: Virginia Cooperative Fishery Research Unit, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.—The species composition and flight periods of Plecoptera along a woodland stream in Massachusetts was studied by 3 yr of nymphal and adult sampling. Twenty-two genera and 45 species emerged between mid-February and early September. Most species were collected in May and June at stream temperatures between 8–15 C. A comparison with other stonefly surveys indicated a diversity gradient for Plecoptera in North America.

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Introduction

During initial productivity studies in a Massachusetts woodland stream, stoneflies exhibited considerable diversity in the benthic community and constituted a major component of the invertebrate trophic structure. A literature review revealed extensive taxonomic studies on the Plecoptera of New England but little ecological data on the diversity and seasonal progression of species from one stream. Stonefly surveys on specific streams have been published for several regions of the U.S. (Knight and Gaufin 1966; Sheldon and Jewett 1967; Hilsenhoff et al. 1972; White 1974; Ellis 1975; Kerst and Anderson 1975) but not for the Northeast. This paper summarizes 3 yr of nymphal and adult stonefly collections along Factory Brook and presents the species composition and appearance of adults throughout the year.

Study Area

Factory Brook (lat. 42°20'64"N, long. 73°00'95"W) is a 13 km tributary of the West Branch, Westfield River in Hampshire County, western Massachusetts. The stream drains 2,204 ha and has a gradient of 18.6 m/km. Base flow during late summer averages 0.004 m<sup>3</sup>/s; mean annual precipitation for the region is 114 cm/yr. Soil composition is shallow glacial tills underlaid by gneiss bedrock. Land use in the drainage basin is as follows: woodland 90%, cropland and pasture 8%, wetland 1%, and urban land 1% (MacConnell 1975). The woodland is a typical mixed northern hardwood and eastern

hemlock forest providing a canopy over most of the stream. Fish species composition is typical of trout streams in the Northeast (Enoch 1976).

Stream sediments are predominantly coarse particle sizes ranging from pebbles to boulders; bedrock outcrops occur at intervals downstream. The stream does not freeze over in winter, although ice shelves nearly cover pools and slow riffles; frazil ice is common in February. Mid-monthly physico-chemical analyses of water parameters during 1974 yielded the following ranges: temperature (0–19.5 C), discharge (0.004–2.6 m<sup>3</sup>/s), dissolved oxygen (9–12 mg/l), total hardness (14–24 mg/l), and pH (6.5–7.5).

### Materials and Methods

Stonefly nymphs and adults were collected along accessible sections of Factory Brook from September 1973 to June 1976. I captured adults by aerial net, aspirator, forceps, and blacklight insect-trap. Examination of bridge abutments, railings, and snow crests during winter and spring, and tri-weekly sweepnet collections in riparian vegetation from May to September, 1974 and 1975 proved effective for most species. Weekly blacklighting for 1 h after dusk was conducted from May to September 1975.

Emerging nymphs were captured by spreading Stikem Special (Michel and Pelton Co., Emeryville, Calif.), a non-drying adhesive, above the waterline on two bridges over the stream. I reared last instar nymphs in screen cages in the stream and laboratory. Monthly benthic samples obtained by Surber sampler, D-frame net, or periodic sets of rectangular drift nets (30 × 45 cm) were sorted and identified to supplement adult collection records. Water temperature was monitored for two consecutive years with a Ryan Model D-30 recording thermometer.

All insects were preserved in 70% isopropanol. Species identifications were based on the keys of Frison (1935, 1942), Ricker (1952), Hitchcock (1974), Baumann (1975), Ricker and Ross (1975), and Stark and Gaufin (1976); nomenclature followed Illies (1966) and Zwick (1973).

### Results

The stonefly fauna of Factory Brook totaled 45 species and included nine families and 22 genera (Table 1); nymphs for 17 of these genera (77%) were collected in benthic samples. Two species, *Perlinella drymo* and *Amphinemura wui*, were taken only as nymphs. I captured nearly 5,000 adults and many more immatures during this survey, but collections of some females and nymphs could not be identified to species. Six species were represented by single male specimens, *Ostrocerca truncata*, *O. complexa*, *O. albidipennis*, *Prostoia similis*, *Isoperla clio*, and *Perlesta placida*. Perlids and perlodids were occasionally taken by light-trap, while other families were rarely attracted to the blacklight. I collected most perlids and *Allonarcys biloba*

Table 1. Checklist of Plecoptera collected along Factory Brook, September 1973 to June 1976.

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Pteronarcidae

*Allonarcys biloba* (Newman)

Peltoperlidae

*Peltoperla maria* Needham & Smith

Taeniopterygidae

*Taenionema atlanticum* Ricker & Ross

*Ocmopteryx contorta* (Needham & Claassen)

*Taeniopteryx maura* (Pictet)

Leuctridae

*Leuctra ferruginea* (Walker)

*Leuctra grandis* Banks

*Leuctra sibleyi* Claassen

*Leuctra tenella* Provancher

*Leuctra tenuis* (Pictet)

*Paraleuctra sara* (Claassen)

Capniidae

*Allocapnia maria* Hanson

*Allocapnia minima* (Newport)

*Allocapnia nivicola* (Fitch)

*Allocapnia pygmaea* (Burmeister)

*Paracapnia angulata* Hanson

Nemouridae

\* *Amphinemura wui* (Claassen)

*Ostrocerca albidipennis* (Walker)

*Ostrocerca complexa* (Claassen)

*Ostrocerca truncata* (Claassen)

*Prostoia completa* (Walker)

*Prostoia similis* (Hagen)

Chloroperlidae

*Alloperla atlantica* Baumann

*Alloperla caudata* Frison

*Alloperla chloris* Frison

*Alloperla concolor* Ricker

*Alloperla voinae* Ricker

*Hastaperla brevis* (Banks)

*Sweltsa lateralis* (Banks)

*Sweltsa mediana* (Banks)

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Table 1. Continued.

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 Perlodidae

- Isogenoides hansonii* (Ricker)
- Isoperla bilineata* (Say)
- Isoperla clio* (Newman)
- Isoperla cotta* Ricker
- Isoperla dicala* Frison
- Isoperla francesca* Harper
- Isoperla holochlora* (Klapalek)
- Isoperla lata* Frison
- Isoperla similis* (Hagen)

## Perlidae

- Acroneuria abnormis* (Newman)
  - Acroneuria carolinensis* (Banks)
  - Paragnetina immarginata* (Say)
  - Perlesta placida* (Hagen)
  - \* *Perlinella drymo* (Newman)
  - Phasganophora capitata* (Pictet)
- 

\* Collected only as nymphs.

adults from bridge and railing cracks bordering the stream; sweepnet and aspirator were effective on the remaining species.

Water temperatures were lowest in February (0 C) and highest in late July (21.5 C) (Figure 1). Winter species emerged over several weeks on days when water and air temperatures were slightly above freezing. Emergence of spring species corresponded with a gradual rise in water temperature during late March and April. The greatest number of species was collected in May and June at stream temperatures between 8 C and 15 C.

Adult stoneflies first appeared in mid-February, with a progression of species emerging into September (Figure 2). Discontinuous collections of a species (3 wk or less) were attributed to sampling inefficiency and not adult absence. Seasonal occurrence of the various forms ranged from 1 wk to 12 wk. Prolonged flight periods were evident for *Leuctra ferruginea*, *L. tenuis*, *Paragnetina immarginata*, *Alloperla chloris*, *A. caudata*, *Taeniopteryx maura*, and *Allocapnia* spp. Emerging nymphs of *Allocapnia*, *Alloperla*, and *Isoperla* showed considerable congeneric overlap. Collections of nymphs and exuviae on the non-drying adhesive indicated that times of individual species emergence were within 5 days of each other in 1974 and 1975. The

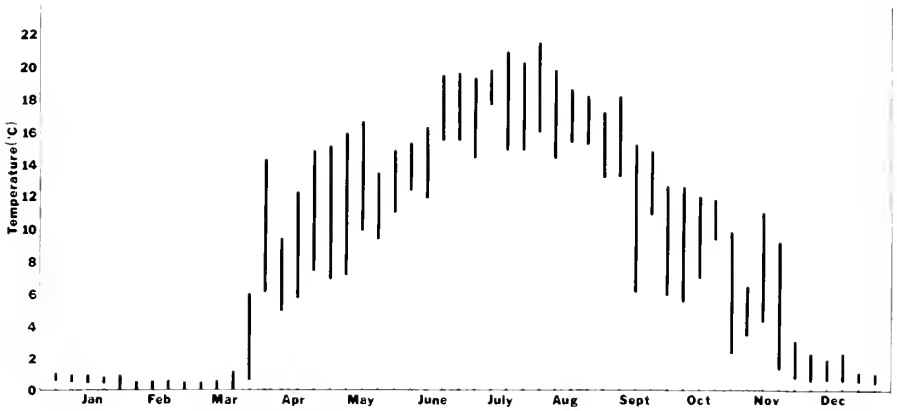


Figure 1. Combined weekly range of water temperatures for Factory Brook, September 1973 to August 1975.

relative abundance of species, based on adults and identifiable nymphs was as follows (Figure 2): 9 abundant (A), 14 common (C), 11 uncommon (U), and 11 rare (R).

### Discussion

Sampling problems due to seasonal availability and distribution of nymphs and adults were overcome by the prolonged period and multiple sampling methods used in this survey. The alternative sampling approach, extensive use of emergence traps, can theoretically collect representatives of all species emerging from a stream and eliminate potential immigrants from collections. However, the advantages and disadvantages of emergence traps should be evaluated prior to field use (Gledhill 1960; Harper and Pilon 1970; Langford and Daffern 1975). The years of collecting required to obtain a relatively complete list of organisms from one stream (Cummins 1975) is indicative of the sampling difficulty in evaluating aquatic insect diversity.

The longitudinal zonation and life cycle differences among species (Minshall 1968; Hynes 1971; Woodall and Wallace 1972) required stratified sampling for an extended period to collect all nymphs present. For example, winter and early spring species remain in the egg or diapause stage for several months (Harper and Hynes 1970) and were not collected in my benthic samples from June to September. Considerable sampling effort was also required to obtain adults of all species, since they were seldom taken by light-trap and have limited dispersal ability. The greater longevity of females (Finni 1975; Lillehammer 1975) and the relatively long egg development period for many species greatly extended the flight period of fe-



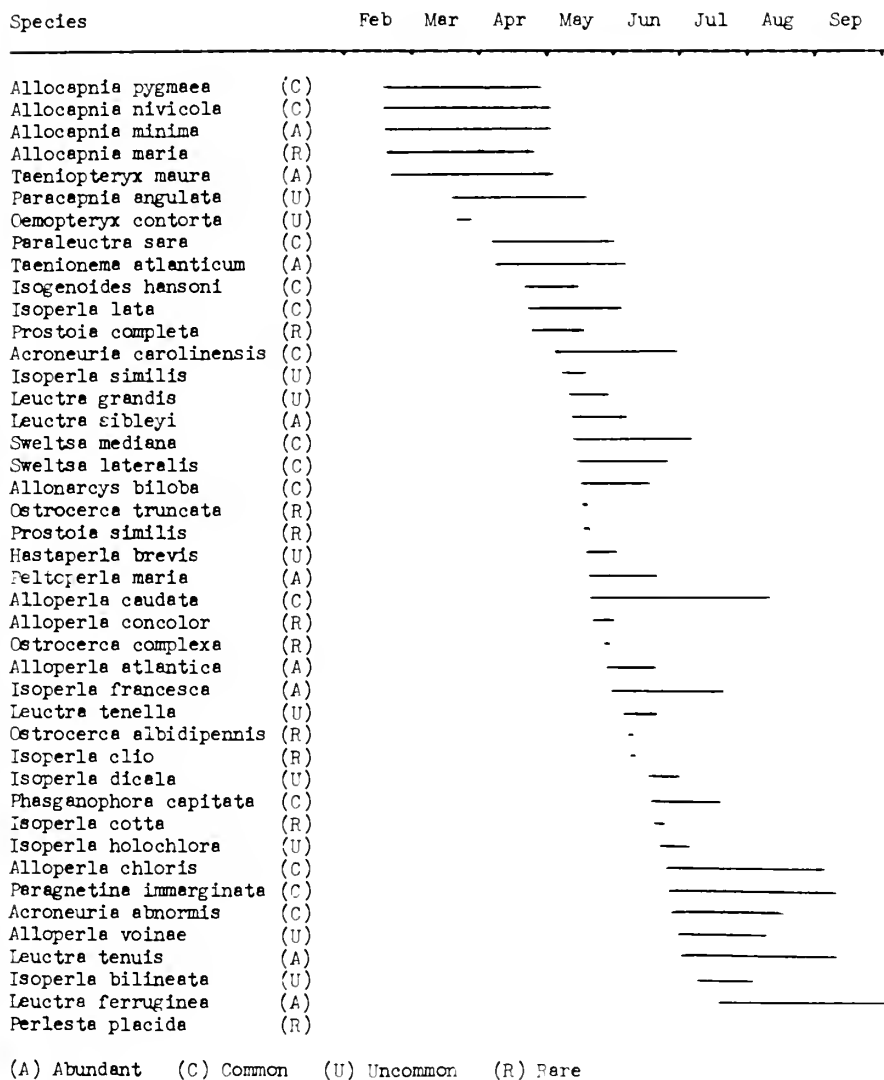


Figure 2. Seasonal occurrence of adult Plecoptera along Factory Brook, 1974 to 1976.

males. The slightly earlier emergence of males (Brink 1949; Nebeker 1971) and shorter adult life made their presence a better indicator of emergence times for each species. Emergence periods for species captured as nymphs on the non-drying adhesive agreed closely with male collection records.

Segregation of congeneric species by sequential emergence (Harper and Pilon 1970) had exceptions in several genera. *Allocapnia*, *Isoperla*, and *Al-*

Table 2. Stonefly surveys of various streams in North America.

Stream	Latitude	Number of Species	Investigator
Sashin Creek, Alaska	56°20N	17	Ellis 1975
Kananaskis River, Alta.	50°00N	37	Radford & Hartland-Rowe 1975
L'Achigan River, Que.	46°30N	50	Harper 1976
Pine-Popple River, Wis.	45°50N	34	Hilsenhoff et al. 1972
Oak Creek, Oreg.	44°30N	43	Kerst & Anderson 1974
Hubbard Brook, N.H.	44°00N	42	Fiance 1977
Factory Brook, Mass.	42°20N	45	This study
Sagehen Creek, Calif.	39°30N	31	Sheldon & Jewett 1967
Gunnison River, Colo.	38°30N	34	Knight & Gaufin 1966
Salt River, Ky.	38°00N	12	White 1974

*loperla* exhibited concurrent emergence of sibling species and supported previous emergence trap and rearing studies (Radford and Hartland-Rowe 1971; Narf and Hilsenhoff 1974). Reproductive isolation by genital incompatibility or behavioral mechanisms may be as effective in assuring species identity as temporal separation. Seasonal occurrence of adults fell into two basic types, synchronized and prolonged (Corbet 1964; Harper and Pilon 1970). Since the ecologically distinct phases of species with complex life cycles evolve independently (Istock 1967), short emergence periods would increase the chances of adult intra-specific contact. Macan (1958) and Corbet (1964) reviewed other possible causes and consequences of synchronized emergence. Conversely, it is advantageous for carnivorous immatures to have a wide size distribution and exploit the range of prey available (Hynes 1961). The extended emergence of many perlids, perlodids, and chloroperlids may therefore be related to the predacious habits of their nymphs. This ecological strategy to reduce competition and increase nymphal population size can also serve as a means of habitat partitioning (Kerst and Anderson 1974, 1975).

The 45 species collected from Factory Brook appear typical of stonefly diversity in undisturbed streams of north temperate latitudes (Table 2). In spite of differences in stream size and sampling effectiveness among these surveys, the general trend is for maximum stonefly diversity to occur in north temperate streams, with decreasing species numbers north and south of the temperate zone in North America. Additional surveys in the southern U.S. and Canada are required to confirm this continental diversity gradient for Plecoptera. A valid comparison between rheophilic insect diversity in mid-latitude versus tropical streams (Stout and Vandermeer 1975; Fox 1977) must await comparable tropical stream surveys to resolve this apparent exception to the diversity-latitudinal gradient rule (Pianka 1966).

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### Footnote

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DEFENSIVE BEHAVIOR AGAINST TERTIARY PARASITISM  
BY THE LARVA OF *DENDROCERUS CARPENTERI*<sup>1</sup> AN  
APHID HYPERPARASITOID<sup>2</sup>

Alfred W. Bennett<sup>3</sup> and Daniel J. Sullivan, S.J.<sup>4</sup>

*Abstract.*—Bennett, Alfred W. and Daniel J. Sullivan, S.J., Department of Biological Sciences, Fordham University, Bronx, New York 10458.—Using the pea aphid as the host and *Aphidius smithi* as the primary parasitoid, the ovipositional behavior of the aphid hyperparasitoid, *Dendrocerus carpenteri*, is described. Laboratory experiments indicate that the possibility of tertiary parasitism by a 2nd *Dendrocerus* is greatly reduced to an average of 6.0% during the last 9 days of the development of the 1st *Dendrocerus* within the mummy. It is suggested that *Dendrocerus* has evolved a defensive behavior which deters tertiary parasitism at least by its own species. The 4th instar larva and the prepupa have a conical process at the posterior end which enables it to twitch violently and move about in the mummy when probed by the ovipositor of a 2nd *Dendrocerus*, thus inhibiting oviposition.

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Introduction

Members of several families of Hymenoptera are aphid hyperparasitoids or secondary parasitoids in that they attack, not the aphids themselves, but the primary parasitoid which is developing inside either a live aphid or the "mummy" (a dead aphid). This secondary parasitoid can in turn be attacked by another hyperparasitoid which would result in tertiary parasitism. This was demonstrated by Sullivan (1972) with the aphid hyperparasitoid, *Asaphes californicus* Girault, which successfully attacked and oviposited on another aphid hyperparasitoid, *Alloxysta victrix* (Westwood). The progeny of the *Asaphes* fed on the *Alloxysta* larva inside the mummy and eventually emerged as an adult 21 days later. He noted, however, that such tertiary parasitism diminished with time as the *Alloxysta* developed to the pupal stage. These were but two of a complex of five different families of hyperparasitoids which were studied in the field (Sullivan and van den Bosch 1971). Another species of hyperparasitoid, *Asaphes lucens* (Provancher), will even attack a developing larva of its own species. Thus this type of tertiary parasitism can be both interspecific and intraspecific. In the laboratory experiments described herein, one such aphid hyperparasitoid, *Dendrocerus carpenteri* (Curtis), exhibits a defensive behavior as a 4th instar

larva and prepupa. This behavior reduces the possibility of it being parasitized and thus avoids tertiary parasitism.

### Materials and Methods

Apterous, viviparous pea aphids, *Acyrtosiphon pisum* (Harris), were reared in the laboratory on broad bean plants, *Vicia fava* L. (Windsor variety), in a Percival bioclimatic chamber (E-54U). The daytime regime had a photoperiod of 16 hr, a temperature of  $21.1 \pm 0.6^\circ\text{C}$ , and a relative humidity of  $75 \pm 5\%$ . At night, the photoperiod was 8 hr, with a temperature of  $15.5 \pm 0.6^\circ\text{C}$  and  $85 \pm 5\%$  RH.

The primary parasitoid was *Aphidius smithi* Sharma and Subba Rao. After mating, 2–4 females were introduced into a glass "stinging-tube" containing a cut broad bean stem and 10–15 pea aphids. The stinging tube was kept in the bioclimatic chamber for 6 hr. At the end of that time, the wasps were removed, and the aphids placed on growing bean sprouts and returned to the bioclimatic chamber.

After 8 days, mummies were formed, and on the 9th day they were removed from the plant by cutting the leaf in a circle around the mummy in order to avoid damaging the mummy itself and to allow sufficient leaf substrate on which the *Dendrocerus* female could stand. Each mummy was then placed separately in a plain, uncoated Dixie Cup container (No. 2168-SE) and sealed with a clear plastic cover (Dixie No. 3068). The hyperparasitoid which was used, had formerly been called *Lygocerus niger* (Howard, 1890), but Dessart (1972) compared the Fordham University specimens with those in Europe and the U.S. National Museum of Natural History (Systematic Entomology Laboratory). He determined that they are the same species, viz.—*Dendrocerus carpenteri* (Curtis, 1829).

One mated *Dendrocerus* female was then introduced into the container, and her oviposition behavior observed. When egg deposition onto the *Aphidius* larva was completed, this 1st *Dendrocerus* was removed. Unsuccessful hyperparasitization could easily be determined by the fact that the *Aphidius* would continue its development and eventually emerge as an adult. In such cases, these replicates were discarded.

In the laboratory experiments on tertiary parasitism, although the developing *Dendrocerus* No. 1 could be attacked over a period of 15 days while developing inside the mummy (cf. Life Cycle—Table 1), Days 0–1–2–3 were omitted from the experiments because of the difficulty in determining whether the adult which eventually emerged was the progeny of the 1st or 2nd *Dendrocerus* female. Hence, only 12 test-days were used (Days 4–15), when the emergence of *Dendrocerus* No. 1 or 2 could be accurately determined. Normally the adults emerge on the 16th day after oviposition.

On each of the 12 test-days, the same procedure was followed, viz.—a 2nd mated *Dendrocerus* female was introduced into the container having a

Table 1. Composite life cycles of the primary parasitoid, *Aphidius smithi*, and the hyperparasitoid, *Dendrocerus carpenteri*, under experimental laboratory conditions.

Day <i>Aphidius smithi</i>		Day <i>Dendrocerus carpenteri</i>	
0	Egg deposited in aphid	0	Egg deposited on <i>Aphidius</i>
1		1	1st larval instar
2	1st larval instar	2	
3		3	2nd larval instar
4	2nd larval instar	4	
5		5	3rd larval instar
6	3rd larval instar	6	
7		7	4th larval instar
8	Host aphid mummified	8	
9		9	Prepupa (meconium voided)
10	Prepupa (meconium voided)	10	Pupa
11	Pupa	11	
12	Adult emerges <sup>a</sup>	12	
		13	
		14	
		15	
		16	Adult emerges <sup>b</sup>

<sup>a</sup> In these experiments, because of hyperparasitization by *Dendrocerus*, the *Aphidius* is attacked on Day 9, and does not develop to an adult.

<sup>b</sup> Similarly, if *Dendrocerus* No. 1 is successfully hyperparasitized by *Dendrocerus* No. 2 during the experimental test-days (4-15), it will not develop to an adult.

mummy which had been previously hyperparasitized by the 1st *Dendrocerus*. The 2nd *Dendrocerus* female was removed after normal drilling and possible oviposition had been completed. Each mummy was then left undisturbed in its container, and returned to the bioclimatic chamber. At least 100 replicates were done for each of the 12 test-days (4-15).

### Results and Discussion

The ovipositional behavior of *Dendrocerus carpenteri* has the following sequence. The female approaches the mummy and antennates it in a rather aggressive manner. She then walks on top of the mummy, but almost immediately walks off it at the spot where she will eventually drill a hole. This

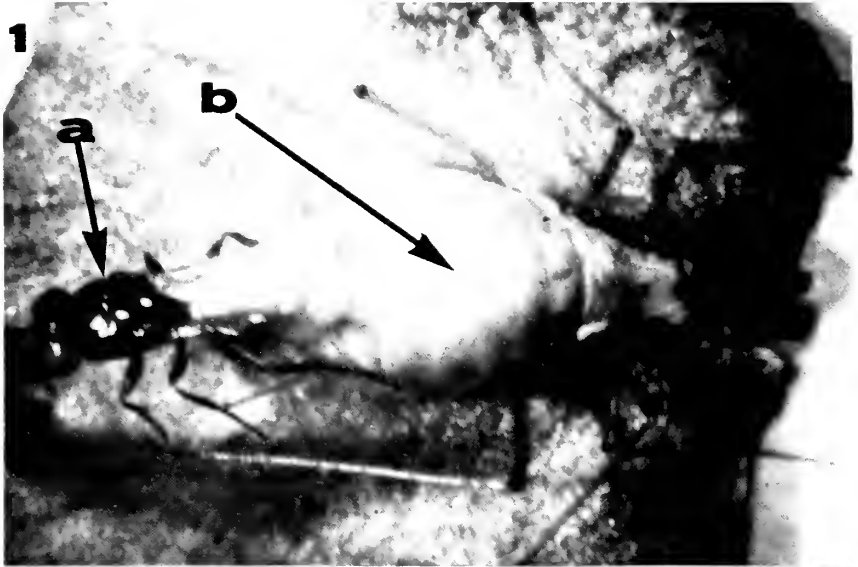


Fig. 1. *Dendrocerus* female (a) backs into the pea aphid mummy (b), drills a hole and oviposits on the *Aphidius* larva developing inside. (20×)

Fig. 2. An 8-day old, 4th instar *Dendrocerus* larva showing the posterior conical process (a) and some of the spine-like projections (b). (55×)



site is usually on the side or rear of the mummy. The female backs into the mummy and anchors herself to the leaf substrate with her prothoracic and sometimes mesothoracic legs (Fig. 1). This is in sharp contrast to *Asaphes* which drills the hole while standing on top of the mummy. The metathoracic legs are hooked into the mummy wall, cornicles, or appendages of the dead aphid. She extends her ovipositor and with a jackhammer-like action drills a hole in the mummy with a twisting and pushing motion. Her antennae are held motionless, being extended forward and usually resting on the leaf. The egg is laid immediately on the primary larva within the mummy. Unlike *Asaphes* (Keller and Sullivan 1976), there is no feeding-tube construction or host-feeding even by a female ovipositing for the 1st time. Two or more eggs are frequently deposited, and although only one larva will normally develop to an adult—occasionally two dwarf-size adult wasps will emerge from the same mummy. The entire ovipositional process may take 3–20 minutes depending on the hardness of the part of the mummy being drilled. In general, however, the time spent searching, antennating, drilling and ovipositing was much shorter in the case of *Dendrocerus* females than with *Asaphes*. The former, therefore, seems to be a much more aggressive and efficient hyperparasitoid.

In maintaining the *Dendrocerus* colony under laboratory conditions, the sex ratio of the adult progeny was 62.8% females (3,622) to 37.2% males (2,149).

The results of the laboratory experiments on tertiary parasitism are given in Table 2, where the emergence of *Dendrocerus* No. 2 was greatest on Day 4 (22.4%). On this day, *Dendrocerus* No. 1 is a 2nd instar larva. Later tertiary parasitism was reduced by almost one-half on Days 5 and 6 to 12.1%, at which time the larva of *Dendrocerus* No. 1 is in the 3rd instar. It should be pointed out, however, that even at these stages of *Dendrocerus* No. 1 development, it may be that it is the primary *Aphidius* larva which is really being attacked. This is because the 2nd and even the 3rd instars of the 1st *Dendrocerus* are still relatively small, and true tertiary parasitism may not be occurring.

The remaining test-days revealed an even more dramatic change. Beginning with Day 7, when *Dendrocerus* No. 1 is in the 4th instar, the emergence of *Dendrocerus* No. 2 decreased even further to an average of 6.0%, and remained fairly constant over Days 7–15. The totals for the entire series of 12 test days (4–15) showed that of 1,383 adult wasps which emerged during these experiments, only 8.0% were *Dendrocerus* No. 2, which indicates a relatively low percentage of successful tertiary parasitism.

One explanation for these results might be the defensive behavior of the larva beginning with Day 7. Observations of dissected mummies revealed that on this test-day, the larva of *Dendrocerus* No. 1 is in the 4th instar, and was not merely larger, but unlike earlier instars, each segment had a

Table 2. Adult emergence and non-emergence (mortality) of *Dendrocerus* No. 1 vs. *Dendrocerus* No. 2, arranged according to attack on mummies during the 12 Test-days (4-15).<sup>a</sup>

Test-day	<i>Dendrocerus</i> No. 1		<i>Dendrocerus</i> No. 2		Total emerged	Mortality <sup>b</sup>		Total mummies
	No.	%	No.	%		No.	%	
4	59	77.6	17	22.4	76	26	25.4	102
5	102	87.9	14	12.1	116	7	5.7	123
6	102	87.9	14	12.1	116	21	16.0	137
7	110	94.0	7	6.0	117	18	13.3	135
8	104	94.5	6	5.5	110	14	11.3	124
9	107	93.9	7	6.1	114	15	11.6	129
10	106	95.5	5	4.5	111	24	17.8	135
11	110	92.4	9	7.6	119	28	19.0	147
12	111	94.1	7	5.9	118	23	16.3	141
13	109	93.2	8	6.8	117	25	17.6	142
14	129	95.6	6	4.4	135	21	13.5	156
15	124	92.5	10	7.5	134	22	14.1	156
Totals	1273	92.0	110	8.0	1383	244	15.0	1627

<sup>a</sup> Days 0-1-2-3 not included explained in text.

<sup>b</sup> Refers to those mummies from which no *Dendrocerus* emerged.

number of rows of small, lateral and dorsal spine-like projections. In addition, there was a distinctive conical process at the posterior end (Fig. 2) which was also visible in the prepupa. This conical process could even be extended beyond the length visible in the photograph. In parallel experiments on tertiary parasitism presently being conducted with *Asaphes*, this other hyperparasitoid does not possess such a conical process. Perhaps this is the reason why tertiary parasitism with this species is quite high.

Related to this morphological difference between *Dendrocerus* and *Asaphes*, there is also a noticeable difference in behavior. The 4th instar larva and prepupa of *Dendrocerus* No. 1 are easily disturbed when touched either by the ovipositor of a 2nd *Dendrocerus* or even by a mechanical probe. Such prodding resulted in the larva or prepupa twitching violently and seeming to use the conical process as a lever to help it move about in the mummy and away from the stimulus. This is not the case with *Asaphes*.

Hence, it is suggested that, unlike *Asaphes*, the *Dendrocerus* larva has evolved a defensive behavior which prevents or at least drastically reduces tertiary parasitism, at least by its own species. The net result of this ability of the 4th instar larva and prepupa to react to the probing of an ovipositor and even to move about in the mummy by means of the conical process serves as a 94% successful deterrent against hyperparasitization by a 2nd *Dendrocerus* during these stages of development beginning with Day 7.

The pupal stage also seems relatively immune to tertiary parasitism. However, as Sullivan (1972) pointed out when *Asaphes californicus* was used in experiments of tertiary parasitism on another hyperparasitoid, *Alloxysta victrix*, as the pupa becomes sclerotized, tertiary parasitism is greatly reduced. This is probably also the case with *Dendrocerus*.

As shown in Table 2, the mortality or non-emergence of any adult from mummies used in these experiments was rather high, the overall average being 15.0%. This compares favorably, however, with the 18.0% reported by Sullivan in the experiments mentioned above. After being held for several months, these *Dendrocerus* mummies were dissected. All that was visible was a dark-brown, unidentifiable mass on the floor of the mummy. This indicated that diapause was not involved, but rather death of the larvae occurred, due to competition or ovipositional probing.

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### Footnotes

<sup>1</sup> Hymenoptera: Ceraphronidae.

<sup>2</sup> This research was supported in part by a National Science Foundation Grant GU-3554 to the second author. Manuscript is a portion of a dissertation submitted by the first author in partial fulfillment of the requirements for the Ph.D. degree in the Department of Biological Sciences, Fordham University, Bronx, New York 10458.

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A REVISION OF THE GENUS *MORMIDEA*  
(HEMIPTERA: PENTATOMIDAE)

L. H. Rolston

*Abstract.*—Rolston, L. H., Department of Entomology, Louisiana State University, Baton Rouge, Louisiana 70803.—The 33 species of *Mormidea* are described and keyed. One of these species, *M. geographica*, is provisionally retained in the genus, although certainly it mars the phyletic homogeneity of the genus. Seven new species are described: *M. dana*, *M. faisana*, *M. isla*, *M. lunara*, *M. pama*, *M. rugosa* and *M. vaya*.

The following new synonymy is recognized: *M. angustata* Stål (= *M. pulchella* Walker, = *M. lemoulti* Bergroth); *M. cornicollis* Stål (= *M. jheringi* Berg); *M. fusca* Stål (= *M. angulosa* Stål); *M. geographica* (F) (= *M. brevis* Walker, = *Oenopiella testacea* Ruckes); *M. hamulata* Stål (= *M. pullata* Berg); *M. paupercula* Berg (= *M. profana* Breddin); *M. v-luteum* (Lichtenstein) (= *M. spegazzini* Berg, = *M. tristis* Bergroth); and *M. ypsilon* (L) (= *Pentatoma scutellata* Westwood).

*M. discoidea* (Dallas) is removed from the synonymy of *M. notulata* and recognized as a good species.

A lectotype is designated for each of the following: *M. aglaeopus* Dallas, *M. angulosa* Stål, *M. compta* Walker, *M. cornicollis* Stål, *M. fusca* Stål, *M. hamulata* Stål, *Euschistus integellus* Distant, *M. jheringi* Berg, *M. metallica* Stål, *M. pictiventris* Stål, *M. sordidula* Stål, *M. spegazzini* Berg and *M. spiculigera* Stål.

*Moromorpha* n. gen. is erected for *Mormidea tetra* Walker, type species. The genus is described, as is *Mormidea*, and a key provided to separate these genera from each other and from *Oebalus*.

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As the genus *Mormidea* was conceived initially, its limits were so generous that for several decades afterward many rather distantly related species were placed therein. Subsequent refinements in classification left in *Mormidea* only species of the Western Hemisphere, most of which are indeed congeneric. However, the genus has not been revised prior to this time.

This revision leaves, with one exception, a homogeneous group of 33 species, seven of which are previously unrecognized, and removes one species to a new genus. The generic placement of *Mormidea geographica* (Fabricius) is not disturbed for now, even though the male genitalia would support removal of this species to a new genus. This timorous treatment of

the species is excused on the grounds that the entire nominate tribe in the Western Hemisphere needs reviewing, and the addition of a genus now on the basis of cryptic characters may be a disservice.

### Index to Species of *Mormidea*

#### Subgenus *Melanochila*

- bridarolli* Pirán
- lugens* (Fabricius)
- montandoni* Kirkaldy
- purpurescens* Van Duzee

#### Subgenus *Mormidea*

- albisignis* Stål
- ambigua* Berg
- angustata* Stål
- bovilla* (Distant)
- collaris* Dallas
- cornicollis* Stål
- cubrosa* (Dallas)
- dana** n. sp.
- discoidea* (Dallas)
- faisana** n. sp.
- fusca* Stål
- geographica* (Fabricius)
- hamulata* Stål
- integella* (Distant)
- isla** n. sp.
- laevigata* Distant
- lunara** n. sp.
- maculata* Dallas
- metallica* Stål
- notulata* (Herrich-Schäffer)
- notulifera* Stål
- pama** n. sp.
- paupercula* Berg
- pictiventris* Stål
- rugosa** n. sp.
- speciosa* Haglund
- vaya** n. sp.
- v-luteum* (Lichtenstein)
- ypsilon* (Linnaeus)

## Related Genera

Among American pentatomids, the genera most like *Mormidea* are *Oebalus* and a new monotypic genus, characterized below, which is based on the species previously known as *Mormidea tetra*. The following key separates the three genera.

1. Superior surface of tibiae sulcate; a small flat spine arising at posterior pronotal angle and extending over each corium  
*Moromorpha* n. gen.
- Superior surface of tibiae rounded; posterior pronotal margin unarmed 2
2. Apex of first rostral segment not or scarcely surpassing bucculae  
*Oebalus* Stål
- Apex of first rostral segment clearly surpassing bucculae  
*Mormidea* Amyot & Serville

*Moromorpha* n. gen.

Small flat spine on each side of pronotum arising at posterior angle and projecting over corium (Fig. 1).

Distal end of first antennal segment not quite reaching apex of head; other four segments each longer than first. Juga and tylus subequal in length. Bucculae toothed anteriorly, truncate posteriorly, clearly exceeded by distal end of first rostral segment. Propleura without anterior lobe. Prosternum slightly concave longitudinally, without carina; mesosternum bearing low median carina cephalad of xyphus; metasternum nearly flat. Orifice of scent gland auriculate, neither much prolonged as canal nor accompanied by elongated ruga. Femora unarmed; tibiae sulcate on superior surface; tarsi three segmented. Lateral angle of corium surpassing apex of scutellum, attaining fourth connexival segment. Abdominal venter without median tubercle or spine at base; spiracles lying on or near imaginary line passing between the two trichobothria on each of first five visible sternites.

*Type species.*—*Mormidea tetra* Walker, 1868.

The generic placement of *Mormidea tetra* has escaped challenge until now, presumably because in general appearance and most characters this species resembles some common *Mormidea* species. The sulcate tibiae have been regarded as a generic anomaly and a convenience in distinguishing the species. The pronotal projections seem not to have been noticed or at least not to have provoked comment. This combination of characters preclude accommodating the species in the genus *Mormidea* and seem to exclude it from any previously established genus.

The construction of the male genitalia of the type species, together with other characters, place *Moromorpha* near *Mormidea*. This species and *Mormidea ypsilon*, the type species of *Mormidea*, are similar in the form of the theca, placement of major conjunctival lobes, great development of the median penial lobes and presence of a large vesical plate (Figs. 2, 3).

*Mormidea* Amyot & Serville, 1843

*Mormidea* Amyot & Serville, 1843, p. 134–135—Dallas, 1851, p. 195, 210 (keyed)—Stål, 1867, p. 527 (keyed)—Stål, 1872, 19–22 (synonymy, key to spp.)—Distant, 1880, p. 53 (synonymy, diagnostic note)—Provancher, 1886, pp. 26, 43 (keyed, desc.)—Lethierry & Severin, 1893, p. 123 (synonymy)—Summers, 1898, p. 44 (keyed)—Kirkaldy, 1909, p. 59 (synonymy)—Zimmer, 1912, p. 222 (keyed)—Parshley, 1915, p. 173 (keyed)—Van Duzee, 1917, p. 37 (synonymy)—Stoner, 1920, pp. 62, 74 (keyed, description)—Blatchley, 1926, p. 212–213 (keyed, described, key to spp.)—Barber & Bruner, 1932, p. 249, 251–252 (keyed, key to Cuban spp.)—Torre Bueno, 1939, p. 210, 217–218 (keyed, key to N. Amer. spp.)—Froeschner, 1941, p. 217, 219 (keyed)—Bruner & Barber, 1949, p. 157 (list Cuban spp.)—Alayo, 1967, p. 8, 10–11 (keyed, key to Cuban spp.)—McPherson, 1970, p. 44 (keyed)—Hoffman, 1971, p. 29, 43 (keyed)

Distal end of first antennal segment not surpassing apex of head; each of remaining four segments longer than first. Tylus slightly longer than juga, apex of head parabolic. Bucculae toothed anteriorly, terminating convexly or rarely abruptly near base of head, clearly exceeded by distal end of first rostral segment. Propleura without anterior lobe partially covering genae.

→

PLATE I

Figs. 1–2. *Moromorpha tetra*. Fig. 1. Spine at posterolateral angle of pronotum. Fig. 2. Part of genitalia inside pygophore, ventral view: median penial lobes (m); vesical plate (v).

Fig. 3. *Mormidea ypsilon*. Part of genitalia inside pygophore, ventral view: basal lobes of conjunctiva (c), median penial lobes (m); vesical plate (v).

Figs. 4–5. *M. lugens*. Fig. 4. Basal plates. Fig. 5. Pygophore, caudal view.

Figs. 6–8. *M. montandoni*. Fig. 6. Basal plates. Fig. 7. Pygophore, caudal view. Fig. 8. Left paramere, dorsomesial view with anterior part to right.

Fig. 9. *M. bridarolli*. Left paramere, dorsomesial view with anterior part to right.

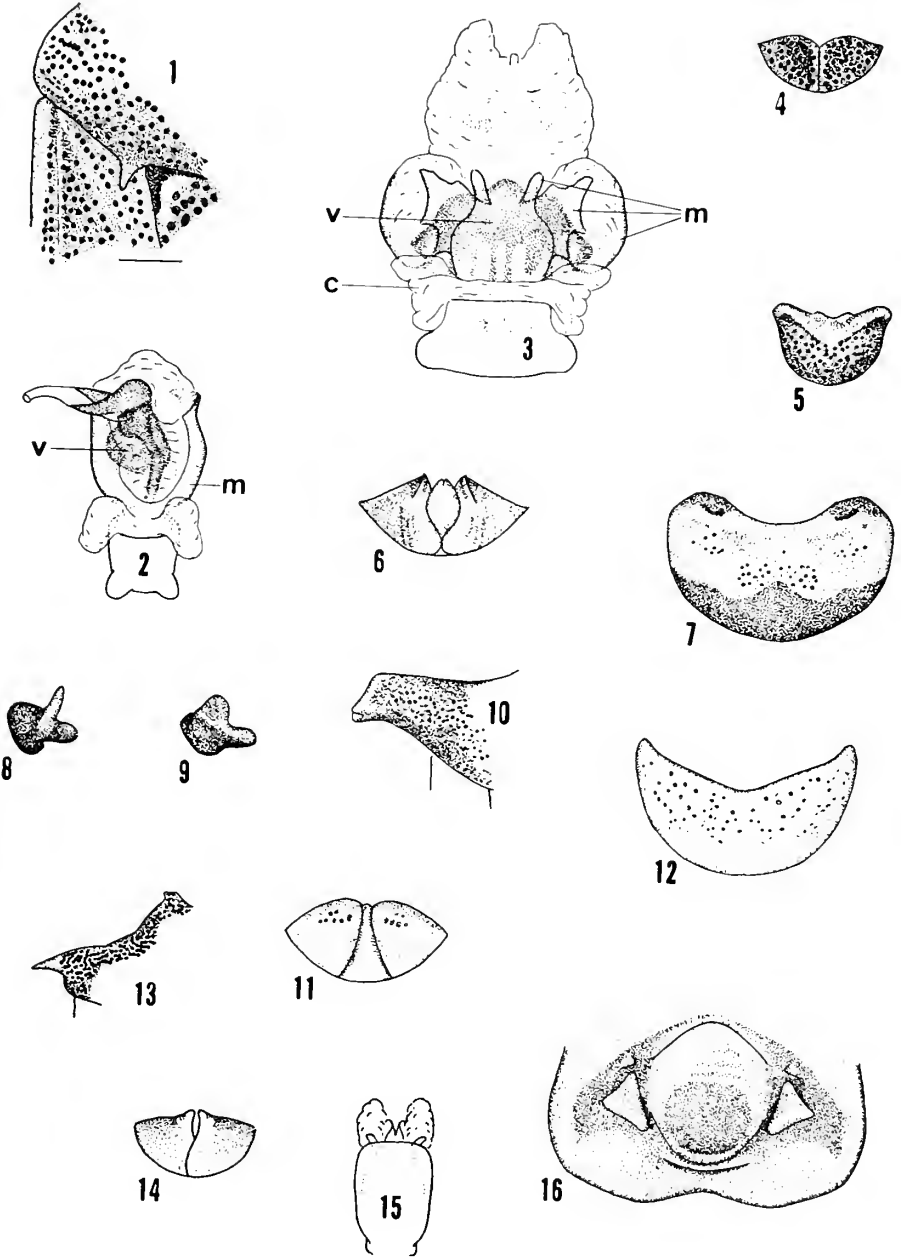
Figs. 10–12. *M. bovilla*. Fig. 10. Left humerus. Fig. 11. Basal plates. Fig. 12. Pygophore, caudal view.

Figs. 13–15. *M. geographica*. Fig. 13. Left humerus. Fig. 14. Basal plates. Fig. 15. Part of genitalia inside pygophore, dorsal view.

Fig. 16. *M. speciosa*. Genital cup, dorsal view.

Dimensional line in Fig. 1 equals 0.5 mm and applies to Figs. 1, 4–7, 11–12, and 14. Figs. 2, 3, 8–9, 15–16 are twice this magnification. Figs. 10 and 13 are half this magnification.





Prosternum shallowly concave longitudinally, without carinae; mesosternum bearing low median carina cephalad of xyphus; metasternum nearly flat. Orifice of scent gland auriculate, not greatly prolonged into canal or accompanied by elongated ruga. Femora unarmed; superior surface of tibiae asulcate. Posterior angles of pronotum unarmed. Lateral angle of corium extending well beyond apex of scutellum, reaching fourth or fifth connexival segment. Abdominal venter lacking median spine or tubercle at base; spiracles lying within or just dorsad of imaginary band formed by longitudinal lines drawn through the two trichobothria on each of first five visible sternites.

*Type species*.—*Cimex ypsilon* Linneaus, 1758, by subsequent designation (Kirkaldy, 1909).

*Subgenus Melanochila* Stål, 1872

Subgen. *Melanochila* Stål, p. 19—Kirkaldy, 1909, p. 59, 61 (type species designated) Stoner, 1920, p. 75 (description)

This subgenus is characterized by an ivory callous traversing the pronotum at the posterior margins of the cicatrices but terminating short of the anterolateral margins of the pronotum.

This group seems to be one of convenience since the four included species appear not to differ basically from all others of the genus.

Kirkaldy (1909) designated *Cimex lugens* Fabricius, 1775, as type species.

Key to Species of *Mormidea*

1. Pronotum traversed at posterior margin of cicatrices by narrow ivory callous (Subgen. *Melanochila*) 2
  - Pronotum at posterior margin of cicatrices uncalloused or with calloused (usually pale) spot at each cicatrice (Subgen. *Mormidea*) 5
2. Scutellum with an ivory callous along lateral or all margins 3
  - Scutellum without marginal callous (Andean region) 3

*M. purpurescens* Van Duzee
3. Ivory callous along basal and lateral margins of scutellum; disk of coria with prominent ivory callous along radial vein 4
  - Ivory callous along lateral margins of scutellum only, disk of coria lacking linear callous along radial vein (North America) *M. lugens* (F.)
4. Proximal and distal ends of tibiae broadly banded in black, usually with narrow intermediate black band (Andean region)
  - Tibiae with numerous small black spots (Andean region)
    - M. montandoni* Kirkaldy
    - M. bridarolli* Pirán

5. Dorsum mostly metallic green, head and pronotum anteriorly light brown (Amazon region) *M. speciosa* Haglund
- Dorsum mostly brown or black, often with ivory markings 6
6. Humeri cornute, sweeping laterad and dorsad, usually with a subapical tubercle on posterior margin (Fig. 10) (northern South America) *M. bovilla* (Distant)
- Humeri less strongly produced, lacking a subapical tubercle 7
7. Acutely produced humeri conspicuously emarginated posteriorly (Fig. 13); dorsum lacking pale markings (Venezuela, Guyana, northern Brazil) *M. geographica* (F.)
- Humeri obtuse or acute, if acute and emarginated then dorsum with pale markings 8
8. Anterolateral margins of pronotum angularly concave with anterior half crenulate (Fig. 61) (Argentina, southern Brazil) *M. paupercula* Berg
- Anterolateral margins entire, vertically rugose at most (Fig. 17) 9
9. Scutellum black or fuscous excepting at most three small pale dots or marks at base 10
- Scutellum brown to black but pale at apex or with pale marks at least along frena 15
10. With anterior and posterior pronotal margins on same focal plane, pale border clearly visible at least on cephalic half of anterolateral margins 11
- Anterolateral margins of pronotum black or fuscous from above 12
11. Males: superior ridge of pygophore reduced to subquadrate projection on each side of meson (Fig. 20). Females: mesial margin of basal plates nearly straight, widely separated proximally and contiguous distally (Fig. 18) (Argentina, Brazil) *M. cornicollis* Stål
- Males: superior ridge not reduced, arcuate, with deep mesial notch (Fig. 23). Females: mesial margins of basal plates contiguous from base to apex (Fig. 21) (Colombia) *M. fusca* Stål
12. Apex of scutellum acute (Fig. 31); most distal part of basal plates located above paratergite 9 (Panama) *M. vaya* n. sp.
- Apex of scutellum narrowly rounded (if acute in male, inferior ridge projecting caudad into triangle which nearly reaches posterior pygophoral margin (Fig. 30)); most distal part of basal plates above gonocoxae 2 13
13. Antennifers usually swollen. Males: pygophore deeply impressed mesially beneath inferior ridge. Females: mesial margin of basal plates quite concave (Fig. 25) (South America, Trinidad) *M. hamulata* Stål
- Antennifers normal. Males: pygophore rather evenly excavated

- behind inferior ridge. Females: mesial margin of basal plates straight for most or all of their length 14
14. Males: inferior ridge of pygophore produced as triangular process with apex directed posteriorly (Fig. 30). Females: basal plates subtriangular, rounded distally (Fig. 28) (Costa Rica, Panama) *M. integella* (Distant)
- Males: inferior ridge of pygophore simple. Females: basal plates truncate distally, angulate above paratergite 9 (Fig. 21) (Columbia, Venezuela) *M. fusca* Stål
15. Thin callous along frena somewhat paler than scutellar disk, but apex of scutellum concolorous with disk (Yucatan) *M. faisana* n. sp.
- Scutellum pale at apex, often with additional pale markings 16
16. Black mottling on abdominal venter arranged as irregularly contiguous and poorly defined vittae (northern Argentina, southern Brazil) *M. v-luteum* (Licht.)
- Abdominal venter with well-defined mesial vitta (sometimes accompanied by additional vitta on each side) or mesial row of spots, or disk uniformly colored 17
17. Abdominal venter pale with dark mesial vitta (sometimes in addition a lateral vitta on each side) or a mesial row of spots 31
- Abdominal venter dark (excepting pale lateral margins and small subspiracular spots) or pale and without mesial vitta (occasionally on fifth visible sternite a thin dark mesial line which rarely continues interruptedly onto base of one or more preceding sternites) 18
18. Abdominal venter entirely dark brown to black excepting pale lateral margins and small subspiracular spot on each side of some or all sternites (C. Amer., W. Indies) *M. cubrosa* (Dallas)
- Abdominal venter pale 19
19. Dark spot at distal end of supracoxal clefts, that above mesocoxae larger than least diameter of tibiae; antennae nearly uniform in color (W. Indies, Middle Amer., S. Amer.) *M. angustata* Stål
- Distal end of supracoxal clefts immaculate or with tiny dark mark; at least last antennal segment bicolored with proximal part pale 20
20. Humeral angles acute to spinose and directed obliquely cephalad, or spinose and curved strongly dorsad (Middle Amer.) *M. lunara* n. sp.
- Humeral angles obtuse, or acute to spinose and slightly retroarcuate or directed laterad 21
21. Females 22
- Males 26
22. Basal plates inconspicuously punctate, with fine curved wrinkles; distance from imaginary line drawn through lateral angles of basal plates to most distal margin of plate  $\frac{4}{10}$  or less of distance from line

- to base of plates at meson (Fig. 79) (West Indies, Middle America, South America) *M. isla* n. sp.
- Basal plates usually without wrinkles, with fine punctation; distance from imaginary line to most distal margin of basal plates  $\frac{5}{10}$  or more of distance from line to base of plates at meson *M. ypsilon* (L.) 23
23. Distance from imaginary line to most distal margin of basal plates usually  $\frac{7}{10}$  or more of distance from line to base of plates at meson; punctation on sides of first visible abdominal sternite much weaker than on adjacent part of metathorax (northern South America) *M. maculata* Dallas
- Distance from imaginary line to most distal margin of basal plates usually  $\frac{5}{10}$  to  $\frac{6}{10}$  of distance from line to base of plates at meson; punctation on sides of first visible abdominal sternite about as strong as that on adjacent part of metathorax (but usually less dense) 24
24. Tiny dark mark present at distal end of supracoxal clefts (Middle America) *M. collaris* Dallas
- Pleura immaculate (occasionally faintly marked) at distal end of supracoxal clefts 25
25. Body length including membranes 7.0–8.5 mm (eastern South America) *M. notulifera* Stål
- Body length including membranes 5.0–6.9 mm (Greater Antilles) *M. albisignis* Stål
26. Dorsal margin of pygophore tuberculate near lateral limits (Fig. 76) (West Indies, northern South America, Central America) *M. isla* n. sp.
- Dorsal margin of pygophore smoothly curved 27
27. Dorsal margin of pygophore broadly and shallowly concave from caudal view, without mesial emargination or deep marginal impression on posterior surface (Fig. 80) (West Indies, South America, Middle America) *M. ypsilon* (L.)
- Dorsal margin of pygophore conspicuously emarginated or with deep marginal impression on posterior surface (Figs. 51, 44) 28
28. Dorsal margin of pygophore deeply emarginated from caudal view (Fig. 51) (northern South America) *M. maculata* Dallas
- Posterior surface of pygophore with semicircular mesial impression at dorsal margin, usually bordering shallow emargination (Fig. 44) 29
29. Tiny dark dot located at distal end of supracoxal clefts; proctiger truncate distally (Fig. 45) (Middle America) *M. collaris* Dallas
- Pleura immaculate (rarely faintly marked) 30

30. Proctiger with mesial spine on distal margin, serrate posterolaterally (Fig. 48); body length with membrane 7.0–8.5 mm (eastern South America) *M. notulifera* Stål  
 – Proctiger bilobed distally (Fig. 73); body length with membrane 5.0–6.9 mm (Greater Antilles) *M. albisignis* Stål
31. Humeral angles connected by narrow irregular calloused fascia concolorous with or little paler than disk of pronotum; legs and apex of scutellum usually bright, ferruginous (Brazil) *M. rugosa* n. sp.  
 – Pronotal disk not divided transversely by calloused fascia connecting humeral angles; apex of scutellum usually ivory 32
32. Mesial vitta on abdominal venter interrupted, usually lacking on fourth visible sternite and sometimes faint on third; when rarely present on fourth, vitta severely restricted (Colombia, Panama) *M. metallica* Stål  
 – Mesial vitta continuous or consisting of a row of spots 33
33. All of scutellum except base bordered in ivory (Mexico) *M. laevigata* Distant  
 – Sides of scutellum not or incompletely bordered in ivory 34
34. Dark spot at distal end of supracoxal cleft on mesocoxae larger than least diameter of tibiae; antennae nearly uniform in color (West Indies, Middle America, South America) *M. angustata* Stål  
 – Spot at distal end of supracoxal cleft on mesocoxae no larger than least diameter of tibiae; at least fifth segment of antennae usually bicolored with pale basal ring 35
35. Femora yellowish proximally, becoming rufous distally (Colombia, Venezuela) *M. fusca* Stål  
 – Femora almost uniformly colored excepting dark dots 36
36. Lateral margins of scutellum bordered along frena by pale callous 42  
 – Pale areas of scutellum confined to apex and basal spots 37
37. Anterolateral margins of pronotum decidedly concave from dorsal view 42  
 – Anterolateral margins of pronotum straight or nearly so 38
38. Males 39  
 – Females 41
39. Dorsal margin of pygophore from caudal view nearly straight, bearing on each side a short transverse marginal ridge (Fig. 65) (West Indies, southwestern United States to Colombia) *M. cubrosa* (Dallas)  
 – Dorsal margin of pygophore from caudal view concave 40
40. Small obtuse mesial production on posterior pygophoral margin from caudoventral view (Fig. 55); dorsum shiny metallic brown when viewed without magnification (Colombia, Peru, Ecuador) *M. dana* n. sp.

