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A SURVEY OF ARTHROPODS ASSOCIATED WITH GOPHER TORTOISE BURROWS IN MISSISSIPPI[1]

Paul K. Lago[2]

ABSTRACT: A survey of arthropods associated with gopher tortoise burrows in Mississippi revealed the presence of seven burrow commensals: *Chelyoxenus xerobatis* (Coleoptera; Histeridae); *Aphodius troglodytes* and *Onthophagus polyphemi sparsisetosus* (Coleoptera: Scarabaeidae); *Philonthus gopheri* (Coleoptera: Staphylinidae); *Eutrichota* sp. (Diptera: Anthomyiidae), *Machimus* n. sp. (Diptera: Asilidae) and *Amblyomma tuberculatum* (Acari: Ixodida: Ixodidae). *Eutrichota* sp. ranked first in abundance, followed by *P. gopheri, O. polyphemi sparsisetosus* and *Machimus* n. sp. (although the primary sampling method, a vacuum apparatus, biased abundance data in favor of surface dwellers within burrows). An additional 24 species were considered to be opportunists in the burrows, and seven more were apparently accidental. Among the non-commensals were 20 species of Coleoptera, five Hymenoptera, two Orthoptera, two Lepidoptera and two Diptera.

The gopher tortoise (*Gopherus polyphemus* Daudin) is a large, terrestrial turtle endemic to the southeastern United States, including southeastern Mississippi. Except when foraging during mornings and late afternoons of spring, summer and autumn months, the reptiles spend most of their time within burrows they construct in sandy soil. These burrows are usually rather simple, but may exceed seven meters in length (Hansen, 1963), and are used for several years. The relative permanency of the burrows, coupled with the presence of unique resources (tortoise dung, in particular) has resulted in the evolution of a unique fauna of vertebrates and invertebrates that reside with the tortoise.

Arthropods comprise a major part of the gopher tortoise burrow fauna and this group has received considerable attention in the past. Most work done with this interesting assemblage, however, has been conducted in Florida, and records for other areas are few and scattered. Franz and Bryant (1982) summarized much information on tortoise - habitat relationships and included a section entitled "Arthropods of Gopher Burrows" (Woodruff, 1982a). A list of 39 species of arthropods associated with burrows in Florida was presented along with notes on presumed relationships (obligates, accidentals, etc.). Mistrey (1987) presented a considerably longer list (267 + species) and included much information on biology of Florida burrow arthropods. He classified burrow inhabitants as: a) commensals: obligate inquilines, basically restricted to the habitat provided by their host, b) opportunists: species

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[2] Department of Biology, University of Mississippi, University, MS 38677

using the burrow for cover, or feces for food, but found commonly in other habitats, or consuming other types of feces and c) accidentals: species normally occurring in other habitats and not regularly using burrow resources.

The burrow commensals are generally coprophagous, parasitic on the tortoises, or predaceous primarily on other burrow arthropods. As is true for any organisms with very narrow habitat requirements, any major change in habitat availability could have devastating effects on the species involved. The status of the gopher tortoise varies from threatened to endangered throughout its range; consequently, the status of the obligate burrow inquilines is generally considered threatened or endangered (Woodruff, 1982b), and with obvious good reason.

Howden and Cartwright (1963) described a new subspecies of coprophagous scarab, *(Onthophagus polyphemi sparsisetosus)*, collected from gopher tortoise burrows in Alabama, Florida and Mississippi. The Mississippi specimens, collected 6.5 miles south of Lucedale, George County, represent the only known record for a tortoise burrow inquiline from the state. A primary reason for the lack of records would appear to be lack of collecting effort. Recently (1983) Andrew F. Beck (pers. commn.) used a modified vacuum to sample several burrows in Harrison County. Also in 1983, I excavated two burrows in Harrison and George counties, and throughout the early 1980's, set pit traps and blacklight traps in areas with good gopher tortoise populations. No burrow inquilines were collected during any of the above activity. The only insect specimens I examined that were in any way associated with tortoises in Mississippi was a series of beetles taken from tortoise droppings at the mouth of a burrow in Jones County, 21 August, 1985, by Robert Jones and Jerry Watkins. Three species were represented: *Myrmecaphodius excavaticollis* (Blanchard) (2 specimens) is an inquiline in fire ant nests and is not coprophagous. Its presence in this series is accidental. *Ataenius platensis* (Blanchard) (53 specimens) was considered to be accidental in tortoise burrows in Florida by Woodruff (1982a), but the presence of so many in this series would seem to indicated a more meaningful relationship, and this will be discussed later. The final specimen in the series was *Ataenius cylindrus* Horn, a species normally associated with cattle dung (Woodruff, 1973), and one that is not very common in Mississippi.

Recently there has been increased interest in "non-game" species by state departments of wildlife conservation, in particular those species that may be threatened or endangered. The above-mentioned *Onthophagus* was appropriately placed on the Mississippi list of species of special concern, and during 1987, I conducted a status survey of *O.*

polyphemi sparsisetosus in conjunction with a general survey of the arthropod fauna of gopher tortoise burrows in the state.

METHODS

The most obvious problems encountered during this study were: 1) finding active tortoise burrows, and 2) sampling the arthropod fauna within the burrows. The first problem proved not as difficult as originally anticipated. There is great interest in the status of Mississippi gopher tortoise populations among herpetologists and other wildlife biologists in the state. Several surveys, both formal and informal, have been conducted (e.g. Lohoefener, 1982) and much of this information has been compiled by the Mississippi Natural Heritage Program. The information provided by the Heritage Program included localities of supposedly active burrows in all counties where the tortoise is known to occur. Additionally, Harry Pawelczyk provided information on populations within the DeSoto National Forest and several individuals assisted by taking me to burrows of which only they had knowledge. Although the information provided by the Heritage Program and Pawelczyk was invaluable in finding localities, the majority of actual field time was spent making transects through the areas in an attempt to find active burrows. Specific localities were chosen on the basis of success potential (large numbers of active burrows) and on the basis of distribution (in all counties within the range of the tortoise, including localities near the margin of that range to get the broadest picture of the distribution of arthropods encountered).

Samples were collected from burrows using a gas-powered leaf blower that had been modified into a vacuum. An adapter, with an in-line filter, was added to the air intake of the blower and a 1.25 inch diameter, smooth bore vacuum hose attached. A 30-foot hose enabled sampling of even the longest burrows. The procedure involved snaking the hose into a burrow, attaching the hose to the vacuum, then slowly extracting the hose with a twisting motion. The in-line filter caught debris and any arthropods, while allowing sand to pass through. The filter was then removed, its contents placed in an enamel pan and the athropods collected. This method of extraction has proven to be very efficient in sampling burrows in Florida (A.F. Beck, pers. comm.; E.G. Milstrey, pers. comm.), and is certainly less labor intensive than burrow excavation. (It should be noted that excavation of burrows has not been allowed since gopher tortoises were placed on the Mississippi list of endangered species.) Many additional specimens were obtained by examining tortoise feces found around burrow openings. Occasionally, pit traps baited with fresh tortoise feces were set near burrows. Blacklight traps were run in several colonies in an attempt to capture specimens of *Copris gopheri* Hubbard and *Aphodius troglodytes* Hubbard, burrow inquilines occasionally attracted to light (Woodruff, 1973). A total of 21 days was spent searching for and sampling burrows from 7 May through 24 June, 1987. Voucher specimens have been placed in the insect collection of the University of Mississippi.

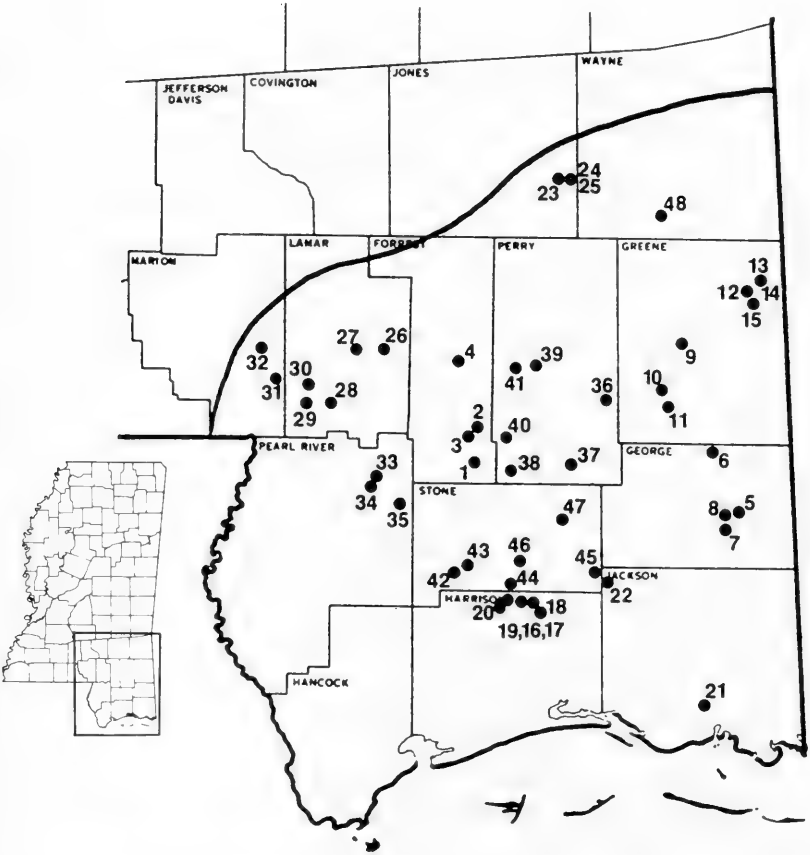

Figure 1. Distribution of collecting localities within the approximate range of the gopher tortoise in Mississippi.

RESULTS AND DISCUSSION

During this study, light trapping was ineffective in capturing burrow inquilines. Although pit trapping did yield a few specimens of coprophagous species, no inquilines were collected using this method. The vacuum method, however, was quite successful in capturing both inquilines and other burrow inhabitants, and unless otherwise indicated, comments below refer to specimens collected in this manner. Using the vacuum, samples were taken from 246 burrows at 48 localities in 12 counties. Active burrows were not found in Hancock county, but historically tortoises are not common here (R. Lohoefener, pers. comm.). Burrows were sampled in all other counties where tortoises occur in Mississippi (Fig. 1). Table 1 presents locality data and the number of burrows sampled at each site.

Table 1. Mississippi localities where active gopher tortoise burrows were sampled for inquilines.

County	Loc. No.	Locality	Burrows Sampled
Forrest	1	7.5 mi. S Brooklyn	1
Forrest	2	1.5 mi. SE Brooklyn	8
Forrest	3	2.5 mi. SSE Brooklyn	2
Forrest	4	2 mi. S McLaurin	4
George	5	6.5 mi. SE Lucedale	5
George	6	5 mi. N Lucedale	1
George	7	7 mi. SSE Lucedale	10 (two dates)
George	8	6 mi. SE Lucedale	6
Greene	9	7.5 mi. NW Leakesville	3
Greene	10	10.5 mi. WSW Leakesville	5
Greene	11	10 mi. SW Leakesville	2
Greene	12	8 mi. S State Line	9
Greene	13	7.5 mi. S State Line	7
Greene	14	7.5 mi. S State Line	2
Greene	15	9.5 mi. S State Line	8
Harrison	16	5 mi. ENE Saucier	2
Harrison	17	6 mi. ENE Saucier	1
Harrison	18	7 mi. E Saucier	1
Harrison	19	3.5 mi. NE Saucier	9 (two dates)
Harrison	20	3.5 mi. NE Saucier	6
Jackson	21	3 mi. N Gautier, Sandhill Crane National Wildlife Refuge	3
Jackson	22	16 mi. NE Vancleave	1

County	Loc. No.	Locality	Burrows Sampled
Jones	23	13 mi. ESE Ellisville	11
Jones	24	14 mi. ESE Ellisville	5
Jones	25	14 mi. ESE Ellisville	5
Lamar	26	1.1 mi. NNE Purvis	7
Lamar	27	3.5 mi. WNW Purvis	1
Lamar	28	5.5 mi. NWLumberton	6
Lamar	29	0.7 mi. S Baxterville	5
Lamar	30	1.3 mi. N Baxterville	2
Marion	31	13.5 mi. SE Columbia	6
Marion	32	10 mi. SE Columbia, Marion Co. Wildlife Management Area	12
Pearl River	33	9 mi. NE Poplarville	2
Pearl River	34	9 mi. NE Poplarville	6
Pearl River	35	11 mi. ENE Poplarville	9 (two dates)
Perry	36	8.5 mi. ESE Beaumont	1
Perry	37	16.5 mi. S. Beaumont	2
Perry	38	4.5 mi. NE Fruitland Park	6
Perry	39	4 mi. SW New Augusta	9
Perry	40	6 mi. SW New Augusta	5
Perry	41	14.5 mi. SSW New Augusta	5
Stone	42	3.5 mi. WNW McHenry	4
Stone	43	4.5 mi. WNW McHenry	2
Stone	44	9 mi. SE Perkinston	7 (two dates)
Stone	45	15.5 mi. ESE Perkinston	5
Stone	46	6.5 mi. ESE Perkinston	1
Stone	47	11.5 mi. E Wiggins	5 (two dates)
Wayne	48	16.5 mi. SW Waynesboro	13

Milstrey (1986) discussed various collecting techniques used to sample burrow arthropods, and concluded that the vacuum method was most efficient for sampling large numbers of burrows in a short time with the least amount of habitat disturbance. Certain disadvantages of the method are obvious: no direct observation of behavior is possible, there is no real control over the amount of burrow surface sampled, and strong fliers (Diptera, Hymenoptera) may escape the airstream or very small specimens be sucked through the inline filter (Milstrey, 1986). In addition, the vacuum collects primarily from the burrow surface and insects that tunnel in the floor of the burrow (such as some dung beetles) may be protected from the hose. Consequently, this method provides data that, at best, indicates relative abundance for burrow surface dwellers, but presence only for burrowers.

Representatives of 37 species in 11 families and five orders of insects, and one species of tick were collected from tortoise burrows or tortoise feces during this study. In the following discussion of individual species, presumed relationships with the tortoise are indicated using the terms defined by Milstrey (1986): commensals, opportunists or accidentals (as discussed above). Admittedly, the distinction between opportunistic and accidental species, while obvious by definition, is somewhat subjective for rarely encountered species. Consequently, some classification changes may be necessary in the following list as additional information comes to light.

ANNOTATED LIST OF SPECIES

Coleoptera

Histeridae

Chelyoxenus xerobatis Hubbard. Commensal. Localities 5, 10, 12, 20, 26. 26 May - 24 June. Specimens collected - 5. This species burrows in the floor of tortoise galleries and is also found in tortoise feces (Hubbard, 1894; Young and Goff, 1939). The larvae are apparently predaceous on maggots feeding on tortoise dung (Hubbard, 1896). The five specimens collected were taken from widely scattered localities indicating a range co-extensive with that of its host. The small number of individuals collected may be explained by the burrowing habits of this species, or by the fact that it is simply not common in Mississippi. Burrow excavation would be necessary to determine if either or both of these statements is true.

Phelister rouzeti Fairmaire. Opportunist. Locality 24. 15 June. Specimens collected - 9. This small series was taken from fresh tortoise feces near the mouth of a burrow. The species was previously unknown east of the Mississippi River (R. Wenzel, pers. comm.)

Hydrophilidae

Cercyon pygameus Illiger. Opportunist. Locality 24. 15 June. Specimens collected - 1. Various species of *Cercyon*, including *C. pygmaeus*, are commonly found in dung (Smetana, 1978). This specimen was collected from fresh tortoise feces near the mouth of a burrow.

Scarabaeidae

Aphodius rubeolus (Beauvois). Accidental. Localities 29, 34. 21, 22 June. Specimens collected - 2. *Aphodius rubeolus* is common in a variety of types of feces in Mississippi, so the presence of only two specimens in burrow samples seems best described as accidental.

Aphodius stercorosus Melsheimer. Accidental. Locality 48. 24 May. Specimens collected - 1. The presence of this generalist dung beetle represents the same situation as *A. rubeolus*. Both species are very common here but neither was taken from readily available tortoise feces.

Aphodius troglodytes Hubbard. Commensal. Locality 48. 15 June. Specimens collected - 3. Adults and larvae of this species feed only on gopher tortoise feces (Woodruff, 1973). Although they are common in Florida burrows, specimens are most often found in the driest, sandiest areas (Milstrey, 1987). The single Mississippi location, in southern Wayne County, fits this description better than any other area visited during this study. All specimens were taken from one burrow. Since adults remain associated with tortoise feces (rather than burrowing), and since feces were often vacuumed from burrows, its appears the species is very rare in Mississippi, and has a range that is not co-extensive with that of its host.

Ataenius cylindrus Horn. Opportunist. Localities 12, 16, 21, 22, 25, 32, 36, 44, 47. 19 May - 24 June. Specimens collected - 20. Specimens were collected from tortoise feces, vacuumed from burrows and taken in a pit trap baited with fresh tortoise dung. This species occurs in cattle feces and must be considered an opportunist here, but the large number of specimens collected and the wide range of collection sites indicated that tortoise droppings may represent a preferred opportunity.

Ataenius fattigi Cartwright. Accidental. Locality 48. 15 June. Specimens collected - 1. Typically found in cattle feces, and fairly common in Mississippi, the presence of one specimen of *A. fattigi* in a vacuum sample is probably best described as accidental.

Ataenius ovatulus Horn. Opportunist. Localities 23, 32. 15 and 22 June. Specimens collected - 3. Virtually nothing is known of the biology of this rare species. Supposedly they do not use feces as a food source (Woodruff, 1973), but I have taken specimens in pit traps baited with human feces and, during this study, three specimens were collected from tortoise feces.

Ataenius platensis Blanchard. Opportunist. Localities 16, 21, 23, 24, 25. 15, 17 and 18 June. Specimens collected - 127. This is a common, wide ranging species that uses a variety of feces for food. Although Woodruff (1982a) considered this to be accidental in tortoise burrows, I collected 101 specimens from tortoise feces indicating a relationship better described as opportunistic. Although the majority of these specimens were taken from feces near the mouths of burrows, several were collected from fecal masses vacuumed from distal ends of burrows.

Onthophagus polyphemi sparsisetosus Howden and Cartwright. Commensal. Localities 2, 5, 7, 9, 15, 19, 23, 28, 29, 32, 47, 48. 9 May - 24 June. Specimens collected - 26. Adults feed on tortoise feces (Woodruff, 1973), but larval habits remain unknown. Since adult *Onthophagus*, in general, burrow and bury dung for larval food, it seems likely that the vacuum method did not give a good estimate of the relative abundance of this species. However, the 26 specimens ranked second only to *Philonthus gopheri* Hubbard (Staphylindae) among beetle commensals collected. The ranges of the beetle and the tortoise are coextensive in Mississippi. This was the only commensal collected outside burrows. One individual was observed flying into a burrow on a sunny day (about 2:00 pm, 80°F.). The beetle flew back and forth across the opening two or three times, each time flying less distance and moving closer to the hole, and finally landed about 20 cm into the burrow. A second specimen was found at the mouth of a burrow where it was being subdued by fire ants (*Solenopsis invicta* Buren).

Staphylinidae

Alenochora notula Erichson. Opportunist. Locality 24. 15 June. Specimens collected - 1.

Taken from tortoise feces at mouth of burrow.

Anotylus sp. Opportunist. Locality 24. 15 June. Specimens collected -5. Taken from tortoise feces at mouth of burrow.

Falgaria dissecta Erichson. Opportunist. Locality 24. 15 June. Specimens collected - 1. Collected with the preceding two species.

Gabronthus mgogoricus Tottenham. Opportunist. Localities 24, 29. 15, 21 June. Specimens collected - 5. Four specimens were taken from fresh tortoise feces near a burrow mouth, the fifth was vacuumed from a burrow.

Lithocaris sp. Opportunist. Locality 24. 15 June. Specimens collected - 1. Taken from tortoise feces near burrow.

Mycetoporus sp. Opportunist (?). Localities 3, 44. 8, 23 May. Specimens collected - 2. Both specimens were vacuumed from burrows.

Philonthus gopheri Hubbard. Commensal. Localities 7, 19, 27, 28, 32, 35, 37, 38, 39, 48. 7 May - 24 June. Specimens collected - 56. This was the most abundant of the coleopteran burrow commensals, and its range coincides with the tortoise's here. Woodruff (1982a) consolidated the scattered information on *P. gopheri,* but within that material there was no information as to the role of the species in the burrows.

Philonthus spp. Two species (35 specimens) were collected at location 24 from tortoise feces (15 June) and an additional species (1 specimen) at location 29 from a burrow (21 June). These are probably opportunistic predators.

Three additional unidentified species (6 specimens) within the Aleocharinae were collected from tortoise feces near the mouth of a burrow at location 24 (15 June). Probably opportunistic predators.

Since the majority of the specimens of staphylinids (not including *Philonthus gopheri*) were collected from tortoise feces, it seems logical that they were feeding on organisms there and that they should be considered opportunists. However, most were collected at the same locality (24) and from near the same burrow, unusual in the fact that it was shaded by a dense shrub. "Accidental" may better describe the relationship between any of these species and the gopher tortoise, but further observations are necessary.

Diptera

Anthomyiidae

Eutrichota sp., probably *E. gopheri* (Johnson). Commensal. Collected at all localities except 3, 6, and 18, throughout sampling period. Specimens collected - 75. It is estimated that less than 10% of the flies in vacuum samples were retained. A trip through the vacuum hose was fairly hard on these delicate individuals and confirmation of their identity awaits collection of good specimens of males. This was the most abundant commensal encountered. Adults dominated vacuum samples from most burrows and larvae were very common in fresh tortoise feces. The number of "specimens collected", which does not include larvae, greatly underestimates the number present in samples. When the in-line filter was removed, most of the flies escaped. This was not considered to be a problem because several stunned individuals were usually present. Many in the filter were discarded because of damage caused by the vacuum ordeal. I suspect this species is the primary prey for most of the predatory burrow arthropods, but no act of predation was actually observed.

Asilidae

Machimus n.sp. Commensal. Localities 7, 28, 35, 45, 47, 48. 21 May - 22 June. Specimens collected - 14. S.W. Bullington has verified the identity of this robber fly as the species he and A.F. Beck are describing from tortoise burrows in Florida and Georgia. Adults roost on the roofs of burrows just inside the entrance (within 40 cm). Only under extreme harassment could they be forced to leave the burrow, and then they immediately reentered. Most specimens were collected while the vaccum hose was being withdrawn from a burrow. An assistant would stand near the entrance with an aerial net and capture specimens when they made their brief appearance. Only three specimens were collected with the vacuum. Although four specimens emerged from one burrow and three from another, one or two per burrow was the rule. Many more specimens were seen than were captured, including individuals at two localities not listed above. They were quicker than we. The range of the species here is co-extensive with that of the tortoise. According to Milstrey (1987), this robber fly is predaceous on the anthomyiid fly, *Eutrichota gopheri* (Johnson), another burrow commensal.

Dolichopodidae

Hercostomus sp. Accidental (?). Localities 8, 38, 48. 21 - 26 May. Specimens collected -3.

Sphaeroceridae

Rachispoda sp. Opportunist (?). Locality 44. 8 May. Specimens collected - 1.

Hymenoptera

Formicidae

All of the following species of ants are predaceous and are considered opportunistic burrow inhabitants. On one occasion, an individual of *Onthophagus polyphemi sparsisetosus* found at the mouth of a burrow was being attacked by many fire ants *(Solenopsis invicta)*. Although the beetle was still alive, it was incapable of coordinated movement. No other instance of ant predation in a burrow was observed.

Aphaenogaster rudis Emery. Localities 20, 35. 22, 24 June. Specimens collected - 5.

Cyphomyrmex rimosus (Spinola). Locality 44. 19 May. Specimens collected - 1.

Iridomyrmex pruinosus (Roger). Locality 3. 23 May. Specimens collected - 1.

Solenopsis invicta Buren. Localities 3, 10, 15, 20, 22, 23, 35, 48. 23 May - 24 June. Specimens collected - 18.

Pompilidae

Anoplius atrox (Dahlbom). Opportunist. Locality 28. 21 June. Specimens collected - 1. Although only one specimen was collected, individuals were observed exiting burrows at several locations. They left their roosting places on the burrow roofs just as the vacuum hose entered. In all instances, individuals were observed only in the first few burrows sampled in early morning (before 9:30 am) suggesting that the wasps use the burrows as overnight refuges.

Lepidoptera

This order was represented in the samples by two larvae, one a pyralid, the second, a tortricid. Neither was identified to genus. Nothing indicated other than an accidental occurrence for either.

Orthoptera

Blattellidae

Cariblatta lutea (Saussure and Zehnter). Locality 2. 23 May. Specimens collected - 1. The presence of one specimen of this common species in a burrow must be considered accidental.

Gryllacrididae

Ceuthophilus divergens Scudder. Opportunist. Localities 2, 7, 8, 9, 11, 12, 13, 15, 20, 23, 28, 31, 32, 35, 37, 38, 40, 41, 45, 47, 48. 9 May - 24 June. The second most abundant species encountered during this study, it has not been reported from tortoise burrows previously, although congeners are documented burrow inhabitants (Milstrey, 1987; Woodruff, 1982a). The vast majority of individuals were seen when they escaped burrows as the vacuum hose was removed; however, the inline filter usually contained a few salvageable specimens. Like the *Eutrichota* sp. mentioned previously, probably less than 10% of individuals seen were collected. This species occurs in various habitats (Dakin and Hayes, 1970); consequently, it must be considered an opportunist using the burrows for cover.

Acari: Ixodida

Ixodidae

Amblyomma tuberculatum Marx. Commensal. Localities 35, 48. 15 - 24 June. Specimens collected - 3 adults, 1 nymph. The large gopher tortoise tick was collected at only two localities during this study, and no specimens were found on the few tortoises examined. Population numbers peak in late October and November in Florida (Milstrey, 1987), and it is possible that had I collected later in the year, more individuals might have been found. Based on the distribution of collection localities, I suspect the range of the tick is coextensive with that of the tortoise here.

SUMMARY

During May and June, 1987, samples of arthropods were taken from

246 gopher tortoise burrows in southeastern Mississippi. Of the 38 species of arthropods represented in the samples, seven were true commensals, 24 were considered to be opportunistic and seven were probably accidental in occurrence. The commensals were *Chelyoxenus xerobatis* (Histeridae), *Aphodius troglodytes* and *Onthophagus polyphemi sparsisetosus* (Scarabaeidae), *Philonthus gopheri* (Staphylinidae), *Asilus* n.sp. (Asilidae), *Eutrichota* sp. (Anthomyiidae) and *Amblyomma tuberculatum* (Ixodidae). *Eutrichota* sp. ranked first in abundance among the commensals, followed by *P. gopheri, O. polyphemi sparsisetosus* and *Machimus* n.sp. With the exception of *Aphodius troglodytes*, the ranges of the commensals appear to coincide with the range of the gopher tortoise in Mississippi.

Most of the opportunistic species were beetles (18 species), along with five hymenopterans and one orthopteran. Five of the opportunists were coprophagous, 17 were predaceous and two appeared to be using the burrows for cover.

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ERRATA

In the Nov. - Dec. 1990 issue of *Entomological News,* there are two small errors in the article entitled "New Records of Mayflies (Ephemeroptera) from Maine" by Steven K. Burian and Ronald G. Mack (ENT. NEWS 101(5):297-300). These are corrected below:

On page 297, second paragraph, line seven and on page 299, first line, there should not be any parenthesis [( )] around Traver. These should both read: *Acentrella ampla* Traver.

On page 297, second paragraph, line eight, *Centroptilus* should read *Centroptilum.*

Both the editor and the authors apologize for these errors.

PREDATION BY *DOLICHOVESPULA MACULATA* (HYMENOPTERA: VESPIDAE) ON ADULT GYPSY MOTHS[1]

Paul W. Schaefer[2]

ABSTRACT: Field observations of foraging *Dolichovespula maculata* showed successful capture of flying male *Lymantria dispar* responding to a synthetic pheromone source. Successful capture rate was 5.9% while capture attempts frequently occurred in repeated sequence, up to 18 in succession. Capture of a female gypsy moth and a damselfly by *D. maculata* and an attempted capture of a male gypsy moth by *Vespula maculifrons* is included.

Dolichovespula maculata (L.) is a large black and white social wasp commonly known as the baldfaced hornet (BFH) (Stoetzel 1989). This hornet is more accurately one of several "yellowjackets", the common names of which have been much confused and only recently has clarification of the nomenclature been attempted (Greene & Caron 1980). It primarily hunts live prey and its food consists mostly of tissue of a variety of insects, including gypsy moths (GM) *Lymantria dispar* (L.) (Lepidoptera: Lymantriidae) as previously recorded (Smith & Lautenschlager 1981).

In this study, I recorded the capture success rate of BFH as they pursued potential prey of flying GM males. This study resulted from observations of aerial predation on GM males in August 1989 when recordings were made of the success rate of aerial capture and processing of the captured prey. General notes on foraging behavior, particularly as it relates to flying male adult gypsy moths, capture of a sedentary female GM, a damselfly, and another vespid attempting to capture a GM male, are included.

MATERIALS AND METHODS

All observations took place at a cabin on the shore of Lower Lead Mountain Pond, in unorganized township T28 MD, Maine, during the period 13-22 August 1989. The surrounding habitat was a mixed deciduous forest (oak, maple, white birch and some white pine) which supported a very light GM population.

The observation area was the outside surface of a three-sided, screened-in porch (3.4.X 2.1 m) attached to a cabin. Located inside the porch was a 2-yr old ± disparlure tape attractive to feral GM males. The

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[2] U.S. Dept. Agric. Beneficial Insects Research Lab., 501 S. Chapel St., Newark, DE 19713

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area could be observed from a convenient distance of ca. 3 m from the corner of the front and one side. Either the left side or right side plus the porch front was used at any one time. Use of side (right or left) depended on the direction of the breeze during observations. The leeward side was always observed.

Observation periods involved recording the entrance into the observation area of scavaging BFH or pheromone responding GM males. The limits of the area were judged by eyesight from the point of observation. Time of entrance into the area was recorded but duration within was not. When coincidence of entry into the area of the two species occurred, particular attention was paid to the behavior of the BFH in response to any potential GM prey. Orientation and attack behavior was noted. Frequency of attacks and captures were recorded. Behavior following a successful capture was noted in as much detail as possible without disturbing the BFH. Data were summarized to illustrate aerial capture success.

One experiment entailed finding a single ovipositing female GM in the surrounding woodlands and moving her into the observation area by placing her on the window screen to watch any BFH response.

RESULTS AND DISCUSSIONS

A total of 8.5 hours of observation on six different days yielded 15 observed BFH captures of flying GM males (on four different days). During those observation periods when both species were active, on average both GM and BFH entered the observation area at about the same rate, i.e. one entry every three minutes. I recorded 251 observed attacks by the BFH on flying (or active fluttering against the screening) GM, including the 15 observed captures, resulted in an overall 5.9% successful capture rate.

Overall, observations permitted an in-depth analysis of the BFH's behavior. When GM were not present in the area, BFH often "patrolled" the camp surface in search of insects, as previously described by Balduf (1954) and similar behavior to that observed at a dead mammal bait source by Heinrich (1984). At other times, the BFH sat on convenient spots on the external porch woodwork around the screens, or on a railing down the front steps to await the passing of a flying GM. First reaction of the BFH was usually a quick orientation in the direction of the flying GM. This often preceded flight, but not always. In flight there was usually a perceptible pause in movement while hovering, involving an orientation, or fixation of eyesight upon the target moth. An attack usually followed immediately, with an apparent attempt at grabbing the fluttering male GM in its mandibles, possibly with the assistance of legs. With capture success rate only ca. 6%, many GM males continued to flutter toward the pheromone source after the first or subsequent attack attempts. If the moth happened to be closely appressed to the window screen, capture appeared to be facilitated only slightly by trapping the moth against the screen. This only contributed a minor advantage to the BFH as many attacks under these conditions still failed. In unsuccessful attacks GM males continued to flutter about the screen and would often then be subjected to repeated attacks or sequences of attacks that followed one another in rapid succession. This was repeated 18 times in one case before a successful capture occurred. On average each BFH made 4.8 attempts (N = 15, range 1 to 18) or encounters before a successful capture. Such an attack sequence often terminated after several encounters with the BFH, and the GM would fly upward at a steep angle (similar to when males collide in flight near a pheromone source or become satiated and then terminate searching behavior as previously recorded (Doane & Cardé 1973)).

The 15 successful captures occurred between 0919 and 1724 hours. A typical capture was followed by a brief ascending flight by the BFH as it cradled the motionless GM. Landing on a leaf, branch or the camp structure, the BFH would promptly begin to process the prey. This procedure was to cut off the wings (often causing each wing to fall separately), legs, antenna, sometimes head, and sometimes parts of the abdomen. Without exception, in those observed, thoracic musculature was saved. These tissues were mascerated somewhat into a bolus before flight back to the nest. The processing of the GM cadaver required on average 188 seconds (N=10, range 89-431) between the time of capture and departure on a flight toward the nest. In the cases where it was fairly certain that only one individual BFH was active in the area (since only once were 2 BFH observed simultaneously), the predator was back in the area on average 232 seconds (N=8, range 68-580) after departing with previously collected food.

All evidence suggested that the BFH had become well conditioned to patrol the area, even in the absence of any GM, as had occurred on August 20 when conditions were unusually cool (16°C at 0800). Observed foraging behavior, as described by Balduf (1954), occurred frequently when no GM were present or very early in the day before commencement of any observed male GM flight activity. In the evening, BFH were observed (and could more easily be detected by their characteristic buzz) well after dusk when GM males showed a continuation of flight activity. This long duration of BFH activity was also noted by Heinrich (1984).

On two occasions when rain interrupted observation periods, all flight activity of the BFH ceased in the area.

The single female GM placed on the screen within view very promptly fell prey to a BFH. Only 170 seconds after positioning the female, a BFH detected the stationary female and flew in close to inspect. At that instance, from a distance judged to be 3 cm away, the BFH hovered in place for more than two seconds before attacking the female by a direct pounce. No attempt to fly followed this capture suggesting that the predator clearly perceived this prey as so heavy that flight was impossible. Processing this female was as with the males except that a large portion of the prothorax and about 2/3 of the abdomen was severed and discarded. Meso- and metathoracic tissues were saved. This process required 4 minutes before departing flight occurred.

Apart from GM as prey, one BFH captured a damselfly, likely *Argia fumipennis violacea* (Hagen) (Odonata: Zygoptera: Coenagrionidae) (as determined by a single wing severed by the BFH). Although the actual capture was not witnessed, it was observed cutting off legs, wings and head, and much of the abdomen, before flying off with a food bolus. During the observation period, a single yellowjacket, *Vespula maculifrons* (Buysson) (Hymenoptera: Vespidae) entered the area and made a single attack on a GM male but failed to capture it.

These observations of BFH feeding on both sexes of GM enhance our understanding of both the natural enemies associated with GM populations and on the food acquisition behavior of BFH. Previous records of BFH food sources have been compiled (Akre *et al.* 1980, often citing others) and can be summarized as (1) apparently only occasionally scavenging for protein from flesh of a mammal, reptile or fish carcass, or more frequently (2) foraging for live insect prey. With live insects being the most preferred, flies, other yellowjacket species, and larger insects, including cicadas, are common prey. In another Maine habitat, Heinrich (1984) observed BFH feeding on a muscid fly and a moth, however, perhaps more significant were the records of foraging BFH that made many erroneous attacks on objects or visual clues perceived as potential prey. Grant (1959) reports the unusual occurrence of BFH attacking a hummingbird by bringing it to the ground before it then escaped. From present observations, actively flying male GM are clearly very acceptable prey and are not free from aerial attack. Similarly, sedentary GM females are readily recognized as prey and may even be much more vulnerable than are the highly active males. Just what impact BFH predation may have on a low density GM population remains unknown but warrants investigation.

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SUNIUS MELANOCEPHALUS (COLEOPTERA: STAPHYLINIDAE), A PALEARCTIC ROVE BEETLE NEW TO NORTH AMERICA[1]

E. Richard Hoebeke[2]

ABSTRACT: *Sunius melanocephalus*, a paederine rove beetle common throughout most of Europe, is reported for the first time from North America (New York), based on the examination of specimens in the Cornell University Insect Collection and collections made by the author. Notes on its distribution, biology, and possible adventive status are provided, and a habitus of the adult, male fifth and sixth visible sternites, and aedeagus are illustrated to facilitate identification.

While several modern monographic papers have dealt with the fauna of the staphylinid subfamily Paederinae for portions of the Palearctic region (i.e., Bohac, 1985a, 1985b, 1986; Coiffait, 1978, 1982, 1984; and Lohse, 1964), no such comprehensive works have been attempted for paederine rove beetles of North America. Thus, in many cases, species level identification of these beetles from the available literature has proven difficult at best.

While identifying numerous Staphylinidae that have recently accumulated in the Cornell University Insect Collection, I found several specimens of the Palearctic paederine *Sunius melanocephalus* (F.), all collected in New York State. The specimen records, listed below, represent the first documented presence of this Palearctic species from North America.

The present paper is intended to contribute to the understanding of this newly detected species in the eastern United States. Distributional data are given, known bionomics of the species are summarized, and morphological characters are described and illustrated to allow for the identification of adults.

There is considerable variation in the number of nominal species recorded in the paederine genus *Sunius* Stephens (= *Hypomendon* Mulsant & Rey). Coiffait (1961) lists "une cinquantaince d'species" (about 50 species) for the world fauna, while Bohac (1985b:446) records "about 30 species distributed mainly in the southern parts of the Palearctic region and the Oriental and Nearctic regions. Some species are known from the Australian and Ethiopian regions." The North American species are in need of revision (see under "Remarks").

Sunius is apparently closely related to *Medon* Stephens with which it

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[2] Department of Entomology, Cornell University, Ithaca, New York 14853

once was treated as a subgenus. Both taxa are distinguished from other genera of the *Medon* group (cited by some authors as the subtribe Medonina) by the combination of the coarse, moderately dense umbilicate punctures on the disc of the head, the lack of a median tooth of the labrum, and the separate gular sutures (Moore and Legner, 1975). Adults of *Sunius* are weakly differentiated from those of *Medon* on the basis of the gular sutures diverging from before the middle to the apex (Moore and Legner, 1975). In *Medon,* the gular sutures are parallel in the center of the head.

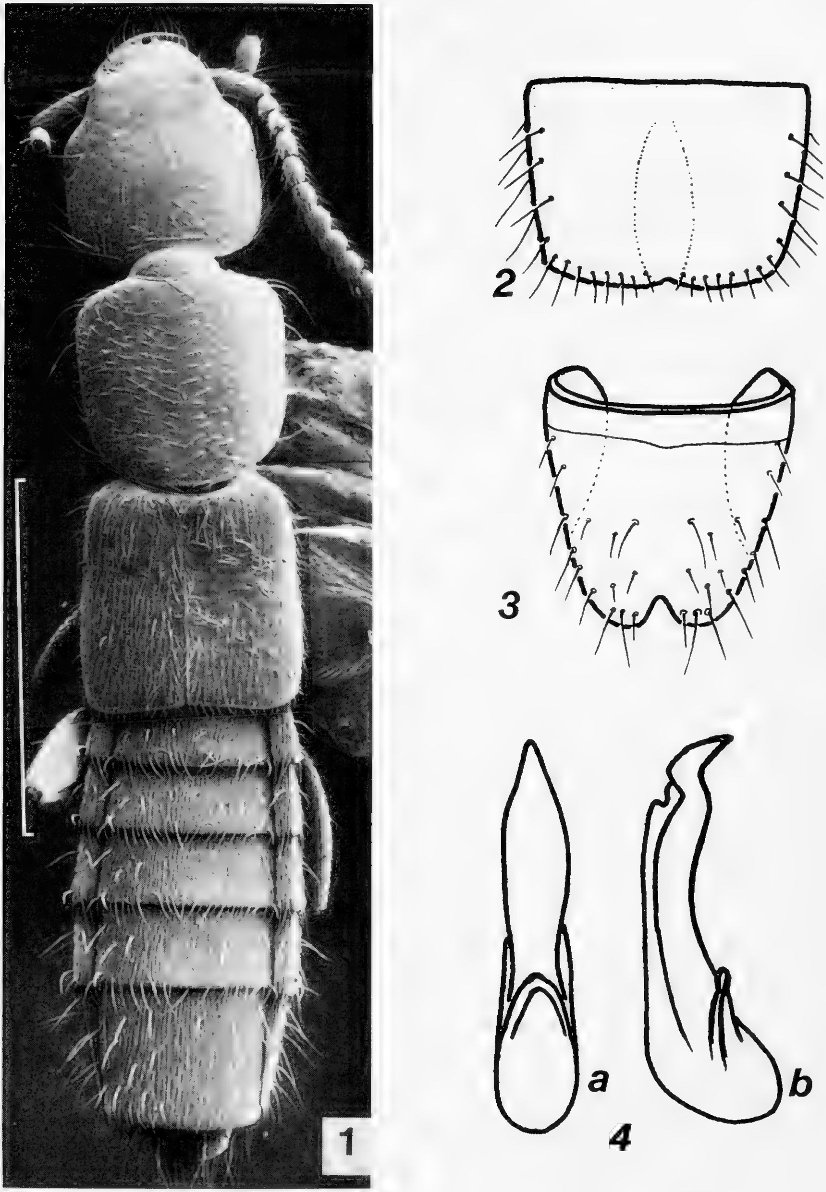
Sunius melanocephalus (F.)

Description. - Dorsal habitus as in Fig. 1. Length 3.0-3.2 mm. Head usually black to pitchy red; pronotum orangish to red; elytra pitchy red, often brownish; and abdomen dull black with apex more or less reddish. Legs, antennae, and mouthparts testaceous. Head and pronotum coarsely and sparsely punctate. Dorsum of head and pronotum without microsculpture, very glossy between punctures. Elytra usually as long as, or apparently a little shorter than, pronotum. Punctation of elytra and abdomen distinctly finer than that of pronotum. Abdominal surface with very faint microsculpture. Apical margin of the male fifth visible sternite slightly emarginate at the middle, with a rather broad longitudinal impression before the emargination (Fig. 2), and of the male sixth visible sternite deeply emarginate at the middle (Fig. 3). Aedeagus broad, robust; apical process of median lobe strongly arched and concave ventrally at apex as in Fig. 4. Armature of the internal sac consisting of a single, elongated, stylet-like plate (not drawn).

Diagnosis. - In eastern North America, adults of *S. melanocephalus* are somewhat similar to those of *S. debilicornis* Wollaston (S.C., Fla., Tx.), a species also introduced into North America with commerce and cosmopolitan in world distribution (Coiffait, 1961; Bohac, 1985b), but differ by the longer antennae and the glossy, reddish pronotum without microsculpture (shorter antennae and yellow pronotum with strong microsculpture in *S. debilicornis*). Among all other North American *Sunius* spp., *S. melanocephalus* differs by the combination of the dorsal coloration (described above), head and pronotum glossy without microsculpture, elytra shorter than or equal to length of pronotum, body length, and the characters of the male fifth and sixth visible sternites and aedeagus.

Specimens examined. - UNITED STATES: NEW YORK: Niagara Co., Olcott, 23 March 1924, H. Dietrich (1♀). Tompkins Co., Town of Ulysses, N of Jacksonville, 13 April 1986 (3♂♂), 19 April 1986 (1♀), 14 April 1990 (1♂, 2♀♀), 20 April 1990 (1♀), 22 April 1990 (1♂), 4 November 1989 (1♀); Ithaca, nr. Cornell Univ. golf course, 28 October 1989, R. Vavrek (1♀). All specimens were collected by the author, unless noted otherwise, and are deposited in the Cornell University Insect Collection.

Biology. - Adults of *S. melanocephalus,* an apparently semi-synanthropic



Figs. 1-4. *Sunius melanocephalus.* 1, dorsal habitus, male; scale line = 1.0 mm. 2, male fifth visible sternite. 3, male sixth visible sternite. 4, aedeagus: a, vental aspect; b, lateral aspect.

species, are found in various wet and dry habitats, such as swamps, banks of streams, wet forests, meadows, gardens, fields, forest-steppes, and sand banks, occurring under decaying matter, moss, haystack refuse, stones, compost piles, between tufts of grass, and in nests of small mammals and ants (Fowler, 1888; Horion, 1965; Bohac, 1985b). Bohac also noted that adults occasionally overwinter in nests of the common mole, *Talpa europaea* L. Adults occur throughout the year, with larval stages obtained in April and October.

Specimens at hand, collected from Tompkins County, New York, were taken under large flat stones, under mats of knotweed (*Polygonum aviculare* L.) overgrowing the edge of a sidewalk, and in a core sample from turf grass (Kentucky bluegrass). New York specimens were collected in March and April, and in October and November.

Distribution. - This Old World species, the type species of the genus, is widely distributed in cental and southern Europe and ranges into the southern parts of Asia Minor (Bohac, 1985b).

REMARKS

Cataloguers of the Staphylinidae (e.g., Bernhauer and Schubert, 1912; Leng, 1920; and Moore and Legner, 1975) have not previously recorded *Sunius melanocephalus* as part of the North American fauna, nor have early coleopterists (i.e., T.L. Casey, J.L. LeConte and T. Say) mentioned in their works the presence of this species in North America. Since the genus *Sunius* is still relatively poorly-known and unrevised, the logical question arises whether the newly detected specimens of "*S. melanocephalus*" are conspecific with some previously recorded species of the genus in North America.

In America north of Mexico, Moore and Legner (1975) list 28 species of *Sunius* (inclusive of the nominate subgenus, and *Caloderma, Trachysectus,* and *Hypomendon*). All but 5 species were described by T.L. Casey (most as *Caloderma* and subsequently reassigned to *Hypomedon*) in his monograph of the American Paederini (Casey, 1905). The majority of the total (22 spp.) are recorded west of the Rocky Mountains.

After critical examination of the original descriptions of the Casey species, and especially of those occurring in the East, I can unequivocally conclude that the specimens of "*S. melanocephalus*" are distinctive, differing significantly from those previously described from North America.

Because *S. melanocephalus* is partially associated with man-made habitats in Europe and North America (=semi-synanthropic), and because another congener (*S. debilicornis*) has been found to be immigrant in North America (Coiffait, 1961:16), I strongly suspect that *S.*

melanocephalus has been accidentally introduced into North America with commerce. Species level work is rarely attempted for most small staphylinids in North America, thus it is not surprising that *S. melanocephalus* (3.0 mm) has escaped previous detection.

At present, specimens are available from only one collection and one area (New York). With no information on the presence or absence of this species elsewhere in North America, one corroborative piece of evidence is missing which would be important in predicting the adventive status of *S. melanocephalus.* Therefore, I cannot rule out the possibility that this species has a broad distribution range across much of the northern hemisphere. Only a detailed inspection of other institutional and university collections will reveal this information. If, however, this species is found to have a restricted distribution pattern in North America (i.e., eastern U.S.), then I am confident that the major criteria for recognizing an introduced species (see Lindroth, 1957:135-143) have been satisfied.

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SOCIETY MEETING OF OCTOBER 24, 1990

DESERT CRANE FLIES

by Dr. Jon Gelhaus

Dr. Jon Gelhaus from the Academy of Natural Sciences in Philadelphia presented the talk at the first society meeting of the 1990-91 year. The meeting was held in Townsend Hall at the University of Delaware with 21 members and guests present. Dr. Gelhaus spoke on desert crane flies of the subgenus *Tipula (Eremotipula)*, a group that he revised for his doctoral work at the University of Kansas.

Crane flies are an ancient group of Diptera that has been able to adapt to both aquatic and terrestrial habitats. There is even a leaf mining species in Hawaii. They usually feed as larvae on decaying plant matter. Adults have long fragile legs that are easily lost and thus, despite their often impressive appearance as adults, they make poor specimens unless properly handled and are usually avoided by collectors. One wag in the audience defined a crane fly as an insect with fewer than six legs.

Interestingly, those species of *Eremotipula* found in the deserts of the western United States do not have any apparent morphological adaptations to arid habitats. Rather their adaptations seem to be physiological and behavioral. Eggs laid under shrubs diapause through the hot summer when daytime temperatures average near 40°C. They apparently hatch in the fall, if conditions are favorable, but are probably capable of remaining dormant for several years of drought. The larvae are found in the top few centimeters of soil beneath plants such as sagebrush. Adults are found in these bushes in the spring.

Of the about 14,000 known species of crane fly, over 10,000 were described by the late Dr. C.P. Alexander, a benefactor of the Society and an aquaintance of several members in the audience. Following the talk there was a lively exchange of anecdotes. For example, Dr. Curtis Sabrosky related that Dr. Alexander never learned to drive and thus was driven by his wife on all of his field expeditions. Howard Boyd noted that Dr. Alexander's house had a very large room devoted solely for his collection. Dr. Alexander's first publication, one of his last, and many in between were printed in the Society's journals.

Several members of the audience reported on their summer activities. Dr. Paul Schaefer displayed an inverted box he designed to attract nesting *Polistes* wasps so that he could study their Strepsipteran parasite, *Xenos peckii.* (See *Ent. News 101: 182 (1990)).* He mounted

(Continued on page 30)

DISTRIBUTION RECORDS OF *CORYDALUS CORNUTUS* (MEGALOPTERA: CORYDALIDAE) IN COLORADO[1]

Scott J. Herrmann, Henry L. Davis[2]

ABSTRACT: *Corydalus cornutus* is reported for the first time for 14 sites of the Purgatoire River, a tributary of the Arkansas River which lies on the eastern slope of the Continental Divide in Colorado. Distribution records of *C. cornutus* are cited for western slope rivers of the Colorado River basin.

The taxonomic status of dobsonflies (Megaloptera:Corydalidae) in Colorado has been confusing, and their distributional status largely unknown and unreported. The objectives of this publication are to report dobsonfly occurrence and distribution in Colorado, and to clarify the taxonomic status of the species occurring in Colorado. Since 1984 we have made numerous collections of larval and adult corydalids in Colorado east and west of the Continental Divide. The Purgatoire River, a tributary of the Arkansas River located on the eastern slope of the Continental Divide in the southeast quadrant of the state, was sampled as part of a pre-training environmental study of the Pinon Canyon Maneuvers Site (PCMS) for the U.S. Army. Aquatic macroinvertebrate surveys (Fausch *et al.* 1985) completed during 1983, 1984 and 1985 within the 48 km segment of the Purgatoire River along the east boundary of the PCMS, showed corydalids to be present and common, if appropriate collecting devices were used. In 1987, nine main stem sites within the PCMS were again surveyed, resulting in eight corydalid collections. In March and November 1987, we collected corydalids at six of ten sites outside the PCMS extending from Trinidad, CO to the confluence of the Purgatoire and Arkansas Rivers near Las Animas, CO. Other eastern slope rivers (Arkansas, South Platte and North Platte) in Colorado and their major permanent tributaries were monitored in our earlier research studies.

The rivers and streams on the western slope of the Colorado Continental Divide that were sampled as part of this corydalid inventory included the Rio Grande, Conejos, San Juan, Piedra, Los Pinos, Florida, Animas, LaPlata, Mancos, McElmo, Dolores, San Miguel, Gunnison, Colorado, White, Yampa, and Green. Several entomologists from Colorado and adjoining states provided additional material for inclusion in this report.

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[2] Department of Life Sciences, University of Southern Colorado, Pueblo, CO 81001-4901

Corydalid records from the Colorado western slope contained in these and government reports are included in this paper.

Adult male and female corydalids from east and west of the Colorado Continental Divide were sent to Dr. Elwin D. Evans for identification; Evans (1988) reported all our Colorado specimens to be *Corydalus cognatus* Hagen, a species originally described from the Pecos River, western Texas, by Hagen (1861). For his dissertation Evans (1972) examined over 350 adults from Arizona, California, Nevada, New Mexico, Texas, Utah and eight states in Mexico; he identified these western specimens as *C. cognatus*. According to Evans (1972) and Evans and Neunzig (1984) two species of *Corydalus* occur in North America north of Mexico, an eastern form *C. cornutus* (Linnaeus) and a western form *C. cognatus*. Evans (1972) reported males of *C. cognatus* differ from males of *C. cornutus* in being light grayish brown in color; having shorter wing lengths, rarely exceeding 45 mm; and having shorter mandibles, usually less than 7 mm and a lightly sclerotized aedaegal bar with projections widely separated.

Glorioso (1981) examined about 900 specimens from all the western states of the United States (except Nevada) and the states of Mexico cited by Evans (1972), and from Canada and many of the eastern states of the United States; he identified them as *C. cornutus*, and did not include *C. cognatus* in his list of 13 valid species of *Corydalus*. Glorioso did examine the female holotype of *C. cognatus* and concluded it was a synonym of *C. cornutus* (Flint 1986). Unfortunately Glorioso never completed his work defining the dozen or so species of *Corydalus* he felt were valid and describing the wide range of intraspecific variation in the genus.

Historically, Weele (1910) synonymized *C. cognatus* under *C. cornutus*. Without any explanation Chandler (1956) cited the western form of *Corydalus* to be *C. cognatus*. According to Evans (1972) Chandler's personal notes gave no reason for his statement. Penny (1977) cited *C. cognata* Hagen (1861) as a *nomen nudum* even though Hagen included a description with the published binomial name; perhaps Penny more correctly should have declared the species *nomen dubium*.

Until new information is forthcoming to justify separating *Corydalus* into two species, we shall follow the recent conclusion of Glorioso (1981), namely, only one species *C. cornutus* occurs in Canada and throughout the United States with much intraspecific variation. We have designated all Colorado material to be *C. cornutus*.

Dobsonfly larvae (hellgrammites) and adults commonly occurred in the Purgatoire River at 14 sites (Fig. 1) from its confluence with the Arkansas River near Las Animas upstream 201 km (125 mi) to near the

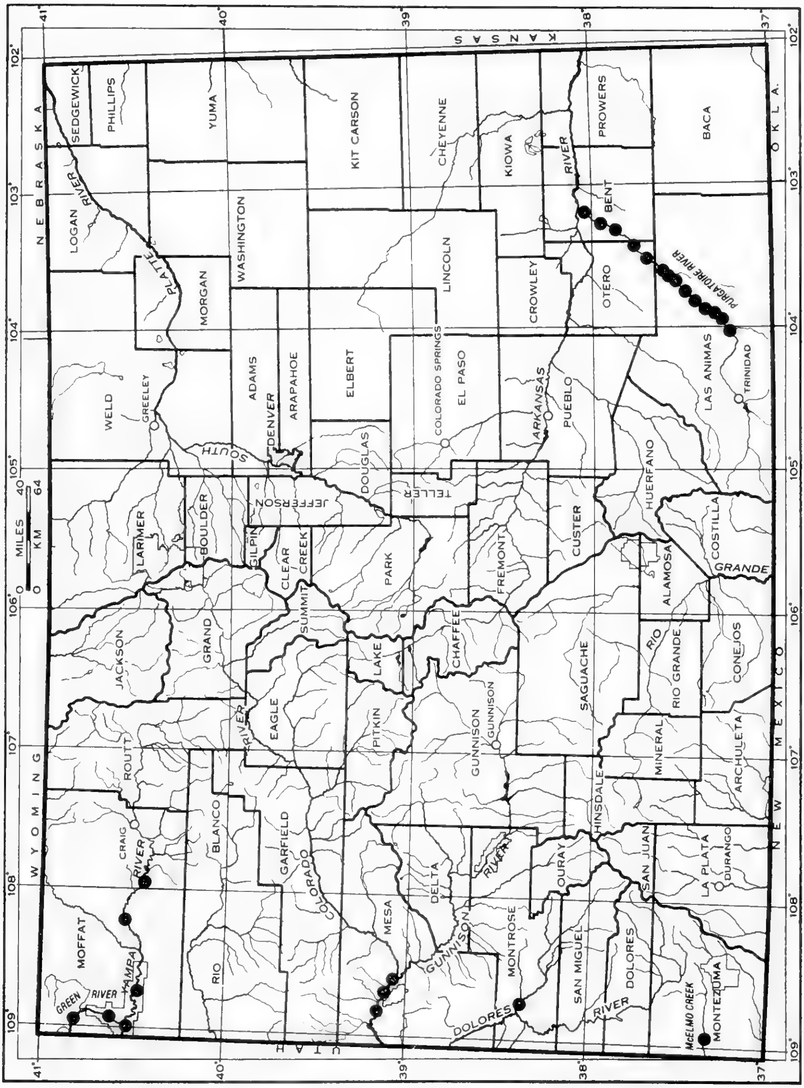

Figure 1. Distribution records of *Corydalus cornutus* in Colorado. Solid circles mark specific collection sites.

head or start of the Purgatoire River Canyon. No corydalid larvae have been collected upstream from the head of Purgatoire Canyon at the confluence of San Francisco Creek, or from any other tributary or the main stem of the Arkansas River in Colorado. Both the North Platte and South Platte River drainages in Colorado appear devoid of corydalids at this time. One hellgrammite was reportedly collected from the Republican River drainage in extreme eastern Colorado by a representative of the Colorado Division of Wildlife; this report is unsubstantiated by museum material.

Nonspecific reports of corydalids from the Colorado River on the western slope have been reported by Ward (1985) and Ward, Zimmerman and Cline (1986); the specimens serving as a basis for these reports could not be located. We have collected *C. cornutus* in the Colorado River from Grand Junction to the Utah-Colorado border, as well as from the Gunnison, Yampa and Green Rivers. During 1964 and 1965 Pearson (1967) collected *C. cornutus* from the Green River in Colorado and Utah and from the Yampa River in Colorado. It is noteworthy that Carlson *et al.* (1979) reported collecting no corydalids from the White or Yampa Rivers in their extensive fish and macroinvertebrate sampling efforts; we have corydalid records from sites between their macroinvertebrate collecting stations Y4 (4.8 km west and south of Craig) and Y6 (24.1 km west of Maybell). *Corydalus cornutus* has been reported from two other Colorado tributaries of the Colorado River, the San Miguel River below Uravan (Smith 1977) and McElmo Creek at Stateline (Smith 1979).

Abrupt breaks in the corydalid distribution pattern in Colorado appear to be a result of unsuitable habitat conditions. We have concluded that four environmental criteria must be present if hellgrammites are to occur in a segment of the Purgatoire River of Colorado: (1) large (> 40 cm longest dimension), submerged, flat rocks overlying but not embedded in the streambed for prey organism production and hellgrammite predation, (2) alternating pool/riffle zones for oxygenation of water, (3) overhanging trees and rock ledges not exposed to direct sunlight for oviposition sites, (4) temperature regime appropriate to altitudinal zones or regions of Colorado below about 1830 m (6000 ft) elevation. In Texas, Brown and Fitzpatrick (1978) cited larval growth ceased during periods of low temperature (<10°C) and food scarcity, and observed large hellgrammite populations only in riffles downstream of suitable upstream oviposition sites. Purturbation from trace metals, impoundments, dewatering and wastewaters may have extirpated *C. cornutus* from the main stem of the Arkansas River leaving a remnant population in the Purgatoire River Canyon where suitable conditions still exist.

Collection Sites of Material Examined from East of Continental Divide: Bent Co.: Purgatoire R. at Colo. Hwy. 101 bridge, Las Animas/Picketwire Valley, alt. 1184 m (3885 ft), T23S, R52W, S23; Purgatoire R. at Davidson Ranch ford sites, alt. 1216 m (3990 ft), T24S, R53W, S36; Purgatoire R. at pipeline crossing, alt. 1237 m (4060 ft), T25S, R53W, S27. Otero Co: Purgatoire R. at Colo. Hwy. 109 bridge, Ninemile Valley, alt. 1269 m (4165 ft), T26S, S23; Purgatoire R. at Jack Canyon conflu. and U.S.G.S. gag. sta., alt. 1292 m (4240 ft), T27S, R55W, S12//R54W, S7. Las Animas Co.: Purgatoire R. at Minnie Canyon confl., (PCMS), alt. 1323 m (4340 ft), T28S, R55W, S4; Purgatoire R. at Iron Canyon confl., (PCMS), alt. 1333 m (4373 ft), T28S, R56W, S24; Purgatoire R. at Bravo Canyon confl., (PCMS), alt. 1345 m, (4412 ft), T28S, R56W, S35; Purgatoire R. at Red Rock Canyon confl., (PCMS), alt. 1368 m (4488 ft), T29S, R56W, S18; Purgatoire R. at Lockwood Canyon confl., (PCMS), alt.1384 m (4540 ft), T29S R57W, S36; Purgatoire R. at Spring Canyon confl., (PCMS), alt. 1398 m (4585 ft), T30S, R57W, S10; Purgatoire R. at Taylor Arroyo confl., (PCMS), alt. 1417 m (4650 ft), T30S, R57W, S19; Purgatoire R. at Van Bremer Arroyo confl., (PCMS), alt. 1465 m (4805 ft), T31S, R58W, S16; Purgatoire R. at Silva cattle crossing, alt. 1532 m (5025 ft), T32S, R59W, S15.

Collection Sites of Material Examined from West of Continental Divide: Mesa Co.: Colorado R. so. Fruita, alt. 1359 m (4460 ft), T1N, R2W, S19/20; Colorado R. Colo. Natl. Mon. Fruita Entrance, alt. 1439 m (4720 ft), T1N, R2W, S32; Colorado R./Gunnison R. confl. at Grand Junction, alt. 1390 m (4560 ft); T1S, R100W, S22. Moffat Co.: Yampa R. so. Sunbeam, alt. 1789 m (5870 ft), T7N, R96W, S2; Yampa R. Din. Natl. Monu., alt. 1704 m (5590 ft), T6N, R99W, S21; Yampa R. between Craig and Maybell, alt. 1801 m (5910 ft), T6N, R95W, S2. (All material on loan or deposited in the Aquatic Ecosystems Research Institute (AERI)/Life Sciences Museum of the University of Southern Colorado.)

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We thank Jay H. Linam and James E. Sublette for prepublication reviews; Elwin D. Evans for assistance with identifications; Boris C. Kondratieff and Rick Ballard for loan of Colorado specimens; Robert Bramblett, Doug Sinor, Dave Anderson and George Fischer for assistance with field collections; Thomas L. Warren for U.S. Army assistance and clearance; and especially Bruce D. Rosenlund for travel assistance, partial project support and specimen collection.

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(Continued from page 24)

19 of these boxes around his house in early March and 14 were colonized. In September about 20% of the wasps were parasitized with a high of 41% of hosts in one colony and a maximum of 9 males in one host. Paula Haines also placed several of the same boxes around her house but found it prudent to paint a round black spot on each to mimic the entrace of a bird house. She thereby averted hard-to-answer questions by curious, but entomophobic, friends and neighbors.

Howard Boyd reported that Mildred Morgan and Jane Ruffin put on a Monarch butterfly tagging exhibition at Cape May on the 21 to 23 of September for the New Jersey Audubon Society, Roger Fuester reported that *Coccygomimus disparis*, an ichneumonid parasite of the gypsy moth introduced from Japan by Paul Schaefer in 1976, is now one of the major parasites found in pupae in urban areas of Delaware.

Harold B. White,
Corresponding Secretary

NOTES ON THE DISTRIBUTION AND BIONOMICS OF *MYODOCHA SERRIPES* (HETEROPTERA: LYGAEIDAE)[1]

M.-C. Larivière[2], A. Larochelle[3]

ABSTRACT: The Nearctic lygaeid *Myodocha serripes* is recorded for the first time for Nova Scotia, West Virginia, Kentucky, and Arkansas. Individuals display eurytopic characters and excellent ability to fly.

SOMMAIRE: Le lygéide néarctique *Myodocha serripes* fait l'objet d'une première mention pour la Nouvelle-Ecosse, la Virginie occidentale, le Kentucky et l'Arkansas. Les individus présentent des caractères eurybiotiques et une excellente aptitude au vol.

The lygaéid *Myodocha serripes* Olivier is widely distributed in America north of Mexico, occurring from New England and southern Québec, southward to Florida and Texas, and westward to Colorado and New Mexico (Larochelle 1984; Ashlock and Slater 1988). The species is very uncommon from the northwestern highlands of Connecticut northward (Sweet 1964). The first report of the species from Canada (Québec and Ontario) was by Béique and Robert (1964). From 1983 to 1987, we have collected members of the species not only in Québec, Maine and Louisiana, where it has been previously reported, but also in the following regions (which represent first province and state records):

NOVA SCOTIA:**Queens Co.**, Kempt, 6. VII. 1987, one female collected by a roadside, on moist gravelly-clayish soil, under dead *Carex* stems; first record for the Atlantic provinces of Canada; northeasternmost point of capture of the species in North America.

WEST VIRGINIA: **Gilmer Co.**, Cedar Creek State Park, 14. VII. 1986, one female taken at the edge of a brook, on moist, sterile, half-shady ground, under a stone. **Greenbrier Co.**, Rainelle, 8.VII.1986, one female captured at a roadside running across a deciduous wood clearing, on sandy-gravelly, moderately dry soil, under dead leaves.

KENTUCKY: **Carter Co.**, Carter Caves State Resort Park, 28.VII.1983, one female attracted to black light, at night (lamp set upon a lawn through an open deciduous wood). **Harrison Co.**, Antioch Mills, 31.VII.1986, one female collected by a river bank, on open, wet muddy soil, at the crowns of grasses.

ARKANSAS: **Calhoun Co.**, Locust Bayou, 18.VII.1983, one male found while sweeping vegetation along a river bank, on open, wet, muddy-gravelly soil, sparingly vegetated with grasses. **Conway Co.**, Petit Jean State Park, 21.VII.1983, one female swept from weeds growing throughout an open, dry rocky wood. **Pope Co.**, Lake Dardanelle State Park, 20.VII.1983, one male and one female caught at night, at black light set upon a lawn among

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[2] Biosystematics Research Centre, Agriculture Canada, Ottawa, Ontario KIA OC6, Canada.

[3] Lyman Entomological Museum and Research Laboratory, Macdonald College of McGill University, Ste-Anne-de-Bellevue, Québec H9X 1CO, Canada.

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sparse deciduous trees, on dry soil. **Washington Co.**, Lake Wedington, 22.VII.1983, two males and one female collected at black light, at night, on open, dry ground.

Individuals collected in Québec and Maine were found mostly in dry sandy-gravelly meadows and roadsides, by sweeping forbs and grasses. Material is deposited in the Lyman Entomological Museum and in the authors' collection.

Sweet (1964), who studied intensively the biology and ecology of Lygaeidae in New England, mentions that *Myodocha serripes* adults hibernate in woods, in leaf litter or under bark; in southern Québec, we have found overwintering individuals at the edge of a deciduous wood, among dead leaves. Sweet (*l. c.*) reports also that this seed bug is most commonly found in New England, in new habitats such as fallow fields, gardens, and embankments, vegetated with forbs. Our field-collecting suggests that *M. serripes* is rather eurytopic, being found in many types of habitats (fields, lawns, roadsides, river-banks, clearings, edges of woods, open deciduous woods), on dry or wet soil, with varied density and kinds of low vegetation, forbs and grasses being preferred. In the daytime, individuals stay either on vegetation or on the soil, under vegetal debris and stones; Sweet (*l. c.*) has never taken the insect under rocks but such occurrence has been reported by Torre-Bueno (1908), Blatchley (1926), and Froeschner (1944). The lygaeid has a preference for open habitats, but tolerates open woodlands, provided that sunlight reaches the low vegetation.

The wide range of the species in North America might be explained by its polyphagy (observed by Sweet (*l. c.*) in laboratory), its eurytopic characters, and its excellent ability to fly, especially to light at night.

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IDENTIFICATION OF *CRYPTOLESTES FERRUGINEUS* AND *CRYPTOLESTES PUSILLUS* (COLEOPTERA: CUCUJIDAE): A PRACTICAL CHARACTER FOR SORTING LARGE SAMPLES BY SPECIES[1]

Richard T. Arbogast[2]

ABSTRACT: A character for rapid sorting of mixed species samples of *Cryptolestes ferrugineus* and *Cryptolestes pusillus* is described for the first time, and other characters for identifying these species and *Cryptolestes turcicus* are reviewed.

During a study of insect populations infesting corn stored on farms in South Carolina, it was necessary to separate large numbers of rusty grain beetles, *Cryptolestes ferrugineus* (Stephens), and flat grain beetles, *Cryptolestes pusillus* (Schonherr), collected in pitfall traps. These samples often contained several hundred *Cryptolestes* as well as other beetles.

Species of *Cryptolestes* are small, similar in appearance, and difficult to identify with confidence on the basis of external characters. Consequently, identification is often not carried to the species level. Seven species of *Cryptolestes* have been recorded from stored products (Banks 1979). Of these, three species occur in North America. *Cryptolestes ferrugineus* and *C. pusillus* are widespread and abundant (Howe 1957). The third species, *Cryptolestes turcicus* (Grouvelle), occurs largely in flour mills although it has been recorded from whole grain. It was found only once in an extensive survey of farm storages in South Carolina (Horton 1982).

Identification keys based on external morphological characters (Reid 1942, Lefkovitch 1959) are of limited use, because the characters are variable and differences among species are small. *Cryptolestes ferrugineus* can be separated with certainty from *C. pusillus* and *C. turcicus* by ridges on the head (Biege and Partida 1976), but the ridges are weak and sometimes difficult to see except with a scanning electron microscope or in cleared specimens under a compound microscope. The following summarizes the most useful external characters that have been proposed for separating the three species (Lefkovitch 1959, Biege and Partida 1976, Banks 1979, Agricultural Research Service 1986):

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[2] Stored-Product Insects Research and Development Laboratory, ARS, USDA, P.O. Box 22909, Savannah, GA 31403

C. ferrugineus: male and female antennae subequal; males with external mandibular tooth; head without transverse ridge near dorsal posterior margin; pronotum narrowed posteriorly, especially in males; four rows of setae between first and second, and between second and third elytral striae.

C. pusillus: male antennae much longer than those of female, about two-thirds as long as the body; males lacking an external mandibular tooth; head with transverse ridge near dorsal posterior margin; pronotum transverse, slightly narrowed posteriorly in males; four rows of setae between first and second, and between second and third elytral striae.

C. turcicus: male antennae much longer than those of female, as long as or longer than the body; males lacking external mandibular tooth; head with transverse ridge near dorsal posterior margin; pronotum nearly quadrate; three rows of setae between first and second, and between second and third elytral striae.

Figure 1. Males of *C. ferrugineus (Cf)* and *C. pusillus (Cp)* illustrating the difference in sclerotization of the abdominal tergites.

In general, positive identification requires examination of male or female genitalia. The usual method for this involves clearing in KOH and dissection of the genitalia, a time-consuming procedure that is impractical for sorting large samples by species. Banks (1979) described a clearing method that permits observation of male and female genitalia *in situ.* The method preserves the relative positions of the various genitalic structures (which is an aid in identification) and permits more rapid processing of specimens, but the time required for clearing, mounting, and identification is still impractical for very large samples.

In examining several thousand specimens of *C. ferrugineus* and *C. pusillus* that had been stored in 70% ethanol, I found that the two species could readily be separated by the appearance of the abdominal dorsum. The abdominal tergites of *C. ferrugineus*, which are more heavily sclerotized than those of *C.pusillus*, appear as a series of distinct dark bands (Fig. 1). The weakly sclerotized abdominal tergites of *C. pusillus* are faint. The contrast between the two species is actually greater than suggested by the micrograph in Fig. 1. When viewed by reflected light under a dissecting microscope (150X), the abdominal dorsum of *C. pusillus* appears uniformly colored without noticeable sclerotization. This character, which applies to both sexes and can be observed quickly with little manipulation of specimens, makes it practical to identify large samples to species. The elytra of specimens preserved in alcohol are often open or can be opened with little difficulty to expose the abdominal dorsum, but the dark tergites of *C. ferrugineus* can also be observed through the elytra.

The storages sampled in our South Carolina study were an unlikely habitat for *C. turcicus*. Furthermore, examination of genitalia and various external characters of several hundred specimens failed to detect any *C. turcicus.* In such situations, in which it has been established with reasonable certainty that a mixed species sample of *Cryptolestes* consists only of *C. ferrugineus* and *C. pusillus,* the sample can be sorted by species using the character described in this paper.

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SOCIETY MEETING OF NOVEMBER 28, 1990

LYME DISEASE - TOO MUCH ADO ABOUT NOTHING?

by Dr. Cara Fries

A provocative title addressed to an at-risk population of entomologists attracted nearly 40 members and guests to the Academy of Natural Sciences of Philadelphia to hear about Lyme disease. The talk was given by Dr. Cara Fries, an immunologist in the School of Life and Health Sciences at the University of Delaware. She presented a thorough background on the discovery, pathology, treatment, and distribution of Lyme disease and then described her research on the distribution of infected deer ticks in Delaware.

The disease now called Lyme disease was first described in 1904 in Sweden. It was not until the mid-1970's when a large number of arthritic children living in a wooded area near Lyme, Connecticut, focused public attention and research on the then mysterious disease. *Borrelia burgdorferi*, a spirochete so slender (about 0.2 µm x 20 µm) that it is not seen by ordinary light microscopy, causes the disease. Infection occurs from the bite of the deer tick, *Ixodes dammini*. Usually, but not always, the bite is followed by a characteristic bull's eye rash. At this point the disease is easily treated with antibiotics, and the more severe and less tractable symptoms of the untreated disease are avoided.

The tiny six-legged tick larvae hatch and feed on small mammals such as the white-footed mouse that frequently are infected with the spirochete. Subsequently the various eight-legged nymphal stages and the adult can go on to infect other hosts including humans, domestic animals, and birds. A small number of larvae may become infected directly from the parents through direct transfer in the egg or sperm. Because the spirochete is shed in the urine, there are other direct routes of transmitting the disease among mammals that do not involve ticks.

In an effort to define the range and abundance of infected ticks in Delaware, Dr. Fries and associates collected over 3000 ticks from deer killed during the 1988 hunting season. Using immunological and microscopic techniques, ticks were analyzed for *Borrelia burgdorferi*. In the heavily populated northern part of Delaware, between 10 and 20% of the ticks were infected, while the southern half of the state yielded spirochete-free ticks with rare exceptions. This pattern raises questions about the spread of the disease and the ticks since infected birds and domestic animals could spread both.

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HEAD DAMAGE FROM MATING ATTEMPTS IN DRAGONFLIES (ODONATA:ANISOPTERA)[1]

Sidney W. Dunkle[2]

ABSTRACT: Damage to the female's head occurs during mating in some species of dragonflies, most prominently in Gomphidae. In 12 species of Nearctic Gomphidae, 88-100% of mature females had 2-6 holes in their heads resulting from the grip of male abdominal appendages. Similar damage occurs during homosexual mating attempts in some male dragonflies.

As one of the first events in mating, male dragonflies of nearly all species grasp the occipital area of the female head with terminal abdominal claspers to form a tandem pair. The male abdominal claspers consist of a ventral epiproct and two dorsal cerci, together forming a vertically adjustable clamp. During tandem, the tip of the male abdomen is curled ventrally so that the dorsal surface of the epiproct presses against the dorsal surface of the female's head, while the cerci grip the posterior surface (Figure 1). If the female is willing to mate in response to tactile and other cues, she swings her abdomen downward and forward to receive sperm from the male genitalia on the basal ventral part of his abdomen. The mating pair thus forms a wheel which lasts only a few seconds in some species, most of an hour in others, such as most Gomphidae. The discussion below does not include damselflies (Zygoptera), because the male damselfly holds his mate by her thorax, not her head. A few examples of damage to the female during mating are known in other insects, including puncturing of the right elytra by the male mandibles in the lycid beetle *Calopteran discrepans* (Newn.) (Sivinski, 1981), and the hemocoelic insemination of bedbugs (Hemiptera, Cimicidae) and twisted-wing parasites (Strepsiptera) (Carayon 1966, and Kathirithamby 1989).

Calvert (1920) first noted scars on the heads of female dragonflies. I have previously reported some damage to the heads of female dragonflies due to mating attempts; in Aeshnidae the male epiproct often gouges the dorsal surface of the female's compound eyes (Dunkle, 1979), while in some species of *Ophiogomphus* (Gomphidae) spines on the male epiproct may punch holes in the female's vertex (Dunkle, 1984). The damage described below is much more extensive, and involves wounds

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[1] Received January 9, 1990. Accepted September 9, 1990.

[2] International Odonata Research Institute, P.O. Box 1269, Gainesville, Florida 32602-1269

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inflicted by spines on the male cerci as well as by the epiproct.

METHODS

All appropriate individuals, hundreds of specimens, of dragonflies were examined from my collection, the Florida State Collection of Arthropods, and the International Odonata Research Institute collection. These collections are located in Gainesville, Florida. Specimens which were teneral or juvenile when collected, as shown by shiny wings or wrinkled exoskeleton, had probably not had an opportunity to mate and were not included in this study. As necessary, a detergent solution was used to relax neck membranes of dry specimens to obtain a clear view of the rear of their heads.

RESULTS

Among the extant families of dragonflies, Petaluridae, Neopetaliidae, and Macromiidae possess male cerci of shapes that do not usually damage the female head. Some Aeshnidae, Cordulegastridae, Corduliidae, and Libellulidae have spines on the male cerci, but little damage to the female head seems to be incurred [significant damage seen only in 1 of 12 *Somatochlora linearis* (Hagen) and 1 of 2 *Heteronais heterodoxa* (Selys), both Corduliidae, and 1 of 6 *Cordulegaster diadema* Selys, Cordulegastridae]. This leaves the Gomphidae, where small to large holes in the backs of female heads caused by male cerci were noted in the species listed in Table 1. These represent 2/13 = 15% of the Nearctic genera, and 12/93 = 13% of the Nearctic species. Some other gomphids examined showed less severe damage (subgeneric classification according to Carle, 1986), including the Nearctic *Gomphus (Phanogomphus)* [10 spp.], *Gomphus (Stenogomphurus)* [2 spp.], *Lanthus* [2 spp.], and *Ophiogomphus* [6 spp.], the Neotropical *Epigomphus* [3 spp.] and *Neogomphus* [2 spp.], the European *Gomphus (Gomphus) vulgatissimus* (L.), and the Japanese *Lanthus fujiacus* Fraser.

Hagenius brevistylus Selys, the largest Nearctic gomphid, exhibits the most severe head damage due to mating attempts so far discovered in any dragonfly (Figure 1). The laterodistal spines of the male epiproct gouged the edge of the female's compound eyes, and punctured the exoskeleton in 8/25 = 32% of the females in which the male cerci also punctured the head. A proximodorsal ridge on each side of the male epiproct often (6/25 = 24%) cracks the lateral corners of the female occiput. Finally, a distal spine and a mediolateral spine on each male cercus puncture the rear of the female head (postgenae). The pressure of

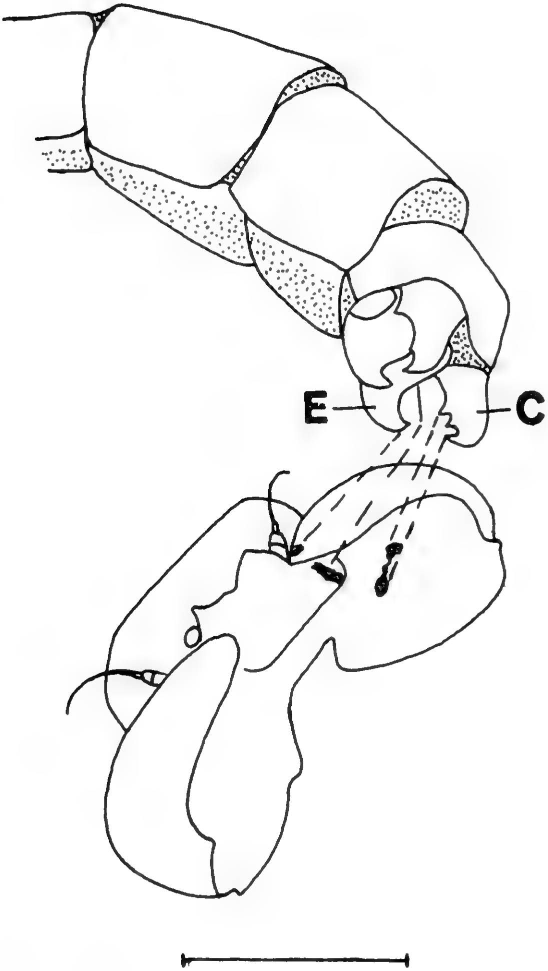

Figure 1. *Hagenius brevistylus*, female head and tip of male abdomen, showing on the right side where the male abdominal appendages puncture the female head during mating attempts. C = right cercus, E = right branch of epiproct, scale bar = 5 mm.

the male grip splits the exoskeleton between the holes made by the cercal spines, resulting in a vertical split in each postgena. Thus a maximally damaged female would have 6 holes of varying sizes punched in her head. A live female *H. brevistylus* was punctured with a dissecting needle to duplicate damage caused by the male appendages; the punctures were into the hemocoel, not air sacs, and did not have any immediate effect on the strength of this female. The postgenal slits usually remain open in wild females; they are not sealed by blood clots. The male grasp does not always damage the female, as 3 females showed epiproctal scars on the eyes but no other damage. The damage is probably cumulative, with each successive mating attempt enlarging the wounds, because old females with chipped wings tended to have the most severe head damage. Johnson (1972) from a study of dried specimens of this species concluded, incorrectly according to the evidence stated above, that the male grasps only the edge of the female occiput. *Hagenius* is often considered a monotypic genus; the few available specimens of the closely related Asiatic *Sieboldius* did not exhibit head damage.

Among the other gomphids in Table 1, all 6 Nearctic species of *Gomphus (Gomphus)* have a sharp distal spine on each male cercus which pokes a hole in each female postgena. These holes are large in *G. adelphus* Selys and *G. viridifrons* Hine, small in the other species. In 5 of the 12 species of

Table 1. Head capsules punctured by male abdominal appendages in Nearctic Gomphidae dragonflies during mating attempts.

Species	% Females (N)	% Males (N)
Hagenius brevistylus Selys	89 (28)	83 (101)
Gomphus (Gomphus) abbreviatus Hagen	100 (10)	0 (18)
G. adelphus Selys	100 (40)	49 (71)
G. apomyius Donnelly	100 (5)	13 (30)
G. geminatus Carle	100 (22)	8 (64)
G. parvidens Currie	88 (8)	9 (22)
G. viridifrons Hine	100 (10)	15 (48)
Gomphus (Gomphurus) dilatatus Rambur	95 (19)	7 (114)
G. lineatifrons Calvert	90 (19)	2 (107)
G. modestus Needham	100 (2)	17 (12)
G. ozarkensis Westfall	100 (32)	3 (36)
G. vastus Walsh	93 (40)	2 (94)

Gomphus (Gomphurus), distolateral cercal spines of the male cut slits in the female postgenae.

Table 1 shows that the heads of males too are damaged by other males during mating attempts, though at a lower rate than in females. The qualitative damage to heads of males was as severe as that of females.

DISCUSSION

Unfortunately, I can only report the existence of the interesting phenomenon described above, not explain it. Nor will it be easy to gather further data on those species which show head damage most clearly (those listed in Table 1), because they are scarce in the field, usually wary and difficult to catch (especially females), and mate in tree crowns. They also do not behave naturally in captivity.

Head damage due to mating attempts in dragonflies does raise some intriguing questions for which answers should be sought if an opportunity arises. For example, does a female dragonfly die sooner, or produce fewer eggs, than expected if microbes enter her head punctures? If a male damages his mate, is she likely to be a less available or fecund mate for other males? Do male dragonflies damage the heads of other males only by mistaken mating attempts, or are there some species in which males use their abdominal appendages as weapons against rival males?

ACKNOWLEDGMENTS

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A NEW SPECIES OF *IDIASTA* (HYMENOPTERA: BRACONIDAE) FROM SPAIN[1]

J. Tormos[2], S.F. Gayubo[2], J.D. Asis[3]

ABSTRACT: A new species of *Idiasta* is described from Spain, and compared with *I. maritima* and *I. paramaritima.*

The Palearctic and Nearctic faunas of the genus *Idiasta* Foerster, 1862 were reviewed by Königsmann (1960) and Wharton (1980) respectively.

Wharton, dealing with the Nearctic Alysiini, established what is known as the '*Phaenocarpa* complex', a complex of genera that is mainly characterized by the second flagellomere being longer than the first. The '*Idiasta* group' lies within this complex. It has the most plesiomorphic features of the complex: a) the first transversal-cubital vein usually longer than the second segment of the radius; b) parallel vein entering the central or posterior part of the brachial cell; c) a well-developed postnervellus; d) ovipositor sheath with short and dense pilosity. Similarly, *Idiasta* is the most primitive genus of this group and conserves the most plesiomorphic features of the mandibles, wing vein pattern and body sculpture. These characteristics are common to other complexes such as the genus *Alysia* Latreille, 1804.

The genus *Idiasta* is extremely difficult to study because of the following: a) the paucity of specimens that have been collected; b) the sexual dimorphism that is fairly pronounced in certain species; c) the lack of biological information (i.e., hosts unknown); d) the lack of studies on intraspecific variation. Docavo *et al.*, 1985 were the first to report two species of this genus from the Iberian fauna: *Idiasta maritima* (Haliday, 1838) and *Idiasta paramaritima* (Königsmann, 1960), captured using 250 W light traps. The species described in the present work is similar to these.

Idiasta titaguensis sp. nov.

Female:- Head: Vertex and occiput with abundant pilosity. Head in dorsal view forms a broad rectangle. Temples 2/3 the size of eyes. Occiput fairly concave. Epicranial suture in the form of a smooth groove. Face rugulose and with a small central keel, with sparse, pale hairs; regular in length, very long near the eyes. Clypeus with long hairs. Eyes black, without pilosity. A smooth shiny pit present between the insertion of the antennae and

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[1] Received September 25, 1989. Accepted March 27, 1990.

[2] Departamento de Biología Animal. Facultad de Biología. Universidad de Salamanca. 37071 Salamanca. Spain.

[3] Fundación Entomológica "Torres Sala". Passeig de la Petxina, 15. 46008 Valencia. Spain.

vertex. Mandibles yellow-brown, teeth with brown edges. Teeth 1 and 3 not very sharp-pointed, tooth 2 approximately 2.5 times longer than teeth 1 and 3. Labial and maxillary palps brown. Antennae fine, black (without a white subapical ring); scape and pedicel slightly lighter. Second flagellar article longer than the first; flagellum with 26 articles; as long as the body.

Thorax: Scutum bulging in anterior part, convex, with some lateral hairs where the parapsidal sulci are situated. Notaulices crenulated and ending in a elongated dorsal pit which extends to the ante-scutellar furrow. The region surrounding the dorsal pit is smooth and shiny. Prescutellar pit broad and subrectangular with pronounced ridges arranged irregularly. Scutellum saddle-shaped, shiny, smooth, bare, with anterior and posterior edges of the same width and with a slight pattern on its sides, thus being neither rounded nor triangular. Sternauli straight, rugose, broad; anterior groove of mesopleuron crenulate, posterior groove narrow and punctate. Pronotum shiny, exhibiting a broad groove with slight identations on each side; its posterior part with long, strong crenulae arranged regularly. Metanotum without keel; black and with long hairs and a smooth shiny base on each side. Propodeal spiracles very small. Legs black, shining.

Gaster: Petiole black, broader at apex than at base; two keels arise from its anterior corners and join to form a central keel that later fuses with the longitudinal striations. Spiracles small and situated more or less in center of the tergite. Remaining tergites also black. T8 with a strong incision in apex. T5-7 split. Length of ovipositor 2/3 length of gaster; ventral valves with 5 teeth each.

Wings: Veins and stigma of forewings dark brown. Forewing otherwise totally transparent and hyaline, with no coloring; only the first three abscissae of radial vein are darker on sides. Pterostigma oval in shape, elongated and well-separate from metacarpus. Radius arising from distal third of pterostigma; length of the first abscissa aproximately equal to diameter of stigma and to length of second abscissa; third abscissa straight, not reaching wing apex. five times longer than second abscissa. Recurrent vein interstitial. Cu2 narrowing towards apex. Brachial cell closed. Parallel vein entering brachial cell below the middle of its distal border. Nervulus interstitial. Tegulae brown. Medius-discoidal vein of the hindwing arising from the middle of median vein.