- Posterior margin of pygophore smoothly concave from caudover-  
tral view; dorsum dull brown to fuscous when viewed without mag-  
nification (Argentina) *M. ambigua* Berg
- 41. Mesial margins of basal plates well separated except basally (Fig.  
64) (West Indies, southwestern United States to Colombia) *M. cubrosa* (Dallas)
  - Mesial margins of basal plates contiguous or nearly so for most of  
length (Fig. 54) (Colombia, Ecuador, Peru) *M. dana* n. sp.
- 42. Males 43
  - Females 48
- 43. Dorsal margin of pygophore from caudal view moderately concave  
(Figs. 37, 39) 44
  - Dorsal margin of pygophore from caudal view shallowly concave or  
truncate (Figs. 65, 67, 70) 45
- 44. Connexiva black with pale spot on each segment arching mesad  
from margin; an incomplete lateral vitta usually present on each  
side of mesial abdominal vitta (Mexico) *M. discoidea* (Dallas)
  - Lateral margin of connexiva entirely pale; only mesial abdominal  
vitta well defined (Middle America, South America) *M. notulata* (H-S)
- 45. Posterior margin of pygophore from ventral view conspicuously  
notched mesially (Florida, West Indies, southwestern United  
States to Colombia and Venezuela) *M. pama* n. sp.
  - Posterior margin of pygophore from ventral view weakly concave  
or convex 46
- 46. Small sharp tooth on dorsal margin of pygophore at beginning of  
chevron shaped deflexed carina on posterior surface of pygophore  
(Fig. 67) (Middle America, Colombia) *M. pictiventris* Stål
  - Dorsal margin of pygophore unarmed 47
- 47. Posterior margin of pygophore with short transverse marginal ca-  
rina on each side; faint semicircular impression on surface of py-  
gophore between carina and immediately beneath dorsal margin  
(Fig. 65) (West Indies, southwestern United States, Middle Amer-  
ica) *M. cubrosa* (Dallas)
  - Carinae absent on posterior margin of pygophore; surface impres-  
sion extending from each side beneath central area at dorsal pygo-  
phoral margin (Yucatan) *M. faisana* n. sp.
- 48. Pale border of anterolateral pronotal margin intruding onto disk as  
indicated by arrow in Fig. 68 (Florida, West Indies, southwestern  
United States to Colombia and Venezuela) *M. pama* n. sp.
  - Pale border if present not intruding onto disk 49
- 49. Viewed laterally, basal plates subvertical (West Indies, southwest-  
ern United States, Mexico) *M. cubrosa* (Dallas)
  - Basal plates inclined 30 degrees or more from vertical 50

50. Mesial margins of basal plates concave (Middle America, Colombia, Peru) *M. notulata* (H-S)  
 – Mesial margins of basal plates contiguous or nearly so for entire length 51
51. Basal plates entirely or almost entirely light brown (Yucatan) *M. faisana* n. sp.  
 – Basal plates mostly fuscous 52
52. Lateral border of connexiva uniformly yellowish-brown (Middle America, Colombia) *M. pictiventris* Stål  
 – Connexiva black, draped with yellowish brown between sutures (Mexico) *M. discoidea* (Dallas)

*Mormidea lugens* (Fabricius, 1775)

- Cimex lugens* Fabricius, 1775, p. 716—Herrich-Schäffer, 1840, p. 66, fig. 510.
- Cimex albipes* Fabricius, 1798, p. 535.
- Cydnius lugens*: Fabricius, 1803, p. 187.
- Cimex gamma* Fabricius, 1803, emendation (replacement name for *Cimex albipes* F.).
- Pentatoma punctipes* Palisot de Beauvois, 1805, p. 113 Hem. Pl. 8, fig. 6.
- Pentatoma punctipes* Say, 1825, p. 313 (as new species).
- Pentatoma gamma*: Say, 1831, p. 10.
- Pentatoma lugens*: Herrich-Schäffer, 1844, p. 96 (keyed).
- Mormidea lugens*: Stål, 1862, pp. 103–104 (description)—Stål, 1872, p. 19 (synonymy, records)—Uhler, 1872, p. 395 (records)—Uhler, 1876, p. 285 (records)—Uhler, 1877, p. 402 (records)—Uhler, 1878, pp. 376–377 (records)—Provancher, 1885, pp. 43–44 (synonymy, description)—Van Duzee, 1889, p. 2 (record)—Van Duzee, 1894, p. 171 (record)—Gillette & Baker, 1895, p. 14 (record)—Torre-Bueno, 1908, p. 225 (record)—Van Duzee, 1909, p. 155 (record)—Morse, 1910, p. 155 (record)—Olsen, 1912, p. 52 (hosts)—Van Duzee, 1912, p. 138 (Provancher det. verified)—(Parshley, 1914, p. 148 (records)—Barber, 1914, p. 522 (records)—Parshley, 1915, p. 174 (descriptive note)—Stoner, 1916, p. 306 (la. distribution)—Stoner, 1917, p. 44 (record)—Van Duzee, 1917, pp. 37–38 (synonymy, distribution)—Parshley, 1917, p. 19 (N. England distribution)—Hart, 1919, p. 188 (host)—Stoner, 1920, pp. 75–76 (description, hosts)—Britton, 1920, p. 82 (record)—Hussey, 1922, p. 13 (host)—Parshley, 1923, p. 761, Pl. 18, fig. 12 (descriptive note, records, host)—Stoner, 1925, p. 54 (on reeds) Blatchley, 1926, pp. 123–124 (keyed, description, hosts)—Leonard, 1926, p. 80 (records)—Torre-Bueno, 1939, p. 217 (keyed)—Froeschner, 1941, p. 129 (descriptive note, records)—Esselbaugh, 1946,



p. 676 (eggs)—Esselbaugh, 1948, pp. 23–25 (biology, hosts)—Decoursey & Esselbaugh, 1962, pp. 327–328, fig. 2 (nymph)—McDonald, 1966, p. 19, figs. 115–118 (male genitalia)—McPherson, 1970, p. 48, fig. 31 (Mich. distribution)—Hoffman, 1971, p. 43 (record)—Oetting & Yonke, 1971, pp. 456–457 (biology, hosts)—Furth, 1974, pp. 27–28, fig. 12 (description, hosts, record)—Schaefer, 1974, p. 230 (trichobothria)—McPherson, 1974, pp. 940–941 (biology)—McPherson & Mohlenbrock, 1976, p. 148 (hosts, parasites).

Dorsum yellowish brown to medium brown with head, anterior part of pronotum and scutellum darker brown to black; ivory markings consist of part or all of pronotal collar usually, transverse callous behind cicatrices, anterolateral margins of pronotum, on scutellum submarginal callous along frena and marginal border apically, mesial spot at base of scutellum, costal margin of coria basally, and lateral margin of connexiva; membrane hyaline excepting large heavily fumose area at inner angle. Venter dark castaneous to black excepting ivory lateral margins of abdomen and posterolateral angle of metapleura. Legs including coxae and sometimes genital plates yellowish brown; coxae darkly punctate, femora and tibiae darkly dotted. Third antennal segment distally, all of last 2 segments excepting narrow basal rings, fuscous to black; remainder of antennae brownish yellow.

Humeri obtusely rounded, scarcely produced; anterolateral margins of pronotum shallowly concave or sinuous. Scutellum about as wide as long, 1.8–2.6 mm wide at base, 1.9–2.6 mm long. Body length with membranes 5.7–7.2 mm.

Basal plates densely punctate, their mesial margins contiguous and together tectiform; distal margins convex; surface impressed near lateral angles (Fig. 4).

Dorsal margin of pygophore sinuous, deeply emarginated mesially; emargination largely bridged by inferior ridge (Fig. 5).

*Distribution.*—Ontario and Quebec in Canada; from Maine to Florida and westward into the Dakotas, Wyoming, Colorado, Oklahoma and Texas in the United States; and Mexico (Tamaulipas). Uhler's (1887) report of this species in Cuba, reiterated often without indication of source, is undoubtedly erroneous.

I have seen specimens from Alabama, Arkansas, Georgia, Louisiana, Maryland, Mississippi, Tennessee and West Virginia, states for which no previous record seems to exist.

*Comments.*—There are several references to hosts of this species, but the insect has been reared through all nymphal instars only on a sedge (McPherson, 1974). However, the bug will feed on several diverse plants and may utilize a succession of hosts in the field.

This is the only North American species of the subgenus *Melanochila*.

*Type*.—Zimsen (1964) did not locate Fabricius' type material of this species.

*Mormidea montandoni* Kirkaldy, 1902

*Mormidea montandoni* Kirkaldy, 1902, p. 165.

Black above, with yellowish border on juga from apex caudad almost to ocelli, on base of head laterad of ocelli, on anterolateral and posterolateral margins of pronotum, on all sides of scutellum, and on costal margin of coria basally; callous traversing pronotum at posterior limit of cicatrices (but separated from anterolateral borders), callous along radial vein, connexiva where exposed, all yellowish; membrane darkly fumose. Venter basically yellowish with black markings; abdomen with 7 longitudinal black vittae, 3 on each side of mesial one; the two most lateral vittae on each side extend along thorax, these interrupted at posterior margin of prothorax and with complete or partial connections near anterior margin of mesothorax and both anterior and posterior margins of prothorax; black macule present on head anterior to antennifer, another beneath rostrum. Antennae black except about basal 7 tenths of last segment, and sometimes joints, yellow. Femora yellowish with broad preapical black band; tibiae black basally and distally, usually with a relatively narrow intermediate black band separating yellowish bands, sometimes with basal black band broken into macules.

Humeral angles little produced, acute, clearly emarginated on posterolateral margin; anterolateral pronotal margin shallowly concave, entire. Scutellum much longer than wide at base, 2.3–2.8 mm wide, 2.9–3.3 mm long. Body length with membranes about 7.0–8.1 mm.

Mesial margin of basal plates quite concave, contiguous basally, widely separated apically; basal plates compressed at acute apical angle; posterior margin of plates nearly straight (Fig. 6).

Dorsal pygophoral margin from caudal view moderately emarginated mesially, barely impressed on each side where dark marking begins on reflexed margin; macule at base of pygophore broad, black (Fig. 7). Parameres as in Figure 8.

*Distribution*.—Peru, Ecuador.

*Comment*.—From *M. bridarolli*, which is similar in appearance, this species is readily distinguished by the black leg bands. The legs of *M. bridarolli* have numerous scattered dark spots but no bands.

*Type*.—The type was not located.

*Mormidea bridarolli* Pirán, 1963

*Mormidea bridarolli* Pirán, 1963, p. 108–109.

The following differentiates *M. bridarolli* from *M. montandoni* and in part amplifies the original description.

Coria mesad of yellowish callous, or all of coria, and sometimes scutellum and pronotum posteriorly, brown to fuscous. Numerous dark spots scattered on femora and tibiae but no broad dark band. Dark ventral vittae (7 on abdomen, 2 on each side of thorax) usually absent or much reduced. Basal 2–3 tenths of fourth antennal segment as well as basal 5–6 tenths of last segment and usually at least basal portion of first three segments, pale.

Basal plates similar to those of *M. montandoni*, but mesial margins well separated throughout.

Reflexed dorsal margin of pygophore conspicuously impressed on each side; dark marking at base of pygophore and laterally on reflexed dorsal margin absent or represented by a few small spots. Parameres as in Figure 9.

*Distribution*.—Peru, Colombia (Putumayo), Ecuador and Bolivia (type locality: Chulumani, Sur Yungas, La Paz Dept.).

*Comment*.—The first antennal segment does not quite reach the apex of the head contrary to the statement in the original description that this segment surpasses the apex of the head.

*Types*.—The type material, in the private collection of A. A. Pirán, was not seen.

*Mormidea purpurescens* Van Duzee, 1931

*Mormidea purpurescens* Van Duzee, 1931, p. 93.

Black above; lateral border of head to ocelli, base of head narrowly to ocelli, anterolateral margins of pronotum, transverse callous across pronotum at posterior margin of cicatrices (but not extending to anterolateral border), costal margin of coria basally, and connexivum, all yellowish or ivory; membranes fumose. Venter brownish yellow, darkly marked as basal macule on disk of first visible abdominal sternite. Basal half of last antennal segment and basal 2 tenths of fourth pale, remainder of these segments fuscous. Femora and tibiae with numerous dark spots.

Anterolateral margins of pronotum moderately concave, entire; humeral angles somewhat produced laterad, narrowly rounded. Scutellum 2.5–2.8 mm wide at base, 2.5–2.7 mm long.

Mesial margin of basal plates concave, contiguous basally only; posterior

margin slightly convex; acute apex of basal plates compressed, covered by dark macule.

*Distribution*.—Bolivia (La Paz) and Peru (Cuzco).

*Comment*.—Of the four species in the subgenus *Melanochila* this is the only one that has none of the scutellar margins bordered with ivory.

*Type*.—The female type, in the California Academy of Sciences, was examined.

*Mormidea bovilla* (Distant, 1887)

*Euschistus bovillus* Distant, 1887, p. 61—Synave, 1969, p. 5 (type data).

*Mormidea bovilla*: Bergroth, 1891, pp. 220–223—Bergroth, 1906, pp. 2–3 (generic placement reaffirmed).

*Euschistus bovillus*: Distant, 1899, p. 438.

Dorsum castaneous or brown; coria along basal half of costal margin, exposed part of connexiva and often tip of humeri paler; membranes fumose. Appendages and venter rather uniformly colored and lighter than dorsum, or almost concolorous with dorsum excepting pale narrowly calcaused margins of abdomen.

Humeri cornute, sweeping upward, usually with a preapical tubercle on posterior margin (Fig. 10). Scutellar width at base subequal to length, 3.2–3.5 mm wide by 3.4–3.5 mm long. Body length with membranes about 9–10 mm.

Basal plates subtriangular, both mesial and posterior margins convex; mesial margins well separated at base, contiguous or nearly so at apical angles (Fig. 11).

Punctuation on ventral surface of pygophore strong, rather sparse, irregularly arranged; dorsal margin from caudal view with broad, moderately deep, V-shaped emargination (Fig. 12).

*Distribution*.—Brasil (Mato Grosso, Minas Gerais, Rio de Janeiro); Ecuador (Napo-Pastaza); Surinam.

*Comment*.—The form of the humeri distinguishes this species. In transferring this species from *Euschistus* to *Mormidea*, Bergroth (1891) quipped “—il a le facies [of *Euschistus*], mais non les caracteres.” In fact, it does not closely resemble any other member of either genus.

*Types*.—In describing this species, Distant (1887) wrote: “One specimen is contained in the Van Volxem collection and a second unlocalised one, has been for years in my possession.” Synave (1969) lists the Van Volxem

specimen, among the type material in the Institut Royal des Sciences Naturelles de Belgique, as the holotype. Since the second specimen cannot be recognized surely, the Van Volxem specimen may be regarded as the sole specimen identifiable as one of the two syntypes. This specimen, a male, was examined.

*Mormidea geographica* (Fabricius, 1803)

*Cimex geographicus* Fabricius, 1803, p. 159.

*Mormidea brevis* Walker, 1867, p. 256, NEW SYNONYMY.

*Mormidea geographica*: Stål, 1868, p. 27 (description of type).

*Euschistus brevis*: Distant, 1899, p. 437.

*Oenopiella testacea* Ruckes, 1958, pp. 150–152, NEW SYNONYMY.

Dorsum light brown or castaneous, mottled on pronotum and scutellum with darker blotches; punctation dark castaneous to fuscous; thin impunctate line along meson of pronotum often continues onto scutellum, from each side of this line a pale vague ray diverges from anterior pronotal margin onto pronotal disk; anterior half of pronotal margin sometimes fuscous; membrane slightly fumose; connexiva concolorous with venter, marked by dark marginal spot on each side of sutures. Venter and appendages yellowish brown with thoracic punctures, dots on legs and usually distal 6–7 tenths of each of last two antennal segments fuscous to black.

Anterolateral margins of pronotum entire, sinuous, deeply concave before humeri; humeral angles spinose, directed laterad, slightly retroarcuate, deeply emarginated on posterolateral margin (Fig. 13). Scutellum as wide or a little wider at base than long, 2.1–3.0 across base, 2.0–2.8 long. Body with membrane about 6–7 mm long.

Basal plates almost uniformly colored; mesial margins sinuous, overlapping basally, contiguous distally, parenthetically separated subapically; posterior margin sinuous; apical angle of each plate acute (Fig. 14).

Posterior pygophoral margin with deep wide arcuate emargination from ventral view. Theca with pair of dorsal appendages attached internally (Fig. 15).

*Distribution*.—Bolivia (Beni); Brazil (Amazonas, Pará); Peru (Amazonas, Loreto, San Martin); and Venezuela (Amazonas). This species seems to be distributed through much of the drainage area of the Amazon River and its tributaries.

*Comment*.—Stål correctly noted the aberrance of this species within *Mormidea* and its similarity to *Euschistus*, in which genus Distant (1899) placed Walker's species. The insect has attributes of both genera. Although the

male genitalia are like those of numerous *Euschistus* species, considering the difficulties of a practical classification of the subfamily it seems best simply to note the aberrant nature of the species and to leave undisturbed its generic placement.

*Types*.—The type of *Cimex geographicus*, a female, in the Universitetets Zoologiske Museum, Copenhagen, of *Mormidea brevis*, a female, in the British Museum (Natural History) and of *Oenopiella testacea*, a male, in the American Museum of Natural History, were examined and found not to differ significantly other than in sex.

*Mormidea speciosa* Haglund, 1868

*Mormidea speciosa* Haglund, 1868, p. 155—Stål, 1872, p. 20 (keyed).

Head, band along anterior of pronotum to include cicatrices and extending submarginally with diminishing breadth toward humeri, and submarginal callous along basal part of frena light brown; anterolateral margins of pronotum, posterolateral margins thinly, costal margin of coria basally, apex of scutellum, and connexivum ivory; remainder of dorsum metallic green; punctation dense and strong on exocoria, rugose on pronotum and scutellum where metallic green, elsewhere on dorsum less dense and weaker; membrane darkly fumose. Venter brownish yellow, concolorously punctate excepting several weak dark punctures on prothorax; disk of abdomen smooth. Antennae entirely fuscous excepting basal segment, this pale beneath. Femora brownish yellow with black spots which distally become larger and coalesce; tibiae excepting a few small pale macules and tarsi fuscous.

Humeri acutely angular; anterolateral margins of pronotum nearly

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PLATE 2

Figs. 17–20. *M. cornicollis*. Fig. 17. Left humerus and anterolateral margin of pronotum. Fig. 18. Basal plates. Fig. 19. Pygophore, caudal view. Fig. 20. Superior ridge of pygophore, dorsal view.

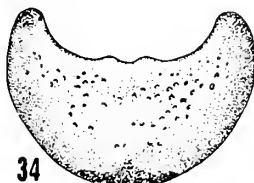
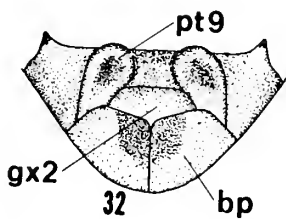
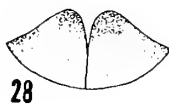
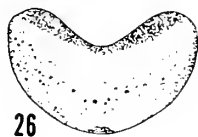
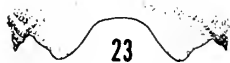
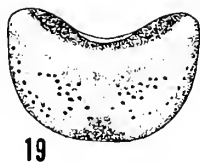
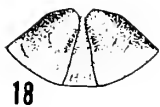
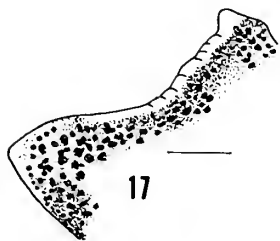
Figs. 21–24. *M. fusca*. Fig. 21. Basal plates. Fig. 22. Pygophore, caudal view. Fig. 23. Superior ridge of pygophore, dorsal view. Fig. 24. Left paramere, dorsomesial view with anterior part to right.

Figs. 25–27. *M. hamulata*. Fig. 25. Basal plates. Fig. 26. Pygophore, caudal view. Fig. 27. Superior ridge, dorsal view.

Figs. 28–30. *M. integella*. Fig. 28. Basal plates. Fig. 29. Pygophore, caudal view. Fig. 30. Inferior ridge of pygophore, dorsal view.

Figs. 31–34. *M. vava*. Fig. 31. Apex of scutellum. Fig. 32. Genital plates: basal plates (bp); second gonocoxae (gx2); ninth paratergites (pt9).

Dimensional line in Fig. 17 equals 0.5 mm and applies to Figs. 17–19, 21–22, 25–26, 28–30, 32–34. Figs. 20, 23–24, 27, 33 are twice this magnification. Fig. 31 is half this magnification.



straight, entire. Scutellum 2.5 mm wide at base, 2.9 mm long. Length of body with membranes about 7.5 mm.

Posterior margin of pygophore bisinuate from both ventral and dorsal view (Fig. 16); proctiger terminating convexly, distal margin reflexed.

Female unknown.

*Distribution*.—Amazon region. Known only from type.

*Comment*.—The metallic green color of most of the dorsum sets this species apart from all known congeners.

*Type*.—Male, in Naturhistoriska Riksmuseet, Stockholm. Examined.

*Mormidea cornicollis* Stål, 1860

*Mormidea cornicollis* Stål, 1860, p. 21—Stål, 1872, p. 21 (keyed).

*Mormidea jheringi* Berg, 1891, pp. 241–242. NEW SYNONYMY.

*Mormidea iheringi*: Backup, 1961, p. 11 (record).

Dorsum black, ivory along anterolateral margins of pronotum, costal margins of coria basally, and lateral margin of connexiva; a small pale mesial spot present on base of scutellum, occasionally also behind each cicatrice and in each basal angle of scutellum; membranes fumose. Venter brownish yellow with black mesial vitta on abdomen; punctation, apex of humeri, small diffuse spot at distal ends of supracoxal clefts, and spiracles all black or fuscous; mesial abdominal vitta continuous, composed of contiguous subtrapezoidal spots, one on each sternite; many punctations on abdominal venter usually arranged in vague subspiracular vitta on each side. Basal segment of antennae ivory with dorsolateral dark dot or stripe distally; succeeding segments black with ivory basal ring, that on last segment occupying about half of segment.

Humeri acute or subacute; anterolateral margins entire, angularly concave, vertically rugose (Fig. 17). Scutellar width at base a little less than length, 2.8–3.1 mm wide by 2.9–3.3 mm long. Body with membranes about 8.5–10.5 mm long.

Distal two-thirds of basal plates black, roughened by a few diagonal furrows; mesial margins nearly straight, widely separated basally, contiguous or nearly so distally (Fig. 18).

Dorsal margin of pygophore concave from caudal view (Fig. 19). Superior ridge reduced to subquadrate projection on each side of meson. (Fig. 20).

*Distribution*.—Argentina (Misiones); Brazil (Paraná, Rio Grande do Sul, Rio de Janeiro, Santa Catarina, São Paulo).

*Comment*.—This species may be distinguished from *M. fusca* by the form of the basal plates and the superior ridge.



*Types*.—From the syntypes of *Moridaea cornicollis* Stål the following specimen is selected as LECTOTYPE: female, labeled (a) Rio Jan (b) Stål (c) Type (d) Paratypus (e) 408/75 (f) Riksmuseum Stockholm. The PARALECTOTYPE is a male, labeled (a) Brasil (b) F. Sahlb (c) ♂ (d) Type (e) Typus (f) 145/56 (g) 407/75 (h) Riksmuseum Stockholm.

These specimens have the humeri produced to a degree found in only a small minority of specimens.

Regarding *Mormidea jheringi*, Berg's (1891) statement "El ejemplar tipico brasilero conserva el Museo de Montevideo, los dos argentinos forman parte de mi coleccion hemipterologica." can be construed to mean that the Brazilian specimen is the holotype, but I do not so interpret it because he habitually treated all specimens of a type series as syntypes and labeled them "typus." Therefore, I designate as LECTOTYPE of *Mormidea jheringi* Berg a female labeled (a) Typus (b) Misiones (c) *Mormidea jheringi* Berg 1891 (d) Berg (e) Museo La Plata. PARALECTOTYPES: male, labeled (a) Typus (b) Misiones (c) 1378 (d) Col. Berg (e) Museo La Plata; male labeled (a) Brasil (b) Typus. (in Museo Nacional de Historia Natural, Montevideo).

*Mormidea fusca* Stål, 1872

*Mormidea fusca* Stål, 1872, p. 21.

*Mormidea angulosa* Stål, 1872, p. 21. NEW SYNONYMY.

Dorsum fuscous with humeral angles, pronotum anteriorly and head black, or entirely black; spot behind each cicatrice, small tooth at anterolateral angles of pronotum, narrow costal margins of coria basally, and lateral margins of connexiva brownish yellow; often in addition on scutellum a small mark in basal angles, another mesially at base, and apical margin pale; membranes fumose. Venter brownish yellow; punctation, thoracic sterna, small spot near distal end of supracoxal clefts, apex of humeri usually, mesial abdominal vitta, spiracles usually, all fuscous or black. Proximal 3 segments of antennae brownish yellow or rufous, distal 2 segments fuscous or black with basal ivory rings covering about a third of segment 4, half of last segment. Legs about color of venter with numerous black dots; femora usually becoming rufous on distal half.

Anterolateral margins of pronotum concave, entire; humeral angles usually acute, directed obliquely forward, with posterolateral margin of humeri and costal margin of coria forming continuous contour, but sometimes narrowly rounded to acute and produced laterad. Scutellum longer than wide, 2.7–3.0 mm wide at base, 2.9–3.2 mm long. Body with membrane about 8.5–9.5 mm long.

Basal plates impunctate or shallowly punctate, usually with a few fine

longitudinal furrows, fuscous above second gonocoxae; mesial margins straight, usually somewhat divergent distally; posterior margins convexly arcuate (Fig. 21).

Dorsal margin of pygophore moderately concave from caudal view; a large black mesial spot at base of pygophore (Fig. 22). Superior ridge not reduced, mesially emarginated (Fig. 23). Parameres as in figure 24.

*Distribution*.—Colombia (Antioquia, Choco, Cundinamarca, Magdalena); Venezuela (Aragua, Merida, Miranda). Kirkaldy (1909) lists Bolivia and Trinidad under *M. angulosa*, but these records are doubtful.

*Comment*.—Most specimens of this species so far examined have femora that become rufous on the distal half, differing in this respect from congeners with a fuscous or black dorsum that is inconspicuously relieved by pale markings. *M. fusca* is much like *M. cornicollis* in appearance, but the two species differ vastly in the form of the basal plates and superior ridge.

*Types*.—From the type series of *Mormidea fusca* Stål, the following specimen is selected as LECTOTYPE: male, labeled (a) Bogata (b) Lindig (c) Type (d) Paratypus (e) 299/76 (f) Riksmuseum Stockholm. PARALECTOTYPES are: female, labels (a) (b) (c) (f) as lectotype (d) Paratypus (e) 300/76; female, labels (a) (b) (f) as lectotype (c) Allotypus (d) 144/56 (e) 302/76. The last specimen listed is proportionately a little broader and more densely punctate than common.

From the type series of *Mormidea angulosa* Stål, the following specimen is designated as LECTOTYPE: female, labeled (a) Bogota (b) Lindig (c) Type (d) *angulosa* Stål (e) Typus (f) 146/56 (g) 405/75 (h) Riksmuseum Stockholm. PARALECTOTYPE: female, (a) Bogota (b) Lindig (c) Type (d) Paratypus (e) 406/75.

#### *Mormidea hamulata* Stål, 1860

*Mormidea hamulata* Stål, 1860, p. 21—Stål, 1872, p. 21 (keyed).

*Mormidea pullata* Berg, 1891, pp. 242–243. NEW SYNONYMY.

Fuscous above, costal margins basally, connexiva, often a spot behind each cicatrice, mesial spot at base of scutellum and spot on disk of each corium brownish yellow to ivory; punctation except on endocoria dense, somewhat rugose on pronotum and scutellum; membrane heavily fumose. Venter brownish yellow, sometimes rufously suffused; lateral margins of abdomen and of metepimeron narrowly calloused, impunctate or nearly so, yellowish. Black or fuscous subtriangular or semicircular spot on each abdominal sternite usually solidly colored on first and fifth visible sternites, usually only outlined or partially obscure on intervening sternites, together forming a continuous or interrupted mesial vitta. Legs mostly rufous with small fuscous spots. Basal 3 segments of antennae nearly concolorous with

venter, third often darker distally; last 2 segments fuscous with about basal 2 tenths of fourth and basal half of fifth segment ivory.

Anterolateral margins of pronotum entire, concave; humeral angles produced laterad, acute or subacute. Scutellum slightly longer than wide, 3.0–3.4 mm across base, 3.1–3.6 mm long. Body length with membranes about 9–10.5 mm.

Mesial and posterior margins of basal plates concave; apex of plates digitiform, black, longitudinally furrowed (Fig. 25).

Pygophore emarginate in broad even arc from caudal view, deeply impressed mesially beneath inferior ridge (Fig. 26); superior ridge semicircularly emarginated at meson (Fig. 27).

*Distribution.*—This species seems most common in southeastern Brazil (Distrito Federal, Rio de Janeiro, Santa Catarina). Specimens were seen from Argentina (Misiones), Bolivia (Santa Cruz) and Trinidad. Stål (1872) gave "Nova Granada" as a locality. The listing of *M. hamulata* by Stål (1862) in "Hemiptera mexicana—" must have been inadvertent. This error was perpetuated by Walker (1867, p. 254), Distant (1880, p. 56) and Uhler (1886, p. 6).

*Comment.*—Of sympatric congeners, *M. hamulata* resembles most closely *M. cornicollis*. The latter species is readily separable from the former by the pale border, visible from above, along the anterolateral margins of the pronotum, by the form of the basal plates, and by the shape of the superior ridge in the genital cup.

*Types.*—From the syntypes of *Mormidea hamulata* the following specimen is designated LECTOTYPE: male, labeled (a) Brasil (b) F. Sahlb. (c) ♂ (d) Type (e) Typus (f) 143/56 (g) 410/75 (h) Riksmuseum Stockholm. The three following specimens are PARALECTOTYPES: female, labeled (a) hamulata Stal (b) Type (c) Rio Jan (d) Allotypus (e) 411/75 (f) Riksmuseum Stockholm; female, labeled (a) Rio Jan (b) Stal (c) Paratypus (d) 412/75 (e) Riksmuseum Stockholm; male, labeled (a) Brasil (b) F. Sahlb. (c) Paratypus (d) 413/75 (e) Riksmuseum Stockholm.

The type of *Mormidea pullata* Berg, a male, in the Universidad Nacional de La Plata, Facultad de Ciencias Naturales y Museo, seems not to differ in any significant aspect from the specimens upon which Stål based the senior synonym *M. hamulata*.

*Mormidea integella* (Distant, 1893)

*Euschistus integellus* Distant, 1893, p. 456.

*Mormidea integella*: Rolston, 1974, p. 6.

Black above, or fuscous with humeri, pronotum anteriorly and head black; spot on disk of each corium paler; connexiva ivory; membranes

heavily fumose. Venter pale yellow to brownish yellow; most punctures, sterna, small spots near end of supracoxal clefts, and mesial vitta of abdomen fuscous or black. Appendages basically brownish yellow; legs dotted with black; basal 3 segments of antennae specked with black, last two segments black excepting about basal 2 tenths of segment 4 and basal half of fifth segment.

Anterolateral margins of pronotum concave, entire; humeral angles narrowly rounded. Width of scutellum less than length, 3.1 mm wide at base, 3.3 mm long. Body with membranes about 8–9 mm.

Basal plates impunctate, convex; mesial margins straight, contiguous basally, slightly divergent distally; posterior margins sinuous; apical angles rounded, fuscous (Fig. 28).

Dorsal margin of pygophore from caudal view truncately concave (Fig. 29); inferior ridge produced caudad into triangle extending nearly to pygophoral margin (Fig. 30).

*Distribution*.—Known only from the type locality, Chiriquí, Panama. Specimens were again captured there in 1974.

*Comment*.—Of those species of *Mormidea* that are fuscous or black above save for a few inconspicuous paler markings, only *M. integella* and *M. vaya* are known to occur in Panama. The remarkably formed inferior ridge of *M. integella* is distinctive within the genus.

*Types*.—Distant (1893) in describing this species stated that he had seen only 6 specimens. The number is no doubt a typographical error, perhaps an inversion, because there are 9 specimens in the British Museum (Natural History) the labeling of which indicates that all belong to the syntype series. From these syntypes the following specimen of *Euschistus integellus* Distant is designated LECTOTYPE: Male, labeled (a) Type (b) V. de Chiriquí, 25–4000 ft. Champion (c) B.C.A. Hem. I *Euschistus integellus* (d) Brit. Mus. Type No. Hem. 1040. The remaining 8 specimens, the PARALLECTOTYPES, consist of 6 males and 2 females bearing labels indicated above as (b) and (c).

*Mormidea vaya* n. sp.

Black above, except exposed connexiva, mesial dot at base of scutellum and very apex of scutellum pale; membrane heavily fumose. Venter brownish yellow; on abdominal disk first and last sternites and anterior margin of intervening segments black, as well as spot at base of pygophore and thoracic sterna; punctation black, rather dense and irregular on each side of abdomen, sparse on abdominal disk. Legs brownish yellow with black spots; apex of tibiae and all tarsi black. Antennae black, with very base of third segment, basal 2 tenths of fourth and basal half of last brownish yellow.

Humeri produced laterad, narrowly rounded at apex; anterolateral margins of pronotum entire, sinuous. Scutellum about 3.4 mm wide at base, 3.6 mm long; apex acute (Fig. 31). Body length with membrane about 9.7 to 10.2 mm.

Mesial margins of basal plates contiguous; most distal part of posterior margin above paratergite 9 (Fig. 32); apical angles fumose.

Dorsal pygophoral margin broadly concave to moderate depth; emargination sinuous mesially (Fig. 34). Digitiform projection on parameres (Fig. 33).

*Distribution.*—Panama.

*Types.*—Holotype: female, labeled Cerro Campana 800M, Distr. Chame, Panama, 2-V-76. Col. H.D. Engleman. USNM type no. 72135. Segments 4 and 5 of the right antenna are fused, without the pale band at the base of 5. Paratype: male, labeled (a) El Valle, Panama, Prov. Cocle 500 M, 2-VII-74 (b) Col. Henry Hesperheide. (HDE)<sup>1</sup>.

*Comment.*—The other black or fuscous species of *Mormidea* without a conspicuously pale scutellar apex that are or may be sympatric with this species are *M. fusca* and *M. integella*. Females of *M. vaya* are distinguished from these species by the basal plates. The unique inferior ridge of *M. integella* identifies this species. Differences in the pygophoral margin and parameres (Figs. 32, 24) and usually the scutellar apex and femoral coloration separate *M. vaya* and *M. fusca*.

*Mormidea discoidea* (Dallas, 1851)

*Rhaphigaster discoideus* Dallas, 1851, p. 290.

*Mormidea discoidea*: Walker, 1867, p. 555—Stål, 1872, p. 20 (keyed, description).

*Mormidea notulata*: Distant, 1880, pp. 55–56 (in part)—Distant, 1889, p. 328 (in part).

Dorsum black; ivory spot present behind each cicatrice, mesially at base and at apex of scutellum, on disk of each corium; small blunt tooth at anterolateral angles of pronotum and lateral margin of coria basally also ivory; connexiva black with yellowish brown marginal macule of various shapes on each segment; membranes fumous. Venter brownish yellow with broad border along lateral cephalic margins, thoracic sterna, thoracic punctures, humeri near apex, a continuous mesial abdominal vitta and on each side basally a diffuse lateral subspiracular vitta, and spiracles fuscous or black. Basal segment of antennae brownish yellow, usually with dorsolateral longitudinal dark streak; following segments darker, distal two fuscous with about basal 2 tenths of each pale.

Anterolateral margins of pronotum subangularly concave, entire; humeri little produced, rounded. Scutellum a little longer than wide at base, 2.8—3.1 mm wide by 3.0—3.4 mm. long. Body length with membrane about 8.5—10 mm.

Basal plates almost entirely covered by large fuscous spot; mesial margins contiguous, posterior margin unevenly concave (Fig. 35).

Mesial 2 thirds of dorsal pygophoral margin moderately concave from caudal view; surface of pygophore unevenly contoured, with black mesial spot at base (Fig. 37). Parameres with process directed posterodorsad (Fig. 36).

*Distribution*.—Mexico (Colima, Guanajuato, Guerrero, Jalisco, Michoacán, Morelos, Oaxaca). Records given by Distant (1880, 1889) must be disregarded because he confused this species with the more common *M. notulata*.

*Comment*.—Distant (1880) regarded *M. discoidea* as a junior synonym of *M. notulata*. Although these two species are similar in appearance, the genitalia differ appreciably in both sexes.

*Type*.—Male, in British Museum (Natural History). Examined.

*Mormidea notulata* (Herrich-Schäffer, 1844)

*Pentatoma notulatum* Herrich-Schäffer, 1844, p. 100, fig. 765.

*Mormidea notulata*: Dallas, 1851, p. 213—Stål, 1862, p. 103 (descriptive

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PLATE 3

Figs. 35–37. *M. discoidea*. Fig. 35. Basal plates. Fig. 36. Left paramere, dorsomesial view with anterior part to right. Fig. 37. Pygophore, caudal view.

Figs. 38–40. *M. notulata*. Fig. 38. Basal plates. Fig. 39. Pygophore, caudal view. Fig. 40. Left paramere, dorsomesial view with anterior part to right.

Figs. 41–42. *M. angustata*. Fig. 41. Basal plates. Fig. 42. Pygophore, caudal view.

Figs. 43–45. *M. collaris*. Fig. 43. Basal plates. Fig. 44. Pygophore, caudal view. Fig. 45. Proctiger, dorsal view.

Figs. 46–48. *M. notulifera*. Fig. 46. Basal plates. Fig. 47. Pygophore, caudal view. Fig. 48. Proctiger, dorsal view.

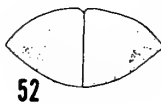
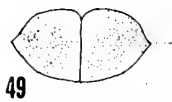
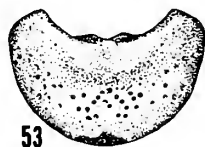
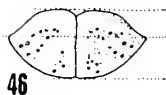
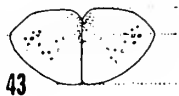
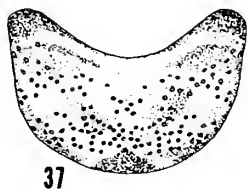
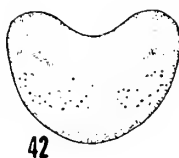
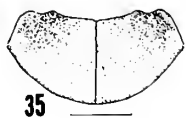
Figs. 49–51. *M. maculata*. Fig. 49. Basal plates. Fig. 50. Proctiger, dorsal view. Fig. 51. Pygophore, caudal view.

Figs. 52–53. *M. rugosa*. Fig. 52. Basal plates. Fig. 53. Pygophore, caudal view.

Figs. 54–55. *M. dana*. Fig. 54. Basal plates. Fig. 55. Pygophore, caudoventral view.

Figs. 56–57. *M. faisana*. Fig. 56. Basal plates. Fig. 57. Pygophore, caudoventral view.

Dimensional line in Fig. 35 equals 0.5 mm and applies to Figs. 35, 37–39, 41–57. Figs. 36, 40 are twice this magnification.



note)—Stål, 1872, p. 20 (keyed, synonymy)—Distant, 1880, pp. 55–56 (in part), Pl. 5, fig. 12—Distant, 1889, p. 328 (in part).

Appearing black, but coria, scutellum and basal disk of pronotum actually in large part yellowish brown between dense black punctation; margin of coria basally and connexiva laterally, ivory; small ivory spot located behind each cicatrice, in each basal angle, mesially at base of scutellum, and on disk of each corium; apex of scutellum covered by large white or ivory spot; spot in basal angles of scutellum occasionally elongated as submarginal band along frena. Venter yellowish brown with sparse black punctation on thorax; lateral band of punctures on abdomen often in part black mesad of black spiracles; sterna and spot at distal end of supracoxal clefts black; mesial vitta on abdomen black, irregularly margined, composed of more or less triangular spots, one on each segment. Basal segment of antennae pale with fuscous streak distally on outer side; next 2 segments fuscous, pale at joint between them; distal 2 segments fuscous excepting pale band around basal fourth of penultimate segment and basal third of last segment.

Humeri narrowly rounded to spinose; anterolateral margins concave, often angularly so, entire. Scutellum longer than basal width, 2.3–2.7 mm wide, 2.7–3.2 mm long. Body length with membrane about 7.8–9.0 mm.

Basal plates subtriangular, mesial margins clearly concave, distal margin nearly straight; apical angle of each plate covered by large dark spot (Fig. 38).

Dorsal margin of pygophore moderately concave from caudal view, concavity extending for entire width, occasionally with small mesial convexity (Fig. 39); posterior margin from ventral view usually straight, occasionally somewhat trisinate; black mesial spot present on ventral surface of pygophore at base. Parameres triangular without a posterodorsal process (Fig. 40).

*Distribution.*—From Nuevo Leon state, Mexico, southward throughout Central America. Also present in Colombia (Magdalena) and Peru (Lambayeque).

*Comment.*—Similar to *M. discoidea* in general appearance, the males of the two species are best separated by the parameres and the females by the basal plates.

*Type.*—The type was not located.

*Mormidea angustata* Stål, 1862

*Mormidea angustata* Stål, 1862, pp. 102–103—Stål, 1872, p. 20 (keyed)—Distant, 1880, p. 55, Pl. 5, fig. 10 (synonymy)—Barber & Bruner, 1932, pp. 250–251 (keyed, descriptive note)—Barber, 1939, pp. 287–288 (keyed,



hosts)—Wolcott, 1936, p. 175 (record)—Wolcott, 1948, p. 191 (hosts)—Alayo, 1967, pp. 10, 11, Pl. 9, figs. 1, 2 (keyed, synonymy, descriptive note).

*Mormidea pulchella* Walker, 1868, pp. 552–553—Distant, 1900, p. 430 (generic placement). NEW SYNONYMY.

*Mormidea lemoulti* Bergroth, 1914, pp. 426–427. NEW SYNONYMY.

*Mormidea ypsilon*: Wolcott, 1923, p. 253—Wolcott, 1936, p. 175 (misdetermination fide Wolcott, 1948).

Dorsum light brown with darker punctation; humeral angles black at apex; ivory spot varying in size usually present behind each cicatrice, also mesially at base and at apex of scutellum, and on each corium; submarginal callous extending from each basal angle to distal end of frenum usually ivory; punctation on exocoria often rufous, color suffusing from punctures; endocoria semitransparent; connexiva light brown; membrane hyaline. Venter brownish yellow; thorax darkly punctate with black spot near distal end of supracoxal clefts, those spots on mesothorax and metathorax largest, as large or larger than diameter of tibiae; abdominal venter immaculate or with mesial row of brown to fuscous spots, each at base of sternite. Basal segment of antennae usually lighter in color than remaining segments, these light brown to dark castaneous or fuscous, none with white basal band.

Humeri acute to spinose; anterolateral margins of pronotum entire, sinuous or concave. Scutellum longer than wide at base, 2.2–2.5 mm wide by 2.7–3.1 mm long. Body with membrane about 7–8 mm long.

Basal plates almost uniformly colored, contiguous at mesial margins, each evenly convex at posterior margin (Fig. 41).

V-shaped emargination in dorsal margin of pygophore bordered by impunctate tumescence on posterior pygophoral surface (Fig. 42).

*Distribution*.—Apparently widely spread, but uncommon, in Middle America, South America and the West Indies. Specimens examined were from Brazil (Distrito Federal, Goiás, Mato Grosso, Minas Gerais, Pará), Cuba, Dominican Republic, Ecuador, Guyana and Nicaragua. Additionally, the species is reported from French Guiana, Mexico and Puerto Rico.

*Comment*.—The large dark spot near the distal end of the supracoxal clefts on the metathorax and mesothorax, with a smaller spot on the prothorax, is diagnostic.

*Types*.—The specimens upon which Bergroth based the name *Mormidea lemoulti* were not located. His description fits some specimens of *M. angustata* and his diagnosis nearly all of them: "Bien voisine de *M. angustata* Stål dont elle se distingue cependant facilement par les deux callosités du pronotum et par les angles apicaux du sixième segment abdominal prolongés en une épine aiguë dirigée en arrière." The two calloused spots on the

pronotum are sometimes absent in *M. angustata* but are usually present and variable in size. The acuteness of the apical angles of the sixth (fifth visible) abdominal segment and of the humeral angles is correlated and both are usually spinose.

The type of *Mormidea pulchella* Walker, a female, in the British Museum (Natural History) is an ordinary example of the species, with spinose humeri and a mesial row of spots on the abdominal venter.

The type of *Mormidea angustata* Stål, a female, in the Signoret collection conserved by the Naturhistorisches Museum Wien, was not examined.

*Mormidea collaris* Dallas, 1851

*Mormidea collaris* Dallas, 1851, pp. 211–212—Stål, 1872, p. 19 (keyed)—Distant, 1880, p. 54, Pl. 5, fig. 9 (descriptive note, records)—Distant, 1889, p. 328 (records).

Dorsum usually light brown, posterior disk of pronotum darker, grading to fuscous on humeri; frequently all of dorsum dark brown to fuscous excepting anterior pronotal disk and head which are light brown to yellowish brown; punctation fuscous; large ivory spot behind each cicatrice occasionally reduced, rarely absent; small tubercle at anterolateral angles of pronotum, often an impunctate border along about half of anterolateral margins just cephalad of humeri, costal margin of coria basally, all pale yellow; submarginal ivory callous along frena sometimes reduced to large macule in basal angles, sometimes expanded to cover most of scutellum; mesial spot at base and at apex of scutellum, large spot on disk of coria, and connexiva ivory; membranes lightly fumose. Venter pale yellow; dots at distal end of supracoxal clefts, mesial blotch on first visible sternite of abdomen, suture mesially between this and following sternite, dark; linear mesial vitta often present on ultimate sternite usually faint, sometimes extending discontinuously onto preceding one or two sternites; punctation laterally on abdominal disk nearly as strong as that on thoracic pleura. Antennae light to dark brown with distal 7 to 8 tenths of each of last two segments fuscous.

Anterolateral margins of pronotum slightly sinuous, entire; humeri usually little produced, lateral angle narrowly rounded or acute, sometimes spinose and somewhat retroarcuate. Scutellum longer than wide, 2.2–2.8 mm wide at base, 2.6–3.4 mm long. Body with membranes about 7.5–9.5 mm long.

Mesial margins of basal plates contiguous at meson, posterior margins convex, usually unevenly so (Fig. 43); distance from imaginary line drawn through lateral angles of basal plates to most distal margin of plates usually 5–6 tenths, rarely less, of distance from line to base of plates at meson.

Dorsal pygophoral margin shallowly concave from caudal view, posterior

surface conspicuously depressed at dorsal margin (Fig. 44). Proctiger as in Figure 45.

*Distribution*.—From Sonora and San Luis Potosí, Mexico, southward into Panama. Stål (1872) records this species from Colombia, as well as Mexico, and this record is probably correct.

*Comment*.—This species varies considerably in color and markings. Some specimens are colored and marked like those of *M. maculata*, a species whose range includes Colombia. Females of the two species may usually be separated by proportional differences in the basal plates and the relative strength of punctation on the abdominal venter. Males of these two species are readily separable by the pygophore.

*Type*.—Male, in the British Museum (Natural History). In the form of the humeri, color and markings, the type is representative of only about 5 percent of the males. The humeri are spinose, the scutellar callous along the frena is reduced to a large macule in each basal angle, and the dorsum is strongly bicolored with the anterior pronotal disk and head much lighter in color than the remainder of the dorsum. Distant (1880) figured a specimen that is similar in appearance to the type.

*Mormidea notulifera* Stål, 1860

*Mormidea notulifera* Stål, 1860, p. 21—Stål, 1872, p. 21 (keyed)—Berg, 1878, p. 300 (record)—Buckup, 1961, p. 11 (record).

Light brown to fuscous above, usually darkest at humeri, sometimes with pronotum and/or base of scutellum darker than remainder of dorsum; ivory dot behind each cicatrice, medially at base of scutellum, and on disk of each corium varying in size, sometimes absent on pronotum; pale callous in each basal angle of scutellum usually present and extending submarginally along frenum; scutellar apex ivory; connexiva brownish yellow; membranes lightly fumose. Venter brownish yellow; punctation concolorous, close and somewhat coarse on pleura, subequal in strength but more sparse along sides of abdominal venter. Basal segment of antennae usually brownish yellow with darker lateral stripe, next two segments brown, distal two black with basal 2 tenths of fourth and basal 2 to 3 tenths of fifth ivory.

Humeri little produced, rounded; or produced laterad, somewhat retrorse, spinose; anterolateral margins of pronotum sinuous, entire. Scutellum longer than wide, 2.3–2.6 mm across base, 2.6–3.0 mm long. Length of body with membranes about 7–8.5 mm.

Mesial margins of basal plates contiguous, together forming slight tectiform elevation; posterior margins convex; distance from imaginary line drawn through lateral angles of basal plates to most distal part of posterior

margin usually 5 to 6 tenths of distance from line to base of plates at meson. (Fig. 46).

Margin of pygophore shallowly emarginate mesially from both caudal and ventral views (Fig. 47). Proctiger as in Figure 48.

*Distribution*.—Argentina (Misiones); Brazil (Bahia, Ceará, Distrito Federal, Paraná, Minas Gerais, Rio de Janeiro, Rio Grande do Norte, Rio Grande do Sul, Santa Catarina); Peru (Loreto); Uruguay (Rivera).

*Comment*.—In appearance this species is most like *M. maculata*. Males of the two species are easily distinguished by the markedly different proctiger and pygophore. The females may usually be separated by the strength of the punctation along the sides of the abdomen relative to that on the thoracic pleura. About 80% of the females of these two species are separable by the proportional length of the basal plates distad and basad of an imaginary line drawn transversely through the lateral angles of the plates.

*Type*.—The holotype, in the Naturhistoriska Riksmuseet, Stockholm, is a female that, unfortunately, is not very representative of the species. It lacks the usual pale spot behind each cicatrice, the mark in the basal angles of the scutellum is only obscurely elongated along the frena, and the proportional length of the basal plates basad and distad of a line through the lateral angles is near the mean for *M. maculata*. The abdominal punctation is characteristic, however.

*Mormidea maculata* Dallas, 1851

*Mormidea maculata* Dallas, 1851, p. 212.

Color and markings variable, usually medium brown grading to dark castaneous on basal disk of scutellum and exocoria, to black on humeri; ivory spot of variable size behind each cicatrice, on disk of each corium, on scutellum mesially at base and apex, and in basal angles; spots on pronotum often much reduced or absent, those in basal angles sometimes punctate and spread over much of scutellum; membrane fumose. Venter yellowish brown, most punctures concolorous, with or without small dark dot at distal end of supracoxal clefts; punctation laterally on abdominal sternites about as strong as that on metapleura. Proximal three segments of antennae almost uniformly colored, light brown to fuscous; distal two segments fuscous with basal fourth of each pale.

Humeral angles narrowly rounded to spinose; anterolateral margins of pronotum shallowly concave, entire. Scutellum longer than wide, 2.3–2.5 mm wide, 2.6–3.1 mm long. Body length with membrane about 7.4–8.6 mm.

Distance from imaginary line through lateral angles of basal plates to most distal margin of plates from 6 to 9 tenths of distance from line to base of

plates at meson (Fig. 49); mesial margins contiguous, elevated; posterior margins convex; apical angles covered by dark spot.

Deep mesial emargination covering two-thirds of dorsal pygophoral margin V-shaped from caudal view, sometimes slightly sinuous (Fig. 51); punctation in transverse depression beneath emargination sparse, fine, black. Proctiger as in Figure 50.

*Distribution*.—Northern South America south to northern Brazil (Acre, Amazonas, Pará), Bolivia (Bení), and Peru (Amazonas, Huánuco, Junin, Loreto, Madre de Dios, Pasco). A common species in Colombia.

*Comments*.—This species most resembles *M. notulifera*, both varying greatly in color and markings. Males of the two species are easily separated by the proctiger and the pygophore, but identification of females on the basis of basal plate proportions and relative strength of punctation on the abdominal venter is not always certain.

*Type*.—The holotype, a male, in the British Museum (Natural History) was examined.

*Mormidea rugosa* n. sp.

Ferruginous to black above, usually with a pale spot behind each cicatrice, on disk of each corium, and on scutellum mesially at base, in each basal angle and at apex; above spots, lateral margins of connexiva, costal margin of coria on basal fourth, and lateral margins of pronotum dull yellow to rufous; punctation black, usually contrasting with background; membrane slightly fumose. Venter brownish yellow; punctation black, sparse, strong; mesosternum (excepting median carina) and metasternum black; mesial vitta on abdominal venter consisting of broad basal macule on first visible sternite, a small spot (sometimes lacking) near middle of next, and progressively larger macule on each succeeding sternite; each sternite usually bearing subspiracular patch of denser punctation, together forming vague lateral vitta on each side; spiracles pale or peritreme narrowly dark. Legs brownish yellow to rufous with dark dots; antennae fuscous or black excepting mesial face of first segment, narrow basal ring on fourth, and basal 3 tenths of fifth segment, pale.

Pronotum traversed between humeri by calloused irregular fascia; humeral angles narrowly rounded to acute; anterolateral margins sinuous, entire. Scutellum 2.5–2.7 mm wide at base, 2.6–3.0 mm long. Body length with membrane about 7.9–8.7 mm.

Basal plates weakly punctate, apical angles immaculate or faintly darkened; mesial margins contiguous, posterior margins evenly convex (Fig. 52).

Dorsal pygophoral margin broadly and moderately concave from caudal view (Fig. 53), labiate from lateral view; a median dark spot basally.

*Distribution*.—Paraná and Santa Catarina states, Brazil.

*Comment*.—Most specimens are recognizable by the ferruginous color. The transverse calloused fascia between the humeri is diagnostic.

*Types*.—Holotype: male, labeled; Brasilien, Nova Teutonia, 27°11' B 52°23' L, Fritz Plaumann, 200–500 M (on edge). XII 1973 (on opposite edge). Deposited in Museu Nacional, Universidade do Brasil. Paratypes, 15♂♂, 12♀♀. Labeled as holotype excepting dates: I-6-1960 (♂♀ AMNH); XI-1-1958 (♀ AMNH); XI-19-1959 (♀ AMNH); X-1967 (♀ AMNH); XI-1973 (♂ CAS); II-1973 (♂ CAS); XI-1973 (♂ UNLP); II-1974 (♀, 4♂♂ LHR); X-1974 (♂ BMNH, ♀ USNM); XI-1974 (♂ FSCA, ♂ TAMU, ♂ MRCN, ♀ FSCA, ♀ NR); II-1974 (♂ NR); XII-1974 (♀ UNLP); XII-1975 (3♀♀ LHR); (a) Cauna, S. Cath., Brazil XII-1945 (b) A. Maller, Coll., Frank Johnson Donor (♂ AMNH); New Teutonia, Brazil Jan. 1939, Fritz Plaumann (♂ AMNH).

*Mormidea albisignis* Stål, 1872

*Mormidea albisignis* Stål, 1872, p. 20—Barber & Bruner, 1932, p. 251 (keyed, descriptive note)—Alayo, 1967, pp. 10, 11 (keyed, synonymy, descriptive note).

Light to dark castaneous above with darker punctuation at least on head; anterolateral margins of pronotum, costal margin of coria basally, spot on

→

PLATE 4

Figs. 58–59. *M. metallica*. Fig. 58. Genital plates: ninth paratergites (pt9). Fig. 59. Pygophore, caudoventral view.

Fig. 60. *M. ambigua*. Pygophore, caudal view.

Figs. 61–63. *M. paupercula*. Fig. 61. Left humerus and anterolateral margin of pronotum. Fig. 62. Basal plates. Fig. 63. Pygophore, caudal view.

Figs. 64–65. *M. cubrosa*. Fig. 64. Basal plates. Fig. 65. Pygophore, caudal view.

Figs. 66–67. *M. pictiventris*. Fig. 66. Basal plates. Fig. 67. Pygophore, caudal view.

Figs. 68–70. *M. pama*. Fig. 68. Left humerus and anterolateral margin of pronotum. Fig. 69. Basal plates. Fig. 70. Pygophore, caudal view.

Figs. 71–73. *M. albisignis*. Fig. 71. Basal plates. Fig. 72. Pygophore, caudal view. Fig. 73. Proctiger, dorsal view.

Figs. 74–75. *M. laevigata*. Fig. 74. Basal plates. Fig. 75. Pygophore, caudal view.

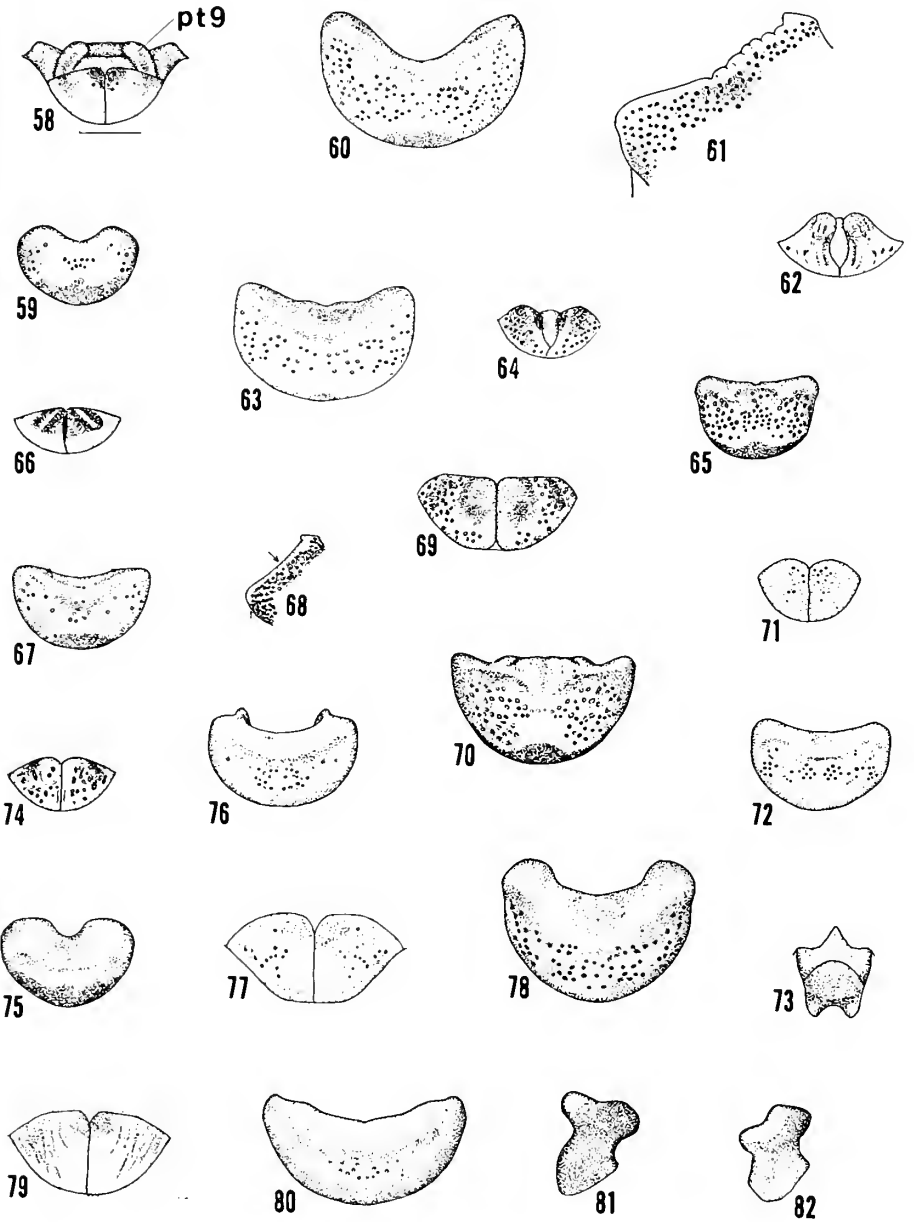
Fig. 76. *M. isla*. Pygophore, caudal view.

Figs. 77–78. *M. v-luteum*. Fig. 77. Basal plates. Fig. 78. Pygophore, caudal view.

Figs. 79–81. *M. ypsilon*. Fig. 79. Basal plates. Fig. 80. Pygophore, caudal view. Fig. 81. Left paramere, dorsomesial view with anterior part to right.

Fig. 82. *M. lunara*. Left paramere, dorsomesial view with anterior part to right.

Dimensional line in Fig. 58 equals 0.5 mm and applies to all figures except Fig. 68 which is half this magnification and Figs. 81–82 which are twice this magnification.



disk of each corium, rather broad band curving along each frena from basal angle of scutellum to submarginal position near distal end of frenum, mesial spot at base of scutellum and spot at posterior margin of each cicatrice, all ivory, with spots varying greatly in size; basal disk of scutellum within parenthetical ivory markings, coria about or distad of ivory spot, posterolateral surface of humeri and pronotal surface laterad of cicatrices, all sometimes fuscous to black; lateral margins of connexiva pale; membranes lightly fumose or frosty. Venter brownish yellow with pleura sometimes dark in large part, occasionally becoming as dark as dorsum in area laterad of evaporative surface; punctation excepting on head often dark and often strong. Distal 7-9 tenths of last antennal segment, distal 7-8 tenths of fourth, and sometimes distal tenth of third fuscous with remainder of antennae brownish yellow.

Anterolateral margins of pronotum moderately concave, entire; humeri narrowly rounded, or produced laterad as slightly retroarcuate spine. Scutellum 1.9-2.2 mm wide at base, 1.9-2.4 mm long. Body with membranes about 5.0-6.9 mm long.

Basal plates roughly punctate, nearly uniform in color, contiguous and subrectiform along mesial margins, each plate evenly arcuate along posterior margin; distance from imaginary line drawn through lateral angles of basal plates to most distal margin of plates about 5 tenths of distance from line to base of plates at meson (Fig. 71).

Dorsal margin of pygophoral surface impressed mesially (Fig. 72). Proctiger as in Figure 73.

*Distribution.*—Cuba and Hispaniola.

*Comment.*—Although some specimens superficially resemble *M. ypsilon*, this species seems to belong in a group containing *M. collaris*, *M. maculata* and *M. notulifera*, none of which is sympatric with it.

*Type.*—Female, in the Naturhistoriska Riksmuseet, Stockholm. Not seen.

*Mormidea laevigata* Distant, 1880

*Mormidea laevigata* Distant, 1880, p. 55, Pl. 7, fig. 3.

Light to dark brown above, anterior disk of pronotum and head somewhat paler than remainder of dorsum; punctation concolorous with darkest part of dorsum; anterior and anterolateral pronotal margins, area between cicatrices, two large spots at posteromedial margins of cicatrices, and transverse band of varying width between humeri more or less confluent, pale yellow or ivory; equally pale; mesial spot at base of scutellum, narrow border around scutellum except at base, costal margin basally, spot on disk of each corium, lateral margins of connexiva; membranes hyaline. Venter pale



brownish yellow with castaneous to fuscous punctures on head, pleura, and in broad subspiracular band on abdomen, often with longitudinal vitta as dark as dorsum covering thorax between subcoxae and lateral margin and extending over subspiracular punctations of abdomen; sterna dark; spots forming mesial vitta on abdomen solidly colored on first and fifth visible sternites, only outlined, sometimes faintly so, on intervening sternites. Basal 3 segments of antennae brown, distal 2 fuscous with narrow basal band of lighter color.

Anterolateral margins of pronotum nearly straight, entire; humeri little produced, rounded. Scutellum 2.1–2.3 mm wide at base, 2.3–2.6 mm long. Body with membrane about 6–7 mm long.

Dorsal pygophoral margin visible from caudal view broad, sloping convexly ventrad, depressed mesially; opening into genital cup small; pygophoral surface fuscous basally (Fig. 75).

Basal plates submarginally impressed along posterior margin, somewhat rugose, with a few strong punctures; mesial margins straight, contiguous; posterior margins evenly convex (Fig. 74).

*Distribution.*—Mexico (Tabasco).

*Comment.*—Of sympatric congeners, this apparently rare species most closely resembles *M. pama* and *M. pictiventris* in coloration and size. The pygophore is particularly distinctive.

*Type.*—The holotype, in the Museum für Naturkunde an der Humboldt-Universität zu Berlin, was not examined.

*Mormidea dana* n. sp.

Light to dark brown above, shiny, disk of scutellum basally and disk of pronotum anteriorly darkest; vertex, tylus and sometimes most of cephalic disk yellowish brown; anterolateral margins of pronotum narrowly, costal margin of coria basally, connexiva laterally, spots at base of scutellum (one in each angle, one mesially), scutellar apex, and spot on disk of each corium, all ivory; punctation fuscous to black; membranes fumose. Venter yellowish brown with thoracic sterna and broad median vitta on abdomen fuscous; punctation dark, moderately dense, usually extending from thoracic pleura as broad submarginal band along each side of abdomen; disk of abdomen impunctate. Antennae fuscous, only basal 4 tenths of last segment conspicuously pale.

Anterolateral margins of pronotum nearly straight; humeral angles little produced, narrowly rounded. Scutellum 2.0–2.3 mm wide at base, 2.2–2.6 mm long. Body length with membranes 6.4–8.0 mm.

Basal plates contiguous mesially or narrowly separated; posterior margin almost evenly convex; a dark spot covers apical angles (Fig. 54).

Dorsal pygophoral margin broadly and deeply concave from caudal view, shallowly so from ventral view with obtuse median tooth; base of pygophore covered by broad dark spot (Fig. 55).

*Distribution*.—Ecuador (Napo-Pastaza) and Peru (Amazonas).

*Types*.—Holotype: male, labeled (a) Ecuador, Pompeya on Napo R. 40 km from Coca, Napo-Pastaza Prov. V-1965 (b) L. E. Pena (sic) Collector. Deposited in the American Museum of Natural History. Paratypes: (a) Bagus, 3.9.66 W. E. Rose (b) Meunprg. No. 330-66 (♂ LHR, ♀ UNP); Montenegro, Bagua, Amazonas. Sept. 29–Oct. 2, 1963. 350 m. Wygodzinsky (♀ AMNH, ♂ LHR); (a) Peru: Dept. Amazonas, Montenegro, forested Mtn. Slopes. Alt. 300 m. 22–25.1.1964 (b) P. C. Hutchison and J. K. Wright, Collectors (♀ CAS); Quincemil, Peru, IX-15-1962. L. Pena, Coll. (♀ AMNH); (a) Quincemil, Cuzco, Peru. April 27, 1947. Elev. 2400 ft. (b) J. C. Pallister Coll., Donor Frank Johnson (♀ AMNH); Tingo Maria, Huan., Peru. Jan. 11, 194 (sic) Alt. 2200 ft. (b) as above (♀ AMNH); Tingo Maria, Peru, IV-6-1963. L. Pena, Collector (♀ LHR, ♂ AMNH); Quincemil, Peru, IX-15-1962 L. Pena, Coll. (♂ LHR, 4 ♀ AMNH).

*Comment*.—Species most similar in appearance to *M. dana* are *M. metallica* and *M. faisana*.

*Mormidea faisana* n. sp.

Dorsum yellowish brown with much darker punctation; narrow callous along base of scutellum interrupted and sometimes reduced to median spot; callous along each frenum continuous, submarginal; spot on disk of each corium impunctate; above callouses, anterolateral margin of pronotum, small calloused spot behind each cicatrice, connexiva and costal margin of coria basally, all brownish yellow to ivory; membrane slightly fumose. Venter somewhat lighter in color than dorsum, with thoracic sterna and continuous broad mesial vitta of abdomen black; dense dark punctation on thoracic pleura continues as broad submarginal band along each side of abdomen; lateral borders of abdomen impunctate, concolorous with connexiva; vitta impunctate, adjacent light band sparsely punctate. Legs including tarsi yellowish brown, femora and tibiae with dark spots; antennae similarly colored excepting distal 7–8 tenths of each of last two segments dark brown.

Anterolateral pronotal margins nearly straight, entire; humeri little produced, narrowly rounded. Scutellum 1.8–2.4 mm wide at base, 2.1–2.6 mm long. Body with membranes about 6.0–7.4 mm long.

Basal plates contiguous mesially; posterior margin convex; usually a few strong punctures laterally on disk (Fig. 56).

Dorsal margin of pygophore broadly convex mesially from ventral view; ventrad of this arc a large area of pygophoral surface shallowly depressed;

mesial spot located at base of pygophore and smaller spot present along dorsal margin near lateral limits of depression (Fig. 57).

*Distribution*.—Yucatán, Mexico.

*Types*.—Holotype, male labeled (a) Uxmal, Yuc. Mex., VIII-25-1952, J. & D. Pallister (b) C. R. Vose Fund, Explorers Club, A.M.N.H. Exped. Deposited in the American Museum of Natural History.

Paratypes: (a) Temax, N. Yucatan, Gaumer (b) B.C.A. Hem. I, *Mormidea pictiventris* (2♀ BMNH); Yucatan, Yucatan, Mex. VIII-21-1952, J. & D. Pallister (♀ AMNH, ♀ LHR); Mex., Yucatan, Piste, June 3-5, 59, P. & C. Vaurie (♀ AMNH); (a) Colonia Yucatan, Yucatan, Mex. VIII-19-1952, J. & D. Pallister (b) C. R. Vose Fund, Explorers Club, A.M.N.H. Exped. (♀ LHR).

*Comment*.—The similar species *M. metallica* and *M. dana* apparently are not sympatric with *M. faisana*.

*Mormidea metallica* Stål, 1872

*Mormidea metallica* Stål, 1872, p. 20.

Dark brown to fuscous above; dot behind each cicatrice, anterolateral margins of pronotum, mesial dot at base of scutellum and thin submarginal line extending from each basal angle part way along frenum, very margin of scutellar apex, margin of coria basally and dot on disk, lateral margin of connexiva, all brownish yellow to white; membrane darkly fumose with some nearly hyaline areas. Venter brownish yellow, on each side a lateral band of dark punctures extending along body; thoracic sterna black; abdominal disk impunctate between lateral bands of black punctures, black or fuscous mesial vitta incomplete or lacking on fourth visible sternite, occasionally on both third and fourth sternites. Basal segment of antennae pale with dark lateral stripe, rarely entirely dark; following two segments dark excepting articulation between them; basal 1 or 2 tenths of fourth segment and basal 5 to 6 tenths of fifth segment pale, remainder of these segments black.

Humeral angles not produced, rounded; anterolateral margins of pronotum shallowly concave, entire. Scutellum longer than wide at base, 2.0-2.5 mm wide, 2.3-2.9 mm long. Body length with membranes about 6.3-9.3 mm.

Basal plates sparsely punctate about dark area covering apical angle; mesial margins contiguous; posterior margin of each plate arcuate, somewhat depressed above ninth paratergite (Fig. 58).

Mesial convex emargination in dorsal margin of pygophore moderately deep (Fig. 59); pygophore black or fuscous at base.

*Distribution.*—Colombia, Panama.

*Comment.*—The interrupted mesial vitta on the abdomen, much constricted distally on the fourth visible sternite, or at the other extreme virtually absent from both the third and fourth sternites, together with the unproduced humeri, seem diagnostic for the species. *M. metallica* seems more variable in size than most species of the genus.

*Types.*—The type specimens of *Mormidea metallica* Stål, in the Naturhistoriska Riksmuseet, Stockholm, were examined. The following is designated LECTOTYPE: male, labeled (a) Bogota (b) Lindig (c) Type (d) Allotypus (e) 414/75 (f) Riksmuseum, Stockholm. The one PARALECTOTYPE is: female, labeled (a) Bogota (b) Lindig (c) Type (d) *metallica* Stål (e) Typus (f) 142/56 (g) 415/75 (h) Riksmuseum, Stockholm.

A third specimen, numbered 416/75 and bearing among other labels (a) Bogota (b) Lindig (c) Paratypus, is probably an addition to the syntype series. It is an example of *M. notulata* that is aberrant in having the mesial vitta of the abdomen reduced to transverse basal lines on sternites 2–4. The humeral angles are directed more cephalad than usual and the thoracic spots at the distal end of the supracoxal clefts are extraordinarily large. I think it improbable that Stål would have taken this specimen to be an example of *M. metallica*.

*Mormidea ambigua* Berg, 1891

*Mormidea ambigua* Berg, 1891, pp. 240–241—Lethierry & Severin, 1893, p. 123 (listed)—Kirkaldy, 1909, p. 59 (listed).

Light brown to nearly fuscous dorsally; anterolateral margins of pronotum, a callous at posterior margin of each cicatrice near mesial limits, three basal spots on scutellum (one mesial and one near each basal angle), impunctate apex of scutellum, basal 3 tenths of costal margin of coria, spot near distal end of radial vein, and broadly exposed connexiva brownish yellow; membrane slightly fumose. Venter brownish yellow with sterna black excepting hirsute median streak; on pleura a black spot present at distal end of each supracoxal cleft, this spot at posterior margin of evaporatorium on metapleura; a less distinct spot located at each anterolateral pronotal angle; spiracles dark; median row of dark spots on abdominal venter, each nearly semicircular, sometimes forming outline with brownish yellow center; band of strong dark punctures laterad of mesial vitta much less pronounced than in *M. paupercula*. Antennae brownish yellow with distal 2 thirds of fourth and fifth segments dark castaneous.

Anterolateral margins of pronotum nearly straight, slightly reflexed before humeri, entire, without noticeable band of submarginal dark punctures; hu-

meri little produced, rounded. Scutellum longer than wide at base, 2.6 mm wide, 2.9–3.1 mm long. Body length with membranes 8.0–8.2 mm.

Posterior margin of pygophore labiate from lateral view, concave from both ventral and caudal views (Fig. 60), convexly rounded from dorsal view. A median dark spot present at base. Two reticulated carinae, one above other, present above parameres on each lateral wall of genital cup. Proctiger black where deflexed, posterior margin sharply reflexed.

Female unknown.

*Distribution.*—Argentina (Córdoba, Corrientes).

*Comment.*—The only species in Argentina of similar appearance is *M. paupercula*, a species distinguished by the crenulations on the anterolateral margins of the pronotum. *M. ambigua* is known only from the type series.

*Types.*—From the syntype series of three males the following specimen is designated LECTOTYPE: (a) Typus (b) Corrientes (c) *Mormidea ambigua* (d) 1376 (e) Berg (f) Museo La Plata. The two PARALECTOTYPES are labeled: (a) Typus (b) Cordoba (c) 1376 (d) Berg (e) Museo La Plata. All specimens are in the Universidad Nacional de La Plata, Facultad de Ciencias Naturalis y Museo.

*Mormidea paupercula* Berg, 1878

*Mormidea paupercula* Berg, 1878, pp. 300–301—Berg, 1879, pp. 39–40 (reprint original description)—Pirán, 1948, p. 12 (Argentina distribution)—Grazia-Vieira & Casini, 1973, pp. 58–59 (records).

*Mormidea profana* Breddin, 1912, p. 352—Gaedike, 1971, p. 96 (lectotype designation)—Weidner, 1972, p. 120 (type material).

Light brown above, often darker at humeri and submarginally along ivory colored anterolateral margin of pronotum; punctation dark brown to fuscous; calloused spot behind each cicatrice, sometimes mesial spot at base of scutellum, lateral margin of connexiva, costal margin of coria toward base, all ivory; small black fovea present in basal angles of scutellum; membranes of hemelytra fumose. Venter brownish yellow, darkly punctate; thoracic sterna, spot at distal end of supracoxal clefts, spiracles and mesial vitta on abdomen black; vague longitudinal band of denser punctation located between mesial vitta and spiracles. Legs and antennae rufous or light castaneous.

Humeri moderately produced, rounded; anterolateral margin sinuously concave, noticeably crenulate (Fig. 61). Scutellum about as long as wide at base, 2.5–2.9 mm wide, 2.6–3.1 mm long. Body length with membranes about 7.2–8.3 mm.

Basal plates roughly punctate, together pincer-shaped, mesial margins concave; apical angle covered with fuscous spot (Fig. 62).

Dorsal margin of pygophore moderately concave from caudal view (Fig. 63).

*Distribution*.—Specimens examined came from Argentina (Misiones); Brazil (Paraná, Rio Grande do Sul, Santa Catarina) and Uruguay (Paysandú, Rivera). Pirán (1948) adds to the Argentinian distribution the states of Buenos Aires, Córdoba, Entre Ríos and Santa Fe. Grazia-Vieira & Casini (1973) include the department of Artigas in the Uruguayan distribution.

*Comment*.—The crenulated anterolateral margins of the pronotum distinguish this species.

*Types*.—The holotype of *Mormidea paupercula* and the lectotype of *Mormidea profana*, both females, were examined. The former is conserved in the Universidad Nacional de La Plata, Facultad de Ciencias Naturales y Museo, and the latter in the Akademie der Landwirtschaftswissenschaften at Eberswalde.

Weidner (1972) listed a holotype and two paratypes of *Mormidea profana* in the collection of the Zoologischen Museums der Universität Hamburg, but Breddin did not designate a holotype. Breddin indicated that part of the syntype series was in "Mus. Hamb." and the remainder in his collection. These specimens were examined.

#### *Mormidea cubrosa* (Dallas, 1851)

*Pentatoma cubrosa* Dallas, 1851, p. 247.

*Mormidea cubrosa*; Walker, 1867, p. 254—Bergroth, 1891, p. 222 (record)—Barber & Bruner, 1932, pp. 250, 252 (keyed, synonymy, record)—Torre Bueno, 1939, p. 218 (keyed, records)—Wolcott, 1948, p. 191 (hosts, record)—Alayo, 1967, pp. 11, 12 (keyed, synonymy, descriptive note)—Gaud & Martorell, 1974, p. 258 (record)—Rolston, 1976, p. 5 (synonymy).

*Eysarcoris punctifer* Walker, 1867, p. 274 (synonymized by Rolston, 1976).

*Mormidea sordidula* Stål, 1872, p. 21 (synonymized by Barber & Bruner, 1923)—Uhler, 1876, p. 285 (records)—Van Duzee, 1904, p. 43 (descriptive note, record)—Snow, 1906, p. 151 (record)—Van Duzee, 1907, p. 7 (record)—Barber, 1923, p. 12 (record).

*Mormidea punctifer*: Distant, 1899, p. 437.

*Mormidea punctiger* (sic): Van Duzee, 1904, p. 28 (status queried).

*Mordidea punctifera* (sic): Kirkaldy, 1909, p. 61 (listed).

Dorsum dull brown; small spot behind each cicatrice, on base of scutellum at meson and in basal angles, and on disk of each corium, usually pale; a submarginal callous often extending from each basal angle along part or all

of frenum; connexiva brown with lateral margin palely draped by arcuate spot on each segment; apex of scutellum often with narrow pale margin; membranes hyaline. Venter coloration in two intergrading forms. Light form: pale with punctation, thoracic sterna and abdominal vittae fuscous to black; longitudinal mesial vitta usually constricted on third visible sternite, otherwise composed of contiguous subtrapezoidal spots, one on each sternite; mesal vitta paralleled on each side by vitta extending from base of abdomen over one to four sternites. Dark form: all of venter fuscous to black excepting pleura about coxae, lateral margins of abdomen, and usually calloused spot mesad of each spiracle. Antennae light to dark brown with pale basal rings on last two segments, that on last segment covering basal 2 or 3 tenths.

Anterolateral margins of pronotum concave, usually only slightly so, entire; humeral angles little produced, rounded. Scutellum longer than basal width, 2.0–2.3 mm wide, 2.1–2.5 mm long. Body length including membranes about 6.5–7 mm.

Basal plates contiguous basally, separated distally, generally rather broadly so; disk with numerous punctures similar in size to those on fifth visible sternite; apical angles usually darkened; posterior border depressed midway between apical and lateral angles (Fig. 64).

Posterior surface of pygophore somewhat protruding along each side of dorsal pygophoral margin, with a shallow semicircular depression between these protrusions arching ventrad from dorsal margin; pygophoral surface conspicuously and rather densely punctate, fuscous basally (Fig. 65).

*Distribution.*—This species seems to have a divided range, one part in the West Indies and the other continental. It is found in all the Greater Antilles and in the Lesser Antilles as far south as Martinique. On the continent it occurs from southern Texas to southern California and south into Colombia.

*Comment.*—On the continent, specimens from the northern part of the range have the light colored, trivittate venter, while those from the southern part of the range have the dark venter. Both forms and intermediates occur in Nicaragua and in the West Indies. Too few West Indian specimens are available to determine if a color cline exists in the islands, but if one does it is not as clearly defined as on the continent.

*Types.*—The types of *Pentatoma cubrosa* Dallas and *Eysarcoris punctifer* Walker, both females and both in the British Museum (Natural History), were examined, as were the syntypes of *Mormidea sordidula* Stål, preserved by the Naturhistoriska Riksmuseet, Stockholm. From the syntypes of *Mormidea sordidula* the following specimen is designated LECTOTYPE: male, labeled (a) Texas (b) Belfrage (c) Type (d) sordidula Stål (e) Typus (f) 148/56 (g) 303/76 (h) Riksmuseum Stockholm. PARALECTOTYPES are: male,

labels (a) (b) (c) as above (d) Paratypus (e) 305/76 (f) Riksmuseum Stockholm; female, same labeling except (e) 306/76; female, same labeling except (d) Allotypus (e) 304/76.

*Mormidea pictiventris* Stål, 1862

*Mormidea pictiventris* Stål, 1862, p. 103.

Differing from *M. pama* as follows: pale narrow border along anterolateral margin of pronotum usually even, not intruding onto disk about midway between anterior and humeral angles. Narrow band along margin of connexiva entirely pale, not formed by pale area on each segment arching mesad between sutures.

Basal plates sparsely punctate basally; distal margin slightly convex, mesial margins weakly concave; large part of each plate including apical angles fuscous, polished (Fig. 66).

Pygophore truncate from lateral view, 2 minute teeth protruding from dorsal margin; dorsal margin from caudal view shallowly concave between minute teeth; arms of weak chevron-shaped carina on disk of pygophore terminate laterad of teeth (Fig. 67).

*Distribution*.—From Venezuela (Lara) and Colombia (Magdalena) northward into Tamaulipes state, Mexico, and possibly into southern Texas.

*Comments*.—This species has been thoroughly confused with *Mormidea pama*, to which records from Florida and the West Indies apply.

Distant's specimens bearing the label "B.C.A. Hem. 1, *Mormidea pictiventris*" belong to four species: *M. cubrosa* (Dos Arroyos, Guerrero; Venta de Topilote, Guerrero); *M. faisana* (Temax, Yucatán, in part); *M. pama* (Atoyac, Vera Cruz; Chiacaman, Vera Paz; Teapa, Tabasco; Temax, Yucatán, in part); and *M. pictiventris* (Bugaba, Panama; Caldera, Panama; Chilpancingo, Guerrero; Rincón, Guerrero; S. Geronimo, Guatemala; Senhu, Vera Paz; Tamax, Vera Paz; Temax, Yucatán, in part; V. de Chiriquí, Panama).

The following references may apply either to *M. pictiventris* or *M. pama*, or to a mixture of both species: Stål, 1872, p. 20—Distant, 1880, p. 55, Pl. 5, fig. 11—Lethierry & Severin, 1893, p. 124—Uhler, 1894, p. 229—Van Duzee, 1904, p. 42—Barber, 1906, p. 258—Kirkaldy, 1909, p. 60—Banks, 1910, p. 87—Van Duzee, 1916, p. 5—Van Duzee, 1917, p. 38—Torre Bueno, 1939, pp. 217–218.

*Type*.—Of the syntypes, only one specimen seems to remain in the Naturhistorisches Museum, Vienna. This male, which I designate LECTOTYPE, bears the labels: (a) Mexico, Coll. Signoret (b) *pictiventris* det. Stal.



*Mormidea pama* n. sp.

*Mormidea pictiventris* (auct., not Stål). Uhler, 1886, p. 6—Van Duzee, 1907, p. 7. (Jamaica record)—Blatchley, 1926, pp. 123, 124–125 (keyed, described, Florida & Cuban records)—Barber & Bruner, 1932, p. 250, 251 (keyed, descriptive note)—Bruner & Barber, 1949, p. 157 (listed)—Alayo, 1967, pp. 11, 12, Pl. 1, fig. 4 (keyed, descriptive note, host).

Yellowish brown to fuscous above; border along anterolateral margins of pronotum and large spot behind each cicatrice ivory; on scutellum, median basal spot, apex, calloused band extending along frenum from spot in each basal angle, all ivory; spot on disk of coria and draping on connexival segments between sutures pale; costal margin of coria ivory toward base; membranes slightly fumose. Venter brownish yellow, darkly punctate; thoracic sterna, blotches on pleura, broad median vitta on abdomen and on each side a lateral vitta along basal three or four visible sternites, brown to black; spiracles pale. Antennae colored as dorsum excepting most of basal segment and narrow basal rings on segments 4 and 5 pale; legs brownish yellow to light castaneous, sparsely dark dotted.

Humeri little produced, rounded; anterolateral margin of pronotum shallowly concave or sinuous, with ivory border intruding onto disk as indicated in Figure 68. Scutellum 2.0–2.7 mm wide, 2.1–3.0 mm long. Body with membrane about 6.3–7.8 mm long.

Basal plates punctate, contiguous mesially; distal margin convex near lateral angle, then transverse to apical angle; surface deeply impressed along distal margin between lateral angle and dark spot covering apical angle (Fig. 69).

Dorsal margin of pygophore labiate from lateral view, elevated mesially above chevron-shaped impression (Fig. 70).

*Major variation.*—Dorsum mostly impunctate; a few scattered punctures on head; two small mesial patches of punctures on pronotum, one just caudad of cicatrices, the other at base; a line of punctures caudad of frena follows outline of scutellum but well in from margin; on each corium a large lacuna on disk with few or no punctures. Punctuation on venter slightly less dense than usual, normally distributed.

Dorsal colors strongly contrasting: tylus, vertex and base of head, as well as spot near base of each jugum brownish yellow; most of pronotum cephalad of humeri similarly colored excepting cicatrices and patch of punctures fuscous; ivory markings on scutellum unusually broad. Color of venter and appendages normal.

*Distribution.*—Like *M. cubrosa*, this species has a divided distribution, oc-

curing in Florida, Jamaica and Cuba in the east and ranging from Tamaulipas state, Mexico, into Colombia (Antioquia, Meta).

*Comments.*—Species most likely to be confused with *M. pama* are *M. pictiventris* and *M. cubrosa*. The genitalia of both sexes are distinctive in the three species, and *M. cubrosa* has less conspicuous pale, dorsal markings. *M. pama* has a short pale intrusion of the anterolateral margin into the pronotal disk, a feature not seen in *M. pictiventris*. (Fig. 68).

In addition to the synonymy given above, all records under the name *M. pictiventris* for Florida and the West Indies relate to this species, as may some for Middle America.

The major variation is described from a single specimen collected at Homestead, Florida. The collector of the specimen, Dr. R. M. Baranowski, writes that he has seen additional specimens of this form.

*Types.*—Holotype: male, labeled La Lima Honduras 31 X 1972 L. H. Rolston. Deposited in the U.S. National Museum, type no. 72136.

Paratypes: Mexico: Veracruz, 8 mi. ne. Catemaco. July 3, 1971. Taken at light. Clark, Murray, Hart, Schaffer (♂ TAMU); 2 mi se Tecoman, Col., Mex. VII-20-66. F. M. & P. K. Wagner (♀ TAMU); 4 mi NW Sontecomapan, V.C., Mex. VI-9-1965, H. R. Burks, J. R. Meyer, J. C. Schaffner ♀ TAMU); La Lima, Honduras, 2 XI 1972 L. H. Rolston (♂ ♀ TAMU); (a) Cuba (b) EP Van Duzee Collection (2 ♀ ♀ CAS); (a) Cuba (b) H. M. Parshley Collection (♂ CAS); (a) Habana, Cuba F. Z. Cervera, Collr. (b) H. M. Parshley Collection (♂ CAS); (a) Bradentown. Aug. 15'10 Fla. J. C. Bradley (b) EP Van Duzee Collection (♀ CAS); (a) Mandev'le Ja. Apr. 06 (b) Van Duzee Collector (c) EP Van Duzee Collection (♂ CAS); (a) Villavicencio, M. I. Colomb. VIII:4:1939 (b) Col. by Henry Dybas (c) Chicago N. H. Mus. Collection (ex W. J. Gerhard Colln. (9♂♂, 4♀♀ FMNH); same data except date VIII:15:1938 (2♂♂ FMNH); (a) Puerto Berrio, Antio. Colomb. VIII:4:1938 (b) Col. by Henry Dybas (c) Chicago N. H. Mus. Collection ex W. J. Gerhard Colln. (♀ FMNH); same data except date VIII:15:1938 (2♂♂, ♀ FMNH); (a) Tezonapa, Veracruz, Mex. VIII:8:41 (b) Col. by H. Dybas (2♀♀ FMNH); Brooksville (6 mi. NW) Hernando Co., Fla. VI:21:55 HS Dybas leg. (♂ FMNH); (a) Dade Co., Fla. 8-11-1954 (b) O. D. Link, coll. (c) S.P.B. Acc. No. 119454 (♀ FSCA); (a) Davie, Florida. 8-VIII-74. Broward Co. (b) R. L. Chavez. Ixora (2♂♂, ♀ FSCA) Lakeland, Fla. 9 Nov. 1950. R. F. Hussey (♀ FSCA); same data except date 17-V-1949 (♂, ♀ FSCA); same data except date X-27-1947 (♂, ♀ FSCA); (a) Glen Saint Mary, Baker Co., Florida (b) 23-VIII-72. H. Collins. on *Euonymus* (♂ FSCA); (a) Orlando, Fla. (b) J. R. Woodley, Coll. 4-X-61 (♂ FSCA); (a) Emory Univ., Ga. 10-1-1945 H. V. Weems, Jr. (b) Det. by H. G. Barber (c) *Mormidea pictiventris* Stål Det. H. G. Barber (♀ FSCA); same data

except date 10-2-1947, without label (c) ( $\delta$ ,  $\text{♀}$  FSCA); same data as holotype ( $\delta$ ,  $\text{♀}$  AMNH,  $\delta$   $\text{♀}$  NR,  $\delta$ ,  $\text{♀}$  UNLP,  $\delta$   $\text{♀}$  LHR); LaLima, Honduras. 2XI 1972. L. H. Rolston ( $\delta$  Baranowski).

*Mormidea isla* n. sp.

Light brown above, base of scutellum and coria distally sometimes dark brown with humeri and base of scutellum then becoming fuscous; pale spot behind each cicatrice, on disk of each corium and mesially at base of scutellum usually present; calloused submarginal band along frena and apex (or entire scutellar tongue) pale but rarely contrasting strongly with remainder of scutellum. Venter and appendages yellowish brown excepting fuscous spots on legs (femora and tibiae) and about distal 7 tenths of each of last two antennal segments; punctation rather strong on thorax and along sides of abdomen, concolorous, or on thorax in part or whole darkened; mesial macule at base of first abdominal sternite and usually discal portion of suture between first two sternites fuscous; dark mesial line usually present on last sternite, occasionally also on one or more of preceding sternites.

Anterolateral margins of pronotum slightly concave; humeri little produced, angular, narrowly rounded. Scutellum 2.0–2.3 mm wide at base, 2.3–2.7 mm long. Body length with membrane about 6.8–7.7 mm.

Basal plates shaped like those of *Mormidea ypsilon* but somewhat rugosely punctate.

Elevation located on each side of dorsal pygophoral margin at distance from lateral limits about equal to one fifth width of pygophore; dorsal pygophoral margin between these low elevations modestly concave; posterior surface of pygophore broadly flattened along dorsal margin (Fig. 76).

*Distribution*.—West Indies (Grenada, Trinidad), northern South America (Venezuela), and Costa Rica.

*Comment*.—This species closely resembles some small individuals of *Mormidea ypsilon*. Males of the two species are quickly distinguishable by the pygophore. Among females the stronger punctation on the basal plates and sides of the abdomen of *M. isla* should separate this species from *M. ypsilon*.

*Types*.—Holotype, male labeled Costa Rica, Guanacaste Prov. Las Cañas, Finca la Taboga. 17–27 June, 1969. Toby Schuh, Janet Crane. Deposited in the American Museum of Natural History. Paratypes: labeled as holotype (4 $\delta$   $\delta$ , 6 $\text{♀}$   $\text{♀}$  AMNH; 2 $\delta$   $\delta$ , 2 $\text{♀}$   $\text{♀}$  LHR); Caripito, Venezuela. 30 VIII 1942 ( $\delta$  AMNH); (a) Trinidad, WI 6-17 1902 Chipman (b) Distant Coll. 1911-383 ( $\delta$  BMNH); same except date 7-8-1902 ( $\delta$  BMNH); (a) S100 (b) Grenada, Br. West Indies. H. E. Summers ( $\delta$  BMNH); J. M. Ayala Edo. Guaranico, La Puerta, Venezuela. 1-VIII-75 (3 $\delta$   $\delta$  UNAM,  $\delta$  RDE,  $\delta$  FSCA,  $\delta$  LHR).

*Mormidea v-luteum* (Lichtenstein, 1796)

*Cimex v-luteum* Lichtenstein, 1796, p. 106.

*Pentatoma croceipes* Herrich-Schäffer, 1844, p. 97, fig. 759 (synonymized by Bergroth, 1908).

*Mormidea aglaeopus* Dallas, 1851, pp. 212–213 (synonymized by Stål, 1872).

*Mormidea croceipes*: Dallas, 1851, p. 213—Stål, 1860, p. 21 (var. noted)—Stål, 1872, p. 20 (keyed, synonymy)—Berg, 1878, pp. 299–300 (description, nymph)—Berg, 1879, pp. 38–39 (reprint of 1878 paper).

*Mormidea spiculigera* Stål, 1860, p. 21 (var. described) (synonymized by Stål, 1872).

*Mormidea compta* Walker, 1867, pp. 255–256 (synonymized by Stål, 1872).

*Mormidea spegazzini* Berg, 1883, pp. 204–205—Berg, 1884, pp. 20–21 (reprint of 1883 paper)—Buckup, 1961, p. 12 (record). NEW SYNONYMY.

*Mormidea tristis* Bergroth, 1891, pp. 221–222. NEW SYNONYMY.

*Mormidea v-luteum*: Bergroth, 1908, p. 248—Kirkaldy, 1909, pp. 59–60—Buckup, 1961, p. 12 (on rice)—Grazia-Vieira & Casini, 1973, p. 59 (records).

Fuscous to black above, with ivory dot on disk of each corium, another mesially at base of scutellum, usually one behind each cicatrice; on each side of scutellum a calloused ivory strip begins in basal angle and runs submarginally along frenum; scutellar apex and costal margin of coria along basal third, ivory; connexivium light castaneous where exposed; membranes lightly fumose. Venter light castaneous largely covered by disorganized fuscous to black blotches; coarse punctation and thoracic sterna black; abdomen irregularly margined laterally with castaneous or ivory; subspiracular spot at posterior margin of sternites (except last) usually subcalloused, bright castaneous or ivory; spiracles pale. Legs castaneous with dark dots; antennae fuscous or black excepting part of first segment and narrow basal ring on fifth segment pale.

Humeri narrowly rounded to spinosely produced; anterolateral margins of pronotum sinuous, entire. Scutellum longer than wide at base, 2.4–3.0 mm wide, 2.6–3.4 mm long. Body with membranes 7.3–8.9 mm.

Basal plates sparsely punctate, with diffuse dark spot covering apical angles; mesial margins contiguous, posterior margins convex, bent most above ninth paratergite, truncate above second gonocoxae (Fig. 77).

Dorsal margin of pygophore broadly and moderately concave; obtuse posterior edge mesially impressed (Fig. 78).

*Major variation*.—All ivory markings on dorsum are completely suppressed or obscurely represented in part.

*Distribution*.—Argentina (Buenos Aires, Misiones, Tucumán, Salta), Brazil (Ceará, Minas Gerais, Paraná, Rio Janeiro, Santa Catarina, São Paulo), Paraguay and Uruguay.

*Comment*.—The dark mottled abdominal venter of this species is distinctive.

*Synonymy*.—Stål (1872) synonymized *Mormidea aglaeopus* Dallas, 1851, *M. spiculigera* Stål, 1860, and *M. compta* Walker, 1867, with *Pentatoma croceipes* Herrich-Schäffer, 1844, a name which Bergroth (1908) equated with *Cimex v-luteum* Lichtenstein, 1796. The synonymy of the first three names was verified.

The type of *Mormidea tristis* Bergroth, 1893, was not located, but the description fits the form of *M. v-luteum* in which the pale dorsal markings are absent. Stål (1860) noted degrees by which these markings are suppressed, remarking under *M. croceipes* "Variat supra tota nigra" and naming three forms under *M. spiculigera*: the black form "var. *nigricans*," an intermediate form "var. *punctipennis*" and the fully marked form "var. *ornata*."

*Mormidea spegazzini* Berg, 1883, applies to a combination of minor variations in color and humeral angles.

*Types*.—The type series of *Mormidea aglaeopus* Dallas, is in the British Museum (Natural History). The male here designated LECTOTYPE is labeled: (a) Type (b) a (c) Brazil (d) Ent. Club 44-12 (e) Brit. Mus. Type No. Hem. 1015 (f) *Mormidea aglaeopus*. The female PARALECTOTYPE is labeled: (a) 40/3.30/829 (b) b (c) *aglaeopus* Identified by Dallas.

The type series of *Mormidea spegazzini* Berg, in the Universidad Nacional de La Plata, Facultad de Ciencias Naturales y Museo, consists of three specimens. The female here designated LECTOTYPE is the best preserved specimen and is labeled: (a) Typus (b) Buenos Aires (c) *Mormidea pegazzini* (sic) Berg (d) 1382 (e) Col. Berg (f) Museo La Plata. PARALECTOTYPES: female, labeled as lectotype, with all legs save one front leg missing; male, broken and carded, labeled (a) Typus (b) Buenos Aires (c) 1382 (d) Col. Berg (e) Museo La Plata.

The type series of *Mormidea spiculigera* Stål in the Naturhistoriska Riksmuseet, Stockholm, consists of three females corresponding, in the order given below, to the varieties *nigricans*, *punctipennis* and *ornata*. The LECTOTYPE bears the labels (a) Brasil (b) F. Sahlb. (c) ♀ (d) *spiculigera* Stål type (e) Typus (f) 138/56 (g) 339/76 (h) Riksmuseum Stockholm. PARALECTOTYPES: female, labeled (a) Rio Jan (b) Stål (c) var. b (d) 341/76 (e) Riksmuseum Stockholm; female, labeled (a) Brasil (b) F. Sahlb. (c) *flavoornata* Stål type (d) Typus (e) 139/56 (f) 340/76 (g) Riksmuseum Stockholm.

The type series of *Mormidea compta* Walker, 1867, in the British Museum (Natural History), consists of 4 specimens. The specimen here designated LECTOTYPE, a male, is labeled (a) Type (b) Petropolis. Feby, 1857. J. Gray (with 57.57 on reverse side) (c) 24 *Mormidea compta* (d) Brit. Mus. Type No. Hem. 1016. PARALECTOTYPES are: female, labeled: (a) Constancia. Jany, 1857. J. Gray (with 57.57 on reverse side) (b) *Mormidea compta* Walker's catal.; female, labeled: (a) Tejuca. Jany, 1857. H. Clark (with 57.50 on reverse side) (b) *Mormidea compta* Walker's catal.

The remaining specimen of this type series (var. B in Walker's catalog) is a female of *Mormidea hamulata* Stål labeled (a) Rio Janeiro. Decy, 1856. J. Gray (with 57.57 on reverse side) (b) *Mormidea compta* Walker's catal.

*Mormidea ypsilon* (Linneaus, 1758)

*Cimex ypsilon* Linneaus, 1758, pp. 443–444.

*Cimex ypsilon-aenus* De Geer, 1773, p. 332, Pl. 34, figs. 7, 8 (synonymized by Dallas, 1851).

*Pentatoma ypsilon*: Le Peltier & Serville, 1825, p. 56.

*Pentatoma scutellata* Westwood, 1837, p. 37. NEW SYNONYMY.

*Mormidea ypsilon*: Amyot & Serville, 1843, p. 135—Dallas, 1851, p. 211 (synonymy, record)—Stål, 1860, p. 21 (record)—Walker, 1867, p. 254 (records)—Stål, 1872, p. 19 (keyed, records) Berg, 1878, p. 298 (synonymy, records)—Distant, 1880, p. 54, Pl. 6, fig. 7 (synonymy, records)—Distant, 1889, p. 328 (records)—Uhler, 1893, p. 705 (record)—Uhler, 1894, p. 172 (record)—Van Duzee, 1901, p. 344 (record)—Stoner, 1925, pp. 9–10, Pl. 1, fig. 5 (records)—Callan, 1948, p. 121 (record)—Pirán, 1948, p. 12 (records)—Buckup, 1961, p. 12 (records).

*Mormidea inermis* Dallas, 1851, p. 211 (synonymized by Distant, 1880).

*Mormidea scutellata*: Lethierry & Severin, 1893, p. 124.

*Mormidea scutellata*: Distant, 1900, p. 811, Pl. 52, fig. 7—Van Duzee, 1907, p. 7 (record).

*Mormidea ypsilon* (sic): Stoner, 1919, p. 219 (record, host).

Yellowish brown above with darker humeri, often entirely dark brown to black caudad of cicatrices; spot behind each cicatrice and on disk of each corium ivory, former often larger, sometimes absent; ivory Y-shaped mark on scutellum calloused from basal angles to junction of three arms of Y near end of frena, mesial arm usually punctate excepting at apex of scutellum; connexiva pale where exposed; membrane slightly fumose. Venter pale; punctation concolorous or darker on thorax and sides of abdomen, weakly evident on abdominal disk; spiracles concolorous with venter. Basal segment of antennae pale, variously streaked or dotted darker; remaining segments dark excepting about basal 2 tenths of fourth and basal 3 tenths of fifth.

Humeri narrowly rounded to spinosely produced; spinose humeri usually somewhat retrorse, their posterolateral margin occasionally submarginate; anterolateral margins of pronotum straight or concave, entire. Scutellum longer than wide, 2.1–3.0 mm across base, 2.5–3.3 mm long. Body length with membrane about 7.0–9.0 mm.

Basal plates impunctate or nearly so, finely wrinkled; mesial margins contiguous, posterior margins convex, disk slightly depressed; distance from imaginary line drawn through lateral angles of basal plates to most distal part of posterior margin 2 to 4 tenths of distance from line to base of plates at meson (Fig. 79).

Margin of pygophore shallowly concave from both caudal and ventral views (Fig. 80); transverse band of sparse dark shallow punctures connects mild submarginal impression on each side of pygophoral disk. Parameres as in Figure 81.

*Distribution.*—This is the most widely distributed species of the genus, ranging from Uruguay and northern Argentina (Entre Río, Misiones, Santa Fe) northward in the east through the Lesser Antilles at least to Nevis (Stoner, 1925) and in the west at least into the state of San Luis Potosí, Mexico.

*Types.*—The type of *Pentatoma scutellata* Westwood, from St. Vincent, in the Hope Department of Entomology, Oxford, falls within the lower range of size for this species but is otherwise unremarkable. The type is male.

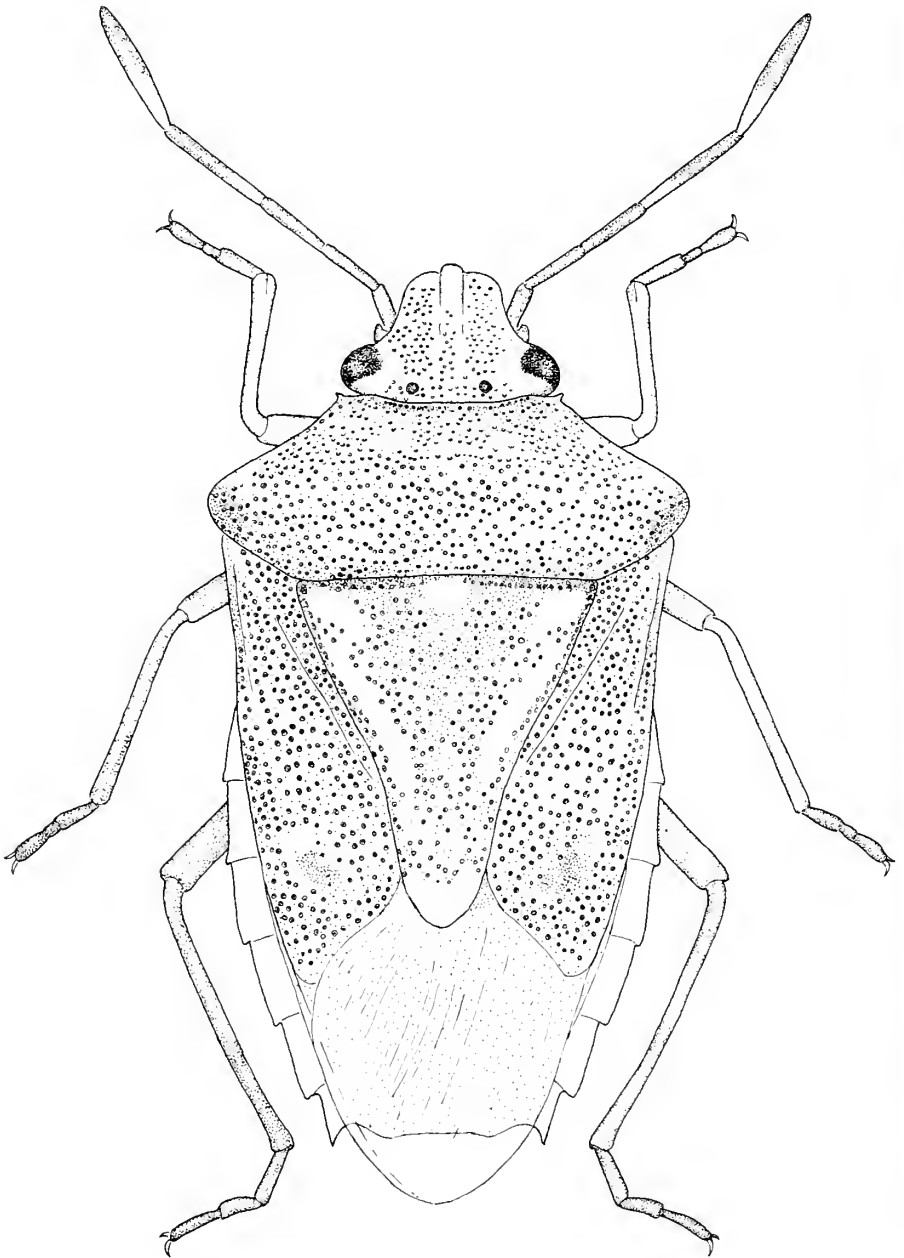
The type of *Mormidea inermis* Dallas, a female, in the British Museum (Natural History), is an ordinary example of the form with narrowly rounded humeri.