Length of body without opositor: 4 mm.

Wing-span: 8.5 mm.

Biometric data:- Head: 1.5 times broader than long; 1.5 times broader than scutum. Face: 2.4 times broader than high. Mandibles: 1.36 times longer than apical width; apex 1.05 times broader than base. First article of flagellum 0.52 times length of second; 0.6 times length of third. Thorax: 1.45 times longer than high; 1.43 times higher than wide. Prescutellar furrow: 2 times broader than long. Wings: stigma about 3.6 times longer than broad. r2 1.1 times longer than r1; r3 5 times longer than r2. n.rec. 0.62 times length of d1. Basal vein 1.2 times longer than cu1. Fore wings 2.5 times broader than thorax. Gaster: Petiole 1.1 times longer than apical breadth, its apex 2.1 times broader than base. Ovipositor 1.4 times longer than hind tibiae.

Male: Unknown.

Material examined: Holotype: 1 female, 10-X-1983. Titaguas (Valencia, Spain). This specimen was captured using a 25 W U.V. light.

The holotype is deposited in the Fundación Entomológica "Torres Sala". Passeig de la Petxina, 15. 46008 Valencia (Spain).

This new species differs from *Idiasta maritima* Haliday and *Idiasta paramaritima* Königsmann as follows: (indicated by an # from *Idiasta*

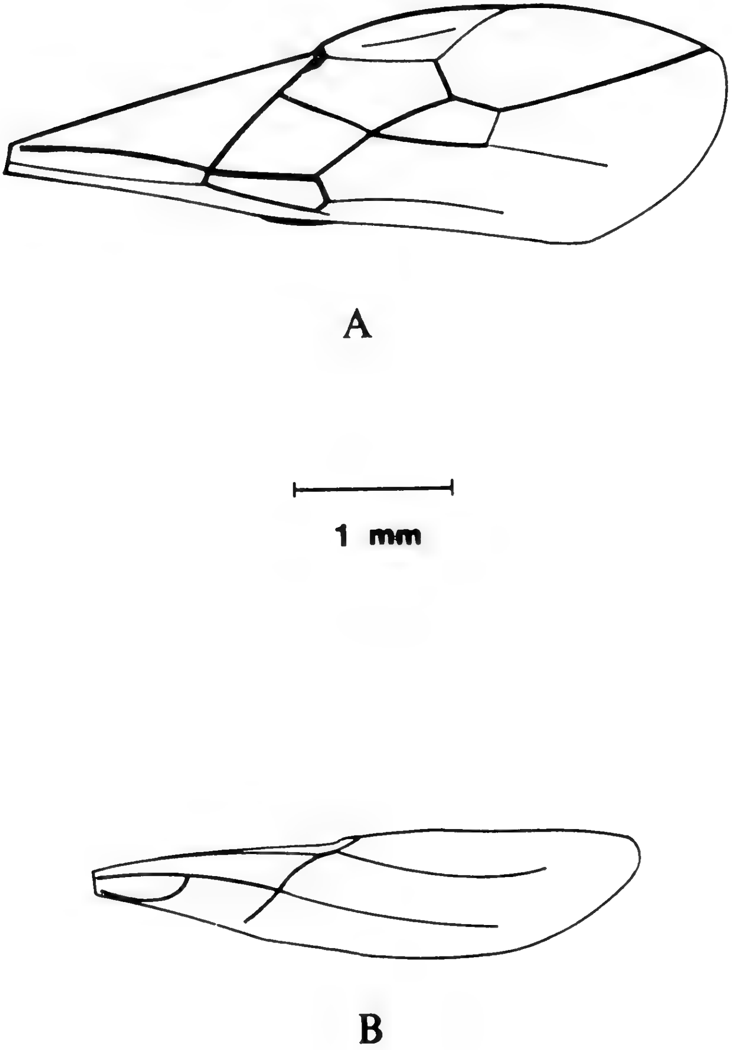

Fig. 1.-A) and B) Fore- and hindwings of *Idiasta titaguensis* nov. sp..

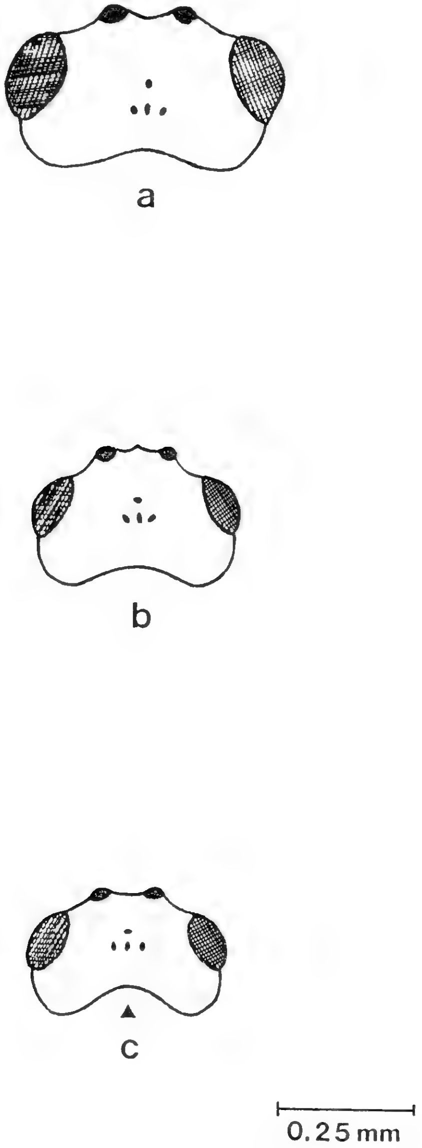

Fig. 2.- Dorsal view of head of *I. maritima* (a), *I. paramaritima* (b) and *I. titaguensis* sp. nov. (c).

maritima and by an * from *Idiasta paramaritima*).

#* Vertex and occiput with abundant pilosity.
#* Fairly concave occiput (fig. 2).
Pilosity of face light colored, scattered, regular in length, longer near the eyes.
Shiny, smooth pit between insertion of antennae and vertex.
Flagellum of antennae black.
* Metanotum without keel (keel poorly developed in *I. paramaritima*).
#* Legs shiny black.
First three abscissas of radius darker on sides.
#* n. rec. interstitial.
#* First abscissa of radius approximately same length as diameter of pterostigma and of second abscissa of radius.
#* Medial-discoidal vein of posterior wing stemming from center of median vein.

The most important characteristic for recognizing this species probably lies in the vein pattern (fig. 1) since the first abscissa of the radius exhibits a similar length to that of the stigma and of the second abscissa of the radius and in no case resembles the features shown by *Idiasta paramaritima* where this transverse vein is approximately ½ that of the diameter of the stigma and ½ that of the second abscissa. It is even more unlike *Idiasta maritima* where this ratio is even less: ⅓ and ¼.

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GOELDICHIRONOMUS AMAZONICUS, (DIPTERA: CHIRONOMIDAE) A POTENTIALLY PESTIFEROUS MIDGE RECENTLY DISCOVERED IN CALIFORNIA[1]

James E. Sublette[2], Mir S. Mulla[3]

ABSTRACT: In the United States, the Neotropical species, *Goeldichironomus amazonicus* has been previously reported from Florida. This California occurrence is the second record from the Nearctic Region.

In a recent investigation of the adult midges emerging from Woodbridge Lake, Irvine, CA, the junior author and coworkers (John D. Chaney and Jettawadee Roadcharoen) collected a series of *Goeldichironomus amazonicus* (Fittkau), a species heretofore unreported from the west coast of the United States. Wirth (1979) listed the sames species from the southern part of Florida and speculated that it may be a recent introduction. In California, adults of this species were collected from premises around a man-made residential recreational lake (Woodbridge). This lake, which is 11 years old, has a surface area of 11 hectares, is 2.1 m deep, and is filled with water from city water mains. The lake watershed is fully developed with homes and recreational facilities on the shoreline and away from the lake. In Woodbridge Lake, *G. amazonicus* is associated with *Cryptochironomus ponderosus (Sublette), Chironomus decorus* Johannsen, *Chironomus frommeri* Atchley and Martin, *Tanypus neopunctipennis* Sublette, and *Procladius subletti* Roback.

The following reviews the history of the species:

Near *Chironomus* (new genus) (species, Nicaragua) Frommer 1967: 17, 26, 36, Figs. 145, 147, 148, morphology, distribution.

Siolimyia amazonica Fittkau 1968: 260, type-locality, Belterra, Rio Tapajos, Para, Brazil; 1971: 27, morphology.

Goeldichironomus amazonicus (Fittkau); Reiss 1974: 86, generic position.

Goeldichironomus amazonicus (Fittkau); Palomäki 1987: 46, distribution.

Extensive collections from southern California have not previously had this species represented (Sublette 1960; Mulla *et al.* 1975; Grodhaus 1963, 1967, 1968; Anderson *et al.* 1964; Brumbaugh *et al.* 1969; Ali *et al.* 1978; Ali and Mulla 1976 a, b; Ali *et al.* 1977.) While this negative evidence

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[1] Received August 8, 1990. Accepted September 10, 1990.

[2] Department of Biology, University of Southern Colorado, 2200 Bonforte Blvd. Pueblo, CO 81001.

[3] Department of Entomology, University of California-Riverside, Riverside, CA 92521.

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is not conclusive, we feel that the species is probably a recent introduction, perhaps a function of increased north-south air traffic within the past two decades.

Sublette and Sublette (1989) listed this species as one of potential public health significance in that nuisance swarms are produced and, further, all members of this genus possess haemoglobin in the larval stage. Such haemoglobin-bearing species constitute a source for one of the most potent allergens for humans when the species form large pest swarms as this one does (Bay 1964). Bay's (1964) material from Nicaragua has been examined by the senior author, confirming that the two populations are conspecific.

This Pan American species is common to tropical and subtropical eutrophic waters and thus has the potential to spread to much of the southern tier of states in the United States. Its known distribution is Brazil, Peru, Panama, Nicaragua, Mexico, Bahamas Islands, and Florida and California in the United States.

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(Continued from page 36)

The discussion following the talk lasted almost as long as the talk. This reflected the high interest in the topic. Dr. Ken Frank displayed nymphal and larval stages of *Ixodes dammini* he had collected from his patients. Dale Schweitzer, who has had Lyme disease twice, warned that local ticks survive a laundry cycle. He also noted that some doctors prescribe prophylactic doses of tetracycline for people who spend lots of time in the field where it is virtually impossible to avoid tick bites. This, however, is a controversial issue among doctors, many of whom refuse to prescribe antibiotics without a positive Lyme test. This situation was lamented by several members. On the side of caution are potential problems with tetracycline such as increased ultraviolet light sensitivity, mottled teeth in children, and digestive tract problems. The fact that there is a new vaccine for dogs provides hope for a human vaccine in a few years.

In notes of local entomological interest Dale Schweitzer noted a variety of unusual late season butterfly records. Among them were a sighting of a Gulf fritillary, *Agraulis vanillae*, on October 27 in Port Norris, New Jersey, and a gray hairstreak, *Strymon melinus*, on November 27 in Cumberland County, New Jersey. A member of the audience observed preying mantis nymphs earlier on the day of the meeting. Ken Frank displayed some lilac branches that had been girdled by giant hornets, *Vespa crabo germana*. Apparently both species are introduced from the same area of Europe. The hornet uses the bark to make the paper for its nest.

Harold B. White
Corresponding Secretary

A DISTRIBUTIONAL STUDY OF *SIALIS* (MEGALOPTERA: SIALIDAE) IN NORTH AMERICA

Michael F. Whiting[1]

ABSTRACT: Locality data for 23 North American species of *Sialis* (Megaloptera: Sialidae) are listed by state and county, 31 new state records are presented, and emergence information for each species is discussed.

There are currently 23 described species of *Sialis* in North America (Ross, 1937; Townsend, 1939; Flint, 1964). When Ross (1937) published his revision of the Nearctic Sialidae, distributional records were rather scanty. Since that time, distributional data has increased from two main sources. First, from studies which emphasized the aquatic larvae (Evans, 1971; Canterbury, 1978). Second, from the publication of state records (Bowles, 1989; Flint, 1964; Liechti & Huggins, 1977; Parfin, 1952; Stark & Lago, 1980; Tarter, 1980; Tarter & Woodrum, 1973a, 1973b; Tarter *et al.* 1976, 1977, 1978, Tennessen, 1968).

Data from over 5,000 specimens of *Sialis* representing more than 1300 localities originating from 23 major North American collections have been recorded. These data are combined with all the published data to give the most complete listing of *Sialis* distributions to date. The purpose of this paper is to provide a comprehensive list of distributions for the further study of *Sialis* in North America.

Locality data for each species are organized as follows: the Canadian records are listed alphabetically by province (in caps) followed by county or internal division if applicable, then the United States data are listed alphabetically by state (in caps), followed by county. Both province and state names are abbreviated using official U.S. postal Zip Code abbreviations. If no county data follows a state, it means that none was recorded with the specimen. Square brackets [] around states or provinces indicate new records. Emergence data are given by listing the earliest and the latest date in the year when the species was collected and includes the states from which each early and late record was recorded. A more complete listing including precise locality, dates, and references for each locality are available from the author upon request.

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[1] Received July 13, 1990. Accepted October 23, 1990.

[2] Department of Entomology, Comstock Hall, Cornell University, Ithaca, New York 14853-0999, U.S.A.

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DISTRIBUTIONS

Sialis aequalis Banks 1920

Type Locality: VA: Falls Church County.
Distribution: CT: Fairfield; DE: Kent; [GA]: Fulton; [KY]: Breathitt; MD: Montgomery; [ME]: Oxford; [MI]: Mason; MN: Itasca; NC: Burke; NJ: Middlesex; NY; OH: Champaign, Hocking; PA: Delaware; SC; VA: Arlington, Brunswick, Fairfax, Falls Church, Suffolk; [VT]: Windham; WV: Cabell, Kanawha, Mason, Wayne.
Emergence: March 20 (SC) to June 13 (MN: Itasca).

Sialis americana (Rambur) 1842

Type Locality: America.
Distribution: CT: New Haven; DC: Washington; FL: Alachua, Baker, Columbia, Highlands, Marion; GA: Wayne; [IN]: Lake; LA: East Baton Rouge, Iberville, St. James; MD: Prince Georges; [MO]; MS: Adams, Hinds, Lafayette; [NH[: Merrimack; [NJ]: Gloucester; OH: Summit; SC; TX; VA: Nansemond; WI: Grant.
Emergence: April 23 (LA: Baton Rouge) to August 13 (IN: Lake).

Sialis arvalis Ross 1937

Type Locality: CA: Calaveras County, Mokelumne Hill.
Distribution: CA: Amador, Butte, Calaveras, Humboldt, Lake, Mendocino, Monterey, Plumas, San Benito, San Luis Obispo, Santa Barbara, Santa Clara, Santa Cruz, Sonoma, Stanislaus, Trinity, Ventura, Yolo; OR: Curry, Douglas, Jackson, Josephine.
Emergence: March 15 (CA: Humboldt) to May 31 (OR: Douglas).

Sialis californica Banks 1920

Type Locality: CA: Kern County, San Emigdio Canyon.
Distribution: AB; BC; CA: Alameda, Amador, Butte, Colusa, Contra Costa, Glenn, Humboldt, Kern, Lake, Lassen, Los Angeles, Marin, Mendocino, Modoc, Mono, Monterey, Napa, Plumas, Sacramento, San Diego, San Joaquin, San Luis Obispo, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Shasta, Siskiyou, Solano, Sonoma, Stanislaus, Tehama, Trinity, Tulare, Ventura, Yolo, Yuba; OR: Baker, Benton, Clackmas, Clatsop, Coos, Curry, Deschutes, Douglas, Hood River, Jackson, Jefferson, Lake, Lane, Lincoln, Linn, Tillamook, Wasco, Washington; WA: King, Klickitat, Pierce, Skamania.
Emergence: March 3 (CA: San Diego) to July 25 (CA: Tulare).

Sialis concava Banks 1897

Type Locality: NY: Tompkins County, Ithaca.
Distribution: [BC]; ON; MD; [ME]: Oxford; NC: Moore, Wake; NY: Tompkins; VA: Augusta, Montgomery, Tazewell; WV: Pocahontas.
Emergence: April 12 (NC: Moore) to July 15 (BC).

Sialis contigua Flint 1964

Type Locality: VA: Highland County, bridge on Route 220 over East Branch Potomac River.

Distribution: TN: Knox; VA: Giles, Highland, Montgomery, Shenandoah, Smyth.
Emergence: April 21 (TN: Knox) to May 5 (VA: Smyth)

Sialis cornuta Ross 1937

Type Locality: OR: Umatilla County, Blue Mountains.
Distribution: AB: ID: Butte, Caribou, Clearwater, Idaho, Latah, Valley; MT: Gallatin, Glacier, Granite, Ravalli; OR: Curry, Umatilla, Union; UT: Duchesne; WA: Asotin, Walla Walla; WY: Crooks.
Emergence: April 29 (OR: Curry) to July 20 (MT: Glacier).

Sialis driesbachi Flint 1964

Type Locality: MI: Schoolcraft County
Distribution: MI: Schoolcraft; MN; [WI]: Sauk.
Emergence: June 5 (MI: Schoolcraft) to June 12 (WI: Sauk).

Sialis glabella Ross 1937

Type Locality: IL: Wabash County, Mt. Carmel.
Distribution: IL: Wabash; KY: Nelson; MS: Adams.
Emergence: May 13 (MS: Adams) to June 16 (IL: Wabash).

Sialis hamata Ross 1937

Type Locality: UT: Cache County, Logan.
Distribution: AB; BC; ID: Ada, Bear Lake, Caribou, Cassia, Kootenai, Latah; MT: Gallatin, Glacier, Lake, Lewis & Clark, Meagher, Ravalli; NV: Elko; OR: Harney, Klamath, Lake, Umatilla, Wasco; UT: Box Elder, Cache, Fremont, Rich, Salt Lake, Summit, Utah, Wasatch, Wayne; WA: Columbia, Garfield, Spokane, Whitman, Yakima; WY: Fremont, Teton.
Emergence: April 13 (ID: Ada) to July 21 (WY: Fremont).

Sialis hasta Ross 1937

Type Locality: MI: Crawford County, Lovells along Au Sable River.
Distribution: AR: Garland, Washington, Yell; IN: Clark, Monroe, Ripley; KY: Breathitt, Bullitt, Fayette, Jessamine, Oldham, Trimble; MI; Crawford, Emmet, Iosco; MO: Greene; OH: Urbana; PA: Allegheny.
Emergence: April 10 (IN: Monroe) to June 16 (MI: Crawford).

Sialis infumata Newman 1838

Type Locality: NJ: Mercer County, Trenton Falls.
Distribution: [ON]: Ottawa-Carleton; AR: Garland, Pike, Washington; IL: Champaign, Cook, Jo Daviess, Kankakee, McHenry, Mclean, Rock Island, Vermilion, Will; IN: Clark, Tippecanoe; KS: Pottawatomie, Riley, Wabaunsee; KY: Oldham, Rowan, Trimble, MI: Tuscola; MN: Lyon; MO; NC: Wake; NJ: Mercer; NY: Genessee, Onodaga, Tompkins; OH: Adams, Butler, Franklin; OK: Pittsburgh; PA: Dauphin, Philadelphia, Snyder; SC; VA: Fauquier, Rockingham; [WV]: Grant.
Emergence: April 7 (KS: Riley) to September 16 (KS: Pottawatomie).

Sialis iola Ross 1937

Type Locality: PA: Allegheny County, Pittsburgh.
Distribution: PQ: L'Assomption, Montreal; CT: Tolland; DC: Washington; [GA]; [IN]: Monroe; MN; MS: Marshall, Tishomingo; NC: Wake; NH: Durham; NJ: Burlington; NY: Clinton, Franklin, Tompkins, Ulster; OH: Champaign, Miami; PA: Allegheny, Dauphin; SC; VA: Alleghany, Montgomery, York; WV: Fayette, Greenbriar, Pocohantas.
Emergence: April 10 (VA: York) to July 29 (PQ).

Sialis itasca Ross 1937

Type Locality: IL: Kankakee County, Momence along Kankakee River.
Distribution: ON: Ottawa-Carleton; PQ: Laprairie, St. Jean; AR: Craighead; DC: Washington; GA: Bibb, Fulton; IL: Coles, Cook, Kankakee, Knox, Piatt, Winnebago; IN: Lagrange, Monroe, Noble; KS: Pottawatomie, Riley; MD: Montgomery; MI: Branch, Cheboygan, Monroe, Washtenaw; MN: Pine; MO; NC: Chatham, Wake; ND: Cass; NY: Chautauqua, Monroe, St. Lawrence, Tompkins; OH: Huron, Washington; OK: Payne; PA: Dauphin; TN: Shelby; TX: Brazos; VA: Augusta, Fairfax, Greene, Rockingham; WI: Douglas; WV: Wayne.
Emergence: April 1 (TX: Brazos) to September 30 (IN: Lagrange).

Sialis joppa Ross 1937

Type Locality: NC: Jackson County, New Found Gap, Great Smokey Mountain National Park.
Distribution: [ON]: Thunder Bay; AR: Crawford, Montgomery; CT: New Haven; DE; [FL]: Liberty; IL; KY: Bullitt, Jefferson, Meade, Oldham; LA: St. James; MD: Montgomery; ME: Cumberland; MI: Cheboygan, Newaygo; NC: Buncombe, Jackson; NH: Coos; NY: Ontario, Schuyler, Tompkins, Ulster, Wyoming, Yates; OH: Jefferson, Noble; OK: Latimer; PA: Delaware, Montgomery, Philadelphia, Westmoreland; VA: Giles, Grayson, Page, Smyth; VT: Orleans; WI: Ozaukee; WV: Pendelton, Summers.
Emergence: April 17 (OH: Jefferson) to July 10 (NH: Coos).

Sialis mohri Ross 1937

Type Locality: WI: Vilas County, Boulder Junction on Trout River.
Distribution: NB: York; ON: Essex, Kenora, Kent, Ottawa-Carleton; PQ; AR: Montgomery, Pike, Washington; CT: New London, Tolland; IL: Champaign, Coles, Cook, Du Page, Edgar, Jackson, Kankakee, Lake, Marshall, Mason, Massac, McHenry, Montgomery, Morgan, Rock Island, Washington, Williamson, Winnebago; IN: Clark, Lake, Monroe, Noble, Porter; KS: Douglas, Pottawatomie; KY: Edmondson; MA: Essex, Middlesex, Norfolk; ME: Aroostook; MI: Cheboygan, Crawford, Emmet, Iosco, Lenawee, Mackinac, Oscoda, Roscommon, Washtenaw, Wayne, Wexford; MN: Anoka, Becker, Beltrami, Goodhue, Hennepin, Houston, Koochiching, Mille Lacs, Pine, Ramsey, Red Lake, St. Louis, Stearns, Todd, Washington, Winona; MS: Hinds, Lafayette, Rankin; MO: [NE]; NH; NJ: Morris, Ocean, Passaic, Rockland; NY: Oswego, Stockton, Westchester; OH; OK: Payne; PA: Luzerne, Monroe, Wayne; RI: Washington; TN: Lake, Obion, Shelby; [VT]: Caledonia; WI: Adams, Barron, Dane, Door, Milwaukee, Sauk, Vilas, Walworth, Winnebago.
Emergence: March 23 (MS: Rankin) to July 14 (WI: Walworth).

Sialis nevadensis Davis 1903

Type Locality: NV: Washoe County, Reno.
Distribution: CA: Amador, El Dorado, Lassen, Madera, Mariposa, Napa, Nevada, Placer, Plumas, Santa Cruz, Shasta, Sierra, Siskiyou, Tehama, Trinity, Tuolumne; NV: Washoe.
Emergence: May 1 (CA: Placer) to 30 July (CA: Nevada).

Sialis nina Townsend 1939

Type Locality: KY: Fayette County, Lexington along North Elkhorn Creek.
Distribution: KY: Fayette
Emergence: April 1 to May 2

Sialis occidens Ross 1937

Type Locality: CA: Tulare County, Sequoia National Park, Wolverton.
Distribution: CA: Alpine, Amador, Calaveras, El Dorado, Fresno, Glenn, Humboldt, Inyo, Lassen Los Angeles, Mariposa, Mono, Nevada, Placer, Plumas, San Bernardino, Santa Barbara, Sierra, Sonoma, Stanislaus, Tulare, Tuolumne; NV: Washoe.
Emergence: From March 23 (CA: Sonoma) to August 30 (CA: Fresno).

Sialis rotunda Banks 1920

Type Locality: BC: Bon Accord.
Distribution: BC; CA: Shasta; OR: Benton, Clatsop, Columbia, Coos, Curry, Deschutes, Douglas, Grant, Jackson, Jefferson, Joseph, Klamath, Lake, Lane, Linn, Marion, Polk, Tillamook, Wasco, Washington, Yamhill; WA: Clallam, Clark, Douglas, Grays, Harbor, King, Kitsap, Lewis, Pacific, Pierce, Snohomish, Stevens, Thurston, Whatcom, Yakima.
Note: Tarter *et al.* (1978) list one male from Wisconsin. Because there is no other evidence to support the occurrance of this species in the Eastern United States, this record is highly questionable.
Emergence: From March 21 (OR: Linn) to September 5 (OR: Jackson).

Sialis spangleri Flint 1964

Type Locality: MD: Garrett County, Swallow Falls State Park near Oakland.
Distribution: MD: Garret.
Emergence: May 14.

Sialis vagans Ross 1937

Type Locality: IN: Whitley County, Columbia City along Eel River.
Distribution: NB: York; NS: Greene; ON: Muskoka, Nipissing, Simcoe; PQ; AR: Greene, Johnson; CT; [FL]: Okaloosa; GA: Coweta; IL: Cook, Cumberland, Du Page, Franklin, Kankakee, McHenry, Pope; IN: White, Whitley; [KS]: Douglas; KY: Jefferson, Oldham; MA: Middlesex, Norfolk, Suffolk; [MD]: Prince Georges; [ME]: Lincoln, Washington; MI: Branch, Crawford, Genessee, Grand Traverse, Iosco, Mecosta, Newaygo, Tuscola, Van Buren, Washtenaw; MN: Cook, Itasca, Morrison, Pine; MS: Amite, Greene, Lafayette, Lincoln, Ranking, Stone; NC: Wake; NH: Strafford; NJ: Burlington, Ocean; NY: Bronx; OH: Gallia, Greene, Summit; OK: Latimer; PA: Chester; VA: Brunswick, Culpeper, Floyd, James City, Prince Edward, Prince William; VT; WI: Washburn; WV: Pocahontas.
Emergence: From March 5 (VA: Prince William) to July 20 (ON).

Sialis velata Ross 1937

Type Locality: MI: Roscommon County, Houghton Lake.
Distribution: AB; BC; MB; ON: Bruce, Grenville, Hastings, Kenora, Ottawa-Carleton, Russell; PQ: Laprairie, Montreal; SK: [CO]: Larimer, Yuma; [CT]: New Haven; DC: Washington; [ID]: Bannock, Cassia, Fremont, Valley; IL: Champaign, Coles, Gallatin, Jersey, Johnson, Madison, Mason, Pope, Rock Island, Wabash, Washington, White; KS: Douglas, Franklin, McPherson, Pottawatomie, Riley; KY; MA: Middlesex, Norfolk; MD: Montgomery; ME: Lincoln, Penobscot; MI: Arenac, Benzie, Cheboygan, Crawford, Gogebic, Ingham, Leelanau, Roscommon, St. Joseph, Washtenaw, Wayne; MN: Anoka, Becker, Beltrami, Cass, Clearwater, Crow Wing, Hubbard, Itasca, Lake, Mille Lacs, Morrison, Olmstead, Pine, Ramsey, St. Louis, Washington; MO: Boone, Marion; [MT]: Flathead, Yellowstone; NC; ND; NB; NH; [NJ]: Rockland; NY: Albany, Clinton, Cortland, Hamilton, Onodaga, Ontario, Oswego, St. Lawrence, Tioga, Tompkins, Yates; OK: Garfield; TN: Marion; TX: Bexar, Kerr, Travis; [UT]: Box Elder, Cache; VA: Appomattox, Giles, Montgomery, Page, Roanoke, Rockbridge, Shenandoah, Smyth, Wythe; VT; WI: Dane, Door, Vilas, Waukesha; WV: Jefferson; [WY]: Carbon, Crook, Laramie.
Emergence: From March 24 (TX: Kerr) to September 15 (MI).

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FUNGAL HOST RECORDS FOR EROTYLIDAE (COLEOPTERA: CUCUJOIDEA) OF AMERICA NORTH OF MEXICO[1]

Paul E. Skelley[2], Michael A. Goodrich[3], Richard A. B. Leschen[4]

ABSTRACT: Host fungi for 35 species of Erotylidae from America north of Mexico are reported. Most species have clear host preferences, with varying degrees of specificity. Host relationships of North American Erotylidae, based on their host preferences, are discussed.

The Erotylidae of America north of Mexico comprise 49 species (Boyle 1956, Goodrich & Skelley 1990). Although they are commonly collected, published information on their life histories and host preferences is limited.

Erotylids feed on macro-Basidiomycetes (Hymenomycetes); bracket fungi (Aphyllophorales) and mushrooms (Agaricales). Adults are sometimes found in numbers on fresh sporocarps and occasionally several species are represented in a collection from one fruiting body. Larvae and adults feed on various parts of the fungal sporocarp. Some species are surface grazers, others gill and context (flesh of cap and stalk) feeders. Some of the rarely collected species may feed on sporocarps which are hidden, subterranean, or subcorticulous. A few species may even feed on the hyphal mat which produced the sporocarp.

The duration of the three larval instars varies among species and may be related to host texture and persistence. Pupation usually occurs in various places outside the host; exposed and hanging from the host log as in *Cypherotylus* (Graves 1965), in the ground as in *Tritoma,* or in rotten wood as in some *Triplax*. The species studied readily transformed to adults without a quiescent period in the larval or pupal stages. The adult stage appears to be the longest lived.

The objective of this study is to compile a fungal host list composed of data from the literature and new data from museum specimens and field collecting. Patterns of host utilization and other phenomena which could be of evolutionary or taxonomic significance are noted.

In compiling the data presented, museum specimens have been of limited value. Since most insect collectors are unfamiliar with fungal taxonomy, most museum specimens lack specific host data. Host data

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[1] Received: November 29, 1990. Accepted: December 24, 1990.

[2] Entomology and Nematology Department, Building 970 Hull Road, University of Florida, Gainesville, FL 32611-0740, U.S.A.

[3] Department of Zoology, Eastern Illinois University, Charleston, IL 61920, U.S.A.

[4] Snow Entomological Museum, University of Kansas, Lawrence, KS 66045, U.S.A.

are often ambiguous (ie: "ex: gill fungus") or give names of one large and inclusive genera (ie: "ex: *Polyporus* sp."). *Polyporus* once included 162 species (Overholts 1953), but now only 18 species are placed in this genus (Gilbertson & Ryvarden 1987). For these reasons, the majority of the records included here are from recent field work and rearing studies carried out by the authors. This work was based in the eastern and central United States, accounting for the larger host lists of these species.

When examining the host list, the following should be recognized: 1) In general, the taxonomy of the host fungi is not as well worked out as the taxonomy of the Erotylidae, and finding mycologists who can identify specimens is difficult. Therefore, it is possible that early host records from the literature, or data taken from museum specimens, were based on mis-identified material. This may also be true for beetle identifications in some early published records. 2) Repeated host records are more likely to be important hosts for the beetle. Those "hosts" with only one collection record of a few specimens are of questionable importance (Ashe 1984). 3) In some beetle genera, host overlap indicates that adults are less specific in their host preference than larvae. Ashe (1984) found this to be true for members of the Staphylinidae. This may explain why adults of different erotylid species are found on the same sporocarp. In most of our rearings, only one species was reared from a series of larvae collected in a fungus. Different beetle species with the same larval host seem to be separted by habitat or season of activity. In the few rearings where two "species" developed; the species are closely related, have questionable specific validity, and will be discussed in future papers. 4) Beetle species are not always completely sympatric with their preferred hosts or they may favor different hosts in different geographic regions. In these cases, different beetle species might utilize the same host fungus, creating an overlap in host records (Newton 1984).

METHODS

Beetles are listed in phylogenetic order (Boyle 1956) and by their currently accepted names. See Boyle (1956) and Goodrich & Skelley (1990) for lists of erotylid synonyms. Host records are reported under each beetle species in the following format:

Beetle name
A, B *Fungus name*
Fungus synonomy {Comments} [Citations]

Names of host fungi are recorded as they appear on museum specimens or in the literature, except for obvious misspellings. Synonyms are indented under the corrently accepted name. Our comments are placed in braces, { }. Records marked with {?} have questionable validity, and indicate that a misidentification may have occurred. When host records were found in the literature, they are cited in brackets, [ ]. Numbers in the code to the left, A, B, represent the number of beetles seen from that host: A = number of collections; B = number of adult beetles and/or larvae taken (ie; a citation of "3, 15" means that beetle has been taken on that host 3 times with a total of 15 specimens collected). When other authors gave the number of specimens collected at a host, these figures are reported within the brackets with the citation after a colon in the same code given above. An asterisk before a host indicates the beetle has been reared from the fungus, and a plus symbol indicates larvae have been collected on the fungus. Larval records are included only where the larvae have been positively identified.

Beetle specimens studied are deposited in collections of the institutions or individuals listed in the acknowledgments and in those of the authors and their institutions.

RESULTS

A total of 3,533 specimens were collected and/or reared from host fungi by the authors. An additional 2,284 museum specimens bearing significant host data were examined and identified, giving a total of 5,817 specimens of Erotylidae (representing 35 species) with host records. The list of host fungi for the Erotylidae north of Mexico follows:

DACNINAE

Dacne Latreille 1796

Dacne quadrimaculata (Say 1835)

1, 1	*Clavicorona pyxidata*
	Clavaria coronata
1, 1	*Ganoderma applantum*
	Hypsizygus ulmarius
	Pleurotus ulmarius [Weiss & West 1920]
1, 1	*Lentinus lepideus*
	Piptoporus betulinus
	Polyporus betulinus [Chagnon & Robert 1962]
5, 49	**Pleurotus ostreatus* [Boyle 1956]
2, 51	**Pleurotus sapidus*
1, 1	**Pluteus cervinus*

11, 93 *Polyporus squamosus*
Melanopus squamosus
1, 1 *Stereum ostrea*

Dacne californica (Horn 1870)
Pleurotus ostreatus [Boyle 1956]
1, 1 near *Pleurotus* ?
1, 3 *Pleurotus* sp.
**Polyporus* sp. [Boyle 1956]

Dacne picea LeConte 1875
No host data available.

Dacne cyclochilus Boyle 1954
1, 6 *Hydnochaete* sp.
1, 4 *Pycnoporellus alboluteus*
Polyporus alboluteus

Dacne pubescens Boyle 1956
No host data available.

Microsternus Lewis 1887

Microsternus ulkei (Crotch 1873)
Inonotus cuticularis
Polyporus cuticularis [Blatchley 1910]
1, 2 *Phellinus gilvus*
Polyporus gilvus
Polypora sp. [Dury 1878]
1, 4 vicinity of *Stereum ostrea*

Megalodacne Crotch 1873

Megalodacne fasciata (Fabricius 1777)
Fomes fraxineus [Weiss & West 1921a]
Fomes sp. [Kitayama 1986: 1, 10]
3. 8 +*Ganoderma lucidum*
Ganoderma curtisii
Polyporus lucidus [Weiss & West 1920, 1921b]
1, 1 *Ganoderma* sp.
1, 3 *Meripilus giganteus*
Pleurotus sapidus [Weiss & West 1920]
1, 1 *Polyporus* sp. [Froeschner & Meiners 1953]
Trametes versicolor
Polyporus versicolor
[Weiss 1920c; Weiss & West 1920]

Megalodacne heros (Say 1823)
1, 2 *Ganoderma applantum* [Boyle 1956]
Fomes applantus [Boyle 1956; Park & Sejba 1935]
1, 1 +*Ganoderma lucidum*
4, 18 *Ganoderma tsugae*
Polyporus tsugae

1, 4	*Ganoderma* sp.
	Peziza sp. {Ascomycete} [Boyle 1956; Park & Sejba 1935]
1. 1	*Pleurotus sapidus*
1, 1	*Polyporus tenuiculus*
	nr. a *Favolus brasiliensis*
1, 3	*Polyporus radicatus*
	Polyporus sp. [Boyle 1956; Park & Sejba 1935]

EROTYLINAE

Cypherotylus Crotch 1873

Cypherotylus californicus (Lacordaire 1842)

	+*Bjerkandera adusta*
	Polyporus adustus [Graves 1965:1,200]
1, 1	*Datronia scutellata*
1, 3	+*Perenniporia medulla-panis*
1, 1	+*Phellinus everhartii*
2, 3	+*Spongipellus unicolor*
1, 7	+*Trametes versicolor*
	Coriolus versicolor

TRIPLACINAE

Tritoma Fabricius 1775

Species group ***humeralis***

Tritoma biguttata affinis Lacordaire 1842

1, 18	*Amanita bisporigera*
1, 4	*Amanita ceasarea*
2, 60	**Amanita excelsa*
9, 89	**Amanita rubescens*
1, 3	*Amanita subsolitaria*
1, 1	*Amanita verna*
2, 7	*Amanita virosa*
12, 73	**Amanita* sp.
2, 3	*Armillariella tabescens*
1, 6	*Boletaceae
1, 12	**Lactarius piperatus*
1, 5	*Lepiota* or *Amanita* sp.
1, 11	*Leucoagaricus naucinus*
1, 3	*Phylloporus rhodoxanthus*
2, 3	*Russula* sp.

Tritoma biguttata biguttata (Say 1825)

1, 1	*Agaricus* sp.
1, 1	*Amanita bisporigera*
1, 7	*Amanita citrina*
1, 1	*Amanita flavorubescens*
	Amanita muscaria [Weiss & West 1921a]

Amanita phalloides [Moennich 1944:1, 4]
3, 57 *Amanita rubescens* [Weiss & West 1921a]
Amanita solitaria [Moennich 1939:1, 1]
Amanita strobiliformis [Chantal 1979; Boyle 1956]
1, 20 *Amanita vaginata*
1, 35 *Amanita* sp.
Armillaria sp. [Weiss & West 1920]
Armillariella mellea
Armillaria mellea [Chantal 1979; Boyle 1956]
1, 1 *Armillariella tabescens*
Collybia sp. [Weiss & West 1922]
Lactarius piperatus [Moennich 1939:1, 1]
Oligoporus tephroleucus
Polyporus lacteus [Weiss & West 1921a]
Russula sp. [Weiss & West 1922]

Tritoma aulica (Horn 1871)
No host data available.

Tritoma humeralis Fabricius 1801
1, 7 *Amanita bisporigera*
2,16 *Amanita vaginata*
Amanitopsis vaginata
4, 31 *Armillariella mellea*
4, 18 **Armillariella tabascens*
Clitocybe maxima [Weiss & West 1920]
1, 1 *Collybia* sp.
1, 1 *Polyporus alveolaris*
Favolus alveolaris
1, 1 *Polyporus arcularius*
2, 10 *Polyporus radicatus* [Chantal 1979; Boyle 1956: as "*Polyposus radicata*"]
1, 1 *Shizopora paradoxa*

Tritoma atriventris LeConte 1847
1, 3 *Amanita* sp.
2, 3 *Armillariella mellea*
11, 118 **Armillariella tabescens*
Carduus sp. [Boyle 1956]
1, 45 *Clitocybe clavipes*
1, 8 **Lentinus dentosus*
1, 1 *Meripilus giganteus*
1, 216 **Omphalotus olearius*
2, 3 *Oudemensiella radicata*
1, 1 *Pluteus cervinus* ?
1, 12 **Pluteus* sp.
1, 4 *Polyporus alveolaris*
6, 35 **Polyporus arcularius*

Tritoma erythrocephala Lacordaire 1842
1, 11 *Amanita vaginata*
Amanitosis vaginata
2, 26 **Armillariella tabescens*

1, 22	**Lentinus dentosus*
1, 1	*Marasmius* sp.
2, 12	**Omphalotus olearius*

Tritoma angulata Say 1826

1, 1	*Armillariella tabescens*
1, 1	*Lactarius argillaceifolius*
1, 3	*Lactarius insulsus*
7, 31	**Lactarius piperatus* [Moennich 1939:1, 3]
2, 15	**Lactarius subvellereus*
1, 1	*Lactarius thejogalus*
1, 1	*Lactarius volemus* [Moennich 1939:1, 5]
1, 1	*Lactarius* sp.
4, 14	*Russula aeruginea*
1, 2	*Russula albidula*
2, 3	*Russula crustosus*
1, 4	*Russula (emetica ?)*
1, 2	*Russula (foetens ?)*
2, 6	*Russula mariae*
1, 2	*Russula paludosa*
1, 9	*Russula subalbidula*
1, 3	*Russula xerampelina*
7, 25	**Russula* sp.

Tritoma unicolor Say 1826

	Calvatia craniformis [Boyle 1956]
1, 5	*Hypholoma* sp. [Boyle 1956]
2, 2	*Omphalotus illudens*
	Clitocybe illudens [Boyle 1956]
4, 138	**Omphalotus olearius*
1, 2	Tricholomataceae

Tritoma tenebrosa Fall 1912

No host data available.

Tritoma mimetica (Crotch 1873)

1, 1	*Amanita vaginata*
2, 3	*Armillariella mellea*
1, 37	**Boletus* sp.
1, 1	*Marasmius* sp.
1, 1	*Oudemensiella furfuracea*
13, 78	*Oudemensiella radicata*
	Collybia radicata [Froeschner & Meiners 1953]
1, 1	**Pluteus cervinus*
4, 122	*Polyporus radicatus*
1, 1	*Tricholomopsis platyphylla*

Species group ***sanguinipennis***

Tritoma sanguinipennis (Say 1825)

Amanita phalloides [Moennich 1944:1, 1]

17, 133 *Polyporus alveolaris*
Favolus alveolaris
Favolus canadensis [Boyle 1956]
Hexagonia alveraris [Boyle 1956]
12, 88 **Polyporus arcularius*
1, 6 *Polyporus badius*
1, 4 *Polyporus radicatus*
1, 3 *Polyporus squamosus*

Tritoma pulchra Say 1826
1, 28 *Ceriporia* sp.
1, 1 *Ganoderma applantum*
Oligoporus floriformis
Polyporus floriformis [Chantal 1979]
1. 2 *Oligoporus stipticus*
Polyporus immitis
1, 8 *Oligoporus tephroleucus*
Polyporus tephroleucus [Judd 1957:1, 1]
1, 2 *Oligoporus* sp.
Piptoporus betulinus
Polyporus betulinus [Chantal 1979; Boyle 1956]
1, 1 *Polyporus squamosus*
Melanopus squamosus
Russula irrescens {*R. virescens* ?} [Weiss 1924]
1, 1 *Stemonitis axifers* {Myxomycete}
2, 5 **Tyromyces chioneus*
Polyporus albellus
Polyporus chioneus
[Weiss 1920b; Weiss & West 1920]

Pseudischyrus Casey 1916

Pseudischyrus extricatus (Crotch 1873)
1, 3 *Lactarius hygrophoroides*
1, 1 *Russula albiduliformis*
1, 5 *Russula (emetica ?)*
1, 13 **Russula levispora* {manuscript species; Murrill, 1972}
1, 1 **Russula (lutea ?)*
2, 40 **Russula* sp.

Pseudischyrus ventriloquax Boyle 1956
No host data available.

Pseudischyrus nigrans (Crotch 1873)
1, 2 *Amanita cylindrispora*
1, 2 *Amanita rudelleus* {*A. rubescens* ?}
1, 6 *Amanita subsolitaria*
1, 1 *Amanita* (nr. *virginiana*) {*A. virginae* ?}
4, 51 *Amanita* sp.
2, 10 *Armillariella tabescens*
1, 3 *Russula subcyanoxantha*
2, 25 *Russula* sp.