The type material of *Cimex ypsilon* was not sought.

### *Mormidea lunara* n. sp.

Light to dark brown or castaneous above with fuscous or black humeri and punctuation; ivory markings on scutellum limited to large spot at apex and often large spot in each basal angle, the latter occasionally somewhat elongated; pale spot at posterior margin of each cicatrice and on disk of each corium small or absent; connexiva pale where exposed; membranes hyaline or slightly fumose. Venter pale, concolorously punctate, sometimes with small dark spot before each mesocoxa, usually with dark basal macule on disk of first visible abdominal sternite, often with dark mesial line on part of one or more of other sternites. Basal segment of antennae marked by dark spot or longitudinal streak on lateral surface or entirely dark except basally; second segment similarly streaked or brown to fuscous with narrow pale ring distally; remaining segments fuscous with about basal 1 to 4 tenths of third, basal 3 tenths of fourth and basal 4 tenths of last pale.

Humeral angles acute to spinose, directed laterad and usually cephalad,





occasionally sweeping upward; anterolateral margins of pronotum concave, entire. Scutellum 2.7–3.0 mm wide at base, 3.2–3.4 mm long. Body length with membranes about 9.3–10.0 mm.

Basal plates and pygophore like those of *Mormidea ypsilon*. Parameres as in Figure 82.

*Distribution*.—From Sinaloa and Tamaulipas states in Mexico southward into Panama.

*Comments*.—The appearance of this species from a dorsal view is much like that of *Mormidea notulata*, but the latter has a well defined mesial vitta on the abdominal venter. Although the genitalia of *M. lunara* and *M. ypsilon* appear the same in undissected specimens, the two species differ in dorsal markings and in size.

*Types*.—Holotype: male, with genitalia dissected, labeled 1 mile northwest of Ayutla, Queretaro, Mexico. July 24–25, 1970. Schaffner, Murray, Phelps, Hart. Deposited in American Museum of Natural History. Paratypes: labeled as holotype ( $\delta$  2 ♀ TAMU,  $\delta$  2 ♀ LHR,  $\delta$  ♀ UNAM); 2 miles southeast Gomez Farias, Tamaulipas, Mexico. July 20, 1970. Murray, Phelps, Hart, Schaffner ( $\delta$ , ♀ FMNH  $\delta$  TAMU); 5 miles sse. of Gomez Farias, Tamaulipas, Mexico. July 19–20, 1970. Murray, Phelps, Hart, Schaffner ( $\delta$  ♀ UNLP); Cerro Campana 800 m. Panama Prov., R. P. 3 Jun 72 (♀ HDE); Santa Fe Veraguas, Panama. 1100'. 7 Oct 73 Col: D. Engleman ( $\delta$  HDE); 45 km. sw. Cintalapa, Chiapas, Mexico. Aug. 12, 1967. el. 2500'. H. R. Burke and J. Hafernik (♀ NR); same data except 57 km and 2100' ( $\delta$  NR); San Benito. 16VI69. Sebaco, Nic. Col: Ev. Vogel ( $\delta$  ♀ LHR); Mexico: Oaxaca, Temascal. July 1, 1971. Taken at light. Clark, Murray, Hart, Schaffner (♀ FSCA); Teopisca, Chiapas, Mexico. VI-20-1965. Burke, Meyer, Schaffner (♀ TAMU); Honduras, Com., 5 mi NW Comayagua, 1600'. VII-18-1974 C. W. & L. O'Brien & Marshal (♀ LHR); Tepic, Nayarit, Mex. 9-13-57. R. & K. Dreisbach ( $\delta$  ♀ AMNH); Vera Cruz, Mex. 7-28-8-11-56 R. & K. Dreisbach (♀ AMNH); same data except date 11-1-57 ( $\delta$  AMNH); Acayucan, V.C. Mex. 10-23-56 R. & K. Dreisbach ( $\delta$  ♀ AMNH); San Blas, Nayarit, Mex. 9-13-57. R. & K. Dreisbach ( $\delta$  ♀ AMNH); Jalapa, Ver., Mexico. 5/21/1946 ( $\delta$  CAS); 17 Mi. S. Loma Bonita, Oax., Mex. Jan. 6, 1951 (♀ CAS); 14 Mi. E. San Blas, Nayarit, Mex. Oct. 8, 1950. Ray F. Smith (♀ AMNH); 3 Mi. E. Arco, Sin., Mex. Sept. 23, 1950. Ray F. Smith (♀ AMNH).

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### Footnote

<sup>1</sup> Repositories of paratypes are indicated as follows: American Museum of Natural History (AMNH); British Museum (Natural History) (BMNH); California Academy of Sciences (CAS); Field Museum of Natural History (FMNH); Florida State Collection of Arthropods (FSCA); L. H. Rolston (LHR); Museu Rio-Grandense de Ciencias Naturais (MRCN); Naturhistoriska Riksmuseet (NR); H. Dodge Engleman, M.D. (HDE); Texas A&M University (TAMU); Universidad Nacional Autónoma Mexico (UNAM); Universidad Nacional de La Plata (UNLP); Universidad Nacional de Peru (UNP).

*EPIBLEMA SCUDDERIANA* (CLEMENS) (LEPIDOPTERA:  
OLETHREUTIDAE), A WINTER HOST RESERVOIR FOR  
PARASITIC INSECTS IN SOUTHWESTERN PENNSYLVANIA

John D. Plakidas

*Abstract.*—Plakidas, John D., 8506 Forest Avenue, Pittsburgh, Pennsylvania 15237.—*Epiblema scudderiana* (Clemens) was studied for two successive winters 1974–1975 and 1975–1976, to evaluate the moth's economic importance as a winter host reservoir for parasitic insects in Southwestern Pennsylvania. From the collection of 5,609 galls for the two year study, an average of 11.12% primary parasitism was observed. Results reveal that *E. scudderiana* harbors 12 primary parasites, including 6 ichneumonids, 4 braconids, 1 eupelmid, and 1 tachinid. Seven of these parasites are known to parasitize a variety of insect pests during their summer generations. As an economically beneficial winter host reservoir, *E. scudderiana* increases the natality of these parasites during periods when alternate hosts are scarce.

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Introduction

The goldenrod gall moth, *Epiblema scudderiana* (Clemens), forms a thin walled, elliptical gall on the stem of *Solidago graminifolia* (L.). Its distribution ranges from Manitoba (Kearfott, 1905), Massachusetts (Clemens, 1860), Pennsylvania, New York, New Jersey, Ohio, Indiana, Illinois, Iowa and Wisconsin (Heinrich, 1923), to Georgia (Hoffmann, 1945). The moth larva is solitary in existence forming a single celled gall toward the upper half of the stem. I have observed that the larva begins gall formation in June and continues to develop through the summer months thus contributing to the long susceptible stage of the larva to stem boring parasites. The larva overwinters in the last instar and pupates late in April or early in May.

Although it is an abundant moth over its range of distribution there is a limited amount of literature on this insect. However, for the first time a large sample of the population has been studied and the results of the parasite frequencies and their alternate hosts are reported here.

Materials and Methods

Galls were collected in Allegheny, Beaver, and Butler counties in Southwestern Pennsylvania from December 1, through April 15, 1974–1976. The galls were opened and examined in the lab to determine their contents. The recovered gall moth larvae were placed in plastic petri dishes equipped with a cardboard grid composed of 21 individual 15 mm × 15 mm × 10 mm com-



partments. One larva was placed per compartment. All other larvae recovered from the galls were stored in the same manner described above. In order to more closely simulate the natural development of these larvae the petri dishes were stored in a closed metal container and placed outdoors away from direct sunlight until April 15. Following this they were brought indoors and kept at approximately 20°C to allow further development of the larvae. This method of storage proved effective in rearing and observing parasitic activity of the moth larvae, especially in the emergence of endoparasites. Reared adult parasitic specimens were sent to the Systematic Entomology Laboratory, United States Department of Agriculture, Beltsville, Maryland, for identification.

### Results and Discussion

In 1974–1975 a total of 4,567 galls were collected having an incidence of 11.37% parasitism. In 1975–1976 1,042 galls were collected having an incidence of 9.98% parasitism. From this sampling of 5,609 galls a combined average of 11.12% primary parasitism was recorded for the two years. In three species hyperparasitism was observed, all by *Perilampus fulvicornis* Ashmead.

The following is a list of the primary parasites, their percent parasitism of the total number of galls collected, and their alternate hosts as reported in the literature.

#### Ichneumonidae (Hymenoptera).

1. *Scambus pterophori* (Ashmead), 2.78%. Its hosts include, Olethreutidae: *Ancylys comptana* (Froel.), *Carpocapsa pomonella* (L.), *Grapholitha molesta* (Busck), *Epiblema otiosana* (Clemens), *E. strenuana* (Wlkr.), Pyralidae: *Pyrausta nubilalis* (Hbn.), Tortricidae: *Proteoteras aesculana* Riley, (Muesebeck, 1951). Because *S. pterophori* commonly attacks stem boring larvae using as host whatever species is available, there is no apparent synchronizing of its life cycle with that of its host (Cushman, 1926).
2. *Glypta rufiscutellaris* Cresson, 1.1%. Alternate hosts include, Olethreutidae: *A. comptana*, *C. pomonella*, *Grapholitha packardii* (Zeller), *G. prunivora* (Walsh), *G. molesta*, *Laspeyresia caryana* (Fitch), *Melissopus latiferreanus* (Wlsm.), *E. strenuana*, Tortricidae: *P. aesculana*, (Muesebeck, 1951). *G. rufiscutellaris* has been reported as an important parasite of the oriental fruit moth, *G. molesta*, (Merritt, 1933) (Putman, 1935). Its life cycle is not synchronous with that of the moth's (Pepper, 1934). Allen (1930) reports that the ragweed stem borer apparently serves as host for this parasite during periods when other moth larvae are scarce.

3. *Calliephialtes notandus* (Cresson), .84%. Other hosts include, Olethreutidae: *Epiblema desertana* ?, *E. strenuana*, Gelechiidae: *Gnorimoschema gallaesolidaginis* Riley, (Muesebeck, 1951). Summer generations of this parasite have been reported by Leiby (1922) who reared an adult of this species from *G. gallaesolidaginis*.
4. *Scambus* sp. either *granulosis* Wly. or *deceptor* Wly., .41%.
5. *Centeterus linearis* (Provancher), .23%.
6. *Calliephialtes grapholithae* (Cresson), .02%. Other hosts include, Olethreutidae: *C. pomonella*, *E. strenuana*, *G. molesta*, and *L. caryana*, (Muesebeck, 1951). Hamilton (1890) reared this parasite from the hickory shuckworm, *L. caryana*, and Merritt (1933) reared it from the oriental fruit moth. I reared a single male and it would seem that it is merely an accidental parasite of this moth.

Braconidae (Hymenoptera).

7. *Apanteles cacoeciae* Riley, 1.89%. Another reported host, Gelechiidae: *G. gallaesolidaginis*, (Muesebeck, 1951). This was the only gregarious species found to parasitize *E. scudderiana*. It was also hyperparasitized by *Perilampus fulvicornis* Ashmead.
8. *Macrocentrus pallisteri* Degant, 1.4%. Other hosts include, Olethreutidae: *E. otiosana*, *E. strenuana*, and *G. molesta*, (Muesebeck, 1951). Thirty occurrences of hyperparasitism by *P. fulvicornis* were recorded here.
9. *Agathis* sp., .94%. Eleven *Agathis* puparia yielded *P. fulvicornis*.
10. *Bracon* sp., .05%.

Eupelmidae (Hymenoptera).

11. *Eupelmus momphae* Gahan, 1.14%. Another recorded host, Olethreutidae: *Epiblema tripartitana* (Zell.), (Muesebeck, 1951). Hoffmann (1945) reared *E. momphae* from a stem boring larva in August, presumably from either *E. tripartitana* or *E. scudderiana*.

Tachinidae (Diptera).

12. *Lixophaga thoracica* Curran, .32%. The biology of this species is poorly understood (Curran, 1931).

Because many parasitic insects do not synchronize their life cycles with that of their host's they must rely on a variety of alternate hosts to maintain establishment within a community. From this study it is evident that *E. scudderiana* is host for a variety of parasites which are not synchronous with its own life cycle. *S. pterophori*, *C. notandus*, *G. rufiscutellaris*, *C. grapholithae*, *E. momphae*, *A. cacoeciae*, and *M. pallisteri*, are all known to utilize a variety of other hosts to maintain a standing population.

Pepper (1934) stated that a study of non-economic insects inhabiting weeds might yield valuable information in the biological control of injurious insects. From these results it is evident that *E. scudderiana* plays an essen-

tial role as a winter host reservoir for some parasitic insects in Southwestern Pennsylvania.

Expanding this concept, it may be advantageous to cultivate this and other suitable species of wild flowering plants in and around orchard and field crops to insure a standing population of specific parasitic insects. This method of cultivating weeds for the purpose of harboring hosts for parasitic species might be termed intercalation. A program utilizing this style of integrated control of insect pests could prove highly affective.

#### Acknowledgments

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REVISION OF THE GENUS *LOXA*  
(HEMIPTERA: PENTATOMIDAE)

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*Abstract.*—Eger II, Joseph E., Department of Entomology, Louisiana State University, Baton Rouge, La. 70803.—A key is provided to separate *Loxa* and four other American genera of similar appearance: *Chlorocoris*, *Chlorocephala*, *Fecelia* and *Mayrina*.

The genus *Loxa* is redescribed and the species are described, or redescribed, and keyed. Of the 10 included species three are new species: *Loxa melanita*, from Peru, Brazil and Guyana; *L. parapallida*, from Peru; and *L. peruviana* from Peru.

New synonymy recognized is *Loxa planifrons* Barber & Bruner, 1932, as a junior synonym of *L. pallida* Van Duzee, 1907; *L. flavicollis obtusa* Horvath, 1925, and *L. prasina* Horvath, 1925, as junior synonyms of *L. virescens* Amyot & Serville, 1843; *L. assimilis* Horvath, 1925, *L. columbiana* Horvath, 1925, *L. exsul* Horvath, 1925, *L. orthacantha* Horvath, 1925, *L. scutellaris* Horvath, 1925, and *L. vicina* Horvath, 1925, as junior synonyms of *L. viridis* (Palisot de Beauvois, 1805).

A lectotype and paralectotype are designated for *L. florida* Van Duzee, 1909, and *L. flavicollis obtusa* Horvath, 1925; and a lectotype is designated for *L. pecticornis* Horvath, 1925.

*Loxa haematica* is considered to be a *nomen dubium*.

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Introduction

The genus *Loxa* Amyot & Serville is similar in appearance to four other small tropical genera: *Chlorocoris* Spinola, *Chlorocephala* Stål, *Mayrinia* Horvath and *Fecelia* Stål. The last three genera have been revised recently (Grazia, 1968; Grazia-Vieira, 1972; Grazia-Vieira, 1973). All five genera may be recognized from descriptions and diagnoses in the literature, but no previous key separated all of them. A key is provided here to facilitate recognition of each, and the genus *Loxa* is redescribed.

The last revision of *Loxa* was based on so few specimens that intraspecific variation was underestimated (Horvath, 1925). Characters used by Horvath, such as color, length of antennal segments and the ratio of the length of the humeral spines to the breadth of the interocular vertex, were found to be quite variable within species. In addition, the male genitalia, which were found to be relatively consistent within species, were not used by Horvath.

Consequently, many junior synonyms were created and the key to species was unreliable.

In the following revision the key to species and descriptions, or redescrptions, of species emphasize the morphology of the parameres, proctiger and first gonocoxae. These structures, in most cases, show distinct interspecific differences and little intraspecific variation.

The terminology used for genitalia is that of McDonald (1966).

### Key to Genera of Similar Appearance

1. Ostiolar rugae very long, extending  $\frac{1}{2}$  or more width of metapleuron from ostiolar orifice to lateral margin, evanescent apically from ventrolateral view. *Chloroepela* Stål, 1867
- Ostiolar rugae extending less than  $\frac{1}{2}$  width of metapleuron from ostiolar orifice to lateral margin, somewhat spatulate apically from ventrolateral view 2
2. Superior surface of femora broadly rounded at apex *Chlorocoris* Spinola, 1837
- Superior surface of femora armed with acute spine at apex 3
3. Distal end of ostiolar rugae evanescent in profile *Mayrinia* Horvath, 1925
- Distal end of ostiolar rugae truncate in profile 4
4. Ostiolar rugae short, extending  $\frac{1}{5}$ – $\frac{1}{6}$  width of metapleuron from ostiolar orifice to lateral margin *Loxa* Amyot & Serville, 1843
- Ostiolar rugae relatively long, extending approximately  $\frac{1}{3}$  width of metapleuron from ostiolar orifice to lateral margin *Fecelia* Stål 1872

### *Loxa* Amyot & Serville, 1843

*Loxa* Amyot & Serville, 1843, p. 137, 198—Stål, 1867, p. 24 (keyed)—Walker, 1867, p. 241 (listed)—Stål, 1872, p. 36 (synonymy)—Distant, 1880, p. 70 (synonymy)—Lethierry & Severin, 1893, p. 149 (listed)—Kirkaldy, 1909, p. 96 (synonymy, names *flavicollis* type species)—Van Duzee, 1917, pp. 54–55 (synonymy)—Hart, 1919, p. 178 (keyed)—Horvath, 1925, pp. 307–324, tab. 4–5—Blatchley, 1926, p. 153 (description)—Barber & Bruner, 1932, p. 285 (keyed)—Barber, 1939, pp. 286, 295 (keyed)—Torre-Bueno, 1939, pp. 207–208 (keyed)—Bruner & Barber, 1949, p. 148 (listed)—Ruckes, 1952, p. 6 (synonymy)—Alayo, 1967, pp. 21–22 (keyed).

Dorsum pale green to dark blue green (apparently often discolored brown in part or whole), densely punctured concolorously or with red, moderately convex transversely behind humeri, strongly declivent before humeri. Venter generally lighter in color than dorsum (frequently discolored), strongly convex transversely, moderately punctured.

Head subtriangular; fine lines directed anterolaterad on anterior part of jugae, transverse on disk, tylus and jugae posteriorly; punctation mostly arranged in longitudinal bands (may be lacking in *pallida*). Jugae surpassing tylus, lateral margins convergent. Antennae 5 segmented; apex of first segment reaching apex of head or nearly so; segments 2-5 each distinctly longer than first segment; antenniferous tubercles visible from dorsal aspect.

Bucculae evanescent basally; each tooth near anterior limit angulate to rounded. Rostrum reaching middle of metathorax to posterior margin of third abdominal segment; basal segment distinctly surpassing distal end of bucculae.

Pronotum densely punctured, with transverse rugae separated by fine lines connecting punctures. Apex slightly wider than breadth of head across eyes, rarely by more than length of first denticle. Anterolateral margins denticulate; submarginal band of punctures moderately to strongly more dense than those of disk. Cicatrices well defined, usually possessing distinct tubercle, (obscure or absent in *planiceps*). Humeri usually produced into acute spines (except in *peruviansis*), moderately to strongly elevated.

Scutellum transversely convex, densely punctured, especially so posteriorly and laterally, 1.4 times longer than wide to subequal in width and length. Coria densely punctured; punctures becoming increasingly smaller and more dense posteriorly, forming dense submarginal band laterally on each corium; irregular scattered pale calli usually present; posterior angles reaching middle to slightly surpassing posterior margin of sixth abdominal segment. Frena extending approximately two-thirds length of scutellum. Membranes clear, immaculate or with scattered colored spots. Connexiva slightly lighter than or concolorous with dorsum; scattered punctures most dense near intersegmental sutures. Tergites slightly lighter than or concolorous with connexiva, impunctate.

Thoracic pleura moderately punctured with red or concolorously. Evaporative area from base of ostiole approximately  $\frac{3}{4}$  width of metapleura, frequently with fine irregular lines. Prosternum longitudinally concave; mesosternum moderately carinate mesally; metasternum nearly flat. Apex of each femur produced dorsally into narrowly angular to acute spine; tibiae sulcate. Abdominal sternites most densely punctured laterally, usually impunctate mesally; medial spine at base of abdomen lacking. Sixth visible abdominal segment of males and eighth paratergites of females produced posteriorly, usually forming distinct spine.

Spermathecal bulb with three digitiform processes. Proximal and distal flanges of pump distinct. Median dilation of spermathecal duct evenly produced, surrounding sclerotized rod (Fig. 5).

Posterior margin of pygophore subquadrate dorsally, subtriangular ventrally. Dorsolateral inner margin of genital cup with distinct denticle on each side about halfway between anterior and posterior limits of cup (except in

*deducta*). Superior ridge emarginate mesally. Inferior ridge strongly developed, forming vertical wall mesally; dorsal margin of wall with pair of pygophoral appendages; appendages (in *parapallida*, *pallida*, *planiceps* and *nesiotes*) with distinct recurved hooks overlapping posterior face of inferior ridge. Proctiger strongly ridged dorsolaterally, variously constricted mesally, deeply concave for approximately caudal half; concavity enclosing striate membrane. Parameres complex, with several processes. Theca large, acentric, constricted mesally, strongly attached to floor of pygophore by large basal plates. Thecal shield bowl-shaped; vesica surrounded by sheath. Conjunctival appendages absent (Figs. 25, 26).

*Distribution*.—Southern Texas and Florida south to Uruguay, Argentina and southern Brazil; restricted to New World.

*Type species*.—*Cimex flavicollis* Drury by subsequent designation (Kirkaldy, 1909).

*Comment*.—The species of *Loxa* are quite variable in color of preserved specimens, ranging from orange-brown and tan to blue-green. The greens are lost upon submersion in hot water, presumably also upon exposure to other high temperatures. The structure of the theca and spermatheca are relatively homogenous, interspecific variation being minimal. In contrast, the parameres and proctiger of males differ among species as do the first gonocoxae of most species, making identification possible in most cases by these structures alone.

#### Key to *Loxa* Males

- |   |                           |
|---|---------------------------|
| 1. Pygophoral appendages each with distinct caudal hook (Figs. 29, 33, 37, 41)                                    | 2                         |
| – Pygophoral appendages each without distinct caudal hook   | 5                         |
| 2. Lateral margins of dorsolateral parameral processes spiculate  | 3                         |
| – Lateral margins of dorsolateral parameral processes glabrous, lacking spicules                                  | 4                         |
| 3. Humeral spines weakly produced, distinctly curved caudad (Fig. 34)   |                           |
|   | <i>planiceps</i> Horvath  |
| – Humeral spines angled slightly caudad at most, usually projecting laterad, sometimes curving cephalad (Fig. 38) | <i>nesiotes</i> Horvath   |
| 4. Lateral margins of dorsolateral parameral processes convex from caudal view (Fig. 33)                          | <i>pallida</i> Van Duzee  |
| – Lateral margins of dorsolateral parameral processes slightly concave from caudal view (Fig. 29)                 | <i>parapallida</i> n. sp. |
| 5. Lateral carina of genital cup distinctly spiculate (Fig. 20)   | <i>deducta</i> Walker     |
| – Lateral carina of genital cup not at all spiculate  | 6                         |

- |   |                                      |
|---|--------------------------------------|
| 6. Posterior dorsal face of proctiger with pair of distinct spines (Figs. 7, 15)                | 7                                    |
| – Posterior dorsal face of proctiger lacking distinct spines                                    | 8                                    |
| 7. Dorsolateral parameral processes elongate, distinctly curving mesad (Fig. 16)                | <i>melanita</i> n. sp.               |
| – Dorsolateral parameral processes projecting laterad, not at all curving mesad (Fig. 8)        | <i>virescens</i> Amyot & Serville    |
| 8. Posterior margins of coria broadly rounded   | <i>peruviensis</i> n. sp.            |
| – Posterior margins of coria moderately to strongly sinuous, the lateral angles produced        | 9                                    |
| 9. Dorsolateral parameral processes from caudal view inclined dorsad, rounded at apex (Fig. 24) | <i>viridis</i> (Palisot de Beauvois) |
| – Dorsolateral parameral processes projecting laterad, acute apically (Fig. 4)                  | <i>flavicollis</i> (Drury)           |

#### Key to *Loxa* Females

- |   |                           |
|---|---------------------------|
| 1. First gonocoxae with mesal margins strongly divergent from base to apex (Fig. 18)  | <i>deducta</i> Walker     |
| – First gonocoxae with mesal margins contiguous or nearly so for most of their length   | 2                         |
| 2. First gonocoxae each moderately to strongly lobed posteriorly, extending onto ninth paratergites   | 3                         |
| – First gonocoxae each at most broadly rounded posteriorly not lobed and only narrowly overlapping ninth paratergites   | 5                         |
| 3. First gonocoxae each strongly produced posteriorly, extending onto ninth paratergites $\frac{1}{2}$ or more length of ninth paratergites (Fig. 14)                   | <i>melanita</i> n. sp.    |
| – First gonocoxae each moderately produced into broadly angular to rounded lobe, extending onto ninth paratergites less than $\frac{1}{3}$ length of ninth paratergites | 4                         |
| 4. Humeral spines moderately produced, curving caudad (Fig. 34); length of first gonocoxae from base at meson to posterior apex 1.6 mm or more                          | <i>planiceps</i> Horvath  |
| – Humeral spines strongly produced, projecting laterad to cephalad (Fig. 38); length of first gonocoxae from base at meson to posterior apex 1.4 mm or less             | <i>nesiotes</i> Horvath   |
| 5. Humeri weakly produced, each lacking distinct spine  | 6                         |
| – Humeri each moderately to strongly produced into distinct spine   | 7                         |
| 6. Posterior margins of coria broadly rounded   | <i>peruviensis</i> n. sp. |
| – Posterior margins of coria moderately to strongly sinuous, the lateral angles produced  | 8                         |



7. Length of first gonocoxae from base at meson to posterior apex greater than 1.7 mm; length of second gonocoxae at meson greater than 1.0 mm 8
- Length of first gonocoxae from base at meson to posterior apex less than 1.5 mm; length of second gonocoxae at meson less than 0.9 mm 9
8. Pronotum between humeri traversed by transverse fascia of rugae; coria each with discoidal pale spot; inferior face of basal two antennal segments with fine piceus line *virescens* Amyot & Serville
- Pronotum between humeri lacking transverse fascia of rugae; coria each without discoidal pale spot; basal two antennal segments lacking fine piceus line *flavicollis* (Drury)
9. Posterior margins of coria broadly rounded *pallida* Van Duzee
- Posterior margins of coria strongly sinuous, the lateral angles produced *viridis* (Palisot de Beauvois)

*Loxa flavicollis* (Drury, 1773)

*Cimex flavicollis* Drury, 1773, p. 67, pl. 36, fig. 4.

*Cimex albicollis* Fabricius, 1781, p. 347—Gmelin, 1788, p. 2138.

*Pentatoma flavicollis*: Palisot de Beauvois, 1805, p. 185.

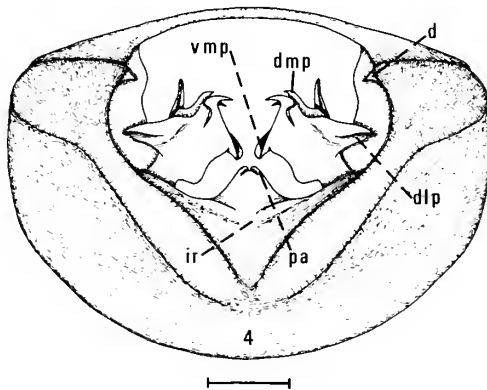
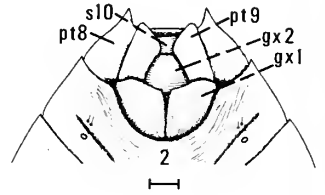
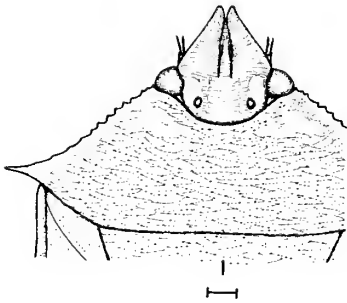
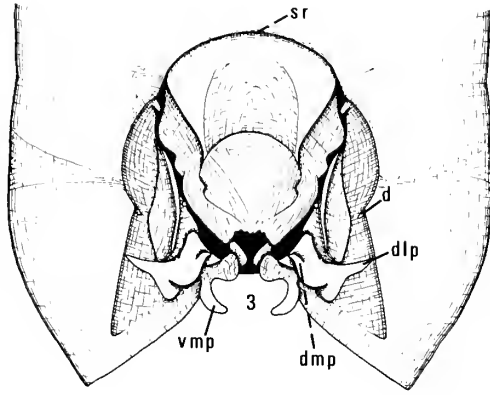
*Loxa flavicollis*: Dallas, 1851, p. 198 (in part)—Stål, 1860, p. 19—Walker, 1867, p. 241 (in part)—Walker, 1868, p. 549 (in part)—Distant, 1880, p. 70 (in part)—Uhler, 1876, p. 290 (in part)—Lethierry & Severin, 1893, p. 149 (in part)—Van Duzee, 1917, pp. 54–55—Horvath, 1925, pp. 319–320, tab. 4, fig. 7, tab. 5, fig. 6 (in part)—Torre-Bueno, 1939, p. 208 (in part)—Bruner & Barber, 1949, p. 158—McDonald, 1966, pp. 27, 51, figs. 224–229, 463 (genitalia)—Alayo, 1967 p. 22.

*Loxa affinis*: Distant, 1892, p. 336 (in part)—Lethierry & Severin, 1893, p. 149—Kirkaldy, 1909, p. 96 (in part).

*Loxa florida* Van Duzee, 1909, p. 156—Barber, 1914, p. 523—Van Duzee, 1917, pp. 54–55—Blatchley, 1926, pp. 28–30—Torre-Bueno, 1939, p. 208—Ruckes, 1952, p. 7.

Length (exclusive of extensions of membranes beyond apex of abdomen) ♂♂ 16.6–20.7 mm, ♀♀ 18.8–23.4 mm.

Jugae with mesal and lateral band of red or concolorous punctures variable in density; lateral margins nearly straight to slightly undulating (Fig. 1), usually lighter than disk. Tylus with mesal band of red to concolorous punctures for at least basal half. Antennae variable, usually uniformly lighter than disk of head, occasionally tinged with red or slightly darker than disk of head, basal two segments sometimes possessing fine dark brown to piceus line on inferior surface; length of segments (both sexes) 1.2–1.8; 2.0–3.0;



2.2–3.8; 2.7–4.6; 2.2–4.1 mm. Width of head across eyes ♂♂ 4.0–4.7 mm, ♀♀ 4.0–4.9 mm; length ♂♂ 3.4–4.3 mm, ♀♀ 3.4–4.4 mm.

Pronotal rugae uncommonly forming transverse fascia between humeri. Anterolateral margins generally paler than disk, with submarginal band of usually red punctures. Humeri moderately produced into spines, slightly elevated, projecting laterad to slightly cephalad (Fig. 1); red submarginal anterolateral band commonly extending onto each spine; humeral spines red to lighter than disk. Width of pronotum across humeri ♂♂ 11.4–14.6 mm, ♀♀ 10.8–15.6 mm; length at meson ♂♂ 4.2–5.3 mm, ♀♀ 3.8–5.4 mm.

Scutellum with numerous fine irregular calli, these usually pale; width at base ♂♂ 6.0–7.8 mm, ♀♀ 6.3–7.8 mm; length at meson ♂♂ 7.6–9.6 mm, ♀♀ 7.6–9.4 mm. Coria with scattered irregular calli, these usually paler than disk; discoidal spots usually lacking; posterior margins strongly sinuous, lateral angles produced.

Legs concolorous with or somewhat lighter than thoracic pleura, occasionally marked with red; apical femoral spines weakly produced.

First gonocoxae contiguous mesally for most of length, narrowly divergent near apex; posterior margins broadly rounded (Fig. 2); breadth at widest point 1.4–1.9 mm; length at meson 1.8–2.5 mm. Second gonocoxae with shallow longitudinal impression mesally; basal width 1.1–1.6 mm; mesal length 1.0–1.6 mm.

Superior ridge of genital cup moderately emarginate mesally; denticles on each inner dorsolateral margin of genital cup small, obtuse; sides of pygophore caudad of parameres relatively broad, somewhat compressed. Pygophoral appendages lacking distinct caudal hooks. Proctiger with two broadly angular projections located mesally along each lateral margin of posterior concavity; proctigeral spines lacking (Fig. 3). Ventral length of abdominal segments 3–6 at meson 0.8–1.2; 0.5–0.8; 0.3–0.6; 3.7–5.0 mm.

Each dorsolateral parameral process acute apically. Dorsomesal processes each with two short acute lobes; dorsal lobes projecting dorsad, curving mesad; ventral lobes projecting ventromesad. Each ventromesal process bilobed; dorsal lobes projecting dorsad, curving caudad and mesad at narrowly angular to obtuse apex; ventral lobes projecting ventromesad, curving laterad at acute apex (Fig. 4).

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←

Figs. 1–4. *L. flavicollis*. Fig. 1. Pronotum and head. Fig. 2. Female genital plates; first gonocoxa (gx1), second gonocoxa (gx2), eighth paratergite (pt8), ninth paratergite (pt9), tenth sternite (s10). Fig. 3. Genital cup, dorsal aspect: superior ridge (sr), denticle (d), dorsolateral parameral process (dlp), dorsomesal parameral process (dmp), ventromesal parameral process (vmp). Fig. 4. Genital cup, caudal aspect, omitting proctiger; inferior ridge (ir), pygophoral appendage (pa). Dimensional lines equal 1.0 mm.

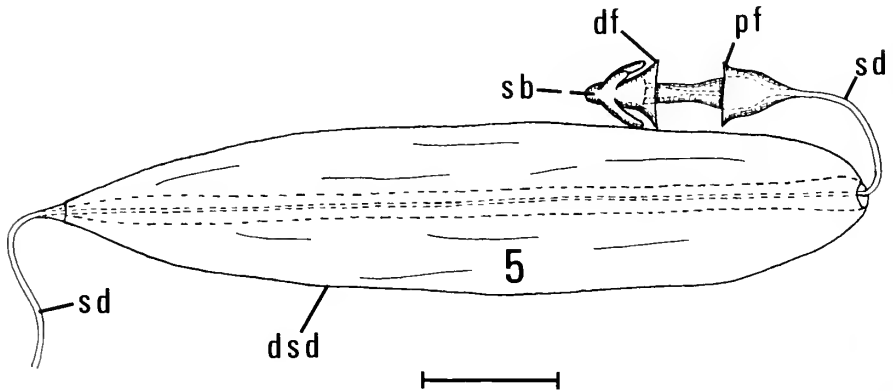


Fig. 5. *L. flavicollis*. Spermatheca and related structures; spermathecal bulb (sb), distal flange of spermathecal pump (df), proximal flange of spermathecal pump (pf), spermathecal duct (sd), dilation of spermathecal duct (dsd). Dimensional line equals 1.0 mm.

*Types*.—The type material of *Cimex flavicollis* is apparently lost. *Loxa florida* was described from Crescent City, Florida (a male) and from Biscayne Bay, Florida (a female). Blatchley (1925) and Ruckes (1952), however, cite only Crescent City as the type locality. No definite lectotype has been designated for this species so the male syntype from Crescent City is designated lectotype and the female from Biscayne Bay paralectotype. *Cimex albicollis* was proposed as a replacement name for *C. flavicollis* and as such is based on the type specimens of *C. flavicollis*.

*Distribution*.—Florida, Alabama, Bahamas, Jamaica (type locality), Cuba, Mexico, and Texas.

*Comment*.—This is a highly variable species in most of its characters, the male genitalia and female genital plates being relatively consistent, however.

*Loxa virescens* Amyot & Serville, 1843

*Cimex albicollis*: Herrich-Schaeffer, 1842, p. 68, fig. 634

*Loxa virescens* Amyot & Serville, 1843, pp. 137–138, tab. 3, fig. 3

*Loxa flavicollis*: Amyot & Serville, 1843, p. 137, tab. 3, fig. 3—Dallas, 1851, p. 198 (in part)—Walker, 1867, p. 241 (in part)—Walker, 1868, p. 549 (in part)—Stål, 1872, p. 36 (in part)—Uhler, 1876, p. 290 (in part)—Distant, 1880, p. 70 (in part)—Berg, 1884, p. 28—Lethierry & Severin, 1893, p. 149 (in part)—Kirkaldy, 1909, p. 96 (in part)—Horvath, 1925, pp. 319–320, tab. 4, fig. 7, tab. 5, fig. 6 (in part)—Torre-Bueno, 1939, p. 208 (in part)—Piran, 1948, p. 12—Becker & Grazia-Vieira, 1971, pp. 14–15.

*Pentatoma albicolle*: Herrich-Schaeffer, 1844, p. 94.

*Loxa affinis* Dallas, 1851, p. 198—Walker, 1867, p. 241—Stål, 1872, p. 36—Distant, 1880, p. 70, tab. 6, fig. 22—Distant, 1892, p. 336 (in part)—Lethierry & Severin, 1893, p. 149 (in part)—Distant, 1899, p. 441—Kirkaldy, 1909, p. 96 (in part)—Fennah, 1935, p. 194—Rolston, 1976, p. 3.

*Loxa invaria* Walker, 1867, p. 242—Lethierry & Severin, 1893, p. 149.

*Loxa flavicollis obtusa* Horvath, 1925, p. 320. NEW SYNONYMY.

*Loxa prasina* Horvath, 1925, p. 322, tab. 5, fig. 8. NEW SYNONYMY.

Length (exclusive of extensions of membranes beyond apex of abdomen)  
♂♂ 18.7–21.4 mm, ♀♀ 19.2–24.7 mm.

Head closely resembling that of *L. flavicollis*. Antennae variable, usually possessing fine light brown to piceus line on inferior face of basal two to three segments, superior face red or tinged with red; apical two or three segments commonly with at least apical half much darker than first two segments, basal part pale; length of segments (both sexes) 1.4–2.0; 2.0–3.7; 2.0–4.8; 3.0–5.6; 1.9–4.7 mm. Width of head across eyes ♂♂ 4.2–4.9 mm, ♀♀ 4.2–5.2 mm; length ♂♂ 3.6–4.5 mm, ♀♀ 3.5–4.6 mm.

Pronotum usually with transverse fascia of pale rugae between humeri (Fig. 6). Humeral spines usually lighter than disk of pronotum, rarely red. Width of pronotum across humeri ♂♂ 12.2–16.0 mm, ♀♀ 11.5–16.0 mm; mesal length ♂♂ 4.4–5.5 mm, ♀♀ 4.2–5.8 mm.

Basal width of scutellum ♂♂ 6.8–8.1 mm, ♀♀ 6.0–8.6 mm; length at meson ♂♂ 8.4–10.3 mm, ♀♀ 7.6–10.3 mm. Coria usually each with pale discoidal spot, this being occasionally concolorous and obscure or entirely lacking; posterior margins strongly sinuous, lateral angles produced.

Legs usually concolorous with or lighter than venter; tibiae occasionally with sparse piceus markings on lateral margins of anterior face.

Breadth of first gonocoxae at widest point 1.6–2.3 mm, length from base at meson to apex 2.1–3.0 mm. Second gonocoxae 1.2–1.7 mm wide at base; 1.2–1.7 mm long at meson.

Proctiger with pair of distinct spines on posterior dorsal face (Fig. 7). Mid-ventral length of male abdominal segments 3–6: 0.8–1.1; 0.4–0.7; 0.2–0.5; 3.9–5.1 mm.

Parameres each occasionally with spine on dorsocaudal face located about midway between dorsolateral process and dorsomesal process. Each dorsomesal process with dorsal lobe rounded, not spinose. Ventromesal processes each with ventral lobe more elongate than in *L. flavicollis* (Fig. 8), this process occasionally possessing rounded to spinose projection about midway between dorsal and ventral lobes.

*Types*.—The types of *Cimex flavicollis* and *Loxa virescens* are apparently not extant. The name *L. virescens*, rather than *L. flavicollis*, is assigned to

this species on the basis of the type localities. The type locality of *L. virescens* is Surinam, that of *C. flavicollis* is Jamaica. The types of *L. affinis* (type locality Paraguay) and *L. invaria* (type locality Guyana) are both females in the British Museum (Natural History), London. The type of *L. prasina* (type locality Venezuela) is a female and the two syntypes of *L. flavicollis obtusa* (type locality unknown) are a male and a female. These three specimens are in the Akademie der Landwirtschaftswissenschaften in East Germany. Type material on which the specific names of *L. affinis*, *L. invaria*, *L. prasina* & *L. flavicollis obtusa* were based was examined.

From the syntypic specimens of *L. flavicollis obtusa* the following is designated the lectotype:

♂, labeled (a)<sup>2</sup> coll. Breddin (b) Typus, *picticornis* var. *obtusa* Horv. (c) Horvath det. (d) Typus (e) *flavicollis obtusa* Horv.

The ♀, same data as lectotype (except label (e) is lacking) is designated paralectotype.

The syntypes of *L. flavicollis obtusa* possess unusually short humeral spines, approaching those of *L. peruviansis*, but are otherwise representative of *L. virescens*.

*Distribution*.—Southern Mexico south to southern Brazil and Uruguay.

*Comment*.—Since *L. virescens* has long been considered a junior synonym of *L. flavicollis*, the literature regarding these two species is confounded. The synonymy given here has of necessity a geographical basis. Fortunately, *L. virescens* and *L. flavicollis* are narrowly sympatric, their ranges apparently overlapping only in southern Mexico.

This species is very close to the preceding, being consistently different only in the structure of the male genitalia. Females usually can be distinguished by the discoidal spot on each coria, the transverse fascia of rugae on the pronotum and the antennal color. Each of these characters, however, is unreliable.

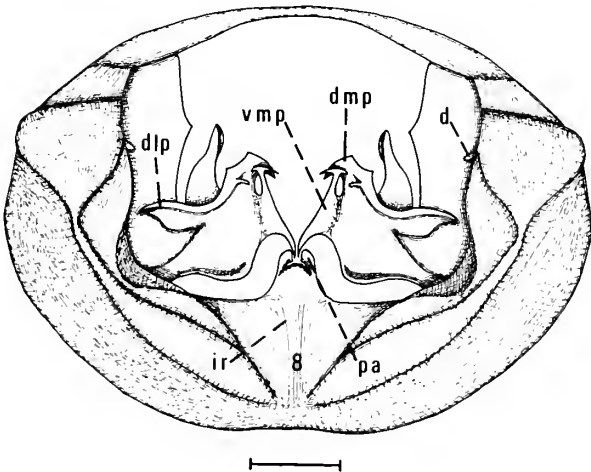
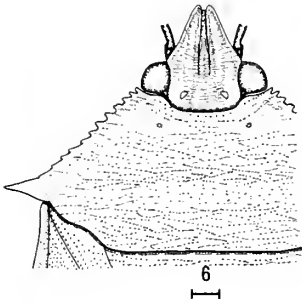
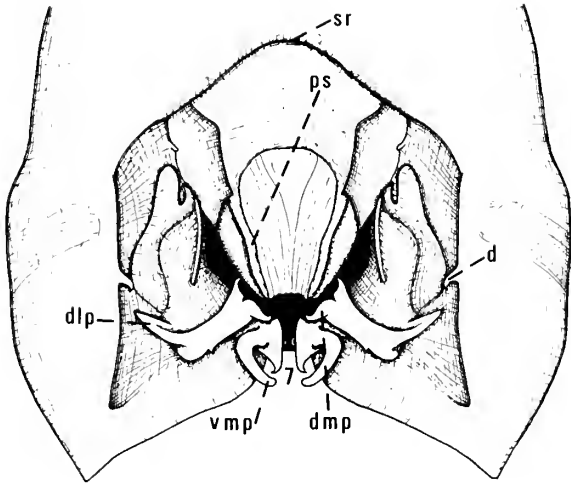
#### *Loxa peruviansis* n. sp.

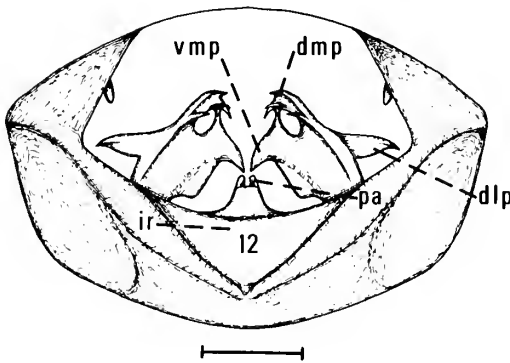
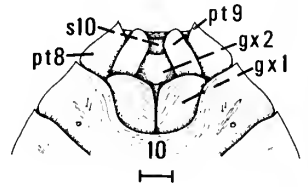
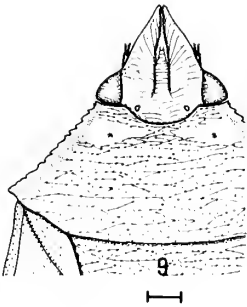
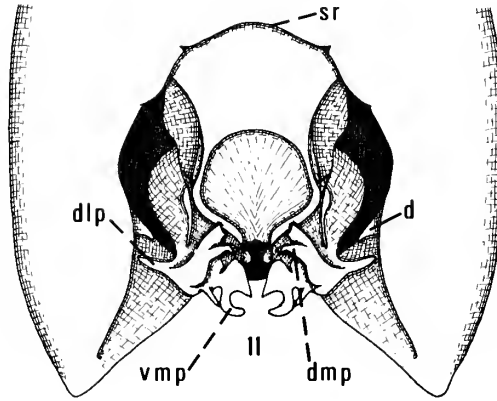
Length (exclusive of extensions of membranes beyond apex of abdomen)  
♂ 15.2 mm, ♀ ♀ 16.8–18.3 mm.

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Figs. 6–8. *L. virescens*. Fig. 6. Pronotum and head. Fig. 7. Genital cup, dorsal aspect; superior ridge (sr), denticle (d), proctigeral spine (ps), dorsolateral parameral process (dlp), dorsomesal parameral process (dmp), ventromesal parameral process (vmp). Fig. 8. Genital cup, caudal aspect, omitting proctiger; inferior ridge (ir), pygophoral appendage (pa). Dimensional lines equal 1.0 mm.







Lateral jugal margins usually moderately convergent for basal half, apical half strongly convergent; jugae usually each with thin submarginal band of dense punctures laterally, submarginal band of scattered punctures mesally. Antennae uniformly straw-colored, occasionally slightly darker near points of articulation. Length of segments 1.2–1.5; 1.8–2.2; 2.3–2.7; 2.6–2.8; 2.5 mm. Head slightly broader than long; width across eyes (both sexes) 3.7–4.0 mm; length 3.3–3.6 mm.

Disk of pronotum becoming most rugose between and anterior to cicatrices. Denticles of anterolateral margins punctured basally. Humeri weakly produced, broadly angular to obtuse apically (Fig. 9). Width across humeri ♂ 8.8 mm, ♀♀ 9.4–10.1 mm; length at meson ♂ 3.4 mm, ♀♀ 3.8–4.0 mm.

Scutellum transversely rugose anteriorly, less so posteriorly; scattered irregular calli usually present, especially posteriorly. Width at base ♂ 5.4 mm, ♀♀ 5.6–5.8 mm; length at meson ♂ 6.4 mm, ♀♀ 6.3–7.3 mm.

Scattered irregular pale calli on coria most dense posteriorly; discoidal spots lacking; posterior margins broadly rounded. Breadth of abdomen at widest point subequal to that of pronotum across humeri, ♂ 9.1 mm, ♀♀ 9.5–10.4 mm.

Legs concolorous with or slightly lighter than venter; apical femoral spines weakly produced, acute to narrowly angular apically.

Female genital plates smaller, but not structurally different from those of *L. flavicollis* and *L. virescens* (Fig. 10). Breadth of first gonocoxae at widest point 1.3–1.4 mm; length from base at meson to apex 1.6–1.8 mm. Basal width of second gonocoxae 1.1–1.3 mm; mesal length 0.8–1.3 mm.

Pygophore and enclosed structures very similar to *L. flavicollis*, differing as follows: *L. peruviansis* with bi-lobed apex of dorsomesal parameral processes thinner; caudal face of parameres at base of dorsomesal processes with distinct spine (Fig. 12); posterolateral margins of proctiger each lacking mesal raised area found in *L. flavicollis* (Fig. 11). Mid-ventral length of abdominal segments 3–6: 0.6; 0.4; 0.3; 4.3 mm.

*Holotype*.—Male, labeled (a) Pajjan, 4.8.67, N. Amaya C. (b) Meunprg No. 1168–68. Type no. 72137, U.S. National Museum.

*Paratypes*.—5 ♀♀; 2 ♀♀ (a) Peru, 1970 (b) Meunprg No. 567-70 (1-LHR, 1-AMNH); 1 ♀ (a) Peru: Dept. LaLibertad, Immediately N. of Trujillo. Pan

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Figs. 9–12. *L. peruviansis*. Fig. 9. Pronotum and head. Fig. 10. Female genital plates: first gonocoxa (gx1), second gonocoxa (gx2), eighth paratergite (pt8), ninth paratergite (pt9), tenth sternite (s10). Fig. 11. Genital cup, dorsal aspect; superior ridge (sr), denticle (d), dorsolateral parameral process (dlp), dorsomesal parameral process (dmp), ventromesal parameral process (vmp). Fig. 12. Genital cup, caudal aspect, omitting proctiger; inferior ridge (ir), pygophoral appendage (pa). Dimensional lines equal 1.0 mm.

American Highway. 31.XII.1963 (b) P.C. Hutchinson and J.K. Wright Collectors (CAS); 1 ♀ (a) Peru, Ancash, Dec. 1965 (b) UA 610-67 (USNM); 1 ♀ (a) Piura, Peru (b) CHTTownsend Collector (USNM).

*Distribution.*—Peru.

*Comment.*—Easily distinguished from most of its congeners by the lack of distinct humeral spines.

*Loxa melanita* n. sp.

Length (exclusive of extensions of membranes beyond apex of abdomen) ♂ ♂ 17.9–19.4 mm, ♀ ♀ 19.4–22.8 mm.

Lateral jugal margins evenly convergent; apical and lateral margins narrowly yellow bordered, with fine piceus line on lateral face at apex and for short distance from apex; both mesal and lateral submarginal band of dense red punctures present. Narrow mesal line of red punctures present along basal half of tylus. First antennal segment reddish, second segment dull yellow, usually with red tinge; two basal segments each with fine piceus line on ventral and posterolateral surfaces, both lines extending entire length of segments; basal  $\frac{1}{2}$  to  $\frac{1}{3}$  of third segment pale, becoming piceus apically, fourth and fifth segments similarly colored, with only basal  $\frac{1}{4}$  to  $\frac{1}{5}$  pale. Length of segments (both sexes) 1.6–1.9; 2.6–3.3; 2.8–3.8; 3.6–5.1; 3.8–4.4 mm. Head slightly wider across eyes than long, ♂ ♂ 4.1–4.5 mm wide, 3.6–4.0 mm long; ♀ ♀ 4.2–4.7 mm wide, 3.4–4.2 mm long.

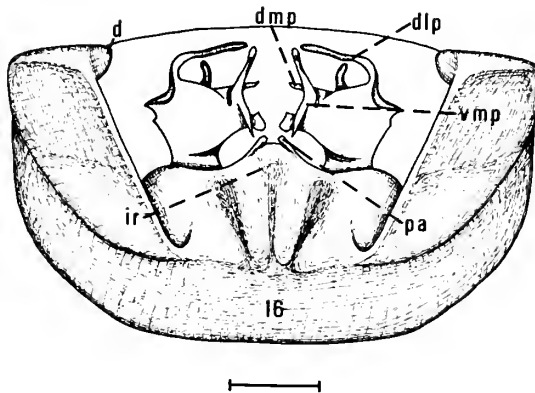
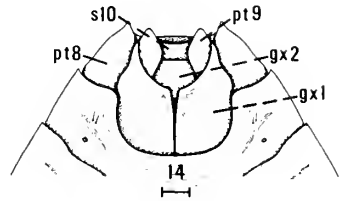
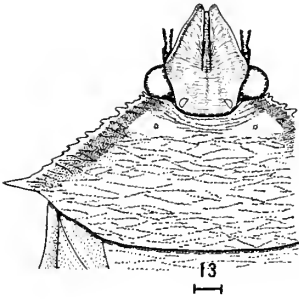
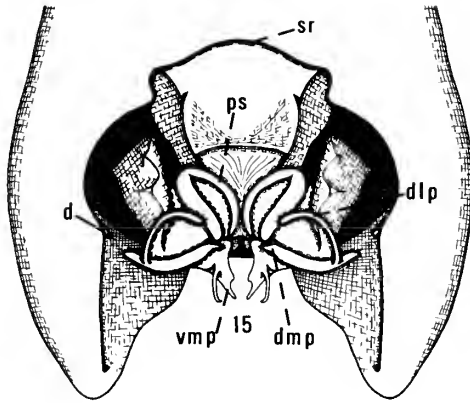
Anterolateral margins of pronotum nearly straight, varying from slightly lighter green than disk to bright yellow-orange. Humeri strongly produced into spines, slightly elevated, lighter in color than remainder of pronotum, sometimes connected by fascia of weak discontinuous rugae. Pronotal width across humeri ♂ ♂ 12.1–14.8 mm, ♀ ♀ 12.7–15.0 mm; length at meson ♂ ♂ 4.3–5.0 mm, ♀ ♀ 4.2–5.1 mm.