Ischyrus Lacordaire 1842

Ischyrus quadripunctatus quadripunctatus (Olivier 1791)
1, 2 *Irpex lacteus*
7, 38 **Oxyporus latemarginatus*
Poria ambigua
Phellinus gilvus
Polyporus gilvus [Weiss & West 1920]
Poria sp. [Weiss 1920a; Weiss & West 1920]

Ischyrus quadripunctatus graphicus Lacordaire 1842
No host data available.

Ischyrus chiasticus Boyle 1954
No host data available.

Ischyrus dunedinensis Blatchley 1917
No host data available.

Ischyrus aleator Boyle 1954
No host data available.

Triplax Herbst 1793

Species group ***macra***

Triplax macra LeConte 1854
1, 26 *Inonotus andersonii*
1, 1 *Inonotus rheades*
Polyporus vulpinus
Pleurotus ostreatus {?} [Adams 1908]

Triplax festiva Lacordaire 1842
2, 34 *Inonotus andersonii*
5, 101 +*Inonotus cuticularis*
Polyporus cuticularis
1, 2 +*Inonotus dryophilinus*
3, 41 **Inonotus hispidus*
1, 78 *Inonotus ludovicianus*
1, 17 **Inonotus (munzii ?)*
1, 323 +*Inonotus* sp.

Triplax frontalis Horn 1862
2, 358 **Inonotus andersonii*
1, 3 *Inonotus cuticularis*
Polyporus cuticularis
1, 1 *Inonotus hispidus*
1, 1 *Inonotus* sp.

Triplax alachuae Boyle 1956
12, 326 **Inonotus andersonii*
1, 1 *Inonotus (munzii ?)*

Triplax marcescens Boyle 1954
1, 2 *Inonotus dryophilus*
    Polyporus dryophilus
  Pleurotus sp. {?} [Dajoz 1985:1, 2]
1, 5 *polypore

Species group ***thoracica***

Triplax mesosternalis Schaeffer 1905
1, 95 **Lentinus lepideus*
2, 40 *Pleurotus ostreatus* ?
1, 12 *Pleurotus* sp. [Dajoz 1985:13, 135]

Triplax flavicollis Lacordaire 1842
1, 1 *Cantharellus cibarius*
1, 4 *Hericum erinaceus*
2, 7 +*Panus strigosus*
1, 1 *Panus* ?
55, 784 **Pleurotus ostreatus* [Weiss 1920d; Chantal 1979; Boyle 1956; Weiss & West 1920]
3, 16 *Pleurotus sapidus*
8, 93 **Pleurotus* sp. [Froeschner & Meiners 1953]
1, 1 *Polyporus alveolaris*
1, 1 *Polyporus arcularius*
2, 2 *Polyporus squamosus*
    Melanopus squamosus
1, 1 **Tricholomopsis platyphylla*
    Collybia platyphylla

Triplax thompsoni Boyle 1962
3, 100 +*Polyporus arcularius* [Johnson 1967]

Triplax wehrlei Boyle 1954
  No host data available.

Triplax dissimulator (Crotch 1873)
1, 1 *Hypsizygus tessulatus*
    Pleurotus ulmus {*P. ulmarius* ?}
3, 10 Oyster mushroom {*Pleurotus* sp. ?}
  Pleurotus sp. [Chantal 1979; Boyle 1956]

Triplax errans Boyle 1956
  No host data available.

Triplax antica LeConte 1861
2, 15 Oyster mushroom {*Pleurotus* sp. ?}
3, 14 *Pleurotus ostreatus*
1, 151 near *Pleurotus* ?
  Polyporus sp. [Boyle 1956; Dajoz 1985:8, 39]

Triplax californica LeConte 1854
1, 4 Oyster mushroom {*Pleurotus* sp. ?}
3, 40 *Pleurotus ostreatus* [Boyle 1956]
1, 81 *Pleurotus* sp. [Dajoz 1985:16, 57]

Triplax lacensis Boyle 1954
No host data available.

Triplax cuneata Boyle 1954
No host data available.

Triplax microgaster Boyle 1956
No host data available.

Triplax puncticeps Casey 1916
2, 3 *Pleurotus ostreatus*
2, 8 *Pleurotus* sp. [Shepard 1976:1, 2]

Triplax thoracica Say 1825
Amanita rubescens {?} [Weiss & West 1921a]
1, 1 *Auricularia auricula* {Ascomycete}
1, 3 *Bjerkandera adusta*
1, 1 *Ganoderma applantum*
1, 1 *Hericium erinaceus*
1, 6 *Hypsizygus tessulatus*
Pleurotus ulmus {*P. ulmarius* ?}
Panus strigosus [Moennich 1944:1, 1]
1, 1 *Panus* ?
1, 1 *Pholiota* possibly *aurivella*
56, 744 *_Pleurotus ostreatus_ [Weiss 1920d; Chantal 1979; Boyle 1956; Weiss & West 1920]
2, 14 *Pleurotus sapidus* [Judd 1957:1, 5]
1, 16 *Pleurotus* ?
14, 62 *Pleurotus* sp. [Dajoz 1985:2, 51]
1, 2 *Polyporus squamosus*
1, 1 *Polyporus* sp.
3, 15 Oyster mushroom {*Pleurotus* sp. ?}

Triplax frosti Casey 1924
6, 24 *Pleurotus ostreatus* [Chantal 1979; Boyle 1956]
1, 1 *_Pleurotus sapidus_
2, 6 Oyster mushroom {*Pleurotus* sp. ?}

Mycotretus Lacordaire 1842

Mycotretus nigromanicatus Boyle 1954
No host data available.

Haematochiton Gorham 1888

Haematochiton elateroides Gorham 1888

1, 1 white resupinate polypore on conifer log, *Poria* ?

Haematochiton carbonarius (Gorham 1888)

No host data available.

DISCUSSION

Host lists for mycophagous Coleoptera are scattered throughout the literature and analyses of host patterns have been discussed for only a small number of taxa: gyrophaenine Aleocharinae in the Staphylinidae (Scheerpeltz and Höfler 1948, Ashe 1984); Ciidae (Pavior-Smith 1960, Lawrence 1973). Beetle-fungus relationships are of dynamic ecological importance when considering erotylid evolution.

Beetle-fungus relationships are similar to situations encountered with insect-higher plant interaction. Basidiomycetes are like higher plant resources in that some species are short-lived (many Agaricales), and others persistent and long-lived (many Aphyllophorales) (Lacy 1984). Textural differences of basidiomycetes are responsible for these temporal differences (Corner 1953, Lawrence 1973, Klimaszewski & Peck 1987, Ashe 1987) and the duration of larval development often positively correlates with sporocarp persistence (Ashe 1981, Leschen & Carlton 1988).

Based on the data presented here, members of the family Erotylidae utilize basidiomycete fungi of the orders Agaricales and Aphyllophorales (mushrooms and polypores). There are a few records of other fungi, but their use is of questionable importance.

Erotylid specificity to host fungi is evident at many levels and aids in establishing species relationships. The phylogenetic relationships described by Boyle (1956) are supported by our host data. Boyle suggested that the Dacninae (*Dacne, Megalodacne,* and *Microsternus*) are more primitive, while the Triplacinae (*Triplax, Tritoma, Pseudischyrus,* and *Ischyrus*) are more derived. Our data suggests that the Dacninae feed primarily on wood-rotting Aphyllophorales (*Polyporus* and *Ganoderma*), while the Triplacinae show a variety of patterns, feeding on both Agaricales and Aphyllophorales (*Tyromyces, Polyporus, Armillariella, Russula, Amanita,* etc.).

The genus *Tritoma* was divided by Boyle (1956) into two species groups; *sanguinipennis* and *humeralis*. Our data show that species group *sanguinipennis* is associated with the soft Aphyllophorales, while species group *humeralis* favors the Agaricales. Similarily, Boyle divided the genus *Triplax* into species groups *macra* and *thoracica.* Our data indicate that species group *macra* is associated with the polypore genus *Inonotus*, while species group *thoracica* is primarily associated with the gilled genus *Pleurotus*. The following European species are also found on *Pleurotus*: *Triplax rufipes* Fab., *T. russica* L., *T. scutellaris* Champ. (Scheerpeltz & Höfler 1948, Rehfous 1955, Dajoz 1966). It is remarkable our host data agrees so well with Boyle's conclusions regarding the taxonomic relationships within these genera, based almost entirely on morphology.

Specific associations are evident throughout the list; *Tritoma biguttata* with *Amanita*, *T. atriventris* and *T. humeralis* with wood-rotting mushrooms (*Armillariella*, *Lentinus*, *Omphalotus*, and *Polyporus*), *T. angulata* with the Russulaceae (*Russula* and *Lactarius*), *T. unicolor* with *Omphalotus*, *Pseudischyrus extricatus* with *Russula*, *P. nigrans* with *Amanita*, etc.

The preceeding discussion dealt with host patterns and other biological features common to the Erotylidae that are interesting from an insect-fungus perspective. Further studies of erotylid fungal hosts may provide additional information on the phylogenetic relationships of both the basidiomycetes and the Erotylidae.

The genus *Pleurotus* has an unsure placement in fungal classification. It can be considered a member of the Tricholomataceae (Agaricales; mushrooms) because of its soft tissue (monomitic), gills, etc. (McKnight & McKnight 1987, Miller 1972, Weber & Smith 1985) or, it can be considered a member of the Polyporaceae (Aphyllophorales; polypores) (sensu Donk 1964) because of its indeterminate growth pattern, lack of a true stalk, asynchronous spore development, etc. Singer (1986) places *Pleurotus* in the Polyporaceae next to *Lentinus* and *Panus*. Host utilization of *Triplax* species tends to be restricted to the Polyporaceae with the exception of *Pleurotus*. Unless these beetles had a host-shift, the utilization of *Pleurotus* by the *Triplax* indicates that *Pleurotus* is more closely related to other Polyporaceae than to the Tricholomataceae. In using these beetles as taxonomists, they support the views of Donk (1964) and Singer (1986).

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5th ANNUAL INSECT FIELD DAY

Sponsored by The American Entomological Society and the Young Entomologists' Society, this event will be held on Saturday, June 22, 1991 from 9 am to 5 pm at the new Fair Hill Nature Center off Route 273, six miles west of Newark, DE. For more information, write to: Insect Field Day, The American Entomological Society, 1900 Race St., Philadelphia, PA 19103.

TWO NEW SPECIES OF *NEOHYPDONUS* (COLEOPTERA: ELATERIDAE) FROM NORTH AMERICA WITH A KEY TO NEARCTIC SPECIES[1]

Samuel A. Wells[2]

ABSTRACT: A key to the North American species of *Neohypdonus* is provided. *Negastrius musculus* is newly transferred to the genus *Neohypdonus*. Two new species from western North America are described.

The click-beetle subfamily Negastriinae in North America is composed of over 30 species that are generally encountered in riparian situations. These beetles are the smallest click-beetles in North America.

Stibick's (1971) generic classification of the subfamily separated what most North American workers were calling *Negastrius* Thompson into six genera. The genus *Neohypdonus* Stibick, 1971 can be distinguished from other genera of Negastriinae by the shining or microreticulate pronotum, prosternal sutures curved outward, presence of elytral striae, short carinae of hind angles, subequal second and third antennal segments, and by the simple tarsal claws.

KEY TO THE NORTH AMERICAN SPECIES OF *NEOHYPDONUS*

1\. Strial punctures absent or with strial punctures equivalent to interstrial punctures 2

\- Striae with several punctures deeper and more pronounced than interstrial punctures 3

2\. Elytra with humeral and subapical maculations; striae five and six extending beyond middle of elytra .... *aestivus* (Horn)

\- Elytra unicolorous, without maculations; striae five and six obliterated on posterior half .... *restrictulus* (Mannerheim)

3\. Prosternum with long depression on anterior half mesad of posternal suture (fig. 4) .... *recavus* n. sp.

\- Prosternum without long depression mesad of prosternal suture 4

4\. Elytra black with humeral and often subapical pale maculations 5

\- Elytra unicolorous dark brown or black, margins of elytra may be paler than disc but never with humeral maculations 6

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[2] Department of Entomology, The Ohio State University, 1735 Neil Avenue, Columbus, Ohio 43210.

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5. Pronotum strongly convex, longer than wide, nearly glabrous, with small punctures and short pubescence (fig. 1); eastern U.S. .... *perplexus* (Horn)

- Pronotum slightly convex, wider than long (fig. 2); more densly pubescent; western U.S. and Canada .... *gentilis* (LeConte) in part

6. Body compact, elytra at middle wider than pronotum; antennae not extending beyond hind angles of pronotum 7

- Elytra at middle as wide as pronotum; antennae extending beyond hind angles of pronotum 8

7. Black; pronotal carinae less than one third length of pronotum .... *musculus* (Eschscholtz)

- Dark brown to black; pronotal carinae half as long as pronotum .... *tumescens* (LeConte)

8. Lateral margin of pronotum sinuate, hind angles not attaining width of pronotum at center (fig. 3) .... *nibleyi* n. sp.

- Lateral margin of pronotum sub-parallel posteriorly, hind angles as wide as or wider than pronotum at center (fig. 2) .... *gentilis* (LeConte) in part

Neohypdonus musculus (Eschscholtz), new combination

Cryptohypnus musculus Eschscholtz 1882: 72: Mannerheim 1853: 239; Horn 1891: 22.
Hypnoidus musculus Leng 1920: 171.
Negastrius musculus Lane 1971: 19.

This is the smallest and most robust species of the genus in North America. The presence of the above listed generic characters distinctly places this species in the genus *Neohypdonus.*

Neohypdonus nibleyi, new species

Male.- Length 3.3 mm (paratypes 2.8 - 3.3 mm); width 0.9 mm. Body depressed. Antennal segments one and two, edges of femora, tibiae, tarsi, pronotal angles, and margin of elytra pale brown. Head, antennal segments 3 - 11, pronotum, elytra, and underside dark brown to black. Body covered with fine yellow pubescence.

Antennae extending slightly beyond hind angles of pronotum. Margin of pronotum sinuate, widest point at middle (fig. 3). Pronotal carinae one third length of pronotum. Elytra widest at center, evenly arcuate to apex; striae distinctly impressed with several punctures deeper than interstrial punctures, interstriae finely reticulate; prosternal sutures single.

Genitalia typical for genus with lateral lobes parallel-sided except for gradual constriction at anterior third. Apices of lobes flattened laterally with two subapical setae, median lobe slender, gradually narrowing to apex.

Female.- Similar to male. Bursa copulatrix with "U"-shaped scleritization, arms more darkly scleritized and denticulate.

Type material.- Holotype male: Utah; Utah Co., Provo River in Provo, July 12, 1989, S.A. Wells. Paratypes: same data as holotype. Brit. Col., 5 km SE Hope, Nicolum Cr., July 8, 1988, Ivie & Philips; Colo.; Grand Co., Willow Creek above Granby, July 10, 1989, S.A. Wells. Montana, Gallatin Co., Bridger Cr., June 17, 1989, D.A. Gustafson.

Holotype is deposited in the U.S. Nat'l. Mus. of Natural Hist. Paratypes are in the Canadian Nat'l. Coll., the Ohio State Univ., Montana State Univ., Brigham Young Univ., and the Wells Coll.

Etymology.- *Neohypdonus nibleyi* is named in honor of Dr. Hugh Nibley in gratitude for his scholarly defense of a clean biosphere.

Neohypdonus nibleyi is readily separated from other species of *Neohypdonus* by the absence of elytral maculations, the sinuate margin of the pronotum (fig. 3), and by the antennae extending slightly beyond the pronotal angles. The biology of *N.nibleyi* is different from that of *N. gentilis* in that it is only known from the banks of third or fourth order streams that have a rocky base with several riffles whereas *N. gentilis* is normally collected by sweeping tall grass near slow first or second order streams with a muddy bottom.

Specimens from Provo were collected within two or three hours after a heavy rain storm and were within two to four feet of the river's edge on stones. Several hours after the storm only one additional specimen was found after considerable searching. The specimens from Colorado were collected under stones in moist sand near Willow Creek and were collected with *Fleutiauxellus manki* and *Migiwa striatulus* both of which are superficially similar.

Neohypdonus recavus,
new species

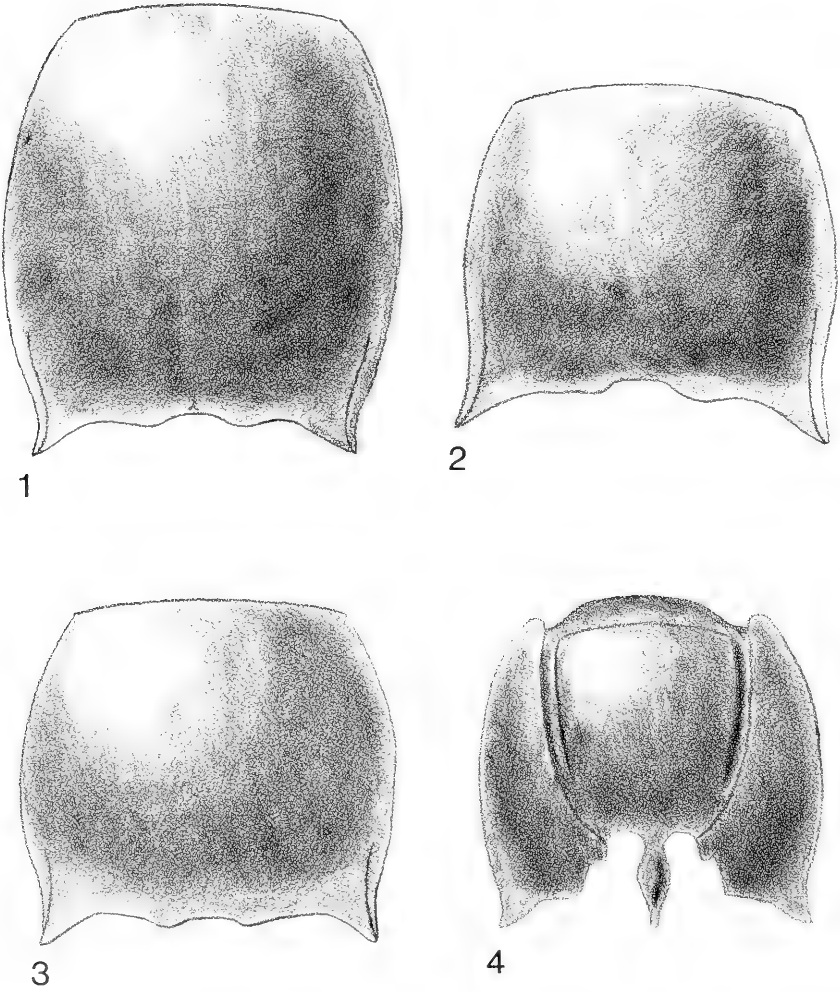
Female.- Length 2.8 mm (paratypes 2.8 - 3.1 mm); width 0.8 mm. Body convex, subcylindrical. Coxae, tibiae, and tarsi pale to dark brown; remainder of body dark brown to black.

Antennae with segments 3 - 11 beadlike, extending nearly to hind angles of pronotum. Margin of pronotum sinuate, widest point at middle (fig. 4). Pronotal carinae one third to one half length of pronotum. Elytra widest at middle, evenly arcuate to apex; striae distinctly impressed, several punctures deeper and more pronounced than interstrial punctures; interstriae finely reticulate. Prosternal sutures single, area immediately mesad of sutures strongly longitudinally depressed.

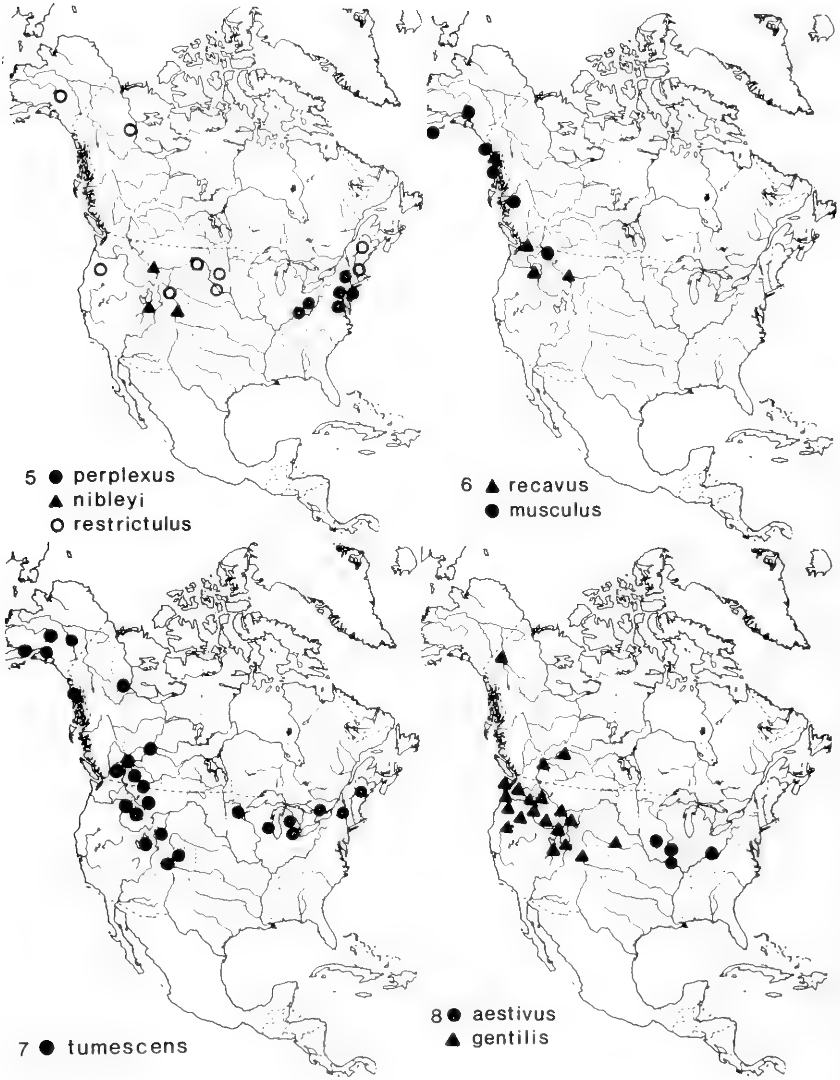
Bursa copulatrix with "U"- shaped sclerotization, anterior margin of sclerite denticulate, margin of arms curved at right angles.

Male.- Similar to female.

Type material.- Holotype female: Alaska; Glacier Bay, Muir Inlet, VI-13-65, D.M. Delong coll. Paratypes: Canada; British Columbia, tributary of Squamish River 24 miles north of Brackendale, July 15, 1988, Baumann, Wells, and Whiting. United States; Montana, Broadwater County, Missouri River, Deepdale, June 22-July 20, 1988, C.E. Seibert; Gallatin County, Jefferson River, April 5-27, 1988. Oregon, Wallawa Mountains, Ice Lake, July 25, 1965; Whitman National Forest, Crane Flat, June 12, 1939. Washington; Okanogan County, West Fork of Granite Creek, July 12, 1988, Baumann, Wells, and Whiting; Lost River above Mazama, July 13, 1988, Baumann, Wells, and Whiting.



Figures 1 - 4. Pronota of *Neohypdonus* species, 1, *N. perplexus.* 2, *N. gentilis.* 3, *N. nibleyi.* 4, *N. recavus.*



Figures 5 - 8. Known distribution of *Neohypdonus* species in North America.

The holotype is deposited at The Ohio State University. Paratypes are at the U.S. National Museum of Natural History, the Field Museum of Natural History, Chicago, Montana State University and the Wells collection.

Etymology.- The term *recavus* is a Latin adjective meaning arched inward and refers to the condition of the prosternum.

N. recavus is easily separated from all other North American species of *Neohypdonus* by the strong concavity on the prosternum. The antennae are beadlike as in *N. tumescens* and *N. musculus* but extend very near to the hind angles of the pronotum.

Specimens have been collected under stones in moist sandy soil along the banks of streams. Adults have been collected with *Fleutiauxellus manki* to which it is superficially similar.

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THE IDENTITY OF *CHELIFER COMMUNIS* VAR. *PENNSYLVANICUS* AND DESCRIPTION OF A NEW SPECIES OF *LUSTROCHERNES* (PSEUDOSCORPIONIDA: CHERNETIDAE)[1]

William B. Muchmore[2]

ABSTRACT: Study of a syntype of *Chelifer communis* var. *pennsylvanicus* Ellingsen reveals that it belongs in the genus *Americhernes*, not in *Lustrochernes* as has long been supposed. The species of *Lustrochernes* actually inhabiting the southeastern United States is described as *L. carolinensis* and is compared with *L. grossus* and *L. viniai*, the other 2 species known to occur in the U.S.A.

Ellingsen (1910:366) described a new variety of *Chelifer communis* Balzan from Pennsylvania, simply:

> "var. *pennsylvanicus* nov.
>
> "Aus Pennsylvanien stammen 4 Ex.(von Zimmermann gesammelt), die keinen wesentlichen Unterschied von kleinen südamerikanischen Tierchen dieser Art zeigen. Die pennsylvanischen Ex. sind klein, scheinen trotzdem vollständig entwickelt und ausgefärbt zu sein; die Hand ist verhältnismässig etwas kräftiger als bei den Südamerikanern."

In the absence of sufficient information, Beier (1932) was unable to place this form precisely, but listed it as an uncertain species of the genus *Lustrochernes* (to which he had transferred *Chelifer communis*). Citing Beier without reservation, Hoff and Bolsterli (1956:167) considered this a distinct species and mentioned new records from Louisiana and Mississippi ("the first — since the original from Pennsylvania"); they also provided measurements for three males from Louisiana (no females were available); purporting to demonstrate that the species does indeed "differ from *L. communis* by having a smaller body size and a stouter chela." The only other references in the literature to *L. pennsylvanicus* (Hoff 1958; Weygoldt 1969; Muchmore 1990) add no new morphological information about the species. Recently, it has been reported that *Chelifer communis* Balzan does not belong in *Lustrochernes* but rather in the genus *Gomphochernes* (Mahnert 1985:78).

Because valid representatives of the genus *Lustrochernes* do occur rather commonly throughout the southeastern United States, it is of interest to know the identity of the specimens on which Ellingsen based

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[2] Department of Biology, University of Rochester, Rochester, NY 14627.

the variety *pennsylvanicus*. Through the kind cooperation of Dr. M. Moritz of the Zoologisches Museum in Berlin, one of the syntypes of that form was borrowed, mounted on a microscope slide and studied carefully, with the following results.

The specimen, a female (ZMB Kat. Nr. 29723; here designated the LECTOTYPE), is much smaller than expected for a *Lustrochernes*. Measurements (mm) are: Body length 2.47. Carapace length 0.695. Chelicera length 0.235. Palpal trochanter 0.37 by 0.205; femur 0.60 by 0.27; tibia 0.54 by 0.275; chela (without pedicel) 0.90 by 0.325; hand (without pedicel) 0.52 by 0.30; pedicel length 0.075; movable finger length 0.445. Leg IV: entire femur 0.56 by 0.215; tibia 0.40 by 0.13; tarsus 0.28 by 0.08. These measurements are, on the other hand, typical of *Americhernes oblongus* (Say), a common species in the eastern United States, which might easily be mistaken for a small *Lustrochernes* (see Muchmore 1976:153). Examination of other features, including shape and proportions of the palpal segments, placement of trichobothria on the palpal chela and shape of the spermathecae, reveals that this specimen is indeed conspecific with *A. oblongus*. Thus *Chelifer communis* var. *pennsylvanicus* Ellingsen (1910) does not belong in *Lustrochernes* (or *Gomphochernes*) at all, but is a synonym of *Chelifer oblongus* Say, which was described in 1821.

This revelation leaves the eastern U.S. form of *Lustrochernes* without a specific name, a situation which is remedied below.

Specimens used in the following study are from the Florida State Collection of Arthropods, Gainesville, FL, [FSCA], unless otherwise noted. Materials from other institutions are designated as follows.

ACC - Academia de Ciencias de Cuba, La Habana, CUBA.
AMNH - American Museum of Natural History, New York, NY.
CUIC - Cornell University Collection of Insects, Ithaca, NY.
MCZ - Museum of Comparative Zoology, Harvard University, Cambridge, MA.
USNM - National Museum of Natural History, Washington, DC.
YALE - Peabody Museum of Natural History, Yale University, New Haven, CT.

Lustrochernes carolinensis, new species

Figs. 1-5

Lustrochernes pennsylvanicus (Ellingsen), Hoff and Bolsterli 1956:167 (in part); Hoff 1958:21 (in part); Weygoldt 1969:114; Muchmore 1990:519 (in part).

Description (based on the type series).- Male and female much alike, but male a little smaller and with slightly stouter appendages. Carapace light brown, palps darker reddish brown, other parts tan. Setae generally long and acuminate or sparsely denticulate. Carapace a little longer than wide; surface smooth, with a distinct, broad transverse furrow at about middle; 2 eyespots; 70-80 vestitural setae, 4 at anterior and 12-16 at posterior margins. Abdomen elongate; tergites 2 or 3-10 and sternites 4-10 divided; surfaces smooth. Tergal chaetotaxy of holotype 18:19:16:21:22:24:23:24:23:24:T5TTTT5T:2 (setae distributed on the lateral, medial and posterior margins and occasionally on the disc of each half tergite); others generally similar. Sternal chaetotaxy of holotype male 22:[3-2]/(3)13(3):(1)6(1):21:24:22:28:26:25:T5TTTT5T:2; other males similar. Anterior genital operculum of female with a compact group of 12-15 small setae centrally located and 3-5 small setae on each side posteriorly, much as in *Americhernes oblongus* (see Muchmore 1976:fig. 4); posterior operculum with marginal row of 10-12 small setae; anterior stigmatic plates with 3 or 4 setae each and posterior plates with 1. Internal genitalia of male as shown in Fig. 1, large and well sclerotized, without any conspicuous projection on the ventral side. Spermathecae of female generally as shown in Fig. 2, somewhat hammer-shaped, but may appear round if not favorably positioned.

Chelicera 0.35-0.40 as long as carapace; hand with 5 setae, *ls* and *is* long, acuminate, others much shorter, sparsely denticulate; flagellum of 3 setae, the distal one serrate; galea in both sexes large, with 6-10 rami.

Palp rather robust (Fig. 3): femur 2.1-2.4, tibia 1.9-2.1, chela (without pedicel) 2.4-2.6 times as long as broad; hand (without pedicel) 1.4-1.55 times as long as deep; movable finger 0.7-0.8 as long as hand. Surfaces smooth except small granules on medial sides of femur, tibia and chelal hand; trochanter with a prominent dorsal protuberance. Trichobothria as shown in Fig. 4; *est* clearly distad of middle of fixed finger, *it* closer to finger tip than distance between *ist* and *isb*. Venom apparatus well developed in movable finger, nodus ramosus closer to trichobothrium *t* than to *st*. Fixed finger with 28-33 and movable finger with 32-38 cusped marginal teeth; each finger with 8-12 external and 3-6 internal accessory teeth.

Legs moderately slender: leg IV with entire femur 2.7-3.2; tibia 3.55-3.85 and tarsus 3.8-4.1 times as long as deep (Fig. 5). Leg IV tibia with a very long acuminate tactile seta near middle, and tarsus with a similar seta about ¼ distance from proximal end; telofemur with a long seta, often bearing 1 or 2 spinules, near distal end. Subterminal tarsal setae curved, simple.

Measurements (mm).- Male (figures given first for holotype, followed in parentheses by those of the 2 paratypes): Body length 3.58 (3.48-3.57). Carapace length 1.01 (1.03-1.16). Chelicera length 0.39 (0.36-0.39). Palpal trochanter 0.56 (0.545-0.62) by 0.31 (0.32-0.39); femur 0.935 (0.92-1.07) by 0.415 (0.43-0.495); tibia 0.90 (0.90-1.04) by 0.45 (0.43-0.53); chela (without pedicel) 1.48 (1.48-1.61) by 0.60 (0.59-0.68); hand (without pedicel) 0.90 (0.87-1.02) by 0.615 (0.595-0.68); pedicel length 0.09-0.12; movable finger length 0.72 (0.66-0.73). Leg I: basifemur 0.29 (0.27-0.32) by 0.20 (0.20-0.21); telofemur 0.49 (0.48-0.55) by 0.19 (0.20-0.21); tibia 0.49 (0.47-0.53) by 0.13 (0.13-0.14); tarsus 0.36 (0.385-0.41) by 0.095 (0.095). Leg IV: entire femur 0.90 (0.875-0.99) by 0.31 (0.32-0.37); tibia 0.695 (0.675-0.775) by 0.185 (0.19-0.205); tarsus 0.495 (0.48-0.545) by 0.125 (0.13-0.135).

Female: Ranges for the allotype and 5 paratypes. Body length 3.91-4.78. Carapace length 1.01-1.12. Chelicera length 0.38-0.42. Palpal trochanter 0.52-0.59 by 0.29-0.315; femur 0.85-0.99 by 0.385-0.43; tibia 0.805-0.96 by 0.42-0.47; chela (without pedicel) 1.42-1.65 by 0.565-0.63; hand (without pedicel) 0.855-0.99 by 0.59-0.64; pedicel length 0.10-0.12; movable finger length 0.64-0.705. Leg IV: entire femur 0.84-0.98 by 0.285-0.31; tibia 0.645-0.73 by 0.18-0.19; tarsus 0.48-0.53 by 0.12-0.13.

The slide-mounted material listed below has been studied and measured and found to conform rather closely to the description of the types, though a few scattered measurements and ratios are a little above or below the ranges given. The other specimens, not mounted on slides, appear certainly to be conspecific with the mounted ones. The specimens from Louisiana reported by Hoff and Bolsterli (1956) as *L. pennsylvanicus* are a little smaller than most of the more eastern representatives, but clearly they are *L. carolinensis.*

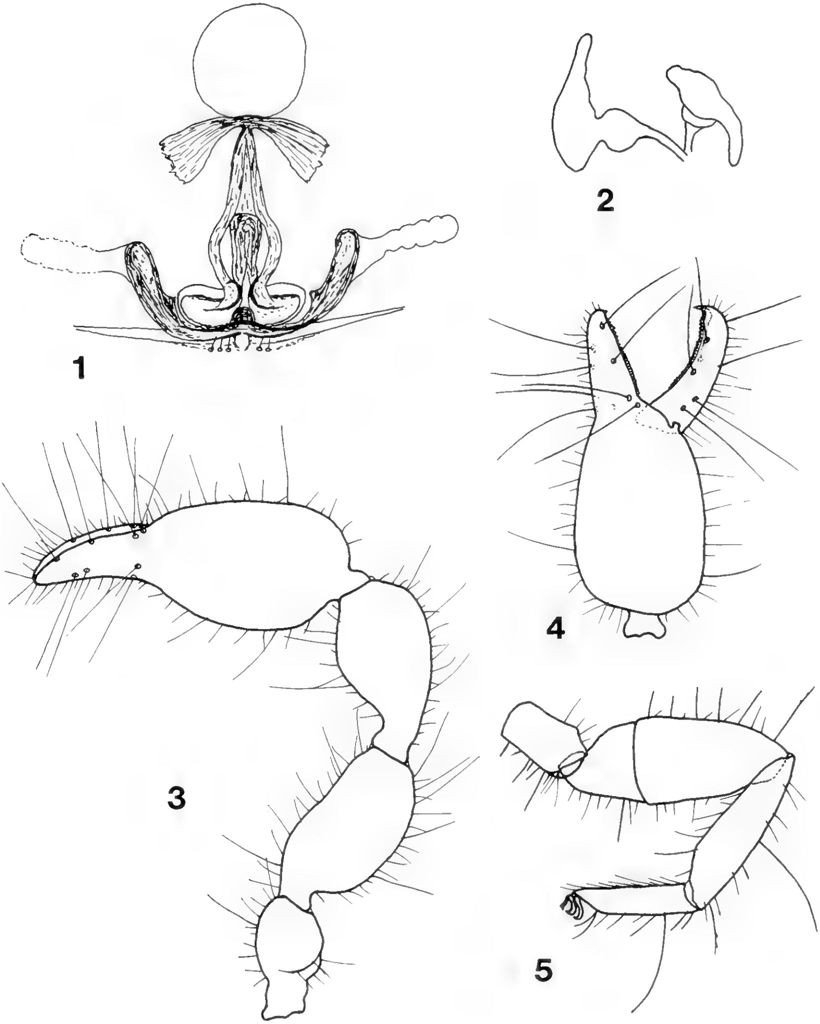
Etymology.- The species is named *carolinensis* for the type locality in North Carolina.

Type data.- Holotype male (WM918.01008), allotype female (WM918.01006) and 9 paratypes (2 ♂, 5 ♀, 1 tritonymph, 1 protonymph): NORTH CAROLINA: Carteret Co., Beaufort, January 1966, P. Weygoldt, under bark of trees. Deposited in Florida State Collection of Arthropods, Gainesville, FL.

Non-type material studied, mounted on slides.- FLORIDA: locality?, 5 May 1949, Jennings, from cerambycid at light, 2 ♂, 3 ♀ ; Alachua Co., December 1947, H.K. Wallace, 1 ♂, 1 ♀; Alachua Co., Sugarfoot Hammock, 1 April 1949, I.J. Cantrall, 1 ♂, 1 ♀; Alachua Co., Gainesville, 9 February 1950, T.G. Steward, 1 ♂; Citrus Co., Yulee State Park, 29 November 1963, S. Peck, 1 ♂; Clay Co., Camp Crystal, 20 May 1961, H.V. Weems, Jr., under bark of dead *Quercus virginiana* Mill., 1 ♀; Marion Co., Rainbow Springs, 25 June 1960, H.V. Weems, Jr., in fungus, 2 ♀; Putnam Co., 5 January 1960, H.V. Weems, Jr., under bark of rotting *Quercus virginiana*, 1 ♀; Putnam Co., 2 March 1960, H.V. Weems, Jr., under bark of *Quercus laevis* Walt., 1 ♂; Volusia Co., New Smyrna Beach, 21 July 1961, G. W. Desin, in truck, 1 ♂; Volusia Co., De Leon Springs, 29 April 1969, R.E. Woodruff, 1 ♀. GEORGIA: Thomas Co., Thomasville, Tall Timbers R. Sta., Millpond, 22 December 1967, W. Sedgewick, 1 ♂, 2 ♀ [MCZ]. LOUISIANA: St. Tammany Par., Slidell, 30 September 1973, W.F. Rapp, 1 ♂. MISSISSIPPI: Hinds Co., Raymond, 10 July 1961, R.C. and A. Graves, 1 ♂, 1 ♀.

Non-type material, not mounted.- FLORIDA: Alachua Co., Gainesville, 3 August 1967, R.P. Esser, under elytra of cerambycid beetle, *Stenodontes dasytomus* (Say), 2 ♂, 1 ♀; Columbia Co., O'Leno State Park, 21 August 1949, H. Dybas, ex herb. polypore, 1 ♂; Hernando Co., 6 mi. NW Brooksville, 21 June 1955, H. Dybas, 1 ♂; Highlands Co., Highlands Hammock, 6 mi. W. Sebring, 23 August 1969, H. Dybas, 1 ♂; Highlands Co., Parker Island, 7 mi. SE Lake Placid, 19 June 1955,; H. Dybas, in Sabal palmetto log, 1 ♂, 1 ♀; Liberty Co., Torreya State Park, 9 June 1975, J. Beatty, on *Stenodontes dasytomus* (Say) taken at black light at night, 1 ♂, 6 ♀; Orange Co. Orlando, 1 June 1972, E. Harper, on desk in office, 1 ♂. NORTH CAROLINA: Johnston Co., Clayton, 4 July 1978, F. Scott, "Apparently phoretic on large carabid beetles attracted to light traps," 2 ♀.

Remarks.- It is interesting to note that *L. carolinensis* seems to be confined to rather low elevations (about 100 m or less) from North Carolina to Louisiana. It has not been found in Pennsylvania (or Maryland or Virginia) despite good collection, and so continued use of the name *pennsylvanicus* would have been inappropriate. Its presence in Texas is suspected but not yet confirmed, because of uncertainties about the characteristics of some more southern species.



Figs. 1-5, *Lustrochernes carolinensis*, n. sp.: 1, internal genitalia of male, anteroventral; 2, spermathecae of female, ventral; 3, right palp, dorsal; 4, right chela, lateral; 5, leg IV, anterior.

Lustrochernes grossus (Banks)

Figs. 6-8

Chelanops grossus Banks 1893:65, 1902:220.
Chelanops (?) *grossus,* Beier 1932:179; Roewer 1937:302.
Lamprochernes grossus, Hoff 1947:475-478, fig. 1.
Lustrochernes grossus, Hoff 1956:10, 1958:21, 1961:446;
Muchmore 1990:519.

This species has been described fairly well in papers by Hoff (1947, 1956, 1961). The ranges in measurements and proportions for the specimens from Colorado and New Mexico reported there [AMNH] are as follows.

Measurements (mm).- Body length 3.3-4.5. Carapace length 0.96-1.07. Palpal trochanter 0.55-0.64 by 0.28-0.39; femur 0.76-0.98 by 0.35-0.44; tibia 0.82-1.03 by 0.34-0.44; chela (without pedicel) 1.28-1.48 by 0.42-0.55; hand (without pedicel) 0.69-0.86 by 0.42-0.55; movable finger length 0.57-0.70. Leg IV: entire femur 0.75-0.88 by 0.26-0.295; tibia 0.56-0.66 by 0.16-0.18; tarsus 0.39-0.43 by 0.11-0.12.

Proportions.- Palpal femur 2.1-2.4, tibia 2.1-2.45, and chela (without pedicel) 2.6-3.0 times as long as broad; hand (without pedicel) 1.4-1.8 times as long as deep; movable finger 0.75-0.88 as long as hand. Leg IV: entire femur 2.8-3.15, tibia 3.4-3.85, and tarsus 3.5-3.9 times as long as deep.

Males generally have smaller bodies than females, but have slightly larger and more slender appendages.

Several other collections, totalling 12 males and 15 females, from Arizona (Cochise, Coconino, Graham, and Navajo counties) and New Mexico (Sandoval Co.) have been studied by me. They conform rather closely to the measurements and proportions given above, only a few data being outside the listed ranges, mostly on the high side. In other respects as well, they are similar to Hoff's specimens and obviously belong to *L. grossus.*

In his redescription of the species, based entirely on females, Hoff (1947) did not mention the spermathecae. Later, however, Hoff (1956:11) characterized them as follows, based apparently on many specimens from New Mexico: "The seminal receptacle of the female appears somewhat variable, ranging from an oval bulb placed transversely at the end of a short stalk to a distinctly T-shaped or hammer-shaped structure." My own restudy of the two female types of *Chelanops grossus* Banks mounted by Hoff (in MCZ) reveals that the lectotype (specimen labelled "#1") displays the spermathecae in excellent fashion (see Fig. 6). They are distinctly hammer-shaped, much like those of *L. carolinensis* (see Fig.

2). The variability mentioned by Hoff is probably due to the varied orientation of the spermathecae in his mounted specimens.

The internal genitalia of the male were not mentioned at all by Hoff. My own study of many males from Arizona and New Mexico shows that the genitalia of this species have an unusual structure (Fig. 7). Generally, the parts are like those of *L. carolinensis* (Fig. 1) and *L. viniai* Dumitresco and Orghidan (1977:fig. 15B), but in *L. grossus* there is a prominent long, cylindrical process extending forward from about the middle on the ventral side. As far as I know such a process is seen elsewhere only in the allied genus *Cordylochernes* Beier (personal observation). The exact nature and function of this structure are not yet known.

Hoff (1956:10, 11) mentioned, but did not illustrate, the fact that there are tactile setae on both tibia and tarsus of leg IV in this genus and species (see Fig. 8). It can be added here that there is also a conspicuous long seta near the distal end of the telofemur; this seta, however, unlike the tibial and tarsal tactile setae, often can be seen to possess 1 or 2 tiny spinules.

Types examined.- COLORADO: Dr. C.F. Baker, female lectotype (here designated, specimen #1 mounted by C.C. Hoff) and female paralectotype (here designated, specimen #2 mounted by C.C. Hoff) [MCZ].