Breadth of scutellum at base ♂ ♂ 6.1–7.7 mm, ♀ ♀ 6.3–7.4 mm; length at meson ♂ ♂ 7.8–8.9 mm, ♀ ♀ 7.6–9.4 mm. Coria each with one large pale discoidal spot; scattered irregular pale calli present; posterior margins strongly sinuous, lateral angles produced.

Legs light green to greenish-brown; apical femoral spines moderately pro-

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Figs. 13–16. *L. melanita*. Fig. 13. Pronotum and head. Fig. 14. Female genital plates: first gonocoxa (gx1), second gonocoxa (gx2), eighth paratergite (pt8), ninth paratergite (pt9), tenth sternite (s10). Fig. 15. Genital cup, dorsal aspect; superior ridge (sr), denticle (d), proctigeral spine (ps), dorsolateral parameral process (dlp), dorsomesal parameral process (dmp), ventromesal parameral process (vmp). Fig. 16. Genital cup, caudal aspect, omitting proctiger; inferior ridge (ir), pygophoral appendage (pa). Dimensional lines equal 1.0 mm.



duced; apex of fore, mid and, occasionally, hind femora tipped with piceus; fore and mid tibiae with lateral and mesal borders of superior face each possessing piceus line, darkest at both extremes, evanescent toward middle of tibiae.

First gonocoxae each strongly and acutely produced posteriorly (Fig. 14), extending for more than half of length of ninth paratergites; breadth at widest point 1.6–2.2 mm, length from base at mesal margin to apex 2.8–4.2 mm. Second gonocoxae with thin obscure to distinct longitudinal concavity along meson; slightly broader than long; 1.2–1.6 mm wide at base, 1.0–1.3 mm long at meson.

Denticles on each inner dorsolateral margin of genital cup small and obtuse. Superior ridge shallowly emarginate mesally, sinuate. Sides of pygophore caudad of parameres thin, strongly compressed. Caudal third of proctiger with two distinct strongly recurved spines lying flush with proctigeral surface (Fig. 15). Pygophoral appendages without caudal hooks. Ventral length of male segments 3–6 at meson 0.7–0.8; 0.3–0.4; 0.2–0.3; 4.3–4.8 mm.

Parameres with several distinctive processes. Each dorsolateral process elongate, recurved from dorsal view, obtuse apically. Dorsomesal processes each acute, curving dorsad at apex. Each ventromesal process bi-lobed; dorsal lobes each obtuse apically and strongly recurved from lateral aspect; ventral lobes each sharply acute apically, slightly curved laterad from caudal view (Figs. 15, 16).

*Holotype*.—Male, labeled (a) Brazil, Mato Grosso: Lat. 12° 31' & Long. 55° 37'. Sinop, October, 1974, M. Alvarenga. Deposited in the American Museum of Natural History.

*Paratypes*.—5♂♂ and 14♀♀; 2♂♂ and 5♀♀ same data as holotype (1♂ BMNH, 1♀ Museu Nacional, Brazil, 1♂ and 4♀♀ AMNH); 1♂ and 2♀♀ (a) Brazil, Mato Grosso: Vila Vera, 55° 30' long., 12° 46' lat., Oct., 1973, M. Alvarenga (1♀ LHR, 1♂ and 1♀ AMNH); 1♀ (a) Brazil: Para Jacareacanga, Dec., 1968, M. Alvarenga (AMNH); 1♂ and 1♀ (a) Tingo Maria, Rio Huallaga (b) WKW 758, Peru, 670 m., XII.46, W. Weyrauch (AMNH); 1♀ (a) Tingo Maria, Huan., Peru, Jan. 20, 194- . Alt. 2200 ft. (b) J.C. Pallister Coll. Donor Frank Johnson (c) *Loxa* sp. nov. (AMNH); 1♀ (a) Peru: Monson Valley, Tingo Maria, XII-18-1954 (b) E.I. Schlinger & E.S. Ross collectors (CAS); 1♀ (a) Peru, S. Amer. Cucharas, Vall. of Riv. Huallaga, 500 mtrs. A.S.L. (b) Dept. Huanuco, II.16.1954, F. Woytkowski (c) J.C. Lutz Collection, 1961 (USNM); 1♀ Santipo, Peru, IV.15.1941, P. Paprzyoki (b) 38 (c) J.C. Lutz Collection, 1961 (USNM); 1♂ Tingo Maria, Peru, I.1950, H.A. Allard (USNM); 1♀ (a) Upper Mazaruni R., Br. Guiana, IX-X, 1938 (b) Coll. A.S. Pinkus (c) *Loxa* sp. nov. Ruckes (AMNH).

*Distribution*.—Brazil, Peru, Guyana.

*Comment*.—This species is, in general, darker in overall coloration and possesses more black or piceus markings than its congeners. From them it is easily distinguished by the remarkably elongate parameral processes and by the shape of the first gonocoxae.

*Loxa deducta* Walker, 1867

*Loxa deducta* Walker, 1867, pp. 242–243—Lethierry & Severin, 1893, p. 149 (synonymy, distribution)—Van Duzee, 1901, p. 344 (distribution)—Horvath, 1925, p. 321, tab. 4, fig. 8, tab. 5, fig. 7—Buckup, 1961, p. 11 (distribution)—Rolston, 1976, p. 4.

Length (exclusive of extensions of membranes beyond apex of abdomen) ♂♂ 13.3–16.3 mm, ♀♀ 16.3–19.4 mm.

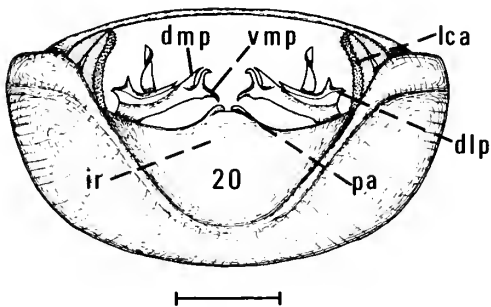
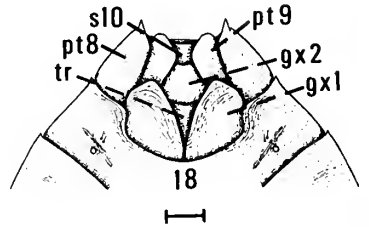
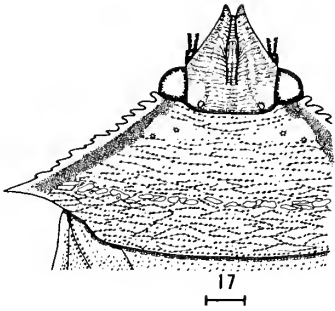
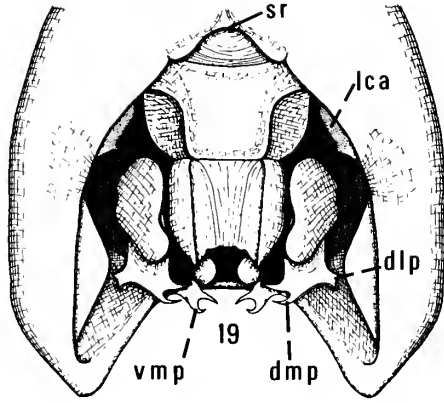
Disk of head with scattered punctures usually concentrated in mesal longitudinal band. Jugae with both mesal and lateral submarginal band of dense red punctures, these occasionally concolorous in mesal band; lateral margins slightly undulating; lateral face at apex and for short distance from apex occasionally with fine piceus line. Tylus with mesal band of usually red punctures on approximately basal half, punctures on apical half scattered. Antennae lighter than head or concolorous with it, occasionally tinged with red; length of segments (both sexes) 1.2–1.4; 1.8–2.4; 2.1–2.6; 2.4–3.2; 2.4–2.8 mm. Width of head across eyes ♂♂ 3.3–3.8 mm, ♀♀ 3.4–3.9 mm; length ♂♂ 2.8–3.3 mm, ♀♀ 2.8–3.4 mm.

Disk of pronotum traversed between humeri by fascia of usually pale rugae. Anterolateral margins nearly straight, paler than or concolorous with disk. Humeri strongly produced into elevated spines, projecting laterad to slightly cephalad (Fig. 17). Width of pronotum across humeri ♂♂ 10.2–12.6 mm, ♀♀ 11.2–13.1; length at meson ♂♂ 3.4–4.2 mm, ♀♀ 3.3–4.2 mm.

Scutellum with scattered irregular, usually pale, calli; basal breadth ♂♂ 4.7–6.0 mm, ♀♀ 4.7–6.0 mm; length at meson ♂♂ 5.7–7.6 mm, ♀♀ 6.6–7.6 mm. Coria with numerous scattered pale calli; discoidal spots lacking; posterior margins slightly sinuous to broadly rounded, lateral angles not produced.

Legs nearly concolorous with venter; apical femoral spines moderately produced.

Mesal margins of first gonocoxae widely divergent from base to apex, distinctly exposing triangulum; posterior margins broadly rounded (Fig. 18); maximum width 1.2–1.7 mm; length from base at meson to apex 1.7–2.2 mm. Second gonocoxae slightly broader at base than long at meson, 1.0–1.3:0.9–1.2 mm, usually with shallow longitudinal sulcus mesally.



Denticles lacking on inner dorsolateral margins of genital cup. Pygophore with posterior margin deeply concave, sides caudad of parameres broad, slightly compressed. Superior ridge deeply emarginate; lateral carina distinctly spiculate. Mesal wall of inferior ridge strongly angled dorsocaudad from below. Pygophoral appendages lacking caudal hooks. Proctiger subquadrate, quadrately emarginated posteriorly; caudolateral margin appearing somewhat spinose (Fig. 19). Mid-ventral length of abdominal segments 3–6, 0.6–0.7; 0.2–0.6; 0.1–0.2; 3.8–4.7 mm.

Caudal face of parameres transversely elongate, each with dorsomesal spine. Dorsolateral processes each bi-lobed from dorsal aspect, both lobes spinose; one projecting cephalad, one mesad. Each ventromesal process also bi-lobed; dorsal lobe strongly recurved caudally, apex acute, slightly turned mesad; ventral lobe broad basally, acute apically, projecting ventromesad, curving ventrad at apex (Fig. 20).

*Type*.—Female in the British Museum (Natural History), London. Type examined.

*Distribution*.—Panama, Venezuela, Bolivia, Brazil (type locality), Uruguay, Paraguay, Argentina.

*Comment*.—This is a very distinctive species, easily distinguished by the shape of the parameres and proctiger, by the spiculate lateral carina of the genital cup, and by the divergent first gonocoxae of females.

*Loxa viridis* (Palisot de Beauvois, 1805)

*Pentatoma viridis* Palisot de Beauvois, 1805, p. 111, pl. Hemip. 8, fig. 1.

*Loxa viridis*: Dallas, 1851, p. 198 (placed in synonymy of *flavicollis*)—Horvath, 1925, p. 311, tab. 4, fig. 1, tab 5, fig 1.

*Loxa picticornis* Horvath, 1925, pp. 312–313, tab. 4, fig. 2, tab. 5, fig. 2—Buckup, 1961, p. 11 (distribution)—Becker & Grazia-Vieira, 1971, p. 58 (distribution). NEW SYNONYMY.

*Loxa scutellaris* Horvath, 1925, pp. 313. NEW SYNONYMY.

*Loxa vicina* Horvath, 1925, pp. 313–314, tab. 5, fig. 3. NEW SYNONYMY.

*Loxa exsul* Horvath, 1925, pp. 314–315, tab. 4, fig. 3. NEW SYNONYMY.

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Figs. 17–20. *L. deducta*. Fig. 17. Pronotum and head. Fig. 18. Female genital plates: first gonocoxa (gx1), second gonocoxa (gx2), eighth paratergite (pt8), ninth paratergite (pt9), tenth sternum (s10), triangulum (tr). Fig. 19. Genital cup, dorsal aspect: superior ridge (sr), lateral carina (lca), dorsolateral parameral process (dlp), dorsomesal parameral process (dmp), ventromesal parameral process (vmp). Fig. 20. Genital cup, caudal aspect, omitting proctiger: inferior ridge (ir), pygophoral appendage (pa). Dimensional lines equal 1.0 mm.

*Loxa columbiae* Horvath, 1925, pp. 315–316, tab. 4, fig. 4—Becker & Grazia-Vieira, 1971, p. 14 (distribution). NEW SYNONYMY.

*Loxa assimilis* Horvath, 1925, p. 316, tab. 4, fig. 5. NEW SYNONYMY.

*Loxa orthacantha* Horvath, 1925, pp. 317–318, tab. 5, fig. 4—Pirán, 1968, p. 21, pl. 1, fig. C (distribution). NEW SYNONYMY.

*Loxa pilipes* Horvath, 1925, pp. 318–319, tab. 5, fig. 5—Barber, 1939, p. 249 (keyed, synonymy)—Bruner & Barber, 1949, p. 159 (distribution)—Ruckes, 1952, pp. 6–7 (synonymy, distribution)—Alayo, 1967, pp. 21, 23 (synonymy, keyed, distribution). NEW SYNONYMY.

Length (exclusive of extensions of membranes beyond apex of abdomen) ♂♂ 18.3–25.5 mm; ♀♀ 18.9–25.3 mm.

Lateral margins of jugae undulating, normally becoming divergent at apex, usually lighter in color than disk of head; each with submarginal band of dense concolorous to red punctures along lateral and mesal margins. Lateral margins of tylus each with submarginal line of dense, usually red, punctures. Antennae highly variable in color, from almost entirely pale to dark, mostly possessing some red coloration and at least one fine brown to piceus line on two basal segments; apical three segments commonly darker at apex than at base; length of segments (both sexes) 1.2–2.0; 1.9–3.2; 2.2–4.7; 2.6–4.6; 2.1–4.0 mm. Width of head across eyes ♂♂ 3.7–4.8 mm, ♀♀ 3.7–4.7 mm; length ♂♂ 3.4–4.4 mm, ♀♀ 3.3–4.5 mm.

Rugae of pronotum occasionally forming transverse fascia between humeri. Anterolateral margins usually lighter than disk. Humeri strongly produced into acute spines, moderately to strongly elevated, directed laterad or laterocephalad (Fig. 21), usually concolorous with anterolateral margins or red. Width of pronotum across humeri ♂♂ 13.8–19.4 mm, ♀♀ 13.3–18.7 mm; length at meson ♂♂ 4.2–5.7 mm, ♀♀ 4.1–5.9 mm.

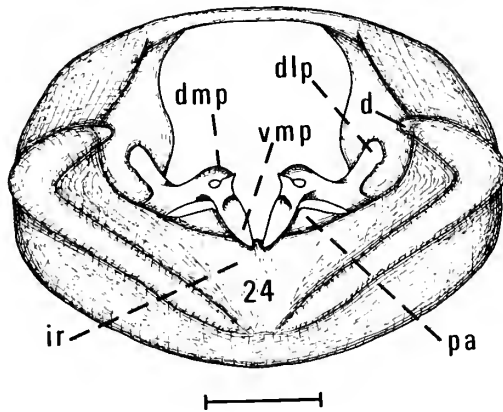
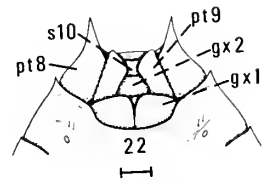
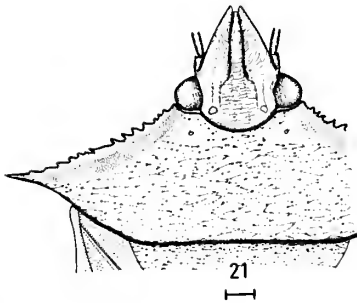
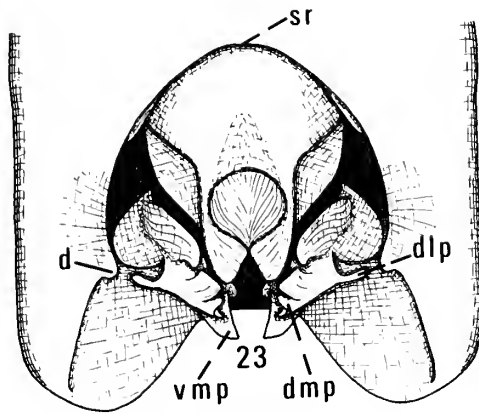
Scutellum frequently with numerous scattered irregular calli, these concolorous to pale; width at base ♂♂ 5.9–8.6 mm, ♀♀ 6.0–8.3 mm; mesal length ♂♂ 7.3–10.2 mm, ♀♀ 6.5–9.7 mm. Coria normally with scattered irregular pale calli; large discoidal spots present or absent; posterior margins strongly sinuous, lateral angles produced.

Legs varying from almost entirely light brown or light green to much darker, bearing some red coloration and frequently piceus markings at apex

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Figs. 21–24. *L. viridis*. Fig. 21. Pronotum and head. Fig. 22. Female genital plates: first gonocoxa (gx1), second gonocoxa (gx2), eighth paratergite (pt8), ninth paratergite (pt9), tenth sternite (s10). Fig. 23. Genital cup, dorsal aspect: superior ridge (sr), denticle (d), dorsolateral parameral process (dlp), dorsomesal parameral process (dmp), ventromesal parameral process (vmp). Fig. 24. Genital cup, caudal aspect, omitting proctiger; inferior ridge (ir), pygophoral appendage (pa). Dimensional lines equal 1.0 mm.





of femora and at base and apex of tibia; apical femoral spines strongly produced.

First gonocoxae nearly contiguous to slightly divergent for much of length along mesal margins, apex of mesal margin rounded; posterior margins nearly straight transversely, slightly undulating (Fig. 22); breadth at widest point 1.1–1.7 mm; length from base at meson to apex 1.0–1.4 mm. Second gonocoxae 0.9–1.3 mm wide at base, 0.5–0.8 mm long at meson.

Superior ridge of genital cup broadly emarginate mesally; denticle on each inner dorsolateral margin of genital cup broadly rounded; sides of pygophore caudad of parameres slightly compressed. Pygophoral appendages lacking distinct hooks. Proctiger lacking distinct spines on dorsal face (Fig. 23). Mid-ventral length of abdominal segments 3–6: 1.0–1.7; 0.7–1.6; 0.3–1.0; 3.7–5.5 mm.

Parameres (Fig. 24) with each dorsolateral process subquadrate, somewhat thinner at base than at apex. Dorsomesal processes broad; each projecting mesad, slightly curving ventrad; apex broadly rounded. Each ventromesal process tri-lobed; ventral lobe projecting ventromesad, rounded to narrowly obtuse apically; dorsal lobe somewhat subtriangular from mesal aspect with point which projects cephalad thinner and more elongate than other two; mesal lobe flattened in mesal aspect, rounded apically.

*Types*.—The type specimens of *Pentatoma viridis*, *Loxa vicina*, *L. orthacantha* and *L. pilipes* are all apparently lost. The holotype of *L. assimilis*, a male, in the Naturhistorisches Museum Wien was kindly compared to a determined specimen of *L. viridis* and drawn for me by Dr. A. Kaltenbach. Holotypes for the following species are in the Akademie der Landwirtschaftswissenschaften: *L. columbiae*, a male; *L. exsul*, a male; *L. scutellaris*, a female. These types were examined.

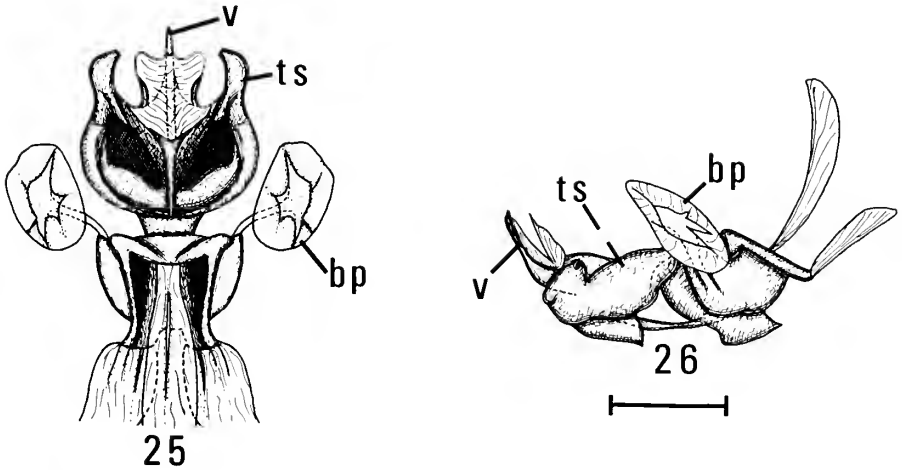
The syntypes of *L. picticornis* are in the following institutions: Akademie der Landwirtschaftswissenschaften; Magyar Nemzeti Muzem Allattara; Naturhistorisches Museum Wien. The entire syntype series for *L. picticornis* was not examined; therefore, a lectotype only is designated as follows:

♂, labeled (a) Porto do Cadi (b) F. Hoffmann coll., Arp dedic. 1921 (c) *Loxa picticornis* Horvath (d) Holotypus. (Magyar Nemzeti Muzem Allattara).

Apparently Horvath intended this specimen to be the holotype, although he did not indicate this in his publication. There is also the possibility that this label was added subsequent to Horvath's revision.

*Distribution*.—Southern Texas and Florida south to southern Brazil and Argentina.

*Comment*.—This species is the most widespread of the genus and the most



Figs. 25–26. *L. viridis*. Fig. 25. Theca and related structures, dorsal aspect; vesica (v), thecal sheath (ts), basal plate (bp). Fig. 26. Theca and related structures, lateral aspect. Dimensional lines equal 1.0 mm.

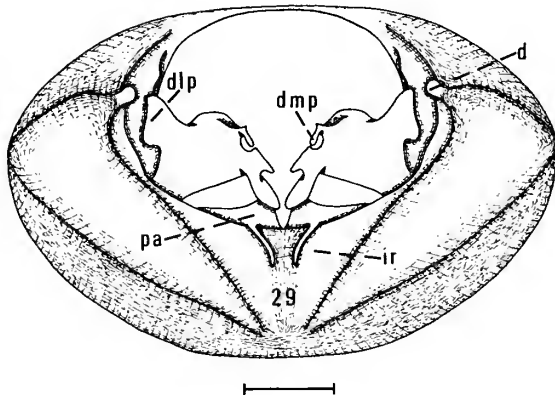
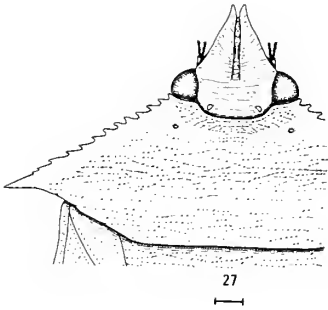
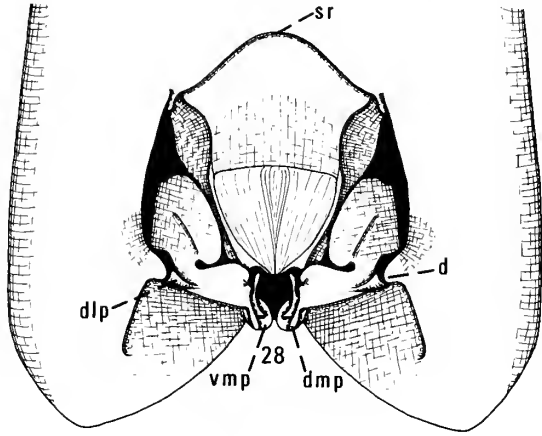
variable, but the male genitalia and female genital plates are relatively consistent throughout. Variability appears to be somewhat geographically correlated, but the examination of a large series shows the intergradation of the different geographical forms.

The pygophore and enclosed structures are similar to those of *L. nesiotus*, *L. pallida*, *L. parapallida* and *L. planiceps*. From these four species, *L. viridis* is especially distinguished by the absence of caudal hooks on the pygophoral appendages. The first gonocoxae resemble only those of *L. pallida* (the female of *L. parapallida* being unknown), but females of *L. viridis* can be distinguished from *L. pallida* by the absence of numerous dense calli on the dorsum (which are normally present in *L. pallida*), and by the sinuous posterior margins of the coria (which are broadly rounded in *L. pallida*).

#### *Loxa parapallida* n. sp.

Length (exclusive of extensions of membranes beyond apex of abdomen) ♂ 18.9 mm.

Disk of head moderately punctured with red. Lateral margins of jugae yellow, undulating, divergent at apex; three bands of red punctures present on each jugum; one marginal laterally, one submarginal along mesal margins and continuing onto vertex of head, one parallel to and laterad of submarginal band and terminating at ocellus. Tylus with submarginal line of red punctures along each lateral margin. Antennae light brown, two basal seg-



ments with fine brown line on inferior face; length of segments ♂ 1.5; 2.2; 3.2; 3.1; 2.8 mm. Width of head across eyes ♂ 4.2 mm; length ♂ 3.9 mm.

Pronotum without pale calli; anterolateral margins yellow, submarginal band of punctures dense. Humeri strongly produced into spines, projecting slightly caudad, moderately elevated (Fig. 27). Width of pronotum across humeri ♂ 15.7 mm; length at meson ♂ 4.7 mm.

Basal breadth of scutellum ♂ 7.0 mm; length at meson ♂ 8.2 mm. Irregular pale calli scattered on coria; each corium with pale discoidal spot, sinuous posterior margin, slightly produced lateral angle.

Legs light brown to green; apical femoral spines strongly produced.

Pygophore and enclosed structures very similar to *L. pallida* (Figs. 28, 29), with the following differences: lateral margins of dorsolateral parameral processes each shallowly concave (convex in *L. pallida*); mesal face of each ventromesal process deeply emarginate (less prominently so in *L. pallida*); pygophoral appendages projecting ventromesad, curving ventrad (projecting ventrad, curving laterad in *L. pallida*). Mid-ventral length of segments 3–6: 0.8; 0.4; 0.3; 4.2 mm.

*Holotype*.—Male, labeled (a) Achinamiza, Peru, VIII-28-27, F. 6001 (b) H. Bassler Collection, Acc. 33591. Deposited in the American Museum of Natural History. No paratypes.

*Distribution*.—Peru.

*Comment*.—The male genitalia are very close to *L. pallida*, but *L. parapallida* is larger and differs in the form of the parameres. In overall size and shape, and in the structure of most of the male genitalia this species is similar to *L. viridis*, but is easily distinguished by the presence of caudal hooks on the pygophoral appendages which are absent in *L. viridis*. The female of this species is unknown.

The punctuation of the jugae, apparently diagnostic, may prove variable within the species.

### *Loxa pallida* Van Duzee, 1907

*Loxa pallida* Van Duzee, 1907, pp. 9–10—Kirkaldy, 1909, p. 197 (synonymy)—Horvath, 1925, p. 317, tab. 4, fig. 6—Barber & Bruner, 1932, pp.

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Figs. 27–29. *L. parapallida*. Fig. 27. Pronotum and head. Fig. 28. Genital cup, dorsal aspect; superior ridge (sr), denticle (d), dorsolateral parameral process (dlp), dorsomesal parameral process (dmp), ventromesal parameral process (vmp). Figs. 29. Genital cup, caudal aspect, omitting proctiger; inferior ridge (ir), pygophoral appendages (pa). Dimensional lines equal 1.0 mm.

259–260—Bruner & Barber, 1949, p. 159 (distribution)—Alayo, 1967, pp. 22–23, pl. 4, fig. 1 (synonymy, keyed).

*Loxa planifrons* Barber & Bruner, 1932, p. 260, pl. 25, fig. 7—Wolcott, 1936, p. 177—Barber, 1939, p. 294 (synonymy, keyed)—Bruner & Barber, 1949, p. 159—Wolcott, 1950, p. 192—Alayo, 1967, p. 23 (synonymy, keyed). NEW SYNONYMY.

Length (exclusive of extensions of membranes beyond apex of abdomen)  
 $\delta\delta$  16.9–19.0 mm;  $\text{♀♀}$  17.4–21.1 mm.

Head with sparse concolorous punctures, scattered pale areas. Lateral margins of jugae concolorous with disk to pale, nearly straight, divergent apically. Antennae uniformly colored, slightly lighter than dorsum, occasionally apical two segments darker or more yellowish. Length of segments (both sexes) 1.2–1.4; 2.0–2.4; 1.9–2.7; 2.3–2.7; 2.2–2.7 mm. Head slightly broader than long; width across eyes  $\delta\delta$  3.5–4.0 mm,  $\text{♀♀}$  3.6–4.2 mm; length  $\delta\delta$  3.3–3.7 mm,  $\text{♀♀}$  3.2–3.7 mm.

Pronotum bearing numerous fine transverse pale calli. Anterolateral margins light yellow in green specimens. Humeral spines strongly produced, acute, moderately to strongly elevated (Fig. 30). Width across humeri  $\delta\delta$  11.7–15.3 mm,  $\text{♀♀}$  12.1–14.5 mm; length at meson (both sexes) 3.7–4.8 mm.

Scutellum longer than broad; basal width  $\delta\delta$  5.6–7.0 mm,  $\text{♀♀}$  5.7–7.0 mm; mesal length  $\delta\delta$  7.2–8.2 mm,  $\text{♀♀}$  7.2–7.9 mm; calli numerous, pale, transverse. Punctuation of lateral submarginal band on each corium hardly more dense than that of disk; numerous irregular calli present; discoidal spot absent; posterior margins broadly rounded.

Legs pale, nearly concolorous with venter; apical femoral spines strongly produced.

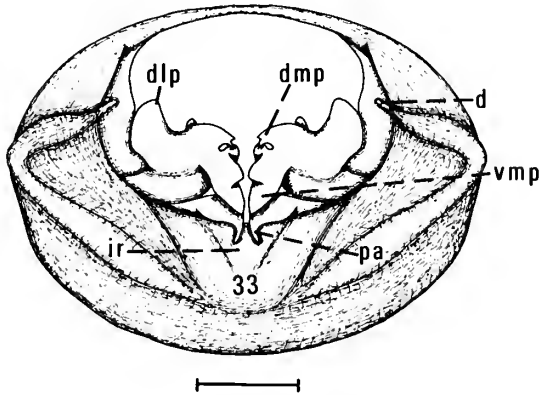
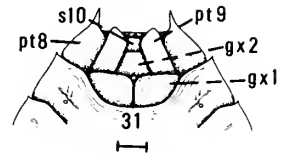
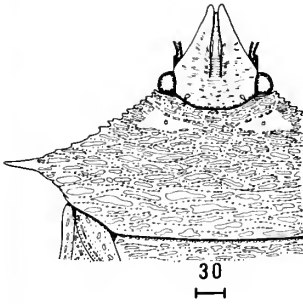
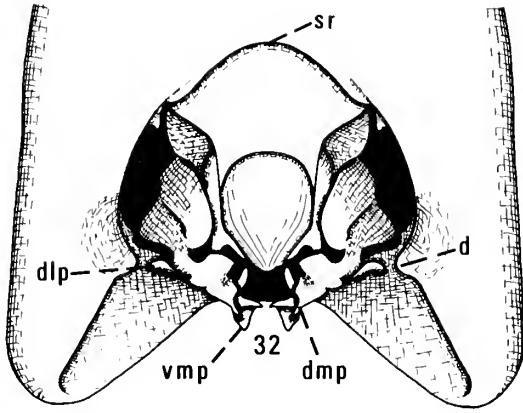
Mesal margins of first gonocoxae contiguous for most of their length, rounded apically; posterior margins nearly straight, slightly angled caudad from mesal margins (Fig. 31). Breadth of each first gonocoxa at widest point 1.3–1.4 mm; length from base at meson to apex 1.2–1.3 mm. Breadth of second gonocoxae at base 1.1–1.3 mm; mesal length 0.6–0.8 mm.

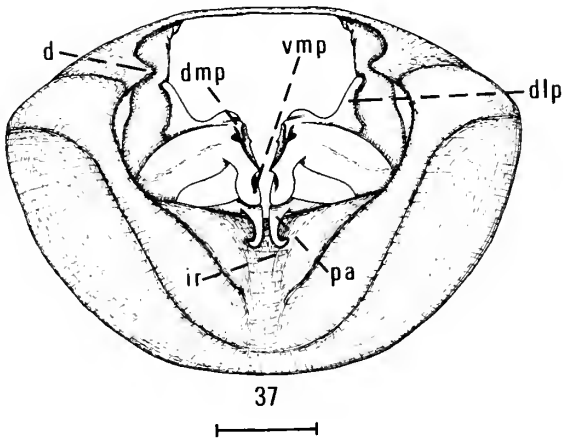
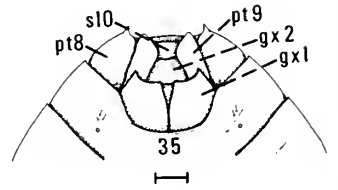
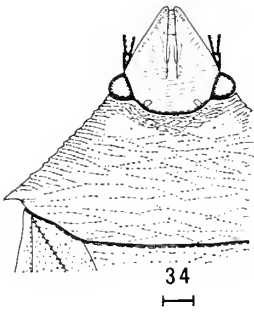
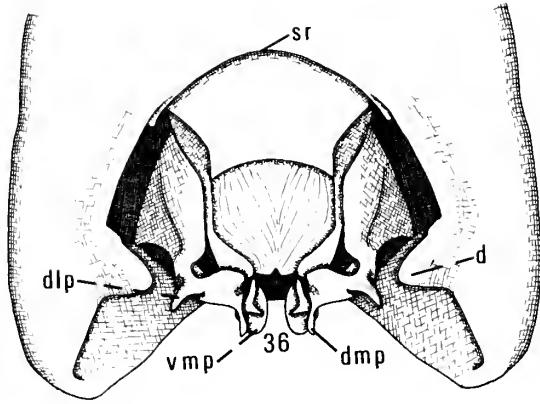
Denticle on each dorsolateral inner margin of genital cup rounded. Superior ridge moderately emarginate. Pygophoral appendages with small slightly recurved hooks. Proctiger simple, without spines on dorsal face

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Figs. 30–33. *L. pallida*. Fig. 30. Pronotum and head. Fig. 31. Female genital plates: first gonocoxa (gx1), second gonocoxa (gx2), eighth paratergite (pt8), ninth paratergite (pt9), tenth sternite (s10). Fig. 32. Genital cup, dorsal aspect: superior ridge (sr), denticle (d), dorsolateral parameral process (dlp), dorsomesal parameral process (dmp), ventromesal parameral process (vmp). Fig. 33. Genital cup, caudal aspect, omitting proctiger; inferior ridge (ir), pygophoral appendage (pa). Dimensional lines equal 1.0 mm.







(Fig. 32). Mid-ventral length of segments 3–6: 0.8–1.0; 0.5–0.6; 0.2–0.4; 3.8–4.7 mm.

Dorsolateral processes of parameres broad basally; rounded apically. Dorsomesal processes small and thin. Ventromesal processes rounded apically (Fig. 33).

*Types*.—The holotype of *Loxa pallida* Van Duzee, a female, in the California Academy of Sciences, was examined. The paratypes of *L. planifrons* Barber & Bruner in the U.S. National Museum (a male and two females) and in the American Museum of Natural History (a female) were examined.

*Distribution*.—Cuba, Dominican Republic, Bahamas, Puerto Rico and Jamaica (type locality).

*Comment*.—Easily distinguished from its congeners by the numerous pale dorsal calli.

*Loxa planiceps* Horvath, 1925

*Loxa planiceps* Horvath, 1925, pp. 323–324, tab. 5, fig. 10.

Length (exclusive of extensions of membranes beyond apex of abdomen) ♂ 17.2 mm, ♀♀ 17.7 mm.

Disk of head finely punctured with red. Lateral jugal margins nearly straight, yellow, with thin submarginal band of red punctures. First and second antennal segments light red; basal segment with fine piceus line beneath; third and fourth segments straw-colored, becoming red at base and apex; apical segment entirely straw-colored. Length of segments (both sexes) 1.4–1.6; 2.2–2.4; 2.6–3.1; 2.4–2.7; 2.4–2.6 mm. Width of head across eyes ♂ 3.9 mm, ♀♀ 3.8–4.2 mm; length ♂ 3.2 mm, ♀♀ 3.3–3.6 mm.

Pronotum becoming more rugose before cicatrices. Anterolateral margins denticulate, much lighter green than disk. Humeri moderately produced into spines (Fig. 34), red tinged, strongly angled rearward, slightly elevated. Width of pronotum across humeri ♂ 10.6 mm, ♀♀ 10.3–11.4 mm, length at meson ♂ 3.7 mm, ♀♀ 3.8–4.3 mm.

Breadth of scutellum at base ♂ 6.1 mm, ♀♀ 6.1–6.7 mm; length at meson ♂ 7.7 mm, ♀♀ 7.2–8.1 mm. Submarginal band of punctures on each corium

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Figs. 34–37. *L. planiceps*. Fig. 34. Pronotum and head. Fig. 35. Female genital plates; first gonocoxa (gx1), second gonocoxa (gx2), eighth paratergite (pt8), ninth paratergite (pt9), tenth sternite (s10). Fig. 36. Genital cup, dorsal aspect; superior ridge (sr), denticle (d), dorsolateral parameral process (dip), dorsomesal parameral process (dmp), ventromesal parameral process (vmp). Fig. 37. Genital cup, caudal view, omitting proctiger; inferior ridge (ir), pygophoral appendage (pa). Dimensional lines equal 1.0 mm.

weak, irregularly discontinuous; disk with scattered pale calli; discoidal spots lacking; posterior margins weakly sinuous to broadly rounded. Breadth of abdomen at widest point subequal to width of pronotum across humeri ♂ 10.7 mm, ♀♀ 10.2–11.2 mm.

Legs light greenish-brown, apical femoral spines moderately produced.

First gonocoxae concolorously punctured; mesal margins divergent for caudal half; each posterior margin concave, acutely produced at postero-lateral angle which overlaps ninth paratergite (Fig. 35); breadth at widest point 1.4–1.5 mm. Second gonocoxae with one mesal and two lateral longitudinal concavities, much broader at base than long at meson, 1.2–1.4:0.8–0.9 mm.

Dorsal margins of genital cup diverging posteriorly, each with large obtuse denticle slightly caudad of meson. Sides of pygophore broad, not strongly compressed. Superior ridge shallowly emarginate mesally. Proctiger simple, lacking distinct spines on dorsal face (Fig. 36). Pygophoral appendages with well developed recurved caudal hooks overlapping mesal wall of inferior ridge (Fig. 37). Mid-ventral length of male abdominal segments 3–6: 0.6; 0.4; 0.2; 4.3 mm.

Lateral face and margin of each dorsolateral parameral process spiculate; apex obtuse, curved laterally and posteriorly from caudal aspect. Dorsomesal processes each protruding rearward, slightly twisted, obtuse at apex. Ventromesal processes each broadly rounded apically.

*Type*.—Apparently lost.

*Distribution*.—Dominica, Guadeloupe (type locality).

*Comment*.—Closely allied to *L. nesiotus* in the structure of the male genitalia and the first gonocoxae of the females, but easily distinguished by the curvature of the humeral spines. Although Horvath's type is apparently lost, the five specimens examined agree closely with his description and the distribution given by him.

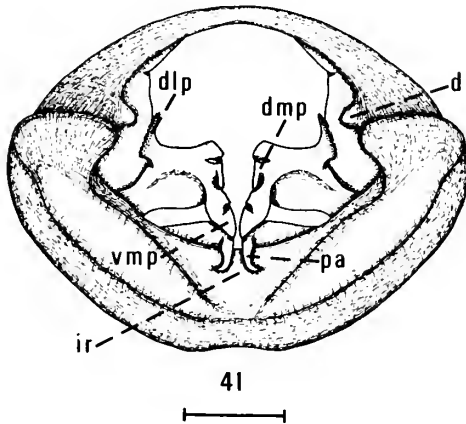
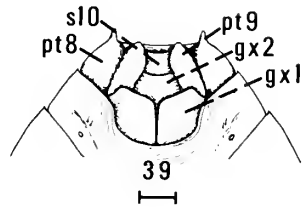
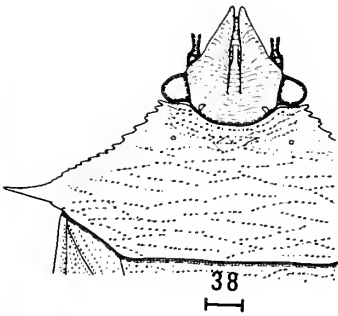
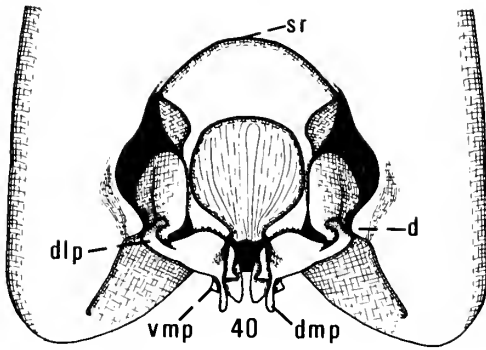
*Loxa nesiotus* Horvath, 1925

*Loxa nesiotus* Horvath, 1925, pp. 322–323, tab. 5, fig. 9.

Length (exclusive of extensions of membranes beyond apex of abdomen) ♂♂ 14.3–16.2 mm, ♀♀ 15.5–18.5 mm.

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Figs. 38–41. *L. nesiotus*. Fig. 38. Pronotum and head. Fig. 39. Female genital plates: first gonocoxa (gx1), second gonocoxa (gx2), eighth paratergite (pt8), ninth paratergite (pt9), tenth sternite (s10). Fig. 40. Genital cup, dorsal aspect; superior ridge (sr), denticle (d), dorsolateral parameral process (dlp), dorsomesal parameral process (dmp), ventromesal parameral process (vmp). Fig. 41. Genital cup, caudal aspect, omitting proctiger; inferior ridge (ir), pygophoral appendage (pa). Dimensional lines equal 1.0 mm.



Jugae each with thin distinct submarginal band of punctures laterally; fine broken band of sparse punctures mesally; mesal margins widely separated to nearly contiguous subapically; lateral margins lightly undulating, usually divergent near apex, slightly to distinctly paler than remainder of jugae. Tylus with lateral line of sparse punctures along each lateral margin. Antennae entirely light green to straw-colored, occasionally two basal segments red at extremities. Length of segments (both sexes) 0.9–1.4; 1.7–2.2; 1.9–2.5; 2.3–3.1; 2.2–2.5 mm. Width of head across eyes ♂♂ 3.4–3.7 mm, ♀♀ 3.5–3.8 mm; length ♂♂ 2.8–3.2 mm, ♀♀ 2.8–3.4 mm.

Pronotum becoming somewhat more rugose before cicatrices. Anterolateral margins nearly straight (Fig. 35), paler than disk. Humeri strongly produced into acute spines, protruding laterad to slightly cephalad, moderately to strongly elevated. Pronotal width with humeri ♂♂ 9.8–12.2 mm, ♀♀ 9.9–13.0 mm; length at meson ♂♂ 3.4–3.9 mm, ♀♀ 3.5–4.1 mm.

Scutellum rugose anteriorly; breadth at base ♂♂ 5.0–5.9 mm, ♀♀ 5.4–6.3 mm; mesal length ♂♂ 6.3–7.3 mm, ♀♀ 6.4–7.3 mm. Coria with scattered calli varying in color from slightly paler than disk to distinctly paler; discoidal spots lacking; posterior margins weakly sinuous to broadly rounded. Breadth of abdomen at widest point ♂♂ 8.9–9.8 mm, ♀♀ 8.7–10.1 mm.

Color of legs somewhat lighter than dorsum; apical femoral spines strongly produced.

First gonocoxae moderately produced posteriorly; caudal angle overlapping ninth paratergites; mesal margins contiguous for almost entire length, divergent and somewhat rounded posteriorly (Fig. 39); breadth at widest point 1.2–1.4 mm; length from apex to base at meson 1.3–1.5 mm. Second gonocoxae with two longitudinal concavities, one on either side of meson; thin mesal longitudinal concavity sometimes present; width at base 1.0–1.2 mm; length at meson 0.6–0.8 mm.

Structure of pygophore and enclosed structures closely resembling that of *L. planiceps*, except dorsolateral parameral processes curve inward apically (Figs. 40, 41). Ventral length of male abdominal segments 3–6 at meson 0.5–0.7; 0.3; 0.1–0.2; 3.7–4.3 mm.

*Type*.—Apparently lost.

*Distribution*.—Guyana, Venezuela, Colombia, Panama, Curacao (type locality) and in the Lesser Antilles (Grenadines & St. Lucia).

*Comment*.—The most similar congener is *L. planiceps* from which it is distinguished by the genitalia in both sexes and the form of the humeri.

*Loxa haematica* (Herrich-Schaeffer, 1842) NOMEN DUBIUM

*Cimex haematicus* Herrich-Schaeffer, 1842, p. 70, tab. 203, fig. 636.

*Pentatoma haematicum*: Herrich-Schaeffer, 1844, p. 94.

*Loxa haemata*: Walker, 1867, p. 242—Stål, 1872, p. 36—Lethierry & Severin, 1893, p. 149—Kirkaldy, 1909, p. 96—Horvath, 1925, p. 324 (unknown species)—Piran, 1963, p. 337.

This species was unknown to Horvath, the type specimens being apparently lost. Recognition of this species is not possible on the basis of Herrich-Schaeffer's description and figure.

#### Acknowledgement

I am deeply indebted to the following individuals for the loan of material: Dr. W. R. Dolling, British Museum (Natural History); Dr. H. Dodge Engleman, Coco Solo, Panama Canal Zone; Dr. Richard C. Foreschner, United States National Museum; Dr. F. Mead, Florida State Collection of Arthropods; Dr. G. Peterson, Akademie der Landwirtschaftswissenschaften; Dr. D. C. Rentz, California Academy of Sciences; Dr. J. C. Schaffner, Texas A&M University; Dr. R. T. Schuh, American Museum of Natural History; Dr. A. Soos, Magyar Nemzeti Múzeum Allattara. I would especially like to thank Dr. A. Kaltenbach of the Naturhistorisches Museum Wien who, in addition to loaning specimens, compared the holotype of *L. assimilis* with specimens of *L. viridis* and *L. flavicollis* and figured the genital cup of *L. assimilis* for me.

I would like to express my deepest appreciation to Dr. L. H. Rolston, Louisiana State University, for constructive criticism and advice during the course of this revision. I am also obliged to Drs. R. A. Goyer, J. B. Graves, L. D. Newsom and B. H. Wilson, all of Louisiana State University, for their encouragement and criticism.

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### Footnotes

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<sup>2</sup> Letters in parentheses indicate the number and position of labels with (a) being the topmost label next to the insect.

ASCIDAE ASSOCIATED WITH THE NASAL CAVITIES OF  
MEXICAN BIRDS (ACARINA: MESOSTIGMATA)<sup>1</sup>

K. E. Hyland, A. Fain and A. S. Moorhouse

*Abstract.*—Mites of the family Ascidae taken from the nasal passages of birds, mostly hummingbirds (Trochilidae) in Veracruz, Mexico, are represented by the genera *Proctolaelaps* and *Rhinoseius*. *P. kirmsei*, *P. belemensis* and *R. heliconiae* are new to Mexico. Three new species are described: *P. mexicanus* from *Euphonia hirundinacea*, *P. spiralis* from *Phaethornis superciliosus*, and *R. mathewsoni* from *Amazilia candida*.

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Introduction

Fain, Hyland and Aitken (1977a, 1977b) have pointed out the diversity of the mites placed in the family Ascidae which have been recovered from the nasal passages of birds in the New World. They described species from three genera, *Rhinoseius*, *Proctolaelaps* and *Lasioseius*, and gave a key to the known species.

In the present work, we continue the series begun earlier on the mites from Mexican birds (Hyland and Moorhouse, 1970; Fain and Hyland, 1970) and we report on the family Ascidae collected during the month of August, 1963. Although we recognize that these mites exhibit a phoretic relationship with their host, and not a parasitic one, we consider it appropriate to treat them in this series because they were collected in the same habitat. In our earlier work (Hyland and Moorhouse, 1970) we described the collecting area, and the conditions under which the hosts and the acarines were taken.

In the descriptions which follow, all measurements are in micrometers ( $\mu\text{m}$ ). Holotypes and allotypes will be deposited in the acarological collection of the U.S. National Museum of Natural History, Washington, D.C. Paratypes are in authors' collections at the Institut de Médecine Tropicale, Antwerp, Belgium, and the Department of Zoology, University of Rhode Island. All specimens were taken in Veracruz by R. W. Dickerman.

The common name of each host is given the first time the host is mentioned.

*Proctolaelaps mexicanus* n. sp.

This species can be separated from all other species of the genus found phoretically associated with birds by the presence of certain setae with expanded (bulbous) tips as follows: Z 5, posterior opisthogasteral, postanal, and setae on the femora of all legs. In addition, the genital plate of the female possesses an anteromedian area which appears to be sclerotized.



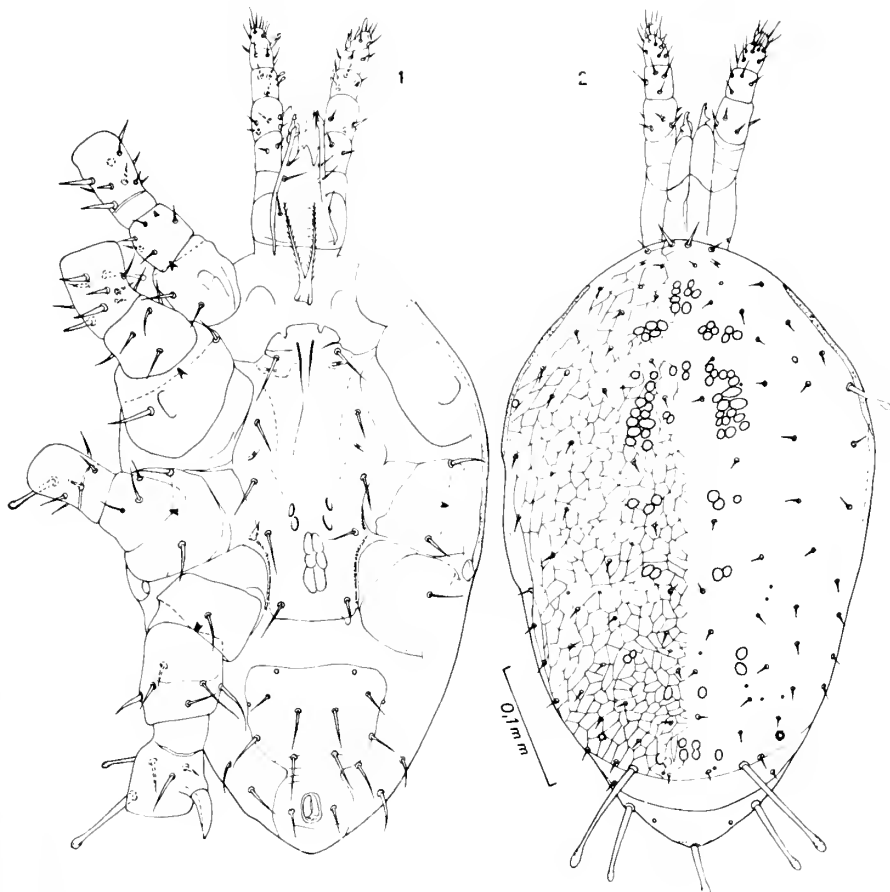


Fig. 1-2. *Proctolaelaps mexicanus* sp. n. Holotype male. 1. Ventrally; 2. Dorsally.

*Male*.—(Holotype) (Figs. 1, 2). Idiosoma 478  $\mu\text{m}$  long, 291  $\mu\text{m}$  maximum width. Dorsum: Anterior part of dorsal plate possesses 22 pairs of setae (6 pairs of *j*, 6 pairs of *z*, 6 pairs of *s* and 4 pairs of *r*) of which the *r* 3 or humeral is long (39  $\mu\text{m}$ ) and with an expanded tip, and *j* 1 is 21  $\mu\text{m}$  long; posterior portion of plate with 20 pairs of short setae except for Z 5 which is 94  $\mu\text{m}$  long and has an expanded tip. Venter: Sternal plate separated from ventrianal plate. The latter has a distinct pattern and bears 5 pairs of ventral setae in addition to the 3 anal setae. Postanal seta 42  $\mu\text{m}$  long and with expanded tip. Gnathosoma: Spermadactyl slender and long (101  $\mu\text{m}$ ) with curved tip. Legs: All femora with a dorsal seta with expanded tip. Leg I with short conical spine on trochanter and femur. Leg II with short conical spines on genu (1), tibia (1) and tarsus (4). Femur IV with a very strong ventral spine which is partly fused to integument at its base. Both tarsi IV have been broken off.