Other material studied, mounted on slides.- ARIZONA: Cochise Co., Southwestern Research Station, 5 mi. W Portal, 26 June 1956, O.L. Cartwright, 2 ♂ [USNM]; Cochise Co., same locality, 17 July 1963, V. Roth, on *Tragosoma chiricahuae* Linsley, 1 ♂, 1 ♀; Cochise Co., E slope Chiricahua Mts., 5000 ft., 13 July 1958, C.W. O'Brien, 3 ♂, 4 ♀; Coconino Co., Walnut Canyon, near Flagstaff, 6500 ft., 7 August 1965, J.G. Franclemont, on prionids, *Ergates spinculatus* LeConte, 1 ♂, 1 ♀ [CUIC]; Coconino Co., Hilltop-Dinosaur Road, 5 April 1968, E.A. Richmond, under bark of butt of cut ponderosa pine, 2 ♂, 4 ♀; Graham Co., Graham Mts., Pinecrest, 6 August 1958, C. O'Brien, under bark Douglas fir, 2 ♂, 1 ♀; Pima Co., Santa Catalina Mts., 8 May 1971, L. McCann, under rock, 1 ♀. NEW MEXICO: Sandoval Co., Frijoles Canyon, 17 August 1961, C.L. and J.E. Remington, under bark dead *Pinus*, 1 ♂, 3 ♀ [YALE].

Remarks.- It was noted above that this species resembles a *Cordylochernes* in the possession of a long ventral process on the male genitalia. But it should also be pointed out that *grossus* lacks two characteristics that have been considered diagnostic for *Cordylochernes*, namely, the prominent protuberance on the palpal tibia and the slender legs (see Beier 1932:82, 99). Given Beier's definition of *Cordylochernes*, this species cannot be considered a representative of that genus, and must, for the present, be retained in *Lustrochernes*.

Lustrochernes viniai Dumitresco and Orghidan

Fig. 9

Lustrochernes viniai Dumitresco and Orghidan 1977:113-118, Figs. 13-15.

This species was well described and illustrated on the basis of a series of specimens collected in a cave in Camaguey Prov., Cuba. Dumitresco and Orghidan properly emphasized the future importance of genitalic structures in chernetid taxonomy and provided excellent illustrations of both female and male internal genitalia (1977:figs. 14F, 15B). Additional specimens available to the present author, from a cave in Pinar del Rio Prov., Cuba, and from Key Largo, Monroe Co., Florida, conform well to the description of the types, necessitating only a few additions and occasional emphasis.

The carapace and palps of *L. viniai* are dark brown, sometimes blackish, in marked contrast to the abdomen and appendages, which are much lighter brown.

The eyes of *L. viniai* are very small and faint on intact animals and are not noticeable at all on mounted specimens.

Both the median and posterior transverse furrows on the carapace are distinct, as pointed out by Dumitresco and Orghidan (1977:113).

The terminal sacs of the spermathecae of present females (Fig. 9) are more ovoid than those illustrated by Dumitresco and Orghidan (1977: fig. 14F); they are, however, not as elongate (hammer-shaped) as those of *L. carolinensis* and *L. grossus*.

The internal genitalia of the male of *L. viniai* are similar to those of *L. carolinensis*; no ventral process like that in *L. grossus* is present.

Dumitresco and Orghidan (p.114) state, with respect to leg IV, "Le tibia et le fémur portent chacun une longue soie 'pseudotactile'. Les autres soies des articles sont courtes et simples, sauf celles de la marge externe du fémur qui sont dentées." Their figure 14E, on the other hand, shows that it is the tibia and especially the tarsus (not the femur) which bear the long "pseudotactile" setae; present specimens agree with the figure, with long, acuminate tibial and tarsal tactile setae. In addition, it should be noted, there is a prominent elongate, denticulate seta near the distal end of the telofemur; this seta is obvious in all present specimens.

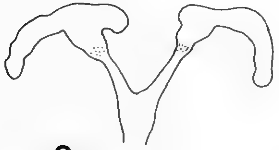
As pointed out by Dumitresco and Orghidan (p.113), the chelal hand, especially of the male, "se caractérise par sa forme bulbeuse," that is, expanded at the base and distinctly rounded (figs. 14A, 14B). This feature seems to be characteristic of *L. viniai* within the genus.

Ranges in measurements and proportions for the mounted specimens from Cuba (1 ♂, 7 ♀) and Florida (2 ♂, 6 ♀) are as follows.

Measurements (mm).- Males (females); Body length 3.00-3.65 (3.14-4.57). Carapace length 0.89-1.01 (0.95-1.11). Chelicera length 0.33-0.37 (0.34-0.385). Palpal trochanter 0.51-0.615 (0.51-0.635) by 0.26-0.31 (0.26-0.37); femur 0.805-1.02 (0.78-1.16) by 0.33-0.41 (0.31-0.46); tibia 0.805-1.04 (0.80-1.11) by 0.355-0.43 (0.35-0.52); chela (without pedicel) 1.33-1.70 (1.33-1.84) by 0.48-0.635 (0.52-0.69); hand (without pedicel) 0.68-0.925 (0.725-1.07) by 0.53-0.665 (0.52-0.70); pedicel length 0.10-0.12 (0.10-0.13); movable finger length 0.69-0.89 (0.62-0.85). Leg IV: entire femur 0.76-0.93 (0.79-1.02) by 0.235-0.275 (0.24-0.31); tibia 0.59-0.77 (0.615-0.835) by 0.14-0.16 (0.14-0.19); tarsus 0.465-0.56 (0.48-0.615) by 0.095-0.11 (0.095-0.125).

Proportions.- Males (females): Palpal femur 2.45-2.6 (2.4-2.7), tibia 2.25-2.4 (2.0-2.45), and chela (without pedicel) 2.65-2.8 (2.5-2.9) times as long as broad; hand (without pedicel) 1.3-1.4 (1.4-1.6) times as long as deep; movable finger 0.96-1.01 (0.78-0.90) as long as hand. Leg IV: entire femur 3.25-3.7 (3.1-3.7), tibia 4.2-4.8 (4.3-4.9), and tarsus 4.9-5.1 (4.7-5.2) times as long as deep.

Material examined.- CUBA: Pinar del Rio Province, Vinales, Cueva del Indio, 23 January 1975, J. de la Cruz, 1 ♂, 5 ♀; same locality, 25 January 1975, J. de la Cruz, on guano, 2 ♀ [ACC]. FLORIDA: Monroe Co., Key Largo, 8 August 1971, S. Peck, hardwood litter, 2 ♂, 3 ♀; Monroe Co., Upper Key Largo, 22 March 1968, R.E. Woodruff, berlese of pack rat nest, 3 ♀; Monroe Co., North Key Largo, 5 March 1976, V. Brach, under log in hammock 1 ♂, 2 tritonymphs; Monroe Co., Key Largo, Pennekamp State Park, 2 November 1984, S. and J. Peck, hardwood hammock, leaf-log litter, 6 ♂, 1 ♀, 6 nymphs [FSCA].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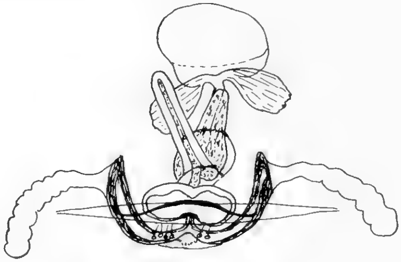
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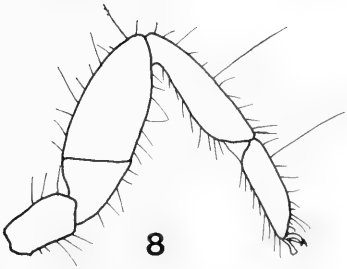
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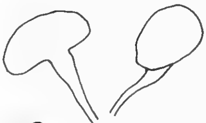
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Figs. 6-8, *Lustrochernes grossus* (Banks): 6, spermathecae of lectotype female, ventral; 7, internal genitalia of male, anteroventral; 8, leg IV, anterior.

Fig. 9, *Lustrochernes viniai* Dumitresco and Orghidan, spermathecae of female, ventral.

The records of *L. viniai* from Key Largo are the first for the United States. The species is presently known only from Cuba and Florida.

DISCUSSION

C.C. Hoff's "List of the pseudoscorpions of North America north of Mexico" (1958) includes 4 species under the genus *Lustrochernes*, namely:

Lustrochernes grossus (Banks)
Lustrochernes pennsylvanicus (Ellingsen)
Lustrochernes? acuminatus (Simon)
Lustrochernes? floridanus (Tullgren)

Hoff followed Beier(1932) and Roewer (1937) in placing *Atemnus floridanus* Tullgren, 1900 tentatively in *Lustrochernes*. Later, however, he concluded that *A. floridanus* is a synonym of *Atemnus elongatus* Banks, 1895, which he had assigned to the genus *Paratemnus* (Hoff 1964).

Chelifer (Chelanops) acuminatus Simon, 1878 has never been studied since the original description. Banks' record of the species from Olympia, Washington is unsubstantiated. Hoff followed Beier (1932) and Roewer (1937) in placing this species in *Lustrochernes*; this assignment may be correct, but its validity must await future study.

The synonymy of *Chelifer communis* var. *pennsylvanicus* Ellingsen with *Americhernes oblongus* (Say) has been demonstrated above.

Chelanops grossus Banks (1893) is here considered a representative of *Lustrochernes*, though the distinctive structure of the male genitalia raises some question about this. Certain placement must await redescription of the type species of *Lustrochernes (Chelifer argentinus* Thorell, 1877) and accurate definition of the genus.

The species of *Lustrochernes* commonly occurring in the southeastern United States is newly described as *L. carolinensis*. It is compared with *L. grossus* from southwestern states and with *L. viniai*, a Cuban species also found on the Florida Keys. These three *Lustrochernes* species may be separated by use of the following key:

1. Internal genitalia of male with a long anteriorly-directed ventral process; in southwestern U.S. .... *grossus* (Banks)

1.' Internal genitalia of male without such a process; in southeastern U.S. and Cuba 2

2. Terminal sacs of spermathecae of female hammer-shaped; chelal hand essentially parallel-sided; mainland U.S., from North Carolina to Louisiana .... *carolinensis* Muchmore

2.' Terminal sacs of spermathecae of female round or oval; chelal hand bulging at base, especially in male; Florida Keys and Cuba .... *viniai* Dumitresco and Orghidan

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PARASITES OF *STELIDOTA* (COLEOPTERA: NITIDULIDAE)[1, 2]

Roger N. Williams[3], Jimmy R. Galford[4], Foster F. Purrington[3]

ABSTRACT: The distribution of *Microctonus nitidulidis* (Hymenoptera: Braconidae) has been expanded to include new locations in Ohio and Florida. The host range of *M. nitidulidis* has been expanded to include *Stelidota octomaculata* and *Carpophilus hemipterus* in the field. The geographical range of *Brachyserphus abruptus* can now be tied to nitidulid hosts (larvae of *S. geminata* and *S. octomaculata*) in Pennsylvania, Florida, and Ohio. Fruit hosts of these *Stelidota* are also provided.

The beetle genus *Stelidota* belongs to a family known as the "sap beetles" because of their affinity for the sap of injured trees. This genus is primarily Neotropical, with only three species that range north of Mexico. Among these, the strawberry sap beetle, *Stelidota geminata* (Say) is the most studied because it causes serious damage to strawberry fruits in the eastern United States (Weiss and Williams 1980a). *S. octomaculata* (Say) is becoming notorious as a pest of oak, causing problems with regeneration of northern red oak, *Quercus rubra* L. by destroying acorn embryos and shoots of young seedlings (Galford 1987). The third species found in North America, *S. ferruginea* Reitter, ranges from Mexico through much of the eastern United States according to Parsons (1943, 1972). However, in these studies, we have not collected it in Ohio or Pennsylvania.

In a review of nitidulid parasites, Williams *et al.* (1984) listed two parasites known to attack *Stelidota: Microctonus nitidulidis* Loan (Hymenoptera: Braconidae) and *Brachyserphus abruptus* (Say) (Hymenoptera: Proctotrupidae). Since that paper no new *Stelidota* parasites have been reported. The purpose of this article is to report additional hosts and expand the known geographical range of these two parasites.

The braconid wasp, *M. nitidulidis,* a solitary endoparasite which attacks adult sap beetles, was first reported by Weiss *et al.* (1979). They recovered

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[3] Department of Entomology, Ohio Agricultural Research and Development Center of the Ohio State University, Wooster, Ohio.

[4] Northeastern Forest Experiment Station's Timber and Watershed Laboratory, Parsons, West Virginia.

it from field collected strawberry sap beetles, *S. geminata* in northeast Ohio. Later, Connell (1980) recovered it from field collected *S. geminata* near Newark, Delaware, thus expanding the range of the braconid. In previously published data, *M. nitidulidis* was only obtained from adults of field collected *S. geminata.* However, in our laboratory at OARDC in Wooster, we have reared *M. nitidulidis* on several nitidulid species (Weiss and Williams 1980b). In fact, we obtained a higher percentage of adult parasites with *C. hemipterus* (33%) as a host than with *S. geminata* (24%). In 1983, Rubink (unpublished data) recovered it from field collected *Carpophilus hemipterus* (L.) near Wooster, Ohio. Recently, this parasite has been reared on several occasions from field collected adults of *S. octomaculata.* This nitidulid species was attracted to pitfall traps baited with acorns of northern red oak. This bait also attracted other species of sap beetles, including *S. geminata.* Therefore, it was necessary to separate the sap beetle adults by species in order to establish the correct host of the parasite. Recoveries of *M. nitidulidis* from field collected adult sap beetles are listed in Table 1.

Table 1. Recovery of *Microctonus nitidulidis* from field collected Nitidulidae

Locality state/county	Date	Sap beetle host[1]	Plant host[2]	Collector
DE Newcastle	26-VIII-79	gemi	fruit ?	Connell, 1980
FL Dade	7-III-81	gemi	fruits	Felland
OH Wayne	9-V-81	gemi	WWBD	Fickle
OH Wayne	22-VII-83	hemi	corn	Rubink
OH Vinton	15-IX-86	octo	acorns	Galford
OH Delaware	23-VIII-87	octo	acorns	Galford
OH Delaware	5-IX-87	octo	acorns	Galford
OH Delaware	27-IX-87	octo	acorns	Galford
OH Vinton	6-VI-88	octo	acorns	Galford

1 gemi = *Stelidota geminata* (Say)
hemi = *Carpophilus hemipterus* (L.)
octo = *Stelidota octomaculata* (Say)

2 WWBD = Whole wheat bread dough, corn = corn kernels,
acorns = Northern red oak acorns.

The biology of *B. abruptus* has been studied for 10 years in the Small Fruit Insects Laboratory at Wooster, Ohio and is the subject of a prospective paper. We have field collected *B. abruptus* in Florida, Pennsylvania, and throughout Ohio, thereby expanding its known range as a sap beetle parasite (Table 2). Heretofore, it had been reported by Townes and Townes (1981) to be distributed from southern Canada to southern Brazil, but the literature is devoid of host records for *B. abruptus* except for Ashmead (1893) who reported, "A single specimen of what I believe to be this species was reared by Prof. Comstock, December 9, 1879, from *Stelidota strigosa.*" [(*S. strigosa* is a junior synonym of *S. ferruginea* (Parsons 1972.)] Since 1879, no other host has been associated with *B. abruptus* even though numerous records exist of collecting *B. abruptus* as adults, (Townes and Townes 1981).

Table 2. Recovery of *Brachyserphus abruptus* adults from field collected *Stelidota* larvae

Locality State/county	Date	Fruit host	Collector
FL, Dade	16-III-81	egg-fruit	Felland
OH, Wayne	19-VIII-81	peach	Fickle
OH, Wayne	28-VIII-81	apple	Fickle
OH, Wayne	1-IX-81	crabapple	Fickle
OH, Wayne	21-IX-81	muskmelon	Fickle
OH, Wayne	27-VIII-82	apple	Fickle
OH, Wayne	11-VIII-82	crabapple	Fickle
FL, Dade	24-II-83	carambola	Williams
OH, Noble	29-VII-83	apple	Williams
OH, Brown	2-VIII-83	apple	Williams
OH, Wayne	3-VIII-83	apple	Fickle
OH, Wayne	16-VIII-83	peach	Fickle
OH, Wayne	27-IX-89	plum	Fickle
OH, Wayne	5&11-X-89	plum	Fickle
OH, Vinton	18-VIII-88	acorn	Galford
PA, Clearfield	3-VIII-89	acorns	Galford

Egg-fruit = *Lucuma rivicola* var. *angustifolia* Miq.
Peach = *Prunus persica* (L.)
Apple = *Malus sylvestris* Mill.
Crabapple = *Malus* spp.
Muskmelon = *Cudumis melo* L.
Carambola = *Averrhoa carambola* L.
Plum = *Prunus nigra* Ait.

In addition to *B. abruptus* larvae (subsequently reared to adults in the laboratory) found in field collected *Stelidota* larvae, we have also collected adults on several occasions. We have found the adults most commonly on fruits which attract their nitidulid hosts. For example, three adult *B. abruptus* were collected on 100 decomposing persimmon (*Diospyros virginiana* L.) fruits on October 16, 1989 at Wooster, Ohio. The persimmons were infested with nitidulid adults and larvae. In another instance, several adults of *B. abruptus* were caught in August 1990 in sap beetle traps baited with whole wheat bread dough. In 1981, Carl Felland, a summer assistant in the OARDC Small Fruit Laboratory, collected two adults from flowers of *Aster novi-beliggi* L. near Wooster, OH. However, in the aforementioned cases we were not able to associate the wasp with hosts. In all cases the parasite adults collected were females.

In conclusion, the host range of *M. nitidulidis* has been expanded to include *S. octomaculata* and *C. hemipterus* in the field and the geographical distribution of *M. nitidulidis* has been expanded to include new locations in Ohio and Florida. The geographical range of *B. abruptus* can now be tied to nitidulid hosts (the larvae of *S. geminata* and *S. octomaculata*) in Pennsylvania, Florida, and Ohio. The fruit hosts of these *Stelidota* are also provided.

ACKNOWLEDGMENTS

The authors are indebted to Paul M. Marsh, Systematic Entomology Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, MD and Norman F. Johnson, Department of Entomology, The Ohio State University, Columbus for identifying the proctotrupid and to C. Conrad Loan, Agriculture Canada, Ottawa, Ontario for identifying the braconid. We also acknowledge Dan S. Fickle for his assistance in making many of the collections in this study.

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ANNOUNCEMENT

The Smithsonian Institution has developed a collection of biographies and photographs of entomologists entitled "Systematic Entomology Laboratory, U.S. Dep't. Agric., Photographs of and Biographical Information on Entomologists, 1797-1988 and undated." This is now available to scholars as record unit 7323 (2.73 linear meters). A finding aid to the collection is available upon request to the Archives.

ANNOUNCEMENT

The publication *Diptera Types In the Canadian National Collection of Insects* is intended to assist systematists throughout the world in locating valuable type specimens for taxonomic work on nematocerous Diptera. The Nematocera portion of the Canadian National Collection contains 654 holotypes, 193 allotypes, 36 lectotypes, and 1 neotype. In addition, 52 species are represented by syntypes, 423 by paratypes, and 40 by paralectotypes. The original description of each taxon is referenced, including citation of valid lectotype designations. The Biosystematics Research Centre of Agriculture Canada invites you to use this book to access their extensive holdings: Paperbound, 120 pages, 22 x 28 cm. Code: 023201. Price: $20.95 (Canada), US $25.15 (Other countries)

ANNOUNCEMENT

International Entomology Resource Guide, 3rd ed., now completely revised and updated, includes over 550 businesses and organizations offering collecting equipment and supplies. Also included are worldwide listings of insect zoos, butterfly houses, and entomological organizations. Send $7.95 US (foreign orders add $2.95 for airmail) to the Young Entomologists Society, 1915 Peggy Place, Lansing, MI 48910-2553.

ON THE MEANING OF THE TERM 'TRICHOBOTHRIUM'[1]

George C. Steyskal[2]

ABSTRACT: It is pointed out that the term 'trichobothrium' has been largely used erroneously ever since its inception to refer to a seta rather than the cuplike integumental receptacle into which the seta is inserted. Suggestions for the proper use of terms for both the seta and the receptacle are given.

Because the term 'trichobothrium' is derived from Greek *bothrion* 'small trench or pit' in the regular manner of forming compound words with the head word last, I have been under the impression that the term referred to a depression or cuplike integumental formation into which a seta (thrix, tricho-) was inserted rather than to the seta itself. I was consequently surprised when a few translations of Russian papers referred to trichobothria being fusiform or capitate.

It turns out that there has been a widespread, nearly universal erroneous use of the word, even from its first use. The word was apparently first proposed by Dahl (1911), who used it as equivalent to the previously used German word 'Hörhaare,' meaning 'hearing hairs.' He first used it in the German vernacular form 'Trichobothrien,' thus even at the beginning using an incorrectly formed word. He was followed by Hansen (1917), who called the term "...well composed as it signifies a hair in a pit..." However, that is not true, because it means rather 'a pit into which a hair is inserted.' We are thus left with a term which should refer to the pit being used for a hair or seta that is in that pit. Only Torre-Bueno (1937) and Christiansen and Bellinger (1980) seem to have been aware of the incongruity, Torre-Bueno in defining it as "hair-bearing spots on the underside of the abdomen in many Heteroptera" and Christiansen and Bellinger in using the term 'bothriotrix (pl. bothriotricha)' and defining it as "in Collembola, unusually thin, flexible, elongate setae, found in characteristic positions..." Here the singular form should be 'bothriothrix.' The edition of Torre-Bueno Glossary (Nichols *et al.*, 1989) cites usage of trichobothria in Arachnids, Collembola, Archaeognatha, Diplura, and Heteroptera. Von Kéler (1956) cites it in Hemerobiidae, Saltatoria, Aphaniptera, Corrodentia, and Mallophaga, as well as in *Gerris* (Heteroptera). Schuh (1975) describes its importance in the Miridae

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[1] Received November 1, 1990. Accepted November 21, 1990.

[2] Cooperating Scientist, U.S. Department of Agriculture, Systematic Entomology Laboratory, c/o National Museum of Natural History, Washington, D.C. 20560

(Heteroptera) and includes an extensive bibliography (but with Hansen, 1917, wrongly cited).

It is not too late to rectify this unfortunate mess. Trichobothrium (pl. trichobothria) is a well formed word if used with reference to the receptacle which is at the base of all setae, either cuplike or merely a more or less defined ring. The seta, simple or specialized and often resulting from the fusion of many setae, cannot be referred to as a bothrium of any kind. If the bothrium and its seta is any kind of sense receptor, it may be termed a sensillum (pl. sensilla) and be preceded by any of the numerous adjectival terms designating the kind of sensillum it may be. To unabiguously refer to the seta, that word alone, accompanied or not by defining adjectives, is of course available. There is also the term 'trichome' to signify something formed from a hair or hairs, with the plural 'trichomes,' or the Latinized form 'trichoma,' with its plural form 'trichomata.'

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BOOK RECEIVED AND BRIEFLY NOTED

A TAXONOMIC REVISION OF NEARCTIC *ENDASYS* FOERSTER 1868 (HYMENOPTERA: ICHNEUMONIDAE, GELINAE). J.C. Luhman. Univ. of Calif. Press. 185 pp, 89 figs., 22 maps. $24.00

This is the first revision of Nearctic *Endasys*, a common ichneumonid parasite of sawfly prepupae in subterranean cocoons. The purpose of this revision is to diagnose and describe new and old species and to provide keys to them along with illustrations and maps. Biological and host information is summarized and a character analysis and phylogeny are discussed.

AN IMPROVED TECHNIQUE FOR COLLECTING LARGE SAMPLES OF ARTHROPODS[1]

Laurent LeSage[2]

ABSTRACT: A simple sweeping technique unaffected by the size and number of specimens captured is described. It enables collection of live specimens, preservation in different fluids, or treatment using various procedures. The arthropods are killed or anesthetized in a jar with ethyl acetate. Large plant debris is removed in the field using a white pan modified into a sieve. Larger arthropods and the sieved fraction are either sorted in the field or preserved in 70% acetic alcohol for later sorting in the laboratory.

The entomological net is a well-known piece of equipment, but little has been done to improve its efficiency. It is generally productive for hunting butterflies, but the net itself and its use must be modified for collecting minute arthropods (mites, Proctotrupoidea (Hymenoptera), etc.), jumping insects like flea-beetles (Chrysomelidae), or large numbers of fast flyers (Hymenoptera, Diptera, Coleoptera, etc.).

In presenting the technique described here, I hope to provide answers to the following questions often asked by professional or amateur entomologists concerning improvement of sweep net collecting:

— "How does one handle large numbers of arthropods collected in one sample?"

— "Is it possible to sweep arthropods without worrying about numbers captured, sizes of individuals, or taxonomic groups to which they belong?

— "How to preserve the specimens collected using different techniques and/or preservatives?"

— "Can the technique be adapted for the capture of live insects?"

MATERIAL

THE NET. Any standard entomological net can be used for the technique described below, but factors such as the diameter of the rim, the weight of the net and the size of the mesh should be taken into consideration.

My favorite model is not an entomological net but a standard aluminum fish net modified into a sweep net. The broad pentagonal rim, 40-50 cm in diameter, with a straight front edge is convenient for sweeping low grasses. The handle, 45 cm long, can be unscrewed and remounted easily, a feature greatly appreciated during collecting trips in foreign

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[2] Agriculture Canada, Biosystematics Research Centre, Ottawa, Ontario. K1A 0C6.

countries. It is lightweight, averaging only 260 grams, which is important when several nets have to be carried for many hours. The original nylon fish net must be replaced by fine-mesh netting. My own nets are made of fine-mesh curtain cloth: 26-28 mesh/cm, 250 µm opening. Mites and minute insects are readily captured with such nets. This is not the case with the majority of insect nets available on the market; these nets must be replaced with finer mesh netting to collect very small arthropods.

THE KILLING JAR. In my opinion, the best killing container is a one-liter Nalgene® plastic jar. It is unbreakable, chemical-resistant, lightweight and large enough to receive samples of appropriate sizes. A piece of paper towel packed on the bottom is moistened with the killing agent before use.

I recommend ethyl acetate as a killing agent because it is safe when handled properly. It is one of the rare chemicals that keeps appendages of arthropods relaxed, making later mounting, spreading or dissecting easy (usually, a minimum of 6-12 hours is needed for complete relaxation of muscles after death). Also, it may be used as an anesthetic as discussed below.

A killing jar is prepared by pouring 2-3 ml of ethyl acetate on a piece of paper towel just before use. Chemical is added when the killing agent becomes less effective.

THE SIEVE. A simple system for the removal of plant debris consists of a white pan with a screened bottom placed over another unmodified one. White plastic pans used for film development are perfect for this purpose. They are lightweight but very sturdy. The large model (37 x 44 cm) is cumbersome but on the other hand it can be used for sifting arthropods from leaf litter or other kinds of debris. The model of medium size (29 x 34 cm) is what I prefer: not too heavy and bulky to carry over long distances, but big enough to allow efficient spreading of net contents. Occasionally, I carry "mini-pans" (10 x 15 cm) that fit in my collecting bag. For each of these sizes I have one pan with the bottom cut out and replaced by 5 mm (¼") mesh screen. A larger mesh size does not intercept enough detritus while a smaller one will retain too much.

THE PRESERVATIVE. For general purpose, any kind of commercial alcohol is appropriate: *methanol,* called "wood alcohol" or "methyl hydrate" in hardware stores; *ethanol* is extensively used by entomologists but is usually difficult to obtain due to government regulations; *isopropanol* better known as "rubbing alcohol" may also be used. Arthropods become stiff when placed directly in these alcohols. If the original liquid is diluted and 2-5% *acetic acid* added, the appendages and body tissues will remain soft and relaxed.

Acetic alcohol is prepared as follows:

- commercial alcohol	70 parts
- water	25 parts
- glacial acetic acid	5 parts

or simply mix:

- commercial alcohol	70 parts
- vinegar	30 parts

Seventy percent acetic alcohol is an excellent general preservative although not necessarily the best for arthropod groups which require special treatment. Solutions with formaldehyde should be avoided unless they are required for a special purpose.

DESCRIPTION OF THE TECHNIQUE

The present sweeping method is an adaptation of techniques previously described for handling insects collected with emergence traps (LeSage 1979).

The technique consists of six main steps:

1- Insects are swept from a specific habitat until a handful of plant debris and insects accumulate at the bottom of the net. With one hand, the collector grasps the middle of the net to prevent insects from escaping (Fig. 1).

2- The whole contents are placed in a killing jar previously treated with ethyl acetate (Fig. 2).

3- After 2-5 minutes, the contents are spread on the screen of the white pan modified into a sieve, itself placed over a white pan (Fig. 3).

4- Large insects, retained by the sieve, are picked out individually and preserved in an appropriate manner. The debris is discarded.

5- Smaller insects and other arthropods that are sorted out in the field are processed using the best preservation techniques and preservatives.

6- Residues are carried dry in plastic jars, or preserved in the field with 70% acetic alcohol.

These steps are described and commented in greater detail below.

Figures 1-2. Illustrations of various steps for improved sweeping technique: 1, how to handle the net contents; 2, nets with their contents placed in killing jars.

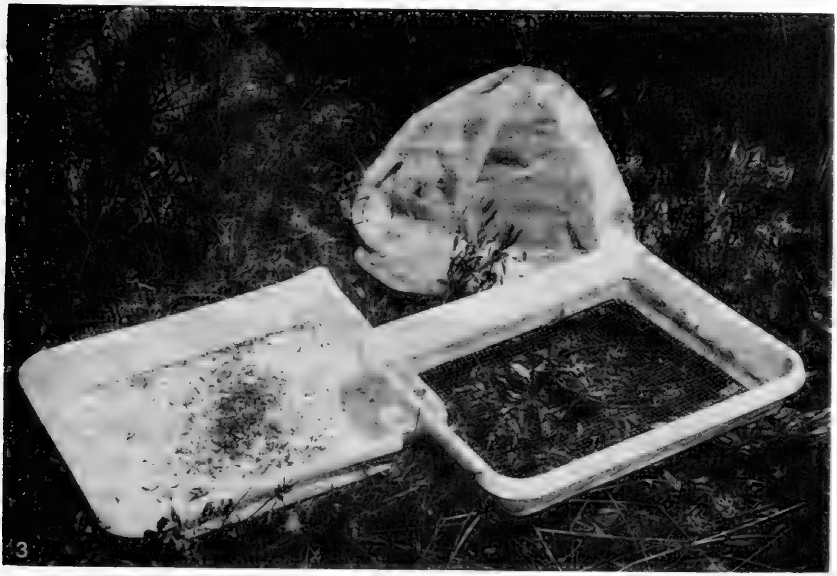

Figure 3. On the left a large unmodified white pan for sorting in the field, on the right a white pan modified into a sieve for screening plant debris and larger arthropods.

PROCESSING SAMPLES

SIZE OF SAMPLES. Try to avoid large samples. The accumulation of leaves, seeds, or twigs may damage the specimens, especially soft-bodied insects or other arthropods. Aphids, small flies, and larvae are the most vulnerable. Clean samples are obtained when the vegetation is not struck, for example, when collecting swarming chironomids at dusk along the banks of streams. However, if one must beat the vegetation this should be done moderately in such a manner that a minimum of plant debris is collected.

HANDLING NET CONTENTS. Accumulate the insects at the bottom of the net by quick sweeps in the air. Dislodge those insects gripping the net by knocking the rim of the net, while keeping an eye on the strong flyers (Diptera, Hymenoptera) that are always eager to escape. Grasp the net with one hand just above the contents when the specimens are concentrated at the bottom (Fig. 1).

KILLING AGENT. As mentioned above, ethyl acetate is the best killing agent because it keeps bodies and appendages relaxed, and can also be used as an anesthetic. Poisons like potassium cyanide or sodium cyanide should be avoided due to their extremely high toxicity. In addition, they stiffen the specimens and make later spreading difficult if not impossible when working with beetles.

Lepidopterists often use tetrachloroethane to kill moths and butterflies. This chemical seems very satisfactory for killing Lepidoptera, especially Microlepidoptera, but the smell is so bad that it can make some persons sick.

TIME REQUIRED FOR POISONING. If a one-liter Nalgene® container is used as a killing jar and treated with two to three ml of ethyl acetate, insects usually die within two to five minutes but the net contents should remain inside the killing jar longer when the vegetation is wet, or when the collected material is packed inside the net.

SORTING AND PRESERVING ARTHROPODS IN THE FIELD. When the insects are dead, spread the net contents on the pan which has a screened bottom. Shake moderately to allow small arthropods and plant particles to go through the screen and fall in the other pan beneath it. Pick out larger arthropods found on the screen. Process the sifted fraction as explained below, and finally discard detritus.

You do not have to sort the material in the field if weather conditions are not suitable or if you want to save time, but doing so enables you to preserve arthropods which require immediate treatment. The greatest advantage of the present technique is that it consistently produces specimens in excellent condition.

For example, beetles can be transferred to vials containing sawdust slightly moistened with a few drops of ethyl acetate. As long as the vapors persist in the vials, beetles remain relaxed for a year or more, thus making later mounting, spreading or dissecting easy, as though one were working with fresh material.

Grasshoppers, dragonflies, damselflies, large mayflies, etc. are usually preserved dry and placed in pillboxes equipped with a small fresh leaf to provide moisture, or placed individually in envelopes. Butterflies and moths may be treated the same way, but sweeping should stop immediately following capture to reduce damage to the wings.

Diptera can be preserved in various ways. Some dipterists working with Brachycera (Tabanidae, Syrphidae, etc.) usually prefer their specimens dry, which presents no problems. Specimens are simply selected from the pan and placed in appropriate vials or pillboxes. Other dipterists prefer to work with specimens preserved in alcohol (Chironomidae, Ceratopogonidae), which can also be picked out and preserved selectively in 70% acetic alcohol.

Aphids, Collembola, other soft-bodied insects, spiders, as well as immature arthropods, are usually preserved in alcohol and may be stored by taxonomic group in vials or all groups placed together in larger containers.

Mites can be treated separately and preserved in different fluids. Oudemans's fluid is recommended for the preservation of specimens with appendages spread. Lactic acid is appropriate for clearing small specimens and Koenicke's fluid is suggested when specimens are heavily sclerotized (see Martin 1977 for details).

PRESERVATION OF RESIDUES. For a variety of reasons most entomologists specialize in the study of a given order, family or even genus, and consequently are usually very selective in their collecting. Thus specimens which do not interest them are either ignored or discarded. Such waste of time and energy should be avoided. Why not preserve residues without additional work on your part? Often, people working with small arthropods discover that residues may contain even more specimens than they can recognize and sort out in the field. Furthermore, one should consider exchanging residues with other entomologists using the same technique. This is probably the easiest and cheapest way of obtaining specimens of interest from other areas.

COLLECTION OF LIVE SPECIMENS

The technique described above can be adapted for the capture of live arthropods. However, the period of time during which the net contents are maintained inside the killing jar is reduced. Thus, arthropods are stunned or anesthetized rather than killed.

To collect live specimens using the above-mentioned technique, it is useful to know that the period of time required to kill the arthropods varies with the outdoor temperature, the amount of ethyl acetate in the killing jar, the kinds of arthropods, the size of samples, and also the degree of wetness of the vegetation. Field tests must be carried out at each site to determine the length of time that samples should remain in the jar.

Minute Hymenoptera and Diptera die quickly in ethyl acetate. Larger Hymenoptera, Diptera, Coleoptera and Orthoptera show greater resistance, with the largest individuals generally being the least affected. Many spiders are still active when all insects are already dead.

Ethyl acetate can be used as an anesthetic when samples are placed in the jar for a shorter period of time. It has been successfully used for the collection of live Chrysomelidae needed for various projects. Beetles have been transferred into empty jars or bottles for recovery just after they had been stunned. The majority became active again after a few minutes, but some after several hours.

This treatment does not harm beetles. Matings are still observed and females produce fertile eggs. I have tested the technique extensively for the capture of several hundred live Ragweed beetles (*Zygogramma suturalis* (Fabricius)) shipped to China for introduction as a biological control agent against ragweed. According to Wan *et al.* (1989), the beetles become established immediately. Over a thousand individuals of *Labidomera clivicollis* (Kirby), *Calligrapha multipunctata bigsbyana* (Kirby), *C. philadelphica* (Linné), and *Z. suturalis* (Fabricius) sent to Belgium for analysis of their defensive secretions, have survived very well and are still alive today (Dr. J. Pasteels, pers. comm.)

I have no detailed data regarding the survival of other groups of insects, but I am convinced that the same technique can easily be adapted for use with many groups of arthropods. Appropriate adjustments must be made with respect to the anesthetizing period, the size of arthropods and weather conditions.

Editor's note: Shipment of live insects in and/or out of most countries, including the U.S.A. and Canada, is strictly controlled by governmental regulations. Individuals contemplating any such activity should first check with regulatory authorities before taking any such action.

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I thank my colleagues H. Goulet, R. Hutchinson, L. Masner, as well as the two unknown external reviewers for their useful comments on the manuscript.

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ANNOTATED LIST OF INSECTS OF MACAU OBSERVED DURING 1989[1]

Emmett R. Easton[2]

ABSTRACT: Nineteen species of beetles, 2 species of roaches and mantids, 10 flies, 8 Heteroptera, 11 Lepidoptera, 6 Hymenoptera, 2 Orthoptera and 1 species of flea and of silverfish are listed from this Portugese administrated area which is connected by a peninsula to the Peoples Republic of China. The majority of species reported were associated with buildings situated on the University of East Asia campus on the island of Taipa where artificial light is normally provided at night to illuminate the premises.

Zoogeographically the fauna of Macau would be expected to be similar to that of the Hong Kong colony which is located across the Pearl River delta from Macau. Hill and Phillipps (1981) claimed that Hong Kong colony lies in the intermediate area between the Oriental and the Palearctic faunal regions so it can be interpreted that Macau, like Hong Kong, possesses a mixed fauna with elements from both regions. Seasons exist in Macau and Hong Kong typical of the temperate regions of the world. Macau geographically consists of a peninsula connected to mainland China as well as to two islands, Taipa and Coloane, which are interconnected by a road bridge or a causeway. All of the species listed were found on the island of Taipa but most of them are believed to exist on the island of Coloane as well where habitats are similar. The insect fauna of Macau is probably rich in diversity of species and very likely is similar to Hong Kong territory but written accounts are absent from the literature, at least in English. Identifications of the fauna were carried out with the aid of Hill *et al* (1982), Hill and Cheung (1978), Hill (1982) and Hodgkiss *et al* (1981) and collected material was compared with identified specimens maintained in the Agriculture and Fisheries entomology collection at Tai Lung Farm, Sheung Shi, New Territories, H.K. as well as the B.P. Bishop Museum, Gressitt Entomological Center, in Honolulu, Hawaii. Common names listed were taken from Hill and Cheung (1978) or Hill (1982) and are not among the official list of names supplied by the Entomological Society of America.

Observations made at different sites on the University campus daily (700 hrs) during this period, such as the Skyway lobby, Tai Fung bldg., S.K. Wong bldg., Block I or Block III bldg., indicated that light normally supplied at night was serving as an attractant. Insects were not routinely found where light was absent except for the library which was not

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[2] Visiting Professor of Entomology, University of East Asia, P.O. Box 3001, Taipa, Macau.

illuminated at night but the presence of stainless steel railings inside the windows was noted to produce different wave lengths of light when viewed from the outside that may have simulated a black or Ultra violet portion of the spectrum. These observations suggest that a seasonal effect is apparent in the occurrence of the insect fauna despite the tropical diversity of the species composition. Unless otherwise stated only 1 specimen was collected at a time.

LIST OF SPECIES

THYSANURA

Lepisma saccharina (L.), the house silverfish, Oct. This insect was a common resident of flats and apartments on the campus.

ORTHOPTERA

Acrididae

Chondracis rosea (de Geer), the large green grasshopper, 6 Aug. was found resting on elephant grass near the campus tennis courts. Hill *et al* (1982) also list it for Hong Kong.

Gryllotalpidae

Gryllotalpa africana Beauv., the African mole cricket, 24 Oct. near a rain gutter below the Tai Fung bldg. This is a cosmopolitan species found in the warmer regions of the world that can destroy the roots of herbaceous crops in the seedling stage (Hill, 1983). According to a recent communication from Dr. Hill the insect described in his Hong Kong books (Hill *et al.* 1982), (Hill and Cheung, 1978) may actually be *G. orientalis*.

DICTYOPTERA

Blattidae

Opisthoplatia orientalis[3] the litter cockroach, 22 Aug. in the table tennis room. This roach ordinarily does not invade buildings or domiciles but the open access of this site allowed insects to gain access from the outside. Hill *et al* (1982) report this roach as semiaquatic with observations of it entering water.
Periplaneta americana (L.), the American cockroach is common at most times of the year on campus except for the months of Dec.-Feb. which are the coldest and constitute the local winter season. The insect is also a common household pest in Hong Kong.

Mantidae

Hierodula sp. the large green mantid, 28 Sept. on S.K. Wong bldg.
Tenodera sinensis Saussure, the large brown mantid, 3 Dec., on Block III.

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[3] Name of describer of species not possible to be obtained by author of paper due to limited research resources.

HEMIPTERA

Coreidae

Notobitus meleagris (F.), the bamboo coreid or leaf-footed bug, 17 Oct. This insect is believed to be common throughout South China according to Hill (1983) in which the saliva is toxic to bamboo plants.

Pentatomidae

Calliphara sp., the blue shield bug, 12 Dec. on Block III.
Cantao ocellatus (Thunb), the Mallotus shield bug, 12 Oct., library. This brightly colored orange bug is believed to be associated with *Mallotus paniculatus* trees, according to Hill (1982).
Erthesia fullo (Thunb), Aug. on trunks of the horsetail tree, *Causuarina equisetifolia* on campus. This blackish stink bug was observed by the author to feed and oviposit on this host.
Nezara viridula (Linn), the green stink bug, 7 July, 7 Aug. on the Tai Fung bldg. This insect is a common pest of vegetables, potatoes, carrots and citrus and is widespread extending from southern Europe and Japan south to Australia and Southern Africa (Hill, 1983).
Tessaratoma papillosa (Drury), the Litchi stink bug, 17 July, 13 Aug., near base of Block III. The bug commonly feeds on the sap of the Litchi and the Longan (*Euphoria longan*) fruit trees in southern China. Immature nymphs as well as adults have been found on Longan fruit trees on the island of Coloane here in Macau. The bug apparently overwinters in the foliage of the trees.

HOMOPTERA

Cicadidae

Cryptotympana pustulata Fabr., the large brown cicada, 23 June resting on branch of *Acacia confusa* tree on campus. Hill *et al*, (1982) in their works on Hong Kong insects refer to this species as *C. mimica* (Walk.). This insect can produce a deafening call at close range and can be often heard starting at dawn from late May and continuing during daylight hours through the month of July in Macau and Hong Kong.
Huechys sanguinea (Deg.), the red-nosed cicada, 23 Aug., 30 Sept. attracted to lights near the S.K. Wong bldg. Emergence from the ground in this species is later in the season and in Macau has been noticed from Sept. through November. Hill (1982) and Hill *et al* (1982) refer to this species, now incorrectly, as *Scieroptera sanguinea*.

NEUROPTERA

Myrmelionidae

Myrmeleon sp. 31 July inside Block I.

LEPIDOPTERA

Anatidae=Syntomidae

Syntomis polymita Sparrm., 25 Nov. near the library.

Syntomis sperbius F., striped tiger wasp moth, 11 July near the library. Both *S. sperbius* and *S. polymita* have been observed in small numbers on campus throughout the year except during the coldest months.

Danaidae

Danaus genutia Cr., Orange Tiger butterfly, noted in summer in table tennis room.
Euploea core (Godart), the common crow butterfly, 12 & 17 Oct. in temporary classroom corridor.

Papilionidae

Graphium sarpedon (L.), the common bluebottle, Sept. in temporary classroom corridor.
Papilio memnon L. the citrus swallowtail, 27 Oct. in temporary classroom.
Papilio polytes L., the common mormon, 16 Oct. in temporary classroom.