*Female*.—(Allotype) (Figs. 3, 4, 5). Idiosoma 577  $\mu\text{m}$  long, 359  $\mu\text{m}$  wide. Dorsum: Anterior part of dorsal plate with 22 pairs of setae (6 pairs of *j*, 6 pairs of *z*, 6 pairs of *s*

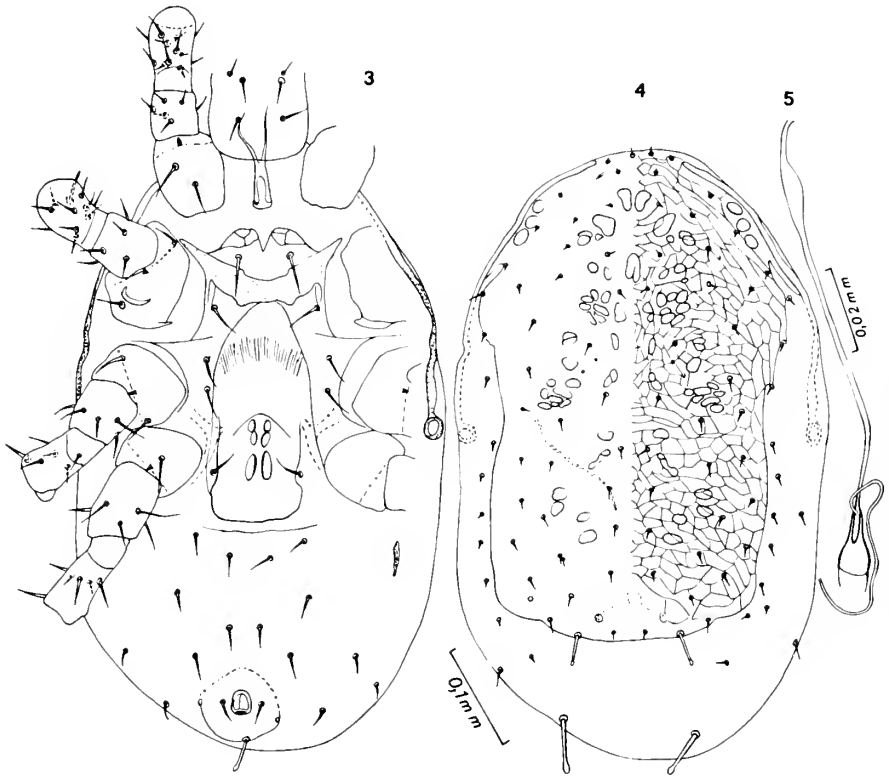


Fig. 3-5. *Proctolaelaps mexicanus* sp. n. Allotype female. 3. Ventrally; 4. Dorsally; 5. Inseminating apparatus.

and 4 pairs of *r*), posterior part with 15 pairs (5 of *J*, *Z* and *S* each). All setae are small, with a maximum length of 13  $\mu\text{m}$ , except for *Z* 5 which is 31  $\mu\text{m}$  long and possesses an expanded tip. Distance between anterior tips of the peritremes 86  $\mu\text{m}$ . Venter: Sternal shield with anterior lobes containing a network of striations; an ill-defined thicker band (stippled in Fig. 3) runs horizontally across the center of the plate; distance between anterior pair of setae 39  $\mu\text{m}$  long and distance between their bases 52  $\mu\text{m}$ . Genital plate truncate posteriorly with setae off the plate, anterior tongue moderately elongate and with a median longitudinal sclerotized area as illustrated. Anal plate 28  $\mu\text{m}$  long, 18  $\mu\text{m}$  wide. Postanal seta with inflated tip. Ten pairs of opisthogasteral setae, the postmedian pair being well developed (49  $\mu\text{m}$  long) and with expanded tips. Maturation pouch of inseminating apparatus membranous, the spermiduct joins at the distal end of this pouch and the adductor canal is long and only slightly enlarged distally. Gnathosoma: Tectum denticulate as in *P. hunteri*. Legs: Each femur possesses distally on its dorsal surface a seta with an expanded tip.

*Host and locality*.—Holotype male, allotype female, 16 paratype females and one nymph were taken from the nasal cavities of a single specimen of Bonaparte's euphonia, *Euphonia hirundinacea* Bonaparte, 1838 (family Thraupidae) in Veracruz, Mexico, 23 Aug. 1963, host M63-08-23-10/2040, R. Dickerman, coll.

Since this host is not a trochilid the question has arisen concerning the authenticity of our collection data. Norgaard-Olesen (1973/74) and Van Boeckstaele (1977) have indicated that the diet of many tanagers consists of a significant quantity of flowers and nectar, so it seems likely that this host legitimately acquired these acarines.

*Proctolaelaps spiralis* n. sp.

This species is close to *P. belemensis belemensis* Fain, Hyland and Aitken, 1977, and *P. b. cyanocompsae* Fain, Hyland and Aitken, 1977, in having the genital plate prolonged anteriorly, seta *j* 1 unusually long and the 5th and 6th rows of deutosternal teeth more expanded. It can be separated from females of both these subspecies by the spiral shape of the inseminating apparatus and decrease in the number of setae on both anterior and posterior portions of the dorsal plate (19 and 14 respectively compared with 23 and 18 for both subspecies).

*Female*.—(Holotype) (Figs. 6, 7, 8). Idiosoma 624  $\mu\text{m}$  long, 390  $\mu\text{m}$  wide. Dorsum: Shield not incised but slightly constricted toward the middle; anterior half of plate bears 19 pairs of setae of which *j* 1 is 23  $\mu\text{m}$  long and *z* 6 is 42  $\mu\text{m}$ ; posterior portion with 14 setae of which *Z* 5 is 55  $\mu\text{m}$  long, only 3 of *S* series remain on the plate, and none of the *R* series occur on the plate. Distance between anterior tips of peritremes is 49  $\mu\text{m}$ . Venter: Sternal shield evenly sclerotized with distinctive pattern consisting of 3 pairs of median scales and with small anterior lobes. All sternal setae located on plate, anterior pair 31  $\mu\text{m}$  long and their bases 65  $\mu\text{m}$  apart. Genital plate truncate with anterior projection attenuated as in *P. belemensis cyanocompsae*; genital setae on the plate. Anal plate 96  $\mu\text{m}$  long, 86  $\mu\text{m}$  wide, with anus located toward the anterior end; postanal seta 52  $\mu\text{m}$  long. Opisthogastereal setae nearly equal in size (34  $\mu\text{m}$ ) except for posterior median pair which are 60  $\mu\text{m}$  long. Inseminating apparatus with a long, thin, aductor canal which is enlarged slightly toward the distal end and possesses a membranous maturation pouch which is spiral shaped. Gnathosoma: Tectum broad and finely denticulate anteriorly. Chelicerae 129  $\mu\text{m}$  long. Legs: All leg setae of usual size, coxa I without denticles, and posterior seta on coxa II is not spinous.

*Host and locality*.—Holotype female and 5 paratype females were collected from the long-tailed hermit, *Phaethornis superciliosus* (Linnaeus, 1766), in Veracruz, Mexico, 13 Aug. 1963, host M63-08-23-12/2022, R. Dickerman, coll.

*Proctolaelaps kirmsei* Fain, Hyland and Aitken, 1977

This species was described from *Phaethornis augusti* Bourcier, 1847, collected in Venezuela. We have now encountered a single female specimen in the nasal cavity of *Phaethornis superciliosus* from Veracruz, collected 26 Aug. 1963, host M63-08-26-4/2078, by R. Dickerman.

This female agrees very closely with the type with respect to the length of setae *j* 6, *s* 5, *J* 1 and *Z* 5. The anterior pair of sternal setae are 29  $\mu\text{m}$  apart compared with 21  $\mu\text{m}$  but this difference is within the range exhibited by the paratypes. The inseminating apparatus agrees closely.

*Proctolaelaps belemensis* Fain, Hyland and Aitken, 1977

This species was described from Brazil where it was taken in association with *Threnetes leucurus* (Linnaeus, 1766) and from several other hosts including *Phaethornis superciliosus*. We have three representatives in the Mexican collection, one female from *Phaethornis superciliosus* collected 26 Aug. 1963, host M63-08-26-4/2078, by R. Dickerman.

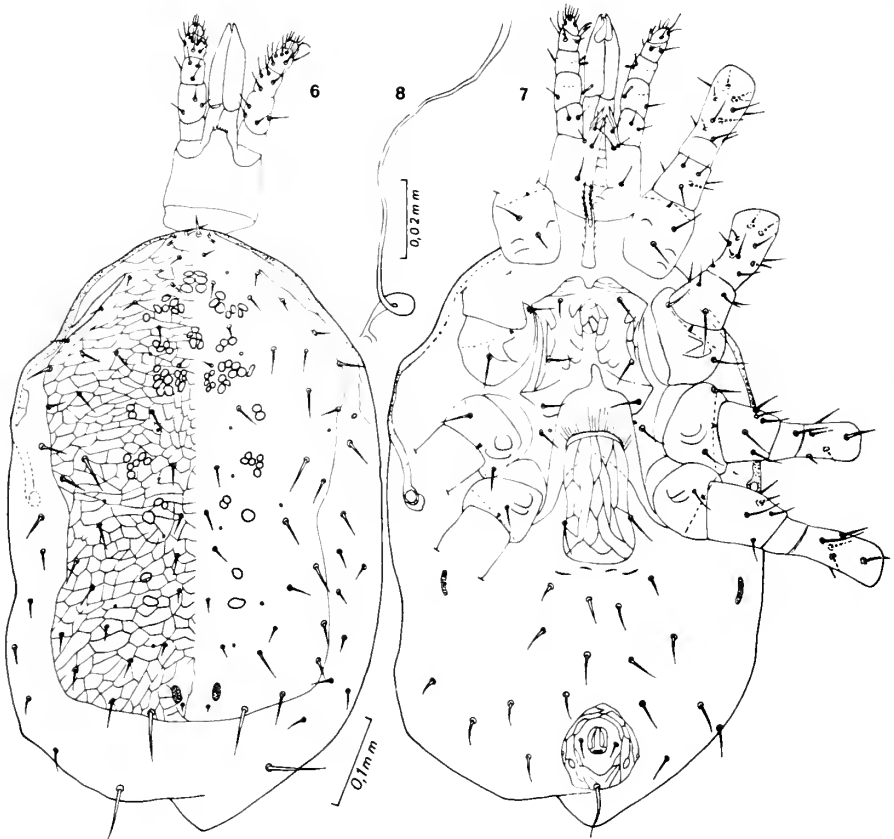


Fig. 6-8. *Proctolaelaps spiralis* sp. n. Holotype female. 6. Dorsally; 7. Ventrally; 8. Inseminating apparatus.

man. The remaining two are from the violet sabre-wing. *Campylopterus hemileucornus*, collected 27 Aug. 1963, host M63-08-27-4/2098, by R. Dickerman.

*Rhinoseius mathewsoni* n. sp.

This species is near to both *R. heliconiae* Baker & Yunker and *R. phaethornis* Fain, Hyland and Aitken. The males can be separated from *R. heliconiae* by the presence of long *s* 3 and *s* 4 and *S* 1 to *S* 5 setae on the dorsum and from *R. phaethornis* by the presence of extremely small posterior opisthogasteral setae and the enlarged *S* setae. The female can be separated from *R. heliconiae* by the presence of seta *Z* 5 and from *R. phaethornis* by the nearly absent cuticular network on the dorsal shield, the smaller opisthogasteral setae, especially the posterior median pair and the more oval shape of the anal plate.

*Male*.—(Holotype) (Figs. 9, 10). Idiosoma 504  $\mu\text{m}$  long, 338  $\mu\text{m}$  maximum width. Dorsum: Shield with deep lateral incision and a line extending through the plate. Setae

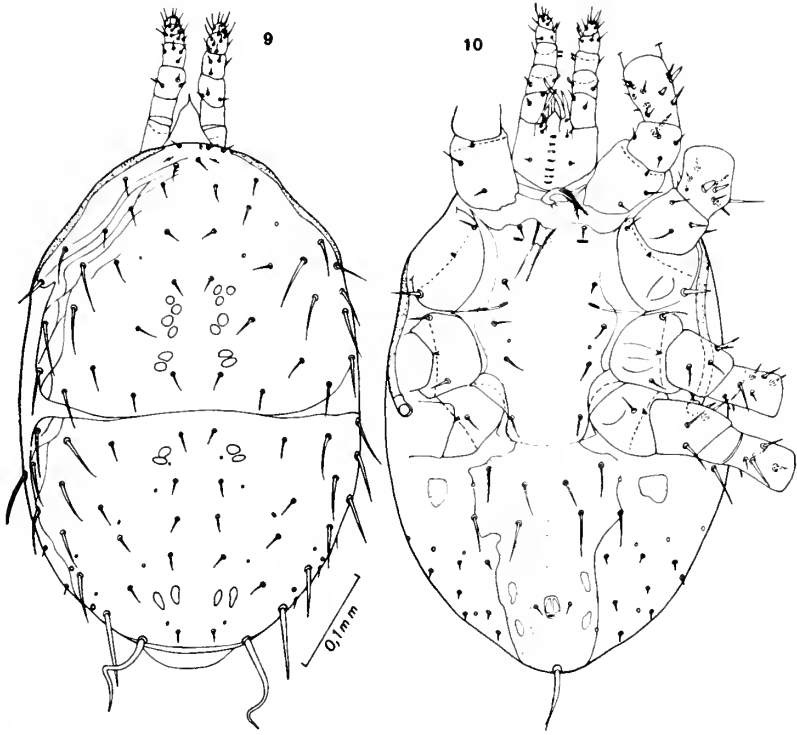


Fig. 9–10. *Rhinoseius matthewsoni* sp. n. Holotype male. 9. Dorsally; 10. Ventrally.

variable in length:  $j\ 1$  and  $z\ 1$  small and nearly of equal length ( $10\ \mu\text{m}$ ),  $z\ 3$  is lacking,  $s\ 3$  and  $s\ 4$  approximately 3 times longer ( $41$  and  $47\ \mu\text{m}$ ) than those of  $j$  and  $z$  rows;  $Z\ 5$  twisted, approximately  $110\ \mu\text{m}$  long;  $S\ 1$  to  $S\ 5$  well developed,  $44$  to  $68\ \mu\text{m}$  in length. Peritremes  $65\ \mu\text{m}$  apart at their anterior tips. Pattern on dorsal shield poorly developed and confined to the periphery of the anterior half of plate. Venter: Tritosternum normal. Ventroanal plate contiguous but not fused with sternogenital plate, and bears 4 pairs of ventral setae plus the 3 anals. All 9 pairs of posterior opisthogasteral setae small, at most  $8\ \mu\text{m}$  long. Gnathosoma: Tectum arched and tapering to a point. Spermadactyl  $44\ \mu\text{m}$  long with small hook at tip. Legs: Blunt, cylindro-conical setae present as follows: Femur I (1), Genu I (1), Femur II (1), Genu II (1), Tibia II (1), Tarsus II (4), Tarsus III (1). Other setae on leg segments frequently long, including those on tibiae III and IV some of which are longer than their respective leg segments.

*Female*.—(Allotype) (Figs. 11, 12, 13). Idiosoma  $510\ \mu\text{m}$  long,  $328\ \mu\text{m}$  wide. Dorsum: Setae generally uniform in shape and length ( $16\ \mu\text{m}$ ) except that  $j\ 1$  and  $z\ 1$  are minute ( $3\ \mu\text{m}$ );  $z\ 3$  is wanting, and  $z\ 5$  is small ( $10\ \mu\text{m}$ ). Shield deeply incised, lacks cuticular pattern except on the border. Anterior tips of the peritremes  $39\ \mu\text{m}$  apart. Venter: Tritosternum  $91\ \mu\text{m}$  long, base  $39\ \mu\text{m}$ . Sternal plate without well defined pattern; anteriorly prolonged into two lobes which bear a few striae. Distance between anterior pair of setae is  $60\ \mu\text{m}$ . Third pair of setae in posterior lateral angles of plate. Remaining pair of setae located off the plate. Genital plate rounded both posteriorly

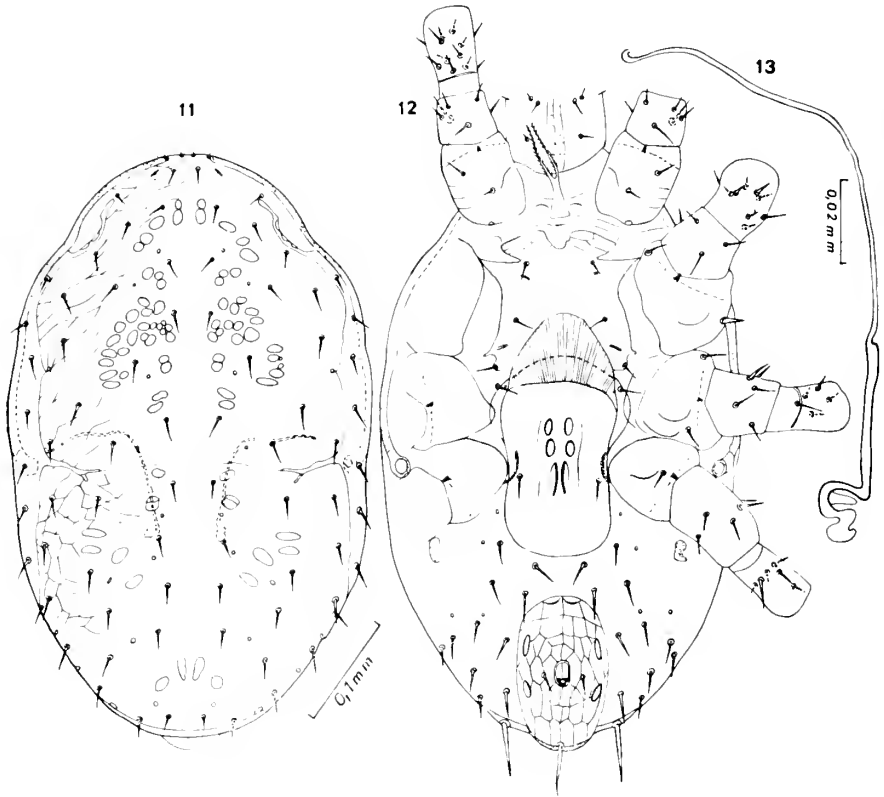


Fig. 11–13. *Rhinosecius mathewsoni* sp. n. Allotype female. 11. Dorsally; 12. Ventrally; 13. Inseminating apparatus.

and anteriorly; anterior tip extends beyond level of sternal setae II. Anal plate elliptical,  $83\ \mu\text{m}$  wide,  $138\ \mu\text{m}$  long. Anus located in middle of plate. Adanal setae smaller than adjacent opisthogasteral setae. Postanal seta  $42\ \mu\text{m}$  long. Setae on opisthogaster comprise 10 pairs; median pair  $49\ \mu\text{m}$  long, at least twice as long as other pairs. Posterior portion of inseminating apparatus "L" shaped; longitudinal part  $39\text{--}44\ \mu\text{m}$  long in holotype. Gnathosoma: Tectum tapering to a point; deutosternal teeth indistinct on allotype but on paratype consists of the usual seven rows. Legs: Posterior seta on coxa II spine-like,  $18\ \mu\text{m}$  long. All setae shorter than their respective leg segments.

*Remarks.*—This species is dedicated to our friend and colleague, Professor John Angell Mathewson, on the occasion of his retirement from the Department of Zoology at the University of Rhode Island.

*Types.*—Holotype male, allotype female and 7 paratype females from the nasal cavity of the white-bellied emerald, *Amazilia candida* (Bourcier & Mulsant, 1846), taken in Veracruz, Mexico, 17 Aug. 1963, host M63-08-17-12/1497; R. Dickerman, coll.

Additional paratypes from *Amazilia candida* as follows: 1 male, 7 females from host

M63-08-13-8/1490, 13 Aug. 1963; 10 females from host M63-08-24-1/2048, 24 Aug. 1963; 1 female from host M63-08-17-9/1494, 17 Aug. 1963. Other paratypes from the rufus-tailed hummingbird, *Amazilia tzacatl* (de la Llave, 1883) as follows: 4 females from host M63-08-13-7/1488, 13 Aug. 1963; 1 female from host M63-08-13-6/1489, 13 Aug. 1963. Also paratypes from *Phaethornis superciliosus* as follows: 7 females from host M63-08-25-4/2078, 26 Aug. 1963; 5 females from host M63-08-23-12/2022, 23 Aug. 1963.

*Rhinoseius heliconiae* Baker & Yunker, 1963

This species is well represented in this collection. Although the holotype was taken from *Heliconia* cuttings of unknown origin at New York, additional specimens were recovered from the nasal passages of *Phaethornis yaruqui* (Bourcier) from Rio Raposo in Colombia, and were considered conspecific by Baker and Yunker.

Our material agrees well with the description and with the types with one exception: the median pair of posterior opisthogastral setae measure 78 to 81  $\mu\text{m}$  in length (this includes a second specimen on the same slide with the holotype). In our material these same setae vary in length from 29 to 57  $\mu\text{m}$ .

Our collection includes the following: From *Amazilia candida*, 7 females, 1 male from host M63-08-24-1/2048, 24 Aug. 1963; 4 females, 1 male from host M63-08-13-8/1490, 13 Aug. 1963. From *Phaethornis superciliosus*, 2 females from host M63-08-23-12/2022, 23 Aug. 1963. One female from host M63-08-26-4/2078, 26 Aug. 1963.

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### Footnote

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Abstracts of papers presented at sessions, workshops, and symposia on  
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Toxicological studies on the molt-inhibiting insecticide (EL-494) against the gypsy moth (*Lymantria dispar* L.) and effect on chitin biosynthesis. A. H. Abdel-Monem, E. A. Cameron and R. O. Mumma, Pest. Res. Lab. and Grad. Study Ctr. and Dept. Entomol., The Pennsylvania State Univ., University Park, PA 16802

All larval instars of the gypsy moth (*Lymantria dispar* L.) were fed on an artificial diet containing 13 different concentrations varying from 0.0 to 2.0 ppm of EL-494 (N-[[[5-(4-bromophenyl)-6-methyl-2-pyrazinyl]amino]-carbonyl]-2,6-dichlorobenzamide), a molt-inhibiting insecticide, and the larvae were scored for their ability to molt subsequently to healthy individuals. Gypsy moths were scored for molting abnormalities as follows: 1) failure to feed, 2) partial ecdysis ranging from retention of old head capsule to failure to completely remove the old cuticle from the abdomen, and 3) death prior to molt. The 5th and 6th larval instars were the most susceptible while the 1st and 2nd larval instars were the least susceptible. Adult emergence, especially of females, was reduced by concentrations of EL-494 that did not show any effect on the larval stages. To investigate the effect of EL-494 on chitin biosynthesis, 5th instar larvae were fed on artificial diet containing either 0 or 20 ppm EL-494 for 24 h and then were injected with 0.1  $\mu\text{Ci}$   $^{14}\text{C}$ -glucose. After 24 h the larvae were sacrificed and the amount of  $^{14}\text{C}$  incorporated into various fractions was determined. Larvae fed on diet containing EL-494 reduced (ca. 80%) the incorporation of  $^{14}\text{C}$ -glucose into chitin relative to the control and clearly indicated the inhibition of chitin biosynthesis by EL-494.

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Toxicological response of Japanese beetle (Copeoptera: Scarabaeidae) grubs to insecticides. S. Ahmad, Dept. Entomol. and Econ. Zool., Rutgers Univ., New Brunswick, NJ 08903

Dosage-mortality response and toxicological symptoms following topical treatment of 3rd stage grubs of a Japanese beetle *Popillia japonica* Newman population from Rivervale, N.J., were studied. The 8-day  $\text{LD}_{50}$  and  $\text{LD}_{95}$  for chlorpyrifos were 1.88 and 55.24  $\mu\text{g}/\text{grub}$ , respectively. For the slower-acting insecticide dieldrin, the 14-day  $\text{LD}_{50}$  and  $\text{LD}_{95}$  were 26 $\times$  and 32 $\times$  more than chlorpyrifos, respectively. Dieldrin resistance in these grubs is thus indicated and is in agreement with similar findings from Connecticut, New York, and Ohio. The high ratio of  $\text{LD}_{95}$  and  $\text{LD}_{50}$  (29:1) with chlorpyrifos may also be indicative of incipient organophosphate resistance in

New Jersey grubs. Grubs treated with either insecticides moved up to the soil surface, remaining there for one or more days, progressed to the advanced stage of poisoning and died. When recovering from insecticide action, the surfaced grubs dug back into the soil. The surfacing behavior may be related to general hyperactivity often discerned as an initial effect of insecticides on insects. Grubs in advanced stage of poisoning were characterized by 3 distinct symptoms: 1. shrinkage in size and reduction in body weight to ca 50%, 2. Yellow-brown coloration of the body instead of the normal whitish appearance, and 3. moribundity.

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Correlation of common plant taxa phenologies to development of *Agromyza frontella* (Rondani) (Diptera: Agromyzidae). J. T. Andaloro, T. M. Peters and A. J. Alicandro, Univ. Massachusetts, Amherst, MA 01003

Throughout the spring and summer of 1978 the phenological stages of various plant species were recorded to determine their utility as indicators of events occurring in the life history of the Alfalfa Blotch Leafminer (ABL) *A. frontella*. A major objective was to determine the reliability of forecasting ABL seasonal development through the use of specific plant phenologies. These data are expected to increase the efficiency of ABL sampling, pest outbreak detection, and possible control programs. In studies at Amherst, MA first emergence of *A. frontella* adults from overwintering pupae was detected on May 11 (Julian calendar day 131) paralleling the beginning of bloom (BOB) stage of Pin Cherry *Prunus pennsylvanica*, and *Magnolia soulangeana* petal fall. Four days later Common Horse Chestnut *Aesculus hippocastanum* (BOB) coincided with initiation of ABL oviposition. Detection of the first mine was not until May 25th in concurrence with Bridal wreath *Spiraea prunifolia* at full bloom (FB), High Bush Blueberry *Vaccinium corymbosum* (FB) and Choke Cherry *Prunus virginiana* (BOB). Alfalfa *Medicago sativa*, flowering (BOB) on June 6 correlated with similar phenological stages of Black Locust *Robinia pseudoacacia* (FB) and Blackberry *Rubus allegheniensis* (FB).

Alfalfa at (BOB) supported an average of 54 mines/stem. Abandoned mines represented 25% of the total number, third instars 30%, first and second instars 37%, and dead larvae due mainly to parasitization 8%. Forty-two days and 875 Degree days elapsed from detection of the first generation egg until adult emergence.

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Integrated control of cotton bollworms in P.D.R. of Yemen. S. A. Ba-An-good, Dept. of Entomol., Macdonald College, McGill Univ., Que., HOA 1C0

P.D.R. of Yemen has recently emerged as a moderate exporter of long stable cotton. During a 7-year period 1971 to 1977 inclusive, extensive studies have been carried out on the control of cotton bollworms. As a result an integrated control program has been planned which resulted in a reduction in cotton bollworm infestation from 70% (in 1971-72) to about 15% (1976-77). The results of these studies which lead to this integrated control program show that (1) early sowing date (late July to late August) produced twice the yield of late sown cotton (late September and October) without insecticidal treatment (2) spraying at 18% bollworm infestation gave significant difference in yield in comparison with 10% and no-spray treatments. This resulted in reducing the number of sprays from 4 to 1. (3) Strict close season from the end of May till the 3rd week of July and early watering of all the land cropped with cotton the previous year reduced infestation with bollworms and specially the Sudan bollworm *Diparopsis watersi* and resulted in high yield. (4) Monocrotophos (nuvacron 40), chlorpyrifos (dursban 4), carbaryl + molasses (sevimole 4) proved to be very effective against bollworm complex. Carbaryl (Sevin 85) was less effective against the American bollworm *Heliothis armigera*. (5) Parasites and predators contributed to control only on early stages of infestation (September-October).

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Bionomics of the New Zealand genera *Neolimnia* and *Eulimnia* (Diptera: Sciomyzidae). J. K. Barnes, Cornell Univ., Ithaca, NY 14853

The endemic New Zealand genera *Neolimnia* and *Eulimnia* are typical members of the cosmopolitan mollusc-eating subfamily Sciomyzinae and of the largely predatory tribe Tetanocerini, and their larvae have evolved diverse food preferences. In *Neolimnia* the four species of the subgenus *Pseudolimnia* have aquatic larvae and puparia that are similar to the majority of known Tetanocerini. As is typical of the aquatic predatory sciomyzids, larvae of most of these species feed upon aquatic pulmonate snails, but *Neolimnia tranquilla* (Hutton) seems to prefer the operculate snail *Potamopyrgus antipodarum* (Gray) (Prosobranchia: Hydrobiidae). Adults and immature stages of the subgenus *Neolimnia* are usually collected in moist forests near marshy areas. The larvae and puparia are not capable of life in open water. The larvae prey upon tiny terrestrial snails, especially those of the family Punctidae (Pulmonata), killing and consuming the snails quickly. Larvae of *Eulimnia philpotti* Tonnoir and Malloch are subsurface predators of fingernail clams (Bivalvia: Sphaeriidae). They are adapted for life in the muddy substrates of marshy areas. Long, narrow, tracheated lobes on the

posterior segments are exposed to passing water currents while the anterior end of the larva is buried in the substrate or in the tissues of fingernail clams. The larvae kill and consume the clams quickly, and they consume many clams before the late third instar larva leaves the water to form a puparium in surface vegetation or debris.

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Simplified artificial diet and rearing techniques for the gypsy moth, *Lymantria dispar* L. (Lepidoptera: Lymantriidae). R. A. Bell, M. Shapiro and C. Owens, USDA SEA/FR, Otis AFB, MA 02542

Large numbers of gypsy moths are required for *in vivo* production of pathogens and parasites and for conducting laboratory and field tests with alternative (autocidal) control measures such as the sterile male technique. Since the high cost of rearing has heretofore been a limiting factor in the development of biological and autocidal control methods, research was initiated to develop a simplified, inexpensive diet and a more efficient rearing system. Thus, a variety of alternative and less expensive diets, containerization and handling procedures were evaluated and modified. Subsequently a simplified wheat germ-casein or soy based formulation was developed that costs ca. 25¢/L and is nutritionally equivalent or superior to other more expensive diets. Of a variety of commercially available containers tested, best results were obtained with 6 oz. polyethylene (ME-6R or XE-6; Sweetheart Plastics) food cups fitted with paper lids. Insects were reared @ 8/cup containing 80/90 ml of diet from newly hatched larvae to pupation without a change of food. Adult recovery was 90% and the average time to pupation at 25°C was ca. 28 and 30 days for males and females respectively for a New Jersey F<sub>16</sub> colonized strain. Wild strains reared by these methods showed similar survival and only a slightly longer developmental time. With these developments, the average cost of rearing the gypsy moth has been reduced from previously projected figures of \$60-80 to a present estimate of \$12/1000. With implementation of envisioned automation of infesting and pupal harvest, cost may be further reduced to \$6-8/1000 insects.

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Development of sequential sampling plans for insect defoliation on soybeans. R. G. Bellinger and G. P. Dively, Dept. Entomol., Univ. Maryland, College Pk., MD 20742

Sequential sampling plans based on the binomial distribution were developed for sampling insect defoliation on soybeans. The plans were simulated on actual data collected from over 300 fields where a fixed-sample size method (30 plants) was employed. Data were from two varieties of soybeans, York and Essex, from Maryland's Eastern Shore and represented a

range of field conditions and levels of infestation of Mexican bean beetle, *Epilachna varivestis* (Mulsant) (Coleoptera: Coccinellidae) over a three year period (1975-77). Plants were rated as economically damaged (>20% defoliated) or not economically damaged (<20% defoliated). Results showed that average savings in sampling time of 30% can be expected, with as much as 70% savings realized in fields with low (<10%) or high (>40%) defoliation. Plans chosen used  $\alpha = .01$  or  $.05$ ,  $\beta = .01$ ,  $\rho_1 = .2$  to  $.3$ , and  $\rho_2 = .8$  to  $.7$ . Sequential sampling plans were in agreement with the fixed-sample method over 90% of the time. Within plant distribution of defoliation was characterized for the two varieties in 1976 and 1977. Differences in defoliation were found at various locations in the plant and were related to the population dynamics of the Mexican bean beetle and the morphogenesis of the plant. These findings are useful in the estimation of whole plant defoliation which is required by the sequential sampling plan. Sequential sampling plans used to sample insect defoliation on soybeans can result in considerable savings in scouting time and render on-the-spot control decisions with a predetermined degree of precision.

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Performance of selected insecticides against pear psylla, *Psylla pyricola* Foerster (Homoptera: Psyllidae). W. M. Bode, Pennsylvania Sta. Univ. Fruit Res. Lab., Biglerville, PA 17307

Randomized and replicated single-tree plots of d'Anjou pear were sprayed with a handgun. Control was evaluated by counting psylla eggs and nymphs on 5 fruiting spurs per plot until petal-fall, and thereafter on 10 new leaves from growing shoots. Eggs and nymphs were counted in the laboratory with the aid of a binocular microscope. Adults were counted in the field by three minute examinations of individual trees and by tapping 3 branches per plot over a 18 in  $\times$  18 in cloth tray. Among prebloom treatments the combination of 2 gal of 70 sec. Superior oil plus 1 qt of either Perthane<sup>(R)</sup> 4 EC, phosalone 3EC, or amitraz 1.5EC per 100 gal of spray were most effective. The fungicide mancozeb suppressed populations of psylla eggs and nymphs appreciably. Petal-fall applications of amitraz (6 oz ai/100 gal), permethrin (0.1 lb ai/100 gal), and fenvalerate (0.05 lb ai/100 gal) were very effective. In summer cover sprays the performances of registered materials were variable, and some lost effectiveness with repeated applications. The pyrethroid products (permethrin and fenvalerate) were extremely effective at low rates (0.1 and 0.05 lb ai/100 gal). Insecticides labeled for pear psylla control may not be reliable unless rates are increased above those currently recommended in Pennsylvania. Mancozeb fungicides have significant activity against small nymphs and should be included in all sprays applied to pear.

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Sampling procedures for collecting *Simulium penobscotensis* Snoddy and Bauer (Diptera: Simuliidae) and other Maine black flies. L. R. Boobar and J. Granett, Entomology Dept., Univ. of Maine, Orono, ME 04473

Two types of polyethylene samplers, ceramic fireplace tiles, Surber samples, 2 types of Hess samplers, vegetation collections and drift nets were used to sample black flies. Quantitative collections were made in the Pleasant and Penobscot Rivers in central Maine and black fly species and numbers compared. *Simulium penobscotensis* Snoddy and Bauer, a summer black fly species which bites humans, and *S. nyssa* Stone and Snoddy do not readily colonize tile samplers and were not collected by bottom samplers in numbers similar to collections on *Potamogeton* and *Sparganium* vegetation. Other black fly species colonized the artificial substrates about equally with bottom samplers being markedly inferior. *S. penobscotensis* and other black fly larvae were collected in drift nets in the Penobscot River. Samples on vegetation indicated that *S. penobscotensis* was found at least down to 1 m in the Penobscot River. The percentage of *S. penobscotensis* in the total black fly population increased with depth. The number of instars and frequency of each instar were estimated by head capsule width measurements. *S. penobscotensis* apparently has 7 instars, however, instar frequency was not uniform in collections. The bulk of the samples consisted of mature larvae and pupae. The lack of early instar larvae in collections indicated a different habitat for this age group.

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Palatability studies on *Euphydryas phaeton* (Lepidoptera: Nymphalidae). M. D. Bowers, Univ. Massachusetts, Amherst, MA 01003

The ecology and behavior of both larva and adult *Euphydryas phaeton*, the Baltimore checkerspot, suggest that it is unpalatable. Thus, both larvae and adults exhibit conspicuous, non-evasive behaviors; the larvae are gregarious; and both larvae and adults are very brightly (warningly) colored. In a series of laboratory experiments using blue-jays as predators and the butterfly, *Cercyonis pegala* (Satyridae), as a palatable control, it was found that *E. phaeton* is indeed unpalatable, and in fact emetic, to the birds when fed throughout larval development on the primary foodplant, *Chelone glabra* (Scrophulariaceae), Turtlehead. Female oviposition and early larval development are confined to *C. glabra*, but in the later instars, larvae may become polyphagous, feeding on plants in 5 families. Butterflies which fed in early larval instars on *C. glabra* and in later instars on *Plantago lanceolata* (Plantaginaceae) were fed to blue-jays, again using *C. pegala* as a palatable control. These *E. phaeton* butterflies were palatable. In a single population of *E. phaeton*, therefore, one could find a range of palatabilities in the butterflies. The palatability of any individual would be dependent on the

amount of *C. glabra* eaten during larval development and could range from highly emetic (larvae fed throughout development on *C. glabra*) to quite palatable (larvae switched to alternate food soon after emerging from diapause in the spring).

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Discriminant function analysis of the abdominal coloration variations in the large milkweed bug, *Oncopeltus fasciatus* (Dallas) (Hemiptera: Lygaeidae). M. W. Brown and C. W. Rutschky, Pennsylvania State Univ., Univ. Pk., PA 16802

The patterns of grey and black ventral abdominal coloration were measured on 25 males and 25 females from six laboratory cultures: Penn. State U., Virginia Polytechnic Institute, Fordham U., U. of Wisconsin, Connecticut A.E.S., and Cornell U. Linear discriminant function analysis of these data resulted in a 66.67% classification of each insect into the correct culture. Discriminant function analyses were also run on each sex separately to eliminate a sex-culture interaction, resulting in a correct classification of 64.00% for males and 70.67% for females. A plot showed that the separation of cultures was correlated with the geographical distance between institutions. The discriminant function distance from the Penn State culture to the Cornell culture was very small. The Connecticut culture lay close to both of these. The discriminant function analysis almost completely separated the V.P.I. culture from the previous three; the Wisconsin culture was located the farthest from the others. The insects from the Fordham culture showed the largest variance and overlapped all the other cultures; it was initiated with milkweed bugs from Connecticut and supplemented with insects from the Albany, NY area. The other cultures were started from insects collected within the vicinity of the institution.

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Measuring honey bee foraging responses with an artificial flower. D. M. Caron and G. D. Waller, Dept. Entomol., Univ. Maryland, College Pk., MD 20742 and USDA Bee Res. Lab., Tucson, AZ 85719

Various sugar solutions were made available to foraging honey bees, *Apis mellifera* visiting artificial flowers. Capillary tubes extended downward through a blue plastic disk so the bees could remove sugar solutions from one of 6 vials. Amounts collected were used to measure relative acceptance by the bees. Up to six sugars or combinations of sugars were compared during each test.

Honey bees preferred sucrose over any other sugar or mixture of sugars. They preferred concentration varied between 30 and 60%. Addition of NaCl

strongly inhibited collection of sugar solutions at levels above 3000 ppm Na, but lower levels improved acceptance. Potassium contamination also inhibits collection. Sucrose solutions to which small amounts of maltose had been added were collected in preference to sucrose without the maltose. Addition of fructose, glucose, or trehalose had no such stimulating effect on honey bee foragers. The bee toxic sugars raffinose, xylose, galactose, lactose, and melezitose all had an inhibitory effect on collection of sucrose solutions by bees visiting the artificial flowers.

Different stock lines responded similarly to sugar and adulterated solutions. Selectivity is reduced if foraging populations are allowed to become too large. Tests are conducted in cages to limit populations and insure response measure from selected stock.

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Observations on the life history of *Pseudeucoila* spp. (Hymenoptera: Cynipidae). P. C. Chabora and S. J. Smolin, Queens College, Flushing, NY 11367

A new endoparasite which attacks the larval stage of several *Drosophila* species was collected from several mid-east coast states. Adults of both sexes were found in shaded habitats on fruits in which *Drosophila* were breeding. This species is morphologically similar to *P. bochii* but differs in developmental and pheromone response characteristics. Studies of the co-evolutionary patterns between interacting populations required a replicable procedure for quantifying the wasp's life history characteristics. Both parasite and host stocks originated from mass collections at Chapel Hill, N.C. in August 1976. Wasps will oviposit single eggs in host larvae 12–72-h-old, but to standardize procedures, hosts 24–48-h-old were used. Six *D. melanogaster* females oviposited on yeasted banana medium for 24 h to provide approximately 250 larvae. Each pair of wasps (23 replicates) were transferred to a fresh host vial daily until death. Emerging offspring were counted daily to provide a schedule of developmental rates and sex ratios. Male and female offspring began emerging at 16.5 and 17.5 days, respectively, until a total of  $376.8 \pm 58.9$  offspring were produced at a 0.46 sex ratio. A net reproductive rate of 202.8 and the weighted generation time of 20.3 days yielded an estimated  $r$  of 0.26. This opportunistic species produced 53% of its total egg output in 24 h which accounted for 72% of its female offspring. Within 72 h, 75% of all eggs and 92% of female eggs were produced. Adult life expectancy was calculated at 15.8 days. (Supported by BHE-PSC Award 10189.)

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Simulated defoliation and depodding effects on yield and quality of baby lima beans. D. L. Coggin and G. P. Dively, Univ. of Maryland, College Pk., MD 20742

Lima bean plants were defoliated and depodded to simulate the injury caused by phytophagous insects. Plants were defoliated at five levels (0, 1/6, 1/3, 2/3, 3/3) during five maturity stages (early prebloom, prebloom, bloom-pin, flat pod, mature pod). In another experiment pods were removed at four levels (0, 1/3, 2/3, 3/3) during three maturity stages (pin pod, flat pod, mature pod). Multiple regression methods were employed to develop separate equations for predicting yield reductions as a result of defoliation and pod loss for any maturity stage of the plant. Defoliation of 15% caused economic yield reductions at prebloom while 10% defoliation caused economic damage from bloom to harvest. Pod removal of 10% resulted in yield losses from the beginning of flat pod production to the beginning of mature pod production. Once mature pod production began, depodding reduced yields at increasingly higher percentages of pod loss. Leaf area and pod production of the lima bean plant were measured at various growth stages from field samples taken during 1976 and 1977 to obtain morphological data on the development of the plant. Based on average leaf area and pod production for each maturity stage and average leaf area and pods consumed in their development, static economic injury levels were calculated for the Mexican bean beetle and corn earworm, respectively.

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Electrophysiological identification of oviposition-detering pheromone receptors in *Rhagoletis pomonella* (Diptera: Tephritidae). R. M. Crnjar, R. J. Prokopy, and V. G. Dethier, Univ. Massachusetts, Amherst, MA 01003

Through structural ablation, it was previously demonstrated that receptors of oviposition-detering fruit marking pheromone in *Rhagoletis pomonella* (Walsh) females are located on the fore tarsi. Ablation tests and behavioral observations suggested that additional but less important or less often utilized receptors may also be present on the mid- or hind tarsi and the mouthparts. Here, we used the hair-tip recording technique to electrophysiologically identify marking pheromone-sensitive sensilla and possible receptor response types.

The D-hairs on the ventral surface of the 2nd, 3rd, and 4th tarsomeres of the fore tarsi and the short (marginal) hairs of the labellum proved highly sensitive to a crude extract of the pheromone. Some pheromone sensitivity occurred also in the A and D hairs of the 5th tarsomere of the fore tarsi, D-hairs of the mid tarsi, and the largest hairs of the labellum. The D-hairs of 3-day-old (immature) females were just as responsive as those of 3-week-old (mature) females. The particular D-hair cell sensitive to the pheromone

does not appear to be the salt cell, though it may be the sugar cell. The pheromonal response pattern of the labellar short hairs implicates more than one cell type, though one cell is predominantly active. Stadler, Boller, and Katsoyannos (pers. comm.) have found tarsal D-hairs of *R. cerasi* females to be sensitive to the marking pheromone of that species.

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Synergistic microbial attack on *Lymantria dispar* L. (Lepidoptera: Lymantriidae). R. A. Daoust and H. B. Gunner, Univ. Massachusetts, Amherst, MA 01003

*In vitro* and *in vivo* studies have demonstrated that chitinases of bacterial origin degrade the peritrophic membrane of the gypsy moth, *Lymantria dispar*, thus increasing larval susceptibility to infection. However, since most bacterial chitinases have a pH optima for activity between 5.0–6.0, the high alkalinity in the mesenteron of *L. dispar* larvae severely limits chitinolysis of the midgut lining. Fermentative acid-producing bacteria isolated from healthy gypsy moth larvae, although nonpathogenic, effectively lowered larval mesenteron pH when administered per os. The combination of fermentative isolates with a crude culture and supernatants from a centrifuged culture of a strong chitinolytic isolate produced synergistic increases in mortality over either dose administered by itself. The principal role of these fermenters was to poise midgut pH and thus to enhance the action of chitinases in the degradation of the peritrophic membrane. This was confirmed through the microscopic examination of cadavers and by classifying dead larvae according to their symptoms and mode of death. Although *in vitro* studies showed that other bacteria isolated from environments foreign to that of the gypsy moth could ferment carbohydrates with acid production at an alkaline pH, *in vivo* studies demonstrated that these bacteria were incapable both of poisoning larval midgut pH and of enhancing mortality when added to chitinolytic bacteria. Microorganisms isolated as resident flora from healthy larvae were, therefore, ecologically better adapted to the pest.

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The nature and distribution of European corn borer (Lepidoptera: Pyralidae) feeding injury on snap beans. G. P. Dively II and J. E. McCully, Univ. of Maryland, College Pk., MD 20742, and Regional Agricultural Agronomist, Green Giant Co., Le Sueur, MN

Egg masses were placed on snap beans at 7, 14, 21 days before harvest to determine the nature and distribution of feeding injury by *Ostrinia nubilalis* (Hübner). Early instars fed first on leaves and then bored into stems and pods as they reach the late 2nd and 3rd instars. About 37% of the stem damage occurred inside the lower portion of the main stem, with the re-



maining damage distributed among lateral stems. Second and later instars invaded all sizes of pods with a significant preference toward the marketable pods (sieve sizes 3–6). External symptoms indicating that the pods had been damaged were not consistently observed. Many marketable pods were completely normal in appearance despite extensive boring, and the only sign of injury was the entry hold. Injury to pin pods (sieve sizes 0–2) invariably was associated with external symptoms, and it is likely that these pods develop to a marketable size. The nature and distribution of feeding injury to pods and stems depended on the time of oviposition. When hatching occurred at bloom, about half of the surviving larvae invaded pods of all sizes and caused little external evidence of injury by harvest time. When hatching occurred one week or more before bloom, surviving larvae bored primarily into lateral stems; however, ca.  $\frac{1}{3}$  of these larvae shifted their feeding activity to pods as they became available.

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Effect of chitinase on the peritrophic membrane of *Lymantria dispar* L. (Lepidoptera: Lymantriidae) larvae. N. R. Dubois, U.S. Forest Service, Hamden, CT, H. B. Gunner, and D. A. Daoust, Dept. Environ. Sci., Univ. Massachusetts, Amherst, MA 01003

Chitinolytic microorganisms have been isolated from healthy instar III, IV and V *L. dispar* larvae. The acquisition of the chitinolytic microflora appears to be correlated with an increase of mobility by the maturing larvae. Selected isolates, two identified as *Bacillus coagulans* and two *Streptomyces* species were inducible for chitinase by the insect host tissue. Stock chitinases produced by the four isolates readily attacked the chitinous integuments of the larvae, releasing N-acetylglucosamine. *In vitro* studies showed that the peritrophic membrane was very susceptible to the chitinase. *In vivo* studies demonstrated that *B. coagulans* was lethal to the larvae when these were fed chitinase induced whole cultures of the bacteria; when the chitinase was fed with sublethal doses of *B. thuringiensis*, significant mortality was observed. When ingested, the chitinase caused localized dissolution and ulceration of the peritrophic membrane. The pH of the mesenteron appears to have a limiting effect on the *in vivo* chitinase activity on the peritrophic membrane.

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Attraction of apple maggot *Rhagoletis pomonella* (Walsh) (Diptera: Tephritidae) females to apple volatiles in wind tunnel bioassays. B. L. Fein, W. H. Reissig, and W. L. Roelofs, Dept. Entomol., NYS Agr. Exp. Sta., Geneva, NY 14456

Apple volatiles from whole Red Delicious and Red Astrachan apples attracted sexually mature female apple maggot flies, *Rhagoletis pomonella*, in wind tunnel bioassays. Forty other apple varieties were tested but these were not attractive. Compressed air was passed through a desiccator filled with apples of a given variety for three days and the volatiles were trapped on a column of Porapak Q. The volatiles were retrieved for testing by rinsing the Porapak with Skelly B, and reducing the solvent volume to 1 ml, and testing 60  $\mu$ l quantities. In wind tunnel tests, two pieces of filter paper were placed adjacent to one another at the upwind end of the tunnel, 36 cm apart. An aliquot of volatile extract was placed on one and an equal volume of solvent was placed on the other as a control. A perforated wax sphere was placed over each filter paper. Tests with smoke showed that non-overlapping plumes emanated from each sphere and remained coherent the length of the tunnel. Two cages, each containing fifty laboratory reared flies, were placed in the downwind end of the tunnel. The cages were aligned to be directly in the plume of the volatiles or the control. The number and rate of flies arriving and the number of flies attempting oviposition was recorded. Attractive volatile rinses were fractionated using gas-liquid chromatography. These fractions were assayed in the wind tunnel and by electroantennography. Fractions which were the most attractive in the olfactometer also elicited the highest electroantennogram responses.

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Queen cell production and control in the honey bee (*Apis mellifera* L.) colony (Hymenoptera: Apidae). R. D. Fell, Dept. Entomol., Cornell Univ., Ithaca, NY 14853

The production of emergency queen cells occurs when a honey bee colony suddenly loses its queen. Young worker larvae are fed royal jelly and are reared into queens. Cell construction begins within 24 hours and continues for several days. The number of queen cells that a colony produces was found to reach a peak within 4 to 5 days and then level off as the first queen cells were capped. Usually no new cells were initiated after capped cells appeared in a hive. This reduction in the number of emergency queen cell starts was not caused by a lack of suitable worker larvae from which to rear queens; but from the presence of capped queen cells. These cells have been found to inhibit further queen cell production. The addition of young worker larvae to a queenless colony with capped queen cells did not stimulate additional queen rearing. Significant queen production only occurred if the

capped queen cells in a test colony were destroyed at the time the worker larvae were introduced. These observations are supported by the finding that the addition of capped queen cells to a recently dequeened colony will also reduce queen cell production. These results indicate that negative feedback controls queen cell production in the honey bee colony. The possibility that a queen cell pheromone is involved in the control of cell production and recognition is currently being investigated.

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Contact action of diflubenzuron on eggs and larvae of gypsy moth, *Lymantria dispar* L. (Lepidoptera: Lymantriidae). A. J. Forgash, N. C. Respicio and B. K. Khoo, Dept. Entomol. and Eco. Zool., Rutgers Univ., New Brunswick, NJ 08903

The contact toxicity of diflubenzuron to eggs and larvae of the gypsy moth was investigated. Egg masses and dehaired eggs were sprayed with 2.07 FL or SULV 5% formulations at the rates of 0.067 and 0.56 kg AI/ha. Contact toxicity to larvae reared on artificial diet was determined via topical and spray applications. Third-instar larvae were treated topically with technical grade or W-25 formulation. Two formulations (2.07 FL and SULV 5%) were sprayed at the rate of 0.067 kg AI/ha on 1st to 5th-instar larvae. Toxicities were evaluated according to the number of successful molts and in the severity of the symptoms in non-surviving larvae. Treatment of eggs with both rates did not affect hatching success. In addition, the molting process of hatched larvae was not affected at the rate of 0.067 kg AI/ha. However, at the rate of 0.56 kg AI/ha, molting of hatched larvae was prevented completely. Topical and spray applications effectively prevented molting of treated larvae. Technical grade diflubenzuron was slightly more effective than W-25 formulation on 3rd-instars by topical application. Spray applications of 2.07 FL and SULV 5% formulations were also toxic to all larval instars; SULV 5% was more effective than 2.07 FL on 1st and 2nd instars. However, there were no differences in toxicity between the two formulations on the older instars. These results established the effectiveness of diflubenzuron on gypsy moth via cuticular penetration and indicate that there may be other species that are equally susceptible to this material by contact.

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The structure and dynamics of arthropod communities of bat guano ecosystems. E. R. Franklin and T. H. Kunz, Dept. Biol., Boston Univ., Boston, MA 02215

The objective of this study was to characterize the composition, structure, and dynamics of arthropod communities associated with bat guano deposits in buildings. Three sites in New Hampshire were sampled from February 1977 through January 1978. Twelve species are reported including three Coleoptera, one Siphonaptera, two Hemiptera, two Psocoptera, three Acarina, and one Pseudoscorpion. Most are cosmopolitan associates of dried organic matter. These communities exploit a seasonally rich food source produced by roosting bats. Seasonal community changes included the presence of fleas only when bats were present, more arthropod species but a lower species diversity when bats were present, and a more equitable distribution and abundance of species when bats were absent. Older communities and those with the most diverse resource base generally supported the most species. There was evidence of the following species interactions: 1) an adverse effect of predatory bdellid mites on flea larva density, 2) predation of mealworms and flea larvae by the masked assassin bug, 3) decreases in fungivorous mite density corresponding with increases in density of mealworms and dermestid larvae, and 4) a fungivorous mite, predatory mite, pseudoscorpion food chain.

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Esterase variation in female *Aedes aegypti* (Diptera: Culicidae): Isozyme characterization and the influence of adult ageing. D. J. Fryauff and D. J. Sutherland, Rutgers Univ., New Brunswick, NJ 08903

Soluble esterase components of female *Ae. aegypti* were resolved through conventional polyacrylamide gel electrophoresis of pooled whole body homogenates. Using a staining reaction that employed the general esterase substrate 1-naphthyl acetate, enzyme activity of pupae and adults was revealed colorimetrically and assessed by densitometry. Subclass and isozyme characterization of esterases as either carboxylesterase (E.C.-3.1.1.1), arylesterase (E.C.-3.1.1.2), or cholinesterase (E.C.-3.1.1.7) was based on comparative inhibition of activity by the specific esterase inhibitors dichlorvos (DDVP), and eserine. Of 9 migrating bands detected in pupae, 6 were characterized as isozymes of carboxylesterase, 2 as arylesterases, and 1 as cholinesterase. More than 90% of the pupal activity was concentrated in the 4 leading carboxylesterases. Newly emerged imaginal mosquitoes contained 11 esterase components with relative activities and banding patterns similar to those of pupae. During the course of emergence an arylesterase was lost and additional carboxylesterase components became apparent in adults. However, combined activity of all adult esterases had declined significantly

from those levels recorded for pupae. Maximum activity of adult esterase, recorded within 48 hours, declined rapidly after 72 hours. This decline was attributed to the (1) reduction in number, and (2) diminished activity of the 4 leading carboxylesterase isozymes. Conversely, cholinesterase, which had contributed insignificantly to the total activity in pupae rose sharply to account for 8% within 6 hours of emergence and continued to register high activity over 14 days of ageing.