Sphingidae

Acherontia styx (Westwood), 18 Aug. near library. This species superficially resembles the death's head hawk moth, *A. atropos* (L.) that can defoliate solanaceous crops throughout southeast Asia. Both species can apparently enter bee hives to obtain the honey.
Agrius convoluli (L.) convolulus hawk moth, 1 Nov. near library. The greenish or brownish larvae defoliate sweet potato in South China, Burma, Malaysia, India, Australia, New Zealand, Papua New Guinea and Irian Jaya (Hill, 1983).
Macroglossum belis[3] hummingbird hawk moth, 12 Aug., 23 Oct. in temporary classroom corridor.
Theretra nessus Drury 23 Oct., 11 Nov., on Tai Fung bldg. Hodgkiss *et al.* (1981) illustrate this species in their ecology of Hong Kong publication.

DIPTERA

Bombyliidae

Ligyra tentalus Fabr. the large black bee fly, 7 Sept. in temporary classroom corridor.
Anthrax sp. 26 Aug. in temporary classroom corridor.

Calliphoridae

Lucilia sp. green bottle fly, 11 & 17 Oct. in Block I.
Chironomus sp. larval bloodworms in drainage area below S.K. Wong bldg.

Culicidae

Culex quinquefasciatus Say., southern house mosquito. Adults are common throughout the year except from Dec-Feb in most buildings on campus where they gain access to classrooms and apartments by flying into the open doors of the pedestrain elevators or lifts. Larvae are common in stagnant water which is often polluted near domiciles on the island. The mosquito can survive for prolonged periods indoors when relative humidity is high due to the lack of room airconditioning.
Aedes albopictus Skuse. larvae were noted in waste or refuse containers (during the spring months) that fill with water along a hiking trail on the top of a hill on Taipa Island.

Psychodidae

Psychoda sp. the moth fly was commonly observed on windows near the library during the spring and early summer.

Stratiomyiidae

Hermetia illucens L., the soldier fly, 20 Aug., 4 Sept. in temporary classroom corridor.

Tabanidae

Tabanus sp. 13 Aug. caught near the Hyatt Regency Hotel on Taipa Island.

Tipulidae

Holorusia sp. 30 May in temporary classroom corridor on campus.

SIPHONAPTERA

Ctenocephalides felis (Bouché), the cat flea, 9 Oct. on local dog on Taipa Island. Leitão (1921) reports this flea as common on both dogs and cats on the Macau peninsula.

HYMENOPTERA

Apidae

Anthophora andrewsi Cockrell, the blue-banded solitary bee, 17 Aug., 18 Sept. in temporary classroom corridor. A common species often seen feeding on flowers in Macau and Hong Kong.
Xylocopa iridipennis Lep. the bamboo carpenter bee, 24 Oct. near library. The bee has been observed to nest in hollow bamboo stems, in which it can cut a hole employing its strong mandibles.

Evaniidae

Evania appendigaster[3] the ensign wasp. 16 Sept. in classroom in Block I. The wasp is commonly observed indoors apparently seeking the ootheca of the American cockroach that it parasitizes. Hill *et al* (1982) report it common in Hong Kong.

Scoliidae

Megascolia azurea Fabr. 4 Sept., in temporary classroom corridor. This is most likely the same species that Hill *et al.* (1982) and Hill (1982) refer to in the genus *Scolia*. The latter author believes the wasp parasitizes beetle larvae.

Vespidae

Vespa bicolor Fabr. the common wasp, 4 Sept., 3 Nov., 10 Dec. in temporary classroom corridor.
Polistes sp. prob ***saggittarius***. A nest of this wasp was located outside of the Tai Fung bldg. in the summer season.

COLEOPTERA

Bostrichidae

Bostrychopsis parallela Lesne, 13 Sept. near library, 26 Sept. near K.C. Wong Bld.

Carabidae

Craspedophorus mandarinus[3], spotted ground beetle, 10 July on floor near library.

Cerambycidae

Anoplophora chinensis (Forster), the citrus longhorn beetle, 22 May near tennis courts under street lamp. The larvae of this species is considered a serious pest of citrus in Hong Kong colony and southern China (Hill *et al.*, 1982) but in Macau citrus trees are wanting and the beetle most likely completes its development feeding upon *Melia azedarach* L.
Batocera rubus (L.), the white-spotted longhorn beetle, 6 July on Block I. The larvae burrow in fig, mango and jackfruit trees from India through southeast Asia to south China including Hong Kong.
Imantocera penicillata (Hope), 8 July near library.
Olenecamptus bilobus[3], 10 Sept. on Block I.

Chrysomelidae

Sagra purpurea Lichtenstein, 7 Aug. on the K.C. Wong bldg. The purple leaf beetle is listed under the family Sagriidae in Lee and Winney (1981). Hill *et al* (1982) list it from Malaysia as well as Hong Kong.

Cicindelidae

Cicindela separata Fleut. the blue spotted tiger beetle, 13 May. This species is commonly observed during the spring months along walking or hiking trails both on the islands of Taipa and Coloane.

Curculionidae

Sipalinus hypocrita[3], wood boring weevil, 7 Sept. near library.

Dytiscidae

Cybister tripunctatus Olivier, predaceous diving beetle, 11 Sept. near K.C. Wong bldg. This species is reportedly consumed as human food by local residents who collect them from the pavement near street lamps.

Elateridae

Campsosternus auratus Drury. large click beetle, 24 May under lights near the tennis courts on campus. Several individuals have been crawling about lacking an abdomen suggesting that this species is a source of food for insectivorous birds on the island.

Lampyridae

Luciola sp. giant glow worm, 19 May in rain gutter after a shower near tennis courts.

Lucanidae

Prosopocoileus biplagiatus (Westw.) the common stag beetle. 13 July, 15 Aug. near library.

Scarabaeidae

Anomala cupripes (Hope), the copper-green flower beetle, 7 July near library. In southeast Asia the adults damage leaves and inflorescences of a wide range of crop plants and ornamentals while the larvae are white grubs feeding on grass roots (Hill, 1983).
Agestreta orichalea[3], the large green flower chafer, 3 Sept. near library.
Dynastes gideon (Linnaeus) most recently known as ***Xylotrupes gideon***, 6 Aug., the unicorn beetle has been commonly found under street lights near the Hovione Pharmaceutical factory on Taipa Island.
Protaetia orientalis G. & P., the green rose chafer, 28 May near library.

Staphylinidae

Phucobius simulator Sharp. 2 males, 2 females, Oct. on sandy beach beneath wooden debris at intertidal zone on Taipa Island.

ACKNOWLEDGMENTS

The author wishes to thank Horace Last (Woodville, West Sussex, England) for the determination of the staphylinid beetle and G.A. Samuelson of the Bishop Museum (Honolulu, Hawaii) for identifications of other beetle species. Representative material listed has been deposited with Last and with the B.P. Bishop Museum, Honolulu.

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SOCIETY MEETING OF FEBRUARY 27, 1991

BUG IN YOUR EAR

Dr. Hal White, Organizer

And now for something completely different! The February meeting of the Society proved to be quite a departure from the normal scientific presentations and discussion as it focused on "music by and inspired by insects". Certainly, the "musical" or sound capabilities of insects has been long recognized and studied. In contrast, the heretofore unknown, musical capabilities of the Society membership was showcased during this intriguing and diverse program.

Dr. Hal White offered a brief introduction to the topic of music inspired by insects by playing a few recorded pieces of music (such as the instantly recognizable "Flight of the Bumblebee" — but played on the trombone!) and by distributing a list of insect-related music that he compiled from his own research and suggestions from others. Dr. Daniel Otte followed with a program of "music" produced by insects, mostly that derived from various Orthoptera, the order of insects in which Dr. Otte specializes. Among some of the calls played were the musical, bird-like calls of katydids in Malaysia (contrasting with the rather mechanical sounding calls produced by our local species), the fastest cricket call known at 210 pulses/second (a Malaysian mole cricket), and the stepwise gradation of pulse rate in calls among a sibling-species complex of Hawaiian crickets. Dr. Otte noted that the "acoustically richest" place he has visited was a half-mile stretch of forest in Malaysia, where he recorded calls of 88 different species of crickets!

Acoustic riches of a sort were provided by the live entertainment at the meeting. Barbara and Alan Kirschenstein played several compositions on autoharp, fiddle and harmonica, including an original piece written for the Society. Mary Berk ended the evening with a well researched program of music which she performed with flute, recorder and voice. Her presentation was a deft interweaving of insect-inspired music and music history, starting with compositions from the 1600s, and including early American gems like "Dog Tick", and several boll weevil songs.

The program at The Academy of Natural Sciences in Philadelphia was attended by 20 members and 13 guests. The general election for officers was held, and the following were elected unanimously: Joe Sheldon, President; Hal White, Vice President; Paul Schaefer, Recording Secretary; Jon Gelhaus, Corresponding Secretary; Jesse Freese, Treasurer.

Jon K. Gelhaus,
Corresponding Secretary

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THE PECULIAR SEX RATIO AND DIMORPHISM OF THE GARDEN FLEAHOPPER, *HALTICUS BRACTATUS* (HEMIPTERA: MIRIDAE)[1]

W.H. Day[2]

ABSTRACT: Nearly 90% of the adult garden fleahoppers, *Halticus bractatus*, collected were females. This unbalanced sex ratio, though it is suggestive of a reproductive anomaly, is probably an artifact caused by the sweep net sampling method, and is likely a result of behavioral differences between the sexes. Nymphs were also inefficiently sampled by sweeping. Nearly 90% of female fleahoppers were the flightless, brachypterous morph. If this is representative of the population, then few females are capable of emigrating. This and the high parasitism rates recently discovered would contribute to the sporadic appearance of this insect in numbers sufficient to cause damage to crops.

Halticus bractatus (Say), the garden fleahopper, was first described from Indiana in 1832 (Henry & Wheeler 1988) by Thomas Say. The partial sexual dimorphism (all adult males are winged, most females have no hind wings under the elytra-like forewings) and the very small size (1.5-2.3 mm) of this mirid likely contributed to its being described as a new species four times (Henry & Wheeler 1988), and its identification as two different species by Uhler (Popenoe *et al.* 1890).

The small size and dimorphism may also have contributed to the present lack of information on several important aspects of its biology, despite the fact that the garden fleahopper has sporadically been reported as an important pest of many legume, vegetable, and fruit crops (Beyer 1921, Underhill 1946, Mangan & Byers 1982). For example, until recently the nymphs of *H. bractatus* were not known to be parasitized in the U.S. (Loan 1980 reported parasitism by *Peristenus clematidis* Loan in Canada), despite the recent discovery of a 50% mortality rate in alfalfa, caused by a native braconid wasp (Day & Saunders 1990). And, although the death of half of the nymphs should have reduced the number of adults sampled to about 50% as many as the nymphs, instead many more adults than nymphs were collected, in 26 of 27 field samples taken by sweep net (Day & Saunders 1990).

In this paper I discuss reasons for the disparity in the nymph:adult ratio, record the apparently different sex ratios of adults and of nymphs, describe the incidence of sexual dimorphism in fleahopper females, and discuss the significance of these findings.

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[2] USDA Beneficial Insects Research Laboratory, 501 S. Chapel St., Newark, DE 19713.

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MATERIALS AND METHODS

All samples were taken in alfalfa, by 50 half-cycles of a sweep net. A total of 11 fields were sampled, in three areas (Blairstown, NJ; Rancocas, NJ; and Newark, DE), but because populations were very low in most fields, the majority of the fleahoppers were collected in two fields near Blairstown. Samples were made regularly through the growing season, weekly from early May to July (1986) or August (1987-1989), and biweekly from then until mid-October. Frequent sampling was necessary because fleahopper numbers were not predictable: in general, they were most abundant in July or August, adults were most numerous in 1987 and 1989, nymphs were most abundant in 1986 and 1987, and abundance of the stages was not necessarily correlated (Day & Saunders 1990).

After the net contents were emptied into a glass-topped sleeve cage, the fleahoppers were counted as they were aspirated into plastic vials, separately by stage. A tip of alfalfa was placed in each vial for food and moisture, and the vials were put in an insulated cooler, with ice, to improve survival during the trip back to the laboratory. They were then frozen (at -20°C), for preservation until time was available for dissection under a binocular microscope, for determination of sex, parasitism, and morph. Additional details on the sampling methods are in Day & Saunders (1990).

RESULTS

Sex ratio: Nearly 90% of the garden fleahopper adults collected by sweep net were females (Table 1), a highly significant departure from the 50:50 ratio which might be expected. In contrast, this ratio in the nymphal stage was not significantly different from a 50:50 ratio.

Sexual morph: Nearly all of the female fleahoppers were of the brachypterous type, a highly significant difference (Table 2). Dissection of an aliquot (n = 20) demonstrated that there were no hind wings under the shortened, elytra-like forewings of this morph, so they were truly flightless, confirming the assertion by Webster (1900) that the brachypterous females could not fly.

DISCUSSION

Sex ratio: The high proportion of females in the adult samples (Table 1A) is intriguing because it is unusual in alfalfa-infesting mirids (Day, unpublished data), and because it suggests the possibility of deuterotokous reproduction. Although some mirid workers are aware that most *H.*

Table 1. Sex ratios of garden fleahopper adults and nymphs in sweep net collections.

Stage	Sex	Number[a]	Total
adult	female	394*** (88%)	449
	male	55	
nymph	female	48^{ns} (43%)	111
	male	63	

[a] Statistical differences by the chi^2 test. Comparisons were made between the numbers of males and the number of females, for each stage, compared to the theoretical 50:50 ratio. The actual proportion of females was significantly different only in the adult stage ($P > 0.001$).

Table 2. Morphological types of garden fleahopper females in sweep net collections.

Morph	Number[a]	Total ♀
apterous	348*** (88%)	394
alate	46	

[a] Statistical differences by the chi^2 test. Statistical comparisons were made between the actual number of apterous females and the two theoretical possibilities, 100% winged and 100% wingless; the actual data above were significantly different from both possibilities, at the same level $P > 0.001$).

bractatus adults in reference collections are female, unfortunately data on the sex ratio of the species in nature have not been recorded by earlier workers (Chittenden 1902, Beyer 1921, Knight 1923; only Blatchley 1926 suggested that males may be much less numerous than females). The large numbers of samples and of individuals examined in the present study, and the statistical tests indicate that females were actually much more abundant than males in the sweep net samples. However, the approximately 50:50 sex ratio of the nymphs (Table 1B) that were also swept indicate that equal numbers of both sexes are being produced in the field. This is supported by the laboratory results of Cagle & Jackson (1947), who reared an equal number of males and females (total n = 365) over a two-year period. The authors also found that both sexes had similar life spans (average 49 d), so males are not more likely to die as the population ages, changing the sex ratio. Thus, the evidence indicates that both sexes of adult fleahoppers are equally abundant, but the females are sampled much more readily in alfalfa, by sweeping. This would also account for Blatchley's (1926) observation. Males probably are lower on the plants than are females, so fewer are collected. Nymphs of both sexes also may feed closer to the soil than do female adults, because nymphs were less abundant than adults in 96% of sweep samples (Day & Saunders 1990). Perhaps the females utilize the higher (younger) leaves because certain nutritive compounds are present in larger concentrations, which would increase their fecundity, as was observed for mites by Hennenberry (1962). Lugger (1900) stated that this fleahopper was difficult to capture, (presumably with a net), probably because they "operate close to the ground," and he suggested that this species was likely more abundant than it appeared.

Sexual morph: Because nearly 90% of female garden fleahoppers sampled by sweep net were the flightless form (Table 2), and the sweep net is the most common sampling tool, it is surprising that the incidence of brachypterous females in field samples has been mentioned in only a few previous papers (Beyer 1921, Blatchley 1926, and Knight 1923, 1941). Although none provided numerical data, they stated that females were usually brachypterous. It is possible that this preponderence of wingless females is not an artifact of the sampling method, because Cagle & Jackson (1947) found that 100% of their female *H. bractatus* were brachypterous (these were lab-reared progeny of 171 females that had been field collected as nymphs). A low percentage of winged females would appear to be a handicap for the fleahopper, because the species would be slow to disperse, especially to distant points. This, together with the high parasitism rates of nymphs recently discovered (Day & Saunders 1990), may explain the uneven fleahopper abundance noted above (significant numbers in only 2 of 11 fields, or 18% of those surveyed).

The high proportion of flightless females also suggests that the comparative scarcity of garden fleahopper nymphs (Table 1) is likely to be a deficiency of the sweep net sampling method, and not an indication that nymphs are produced on other host plants outside the alfalfa fields — because the flightless adult females almost certainly must have earlier been nymphs in the alfalfa.

Bias of sweep net samples: The data strongly suggest that both adult males and nymphs are underrepresented in sweep samples (Table 1 and above discussions). Thus, garden fleahopper population size is considerably underestimated when sweep net sampling is used. Perhaps this underestimation, the very small size of this insect, and its tendency to jump when disturbed, all contribute to the scarcity of reports on its economic importance. And, although the sweep net has some deficiencies, it is likely to remain the most-used sampling tool in alfalfa and similar crops, because it provides useful relative data (for comparing different locations and dates), and is convenient, fast, and inexpensive. It would be interesting to determine if an insect vacuum device would provide more accurate counts of adult males and nymphs.

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MOVEMENT OF GRAVEL BY THE 'OWYHEE' HARVESTER ANT, *POGONOMYRMEX SALINUS* (HYMENOPTERA: FORMICIDAE)[1]

Timothy D. Reynolds[2]

ABSTRACT: Colored aquarium gravel was used in a study to determine the source of small fossil and modern zoological and archeological specimens accumulated in the mounds of harvester ants. Results suggest that mature colonies of harvester ants collect, rather than excavate, most of the materials used to reconstruct mounds.

In the late 1800's, during the heyday of fossil collecting on the plains of the American West, the fossil hunters' holy grail was not the horned dinosaurs or the biggest sauropods, but the scarce microscopic fossil remains of the diminutive mammals that coexisted with the large reptiles. Fossils of early mammals were rare until Hatcher (1896) recognized that harvester ants (*Pogonomyrmex* spp.), while constructing mounds of coarse sand and fine gravel, often incorporated small fossil remains into the mound. These mounds provided a relative abundance of small fossils collected by the ants and intermixed with the gravel covering. Early field workers identified a variety of fossil material collected from the mounds, including small mammal and shark teeth, jaws and bone fragments, and fish scales (Hatcher 1896; Lull 1915). Among the collections were remains of multituberculates and other primitive mammals.

Modern day archaeologists, paleontologists, and field biologists generally conclude that sampling ant mounds is an easy and efficient technique for collecting fossil, as well as extant (Shipman and Walker 1980), animal remains that are often overlooked by other methods (Johnson 1966; Adams 1984). However, some controversy exists concerning the validity, utility, and interpretation of the collections. Clark *et al.* (1967) argue that samples are not only biased according to physical parameters, such as size, color, and weight, of the specimens, but that the area and uniformity of sampling is completely unknown and prevents meaningful statistical analyses. Furthermore, redeposition of geologic materials can produce mixed faunal assemblages in a sample from a single mound, and result in confusion in assigning fossils and artifacts to the correct sediments and ages (Johnson 1966, Guthrie and Allen 1974). Equally perplexing is the source of the gravel and/or fossils: are they

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[2] Radiological and Environmental Sciences Laboratory, U.S. Department of Energy, 785 DOE Place, Idaho Falls, ID 83402-4149

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excavated from below ground as suggested by Hough and Alf (1956) and Clark *et al.* (1967); collected from the surface as indicated by Shipman and Walker (1980); or both (Lull 1915)? Whereas little can be done to easily determine the strata from which mound gravel and fossils may have originated, my objective was, first, to simply determine whether the ants excavated or collected the gravelly material forming the mound and, second, if collected, how far from the colony.

MATERIALS AND METHODS

This study was conducted on the Idaho National Engineering Laboratory, a National Environmental Research Park approximately 65 km NNW of Pocatello, Bannock Co., Idaho. The Research Park is a shrub-steppe rangeland dominated by sagebrush (*Artemisia* spp.) and various semi-arid land grasses characteristic of the upper Snake River Plain.

The 'Owyhee' harvester ant, *Pogonomyrmex salinus* Olsen (= *P. owyheei* Cole)[3], is the most common and ubiquitous mound building ant species on the Research Park (Allred and Cole 1971). My experiment involved 2 colonies located about 100 m apart in the SE portion of the Park. Mounds were similar in size and typical of mature colonies (Clark and Tinkham 1977; Clark 1983): about 18 cm tall, 75-80 cm across, and centered in a clearing nearly 3 m in diameter. In April, gravel mounds were removed from both colonies with a shovel and the bare area surrounding each mound was swept free of gravel. Concentric rings were scratched into the soil around each colony entrance at radii of 80, 113, 138, 160, 178 and 195 cm. The 80 cm radius was chosen because it was the radius of the original mound. The other radii were selected so that the area covered by the original mound (2 m^2) and the area of any band delimited by 2 adjacent rings was equal. Approximately 90,000 grains of medium-sized (ca. 2 mm) colored aquarium gravel were evenly scattered within each of the 5 bands formed by the concentric rings around each colony. A different color was used for each band. The mean weight of 10 samples of 100 grains of gravel was used to calculate the weight of gravel needed to yield 90,000 grains for each color. From outermost to innermost bands, the color sequence for the first colony was white, green, blue, purple and turquoise (Fig. 1). The area previously occupied by the mound was left bare. To determine if the ants selectively chose or avoided a particular color of gravel, regardless of the distance from the colony entrance, gravel was placed around the second colony in the reverse color sequence. In October, the entire reconstructed gravel mound was collected. Material was washed and sieved to remove soil particles.

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[3] Formerly *P. owyheei* Cole; reevaluated as *P. salinus* Olsen by Shattuck (1987).

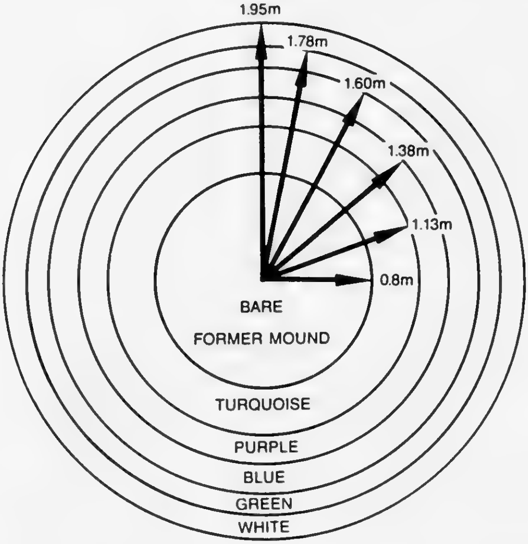

Figure 1. Distribution of colored aquarium gravel around a *Pogonomyrmex salinus* mound on the Idaho National Environmental Research Park in southeastern Idaho. Each band covered 2.0 m^2 and contained ca. 90,000 grains of gravel.

Twenty random, 200 g samples of gravel were collected in separate containers. Gravel was separated by color from each sample and weighed. Based on the previously determined mean weight of 100 grains of each color of gravel, the number of grains of each color in each subsample was calculated. A One-Way Analysis of Variance followed by the Student-Newman-Keuls Multiple Range comparison (Zar 1984) was conducted to determine if ants uniformly brought gravel to the mound from the concentric bands. The level of significance was $P < 0.05$. Correlations between the abundance of each color of gravel on the mound and the relative distance each color orginated from the mound, and the abundance and weight for each color, were examined with Spearman's Rank Correlation (Zar 1984).

RESULTS AND DISCUSSION

Ants abandoned one of the experimental colonies during the study. A mature colony of harvester ants can rebuild a mound in about a month (Cole 1932). The small amount of aquarium gravel concentrated at the colony entrance and the relatively large amount of vegetation growing in the former bare area around the entrance suggested that the colony was abandoned soon after the gravel mound was removed in the spring. Although normal longevity of a colony is 14-30 yr and colonies are rarely abandoned, ants are known to emigrate if the colony is severely disturbed (Porter and Jorgensen 1988). No gravel samples were taken from this colony.

The other experimental colony was not abandoned. Over the 7-months of the study the mound was rebuilt to a height of 14.5 cm and a diameter of 75 cm; that is, nearly the original dimensions. This mound provided the samples for statistical analyses.

Samples included grains of native gravel as well as aquarium gravel (Table 1), suggesting, but not confirming, that gravel was excavated as well as collected. There were significant differences ($F = 586$; $P < 0.001$) in the abundance of the different colors of gravel recovered from the mound. Native gravel was most abundant and represented about 25% of the gravel collected. Following native gravel in descending order of abundance, were blue, white, purple, green, and turquoise gravel (Table 1). Except for the white colored gravel, which was statistically equal in abundance to purple, each color was significantly greater in abundance than all following colors. This pattern of abundance was not significantly correlated with the relative distance of each colored band from the colony entrance ($R = 0.33$, $z = 0.65$).

There was also a significant difference ($F = 9.1$; $P = 0.02$) among the average weights of the different colors of gravel. The average weight ($X \pm SE$) of 100 grains of native gravel was 1.71 ± 0.14 g. This was significantly lighter than any of the colored aquarium gravel (Table 2). Purple gravel was significantly heavier than green. No other weight comparisons among gravel colors were significant. Nor was there any significant correlation between the abundance of each color of gravel on the mound and the average weight for each color ($R = 0.37$, $z = 0.83$).

Because one colony was abandoned, I could not judge if ants were selecting for or against gravel of any particular color. The study did not demonstrate that ants selected the colored gravel for their mound based on either weight or proximity to the mound. The results do strongly suggest that the ants preferred the native over the aquarium gravel. Whether the native gravel was excavated or collected from the surface is unknown. Based on the size of the original mound, and the speed with which it was reconstructed, I assume that the colony was mature and most of the excavation was completed prior to this study. Hence, it is likely that most of the native gravel was collected from the surface. Because the colored gravel comprised about 75% of the rebuilt mound, at least that proportion was collected and not excavated. Likewise, at least 75% of the gravel accumulated on the reconstructed mound came from

Table 1. Results of Student-Newman-Keuls Multiple Range Test of the number of grains of different colors of gravel accumulated on a *Pogonomyrmex salinus* ant mound on the Idaho National Environmental Research Park.

Gravel Color		Turquoise	Green	Purple	White	Blue	Native
	Mean	929.0	1010.0	1425.5	1468.8	1562.2	2066.8
	± SE	13.7	8.7	17.0	8.8	18.0	22.9
	N	20	20	20	20	20	20
Turquoise		---	81.0[1]	495.5[2]	539.8[3]	633.2[4]	1137.8[5]
Green			---	415.5[1]	458.8[2]	522.2[4]	1056.8[4]
Purple				---	43.3	136.7[2]	641.3[3]
White					---	93.4[1]	598.0[2]
Blue						---	504.6[1]
Native							---

[1] Significant difference; $D_{0.05(2,30)} = 48.93$

[2] Significant difference; $D_{0.05(3,30)} = 58.91$

[3] Significant difference; $D_{0.05(4,30)} = 65.01$

[4] Significant difference; $D_{0.05(5,30)} = 69.58$

[5] Significant difference; $D_{0.05(6,30)} = 72.80$

Table 2. Results of Student-Newman-Keuls Multiple Range Test of the average weight (g) of 100 grains of different colors of gravel accumulated on a *Pogonomyrmex salinus* ant mound on the Idaho National Environmental Research Park.

Gravel Color		Native	Green	Blue	Turquoise	White	Purple
	Mean	1.71	2.00	2.17	2.18	2.36	2.51
	± SE	0.14	0.09	0.05	0.06	0.05	0.04
	N	20	20	20	20	20	20
Native		---	0.29[1]	0.46[2]	0.47[3]	0.65[4]	0.80[5]
Green			---	0.16	0.18	0.35	0.50[4]
Blue				---	0.01	0.19	0.34
Turquoise					---	0.18	0.32
White						---	0.15
Purple							---

[1] Significant difference; $D_{0.05(2,30)} = 0.271$

[2] Significant difference; $D_{0.05(3,30)} = 0.327$

[3] Significant difference; $D_{0.05(4,30)} = 0.362$

[4] Significant difference; $D_{0.05(5,30)} = 0.382$

[5] Significant difference; $D_{0.05(6,30)} = 0.405$

within 2 m of the colony entrance. This may reflect the density of the available aquarium gravel, rather than the performance of the ants under more normal conditions. Because *Pogonomyrmex* workers frequently forage at a distance of >15 m from the nest (W.H. Clark, College of Idaho, *in litt.*; P.E. Blom, University of Idaho, *in litt.*), it is likely that they collect gravel, and concomitantly concentrate micro-vertebrate fossils, from the same distance.

Paleontologists have found it profitable in areas rich in fossils to remove the gravel from a mound, and return in a year or 2 to resample the same mound (Adams 1984). My data suggest that most of the subsequent samples of fossil and modern organic remains found on ant mounds are from surficial, rather than subterranean, collections, and likely represent the geological deposit adjacent to the colony.

Additional studies, using colored aquarium gravel more similar in size and weight to native gravel, spread over a larger area at a lower density, should be conducted to more clearly determine the gravel accumulating and fossil concentrating behavior of harvester ants.

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SOCIETY MEETING OF MARCH 27, 1991

Bacillus thuringiensis: utility as a commercial insecticide.

Mr. Robert Leighty

Most students of entomology are acquainted with the pathogenic effects of the spore forming bacterium *Bacillus thuringiensis* (or commonly referred to as "B.T.") on lepidopterous caterpillars, in particular for gypsy moth control or for "organic" gardening situations. Robert Leighty of E.I. DuPont Co. (Stine-Haskell Laboratory) focused his talk on the wider commercial possibilities for this and other microbial insecticides, including a discussion of the history of their use, their mode of pathogenicity, and the process of product development of a microbial insecticide.

Although the spore-forming *Bacillus thuringiensis* was first noticed in 1901 in Japan, it wasn't until Edward Steinhaus' groundbreaking work in insect pathology in the 1950's that much attention was paid to it, and in 1957 the first product based on the bacterium was developed. Originally used as an insecticide against larvae of Lepidoptera, strains of *B. thuringiensis* have been found in the last twenty years showing lethality against various Diptera and Coleoptera, and the bacterium is known to have a worldwide distribution. The 20+ strains are characterized by flagellar and toxic crystal morphology, and molecular composition, with much of this information proprietary to the particular company developing the product. Once the bacterium is digested, the insect stops feeding and dies in 1-4 days. The lethal mode of action of the bacterium is due to an internal bipyramidal crystal which, when encountering the alkaline gut of an insect, dissolves and causes the lysis of gut epithelial cells, allowing the gut contents to enter the insect haemocoel. Although the effect of the crystal is specific to one or a few species (both an advantage and disadvantage for a commercial insecticide), new molecular engineering techniques are allowing the *Bacillus* to express multiple toxins.

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THE IDENTITY OF CHIRONOMINI GENUS C (DIPTERA: CHIRONOMIDAE) IN PINDER AND REISS (1986)[1]

Michael J. Bolton[2]

ABSTRACT: The pupa keyed and described in Pinder and Reiss (1986) as Chironomini Genus C belongs to *Polypedilum (s.s.) ontario* (Walley) based upon a larva-pupa association and analysis of pharate adult hypopygial characters.

Pinder and Reiss (1986) keyed and described a chironomid pupa they called Chironomini Genus C. This taxon was characterized by cephalic tubercles fused to form a dark, strongly chitinized cone with small, rounded and closely adjacent frontal warts and a dark anal comb with an elongate basal stem, possessing apical teeth and a surface covered with numerous, scale-like toothlets. This type of pupa was also keyed in Coffman and Ferrington (1984) as Genus 14. While analyzing a macroinvertebrate sample (Ohio EPA, 1989) from the Little Hocking River at State Route 339, Washington County, Ohio (28-VII-90), I came across several of these pupae including one larva-pupa association and one male pupa with the pharate adult hypopygium visible. I recognized the larval exuviae as *Polypedilum (s.s.) ontario* (Walley), which was illustrated and keyed in Maschwitz (1975) and included in the diagnosis and illustrated as an example of *Polypedilum* in Pinder and Reiss (1983). The hypopygium matched illustrations in Townes (1945) and Maschwitz (1975). Maschwitz (1975) keyed and illustrated selected structures of the larva, pupa and adult male of *P. (s.s.) ontario*, but only provided a description of the adult. Pinder and Reiss (1983, 1986) referenced Maschwitz (1975) and illustrated the larva of one of his informally described species, but failed to recognize Chironomini Genus C as the pupa of *P. (s.s.) ontario*. The specific identity of the south west China and East African congeners by Pinder and Reiss (1986) is unknown. Larvae of *P. (s.s.) ontario* were collected from pupal retreats of *Cheumatopsyche* caddisflies, which they coinhabit. The specimens examined are retained in the author's collection.

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[2] Ohio EPA, 1030 King Avenue, Columbus, Ohio 43212.

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Continued from page 124

Major efforts now are devoted to screening for new strains of *Bacillus*, particularly against major vegetable pests such as *Helothis* spp. and the Colorado Potato Beetle; already the Diamondback moth has developed some resistance. Although it still commands only a small share of the insecticide market, the use of B.T. has increased considerably in the last 10 years, particularly with the development of IPM programs. Its many advantages including low mammalian toxicity and selectivity to target pests insure its continued growth in usage.

Items of local entomological interest concerned the gypsy moth. Roger Fuester predicted 10 million acres will be infested this year, and noted that Ohio had its first defoliation last year. Paul Schaefer reported an epizootic of a fungal pathogen, *Entomophaga maimaiga*, on gypsy moth in Cecil Co., Maryland and in Somerset Co., New Jersey last year; the fungus had reappeared in 1989 over a wide area of New England after remaining undetected for many years. Dr. Schaefer also spoke on his observations of bald-faced hornet predation on gypsy moth males (which appeared in the January/February issue of *Entomological News*). The meeting at the University of Delaware was attended by 13 members and 3 guests.

Jon K. Gelhaus
Corresponding Secretary

MICRODISTRIBUTION OF SCAVENGING FLIES IN RELATION TO DETRITUS AND GUANO DEPOSITS IN A KENTUCKY BAT CAVE[1]

David Bruce Conn[2], Stephen A. Marshall[3]

ABSTRACT: Three fly species were studied with respect to their relative associations with bat guano versus plant detritus in Bat Cave, Kentucky. Samples were collected with baited pitfall traps at nine locations in the cave at weekly intervals during fall and winter when the bat population was at a maximum. Two sphaerocerids exhibited little overlap, with *Spelobia tenebrarum* occurring predominatly in guano areas, and *Leptocera caenosa* occurring only near detritus. *Magaselia cavernicola* (Phoridae) was more evenly distributed among traps near both guano and detritus.

Animals that live in caves normally must rely on food supplies that are brought in from outside the cave. Plant detritus deposited by cave stream flooding and bat guano are the two primary food sources that have been studied in this regard (Barr 1967; Culver 1982). Bat Cave in Carter Caves State Park in eastern Kentucky, USA has restricted human access because it is one of the world's largest hibernacula for the endangered Indiana Bat, *Myotis sodalis*. Substantial guano deposits are left in Bat Cave's upper level by this species in summer and winter (Hardin and Hassell 1970). Spring and winter flooding of the cave's formative stream deposits sustantial plant detritus in the cave's lower level. The most common beetle species in the cave are known to inhabit both guanobic and detritus-based habitats within the cave, with most species showing a greater preference for the former (Conn and DeMoss 1983, 1984). For comparative purposes, the present study was undertaken to determine the intra-cave distribution patterns of Bat Cave's most common flies, sphaerocerids and phorids, especially with regard to their relative abundances in guanobic versus detritus-based habitats.

Weekly collections were made in Bat Cave between September1979 and February 1980 using baited pitfall traps. Details of the trapping techniques and schedule were reported by Conn and DeMoss (1984). Traps were set at nine points in the cave's aphotic zone, chosen for comparison of major organic deposits (4 upper, 4 lower, 1 between levels). The only major organic deposits in the upper level were bat guano, whereas those in the lower level were stream-deposited plant detritus.

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[1] Received February 15, 1991. Accepted March 13, 1991.

[2] Department of Biology, St. Lawrence University, Canton, New York, 13617 USA

[3] Department of Environmental Biology, University of Guelph, Guelph, Ontario, Canada N1G 2W1

A total of 135 adult *Spelobia tenebrarum* (Aldrich), 11 adult *Leptocera caenosa* (Rondani) (both Sphaeroceridae) and 505 adult *Megaselia cavernicola* Brues (Phoridae), were collected. *Leptocera caenosa* was found entirely in two of the lower-level traps, which were in the areas of greatest detritus deposition. *Spelobia tenebrarum* was markedly different (6.0% lower, 93.24% upper, 0.75% between levels); of these, 86.07% occurred in a single upper-level trap that was the primary site of guano deposition during the study period. This suggests a guanobic habit for *S. tenebrarum* in Bat Cave. *Megaselia cavernicola* had a generally uniform distribution among the study sites, although there appeared to be a somewhat greater preference for the lower level (47.21% lower, 20.72% upper, 32.07% between levels). The distributions of the confamilial species, *S. tenebrarum* and *L. caenosa*, were significantly different ($r = 0.15$, $P < 0.025$). The two lower-level traps that yielded 100% of *L. caenosa*, yielded less than 2% of *S. tenebrarum*. The spatial separation of these confamilials may represent niche separation between *S. tenebrarum*, which is entirely restricted to caves (Marshall and Peck 1984, 1985) and *L. caenosa*, which is an opportunistic species associated with many cave-like environments. Rohacek (1982) suggested that *L. caenosa* became synanthropic through association with humans in caves, and has since invaded cellars, mine-galleries, urinals, abattoirs, and suitable human-created habitats. *Leptocera caenosa* has been reported as forming very large populations in septic tanks (Fredeen and Taylor 1964).

This is the first report of microdistributional patterns of these three fly species. The results confirm that *S. tenebrarum*, known to be cave specialist and previously thought to be polysaprophagous (Banta 1907; Marshall and Peck 1984), is the dominant fly species in the bat guano habitat. Conversely, the more opportunistic *L. caenosa* occurs only in detritus deposits, a less cave-specific habitat than bat guano. The phorid, *M. cavernicola*, appears less restricted than either sphaerocerid, occurring more uniformly at sites throughout Bat Cave. Thus, both coleopteran (Conn and DeMoss 1984) and dipteran insects have been demonstrated to exhibit distinct distributional patterns within this major bat cave, apparently related to detritus-based versus guanobic habitat associations.

ACKNOWLEDGMENT

We are grateful to Brian V. Brown, University of Alberta, for confirming the identity of *M. cavernicola*.

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SOCIETY MEETING OF APRIL 24, 1991

Damselflies of Fiji: radiation and evolution on an oceanic island group in the South Pacific

Dr.Thomas Donnelly

Oceanic islands have always held a great fascination and interest for biologists, and study of their distinct faunas was crucial in the development of Darwin's theory of evolution and our more recent ideas concerning speciation. Dr. Donnelly's talk concerning Fijian damselflies touched on these ideas as well as many others during a thought-provoking and enjoyable presentation.

Nearly the entire damselfly fauna of the Fiji Islands consists of the genus *Nesobasis* and two closely related genera, all in the family Coenagrionidae, but the numerous species in these genera have radiated into diverse habitats; when compared with a continental biota, this range of habitats would be occupied by numerous genera and even several families! Of the 35 spp. found on the two main Fijian islands, Viti Levu and Vanua Levu, only one species is found on both islands even though the islands are separated by a relatively short distance of 50 kilometers. The smaller islands show levels of endemicity related to the size of the island and its' distance from the larger islands, consistent with the predictions of island biogeographic theory. Although Viti Levu is at least 13-15 million years old, Vanua Levu is no more than three million years old and yet still has a well-developed endemic fauna. Rapid evolution is also demonstrated in the microgeographic differentiation of many species, possibly related to adaptation to different microclimates.

Several characteristics are seen commonly in the Fijian damselfies which are rare or absent in damselflies occurring in the rest of the world. Some striking examples were presented, including guarding of territory by females, the development of morphological pecularities of the male genitalia and the small body size of females in some species. Larval habitats are also unusual when compared with those of a continental damselfly fauna; large streams and rivers were not utilized, but small cascades and seeps contained many species, with the larvae often living in only thin films of water concealed within small rock pockets or by leaves.

Continued on page 132

RHIZEDRA LUTOSA (LEPIDOPTERA: NOCTUIDAE) NEWLY INTRODUCED TO NORTH AMERICA[1, 2]

Tim L. McCabe[3], Dale F. Schweitzer[4]

ABSTRACT: This is the first report of *Rhizedra lutosa*, a Eurasian moth, occurring in North America. It has been found in New Jersey salt marshes. It is compared with *Ommatostola lintneri*, with which it is easily confused. The adult habitus and male genitalia are illustrated for both species.

Rhizedra lutosa (Hübner) is a common Eurasian noctuid, occurring from Iceland and Scandinavia to Spain, and across the continent to Japan (Sugi, 1982; Bretherton, *et al*., 1983). The pale brown, unmarked larva is illustrated by Spuler (1910), and a technical description can be found in Beck (1960). Eggs overwinter and the larva feeds in the stem-bases and rhizomes of common reed, *Phragmites australis* (Cav.) Trin. ex Steud. [Poaceae], in dry habitats, causing blanching of leaves of infected shoots (Bretherton, *et al*., 1983).

Recently *Rhizedra lutosa* has been collected by the authors on the salt marshes of the New Jersey side of Delaware Bay. All records are from Downe and Commercial Townships in Cumberland County: Egg Island, 1 October 1989 (1) [TLM]; Dividing Creek, Hansey Creek Rd. salt marshes, 18 October 1988 (3); 4 November 1988 (4); Dividing Creek, Bear Swamp East natural area, 28 October 1988 (1); Port Norris [center of town], 18 October 1988 (2); [salt marshes sw of town] 30 September 1988 (7) [all DFS]. All collections were at blacklights, and all but five specimens were females. It seems noteworthy that three of the five males were taken on 4 November 1988. This species was not collected in 1990.

Rhizedra lutosa (Figs. 3-5) can be confused with *Ommatostola lintneri* Grote (Figs. 1, 2, 6), and both moths fly in the autumn. However, *O. lintneri* apparently does not occur along Delaware Bay, although it has been taken along the eastern shore of New Jersey (Smith, 1910) and from Assateague Island in Maryland (specimen figured). It seems to be a dune species, and such habitats are very limited along Delaware Bay.

Based upon an examination of the collections in the American Museum of Natural History (AMNH) and at Rutgers University, it appears that *Rhizedra lutosa* was not taken by any of Rutgers University's pest-survey

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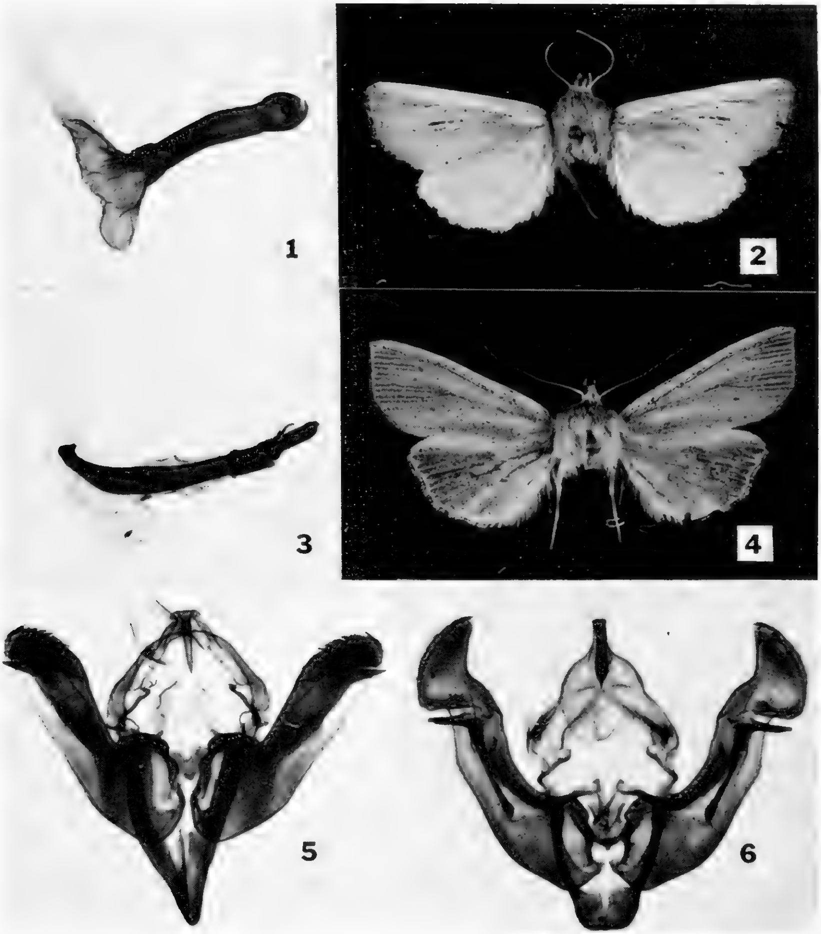
[2] Contribution number 685 of the New York State Science Service.