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A hypothesis for the distribution of holarctic groups of fungus gnats (Diptera: Mycetophilidae). R. J. Gagné, Systematic Entomology Lab, FR, SEA, USDA, Washington, DC 20560

Recent revisions of Mycetophilidae show patterns of holarctic distribution that are repeated many times. These flies are evidently very ancient in that many holarctic genera are represented on the southern continents by vicariant genera. In the holarctic region, most genera, subgenera, and species groups have one or more species that occur in both Europe and North America, one or more that are strictly nearctic, and one or more strictly palearctic. Although most species that occur in North America are widespread from coast to coast, some occur only in the Great Plains eastward, others only in the Rocky Mountains westward. Many of the eastern nearctic species occur in Europe, but none of the exclusively western species do. These patterns are not explained by dispersal via Beringia or by separation due to Pleistocene glaciation. The most likely hypothesis for this particular distribution must take into account the early Eocene land connection between eastern North America and Europe. Species presently ranging throughout the holarctic region are probably virtually unchanged since before the breakup of Laurasia and those species limited to Europe and eastern North America unchanged since the early Eocene when those 2 areas were one continent separated from western North America and Asia by seas. Species restricted to eastern North America resulted some time after the breakup of Euramerica in the middle Eocene. This supposes a very ancient age for extant species of fungus gnats, but that conclusion is supported by the fossil record.

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Temporal patterns of parasitization of face fly (Diptera: Muscidae) by *Thelazia* sp. (Bosc) (Nematoda: Spirurata) on three dairy farms in Western Massachusetts. C. J. Geden and J. G. Stoffolano, Jr., Univ. Massachusetts, Amherst, MA 01003

Two species of nematode bovine eyeworms of the genus *Thelazia*, *T. gulosa* and *T. skrjabini* have been recovered from the eyes of slaughtered

cattle in Massachusetts while a survey during the summer of 1976 showed that of eighteen face fly populations sampled in the state, all contained some members parasitized by immature forms of the parasites. Because of the potentially serious veterinary and economic hazards presented by this group of eyeworms and the scarcity of basic information on the life history of the worms, a study was conducted to determine what temporal patterns of parasitization may be present in the intermediate host. To this end three herds of dairy cattle, all Holsteins from Western Massachusetts, were selected, from which female face flies were collected and dissected throughout the summer of 1977. On all three farms a first peak of infection in the flies was observed at about June 20, followed by a decline in early to mid-August, then an increase to a second peak in early September. These patterns may be due to the biology of the parasites, the age structure of the fly populations or to a combination of these factors.

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Emigration behavior of the East African driver ant, *Dorylus (Anomma) molesta* Gerstaecker (Hymenoptera: Formicidae: Dorylinae). W. H. Gotwald, Jr., Utica College of Syracuse Univ., Utica, NY 13502

Emigration behavior of *Anomma* driver ants and of Old World army ants in general is poorly known. Theoretically, army ants are defined as nomadic, since the most thoroughly studied species periodically emigrate from one nesting site to another. In order to better understand army ant emigration behavior, a study of *D. (A.) molesta* was conducted from July 1971 through December 1973 on a research area of approximately 5 hectares near Nairobi, Kenya. A total of 100 emigrations conducted by 15 colonies were observed and 39 nest sites located and described. One colony emigrated 40 times and was under continuous observation for 432 days. The most extensively used nest site was occupied on 15 separate occasions by 4 different colonies. Specific nest sites were occupied by some colonies for as few as 3 days and as many as 67 days. The following can be concluded: (1) emigrations occur at irregular intervals, indicating that the behavioral stimuli for emigrations do not reside in the colony's reproductive cycle; (2) emigrations often take place over short distances and may not significantly change the colony's trophophoric field; and (3) many emigration trails and nest sites become permanently established and can be reused by a single colony or used and occupied sequentially by several different colonies.

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Differences in maze-learning ability in two species of lepidopteran larvae. S. T. Grant, Zool. Dept., Univ. Massachusetts, Amherst, MA 01003

Larvae of *Vanessa cardui* L. (Lepidoptera: Nymphalidae) and *Danaus plexippus* L. (Lepidoptera: Danaidae) were trained in T-shaped mazes which incorporated electric shock as negative reinforcement for entering the wrong arm of the maze and food reward for entering the correct arm. All larvae were trained daily for one-hour periods, during the fifth larval instar, after a ten to twelve-hour period of food deprivation. The *V. cardui* larvae showed progressive improvement in their performance during training but the *D. plexippus* larvae did not. Latency to the first completed run was significantly lower in *V. cardui* larvae, and the rate at which larvae re-entered the choice point of the maze following encounter with the shock device was significantly higher in *V. cardui*. The two species of Lepidoptera studied differ in their larval ecology, with *V. cardui* caterpillars being polyphagous, cryptically colored, and prone to defoliate their foodplants, while *D. plexippus* caterpillars are oligophagous, aposematically colored, and not prone to defoliate their foodplants. It is concluded that the ecological differences between the two species helps to account for their differing abilities in maze-learning, as the *V. cardui* larvae would be pre-adapted for active exploration of their environment.

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Courtship of the brown-banded cockroach, *Supella longipalpa* (Blattaria: Blattellidae). R. S. Grippo and I. Huber, Dept. Biology, Fairleigh Dickinson Univ., Madison, NJ 07940

Courtship of *Supella longipalpa* (F.) is similar to that of the German cockroach: antennal fencing, male raises wings and rotates 180° to face away from female, female mounts and feeds on male's exposed tergal glands, male grasps female's genitalia with his and pair assume an opposed linear (copulatory) position facing away from each other. In *Supella*, mutual antennal fencing is not a necessary releaser for the male to continue his courtship sequence as it is in the German cockroach. Also, wing-raising precedes rotation whereas these are simultaneous in *Blattella germanica*. The virgin male does not show a positive response, as indicated by wing-raising, to contact with a virgin female until 6 d. after adult ecdysis. The percent males responding increases to a maximum on the 10th and 11th days and is slight after the 17th day. The time needed to elicit a courting response in the male after initial contact with a virgin female was shortest from the 9th through 11th days. Morphological evidence indicates that a primitive blattellid such as *Supella* is a more likely ancestor of the internal-incubating cockroaches (Blaberidae), than is a blattelline such as *Blattella*. Thus, further study of courtship, pheromones and mating in *Supella*, a member of the previously

unstudied subfamily Plectopterinae, should be important in understanding these phenomena in the Blaberidae as well as aiding in the development of methodologies for the disruption of mating in this pest species.

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Changes in food quality of an insect's marginal host species associated with a plant virus. J. D. Hare and J. A. Dodds, Connecticut Agric. Exp. Stn., New Haven, CT 06504

The ecological relationships between insects, plants, and plant viruses are poorly understood. Although changes in several physiological functions of plants caused by plant viruses have been described, their effects on other species, such as herbivores, are virtually unknown. Most varieties of the cultivated tomato, *Lycopersicon esculentum*, are poor hosts for the Colorado potato beetle, *Leptinotarsa decemlineata*. However, when tomato plants are inoculated with either a mild (nearly symptomless) or a severe (symptomatic) strain of tobacco mosaic virus, insect survival is significantly greater. Analyses of leaf tissue show that the total organic nitrogen content of virus-infected plants is up to 40% greater than virus-free plants, and most of this difference can probably be attributed to the presence of viral protein in infected leaf tissue. Recent studies with other plant-insect associations have shown that plant nitrogen content is one of the more important factors governing insect growth, and further experiments are in progress to ascertain if the major differences in plant nutritional quality are the result of virus induced increases in total leaf protein. These results call into question the advisability of using mild strains of plant viruses to confer immunity to more severe strains, and they raise several questions concerning the differential utilization of individual plants of marginal host species and their role in the dynamics of phytophagous insect populations.

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Dusky sap beetle *Carpophilus lugubris* (Coleoptera: Nitidulidae): Control in sweet corn. F. P. Harrison and J. C. Richardson, Dept. Entomol. Univ., Maryland, College Park, MD 20742

Since 1959 a screening program for control of insects attacking sweet corn ears has been conducted in order to evaluate promising compounds. Carbaryl was used in all these tests as the standard comparison material. After examining the effect of spraying ears with carbaryl over many years, it is apparent that the results obtained with this material against dusky sap beetle was unpredictably erratic. These data were examined from more than one aspect. The results of examining these data indicated that the presence of corn earworm was apparently associated with significant control of dusky sap beetle. Also, secondary infestation, that sap beetle infestation that at-



tacks ears that are injured by another insect, was the infestation that was significantly reduced. A series of experiments was conducted in order to determine techniques that would be effective in reducing primary infestations. Plots of sweet corn were planted in series in 2 consecutive years. Plots were divided into 4 sub-plots receiving 0, 1, 2 and 3 applications of 2 lbs. carbaryl each in 25 gallons of water per acre. Observing results of these experiments indicated that primary infestation (ears infested with dusky sap beetle alone) required a greater number of applications of carbaryl than secondary infestation.

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The insects important in no-till corn in Maryland and their control. F. P. Harrison, A. Bean and O. J. Qawiyy. Univ. Maryland, College Park, MD 20742

A survey of the soil-borne insects damaging corn in Maryland indicated that cutworms and armyworms were significantly more injurious in no-till corn than in conventionally tilled corn. Because the producers of sweet corn grown for processing have experienced yield losses in recent years and these yield reductions are mainly attributed to moisture stress, there is some interest within the processing industry in growing no-till sweet corn, the idea being that no-till provides a degree of moisture conservation. Because a no-till culture encourages attacks by cutworms and armyworms, a series of experiments were conducted from 1975 through 1978 to evaluate techniques for reducing losses by cutworms and armyworms. The sweet corn was grown using rye as a cover. In the spring this cover is killed with a contact herbicide in combination with preventive herbicides. Corn seed is then planted through this cover. The cover mats down and provides a mulch which conserves moisture and provides optimum conditions for some insects. These experiments evaluated a number of insecticides applied as banded planter applications and as broadcast sprays. In 1975 and 1976 the losses were from armyworm. In 1978 black cutworm caused stand reduction. Chlorpyrifos 15G, carbofuran 10G and Dyfonate 20G were effective against armyworm. Chlorpyrifos 15G and 4E and Nematak 2L were effective against black cutworm.

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The origin of the cell lining in the nests of *Colletes* bees (Hymenoptera: Colletidae). A. Hefetz, Laboratory of Chemistry, National Heart, Lung, and Blood Inst., Bethesda, MD 20014, and S. W. T. Batra, Beneficial Insect Introd. Lab. USDA, MD 20705

The Dufour's gland, associated with the sting apparatus, is very large in bees of the genus *Colletes*. It is filled with oily, odoriferous material and

occupies most of the abdomen. Since these ground dwelling bees utilize their sting when lining their brood cell, it was interesting to compare the chemistry of their glandular content with that of the cell lining. Dufour's glands of three species, *C. thornicus*, *C. validus* and *C. inequalis*, were extracted in methylene chloride and analyzed by a combined gas chromatography-mass spectroscopy, utilizing an SE-30 capillary column. The major components of the glands are a homologous series of macrocyclic lactones, hexadecanolide, octadecanolide, eicosanolide and docosanolide. An unsaturated lactone, octadecanolide also appears in appreciable amounts. Accompanying these lactones are high molecular weight hydrocarbons and an unidentified compound. The cell lining in the nests of the bees is a white membrane, only slightly soluble in methylene chloride. Analysis of the soluble fraction revealed the presence of the lactones characteristic to the Dufour's gland, as well as the unidentified component. These results suggest that the bees use the content of their Dufour's gland for lining their cells. The origin of the insoluble material in the cell lining is still unknown, but it is possible that the corresponding hydroxyfatty acids, form polyesters rather than lactones, thus creating a waterproof lining.

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Feeding activity of the alfalfa blotch leafminer, *Agromyza frontella* (Rondani) (Diptera: Agromyzidae). R. G. Helgesen and F. Baxendale, Cornell Univ., Ithaca, NY 14853

In developing a pest management program for the alfalfa blotch leafminer, it was necessary to quantify the age-specific feeding activity of the miner because our simulation models function on an age-specific, continuous basis. The alfalfa blotch leafminer feeds on its side in a sickle-like fashion consuming the entire mesophyll of the alfalfa leaflet. The larva leaves behind it three characteristic frass patterns conveniently corresponding to each larval instar. The first instar larva forms a linear mine with frass laid in two parallel rows, the second instar larva produces a transitional mine with frass laid in semi-circular arcs and the third instar larva forms a blotch mine with amorphous frass oriented to the center of the blotch. Newly hatched larvae usually feed toward the margin between the veins of the leaflets and then turn toward the center of the leaflet to form the blotch. We photographed completed mines, enlarged them 10 $\times$  and, with a polar planimeter, measured the area consumed during each larval stage. We found that the area of leaflet consumed was a) ca 2.5 mm<sup>2</sup> in the first instar, b) ca 10 mm<sup>2</sup> in the second instar and, c) ca 45 mm<sup>2</sup> in the third instar producing a complete mine of ca 60 mm<sup>2</sup>. We assumed the feeding rate was an increasing exponential function with regard to age. Using this model we found that we could express the age specific feeding rate (y) as:  $y = e^{.03x}$  and cumulative feeding (z) as:  $z = e^{.041x}$ , where x is percent development.

Establishment of *Dacnusa dryas* (Nixon) (Hymenoptera: Braconidae) and *Chrysocharis punctifacies* Delucchi (Hymenoptera: Eulophidae), parasites of *Agromyza frontella* (Rondani) (Diptera: Agromyzidae) in Delaware. R. M. Hendrickson, Jr., USDA-SEA-FR, Benef. Ins. Res. Lab., 501 S. Chapel St., Newark, DE 19713

These European parasite species were released in 1977 at the laboratory alfalfa field. A total of ca 600 *D. dryas* were released against the 1st-, 2nd-, and 3rd-host generations, and a total of ca 200 *C. punctifacies* against the 2nd- and 3rd-host generations. Both species were recovered by sweeping during the 1st- and 2nd-host generations in 1978. Maximum recovery rates were 20 per 100 sweeps for *D. dryas*, and 1 per 100 sweeps for *C. punctifacies*. Both species have been released in small numbers in 4 other states: New Jersey, Pennsylvania, New York, and Ohio. Recoveries have been made only from Delaware where large releases and extensive recovery surveys were made. These species oviposit on larvae and emerge from puparia. The USA has no effective native parasite species which emerge from puparia. In contrast, *D. dryas* and *C. punctifacies* accounted for a combined 21% parasitism (from 33,573 puparia shipped to Newark, Del., by the USDA European Parasite Laboratory in 1976-77). Since season-long parasitism of *A. frontella* by all native parasite species averaged 36% for 1975-77, the addition of these 2 European species to the native complex may raise total parasitism to 50-60%, perhaps enough to reduce *A. frontella* populations below an economic threshold.

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Acoustical communication during courtship and mating in green lacewings (Neuroptera: Chrysopidae). C. S. Henry, Univ. of Connecticut, Storrs, CT 06268

Courtship and mating of the green lacewing *Chrysopa carnea* Stephens are described in detail. Copulation is preceded by 5 well defined activities; search, antennal contact, mouthpart contact, abdominal approach, and abdominal contact. Rhythmic vibration or jerking of the abdomen in the vertical plane accompanies all stages of courtship in both sexes. Isolated, sexually receptive individuals release long sequences of discrete, short volleys of abdominal vibration or jerking separated by 1 to 2 sec intervals; female solos are rarer than male solos and display significantly longer intervals between bursts than do the latter. Sexually receptive heterosexual pairs of lacewings establish duets of precise reciprocal abdominal jerking between partners; these calls seem like interdigitated solo calls, with each partner

altering its normal interburst interval slightly toward that characteristic of the opposite sex. While each solo sequence typically displays increasing and then decreasing burst intervals, successful heterosexual duets manifest ever increasing burst spacing until terminated by copulation. A pair of sexually receptive males can also establish a duet of reciprocal abdominal jerking. Airborne sound, possibly ultrasound, is used for intraspecific communication. Two lacewings that occur sympatrically with *C. carnea* similarly jerk their abdomens spontaneously and in heterosexual duets, but differ from it markedly in the temporal patterning of their volleys: *C. rufilabris* Burmeister releases sustained, modulated bursts of jerking at 10–12 sec intervals, while *C. oculata* Say produces simple long sequences of closely spaced volleys of abdominal vibration. I postulate that acoustical communication in chrysopids is a short distance phenomenon that functions primarily to isolate reproductively species that are morphologically and ecologically similar.

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Two sex attractants for male speckled green fruitworm moths, *Orthosia hibisci* Guenee (Lepidoptera: Noctuidae). A. S. Hill and W. L. Roelofs, NY Sta. Agric. Exp. Stn., Geneva, NY 14456

Male *Orthosia hibisci* moths, collected from blacklight traps, were used for screening series of monounsaturated, straight-chain 12-, 14- and 16-carbon acetates, alcohols and aldehydes for electroantennogram (EAG) responses. (*Z*)-9-Tetradecenal (*I*) produced the highest EAG response, followed by (*E*)-12-tetradecenal. *I* and (*Z*)-9, (*E*)-12-tetradecadienal (*II*) each produced about equally high EAG responses. *I* and *II* were tested in the field, alone and in a 1:1 combination, at various dosages (totals of 20, 60, 200, 600, and 2000  $\mu\text{g}$ ) on rubber septa in Pherocon 1C traps. The highest dosage resulted in the highest trap catches and, as the dosage diminished, so did trap catches. *I*, *II*, and *I* + *II* were about equally effective at any given dosage. As many as 60 moths were caught in one trap at one time. Catches of 20–40 moths/trap/night were seen frequently with 300  $\mu\text{g}$  *I* + 300  $\mu\text{g}$  of *II*, which was used in 1978 by workers in the area for monitoring this insect. Other insects were not seen in consistent numbers in any of the traps used. No work has been done as yet with the female moths to identify the natural sex pheromone of *O. hibisci*. However, the EAG screening technique used, which required less than 10 moths, resulted in the rapid selection of two effective sex attractants for male *O. hibisci* in the field.

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Kairomone of *Tetranychus urticae* (Acarina: Tetranychidae) influencing host-searching behavior of its predator, *Amblyseius fallacis* (Acarina: Phytoseiidae). R. G. Hislop, N. Alves and R. J. Prokopy, Dept. of Ent., Univ. Massachusetts, Amherst, MA 01003

*A. fallacis* is a predator of phytophagous mites in eastern North American apple orchards. In early summer it invades the trees, often borne there by wind currents. It may either remain for some time searching for prey, or soon depart to search for prey elsewhere. This choice may depend on the frequency of contact with prey. We examined the possible influence of chemical cues deposited by *T. urticae* on the host-finding behavior of *A. fallacis*. First we allowed *T. urticae* adults to infest 2-cm diameter filter paper discs for 2 days, after which we removed all stages. Then we allowed free access to such discs by starved female *A. fallacis*. The predators remained on discs over 4 times longer than on control discs having no previous exposure to *T. urticae*. Using various solvents we made extracts of discs previously infested by *T. urticae*, applied the extracts to fresh discs, and allowed starved female *A. fallacis* free access to the discs. The predators visited the discs treated with methanol extract more than twice as often as check discs (methanol alone). Also, time spent between visits to methanol-treated discs was only one-third that time between visits to check discs. These data indicate that *T. urticae* secretes chemicals which function as kairomonal cues to host-seeking *A. fallacis* females.

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Synthetic pyrethroids to control insect pests of vegetable crops. R. N. Hofmaster and J. Francis, Virginia Truck and Ornament. Res. Stn., Painter, VA 23420

The synthetic pyrethroids, Pounce, Ambush and Pydrin along with the pyrethroid analog, FMC45498, were evaluated as foliage sprays against insect pests of sweet corn, collards and Irish potatoes. The following results were obtained: SWEET CORN—Fall armyworms, *Spodoptera frugiperda* (J. E. Smith) caused 100% loss of untreated ears in N&K 199 sweet corn. Applying 5 treatments of Pounce, Pydrin or Ambush at 2–3 day intervals following first silk gave 90% or better undamaged ears at a rate of 0.1 lb active/acre and virtually 100% control when the dosage was increased to 0.2 lb active/acre. The analog, FMC45498, gave comparable results at only 1/10 the above rates. COLLARDS—Cabbage looper, *Trichoplusia ni* Linn., infestations averaged nearly 30 loopers/collard plant in late August. Following a series of 3 foliage sprays, populations were reduced over 97% by Pounce, Pydrin and Ambush at 0.05 lb active/acre and FMC45498 at 0.01 lb active/acre. Especially interesting was the increase in control generated by combining 0.25 lb Dipel with 0.005 lb Pydrin/acre. IRISH POTATOES—

Beet armyworm, *Spodoptera exigua* (Hubner) and European corn borer, *Ostrinia nubilalis* (Hubner) damage was reduced at least 95% by foliage sprays of Ambush, Pounce or Pydrin applied at 0.1 lb active/acre in a 7-10 day schedule. Beet armyworm infestations averaged 18/hill and corn borers 22.5/hill in the untreated check. The synthetic pyrethroids, Pounce, Ambush and Pydrin together with the analog FMC 45498 offer a potentially valuable means of control of hertofore troublesome vegetable insect pests.

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Introducing integrated control in Virginia apple orchards: Techniques for involving and training growers. R. L. Horsburgh, Shenandoah Valley Res. Sta., VPI & SU, Steeles Tavern, VA 24476

The wide geographic separation and small acreage of apple orchard blocks in central Virginia make private commercial consultation in pest management relatively unattractive economically. Therefore, attempts were made to improve grower capabilities of pest recognition and pest population monitoring during the early growing seasons of 1976, 77, and 78. The technique employed was that of holding weekly in-orchard training sessions that extended over the noon hour. In 1976, 17 such meetings were held, 24 in 1977 and 27 in 1978. Grower capabilities have definitely improved and an integrated control program was commenced in seven commercial orchards in 1978. Other extension objectives have been realized through the utilization of this technique, including familiarization of extension of personnel with local pest problems on a regular basis; dispersal of timely information on a variety of orchard related subjects; routine problem solving and graduate student training under commercial orchard conditions. Interest of fruit producers has been maintained and intensified because the topics discussed each week are directly related to their own commercial orcharding methods. Furthermore, the problems are observed under genuine commercial conditions instead of a less typical research situation.

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Potato leafhopper density and its relationship to alfalfa quality. A. A. Hower, The Pennsylvania Sta. Univ., University Park, PA 16802

Studies were conducted in various regions across Pennsylvania in order to characterize the population densities of potato leafhoppers and to determine corresponding losses in alfalfa quality. Leafhopper numbers at the population peak on a crop ranged from a low 0.6 per sweep in northeastern counties to a high 156 per sweep in the southeast. During 2 years the relationship between leafhopper numbers and reduction in % crude protein appeared nonlinear. A density of 2 leafhoppers per sweep caused an average

2% loss in protein while 50 and 100 leafhoppers per sweep accounted for losses of 5.8 and 7.0 percent, respectively.

A field cage study was initiated to more precisely identify the amount of damage caused by leafhoppers developing on an individual alfalfa stem. Leafhoppers were caged as 1st instar nymphs on 22.9 cm tall alfalfa. A density of 1-2 nymphs per stem reduced crude protein an average 3% on 2nd and 3rd crop alfalfa. Protein declined an average 4-5% on both crops where leafhoppers numbered 3-4 per stem. Alfalfa height and weight also were negatively influenced under leafhopper stress. Dry weight losses exceeded 24% when 3 or more nymphs were allowed to develop to adults on one stem. Additional field and laboratory studies are being continued to more precisely identify the above relationships.

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Hemocytes, cell death, hemolymph coagulation and melanization in insects. J. C. Jones and R. J. Ruschell, Jr., Univ. of Maryland, College Pk., MD 20742

The hemocytes of four species of insects belonging to four orders of insects were studied in relation to cell death, gelation and melanization of the hemoplasma in unfixed whole hemolymph. In *Acheta domesticus* adults, almost all of the hemocytes rapidly disintegrated (their nuclei remained intact) and there was an intense precipitation of the hemoplasma. The hemolymph turned a light gray. In mature *Musca domestica* and *Manduca sexta* larvae only a few hemocytes disintegrated and none of the hemocytes themselves darkened, yet the hemoplasma turned dark and gelled. Gelation of the plasma in mature *Musca* occurred in the absence of podocytes. In mature *Apis mellifera* larvae, only a few hemocytes and fat body cells were seen in the hemoplasma; none lysed; none darkened. The plasma did not gel or darken *in vitro*. It is concluded that while cell death may be associated with plasma coagulation it is not associated with melanization.

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Experience with grape pest management in Erie County, Pennsylvania. G. L. Jubb, Jr., T. H. Obourn, and D. H. Petersen. Pennsylvania State Univ. North East, PA 16428.

A pilot pest management program for grapes was tested in Erie County, Pennsylvania, during the summers of 1976-78. Nine growers participated in 1976 (135.6 ha), 14 growers participated in 1977 (214 ha), and 16 growers participated in 1978 (224.8 ha). Vineyards were scouted weekly for 15 weeks beginning on June 1. Fees of \$3.00 and \$4.75 per 0.4 ha were assessed to

participants in 1977 and 1978, respectively, to help offset costs of the program. Scouts reported insect and mite pest counts to each grower the day their vineyard was inspected. Growers made the final decision on the need to apply pesticides. Insect and mite damage in pest management vineyards was generally light each year. Pests requiring post-bloom sprays in several vineyards were grape leafhopper, grape berry moth, grapevine looper, and European red mite. Participants reduced their post-bloom insecticide sprays as compared to non-participants. Average number of post-bloom insecticide applications in 1976 was 2.5 for non-participants and 0.8 applications for participants and in 1977 was 2.3 applications for non-participants and 1.1 applications for participants. Potential savings in spray costs, depending on materials used, ranged from \$7–12 per 0.4 ha in the pest management program. Scouting costs were \$4.42 per 0.4 ha in 1976 and \$4.63 per 0.4 ha in 1977. Grower opinion of the program was quite favorable. Most growers would like to see the program continued and indicated a willingness to pay a higher seasonal fee.

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Estimation of esterase activity in gypsy moth, *Lymantria dispar* L. (Lepidoptera: Lymantriidae) larval tissues. M. A. Kapin and S. Ahmad, Dept. of Entomol. & Econ. Zool., Rutgers Univ., New Brunswick, NJ 08903

Esterases (EC 3.1.1.) in insects are implicated in the regulation of JH titer, catabolism of fats, cuticular wax synthesis and transport, degradation of undesirable dietary esters, and insecticides. This report relates to our current work on the nature of these enzymes in gypsy moth larvae. Homogenates of fifth-instar tissues were centrifuged at  $12000 \times g$  to obtain clear supernatants as enzyme sources. 1-Naphthylacetate was used as a substrate, which upon enzymic hydrolysis produces 1-naphthol. This product when coupled to a diazo dye, Fast Blue B, produces a blue color that is estimated spectrophotometrically at 590 nm. By this method, relative specific rates and distribution of esterase activity (in parentheses) in larval tissues, excluding hemolymph, were initially estimated as follows: 100 (95.9), 9.7 (1.6), 5.4 (0.2), 2.7 (0.4), 2.0 (1.7), 1.7 (0.1), 1.3 (<0.1), and 0.8 (<0.1) percent in midgut, foregut, gonads, hindgut, brain, Malpighian tubules, nerve cord, and muscles, respectively. Thus, the principal site of esterases in gypsy moth larvae is the midgut, showing the highest concentration (specific activity,  $2.9 \mu\text{moles mg}^{-1} \text{min}^{-1}$  at  $24^\circ\text{C}$ ) of esterases ever recorded in an insect species. Also, the midgut preparation is fairly thermostable (optimum range  $45^\circ\text{--}50^\circ\text{C}$  for 20 min.) and can be stored over 24 h at  $-15^\circ\text{C}$  without any loss in enzyme activity. Further characterization of esterases is in progress.

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Basic studies of chiasma frequency in male *Blattella germanica* (Dictyoptera, Blattellidae). C. B. Keil, VPI & SU, Blacksburg, VA 24061.

This investigation represents the first examination of chiasma frequency in a primitive orthopteroid insect, *Blattella germanica*. The data obtained are useful both in advancing our knowledge of cockroach genetics and in stimulating comparative cytogenetic studies. Experimental animals were reared in a constant temperature and humidity chamber and segregated according to whether they emerged from a first, second, or third ootheca. The testes of 3rd to 4th instar male nymphs were removed, stained with acetic orcein and examined for suitable numbers of primary spermatocytes at diakinesis. Analysis of the chiasma frequency data showed a slight decrease in the mean number of chiasma per bivalent;  $1.3325 \pm 0.0385$  for 1st ootheca cockroaches,  $1.3002 \pm 0.0371$  for 2nd ootheca cockroaches, and  $1.2950 \pm 0.0346$  for 3rd ootheca cockroaches. The variances of the groups decline with the means. Bartlett's test for homoscedasticity showed these variances to be drawn from statistically different populations ( $P < 0.05$ ). The chiasma frequency of a stock heterozygous for a reciprocal translocation involving two mid-sized chromosomes, 8 and 9, was compared to the wild type frequencies. I found an elevated chiasma frequency,  $1.4185 \pm 0.0190$  chiasma per bivalent, in comparison to the first ootheca group. This figure is within values expected if a double chiasma event in either bivalent 8 or 9 in wild type cockroaches is assumed to occur in the majority of primary spermatocytes. In comparison with the 1st ootheca data the variance of the translocation stocks' chiasma frequency is greatly reduced. This reduction may be due to a compression of the frequency distribution upon a mechanical upper limit.

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Induction of multiple progeny emergence of the gypsy moth parasitoid, *Brachymeria intermedia* (Nees) (Hymenoptera: Chalcididae) by Dimilin®. B. K. Khoo, S. B. Ramaswamy, N. C. Respicio, and A. J. Forgash, Dept. Entomol. and Econ. Zool., Rutgers Univ., New Brunswick, NJ 08903.

The effect of Dimilin® (diflubenzuron) on adult *Brachymeria intermedia* (Nees) was investigated. Initially, female and male adults were topically treated with 2.0 or 4.0  $\mu\text{g}$  diflubenzuron. Treated parasites were held for a minimum of 6 days before each mated female was provided with a gypsy moth pupa for 24-h oviposition. Both treatment levels of diflubenzuron induced emergence of multiple progeny. As many as 14 parasites emerged from a single host. There was great variation in the size of the  $F_1$  progeny. This may be related to difference in hatching time of the oviposited eggs and nutrient supply of the host during parasite development. Diflubenzuron has no adverse effect on the parasitization capacity of the parents nor the

F<sub>1</sub> progeny, and its inductive effect was not carried over to the F<sub>1</sub> generation. It was determined that only female *B. intermedia* need be treated and that a virgin state is not a prerequisite for multiple progeny induction. By varying the intervals between diflubenzuron-treatment and the providing of hosts to the treated females, it was found that a holding time of a minimum of 4 days was necessary for manifestation of multiple progeny emergence. Diflubenzuron also induced multiple progeny emergence in *Brachymeria lasus*, an exotic relative of *B. intermedia*, with no apparent effect on its parasitization capacity or on that of the F<sub>1</sub> generation.

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Resource availability and reproductive variation in *Pseudeucoila* spp. (Hymenoptera: Cynipidae). A. Kopelman and P. C. Chabora, Queens College, Flushing, NY 11367

Theory regarding reproductive plasticity as an adaptive strategy has recently emerged and here is investigated in a parasite-host relationship. Individual females were presented excess host (*Drosophila melanogaster*) larvae in three schedules: a) constant exposure to hosts throughout life, b) exposure to hosts for 24 h every third day, c) daily exposure for 1 h throughout life. When without hosts, parasites were kept in vials with host medium and honey. Two patterns of progeny production emerged. 1) With continually available hosts (schedule a), early "explosive" reproduction was followed by an extended period of post reproductive survival. By day 5 about 95% of all female progeny were produced and the sex ratio changed from  $0.31 \pm 0.04$  on day 1 to  $0.72 \pm 0.16$  on day 5. After the last female offspring, males were produced for 4 days prior to a post reproductive period of  $9.6 \pm 0.89$  days. 2) With limited host availability (schedules b and c) reproduction was maintained for all but the last day of life. Female progeny were produced throughout the reproductive period with 95% being produced in 10 days. Sex ratios increased to a maximum of 0.92 and 0.59 for exposure schedules b and c, respectively, on the last day of reproduction. Survivorships were similar between exposure schedules. Reproductive strategies in unpredictable environments show increased survivorship at the expense of reproductive output. The patterns suggested here show that potential longevity affords maximal opportunity for parasitism when hosts are patchily distributed, yet allows opportunistic exploitation when hosts are abundant. (Supported by BHE-PSC Grant No. 10189 to P.C.C.).

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Physical and chemical defenses of the salt marsh shrub, *Baccharis halimifolia* L. (Compositae) against insect herbivory. S. K. Kraft and R. F. Denno, Dept. Entomol., Univ. Maryland, College Park, MD 20742

*Baccharis halimifolia* leafs out in early spring and shows an increase in leaf biomass throughout the growing season. Leaf drop occurs in late fall. *Trirhabda baccharidis* (Weber) (Coleoptera: Chrysomelidae), a univoltine, monophagous species, and the dominant herbivore on *B. halimifolia*, feeds only during spring and early summer. *B. halimifolia* is free of most insect herbivory during summer and fall. This research explores the defensive syndrome of *B. halimifolia* which is apparently effective during much of the growing season.

Leaves increase in toughness and decrease in moisture as the growing season progresses. When simultaneously offered various age (toughness)-classes of leaves, larvae of *T. baccharidis* fed primarily on young, tender leaves. Also, larvae fed young, tender leaves ultimately weighed more, pupated earlier, and incurred less mortality than those fed older leaves. *T. baccharidis* larvae showed no apparent feeding preference for similarly tough *B. halimifolia* leaves painted with differing concentrations of late season acetone and ethanol leaf extracts. Elm leaves painted with the same *B. halimifolia* leaf extracts were avoided by larvae of the elm leaf beetle, *Pyrhalta luteola* (Muller) (Chrysomelidae). Control leaves painted with pure solvents were readily eaten.

These results suggest that the adapted specialist *T. baccharidis* is able to tolerate secondary chemicals, over the concentration range that we examined, and that leaf toughness is the primary factor that dissuades its feeding. However, secondary chemicals present in the leaves of *B. halimifolia* may be effective in preventing herbivory from other insects.

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Effects of field application of gypsy moth *Lymantria dispar* L. (Lepidoptera: Lymantriidae) nucleopolyhedrosis virus (Baculovirus) on birds. R.A. Lautenschlager,<sup>1</sup> J.D. Podgwaite<sup>1</sup> and H. Rothenbacher,<sup>2</sup> U.S. For. Ser., North-eastern For. Exp. Stn.,<sup>1</sup> Hamden, CT 06514 and Dept. Vet. Pathol. Pennsylvania State Univ.,<sup>2</sup> University Pk., PA 16802.

Wild songbirds and caged quail, *Colinus virginianus* (L.) were studied to detect any short-term adverse effects resulting from the aerial application of nucleopolyhedrosis virus (NPV) for gypsy moth control on woodland plots in central PA. NPV was used in two formulations and applied at the rate of  $2.5 \times 10^{12}$  polyhedral inclusion bodies (PIB)/ha. Singing male territory-mapping census techniques were used to determine demographic changes in resident songbird populations. Analysis of pre-spray and post-spray censuses on NPV-treated and control plots indicated that there were

no short-term population changes that could be attributed to NPV treatments. Necropsy and histopathological data were taken on 23 quail that had been caged on the study plots for 3 weeks following NPV application. Similar data were taken on 53 songbirds that were collected from the study plots over a 10-week period following NPV application. Analyses of these data indicated that there were no significant differences between control and treated birds that could be ascribed to the NPV application.

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Flight periods of *Orthosia hibisci* Guenee (Noctuidae: Lepidoptera) in relation to the calendar, temperature and host development. S. E. Lienk and P. J. Chapman, NYS Agric. Exp. Sta., Geneva, NY 14456

Of the green fruitworms that feed on the young fruits of apple and pear in the northeastern quadrant of the United States and in the adjoining provinces of Canada, *O. hibisci* is the commonest species. It overwinters in the pupal stage. Based on records obtained from two (one in 1974) walk-in blacklight traps at Geneva, NY a few adults may be recovered some seasons in March but the main flight occurs in April and May. In 1974, 50% of the seasons' catch was taken by April 26; by May 4 in 1975; by April 17 in 1976; by April 16 in 1977; and by May 11 in 1978. The five year catch of *O. hibisci* adults totaled 3250. Flight was induced when maximum-minimum temperature means of 7°C (45°F) and higher prevailed. Between the years, no agreement was found between key fractions of the flight period and sums of daily mean temperatures above a base of 7°C starting March 1. A good correlation was established, however, between the flight period and the growth stages in apple fruit buds. Thus, in all five years less than 10% (from 1 to 8%) of the flight occurred prior to the "¼ inch green stage"; approximately 50% of the catch was taken by the "early tight cluster" stage; and from 95 to 98% by the "mid-pink" stage.

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Is there intraspecific competition in *Vespula maculifrons* (Hymenoptera: Vespidae)? W. D. Lord and R. R. Roth, University of Delaware, Newark, DE 19711

A 2-yr study of eastern yellow jackets in 9.4 ha of a Delaware woodlot examined nest location, density, and productivity for evidence of inter-colony competition. Worker populations were indexed by weekly counts from a can-trap grid. Nests were located by a thorough search in August and were excavated in October to determine productivity. The number of nests was 29 in 1976 and 72 in 1977. Workers were much more numerous in 1977. Only 16 of 90 plots of 1000 m<sup>2</sup> each had nests in both years (repeat areas) (16 nests in 1976, 19 in 1977). There were 13 nests in 9 plots used only in

1976 and 53 in 37 plots used only in 1977 (non-repeat areas). Colonies in repeat areas in 1977 tended to be more productive by several criteria (queen and worker comb area, number of queen cells, queen cell size and nest biomass) than ones in non-repeat areas. In 1976 the subhabitats were similar in productivity. These results indicate that density dependent phenomena existed among the wasps. When the nest density in a limited "quality" habitat exceeded a certain threshold, additional nests were accommodated only in "peripheral" habitats. This was especially notable in 1977. The consequence for the excluded queens was an apparent reduction in productivity. Such exclusion may occur due to queen aggression in the spring. Reduced productivity could be due to lower food levels in peripheral areas and/or scramble competition among more workers for food. This mechanism may underlie "wasp cycles."

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Diurnal, seasonal and relative abundance of *Myzus persicae* (Sulz.) predators. T. P. Mack and Z. Smilowitz, The Pennsylvania State Univ., University Pk., PA 16802

The diurnal, weekly and seasonal abundance of predaceous natural enemies of *M. persicae*, the green peach aphid (GPA), were determined in potato (*Solanum tuberosum* L. var *Katahdin*) fields in 1977 as a step in the development of a natural enemy sampling procedure. These distributions were determined by visually counting all predators occurring on randomly selected potato stems at 0900, 1115, 1330 and 1545 hours for 7 weeks during the growing season.

*Coleomegilla maculata* (Degeer) adults (Coleoptera: Coccinellidae) and coccinellid larvae were the most abundant known GPA predators found. *C. maculata* adults were approximately 4 times more abundant than other coccinellids. *C. maculata* adults increased in abundance in a linear manner for the entire experiment. The coccinellid larvae population increased with increasing slope until August 12, and then decreased until the experiment's end. Chi square analysis indicated that the 0900 and 1115 hour sample periods produced the highest means for *C. maculata* adults and coccinellid larvae. No time of day effects on variance of the mean were noticeable. *Chrysopa* larvae (Neuroptera: Chrysopidae), syrphid larvae (Diptera: Syrphidae), and hemerobiid larvae (Neuroptera: Hemerobiidae) occurred in extremely low numbers throughout the season. The most abundant general predators were *Orius insidiosus* (Say) adults and nymphs (Hemiptera: Anthocoridae), *Nabis* spp. adults and nymphs (Hemiptera: Nabidae), and various spiders. Field observations indicated that these arthropods were not primarily feeding on the GPA.

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Feeding behavior of mosquitoes (Diptera: Culicidae) on mammals. L. A. Magnarelli, The Conn. Agric. Exp. Stn., New Haven, CT 06504

Precipitin tests have been developed to ascertain host-feeding patterns of mosquitoes. In some studies, mixed blood meals (of different origins) are reported. Incidences of multiple feedings, as determined by precipitin tests, may be conservative estimates because proteins in one of the blood meals may be digested to the point where it is difficult to identify. Accordingly, the feeding behavior of female mosquitoes (representing 8 common *Aedes* species and *Psorophora ferox*) was directly observed on man, anesthetized raccoons, and immobilized white-footed mice in a woodland and salt marsh habitat of southern Connecticut to determine frequencies of intermittent feedings. Results indicate that, when undisturbed, the majority of mosquitoes fully engorged after the initial bite in about 2–3 minutes, but other females sometimes penetrated their fascicles into host skin, exhibited extensive exploratory probing beneath epidermal layers, and withdrew mouthparts 3 times from the same host without ingesting visible amounts of blood. The present study establishes that intermittent feeding occurred in each species, but incidences of such feedings did not exceed 14%. In conclusion, under more natural conditions where hosts react to biting mosquitoes, frequencies of discontinuous feedings are probably much higher than reported here and consequently, repeated biting of different hosts during an ovarian cycle might be epizootiologically significant in the transmission of certain arboviruses.

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Seasonal population growth of the southern red mite, *Oligonychus ilicis* (McGregor) (Acarine: Tetranychidae), infesting Japanese holly in New Jersey. D. L. Mague and H. T. Streu, Dept. Entomol. and Econ. Zool., Rutgers Univ., New Brunswick, NJ 08903

Populations of *O. ilicis*, an important pest of ornamentals in the Aquifoliaceae and Ericaceae, infesting *Ilex crenata* 'Convexa' were assessed in random counts from May 1977 to January 1978 in carbaryl-sprayed and untreated hosts. The treated group showed a five-fold increase in the number of immature mites and a ten-fold increase in the number of adult females and eggs when compared to populations on untreated plants. Initial mite densities in both groups were low (0.002 females/10 leaves) in the spring of 1977 and showed gradual increase over the summer to peak densities (38.7 females/10 carbaryl-treated leaves and 2.5 females/10 untreated leaves) in the fall. Treated populations produced 50.9 diapausing eggs/leaf and caused severe injury to the host foliage. No leaf damage was visible on untreated hosts where only 3.8 overwintering eggs were deposited per leaf. Neither treatment group followed the mite population growth pattern previously

described in the literature as an early summer peak followed by an abrupt mid-summer decline and late season resurgence. Results suggest predation in the unmanaged New Brunswick, NJ plot had maintained mite populations at low densities during previous seasons and was responsible for the variation from population growth trends reported on commercially cultivated ornamentals, where at high initial densities, intraspecific competition on declining food sources during periods of summer plant stress apparently combine to result in an early population crash.

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Evolution of Batesian mimicry in the Syrphidae (Diptera). C. T. Maier, Dept. Entomol., The Connecticut Agric. Exp. Stn., New Haven, CT 06504

Many adult syrphids bear a striking resemblance to aculeate Hymenoptera, their suspected models in Batesian mimicry complexes. Although most, if not all, syrphids probably suffer predation from insectivorous birds, only those species which spend most of their life in forested areas are specialized Batesian mimics (those convincing to the human eye). The overwhelming numbers of these mimics are members of the Milesiinae, one of two large syrphid subfamilies. Mimetic flies including *Ceriana abbreviata*, *Mallota bautias*, *M. posticata*, *Sphiximorpha signifera*, *Spilomyia* spp., and *Temnostoma* spp. have both morphological and behavioral adaptations which enhance their resemblance to their particular model(s). The following probably explain why mimicry evolved principally in species of Milesiinae: (1) They spend proportionally more time than most non-mimetic Syrphinae in forests where potential avian predators are abundant. (2) They have conspicuous foraging and mating behavior which increases the chance of discovery by insectivorous birds. (3) They share many biological attributes such as foraging and larval development sites with their models. These proposals agree with Bates' original postulates. Other factors that probably affect selection for Batesian mimicry include fly abundance, phenology, and size as well as bird behavior. In conclusion, Batesian mimicry is more prevalent in forest-inhabiting syrphid flies because they are apparently more exposed to avian predation than are most non-mimetic species.

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Energy metabolism and heat exchange in flying dragonflies (Odonata: Anisoptera). M. L. May, Rutgers Univ. New Brunswick, NJ 08903

Energy metabolism of dragonflies in flight was estimated from data on body temperature in the field, on flight speed, and on variation in heat loss as a function of flight speed. Ranges of metabolic rate in each of seven species varied from  $0.98-2.9 \times 10^{-2}$  W in *Miathyria marcella* to  $11.2-20.3 \times 10^{-2}$  W in *Macromia taeniolata*. Mean body mass ranged from 0.1-1.2 g,

and energy expenditure increased approximately in proportion to mass. Metabolic rates were comparable to maximum rates in dragonflies during endothermic warm-up. These data were also compared to extensive data from the literature on flight metabolism of other insects. Dragonflies have slightly lower rates of metabolism in flight than most other insects, despite a relatively large mass of flight muscle. The low metabolism correlates with their low wing loading and with the unusual histology of their wing muscles. Data on heat exchange at various wind speeds suggest that heat loss in dragonflies can be roughly described by a simple model of two resistances in series and that the degree of thermal insulation may be adapted to thermoregulatory requirements.

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Laboratory feeding studies with selected spiders (Arachnida: Araneae) from Virginia apple orchards. J. P. McCaffrey and R. L. Horsburgh, Shenandoah Valley Res. Sta., VPI & SU, Steeles Tavern, VA 24476

Laboratory feeding studies were conducted to evaluate the potential influence of spider predation on pests and beneficial insects associated with Virginia apple orchards. Individual spiders were confined with one prey insect in a  $6 \times 2$  cm plastic petri dish for 48 h. Each test was replicated 3 times. The adult spiders tested were *Theridion albidum* Banks, *Anyphaena pectorosa* L. Koch, *Philodromus placidus* Banks, *Misumenops oblongus* (Keyserling), *Hentzia palmarum* (Hentz), *Metaphidippus galathea* (Walckenaer), *Phidippus audax* (Hentz) and *Dictyna sublata* (Hentz). The potential prey included alate and apterous forms of *Aphis* sp. and *Dysaphis plantaginea* (Passerini); adults and larvae of *Platynuota flavedana* Clemens; adult leafhoppers (Typhlocybinæ); adult *Stethorus punctum* (LeConte); adult *Leptothrips mali* (Fitch); and *Chrysopa* spp. larvae. Alate forms of both aphid species were accepted by all spiders, but the apterous forms were accepted only by *T. albidum*, *M. galathea*, and *D. sublata*. Adults and larvae of *P. flavedana* were accepted by all spiders except *T. albidum* and *A. pectorosa*. Leafhoppers were readily accepted by all spiders. The thrips *L. mali* was fed on by *T. albidum*, *D. sublata*, and *M. galathea*. Only *T. albidum* and *D. sublata* captured *S. punctum*. No spiders fed on the chrysoptid larvae. These results indicate that several pests and beneficial insects could serve as prey for the complex of spiders inhabiting Virginia apple orchards.

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Self-regulation in scale insect populations on hemlock. M. S. McClure, Connecticut Agr. Exp. Stn, New Haven, CT 06504.

Population self-regulation in the Homoptera has been linked to the nutrient quality of the host plant and its related effects on the success of feeding nymphs. Studies on the elongate hemlock scale, *Fiorinia externa* Ferris (Homoptera: Diaspididae) have indicated that populations are responsive to changes in the nutrient quality of hemlock related to edaphic conditions of the growing site and to changes in the intensity of feeding following insecticide application. This study investigated the presence of self-regulation in hemlock scale populations by examining the effects of scale density on survival, rate of development, and fecundity. Weekly sampling for two years of ten mature hemlocks in a Connecticut forest revealed that each of these parameters was significantly, negatively correlated with scale density. Scales residing on trees supporting the higher densities suffered up to four times greater mortality, developed more slowly, and produced fewer eggs than did scales on less heavily infested trees. Though initially the densities of feeding nymphs on the ten hemlocks varied considerably (range from 134 to 1011 nymphs per 100 hemlock needles), the densities of scales which subsequently matured were similar (range from 109 to 279). The results indicate that density-dependent self-restraints resulting from a reduction in the quality and availability of essential resources for feeding nymphs maintained populations of *F. externa* at densities below three mature scales per needle. However, hemlocks supporting even these densities suffer significant reductions in growth which may eventuate in tree death. Therefore, it is unlikely that the self-restraints, alone, are sufficient to control hemlock scale.

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Modelling for pest management: Analysis of environmental and inherent developmental rate variation on emergence in the alfalfa blotch leafminer (Diptera: Agromyzidae). W. K. Mellors and R. G. Helgesen, Cornell Univ., Ithaca, NY 14853

The objective was to account for the variation observed in the cumulative adult emergence patterns of field populations of the alfalfa blotch leafminer, *Agromyza frontella* (Rondani). Observed emergence patterns were compared to computer simulated patterns based on (1) variation in developmental rate alone, (2) variation in environmental temperature alone, and (3) the combination of the two. Variation in developmental rate was quantified through controlled laboratory rearings of pupae at constant temperatures. The 10, 30, 50, 70 and 90th percentile developmental rates were determined for the distribution of rates observed at each temperature. Temperature

variation in the soil environment of pupae within a site was analyzed with respect to (1) variation in space and (2) variation with depth. Soil temperatures were recorded in the field throughout pupal development periods. Pupal development to adult emergence was simulated using the temperature records and the temperature-dependent developmental rates. The extent to which a simulated pattern accounted for the observed pattern was computed as the r-squared value between the observed and simulated dates with the same percent cumulative emergence. The simulations based on both temperature and developmental rate variation, on rate variation alone, and on temperature variation alone, respectively, accounted for 94, 90, and 88% of the variation in the emergence patterns observed in the spring of 1978. The two sources of variation accounted similarly for the observed variation under these specific field conditions.

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Thermal requirements for development of the parasite *Microctonus aethioides* Loan (Hymenoptera: Braconidae). J. Morales and A. A. Hower, Pennsylvania State Univ., Univ. Pk., PA 16802

Laboratory studies indicated that the threshold temperature for development of *Microctonus aethioides* larval and pupal stages is 8.4°C (47°F). The regression equations for the developmental time of various life stages of the parasite were computed from the logarithm of the average duration of the stage in days and the log temperature in °C. The regression equations for the rate of development were derived from the daily percent of development in relation to temperature. This relationship was linear within the range of temperatures supporting complete development ( $r^2 = 0.97$ ). Temperatures were converted to a cumulative degree-day summation. Degree-days were computed using the mean duration in days for complete development of various life stages of the parasite above 47°F. Averages of 228 and 240 degree-days were required for development of the larval and pupal stages, respectively. Total parasite development, from first instar larva until emergence of the adult parasite, required an average of 469 degree-days.

During two years of field studies 50% of the first and second parasite generations emerged when means of 463 and 947 degree-days, respectively, had accumulated after January first. These data validate the use of degree-days to forecast *M. aethioides* emergence in the field. Based on this information insecticide application could be timed to avoid the parasite and thus increase its potential against the alfalfa weevil.

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Separation and quantitation of dytiscid defensive secretions using high-pressure liquid chromatography. A. T. Newhart and R. O. Mumma, Pesticide Research Lab. and Dept. of Entomol., The Pennsylvania State Univ., Univ. Pk., PA 16802

High-pressure liquid chromatography methods were developed for the analysis and purification of dytiscid defensive secretions. These methods were rapid, sensitive, quantitative and allowed the simultaneous analysis of pygidial and prothoracic gland contents. Separations were achieved with a normal phase column ( $\mu$ Porasil) using a dioxane:hexane solvent system and with a reverse phase column ( $\mu$ Bondapak) using an acetonitrile:water solvent system. Four species of dytiscids were analyzed using these methods: *Acilinus semisulcatus*, *A. sylvanus*, *A. mediatus* and *Graphoderus liberus* Say (Coleoptera: Dytiscidae). The pygidial glands of all four species were found to contain the antimicrobial agents: benzoic acid, *p*-hydroxymethyl benzoate and *p*-hydroxybenzaldehyde. The prothoracic gland of all three *Acilinus* species produced the same compounds, one of which has been identified as an 4-androsten-3-one steroid. Deoxycorticosterone was the major steroid produced by *Graphoderus*, confirming earlier studies. The seasonal defensive titer of the pygidial and prothoracic gland contents of *A. semisulcatus* was studied over a five month period and were found to vary independently. The pygidial antimicrobial agents reached their maximum titer in July while the prothoracic gland steroid quantified remained at low levels throughout the summer months, rapidly reaching a maximum titer in October.

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Orientation disruption of *Argyrotaenia velutinana* and *Choristoneura rosaceana* (Lepidoptera: Tortricidae) male moths. M. A. Novak, W. H. Reising and W. L. Roelofs, Dept. of Entomol. NY State Agric. Exp. Stn., Geneva, NY 14456

Most species of the complex of tortricid leafroller moths which are pests or potential pests in New York State apple orchards use blends of (Z)-11-tetradecenyl acetate (Z11-14:Ac) and E11-14:Ac as major pheromone components. Various mixtures, release rates, and methods of application of these have been previously tested for their effectiveness as mating disruptants. We now report tests with pheromone components and pheromone analogs, dispensed from hollow capillary fibers, for effectiveness in disrupting orientation to pheromone-baited traps in small field plots. The species selected for the tests were *Argyrotaenia velutinana* (Walker), the redbanded leafroller, and *Choristoneura rosaceana* (Harris), the oblique-banded leafroller. *A. velutinana* was effectively disrupted by Z11-14:Ac alone or combined with other chemicals, at a release rate as low as 3 mg/h/ha. *C. rosaceana* required a mixture containing both Z11-14:Ac and (Z)-11-

tetradecen-1-01(Z11-14:OH), a minor pheromone component. A 1:1 mixture of these compounds, each at a release rate of 5 mg/h/ha, and a mixture of the Z and E 11-14:Ac's and the Z and E 11-14:OH's at 5 mg/h/ha each, were both effective disruptant systems. Neither Z11-14:OH nor (Z)-11-tetradecenyl formate (Z11-14:formate), which decrease trap catches for *A. velutinana*, were effective alone for disrupting either species. (Z)-11-tridecenyl acetate (Z11-13:Ac), an attractant for *A. velutinana*, effectively disrupted this species, but not *C. rosaceana*. These tests show that differences exist in the systems necessary for disrupting these two leafrollers, although their natural pheromone blends are very similar.