[3] The New York State Museum, State Education Department, Albany, NY 12203
[4] The Nature Conservancy, R.D. 1, Box 30B, Port Norris, NJ 08349



Figs. 1-6. 1, 2, & 6: *Ommatostola lintneri*, aedoeagus, habitus, and valves, respectively; Assateague Is., Worcester County, Maryland, 21 September 1986, J. Glaser [McCabe slide 1684]. 3, 4, & 5: *Rhizedra lutosa*, aedoeagus, habitus, and valves, respectively; Egg Island, Cumberland County, New Jersey, 1 October 1989, T. McCabe [McCabe slide 1690].

traps in southern New Jersey in the 1970's and early 1980's. At least three trap sites were in or near salt marshes containing *Phragmites* in Lawrence Township and several others were near Delaware Bay. These traps were operated well into October. The late Joseph Muller had no specimens of this species in his extensive collection (now at AMNH), nor was it taken by any of the several collectors, including Muller and Schweitzer, who from 1973 to 1984 regularly sampled what is now the Nature Conservancy's Eldora Preserve, about 10 km east of Port Norris. *Phragmites* is a problem weed on this preserve. The facts seem to indicate *Rhizedra lutosa* was recently introduced somewhere near the area of the present records, with a limited subsequent spread. However, the deep water ports farther up the Bay on both the New Jersey and Delaware sides, or even the port or international airport at Philadelphia (less than 100 km north of Port Norris), seem much more likely points of introduction. If this is the case, the lack of Rutgers trap specimens would strongly indicate establishment and spread during the 1980s.

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Continued from page 129

There were several items of local entomological interest. Foger Fuester noted that the hatch of gypsy moth caterpillars occurred a few weeks earlier than usual. Also noted was the sighting of several Monarch butterflies in early April in southern New Jersey, including a female on April 8 at Brigantine National Wildlife Refuge. Chuck Mason, recently returned from active duty in Texas during the recent Middle East conflict, informed us that malaria in southern Saudi Arabia prevented troops from being stationed there. Sand flies were problem pests and some cutaneous leshmaniasis was contracted. Interestingly, the term "sand fly" was misunderstood by soldiers and reporters and the news media carried reports that "sand fleas" were common pests to the soldiers. This led to crates of dog "flea collars" being shipped to Saudi Arabia by well meaning citizens!

The meeting at The Academy of Natural Sciences was attended by 19 members and 13 guests.

Jon K. Gelhaus
Corresponding Secretary

RHYOPSOCUS TEXANUS (PSOCOPTERA: PSOQUILLIDAE): ITS SYNONYMY, FORMS AND DISTRIBUTION[1]

Edward L. Mockford[2], Alfonso N. García Aldrete[3]

ABSTRACT: The type of *Rhyopsocus texanus* was examined. It represents the same species as two which were subsequently named: *Rhyopsocus squamosus* Mockford and Gurney and *Rhyopsocus pescadori* García Aldrete, thus the latter two names fall as junior synonyms. The species ranges from the lower Rio Grande Valley in Texas south to coastal Jalisco, Mexico.

The genus *Rhyopsocus* Hagen (=*Deipnopsocus* Enderlein, *Rhyopsocopsis* Pearman) contains 18 described species, most restricted to the tropics and subtropics. Species-level taxonomic characters consist of body coloration, shape of the anal angle of the forewing, distribution of sensilla on the fourth segment of the maxillary palpus, details of external genitalia of both sexes, and details of the spermatheca and its accessory structures in the female. Wing dimorphism has been found in several species (Badonnel, 1949; Sommerman, 1956; Thornton, Lee, and Chui, 1972).

Rhyopsocus texanus (Banks, 1930) was originally described from a single macropterous specimen of (then) unknown sex collected at Brownsville, Texas. The original description is brief and contains little of value for delineating the species.

Mockford and Gurney (1956) described *Rhyopsocus squamosus* from brachypterous males collected at Olmita Resaca near Brownsville, Texas. Mockford (1971) described the brachypterous female of *R. squamosus* from specimens collected at Bentsen Rio Grande Valley State Park, Hidalgo County, Texas.

Recently, one of us (ELM) examined the type of *R. texanus*. The specimen is a female and is identical with *R. squamosus* in the form of the spermapore plate, form of the spermathecal accessory glands (with, however, bilateral asymmetry in this character in the type of *R. texanus*), and the form of the process of the spermathecal sac. The latter structure arises in all *Rhyopsocus* species near the point of junction of the spermathecal sac and its duct. No other differences were found which cannot be attributed to wing dimorphism. We conclude, therefore, that *R. texanus* and *R. squamosus* are names for macropterous and brachypterous forms of the same species. This conclusion is upheld by the finding of samples of macropterous males and females together, and samples of macro-

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[1] Received: January 18, 1991. Accepted: February 17, 1991.

[2] Department of Biological Sciences, Illinois State University, Normal, Illinois 61761

[3] Instituto de Biología, Universidad Nacional Autónoma de México, Departamento de Zoología, Apartado Postal 70-153, 04510, México, D. F.

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pterous and brachypterous specimens together at several Mexican localities (see distribution records, below). The macropterous males are identical with *R. squamosus* males in the form of the distal end of the hypandrium and details of the distal end of the phallosome (structures described and figured by Mockford, 1971). In these males, no other differences from the type series of *R. squamosus* were found which could not be attributed to wing dimorphism.

García Aldrete (1984b) described *Rhyopsocus pescadori* from macropterous and brachypterous adults of both sexes, with the type locality at Chamela, Jalisco, Mexico. He presented six principal differences between *R. squamosus* and *R. pescadori* which are discussed and, we believe, refuted below;

1. Alary polymorphism is found in *R. pescadori*; this is also true of *R. squamosus* (i.e., *R. texanus*).

2. Compound eyes have few facets in *R. squamosus*; this was a misinterpretation by García Aldrete (see Mockford, 1971, Fig. 8).

3. Lobes of the distal end of the hypandrium are more pronounced in *R. pescadori* than in *R. squamosus*; these structures show considerable variation in the Texas specimens, so that the state illustrated by Garcia Aldrete (1984b, Fig 65) may be found in Texas specimens assigned to *R. sqamosus.*

4. The distal end of the phallosome is different. Although García Aldrete's figure (1984b, Fig. 63) differs considerably from that of Mockford (1971, Fig. 11), the principal differences appear to be due to the amount of pressure on the cover slip. Figures 1-3 suggest that an area of relatively soft, pliable cuticle on the inner surface of each of the two distal pieces of the phallosome (fig. 2, S) expands medially as pressure on the cover slip increases. Some rotation in the distal pieces may also occur.

5. The shape of the collar of the spermathecal duct is different. García Aldrete's figure (1984b, Fig. 64) is a partial side view. A direct comparison with Mockford's figure, a ventral view (1971, Fig. 13), suggests greater width of the structure for *R. squamosus*, but the comparison is not valid because of the difference in orientation. There is no apparent difference in the extent of sclerotization of this structure.

6. The spermathecal accessory glands differ in shape. García Aldrete (1984b) found these structures to be rounded in *R. pescadori*, while Mockford (1971) found them slightly elongate in *R. squamosus*. In a series of ten slides which we have examined, variation has been found in this character in local populations. Also, on three slides, including that of the type of *R. texanus*, the gland on one slide is rounded and on the other side slightly elongate.

None of the above differences appear to be valid, and we have found

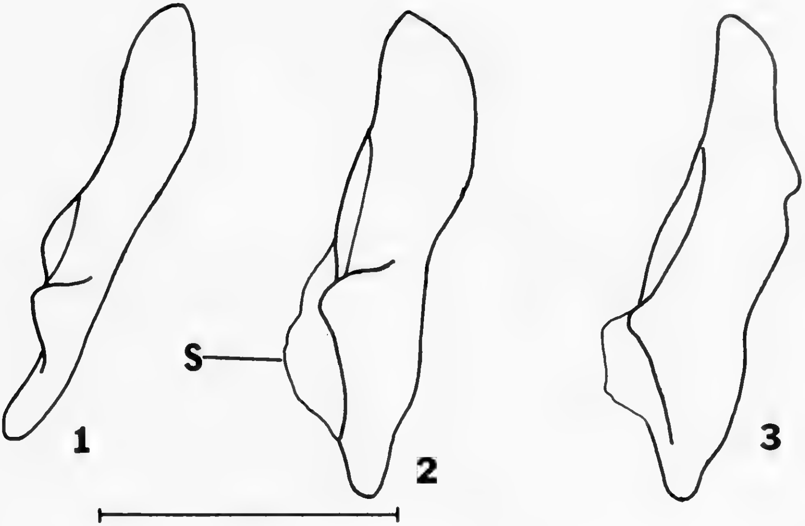

Fig. 1-3. *Rhyopsocus texanus* (Banks) ♂. Left distal piece of phallosome under three levels of cover slip pressure: Fig. 1. Least pressure; Fig. 2. Intermediate pressure (region of pliable cuticle, S. bulging slightly); Fig. 3. Greatest pressure (more bulge in region S). Scale = 0.05mm.

no other differences between *R. pescadori* and *R. squamosus*. Thus, we conclude that *R. pescadori* is a synonym of *R. texanus*. This conclusion is supported by García Aldrete's record (García Aldrete, 1984a) of five males of *R. squamosus* together with two females of *R. pescadori* in dry leaves of a palm (*Sabal* sp.) at Rancho Alamito, Guadalupe, Nuevo León, México, on 22 December 1978.

The synonymy of the species as now known is as follows:

Deipnopsocus texanus Banks, 1930:223.
Rhyopsocus (*Deipnopsocus*) *texanus* (Banks), Sommerman, 1956:145.
Rhyopsocus texanus (Banks), Mockford and Gurney, 1956:357.
Rhyopsocus squamosus Mockford and Gurney, 1956:357, new synonym.
Rhyopsocus pescadori García Aldrete, 1984b:49, new synonym.

Distribution of *Rhyopsocus texanus*

Within the United States, this species is apparently confined to the lower Rio Grande Valley, having been recorded only from the Texas counties of Cameron and Hidalgo (Mockford and Gurney, 1956; Mockford, 1971). In Mexico, García Aldrete (1984a, 1987) recorded it from two localities in the vicinity of Monterrey, Nuevo León, and four localities in the vicinity of Chamela, Jalisco, as well as one locality in Baja California, two localities in Baja California Sur, two localities in Chiapas, and three localities in Guerrero.

The following Mexican records are previously unpublished (M= macropterous, b= brachypterous):

Morelos: Cuautla, 23-I-1984, Berlese sample, leaf litter, 1♂b, 2♀b, coll. E. González. Nayarit: María Madre Island, Arroyo Hondo Springs, el. 380 m, sifting litter, 1♂M, 3♀M, coll. A.N. García Aldrete. Puebla: 6Km N Izúcar de Matamoros, el. 1300 m, 7-VIII-1977, beating branches of shrubs with persistent dead leaves, 1♀M, coll. A.N. García Aldrete; same locality, 7-IX-1977, on hanging dead leaves of herbaceous plants, 1♂M, 2♀M, coll. A.N García Aldrete. San Luis Potosí: El Salto, 28-III-1961, beating branches of trees, some with Spanish moss (*Dendropogon usneoides* [L.] Rafinesque), 2♂M, 1♀M, 4♀b, coll. E.L. Mockford; same locality, 18-VI-1962, beating miscellaneous vegetation, including lemon tree (*Citrus* sp.), 1♂M, 1♂b, 1♀M, coll. E.L. Mockford and F. Hill; El Narajo, Hwy. 80, 6.4 Km E of town, 20-VI-1962, beating *Washingtonia* palm, 1♂M, coll. E.L. Mockford, F. Hill, J.M. Campbell; Tamán,Hwy. 85, 1.6 Km N Hidalgo state line, 16-IV-1964, beating dead persistent leaves along stream, 1♀M, coll. E.L. Mockford. Tamaulipas: Gómez Farías, 27-III-1961, sifting ground litter in woodland, 1♂M, 6♀M, coll. E.L. Mockford; 1.6 Km S road to Xicotencatl on Hwy. 85, 30-III-1961, beating *Typha* sp; 1♀M, coll. E.L. Mockford.

ACKNOWLEDGMENTS

We thank D. Furth (Museum of Comparative Zoology, Cambridge, Massachusetts) for arranging the loan of the type of *R. texanus*; L.E. Brown, D. Schmidt, and C. Schmidt, and two unknown readers for critical reading of the manuscript. Collecting in Mexico by ELM in 1962 was supported by NSF grant G-19263 to Illinois State University.

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SPIDERS (ARANEAE) ASSOCIATED WITH RURAL DELIVERY MAILBOXES, MASHPEE, MASSACHUSETTS[1]

Robert L. Edwards,[2] Eric H. Edwards[3]

ABSTRACT: Spiders were collected from rural delivery mailboxes in Mashpee, Massachusetts from April, 1987 to July, 1990. One hundred fifty-eight species were taken, which represent about one third the known number in the area. Six species were taken only from mailboxes. Collection data are summarized by month, and life history observations are provided. None of the species collected are considered to be of extreme medical importance.

In response to questions concerning the potential danger posed by spiders on or inside rural delivery mailboxes in Mashpee, Massachusetts, a small town in southwestern Cape Cod, Eric Edwards (a rural letter carrier) collected spiders on or in mailboxes as time allowed. The black widow occurs in the Cape Cod region, however none were observed in these boxes. Most people seem to be unaware that there are spiders in or on their mailboxes. Over a three year period, more than 1500 spiders that represent 158 species were collected. At least 465 species of spiders are known from southwestern Cape Cod (R. Edwards, unpubl.).

METHODS

A typical rural delivery (RD) mailbox is constructed of galvanized sheet metal, is 16.5 cm wide, 21.5 cm high, 48 cm long and has a rounded top (Fig. 1). Although not yet common, some mailboxes are made of plastic (<5% in the study area) and even fewer are made of various other materials by the owners. Owners frequently paint or otherwise decorate their boxes. About half of the galvanized mailboxes, which make up the vast majority, are painted black. For a typical box there is a handle (D in Fig. 1) on the door and a matching part on top (C) against which the handle fits, serving to hold the door shut. The door is hinged in such a fashion that an opening, a 5 to 10 mm slot, exists between the door and the bottom of the box when the door is shut. Mailboxes are usually placed on a post, circa 1 m high at roadside. The recommended procedures and standards for all matters with respect to rural delivery are given in the Domestic Mail Manual (Anon., 1990) provided by the Postal

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[1] Received December 24, 1990. Accepted February 10, 1991.

[2] Box 505, Woods Hole, MA 02543

[3] 45 Canterbury Lane, East Falmouth, MA 02536

Service. In the comments that follow, letters in parentheses indicate the various areas on the mailbox as shown in Fig. 1.

Collected specimens were preserved in 75% denatured ethyl alcohol. They were usually examined within a week of capture before the colors were significantly degraded by the preservative. Most of the individuals collected were dominated by adults and penultimate instars. The immatures of later instars prior to the obvious development of secondary sexual characteristics and making up <5% of collected specimens were not too difficult to identify. Immatures that could not be identified with confidence are not reported; most were, in descending order of frequency, species of *Araneus, Grammonota, Tutelina, Mimetus* and *Meioneta*. In all cases these immatures belonged to genera, and probably to species, identified as adults.

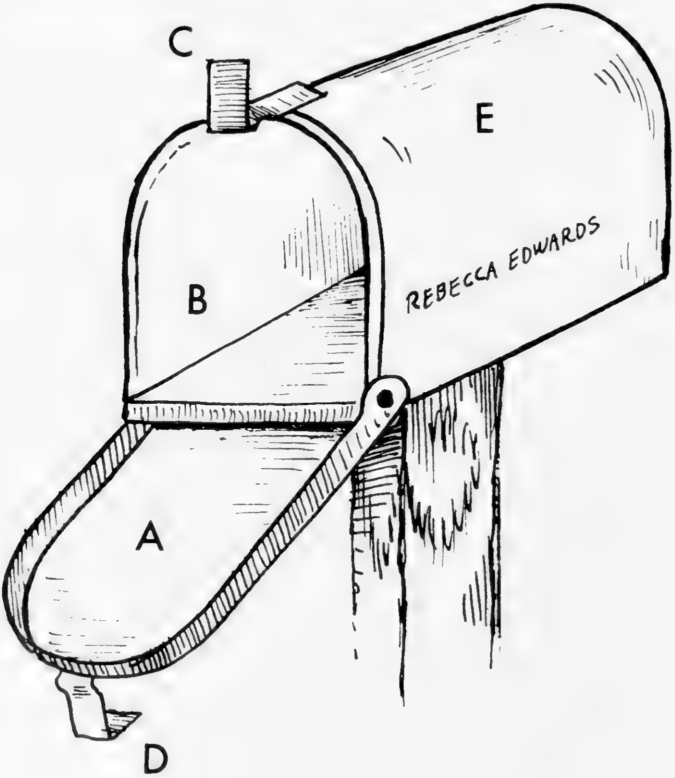

Figure 1. Diagram of a typical rural delivery mailbox. The letters indicate specific areas referred to in text.

RESULTS

Spiders were found on mailboxes in all months of the year (Table 1). Relative abundance can only be inferred by the number of monthly records. Due to strict time constraints, it was not feasible to collect, count, and record every spider seen or encountered.

The number of spider species cycles through the year (Fig. 2). The largest number of adults and species occurs in June; the least in February. The majority of species mature and mate in late May and June, at which time there is much wandering around, particularly by males. There is a second peak of activity in early fall when a lesser number of species mature.

Three general groups of spiders were found; 1) ballooning spiders, 2) spiders searching for prey or a mate, and 3) spiders in short term or permanent residence. The air temperature does not appear to be critical; spiders were taken in temperatures down to 0°C. Sunshine, however, was important. On windy days, whatever else the conditions, few spiders were to be seen on the exterior surfaces of mailboxes. The surrounding habitat does not appear to have much influence on the presence or

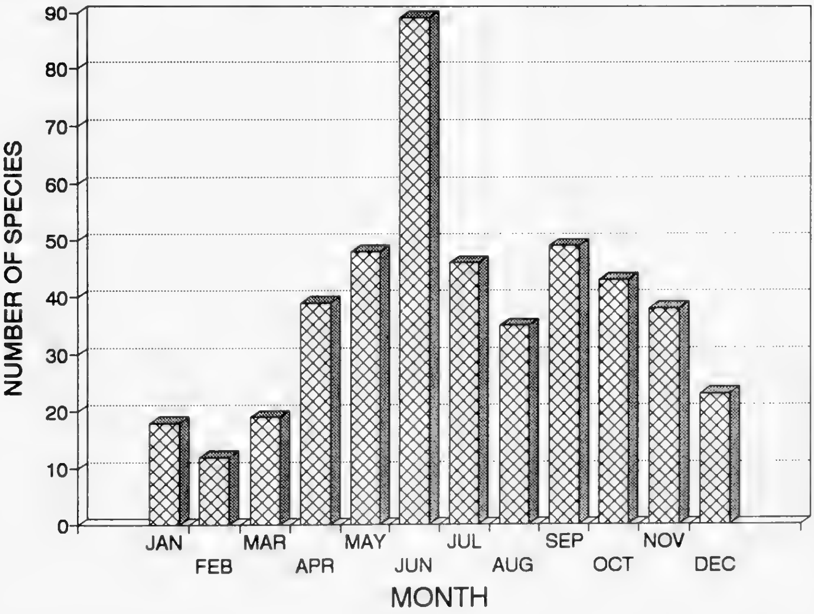

Figure 2. Seasonal cycle of number of spider species found on rural mailboxes by month.

absence of species or individuals of mailbox-inhabiting spiders. However, along busy streets with much traffic, fewer individuals were found. For a route with circa 400 boxes on a warm, sunny and windless day, about 1 in 4 boxes hosted one or more spiders.

The rate of mailbox usage, whether examined by the box holder daily or weekly, apparently did not influence spider habitation. Some spiders seemed indifferent to occasional disturbance. Boxes that were examined infrequently, however, sometimes had *Agelenopsis pennsylvanicus* (C.L. Koch) established inside the box. Darker mailboxes and unpainted galvanized mailboxes seem to be preferred by spiders that were found on the exterior surfaces. White boxes were usually occupied inside only. However, *Uloborus glomosus* (Walckenaer) was an exception to this general observation and was consistently found on the outside of white but not darker boxes. The Domestic Mail Manual (op. cit.) indicates a preference for mailboxes and their posts to be painted white, possibly for increased visibility. White might, in fact, reduce the number of spiders on the exterior surfaces of the mailboxes. Plastic boxes have rounded crevices that seemed to be preferred by spiders for molting retreats; otherwise plastic boxes do not seem to encourage spider habitation.

Most of the species with webs generally were found in two places: outside on the handles (C and D), and just inside the door (A and B) in the lower corners. For the latter, there was ready access in and out through the slot at the bottom of the door. Retreats were usually found inside in this area as well, on the lid or near it.

Six species were found only associated with mailboxes - *Araneus guttulatus* (Walckenaer), *Marpissa wallacei* Barnes, *Peckhamia picata* (Hentz), *Philodromus lutulentus* Gertsch, *Pisaurina brevipes* (Emerton), and *Trachelas tranquillus* (Hentz). Of the six, an adult male *Marpissa wallacei*, collected in June, 1990, was the most surprising because it has not been recorded north of Georgia. We suspect that it might have been a 'hitchhiker' because Cape Cod has many retirees who summer on the Cape and winter down south.

The collection of an adult male and female of *Disembolus sacerdotalis* (Crosby and Bishop) also was a surprise. At the time that Millidge (1981) revised the genus, he had only a damaged male to examine, the holotype, from New York. The female was then unknown. We have found the species elsewhere in the area in woodland litter.

Large orb weavers used mailboxes as one point of attachment for their webs, and seldom as their retreat. Smaller orb weavers were almost always located near the handle (D), occasionally with webbing. In July

1989, *Araneus bivittatus* (Walckenaer) was found in great abundance in many different habitats in the area including the mailboxes. This species was found subsequently in most months of the year. Prior to 1989 we had considered this species to be rare.

Levi (1973) noted that some species of smaller orb weavers normally occurred higher up in trees and that museum collections of these species were few and far between, not withstanding the extensive collecting activities of many arachnologists over the years in New England. Many of the available specimens of smaller orb weavers had been obtained from the nests of wasps (Levi, op. cit.). Amongst these species *Araneus gadus* Levi, *A. juniperi* (Emerton) and *A. guttulatus* (Walckenaer) also have been taken on the mailboxes, the first two commonly. Spiders that appear to prefer tree trunks, and in some cases found only in that microhabitat in any abundance, also appeared on the mailboxes. These include *Admestina tibialis* (C.L. Koch) and *Ceratinops lata* (Emerton) which are often found on the trunks of oaks and other more smoothly barked trees. *Gladicosa pulchra* (Keyserling), *Coriarachne versicolor* Keyserling, and *Philodromus validus* (Gertsch) appear to prefer the trunks of pitch pine.

Completely red individuals of *Tetragnatha viridis* Walckenaer dominated in the winter months, as contrasted with individuals of an overall vivid green color, sometimes with reddish spots at the anterior of the opisthosoma, found in the warmer months. This species is typically found with some webbing on the lower handle (D). *T. viridis* was present in all seasons although adults were seldom seen. The species presumably left the boxes in June and July to mate/or deposit eggs elsewhere.

With the exception of a single adult male collected in June, 1989, all specimens of *Hypsosinga rubens* (Hentz) generally were bright reddish-orange in color with black around the eyes and black spots on the opisthosoma as illustrated in Kaston (1981, Fig. 2198, p. 975). The exception was black overall with a cream colored patch in the center of the prosoma, an irregular whitish stripe down the midline of the opisthosoma and two relatively narrow white stripes laterally on the opisthosoma. Specimens of this 'black phase' coloration have been taken consistently, and in large numbers and all instars, on the trunks of pines; only infrequently on the trunks of deciduous trees. The 'red phase' of *H. rubens* was commonly and only taken in fields and woodland understory. The seemingly strict division by habitat for these two color phases raises questions concerning their specific status. However a careful comparison of male and female genitalia revealed no significant differences. Levi (1971) discussed the similar color differences that he observed in material collected from the Northwest Territories of Canada to Florida. He concluded that the observed color variations were not an example of geographic variation. The possibility that these two color phases may represent sibling species warrants further study.

Steatoda borealis (Hentz) and *Pityohyphantes costatus* (Hentz) were common inside dwellers (B) with webs and seemed relatively indifferent to disturbance. *P. costatus* spins webs at all levels inside the mailboxes - top, bottom, and along the sides, usually closer to the door. It was found with prey, including other spiders, and especially philodromids. Both sexes of *costatus* were observed living together for extended periods of time in some mailboxes. *S. borealis* builds its irregular web anywhere inside the box, but usually between the side and bottom. Elsewhere this species is found elsewhere most often in deep crevices and holes in tree trunks and in piles of old rubbish. Although both *S. borealis* and *P. costatus* are clearly semi-permanent residents of mailboxes, no egg sacs were found of either species. As in the case of *Tetragnatha viridis*, *P. costatus* totally vacated the boxes for two months in the summer, in this case July and August. Except for the fact that many boxes are shaded for much of the day, there is some reason to suggest that the boxes may get too hot for certain species in the summer and that they leave temporarily for this reason. It is also likely that some species have preferences for particular oviposition sites.

The angles of handle and lock (C, D) were used by many small species, including the dictynids, as web-building sites. Theridiids, especially *Theridion murarium* Emerton and *T. lyricum* Walckenaer were found usually on the handle (D) with some webbing. These two species appear to be semi-permanent residents of mailboxes, although egg cases have never been found on or in the boxes. *Mimetus notius* Chamberlin also approached the status of being a semi-permanent resident, but again no egg sacs were found. This species, usually found just inside the box, responded dramatically to disturbance, balling up and falling off the box, or rolling down the door when it was opened.

Phidippus audax (Hentz) and *Platycryptus undatus* (De Geer) constructed retreats inside mailboxes in cracks and corners. Erigonine spiders were occasionally found inside with their webs near the front end along edges.

Anyphaenids and clubionids also were found mostly on the door (A), either inside or outside; occasional retreats of both were found inside (A, B) along the right angled edges. Philodromids and salticids as well are often found on the door or outside surface, but more often outside. Two species of *Philodromus* qualify as permanent residents, *P. praelustris* Keyserling and *P. vulgaris* (Hentz). These two species have been found with egg sacs. *P. vulgaris* was observed standing over egg sacs in three different boxes, always on the inside edge of the door, and once in a black plastic box. One female had an egg sac when first discovered and two weeks later produced a second, adjacent to the first. The female guarded it for several days, after which it disappeared.

The percentage of species for each family found on mailboxes relative to the total number found locally is shown in Fig. 3. Because some of these families, and particularly those with many species, have species adapted to several different habitats, only general inferences can be drawn from these data. The spiders that established residence on or in the boxes were largely those that otherwise showed a habitat preference for trees, especially local conifers. Species that actively forage on vegetation, e.g. jumping spiders (Salticidae) and running spiders (Philodromidae), and as well, cobweb spiders (Theridiidae) and smaller orb web spiders (Aranaeidae) that usually construct webs in shrubs and trees, were well represented. Species that forage on or near the ground, or in litter on the

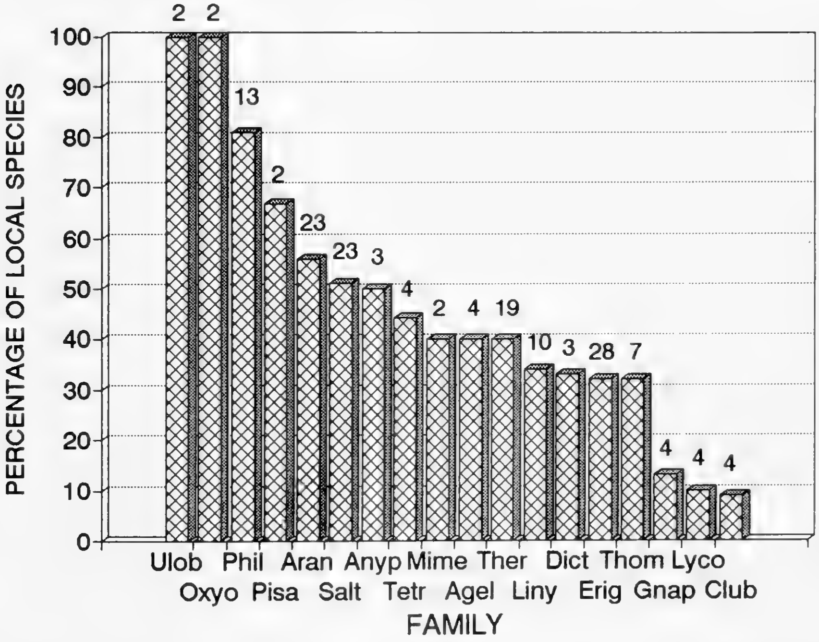

Figure 3. Percentages of numbers of species by spider family associated with mailboxes relative to the total number of species found locally. The number of mailbox species is indicated at the top of each bar. Family names are abbreviated to the first four letters; the subfamilies Erigoninae (ERIG) and Linyphinae (LINY) are listed separately.

ground, were less well represented, e.g. the Thomisidae, Gnaphosidae, Lycosidae, and Clubionidae. We were a little surprised at the relatively small number of erigonine linyphiids found because these small spiders have a reputation for ballooning from the tops of plants and objects like fence posts.

With the exception of the family Uloboridae, all of the mailbox spiders have poison glands and can deliver lethal doses to their small prey (Foelix, 1982). Most are small, some very small, and decidedly non-aggressive and incapable of piercing human skin, let alone delivering a sufficient quantity of poison to create a problem. Species that show any aggressive tendencies, and are large enough to successfully deliver a bite to a human, occur only infrequently on or in the mailboxes. In this regard single specimens of adult female *Trachelas tranquillus* (Hentz) were collected in the month of October, 1988 and 1989, in mailboxes. This species has yet to be taken elsewhere locally. It has been commonly taken in houses in the fall and has a well documented record of biting with potentially serious medical consequences (Platnick and Shadab, 1974).

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Table 1. Monthly occurrence and maturity of spider species collected from rural delivery mail boxes, Mashpee, Massachusetts, April 1987 to July 1990. Abbreviations below.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Box	Field
AGELENIDAE														
Agelenopsis kastoni C.& I.	.	.	.	.	.	F	.	.	.	.	.	.	B	G
" *pennsylvanicus* (C.K.)	.	.	.	.	.	.	.	.	.	F	.	.	Bwe	G
" *potteri* (Blackwall)	.	.	.	.	.	.	.	.	FM	.	.	.	B	G
Coras medicinalis (Hentz)	.	.	.	.	.	F	.	.	.	.	.	.	B	H
ANYPHAENIDAE														
Anyphaena celer (Hentz)	.	.	.	.	.	Fmi	.	.	.	Fi	.	.	Br	D
" *pectorosa* L. Koch	.	.	.	.	.	MFmi	Mf	i	.	.	.	.	Br	D
Aysha gracilis (Hentz)	.	.	.	mfi	Mm	MF	.	.	f	mf	m	.	Br	D
ARANEIDAE														
Acanthepeira stellata (Walck.)	.	.	.	.	.	.	.	M	.	.	.	.	CD	F
Araneus bivittatus (Walck.)	i	.	i	i	.	mi	MF	F	Ff	mfi	i	i	CD	F
" *gadus* Levi	i	.	mf	mfi	mf	MF	M	.	i	i	.	.	CDw	D
" *guttulatus* (Walck.)	.	.	.	.	.	.	M	.	.	.	.	.	–	*
" *juniperi* (Emerton)	.	.	.	.	.	mf	Mm	M	.	.	.	.	D	C
" *marmoreus* Clerck	.	.	.	.	.	.	.	.	M	.	.	.	D	U
" *miniatus* (Walck.)	f	.	.	.	.	.	.	.	.	mi	m	.	CD	F
" *partitus* (Walck.)	.		.	.	.	.	.	.	.	.	f	.	CD	F
" *saevus* (L. Koch)	.	.	.	.	.	.	.	.	.	Fmf	.	.	D	D
" *trifolium* (Hentz)	.	.	.	.	.	.	.	M	M	.	.	.	D	F
Araniella displicata (Hentz)	.	.	.	mi	Fmfi	MF	i	.	i	mi	mfi	mf	CD	F
Argiope aurantia Lucas	.	.	.	.	.	i	M	.	.	.	.	.	CD	F
Cyclosa conica (Pallas)	.	.	.	.	.	M	.	.	.	.	.	.	CD	W
" *turbinata* (Walck.)	.	.	.	.	.	.	.	M	.	.	.	.	CD	W
Eustala emertoni (Banks)	mfi	f	mf	fi	f	Mi	.	i	.	mi	mf	i	CD	U
Hypsosinga rubens (Hentz)	.	.	.	.	M	MF	.	.	.	.	.	.	CD	F
Mangora placida (Hentz)	.	.	.	.	M	i	.	.	.	m	.	i	CD	U
" *gibberosa* (Hentz)	.	.	.	.	.	.	.	.	.	F	.	.	CD	F
Micrathena sagittata (Walck.)	.	.	.	.	.	.	Mf	Mf	F	.	.	.	CD	U
Neoscona arabesca (Walck.)	.	.	.	.	.	F	MFfi	M	.	.	.	.	CD	D
" *hentzi* (Keys.)	.	.	.	.	.	.	.	.	F	.	.	.	CD	D
Wixia ectypa (Walck.)	.	.	.	.	.	.	.	.	.	M	.	.	CD	U
CLUBIONIDAE														
Castianeira variata Gertsch	.	.	.	.	.	.	.	.	F	.	.	.	A	G
Clubiona spiralis Emerton	.	.	.	.	.	.	.	.	f	f	.	.	E	F
Clubionoides excepta (L. Koch)	.	.	.	.	M	MF	mfi	M	Ff	.	.	.	A	D
Trachelas tranquillus (Hentz)	.	.	.	.	.	.	.	.	.	.	F	.	B	*
DICTYNIDAE														
Dictyna foliacea (Hentz)	.	.	.	.	.	M	.	.	.	.	.	.	C	F
" *minuta* Emerton	.	.	.	.	.	M	.	.	.	.	.	.	C	C
" *sublata* (Hentz)	.	.	.	.	.	F	.	.	.	.	.	.	C	F

GNAPHOSIDAE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Box	Field
Drassyllus aprilinus (Banks)	.	.	.	.	.	M	.	.	.	.	.	.	E	G
Herpyllus ecclesiasticus Hentz	.	.	.	.	.	.	f	.	Mm	F	.	.	ABr	T
Litopyllus temporarius Chamberlin	.	.	.	.	.	m	.	.	.	.	.	.	E	T
Nodocion floridanus (Banks)	.	.	.	.	.	.	.	.	f	.	.	.	B	T
LINYPHIIDAE (Erigonine)														
Ceraticelus alticeps (Fox)	.	.	.	.	MF	MF	.	.	.	.	.	.	BCD	C
" *emertoni* (O.P.-C.)	.	.	.	.	.	F	.	.	.	.	.	.	E	C
" *similus* (Banks)	.	.	.	.	.	M	.	.	F	.	.	.	B	F
Ceratinops crenata (Emerton)	.	.	.	F	.	.	.	.	.	.	.	.	B	F
" *lata* (Emerton)	.	.	.	MFf	M	MF	F	.	.	.	.	.	BCD	T
Ceratinopsis interpres (O.P.-C.)	.	.	.	.	.	F	.	.	.	.	.	.	BCD	F
" *nigriceps* Emerton	F	.	.	.	F	F	MF	.	.	.	F	.	CD	F
" *nigripalpis* Emerton	.	.	M	F	MF	MF	.	.	MF	MFf	M	F	BCD	U
Disembolus sacerdotalis (C.& B.)	MF	.	.	.	.	.	.	.	.	.	.	.	A	G
Erigone aletris C.& B.	.	.	.	.	.	M	.	M	.	.	.	.	B	M
" *atra* Blackwall	F	.	.	F	F	M	.	.	.	MF	.	.	BCD	G
" *autumnalis* Emerton	.	.	.	.	.	M	M	M	.	.	.	.	B	F
Eperigone maculata (Banks)	.	M	.	F	.	.	.	.	.	M	F	.	B	G
" *tridentata* (Emerton)	.	.	.	.	.	M	.	.	.	.	.	.	C	G
" *trilobata* (Emerton)	.	.	.	.	.	.	.	M	.	.	.	.	CD	M
Gonatium crassipalpum Bryant	.	.	.	.	.	.	.	.	.	F	.	.	BCD	G
Grammonota capitata Emerton	.	.	.	.	.	M	.	.	.	.	.	.	BCD	C
" *inornata* Emerton	.	.	.	.	.	M	M	.	.	.	.	.	B	M
" *pictilis* (O.P.-C.)	.	.	mf	mf	Fmf	MF	.	.	.	.	mf	.	BCD	C
" *vittata* Barrows	.	.	.	.	.	.	.	.	.	F	.	.	B	M
Hypselistes florens (O.P.-C.)	.	.	.	f	.	.	.	.	.	.	.	.	B	F
Origanates rostratus (Emerton)	M	M	.	M	.	.	.	.	.	.	.	MF	E	G
Pocadicnemis americanus Millidge	.	.	.	.	.	.	.	.	.	.	M	.	C	G
Sciastes truncatus (Emerton)	MF	M	M	.	.	.	.	.	.	MF	M	.	ACD	G
Soulgas corticarius (Emerton)	F	.	.	F	.	.	.	.	MF	M	F	.	ACD	T
Walckenaeria directa (O.P.-C.)	.	.	.	.	.	.	.	.	.	.	.	F	ACD	G
" *spiralis* (Emerton)	.	.	.	.	F	.	.	.	.	.	.	MF	ACD	G
LINYPHIIDAE (Linyphiine)														
Atopogyna cornupalpis (O.P.-C.)	.	.	.	.	.	.	.	.	.	.	MF	.	AB	G
Frontinella pyramitela (Walck.)	.	.	f	.	.	MF	.	.	.	.		.	AB	F
Lepthyphantes sabulosus (Keys.)	.	.	.	.	.	.	.	.	.	.	MF	M	AB	G
" *zebra* (Emerton)	.	.	.	.	.	.	.	.	.	F	.	.	AB	G
Meioneta ?simplex (Emerton)	.	.	.	.	F	.	.	.	.	.	.	.	E	G
Neriene clathrata (Sundevall)	.	.	.	mf	.	.	.	.	.	.	.	.	AB	G
" *radiata* (Walck.)	.	.	.	m	.	.	.	.	.	.	m	m	AB	F
" *variabilis* (Banks)	.	.	.	.	.	M	M	.	.	.	.	.	E	U
Pityohyphantes costatus (Hentz)	mf	Ff	f	MF	MF	F	.	.	mi	Mmf	mf	mf	ABw	C
Tennesseellum formicum (Emerton)	.	.	.	.	.	.	M	.	.	.	.	.	E	G
Wubana drassoides (Emerton)	.	.	.	.	.	.	.	.	.	.	F	.	E	G

LYCOSIDAE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Box	Field
Gladicosa pulchra (Keys.)	.	.	.	.	.	.	.	f	M	.	.	.	E	T
Pardosa milvina (Hentz)	.	.	.	.	.	.	f	.	.	.	.	.	E	G
Trabea aurantiaca (Emerton	.	.	m	i	m	.	.	.	.	.	m	.	B	G
Trochosa ruricola (De Geer	.	.	.	i	f	.	.	.	.	.	.	.	E	G
MIMETIDAE														
Mimetus notius Chamberlin	.	f	i	.	.	MFm	F	F	Fi	Fmf	Fmf	.	AEw	D
" *puritanus* Chamberlin	.	.	.	.	.	.	M	.	M	.	.	.	E	D
OXYOPIDAE														
Oxyopes salticus Hentz	.	.	.	.	.	.	.	M	.	i	.	.	E	F
" *scalaris* Hentz	i	.	.	.	i	M	M	F	f	.	.	i	E	C
PHILODROMIDAE														
Philodromus exilis Banks	i	.	.	i	.	.	.	.	.	m	.	.	E	C
" *imbecillus* Keys.	.	.	.	.	.	F	.	F	.	.	.	.	E	F
" *infuscatus* Keys.	.	.	.	.	.	.	.	.	F	.	.	.	E	F
" *lutulentus* Gertsch	.	.	.	f	.	.	.	.	.	.	.	.	E	*
" *marxi* Keys.	.	.	.	.	Mf	M	M	F	.	.	.	.	E	U
" *mineri* Gertsch	.	.	.	.	.	F	.	.	.	.	.	.	E	C
" *pernix* Blackwall	.	.	.	F	.	.	.	.	.	.	.	.	E	F
" *placidus* Banks	.	.	.	m	.	F	.	.	.	.	.	.	E	F
" *praelustris* Keys.	.	i	mf	Fmf	Mf	F	Ffi	.	mfi	mf	Fmf	mf	ACDE	T
" *rufus* Walck.	.	.	f	mf	Mmf	MF	.	.	m	.	.	i	E	U
" *validus* (Gertsch)	.	.	.	.	.	M	.	.	.	.	.	.	E	T
" *vulgaris* (Hentz)	.	mf	mf	mfi	Fi	MF	.	.	.	mfi	m	f	ABew	T
Thanatus formicinus (Clerck)	.	.	.	i	.	i	.	.	.	.	.	.	E	U
PISAURIDAE														
Pisaurina brevipes (Emerton)	.	.	.	.	.	M	.	.	.	.	.	.	B	*
Pisaurina mira (Walck.)	.	.	.	.	.	.	.	f	.	.	.	.	E	F
SALTICIDAE														
Admestina tibialis (C.K.)	.	.	.	.	.	f	f	M	.	.	.	.	E	T
Agassa cyanea (Hentz)	.	.	.	.	.	M	.	.	.	.	.	.	E	F
Eris militaris (Hentz)	.	.	.	.	m	M	.	.	.	.	.	.	E	D
" *pineus* (Kaston)	.	.	.	.		M	.	F	.	.	mf	.	E	C
Habrocestum pulex (Hentz)	.	.	.	.	i	.	.	.	i	.	.	.	E	G
Habronattus viridipes (Hentz)	.	.	.	.	.	.	.	.	i	.	.	.	E	G
Hentzia mitrata (Hentz)	.	.	.	.	m	MF	.	.	.	.	.	.	E	M
" *palmarum* (Hentz)	.	.	.	m	mf	.	.	.	m	mf	.	.	E	D
Maevia vittata (Hentz)	.	.	.	m	Mi	F	MF	F	Fi	F	.	.	CDE	U
Marpissa wallacei Barnes	.	.	.	.	.	M	.	.	.	.	.	.	E	*
Metaphidippus exiguus (Banks)	.	.	.	.	MF	M	.	.	Mf	MFmf	i	.	CDE	C
" *insignis* (Banks)	.	.	.	.	M	M	MF	.	.	.	.	.	CF	T
" *protervus* (Walck.)	.	.	.	.	MF	MF	i	.	m	i	fi	f	E	F
Peckhamia picata (Hentz)	.	.	.	.	.	M	M	.	.	.	.	.	E	*
Phidippus audax (Hentz)	.	.	i	.	.	.	.	fi	fi	m	f	.	Br	T
" *clarus* Keys.	.	.	.	.	.	Mf	f	.	.	.	.	.	E	F

SALTICIDAE (con.)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Box	Field
Platycryptus undatus (De Geer)	.	.	.	.	F	i	F	f	i	.	.	.	Ar	T
Salticus scenicus (Clerck)	.	.	.	.	f	MF	F	.	.	.	.	.	E	G
Synagles bishopi Cutler	.	.	.	.	.	.	M	.	.	.	.	.	E	F
Talavera minuta (Banks)	.	.	.	.	.	M	.	.	.	.	.	.	E	F
Tutelina elegans (Hentz)	.	.	.	.	f	f	.	.	f	.	.	.	E	F
" *similis* (Banks)	.	.	.	.	.	MF	F	.	i	.	.	.	AE	F
Zygoballus rufipes P.& P.	.	.	.	.	.	Mm	M	.	M	.	.	.	E	F
TETRAGNATHIDAE														
Leucauge venusta (Walck.)	.	.	.	i	.	M	.	.	.	.	i	.	CD	U
Tetragnatha laboriosa Hentz	.	.	.	.	.	.	M	.	.	.	.	.	E	F
" *straminea* Emerton	.	.	.	i	.	.	.	.	.	.	.	mf	E	F
" *versicolor* Walck.	i	i	i	i	m	mf	.	.	i	i	i	i	ACDw	F
" *viridis* Walck.	mfi	mfi	mf	mf	Fm	.	.	i	mi	.	fm	.	ACDw	C
THERIDIIDAE														
Achaearanea tepidariorum (C.K.)	fi	.	.	i	.	Mmi	m	mi	Mmfi	Mmfi	.	i	B	C
Argyrodes trigonum (Hentz)	.	.	.	.	.	.	.	.	f	.	.	.	E	UF
Crustulina sticta (O.P.-C.)	.	.	.	.	F	.	.	.	.	.	.	.	D	G
Dipoena buccalis Keys.	.	.	.	.	.	.	.	F	.	.	.	.	E	G
" *nigra* (Emerton)	.	.	.	.	.	mf	.	.	f	.	.	.	E	CF
Enoplognatha ovata (Clerck)	.	.	.	.	.	f	F	.	.	.	.	.	E	G
Euryopis limbata (Walck.)	.	.	.	.	.	Mfi	F	.	m	.	.	.	E	T
Phoroncidia americana (Emerton)	.	.	.	.	.	MF	.	.	.	.	.	.	E	U
Robertus pumilus (Emerton)	.	.	Ff	F	.	.	.	.	.	.	.	.	E	G
Steatoda americana (Emerton)	.	.	.	.	.	f	m	i	i	.	.	.	Bw	G
" *borealis* (Hentz)	.	.	.	Mmf	Fmfi	Mfi	fmi	fmi	MFmf	Mmfi	Mf.	M	Bw	H
Theridion alabamense G.& A.	.	.	.	.	M	F	.	.	.	.	m	.	ACD	C
" *albidum* Banks	.	.	.	.	.	.	MF	.	.	.	.	.	E	D
" *differens* Emerton	.	.	.	.	.	M	.	.	.	.	.	.	E	C
" *glaucescens* Becker	.	.	.	.	.	M	F	MF	.	.	.	.	E	C
" *lyricum* Walck.	f	mf	f	fi	fi	MFm	.	.	mi	i	fi	i	ACDw	C
" *murarium* Emerton	fi	m	f	fi	fi	MFf	MF	i	mfi	i	mfi	i	ACDw	F
Thymoites marxi (Crosby)	.	.	.	.	.	M	.	.	.	.	.	.	CD	T
" *unimaculatus* (Emerton)	.	.	.	.	fi	MF	M	.	.	mf	f	.	CD	T
THOMISIDAE														
Coriarachne versicolor Keys.	.	.	.	f	i	MF	Fm	F	mf	.	.	.	AE	T
Misumenops asperatus (Hentz)	.	.	.	.	f	MF	.	.	.	fi	m	.	C	F
Ozyptila s. oraria D.& R.	.	.	.	.	f	.	.	.	.	.	.	.	E	G
Tmarus angulatus (Walck.)	.	.	.	.	Mf	MFf		F	.	m	m	.	E	U
Xysticus elegans Keys.	.	.	.	.	.	.	F	.	.	.	.	.	E	G
" *fraternus* Banks	.	.	.	.	.	MF	M	.	.	.	.	.	E	G
" *punctatus* Keys.	.	.	.	.	F	.	.	i	.	mf	.	m	E	C
ULOBORIDAE														
Hyptiotes cavatus (Hentz)	.	.	.	.	.	.	.	.	M	.	.	.	E	U
Uloborus glomosus (Walck.)	.	.	.	.	m	Mmi	.	.	i	i	i	.	CDw	U

Month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Number of species	18	12	19	39	48	89	47	35	49	43	38	23

Abbreviations

Maturity: M,F = Adult male, female; m,f = penultimate and antepenultimate instars; i = immatures without significant development of secondary sexual characters.