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Field evaluation of pheromone baited trap-trees to control elm bark beetles. D. P. O'Callaghan, E. M. Gallagher and G. N. Lanier, SUNY College of Env. Sci. and Forestry, Syracuse, NY 13210

Subsequent to the isolation, identification and synthesis of the aggregation pheromone of *Scolytus multistriatus* (Marsham)—principal vector of Dutch elm disease (DED)—and its use in mass trapping there has been a decline in new cases of DED from 1975 through 1977 in most areas where pheromone traps have been employed.

The concept of baiting diseased trees with pheromone ("Multilure") and killing them with the herbicide cacodylic acid—applied either to axe frills or by pressure injection—is presently being evaluated as a management technique. Elms, thus poisoned, are heavily attacked by the beetles but their broods fail to develop. In three areas—two close to Syracuse, NY and one in Wisconsin, four and five square miles in area respectively—large numbers of diseased elms have been killed and baited. A grid of Multilure baited traps, at ¼ mile intervals on utility poles, serves to monitor beetle populations in these and the concomitant check areas. Results to date indicate that large numbers of beetles are absorbed by trap trees and their brood destroyed. Although this study is less than half way advanced, the indications are that the pheromone baited trap tree approach has a devastating effect on beetle populations and should effectively reduce DED rates.

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Laboratory rearing of *Leptothrips mali* (Fitch) (Thysanoptera: Phlaeothripidae). M. P. Parrella and R. L. Horsburgh, Shenandoah Valley Res. Sta., VPI & SU, Steeles Tavern, VA 24476

*Leptothrips mali* (Fitch) has been found associated with high densities of mites in Virginia apple orchards. Laboratory rearing methods were needed before an adequate assessment of this thrips' biology and mite control potential could be made. Field collected adults were housed in pint cartons

containing apple leaves. The containers were modified by cutting a hole in the bottom allowing the petioles to extend into water and by replacing the top with a fine muslin cloth. Eggs were removed from the leaves with a wetted minuten probe and placed on moistened filter paper in plastic containers (4.1 cm diam  $\times$  1.3 cm deep) with friction-sealed lids. Prior to eclosion, an egg was transferred to the underside of an apple leaf resting on saturated cotton. The egg was placed in an arena (ca. 10 cm<sup>2</sup>) bordered with Stickem<sup>®</sup> which contained European red mite eggs (*Panonychus ulmi* (Koch)). The center of the arena was covered with a portion of leaf tissue. Two days post-eclosion, the larva was transferred to another leaf arena made by inverting the bottom of a plastic petri dish with its top replaced by 100 mesh screen over the underside of an apple leaf. The container and leaf fitted on one-half of a larger petri dish, and the whole apparatus was held firmly in place by a rubber band. The supporting dish rested in saturated cotton. The thrips completed development in this leaf container. Rearing conditions were 23.9°  $\pm$  1°C, 14-h photoperiod, and 80–100% RH.

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Life history and population dynamics of *Heteroplectron americanum* (Walker) (Trichoptera: Calamoceratidae). J. W. Patterson and R. L. Vannote, Dept. of Entomol. and Applied Ecol., Univ. Delaware, Newark, DE 19711

Monthly samples of *Heteroplectron americanum* were taken from the headwaters of Blackbird Creek on Delaware's coastal plain. Adults emerged from mid-May to early June. Females contained an average of 387 eggs which were deposited within a gelatinous matrix either under water on branches and logs or attached to tree roots and mosses on the stream bank. Larvae began to hatch in about 15 days and remained within the gelatinous matrix for a time period varying with the frequency of inundation. Egg masses deposited above the wetted zone of the stream bank desiccated within two days. First instar larvae weighed 0.01 mg, constructed a case of detrital fragments, and fed on leaf fragments and wood. During the second or third instar, larvae began to hollow out twigs for cases. Most individuals attained the final instar (5th) by December ( $\bar{x}$  = 8.7 mg). Growth then ceased until mid-March when the average stream temperature reached 6°C. Larval growth was completed by May when the mean dry weight of mature male and female larvae was 6.5 mg and 16.1 mg, respectively. The pupation period was approximately 21 days. A small proportion of the population (<25% >2%) did not achieve sufficient growth to complete development in one year. A one year generation time was confirmed by following the growth of larvae developing from 40 egg masses introduced into a Piedmont spring brook where this species was not previously present.

Indirect effects of gypsy moth *Lymantria dispar* L. (Lepidoptera: Lymantriidae) insecticides, on the parasite *Apanteles melanoscelus* (Ratzeburg) (Hymenoptera: Braconidae). E. H. Pollack and A. J. Forgash, Rutgers Univ., New Brunswick, NJ 08903

*Apanteles melanoscelus*, an important monophagous parasite of early-instar gypsy moth, is actively searching for hosts around the time of chemical applications for control of the pest. Current knowledge of the effect of insecticides on *Apanteles* consists primarily of qualitative information on direct toxicity of a few insecticides. To aid in filling this void we have devised testing procedures for detecting potential impacts of insecticide-containing hosts on parasite activity, behavior and reproductive success. We have applied these methods to the study of effects of carbaryl, acephate and trichlorfon on *A. melanoscelus*.

Second-instar gypsy moth larvae that survived topical or oral doses of carbaryl, ranging from LD 20 to 85, were parasitized and the progeny were compared to those from untreated hosts with respect to (1) numbers of larvae emerging, (2) number of viable adults, (3) sex ratio and (4) length of time for parasite development. Tests were also conducted to detect (1) parasite discrimination between treated and untreated hosts and (2) chronic effects arising from continuous rearing in treated larvae.

The results show conclusively that *Apanteles* (1) develop normally in carbaryl-treated gypsy moth, (2) are not affected by rearing in treated larvae for 4 successive generations and (3) do not discriminate between treated and untreated hosts. Similar studies, in progress, indicate that larvae which survive topical treatments of acephate or trichlorfon are also compatible hosts for *Apanteles*.

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Morphology and taxonomy of first-stage nymphs of five *Periplaneta* Burmeister (Dictyoptera: Blattidae). P. K. Powell and W. H. Robinson, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061

First-stage nymphs in the genus *Periplaneta* have not previously been well described. First-stage nymphs of four Nearctic and one Palearctic species (*P. japonica*) can be separated on the basis of pattern and number of setae on the dorsum of the thorax, particularly the mesonotum. In *P. australasiae* the mesonotum is very setose, it is less setose in *P. fuliginosa* and *P. brunnea*, and in *P. americana* and *P. japonica* it is almost totally bare. Color pattern is also a useful character for separating all but two of the five species. Nymphs of *P. americana* and *P. japonica* are solid in color. *P. americana* nymphs are characteristically light grayish-tan, while *P. japonica* nymphs are dark brown, almost black. Nymphs of *P. australasiae*, *P. brunnea*, and *P. fuliginosa* are patterned on the mesonotum,

second abdominal segment, and some antennal segments with light bands and patches. *P. brunnea* can be separated from the other two patterned species by abdominal color, which is much lighter than the head or thorax in *P. brunnea* and concolorous with the head and thorax in *P. australasiae* and *P. fuliginosa*. These two species cannot be separated by color pattern; one must rely on setal pattern and number.

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Complementary foraging of bee species in blueberries. E. G. Rajotte and R. B. Roberts, Dept. Entomol. and Econ. Zool., Rutgers Univ., New Brunswick, NJ 08903

Populations of bees were sampled in a field containing 3 cultivars of blueberries (*Vaccinium corymbosum*) in an area of southern New Jersey where both native bees and honeybees are abundant. The flowers of cultivars Earliblue and Coville are known to be unattractive to honeybees while Weymouth is highly attractive.

Ten bushes in each of three positions (edge of field, 21st bush in, 41st bush in) within each cultivar were sampled using a modified automobile vacuum cleaner on each of 15 days from April 18 to May 12, 1976. Collected bees were counted and grouped in three categories (honeybees, bumblebees, other wild bees).

Analysis of variance revealed a significant position effect indicating that the pollinators, especially honeybees, preferred the bushes to the interior of the field that were not buffeted by the wind. There was no significant cultivar effect (i.e., bees were spread evenly among the cultivars) but there was a significant cultivar X bee group effect indicating that certain groups of bees preferred certain cultivars. Although each group of bees differed in their cultivar preferences, their foraging patterns were complementary. Thus, the number of pollinator visits were similar and all three cultivars produced good fruit yields. When bumblebees and other native bees are scarce, complementary foraging does not occur and blueberry cultivars shunned by honeybees produce little fruit.

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Effect of juvenile hormone on mating behavior of female German cockroach, *Blattella germanica* (L.) (Dictyoptera: Blattellidae), S. B. Ramaswamy and A. P. Gupta, Dept. Entomol. and Econ. Zool., Rutgers Univ., New Brunswick, NJ 08903

Studies of the effects of JH on insect behavior are few. This report deals with the effects of JH on mating behavior of female *B. germanica*. JH treatment of last instar nymphs produces black females owing to excessive melanization (Das, Y. T., and A. P. Gupta, 1977, Nature, 268:139-40).

These females elicit a typical pheromone-induced wing raising behavior in normal males but do not mate. Bioassay of methylene chloride-extracts of black females placed on filter papers also shows the wing raising behavior in males. This shows that these treated females are capable of pheromone production. However, based on the bioassays, it appears that there is a delay in pheromone production of about 48 hr in treated females compared with normal ones. Comparison of electroantennograms of treated and untreated females responding to various attractants shows a decrease in the response of treated females.

Preliminary examination of antennae of treated females shows the sensilla to be highly melanized, as the rest of the body, including the sensillar pits which appear black. Therefore, it is likely that the perception of the male pheromone by treated females is either entirely lacking or substantially reduced following JH application owing to the melanized antennal sensilla. This might explain the behavioral anomaly in treated females and the absence of mating.

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Aerial application for the control of alfalfa weevil larvae (*Hypera postica*) in Virginia, 1978. J. E. Roberts and M. T. Snider, Ext. Entomol., VPI & SU, Blacksburg, VA 24061

Treatments were applied on May 11, 1978 to large nonreplicated plots. The airplane used was a Gruman Ag. Cat. G164A equipped with 4664 jet nozzles spraying a swath width of 45 to 50' at a speed of approximately 100 mph. Spray concentrates were applied in 2, 3, or 5 gal. of H<sub>2</sub>O/acre at 22 psi. Weevil larvae data were recorded 2 days prior to treatment and post-treatment at 7 and 14 day intervals. Weevil population data were recorded from 10 stems plucked from each plot. Total population counts were made on the first two of ten stems found containing larvae. The remaining tips were counted as either being infested or not infested and totals were combined and recorded under % Infestation.

Sumithion 8E, Imidan in 5 gal. H<sub>2</sub>O/A and Supracide were the only treatments to give better than 80% control during the test. Sevin UCSF-1 and Imidan in two gallons H<sub>2</sub>O/A were the only treatments that gave consistent or increasing rates of control.

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True armyworm (*Pseudaletia unipuncta*) control in Virginia, 1978. J. E. Roberts and M. T. Snider, VPI & SU, Entomology, Blacksburg, VA 24061

Five insecticides were tested for the control of true armyworms in Montgomery County, Virginia during 1978. Plots were 14' by 50' (4 rows) replicated four times in a randomized complete block design. The two center rows were used for evaluating treatments. A compressed air sprayer oper-



ating at 30 lbs. psi duster was used for the sprayable materials. A hand cranked seeder was used to apply the granular materials in a 7 inch band. Insect population counts were taken on June 14 immediately before treatment. This pretreatment population count was taken randomly of 50 plants over the entire test area to show established infestations. Posttreatment evaluations were made on June 16, and June 19, by counting the insect populations on 50 plants per plot. The percent control was based on the untreated checks. The sprayable materials had the best percent control with PennCapE having the best overall ratings.

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Field evaluation of post emergence control of cutworm (*Agrotis ipsilon*) in Virginia, 1978. J. E. Roberts and M. T. Snider, VPI & SU, Ext. Entomol., Blacksburg, VA 24061

Four insecticides were evaluated for cutworm control in Halifax County, Virginia during 1978. Plots were 14' by 50' (4 rows) replicated four times in a randomized complete block design. The two center rows were used for evaluating treatments. The evaluation was made by counting the total number of live plants per treatment. A compressed air sprayer operating at 30 lbs. psi spraying 36 gal. per acre was used to apply the test materials. Treatments were applied broadcast as a foliar application on June 6, post-plant. Plant population counts were taken pretreatment on June 6, and post-treatment plant population counts were made on June 8. Posttreatment population counts were apparently influenced by a prolonged germination period in certain areas which caused data to show a lesser amount of cutworm damage than was actually present.

Phytotoxicity averaged from .25 to 3.25 on a scale of 0-5 where 0 = no damage and 5 = dead plants. Lorsban 4E had the lowest phytotoxicity average of the four insecticides with .25.

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Variability in nectar production by an American linden. R. B. Roberts and E. G. Rajotte, Dept. Entomol. and Econ. Zool., Rutgers Univ., New Brunswick, NJ 08903

*Tilia americana*, known as basswood or American linden, is renowned as a source of honey. In 1977, a single tree 1 meter in diameter was studied in order to learn how much nectar sugar may be produced and how it is perceived and utilized by bees. The tree produced approximately 3.3 million flowers in 1977, but only a few thousand in 1978. Thus, year to year variability is significant. In 1977, 800 flowers were tagged upon opening and their age was recorded when they were harvested. Half were open to pollinators and half were enclosed in netting to exclude pollinators. Sugar con-

tent of the flowers was analyzed spectrophotometrically. Analysis revealed that the flowers secreted sugar rapidly for the first two days after opening. If not removed, the sugar content remained more or less constant until the 5th day. Sugar content dropped on the 6th day and the flowers usually dropped at the end of the sixth day. The tree bloomed for a period of two weeks. Enclosed flowers yielded an average of 6.0 mg of sugar and open flowers yielded 0.6 mg. Thus, pollinators removed 17.8 kg of sugar from the tree, enough to make 21.6 kg of honey. If nectar is replaced by the flower as a result of its removal, the productivity of the tree would be even higher than measured. Enclosed flowers of the same age harvested on the same date typically showed a 10-fold range in sugar content. Thus, although trends were noted, nectar production varied significantly.

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Aspects of the nesting behavior of *Cerceris watlingensis* in relation to its geographical location (Hymenoptera: Sphecidae). P. Salbert and N. Elliott, Dept. of Biol. Hartwick College, Oneonta, NY 13820

*C. watlingensis* has so far been collected only from San Salvador Island, the Bahamas. Studies of its nesting behavior, conducted during November and December, 1977, indicate differences from previously studied species of *Cerceris*, most of which are northern and continental in distribution. Many of these differences are clearly related to the subtropical and insular location of the species.

As compared with northern species, *C. watlingensis* has a longer season of activity. Females of this species constructed more extensive nests with deeper main burrows and greater numbers of cells. Nests contained cells of a variety of ages, from those with newly laid eggs to old cells from which adults had already emerged. Thus there is an overlap of adult generations, which is one prerequisite for social behavior. There is evidence that nest sharing occurs in *C. watlingensis*.

The remote location of the island contributes to a low diversity of the insects normally associated with sphecid wasps. Females of this species preyed only on curculionids. Of the 62 whole-prey records for *C. watlingensis*, ninety percent belonged to a single species of weevil in the genus *Artipus*. This is the most common weevil on the island; probably few other species of suitable size are present. Many of the parasites and predators that usually attack digger wasps are absent on San Salvador, but ants have been observed to prey on adults and attack the nests.

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The sexual behavior of *Tenodera sinensis* (Saus.) (Orthoptera: Mantidae). M. E. Schauff and J. C. Jones, Dept. Entomol., Univ. Maryland College Park, MD 20742

The sexual behavior of praying mantids is not well known. Upon sighting a female, males of *T. sinensis* immediately "freeze" in position. The duration of the interval between sighting and pursuing of the female varied from 2 minutes to 4 hours. Males always flew to the females. As he flies, the male turns in mid-air, approximately 180° and lands on the female's back, facing her rear. He must re-orient to her front end before he will initiate copulation. After re-orientation, the male begins probing with his genitalia about the posterior end of the female's abdomen, while he lightly strokes the female's head and antennae with rapid alternating strokes of his own antennae. The female either reacts by raising her abdomen, preventing coitus, or she may keep her abdomen level, allowing the male to copulate. Duration of copulation averaged 2 hours 59 minutes. After coitus, most males quickly fell off of or directly flew away from the female. Some males were observed to remain on the female as long as 3 hours 25 minutes following copulation. Courting males were captured and eaten only twice in twenty encounters. Although the genitalia of these males began copulatory movements, they did not copulate. On three occasions, precopulatory abdominal searching movements were elicited without contacting the female.

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The adaptive significance of the latitudinal cline in oviposition site of *Al-sophila pometaria* (Lepidoptera: Geometridae). J. C. Schneider, Dept. Biol., Princeton Univ., Princeton, NJ 08540

Oviposition by the fall cankerworm is usually on twigs in low latitudes (e.g. NC) and on trunks in high latitudes (e.g. NY). In NJ, where oviposition occurs in both places, I have shown that, as for the winter moth *Operophtera brumata*, the degree of synchrony between hatch and foliation greatly affects the fitness of the insect. The variance in time of hatch of egg masses on trunks is higher than that for ones on twigs due to aspect effects. A female ovipositing on a trunk increases the variance in time of hatch of her eggs by ovipositing at two sites. If leaf flush is less predictable at higher latitudes, oviposition on trunks is seen to be a maximization of minimum fitness strategy (a hedge against 100% mortality). Hatch tracks variation in foliation time among stands of different composition. Clones in a gynogenetic system specialize on different hosts and have different developmental requirements. In NJ part of the tracking is accomplished by differences in oviposition time. Diapause development is finished after weather warms above the threshold for embryo development. In New Brunswick, Canada

winters are too cold for this. Thus somewhere north of NJ the tuning of time of hatch by oviposition time is lost so leaf flush may be more unpredictable.

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Dietary preferences and patterns of occurrence of Lepidoptera larvae in a northern hardwoods forest. J. C. Schultz, P. J. Nothnagle and R. T. Holmes, Dept. Biol. Sci., Dartmouth College, Hanover, NH 03755

Lepidoptera larvae at endemic population densities were sampled from four tree species at three levels in the Hubbard Brook Experimental Forest in New Hampshire. 400-leaf samples were visually inspected from over 600 trees during 1977 and 1978. There were no significant differences in density of total larvae among the tree species or among layers over the summer growing season. However, there were significantly more geometrid larvae than expected on maples, and fewer on beech and birch. Noctuid larvae occurred on beech and birch more often than expected. Tortricids were more abundant than expected on beech; gracilariids preferred sugar maples.

Choice tests and growth experiments with both field-collected larvae and those reared from eggs revealed some strong dietary preferences. Some species exhibited little or no host discrimination.

These results, in addition to patterns of occurrence of over 50 larval taxa, indicate that feeding preferences of forest Lepidoptera range from very broad to very narrow within a single community. Our community-wide survey leads us to conclude that the suggestion that forest Lepidoptera should have broad diets because their hosts are chemically convergent may be naive. Factors such as within-tree variation in tissue quality and differential use of trees in predator avoidance may favor specialized diets among forest insects.

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Biological and physical influences on the mass rearing of *Coccygomimus turionellae* (Hymenoptera: Ichneumonidae). P. B. Schultz, Virginia Truck and Ornament. Res. Stn., Virginia Beach, VA 23455 and L. T. Kok, VPI and SU, Blacksburg, VA 24061

Biological and physical factors affecting the rearing of *Coccygomimus turionellae* (L.) on wax pupae were examined to determine the optimum conditions for its mass propagation. The most critical factors were the parasite:host (P/H) ratio, and duration of exposure of host to the parasite. In a study involving seven P/H ratios and three exposure times, optimum parasite emergence occurred with a ratio of 0.4 or 0.5 at 24-h exposure, and with a ratio of 0.1 at 72-h exposure. Production of *C. turionellae* could be increased by retarding pupal development of the wax moth. Decreasing the

storage temperature of wax moth pupae from 32° to 27°C extended the duration of its suitability for parasitism from two to seven days. Prompt removal of wax moth pupae from the 32°C rearing temperature was found to increase the emergence of *C. turionellae*. Mass rearing was unaffected by the age of *C. turionellae*. The optimum temperature for propagation of *C. turionellae* was 27°C but oviposition activity was high at 21 and 32°C. A 12-h photoperiod and 600–6000 lux light intensity were optimum for production. A significant drop in fecundity did occur after 14 generations of laboratory rearing. This 21% reduction in parasite progeny emergence between 1976 and 1977 could be attributed to inbreeding within the colony.

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Occurrence of beneficial insects on flue-cured tobacco treated with soil insecticides. P. J. Semtner and J. E. Roberts, Sr., S. Pied. Cntr. and Dept. Entomol., VPI & SU, Blackstone, VA 23824

There has been a steady increase in the use of soil insecticide-nematicides in tobacco production in Virginia during the last ten years. For this reason, an investigation was initiated to evaluate effects of soil insecticides on several beneficial insects that occur on tobacco. The stilt bug, *Jalysus spinosus* Say, which feeds on eggs of the tobacco hornworm, *Manduca sexta* (L.), and *Nabis* spp., which feed on many tobacco insect pests, were the most abundant beneficial insects in this investigation. Fifteen insecticides and insecticide formulations, including ethoprop, ethrop-disulfoton, fensulfothion, disulfoton, disulfoton aldicarb, Standak, Nematak, carbofuran, Vydate, and a carbofuran-disulfoton combination were evaluated for their effects on beneficial insects and their prey. Stilt bug populations were greatly reduced on tobacco treated with Standak, aldicarb, Nematak, disulfoton, and the carbofuran-disulfoton combination. Tobacco hornworm populations were highest in the Standak and aldicarb treatments, indicating that the reduced number of stilt bugs may have caused increased hornworm populations. This was not the case through all the treatments. Carbofuran had little effect on the stilt bug, other than reducing its food supply. Although low tobacco hornworm populations occurred in the carbofuran treated tobacco, stilt bug populations were only slightly lower than the untreated check. Tobacco receiving ethoprop and disulfoton 6LC had higher stilt bug populations than the check. *Nabis* spp. were least abundant on tobacco treated with Standak, Vydate, and aldicarb.

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Influence of diet upon gypsy moth NPV production. M. Shapiro, R. A. Bell and C. D. Owens. USDA, SEA. Otis AFB, MA 02542

The influence of diet upon gypsy moth NPV production was examined. Major dietary ingredients as wheat germ, casein, vitamins, sucrose, and salts were evaluated. In addition, influence of diet pH and the use of agar substitutes were studied.

Several published diets were compared to the Otis production diets. The modified hornworm and Otis high wheat germ diets were superior to the Leonard-Doane, Odell-Rollinson, Magnoler, Ridet, and Shorey-Hale diets. Although virus yield was greatest using the modified hornworm diet, virus production was least expensive using the high wheat germ diet.

Several wheat germ products were examined, and the raw wheat germ was slightly better than the toasted material. Several protein sources were compared to casein (the standard) and were found to be comparable. An increase in vitamin mix concentration resulted in little increase in virus yield. Several sugars were compared to sucrose (the standard) and were comparable in activity. Wesson salts (standard) were compared with salt mixes used in tissue culture, and the standard was superior.

Little differences in virus yield occurred at diet pHs between 4-7. As the pH increased to 8, virus yield decreased. Several carrageenans were compared to agar at concentrations ranging from 0.75 to 2 percent. The most commonly used carrageenan, Gelcarin HWG, was comparable to agar.

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Interfacing green peach aphid, *Myzus persicae* (Sulz.) damage with season potato plant growth. Z. Smilowitz, M. E. Whalon, C. A. Martinka and E. S. Nolan, The Pennsylvania State University, Univ. Pk., PA 16802

Potato plant growth characteristics were interfaced with green peach aphid, *Myzus persicae* (Sulz.) (GPA) population levels to develop seasonal damage indexes. Potato plots treated with five rates of systemic insecticide, aldicarb, at planting were sampled weekly for GPA following establishment of winged migrants. Temperature dependent models using accumulated day degrees were established for foliage and tuber yields from plant growth production data collected on alternate weeks. The relationship of pest numbers and foliage production was determined from accumulated foliage production at each of the harvest periods. The percent foliage loss was determined from the proportion of foliage harvested and the maximum foliage obtained at each phase of plant growth. The percent foliage loss and GPA numbers were regressed to establish foliage loss/GPA for each sample period. These values were compared with accumulative foliage day degrees to establish the relationship of plant growth and GPA damage throughout the season.

Peak foliage production occurred at approximately 1300 accumulated foliar day degrees. Following this phase of plant growth production remained at a high level at low pest densities, whereas high density caused a decline. GPA had the greatest impact on foliage production early in the season; 1300 accumulated day degrees. Pest impact declined logarithmically as the season progressed.

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The effect of larval host exposure on the oviposition preferences of *Pieris rapae*. J. H. Smith and W. G. Yendol, The Pennsylvania Sta. Univ., University Park, PA 16802

Two experiments were conducted to test the effect of larval host exposure on the oviposition preferences of *Pieris rapae* (L.) (Lepidoptera: Pieridae). In one experiment, groups of *P. rapae* were raised on either 'Savoy King' (*Brassica oleracea* var. *sabauda*) or 'Premium Late Flat Dutch' (*Brassica oleracea* var. *capitata*) cabbages, and as adults their oviposition preferences for these two cultivars were tested. In a second experiment, the oviposition preferences of field-collected gravid females were determined for the same two cultivars.

Preference test procedures were similar for both experiments. Mated females with the same larval host background were released in groups of 5 into outdoor screen cages containing 10 'Savoy King' and 10 'Premium Late Flat Dutch' plants. After 6¼ hours, the females were removed and the number of eggs laid on each plant was determined.

Laboratory-reared females laid the same number of eggs on both cabbage cultivars, regardless of which host cultivar they were reared on. In contrast, field-collected females laid significantly more eggs on 'Savoy King' than on 'Premium Late Flat Dutch' cabbages.

The oviposition preferences of laboratory-reared *P. rapae* were not mediated by pre-imaginal conditioning. In addition, host preferences of the laboratory-reared females did not represent preferences of females from the field population. It seems possible that the development of *P. rapae* oviposition preferences is influenced by adult host experience.

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Effect of low temperature on survival of red pine scale *Matsucoccus resinosa* Bean and Godwin (Homoptera: Margarodidae). G. R. Stephens, Connecticut Agr. Exp. St., P. O. Box 1106, New Haven, CT 06504

During 1976-78 the effect of low temperature on survival of red pine scale overwintering on 4- to 6-year-old potted red pine was studied. During January and February pines were taken from outdoor storage and subjected to 1, 2 or 5, 4-hour exposures at -23 C or continuous exposure for 1 to 80

hours at  $-15$  to  $-27$  C in a large freezer. Thereafter treated trees and controls were maintained above freezing. Mortality was determined 7 to 10 weeks after treatment when surviving nymphs entered the next growth stage. Scale mortality was greatest on 1-year-old branches and decreased as branch age increased. Mortality was generally least on 3-year-old branches where scale populations are often highest. In 1976 scale mortality was 31% on 3-year-old twigs after 5 4-hour exposures at  $-23$  C compared to 27% on controls. In 1977 continuous exposure of 1 to 80 hours at  $-15$  to  $-27$  C revealed that most mortality occurs during the first few hours of exposure and increases slowly thereafter. In 1978 two populations were compared at continuous exposure of 1 to 75 hours at  $-18$  to  $-27$  C. After 25 hours at  $-27$  C there was 97.6% mortality from a source near Long Island Sound compared to 93% for a source near the northern limit of infestation in Connecticut. The lack of complete mortality at prolonged temperature indicates that this scale is capable of infesting red pine throughout southern New England and southern New York and the reduction in mortality compared to a 1957 report suggests that a more cold-hardy scale has developed during the last 20 years.

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White grub control in turf with Bendiocarb (NC 6897). W. W. Surles and W. L. Ekins, Fisons Corp., 2 Preston Court, Bedford, MA 01730

Bendiocarb (NC 6897) is a carbamate insecticide, which exhibits good soil activity and moderate mammalian toxicity. Data generated by university researchers have demonstrated excellent activity against turf-feeding white grubs (numerous species) at 2.0 to 4.0 lb ai/A and varying activities against other turf infesting arthropods. Working under Experimental Use Permit programs approved by the Environmental Protection Agency, Fisons' personnel field-tested three formulations (76 WP, 2.5 G and 5 G) in 1977 and 1978. Non-replicated, practical application trials were conducted in the Central and Northeastern United States on home lawns. Pre and post-treatment population assessments were monitored for: 1) untreated; 2) bendiocarb and 3) plots treated with a standard product. Data were taken and observations were conducted to evaluate: efficacy (for early spring and late summer applications), turf and applicator safety, irrigation effect and ease of application. The results indicated that bendiocarb provided at least 80% control of the white grub complex at 2.0 lb ai/A in most areas; however, 4.0 lb ai/A were required in New York and Central Texas. Late summer and early spring trials demonstrated good activity against all larval stages. Post-treatment irrigation was required to ensure this high level of activity. These findings complement the results obtained from researcher trials and confirm the desirability of eventual registration of bendiocarb.

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Biology and control of the Northern fowl mite on caged layers. E. C. Turner, Jr., Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061

Historically, laying hens have been infested by the common chicken mite, *Dermanyssus gallinae* (De Geer) and the Northern fowl mite, *Ornithonyssus sylviarum* (Canestrini & Fanzago). However, most commercial egg producers now house their hens in cages. This management practice has virtually eliminated the chicken mite as a pest but has greatly encouraged the development of large populations of Northern fowl mites on the caged birds resulting in reports of losses in egg production and complaints by personnel operating the houses and egg packing rooms. Dissemination of mites in large caged layer houses has been observed to be primarily from egg trays, conveyor equipment, and even the eggs. In some cases, wild birds, escaped hens and rats can play a part in this dissemination.

Recent research has indicated that stress, through the release of corticosterones, is an important factor in the ability of the host to support or resist populations of Northern fowl mites. Cages housing two or more birds will result in reduced mite populations while birds housed alone will support large mite populations. The mechanism of host resistance to mites was found to be due to decreased capillary density in the skin proximate to the vent of the bird.

Synthetic pyrethroid insecticides permethrin and SD 43775 applied as sprays at dosages of 0.125 and 0.0125% AI respectively has resulted in excellent long term control of the mite.

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Recognition of virus-diseased gypsy moth larvae by *Apanteles melanoscelus* Ratzeburg (Hymenoptera: Braconidae). P. L. Versoi and W. G. Yendol, Pesticide Res. Lab., Penn State Univ., Univ. Park, PA 16802

The objective was to determine if the parasite, *Apanteles melanoscelus* could discriminate between diseased and healthy gypsy moth (GM) larvae. The disease agent used was the Gypsy Moth Nuclear Polyhedrosis Virus (GMNPV). The incidence and frequency of behaviors including parasite-host contacts, and subsequent ovipositor probing were used for indicating host preferences. The basic procedure involved transfer of 5 mated, female parasites with no prior host encounters into a test chamber containing 10 mid-3rd instar (55–80 mg) GM larvae. During confinement of the parasites with host larvae, behavioral activities of the parasites were video-recorded for 30 min. This approach was repeated a number of times for each of the following 4 preparations: healthy GM with movement unrestricted; healthy GM with movement restricted; diseased GM with movement restricted; and 5 diseased larval GM and 5 healthy larval GM in the same container with movement restricted. The results of this investigation indicated: (1) *A. mel-*

*anoscelus* females were able to distinguish between healthy and diseased hosts, as evidenced by behavioral discrimination, and (2) a greater percentage of the healthy GM larvae were attacked by the parasites when compared to moribund, GMNPV-infected larvae. Such information would be important in assessing the efficacy of these two biological agents when being considered as components of GM management systems.

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The relationship of the maple cambium miner, *Phytobia setosa* (Loew) (Diptera: Agromyzidae) to its host. W. E. Wallner and R. A. Gregory, U. S. Forest Service, Hamden, CT 06514

The maple cambium miner, *P. setosa*, attacks *Acer* spp. producing ray flecks which result in degrade in face veneer and furniture wood. The purpose of this study was to determine the histological relationship of *P. setosa* to sugar maple and determine if mines influenced sap sugar content. It was found that while mines pass close to the vascular cambium the initial cells were unaffected hence even though called a cambium miner it does not mine in the cambium. The zone of newly differentiating xylem provides the path of least resistance for *P. setosa* larvae who mine from young shoots to roots. Mines quickly filled with parenchyma cells. When mature these cells stored starch and increased the starch content of the xylem. To determine if mines influenced sap sugar content 300 sugar maple trees were tapped during the fall and spring and sugar values were determined with a hand held refractometer. The 10 highest and 10 lowest trees were sacrificed and sap sugar levels were correlated with mine abundance at heights of 0, 1, 4, 8, 12, and 14 m on each tree. Flecks constituted up to 1% of cross-sectional area of xylem. However, there was no correlation between fleck number or area to sap sugar levels.

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Implications for parasite effectiveness of crossing *Apanteles melanoscelus* (Ratzeburg) (Hymenoptera: Braconidae) with an exotic *Apanteles* from India. R. M. Weseloh, Connecticut Agr. Exp. Sta., New Haven, CT 06504

An unidentified species of *Apanteles* from India is morphologically very similar to the established gypsy moth parasite, *Apanteles melanoscelus*, which was originally imported to North America from Europe. Behavioral tests showed that males of *A. melanoscelus* responded to the sex pheromone produced by females of the Indian form, but not vice versa. In cross mating tests males of either strain successfully mated with females of the other to produce fertile female offspring, showing that they are functionally the same species. The two strains differ substantially in cocoon morphology, that of the Indian strain being surrounded by a "halo" of coarse silk which is much less evident in *A. melanoscelus* cocoons. F<sub>1</sub> hybrid females result-

ing from crosses between the two strains had intermediate cocoon halo dimensions as measured by the ratio of cocoon width (including halo) to cocoon length (not including halo). Back-crosses of these females with males of either strain resulted in regression of cocoon morphology toward the appropriate pure strain, suggesting multiple gene inheritance. These results have practical implications, as *A. melanoscelus* is heavily attacked by hyperparasites in the field. The Indian strain, whose halo could serve as a barrier against hyperparasites, appears to have an inappropriate diapause response (i.e., not photoperiodically induced as it is for *A. melanoscelus*). Thus, incorporation of the halo into *A. melanoscelus* cocoons while retaining this strain's desirable diapause characteristics might result in larger field populations of the parasite.

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Biotype variation and temperature effects on *Myzus persicae* (Sulz.) (Homoptera: Aphidae). M. E. Whalon and Z. Smilowitz, Pesticide Research Lab., Penn State Univ., University Pk., PA 16802

Offspring, survival and thermal requirements per developmental stage for three biotypes of the green peach aphid (GPA), *Myzus persicae* (Sulz.), were determined over a range of constant temperatures from 12.4°–29.4°C. Biotypes originated from Pennsylvania, Maine and Washington state potato producing regions. Offspring produced, survival and thermal requirements were similar for all three biotypes. Offspring production increased from 12.4° to 15.6°C and then decreased as temperature increased. Percent survival was high except at 29.4°C where only 26.7% survived. Thermal requirements, with 4°C as the lower developmental threshold, were 25.2, 27.1, 30.9, 30.7, 20.7, 74.2, 201.6 and 135.7, respectively, for instars 1–4, prereproductive adults, reproductive adults, longevity and generation time.

Since the three aphid types were of distinct karyotype, by definition they are biotypes. This definition, however, is not operational because many distinct karyotypic colonies are produced within a single potato field through parthenogenetic reproduction. A suggested operational definition for green peach aphid biotypes classifies on the basis of applied characteristics, i.e., resistance or fitness.

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Updating the green peach aphid forecast system with a monitoring procedure. M. E. Whalon, B. A. Bajusz and Z. Smilowitz, The Penn. State Univ., Univ. Park, PA 16802

A dynamic, deterministic-continuous model was developed and validated for predicting green peach aphid (GPA), *Myzus persicae* (Sulz.), population development in the field. Laboratory studies of GPA development over a

range of constant temperatures provided an initial regression equation for predicting generation time. The model was derived by the regression of this independent variable on field sample data from plots maintained under Malthusian conditions, i.e., food limited only. Additional equations relating a management strategy (soil application of a systemic insecticide at planting) and predation were included in the overall model.

A capacity to predict future GPA populations was built into the model by including an algorithm to calculate day degrees from climatic data. Weather forecasts, therefore, provide input for prediction of GPA populations. The model was used to evaluate various control strategies and to predict spray dates based on weather forecasts for 80 acres of commercial potatoes and 4 acres of experimental plots.

The model was updated twice during the growing season. Water pan traps provided peak GPA immigration dates in each grower's field. A subsequent censored sample procedure and programmable calculator were utilized to estimate population parameters and parameter precision. These data were incorporated into the model via an update algorithm.

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Survey and detection of the alfalfa snout beetle, *Otiorhynchus ligustici* (L.) (Coleoptera: Curculionidae). H. R. Willson, Cornell Univ., Ithaca, NY 14853

The distribution of *O. ligustici* in North America is limited to a four county area of New York. Accurate information on the dispersal of this species is essential to regulatory programs. In 1975, a grid survey of *O. ligustici* was initiated using the universal transverse mercator grid system. Alfalfa fields were sampled on a 10 km square grid to document areas of population establishment and dispersal. Initially, a biased method of digging 16 plants around the perimeter of each field sampled was followed to detect larvae of *O. ligustici*. Analysis of the detection results from the first 2 years of survey found that digging of 8 plants per field achieved 90% of the results obtained with digging 16 plants. Thus, inspector time spent per field in larval detection could be reduced. A computerized storage and retrieval system was developed to sort field data by coordinates. Since coordinates were assigned at hectare accuracy, the system can generate graphical printouts of the survey to aid decisions on future field efforts.

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A comparison of the effectiveness of *Bacillus sphaericus*/SSII-1 against *Aedes stimulans* and *Ae. triseriatus* larvae (Diptera: Culicidae) at different temperatures. S. P. Wraight,<sup>1</sup> S. Singer<sup>2</sup> and H. Jamnback,<sup>1</sup> NYS Science Service, Biol. Field Sta., Cambridge, NY<sup>1</sup> and Dept. Biol. Sci., Western Illinois Univ., Macomb, IL 12816<sup>2</sup>

Mid to late third instar field collected *Aedes stimulans* were assayed at two temperatures against *Bacillus sphaericus* Strain SSII-1. Each assay consisted of seven different doses and one untreated control. Fifty larvae were exposed to each concentration of the bacterium in trays containing one liter of water at a depth of 1.5 cm. Larvae remained in the treated trays, and mortality was recorded until adult emergence. The inoculum used was taken from a ten day old synthetic broth culture with a total cell count of  $4.24 \times 10^9$  cells/ml, total viable count of  $2.01 \times 10^8$  cells/ml and spore count of  $1.01 \times 10^8$  spores/ml.

Probit analysis indicated on  $LC_{50}$  of  $7.23 \times 10^5$  cells/ml (95% fiducial limits at  $5.88 \times 10^5$  and  $8.42 \times 10^5$ ; slope = 5.27) at 27°C, while at 15–18°C over four times the number of cells was required to achieve 50% mortality ( $LC_{50} = 2.93 \times 10^6$ ; 95% limits at  $2.27 \times 10^6$  and  $3.54 \times 10^6$ ; slope = 3.5). An even greater difference in the effective number of bacterial cells (5.8 fold) was observed at the  $LC_{95}$  levels (27°C –  $LC_{95} = 1.48 \times 10^6$  cells/ml, 95% limits at  $1.22 \times 10^6$  and  $2.13 \times 10^6$ ; 15–18°C –  $LC_{95} = 8.64 \times 10^6$  cells/ml, 95% limits at  $6.80 \times 10^6$  and  $1.27 \times 10^7$ ). In both of the above assays, a large percentage of the observed mortality occurred during the pupal stage. At dosages near the  $LC_{95}$ , most of the susceptible individuals succumbed within 6 days after treatment at 27°C and 14 days at 15–18°C. Results similar to those observed for *Ae. stimulans* have been obtained using laboratory reared *Ae. triseriatus*.

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Vector potential of *Culiseta melanura* (Coquillett) (Diptera: Culicidae) in central New York State. R. H. Zimmerman and C. D. Morris, State Univ. of New York, College of Env. Sci. and Forestry, Syracuse, NY 13201

The biology of *Culiseta melanura* has been extensively studied, but its vector potential neglected. Whether *Cs. melanura* is also the epizootic vector, as well as the amplifying vector of EEE virus in central New York State is in debate. In either case control of this mosquito decreases virus infections. By using artificial resting shelters the relative abundance and parous rates of *Cs. melanura* were monitored at 3 sites progressively farther from the center of a 5,000 acre swamp. Greatest numbers of *Cs. melanura* were first caught at the center site, but after the first week the perimeter site was more productive. The distant site had the fewest adults. Parity was progressively higher with increasing distance from the swamp. Parous rates at

all three sites increased and were approximately equal at the beginning of the year, but after the second emergence on July 31 parity was highest at the distant site. The number of parous females was 3.4 times greater at the perimeter site than at either of the other sites and, if all other factors were equal, the vector potential was greatest at the perimeter. Only 11% of a total of 405 pars collected at the distant site were caught before July 31. This would suggest an increase in importance of the distant site because EEE isolations occur after the second major emergence of *Cs. melanura* as do equine and human cases.

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#### Erratum

The species figured in the Journal of the New York Entomological Society 86(3):212 is *Mormidea collaris* Distant. The caption for this figure was inadvertently omitted.

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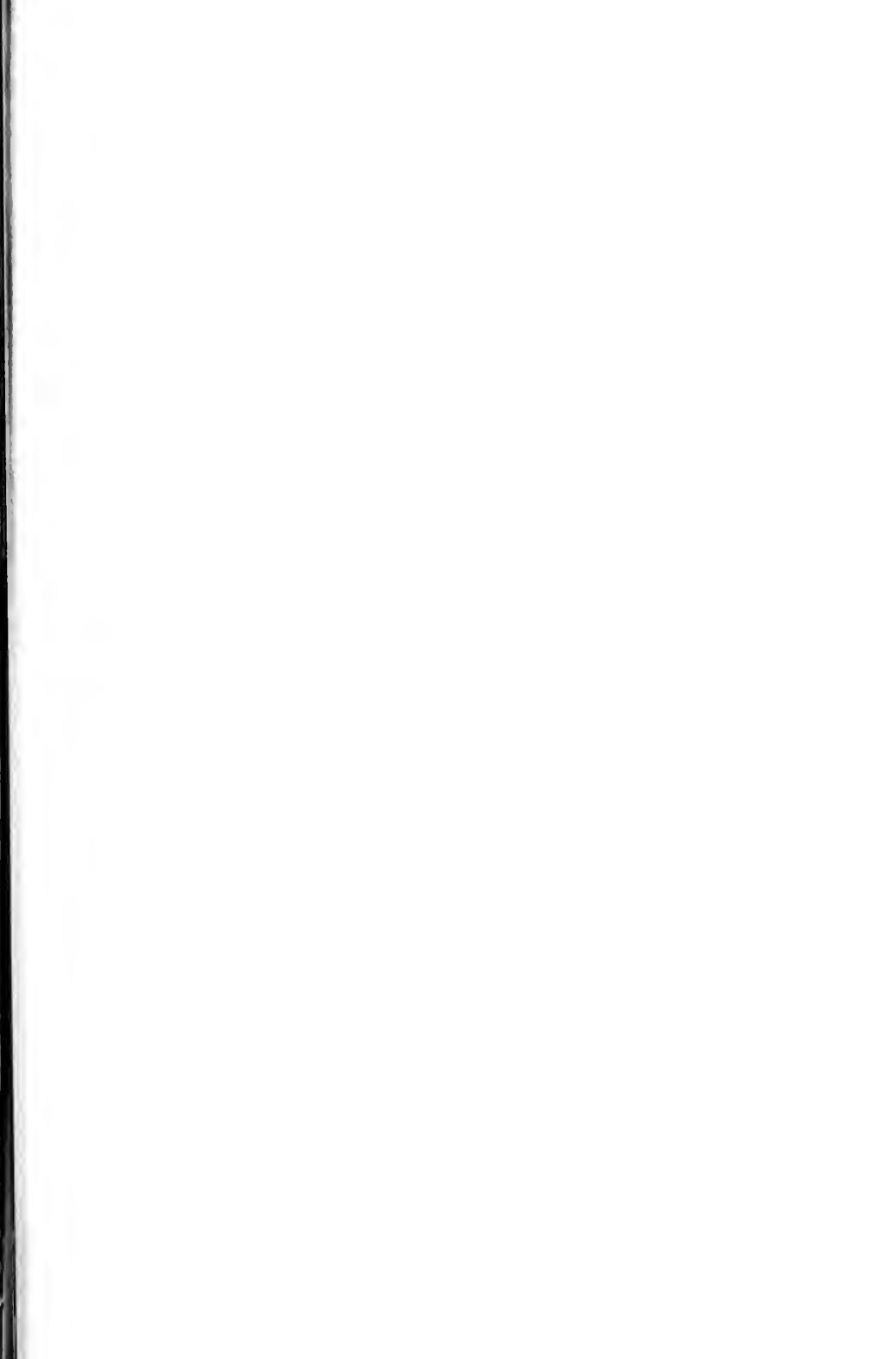
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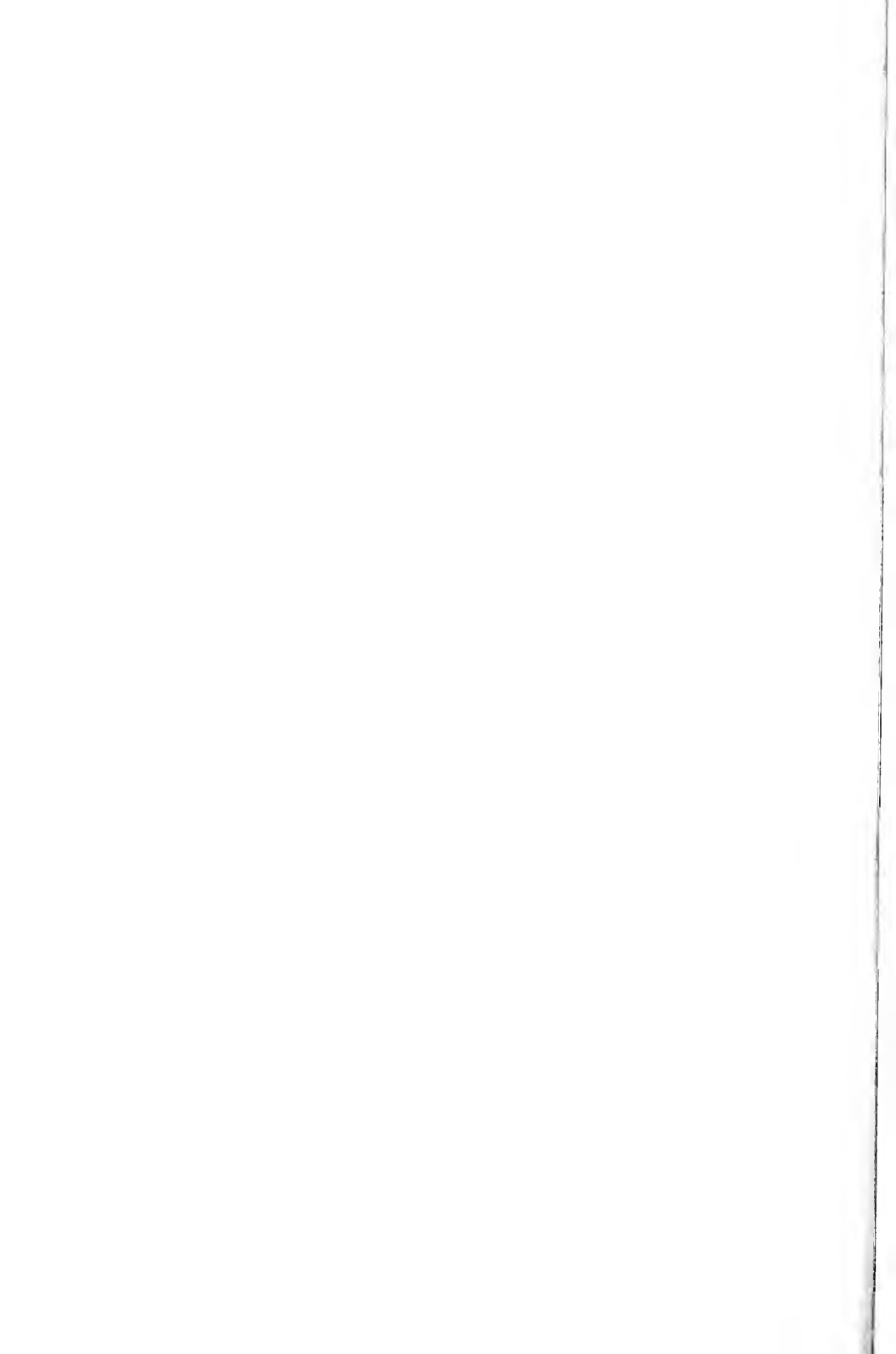
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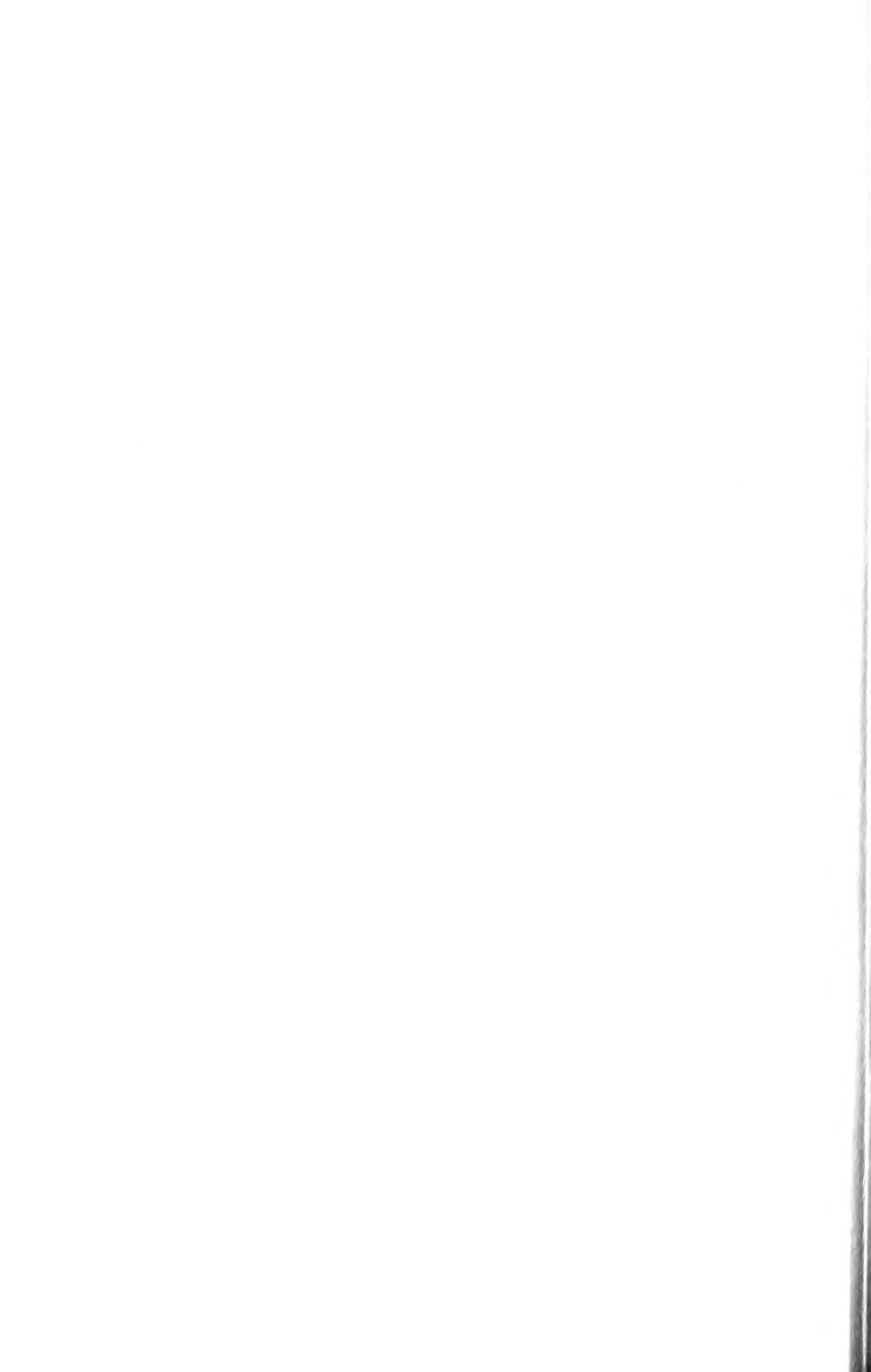
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