'Box' column: Locations on mailbox in Capital letters as shown in Figure 1; e = egg sac; r = retreat; w = web.

'Field' column indicates most likely habitat for finding each species: C = coniferous foliage; D = deciduous tree and shrub foliage; F = fields on grass or forbs; G = on the ground or in litter; H = hollows in trees; M = in or adjacent to marshlands; T = tree trunks; U = woodland understory; * = found only on mailbox.

Authority: C.& I. = Chamberlin and Ivie; C.K. = C. L. Koch; C.& B. = Crosby and Bishop; D.& R. = Dondale and Redner; G.& A. = Gertsch and Archer; Keys. = Keyserling; O.P.-C. = O. Pickard-Cambridge; P.& P. = Peckham and Peckham; Walck. = Walckenaer.

ADDITIONS TO THE PAWNEE NATIONAL GRASSLANDS INSECT CHECKLIST[1]

R. Lavigne, R. Kumar, J.A. Scott[2]

ABSTRACT: Additions to the species list of "Insects of the Central Plains Experiment Range, Pawnee National Grassland" are made: Araneida - 1, Coleoptera - 56, Diptera - 32, Hemiptera - 11, Homoptera - 2, Hymenoptera - 75, Lepidoptera - 8 and Orthoptera - 4. Observations on insect-plant associations have been included, where applicable.

A checklist of the insects of the Central Plains Experiment Range, Pawnee National Grassland, Colorado was published in the mid 70's (Kumar *et al*, 1976), which totaled 1,664 species. In the interim, a number of additional identifications have been received of species not previously recorded from the Pawnee Grasslands. Since the original listing is the only reasonably complete list of the insect fauna of a grassland anywhere in the world, it seems, from a biodiversity point of view, worthwhile publishing additional records.

Records for previously unrecorded species are indicated with an asterisk(*). Numbers preceding the date refer to pasture designations used in the original publication. Included, also, are additional feeding records of already recorded species, where such information is unrecorded elsewhere or not readily available in published form. Coleoptera collected in 1968 and 1969, either dated or undated, were collected by Ross T. Bell, while he collected Carabidae, in various excursions to the Pawnee site.

The Rocky Mountain Systematic Entomology Laboratory at the University of Wyoming has become the repository for most specimens collected on the Pawnee National Grasslands in the period 1968 - 1978. For anyone seeking "Lavigne, R.J., 1975, Food habits of some grassland insects" as referenced in the original 1976 paper, it appeared as Lavigne (1976): Rangeland insect-plant associations on the Pawnee Site. Identifications of insects in IBP Technical Reports are the responsibility of the Report authors; the authors of the present paper take no responsibility for the correctness of those identifications.

The current listing adds 189 species to the known arthropod fauna of the Pawnee National Grasslands as follows: Araneida - 1, Coleoptera - 56, Diptera - 32, Hemiptera - 11, Homoptera - 2, Hymenoptera - 75, Lepidoptera - 8 and Orthoptera - 4.

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[2] Entomology Section, Department of Plant, Soil and Insect Sciences, Box 3354, University Station, Laramie, Wyoming 82071

ARANEIDA

Lycosidae

*_Pardosa sp._

21 Oct. 1973; as prey of _Comantella fallei_ Back (Dennis & Lavigne 1975)

COLEOPTERA

Bruchidae

Acanthoscelides aureolus (Horn)

8 May-7 June 1976; adults reared from _A. bisulcatus_ (Lavigne 1989), adults collected from _Astragalus humistriatus, A. mollissimus_ & _A. sericoleucus_

Acanthoscelides fraterculus (Horn)

25 June 1975, 13-14 July 1976; larvae feed on seeds of _Astragalus drummondi, A. missouriensis_ & _A. pectinatus_ (Lavigne 1989), adults collected from _Astragalus drummondi, A. humistriatus, A. missouriensis, A. mollissimus_ & blossoms of _Oxytropis sericea_

Buprestidae

Agrilus malvastri Fisher

18; 9 June 1972; previously identified as _Agrilis_ sp. in Kumar _et al_ (1976); feeding on petals of _Sphaeralcea coccinea_ (Lavigne 1976)

Cantharidae

Chauliognathus limbicollis LeConte (Yount & Thatcher 1972)

Carabidae

*_Amara musculis_ Say

20 Sept. 1971, 13 Sept. 1975; adults feeding on seeds of _Gutierrezia sarothrae_ (Lavigne 1979)

*_Amara torrida_ Panzer ????????????? not in BRIA Coleoptera checklist

2 July 1968

*_Brachinus_ sp.

Cottonwood Pond (Bell 1971)

*_Helluomorphoides praeustus_ DeJean (Bell 1971)

Cerambycidae

*_Mecas marginella_ LeConte

feeding on pollen of _Thelesperma filifolium_ (Lavigne 1976)

*_Megacheuma brevipennis_ (LeConte)

27; 29 July 1976

*_Moneilema annulatum_ Say

14 Sept 1968

Chrysomelidae

Acalymna virgifera (Yount & Thatcher 1972 [Note: not listed in Checklist of the beetles of Canada, United States, Mexico, Central America and the West Indies])

Altica lazulina LeConte

feeding on leaves of _Gaura coccinea_ (Lavigne 1976)

*_Babia quadriguttata_ (Oliver)

26-27 July, 7 Sept. 1976; adults collected on blossoms & foliage of _Atriplex canscens, Chrysothamnus nauseosus_ & _Eriogonum effusum_

*_Chaetocnema denticulata_ (Illiger)

7 June 1976; in blossoms of _Astragalus mollissimus_

*_Chrysomela knabi_ Brown

23 June-27 Aug.; adults collected on _Salix amygdaloides_, reared on _Salix amygdaloides_

**Chrysomela scripta* Fabricius
  23 June-Aug. 27; adults collected on foliage of *Populus sargenti* & *Salix amygdaloides*
Coscinoptera axillaris LeConte
  9-11 June 1976; adults common on *Eriogonum effusum*
**Cryptocephalus confluentus* Say
  21 June-7 July; adults collected on *Artemisia dracunculoides, Chrysothamnus nauseosus* & *Gutierrezia sarothrae*
**Cryptocephalus venustus venustus* Fabricius
  8-29 June; adults collected on *Artemisia dracunculoides, A. filifolia* & *Gutierrezia sarothrae*
Diabrotica undecimpunctata howardi Barber
  25 Aug 1976; adults feeding on pollen of *Gutierrezia sarothrae,* adults collected when sweeping *Erigogonum effusum*
Diabrotica virgifera LeConte
  26 July-9 Sept.; adults feeding on pollen of *Gutierrezia sarothrae* & *Helianthus annuus,* adults collected on flowers & foliage of *Grindelia squarrosa, Iva* sp., *Polygonum pennsylvanicum, Psoralea tenuiflora* & *Solidago canadensis*
**Glyptina spuria* LeConte
  2 July 1969; adult collected on *Melilotus officinale*
**Myochrous squamosus* LeConte
  26 July 1976; adult collected on stem of *Astragalus crassicarpus*
**Nodonota puncticollis* (Say) (Yount & Thatcher 1972, misspelled as Nodonata)
**Pachybrachis atomarius* (Melsheimer)
  28 June 1969
**Pachybrachis obsoletus* Suffrain
  19 June 1969
**Phyllotreta albionica* LeConte
  2 July 1969
**Phyllotreta pusilla* Horn (Yount & Thatcher 1972)
  2-29 July; adults collected in blossoms of *Cleome serrulata* & *Melilotus officinale*
Psylliodes punctulata Melsheimer
  29 July 1969; adult collected on *Cleome serrulata*
**Zygogramma exclamationis* Fabricius
  28 May-July 7; adults feeding on leaves of *Helianthus annuus* & *H. pumilis,* collected on *H. petiolaris* & *Iva axillaris*
Zygogramma heterothecae Linell
  26 May-13 July; adults collected on *Oxytropis sericea* & *Scutellaria brittonia,* larva collected on leaves of *Heterotheca villosa* where it subsequently pupated

Cicindelidae
**Cicindela pulchra* Say (Rogers 1974)

Coccinellidae
**Brachyacantha albifrons* Say
  summer, 1969 (R.T. Bell, coll.)
**Mulsantina picta* Randall (as *Cleis)*
  summer, 1969 (R.T. Bell, coll.)
**Coccinella monticola difficilis* Crotch
  summer, 1969 (R.T Bell, coll.)
**Hyperaspidius militaris* LeConte
  summer, 1969 (R.T. Bell, coll.)
**Hyperaspidius oblongus* Casey
  summer, 1969 (R.T. Bell, coll., as *trimaculatus*)

**Psyllobora viginti-maculata* Say
summer, 1969 (R.T. Bell, coll., as *taedata* LeConte)

Curculionidae

**Acalles porosus* Blatchley
summer, 1969 (R.T. Bell, coll.)
**Anthonomus* sp., *decipiens* LeConte group
28 Aug. 1972 (emerged); reared from seeds of *Heterotheca villosa*
**Anthonomus* sp., *subvittatus* LeConte group
14 Aug. 1972 (emerged); reared from seeds of *Hymenopappus filifolius*
Anthonomus tenuis Fall
28 Aug. 1972 (emerged), 16 Sept. 1972 (emerged), 2 Oct. 1972 (emerged); reared from seeds of *Astragalus bisulcatus, Heterotheca villosa* & *Guterrezia sarothrae,* respectively
**Apion walshi* Smith (as *vicinum* Smith)
summer, 1969 (R.T. Bell, coll.)
**Cylindrocopturus longulus* LeConte
summer, 1969 (R.T. Bell, coll.)
**Epimechus curvipes* Dietz
32; 20 Sept 1972 (emerged); reared from seeds of *Chrysothamus* sp.
**Mimosestes amicus* (Horn)
collected on *Cirsium undulatum* (Lavigne 1976)
**Pantomorus planitiatus* Buchanan (Baldwin 1971a)
Smicronyx sp.
15-28 June 1971; collected from flowers of *Thelesperma filifolium* & *T. trifidum*
**Thecesternus morbillosus* LeConte (Baldwin 1971a)
Tychius soltaui Casey (as *soltani*)
27; 7, 28 June 1976; adult feeding on sepals, on tissue at base of *Astragalus mollissimus* stem (Lavigne 1989)
Tychius tectus LeConte
23 June 1975; collected on seeds of *Oxytropis lamberti*

Histeridae

**Aphelosternus* sp. (Baldwin 1971b [Note: monophyletic genus, single species only known from California])
Hister interruptus (Baldwin 1971a [Note: not listed in Checklist of the beetles of Canada, United States, Mexico, Central America and the West Indies])

Hydrophilidae

**Tropisternus ellipticus* LeConte (Baldwin 1971b)

Lampyridae

**Lucidota fenestralis* Melsheimer
13 Aug 1968

Languriidae

**Languria mozardi* Latreille
19 June 1968

Meloidae

**Epicauta pruinosa* LeConte (Yount & Thatcher 1972, misspelled as *purinosa*)
**Lytta sphaericollis* Say
19 June 1968
**Nemognatha lurida* LeConte (Yount & Thatcher 1972)

Melyridae

**Collops bipunctatus* Say
2 Aug 1968

Scarbaeidae
  **Aphodius ruricola* Melsheimer
    summer, 1969 (R.T. Bell, coll.)
  **Canthon hudsonias* Forster (Baldwin 1971a, as *C. laevis*)
  **Bothynus* sp.
    summer, 1969 (R.T. Bell, coll. as *Ligyrus*)
  **Onthophagus hecate* Panzer (Baldwin 1971b)
  **Rhyssemus scaber* Haldeman (Baldwin 1971a)
    summer, 1969 (R.T. Bell, coll.)
Staphylinidae
  **Stenus* sp.
    26 July 1968
Tenebrionidae
  **Blapstinus metallicus* Fabricius (Baldwin 1971a, b)
  **Bothrotes canaliculatus* (Say) (Bell 1970)
  **Melanastus implicans* Casey (Baldwin 1971a)
  **Stenomorpha inhabilis* Casey (Bell 1970 as *Euschides retusus* Casey)

DIPTERA

Anthomyiidae
  Hylemya cinerella (Fallen)
    15 Apr 1971; working blossoms of *Lomatium orientale*
  Hylemya platura (Meigen)
    7 June 1976; working blossoms of *Astragalus humistriatus* (Lavigne 1989)
Calliphoridae
  **Eucalliphora lilaea* (Walker)
    21 April 1972; quick trap
  **Paralucilia wheeleri* (Hough)
    14 April-26 May; quick trap
Chloropidae
  **Elachiptera costata* (Loew)
    Owl Creek; 22 Oct. 1971; on *Populus*
  Thaumatomyia glabra (Meigen)
    27; 5 June 1976; working blossoms of *Astragalus bisulcatus*
Culicidae
  **Aedes dorsalis* (Meigen)
    27; 26 Oct. 1971
  **Aedes nigromaculis* (Ludlow)
    31; 5 June 1971
Dixidae
  **Dixa* sp.
    Owl Creek; 22 Oct. 1971; on grass
Drosophilidae
  **Scaptomyza pallida* (Zetterstedt)
    Owl Creek; 22 Oct. 1971; on grass
Ephydridae
  **Lamproscatella sibilans* (Haliday)
    22 Oct. 1971; sweep
  **Lytogaster gravida* (Loew)
    23W; 22 Oct. 1971; working blossoms of *Oryzopsis hymenoides*

Ochthera mantis (Degeer)
Sect 2; 11 Oct. 1971
**Parascatella triseta* (Coquillett)
23W; 13 Aug. 1971; on cow pat

Milichiidae
**Madiza glabra* Fallen
Owl Creek; 1 July 1971; sweeping

Muscidae
Helina sp.
27; 3 June 1976; working blossoms of *Astragalus bisculcatus*
**Musca autumnalis* Degeer
Owl Creek; 1 July 1971
**Orthellia caesarion* (Meigen)
Owl Creek; 14 Apr-22 Oct; sweeping, quick trap
Schoenomyza litorella (Fallen)
18 Oct. 1973; as prey of *Comantella fallei* Back (Dennis & Lavigne 1975)

Sarcophagidae
**Ravinia derelicta* (Walker)
11 July 1972
Ravinia lherminieri (Robineau-Desvoidy)
7 June 1976; working blossoms of *Astragalus mollissimus*
Ravinia planifrons (Aldrich)
27; 5 May-1 July; working blossoms of *Musineon divaricatum;* quick trap

Sciomyzidae
**Sepedon praemoisa* Giglio-Tos
Owl Creek; 22 Oct. 1971; on grass

Syrphidae
**Allograpta obliqua* (Say)
28 Aug. 1976; visiting blossoms of *Eriogonum effusum*
**Eristalis (Eoseristalis) altipator* Osten Sacken
3 Aug. 1973; working blossoms of *Thelesperma filifolium*
**Eristalis brousii* Williston
16 Aug. 1976; visiting blossoms of *Grindelia squarrosa*
**Eristalis hirtus* Loew
27 Aug. 1976; visiting blossoms of *Grindelia squarrosa, Solidago canadensis*
**Eristalis stipator* Osten Sacken
11 June-13 Aug.; visiting blossoms of *Aster* sp., *Helianthus petiolaris, Hymenopappus tenuiflora, Thelesperma filifolium*
Eristalis tenax (L.)
7 June 1976; working blossoms of *Rorippa sinuata*
Helophilus latifrons Loew
27 May-16 Aug., 1976; working blossoms of *Descurainia pinnata, Grindelia squarosa, Heterotheca villosa, Musineon divaricatum, Polygonum pennsylvanicum, Rorippa sinuata, Salix exigua, Senecio mutabilis, S. tridenticulatus* & *Sisymbrium altissimum*
Paragus bicolor (Fabricius)
27; 5 May, 28 June 1976; working blossoms of *Musineon divaricatum,* visiting *Salix exigua*
**Paragus tibialis* (Fallen)
7, 22 May 1974, 9 June 1972, 1, 4, 14, June 1976; visiting blossoms of *Antennaria rosea, Arenaria hookeri, Eriogonum effusum, Lesquerella ludoviciana, Musineon divaricatum, Senecio mutabilis, Senecio tridenticulatus*

**Toxomerus marginatus* (Say)
14 July 1975, 23, 26, 29, July 1976, 25 Aug. 1976; visiting blossoms of *Eriogonum effusum, Heterotheca villosa, Kochia scoparia, Thelesperma megapotamicum*

Tachinidae

**Doryphorophaga* sp.
Owl Creek; 1 July, 22 Oct., 1971

Gonia albagenae Morrison
27; 25 May 1976; working blossoms of *Astragalus pectinatus*

**Gymnosoma fuliginosum* Robineau-Desvoidy
working blossoms of *Senecio tridenticulatus* (Lavigne 1976)

**Promasiphaya confusa* var *irrisor* Rein.
32; 9 June 1972; working blossoms of *Arenaria hookeri*

**Nowickia* sp.
27; 5 May 1976; working blossoms of *Musineon divaricatum*

Tephritidae

**Aciurina bigeloviae* (Cockerell)
19 May 1972; quick trap

**Paroxyna occidentalis* Novak
reared from seeds of *Chrysothamnus nauseosus* (Lavigne 1976)

**Trupanea femoralis* (Thomson)
19 May 1972; quick trap; reared from seeds of *Chrysothamnus nauseosus* (Lavigne 1976)

**Trupanea jonesi* Curran
reared from seeds of *Chrysothamnus nauseosus* (Lavigne 1976)

**Trupanea* sp.
28 April 1972; quick trap

**Urophora timberlakei* Curran
reared from seeds of *Chrysothamnus nauseosus* (Lavigne 1976)

Trixoscelidae

Trixoscelis fumipennis Melander
27; 8 June 1976; working blossoms of *Astragalus bisulcatus*

HEMIPTERA

Lygaeidae

Geocoris bullatus (Say)
32; 21 July 1972; collected on *Bahia oppositifolia*

Lygaeospilus pusio Stal
9 June 1972; feeding on developing ovary of *Senecio tridenticulatus*

**Nysius minutus* Uhler (Yount & Thatcher 1972)

Miridae

Coquilletia insignis Uhler
collected on *Oxytropis lambertii*

**Hadronema militaris* Uhler
27; 2 June 1972, 22 May, 11 June 1974, 28 May 1976; feeding at base of blossoms of *Astragalus pectinatus* (Lavigne 1989), collected in blossoms of *Lepidium densiflorum*

**Hadronema simplex* Knight
22; 20 June 1975; feeding at midribs of leaves of *Astragalus bisulcatus*, feeding at base of blossoms & leaf midribs of *A. humistriatus* (Lavigne 1989), feeding in phloem of *Oxytropis sericea* (Lavigne 1976) & *Thelesperma filifolium*

**Leptoterna dolobrata* (L.)
20 June 1972; feeding on seed heads of *Agropyron desertorum*

Lepoterna ferrugata (Fallen)
feeding in phloem of *Thelesperma filifolium*
**Lopidea teton* Knight
22, 27, 35; 9 June 1971; 20 June 1975, 30 May- 28 June 1975, 30 May, 28 June, 1976; feeding at base of blossoms of *Astragalus bisulcatus, A. humistriatus, & A. pectinatus,* feeding at leaves & stems of *A. drummondi* (Lavigne 1989), feeding on seed of *Oxytropis sericea*; misidentified as *L. confluenta* in Kumar *et al* (1976)
**Lygus desertinus* Knight
14 Aug., 16, 20 Sept. 1972, 11 June 1974 - feeding on developing seeds of *Artemisia frigida* and *Chrysothamnus* sp., feeding in nectaries of *Thelesperma* sp.
**Lygus lineolaris* (P. de B.)
32; 21 July 1972; feeding in blossoms of *Thelesperma filifolium*
**Porpomiris curtulus* (Reut.)
20 June 1972 - feeding on seed heads of *Agropyron desertorum*
**Slaterocoris stygicus* (Say) (Yount & Thatcher 1972, as *Strongylocoris stygicus)*

Pentatomidae
Chlorochroa sayi Stal
feeding on seed of *Opuntia polyacantha*
**Thyanta custator* Fabricius (Baldwin 1971a)

Rhopalidae
Harmostes reflexulus (Say)
27; 13 Sept. 1972, 3 June 1976; feeding on developing seeds of *Gutierrezia sarothrae,* feeding in nectaries of *Senecio tridenticulatus*

Tingidae
**Piesma* sp. (Baldwin 1971a)

HOMOPTERA

Aphididae
Aphis lugentis Wilson
feeding in phloem of *Senecio tridenticulatus*

Cercopidae
Philaronia bilineata (Say)
feeding in phloem of *Agropyron desertorum & Chrysothamnus nauseosus*

Cicadellidae
**Aceratagallia uhleri* (Van Duzee)
13-21 Oct. 1973; as prey of *Comantella fallei* Back (Dennis & Lavigne 1975)
**Agallia quadripunctata* (Provancher)
27; 29 July 1976; feeding on phloem of *Astragalus mollissimus*

Membracidae
Publilia modesta Uhler
27; 28 June 1976; feeding in phloem of *Thelesperma filifolium*

HYMENOPTERA

Andrenidae
**Andrena accepta* Viereck
26 July 1971; collecting nectar/pollen of *Helianthus annus & H. petiolaris*
**Andrena cressonii* Robertson
33; 2 June 1971; collecting nectar/pollen of *Senecio* sp.
**Andrena forbesii* Robertson
28 June 1976; working blossoms of *Salix exigua*

**Andrena gardineri* Cockerell
  26, 27, 33; 16 April - 2 June; collecting nectar/pollen of *Lomatium orientale, Oxytropis sericea, Senecio* sp., *Senecio tridenticulatus*

**Andrena lupinorum* Cockerell
  14, 24, June 1976; working blossoms of *Melilotus officinalis*

Andrena merriami Cockerell
  27, 32; 21 May 1971, 5 May 1976; collecting nectar/pollen of *Lomatium oreintale & Musineon divaricatum*

**Andrena microcholora* Cockerell
  23, 27; 7 May 1974, 28-May-8 June 1976; collecting nectar/pollen of *Musineon divaricatum*

**Andrena prunorum prunorum* Cockerell
  27; 9 May 1976; collecting nectar/pollen of *Astragalus sericoleucus*

**Andrena scurra* x *arabis* x *capricornis* hybrids
  31; 7-11 June; collecting nectar/pollen of *Lesquerella ludoviciana & Rorippa sinuata*

**Andrena* sp., nr. *w-scripta* Viereck
  27; 27 May 1971, 5 May 1976; collecting nectar/pollen of *Musineon divaricatum*

**Andrena tonkaworum* Viereck
  2 July 1971; collecting nectar/pollen of *Thelesperma trifidum*

**Andrena transnigra* Viereck
  23, 27; 7 May-7 June; collecting nectar/pollen of *Musineon divaricatum* and *Rorippa sinuata*

**Andrena vulpicolor* Cockerell
  Stress; 13 Sept. 1972; collecting nectar/pollen of *Chrysothamnus nauseosus*

**Nomadopsis* sp.
  27; 11 June 1974

**Panurginus* sp.
  22, 23W; 23 May-30 June; collecting nectar/pollen of *Sphaeralcea coccinea, Rorippa sinuata & Thelesperma* sp.

**Perdita fallax* Cockerell
  27; 11 June 1974; working blossoms of *Thelesperma* sp.

**Perdita* sp., nr. *lacteipennis* Sw. & Ckll.
  working blossoms of *Ratibida columnaris* (Lavigne 1976)

**Pseudopanurgus* sp.
  30 June-29 July; collecting nectar/pollen of *Helianthus petiolaris, Ratibida columnaris & Thelesperma filifolium*

Anthophoridae

**Anthophora affabilis* Cresson
  13 May 1969 (Kumar *et al* 1976, as *A. montanus*); 7 May-10 June; collecting nectar/pollen of *Astragalus humistriatus, mollissimus & pectinatus* (Lavigne 1989), *Oxytropis lamberti & O. sericea*

Ceratina sp.
  27; 28 June 1976; collecting nectar/pollen of *Argemone polyanthemos*

**Svastra* sp.
  collecting nectar/pollen of *Penstemon angustifolius* (Lavigne 1976)

**Synhalonia chrysophila* (Cockerell)
  22; 10-20 June; collecting nectar/pollen of *Astragalus bisulcatus & A. humistriatus* (Lavigne 1989)

**Synhalonia fulvitarsis* (Cresson)
  27; 14 May-7 June; collecting nectar/pollen of *Astragalus bisulcatus, pectinatus & sericoleucus* (Lavigne 1989)

**Synhalonia hamata* (Bradley)
18, 23W, 27; 7 May-12 June; collecting nectar/pollen of *Astragalus drummondi, missouriensis, mollisimus & pectinatus* (Lavigne 1989), *Oxytropis sericea & Vicia americana*
**Synhalonia lepidia* (Cresson)
22, 27; 14 May-23 June; collecting nectar/pollen of *Astragalus bisulcatus, humistriatus, pectinatus & sericoleucus* (Lavigne 1989)
**Tetralonia edwardsii* Cresson
collecting nectar/pollen of *Oxytropis sericea* (Lavigne 1976)

Apidae
Bombus fervidus (Fabricius)
7 May-24 June; working blossoms of *Astragalus bisulcatus, A. humistriatus, A. pectinatus* (Lavigne 1989); *Oxytropis sericea*
Bombus fraternus (Smith)
27; 8 May 1976; working blossoms of *Astragalus sericoleucus* (Lavigne 1989)
Bombus huntii Greene
27; 25 May-10 June; collecting pollen/nectar from blossoms of *Astragalus bisulcatus, A. humistriatus & A. pectinatus* (Lavigne 1989)
**Bombus nevadensis* Cresson
1-24 June; collecting pollen/nectar from blossoms of *Astragalus bisulcatus & A. humistriatus* (Lavigne 1989)
**Bombus pennsylvanicus* (Degeer)
24, 34; May-27 Aug., 1976; working blossoms of *Astragalus bisulcatus & A. pectinatus* (Lavigne 1989), *Melilotus alba*
**Melissodes* sp.
15E; 12 June-17 July
**Nomada* sp.
14 May 1977; working blossoms of *Astragalus sericoleucus* (Lavigne 1989)

Braconidae
**Cremnops nigrosternum* (Morrison)
29 June 1976; on flower of *Cirsium undulatum*
**Cyanopterus* sp.
25 June-15 July 1976; working blossoms of *Helianthus petiolaris*
**Isomecus coloradensis* (Ashmead)
16 June 1976; at flower head of *Chenopodium album*
**Isomecus croceus* (Cresson)
33; 1 July 71; sweeping vegetation
**Macrocentrus cerasivoranae* Viereck
15 July 1976; emerged from *Rosea woodsi*

Colletidae
**Colletes lutzi* Timberlake
feeding on nectar/pollen of *Sphaeralcea coccinea* (Lavigne 1976)
Colletes phaeceliae Cockerell
15E, 22; 12 June 1975; working blossoms of *Allium textile, Cryptantha* sp.

Eurytomidae
**Haltichella* sp.
2 June 1972; working blossoms of *Lepidium densiflorum*

Formicidae
**Conomyrma insana* (Buckley)
28 June 1976; working in blossoms of *Astragalus bisulcatus;* previously identified as *Dorymyrmex pyramicus* in Kumar *et al* (1976)

**Formica haemorrhoidalis* Emery
    28 June 1976; tending membracids feeding on *Astragalus bisulcatus*
**Formica montana* Emery
    28 June 1976; tending immature membracids, *Publilia modesta*, on *Astragalus mollissimus*
**Formica neoclara* Emery (Baldwin 1971a)
Formica neogagates Emery
    25 May, 28 June 1976; feeding in wounded seed pod of *Astragalus mollissimus*, working in blossoms of *A. pectinatus* (Lavigne 1989)
Formica obtusopilosa Emery
    28 June 1976, 10, 24, 25, 27 May 1977; feeding at base of developing seeds & at opening buds of *Astragalus drummondi*, working blossoms of *A. humistriatus* & *A. pectinatus*, scrapping sides & feeding at base of seeds of *A. mollisimus* (Lavigne 1989), tending immature membracids on *Ratibida columnaris*
Leptothorax tricarinatus Emery
    25 May 1976; working blossoms of *Astragalus pectinatus* (Lavigne 1989)
Monomorium minimum (Buckley)
    8 May - 8 June, 1976; working blossoms of *Astragalus drummondi, A. humistriatus, A. sericoleucus, Oxytropis lambertii*, feeding in wounds at base of sepals of *Astragalus mollisimus*

Ichneumonidae
Phygadeuon sp.
    1 July 1971, 5 July 1972; yellow pan trap

Megachilidae
Anthidium emarginatum (Say)
    10 June 1977; collecting pollen/nectar from *Astragalus humistriatus*
**Ashmeadiella gillettei* Titus
    10 June 1977; collecting pollen/nectar from *Astragalus humistriatus*
**Hoplitis* sp.
    27; 25 May 1976; collecting nectar/pollen of *Astragalus sericoleucus*
**Megachile mucorosa* Cockerell
    27; 14 July 1975; collecting nectar/pollen of *Ratibida columnaris*
Osmia integra Cresson
    25 May - 8 June 1976; collecting pollen/nectar from blossoms of *Astragalus bisulcatus, A. humistriatus, A. missouriensis, A. pectinatus* (Lavigne 1989), *Senecio* sp., *Sophora sericea*
**Osmia physariae* Cockerell
    12 June-23 July, 1975; collecting nectar/pollen from *Astragalus gracilis* & *A. humistriatus* (Lavigne 1989). *Penstemon angustifolius*
**Osmia (Chenosmia)* sp.
    19 May 1977; collecting nectar/pollen from *Astragalus sericoleucus* (Lavigne 1989)
**Osmis trevoris* Cockerell
    7 June 1976; collecting nectar/pollen from *Astragalus bisulcatus* (Lavigne 1989), *Penstemon angustifolius*
**Osmia unca* Michener
    30 May-20 June; collecting nectar/pollen from *Astragalus bisulcatus* & *A. humistriatus* (Lavigne 1989)

Pompilidae
**Ageniella accepta* (Cresson)
    29 July 1976; working blossoms of *Cleome serrulata*

Anoplius aethiops (Cresson)
  9 June-3- July 1976; working blossoms of *Cleome serrulata* and *Rorippa sinuata*
Anoplius marginatus (Say)
  12 July 1976; working blossoms of *Cirsium* spp.
**Anoplius nigritus* (Dahlbom)
  18 June-7 July 1976; working blossoms of *Cirsium* spp., *Cleome serrulata, Melilotus alba* and *Salix exigua*
**Aporinellus completus* Banks
  25 June 1976; on flower of *Atriplex canescens*
**Ceropales nigripes* Cresson
  18 June 1976; working blossoms of *Salix exigua*
**Cryptocheilus terminatum terminatum* (Say)
  13 July 1976; working blossoms of *Sisymbrium altissimum*
Pepsis thisbe Lucas
  13 August 1976

Scoliidae
**Camposomeris pilipes* Saussure
  4 June-7 July 1976; working blossoms of *Asclepias speciosa, Cirsium* sp. and *Cryptantha jamesii*
**Camposomeris confluenta* (Say)
  7 June-13 July 1976; working blossoms of *Cirsium* sp., *Melilotus officinalis, Psoralea tenuiflora* and *Rorippa sinuata*
Trielis texensis (Saussure)
  29 July-25 Aug. 1976; working blossoms of *Cleome serrulata, Eriogonum effusum, Helianthus petiolaris* and *Solidago canadensis*

Sphecidae
**Aphilanthops frigidus* (Smith)
  28 June-15 July 1976; working blossoms of *Helianthus pumilus* and *Salix exigua*
**Bembecinus quinquespinosus* (Say)
  28 June-18 Aug. 1976; working blossoms of *Achillea lanulosa, Cirsium arvense, Helianthus petiolaris, H. pumilus, Oenothera* sp. and *Solidago canadensis gilvocanescens*
Bembix sayi Cresson
  7 July-27 Aug. 1976; working blossoms of *Cirsium undulatum, Heterotheca villosa* and *Solidago canadensis gilvocanescens*
**Cerceris sexta* Say
  29 July 1976; working blossom of *Eriogonum effusum*
**Clypeadon laticinctus* (Cresson)
  7-29 July 1976; working blossoms of *Cleome serrulata, Helianthus petiolaris* and *H. pumilus*
**Crabro latipes* Smith
  1 June 1976; working blossoms of *Oenothera albicaulis*
**Diodontus* sp.
  27; 8 June 1976; working blossoms of *Astragalus bisulcatus* (Lavigne 1989)
**Ectemnius* sp.
  7-25 June; working blossoms of *Rorippa sinuata* and *Salix exigua*
**Eucerceris canaliculata* (Say)
  26 July 1976; working blossoms of *Eriogonum effusum*
**Eucerceris fulvipes* Cresson
  27; 7-July-18 Aug. 1976; collecting pollen/nectar of blossoms of *Achillea lanulosa, Eriogonum effusum; Heterotheca villosa, Hymenopappus filifolius,* and *Thelesperma megapotamicum*

Eucerceris rubripes Cresson
  27; 14 July 1975; collecting pollen/nectar of blossoms of *Thelesperma megapotamicum*
**Larropsis* sp.
  14 June-29 July 1976; working blossoms of *Achillea lanulosa, Cleome serrulata, Cirsium* sp. and *Helianthus petiolaris*
**Mimesa* sp.
  28 June 1976; working blossoms of *Cleome serrulata*
**Philanthus gloriosus* Cresson
  13 July-3 Aug. 1976; working blossoms of *Cirsium arvense, Petalostemon candidus* and *Ratibida columnaris*
**Philanthus inversus* Patton
  24 Aug. 1976; working blossom of *Eriogonum effusum*
Philanthus multimaculatus Cameron
  13 July 1976; working blossom of *Heterotheca villosa*
Philanthus pulcher Dalla Torre
  8 June 1976; working blossoms of *Arenaria hookeri, Musineon divaricatum* and *Thelesperma megapotamicum*
Philanthus siouxensis Mickel
  22 July 1976; working blossom of *Argemone* sp.
**Philanthus psyche* Dunning
  Owl Creek; 28 June-1 July 1976; sweeping; working blossoms of *Cleome serrulata, Cirsium* sp., *Salix exigua* and *Thelesperma megapotamicum*
**Philanthus serrulatae* Dunning
  misidentified as *P. siouxensis* in Kumar *et al* (1976) 32; 26 June - 21 July; working blossoms of *Arenaria hookeri, Eriogonum effusum*
Philanthus ventilabris Fabricius
  17-29 July 1976; collecting pollen/nectar of blossoms of *Cirsium arvense* and *Ratibida columnaris*
**Prionyx parkeri* Bohart & Menke
  30 June 1976; working blossoms of *Melilotus officinalis*
**Sceliphron caementarium* (Drury)
  13 July 1976; working blossoms of *Glycyrrhiza lepidota* and *Helianthus petiolaris*
**Sphex ichneumoneus* (L.)
  23 July-3 Aug. 1976; working blossoms of *Cirsium arvense* and *Petalostemon candidum*
**Stictiella emarginata* (Cresson)
  14 June 1976; working blossoms of *Cryptantha jamesii.*
**Stictiella femorata* (Fox)
  14 June 1976; working blossoms of *Hymenopappus filifolius*

Tiphiidae
**Methocha stygia* (Say)
  29 June 1976; working blossoms of *Cleome serrulata*
**Myzinum quinquecinctum* (Fabricius)
  12-26 July 1976; working blossoms of *Achillea lanulosa, Cirsium* sp., *Eriogonum effusum, Glycyrrhiza lepidota, Melilotus alba, M. officinalis, Petalostemon candidus* and *Solidago canadensis*

Vespidae
Euodynerus annulatus (Say)
  30 June-23 July; working blossoms of *Melilotus officinalis*
**Polistes fuscatus fuscatus* (Fabricius)
  18-27 Aug. 1976; working blossoms of *Solidago canadensis*

LEPIDOPTERA

Hesperiidae
 *_Yvretta rhesus_ (Edwards)
  25 May-3 June 1976, 19 May 1977; working blossoms of _Astragalus pectinatus_ (Lavigne 1989) & _Sophora sericea_
Lycaenidae
 Lycaeides melissa melissa (Edwards)
  30 May 1976, 27 May 1977; working blossoms of _Astragalus pectinatus_ & _A. sericoleucus_ (Lavigne 1989)
Noctuidae
 *_Euoxa siccata_ (Smith)
  working blossoms of _Chrysothamnus nauseosus_ (Lavigne 1976)
 *_Schinia unimacula_ Smith
  working blossoms of _Chrysothamnus nauseosus_ (Lavigne 1976)
Nymphalidae
 *_Vanessa cardui_ (L.)
  19 May 1977; working blossoms of _Cleome serrulata_ (Lavigne 1976)
Pieridae
 *_Colias alexandra alexandra_ Edwards
  3 June 1976; working blossoms of _Astragalus bisulcatus_ (Lavigne 1989)
Prodoxidae
 *_Tegeticula yuccasella_ (Riley)
  feeding on nectar of _Yucca glauca_ (Lavigne 1976)
Pyralidae
 *_Crambus vulgivagellus_ Clemens
  working blossoms of _Chrysothamnus nauseosus_ (Lavigne 1976)
Saturniidae
 *_Hemileuca nevadensis_ Stretch
  lab reared, larvae feeding on _Salix exigua_, pupated in late June, adults emerged 3 Oct. 1976; identified by J. Scott

ORTHOPTERA

Acrididae
 *_Melanoplus complanatipes_ Scudder (Pfadt 1972)
Gryllacrididae
 *_Ceuthophilus pallidus_ Thomas (Pfadt 1972)
Gryllidae
 *_Nemobius fasciatus_ DeGeer (Pfadt 1972)
 *_Oecanthus argentinus_ (Saussure) (Pfadt 1972)

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THE HICKORY FEEDING *CATOCALA* (LEPIDOPTERA: NOCTUIDAE) FAUNA IN THE ABSENCE OF *CARYA OVATA* IN SOUTHERN NEW JERSEY[1]

Dale F. Schweitzer[2]

ABSTRACT: Recent studies by Gall (1991a-c) and Schweitzer (1982), mostly in Connecticut, document at least 19 Nearctic species of *Catocala* species specializing on species of *Carya* section (§) *Eucarya* as larval foodplants. Seven or more *Catocala* species appear restricted to a single such hickory, *Carya ovata*, and all but two of the others show some degree of preference for that plant. Southern New Jersey is within the range of most of these 19 *Catocala*, ten of which currently occur regularly on the adjacent Piedmont where *Carya ovata* is fairly common. However, that hickory is absent from most of the New Jersey Outer Coastal Plain. None of the five available *Carya ovata* specialists appear to be established in southern New Jersey. Only three of the other five available § *Eucarya* feeding species seem able to maintain populations on other hickories in the absence of *Carya ovata*.

It has been known for some time (e.g. Forbes, 1954; Sargent, 1976) that over 20 species of North American *Catocala* Schranck species feed on hickories and walnuts (Juglandaceae: *Carya* Nutt. and *Juglans* L.). Gall (1991a) documents 25 Nearctic *Catocala* species as specializing on Juglandaceae. Occurrence of a dozen or more of these at a single locality is commonplace (Sargent, 1976; Schweitzer, 1982; Gall 1991a-c), and at least 21 of these 25 species have been collected in New Jersey (Smith, 1910; collections consulted below). It would seem reasonable, considering the diversity within *Carya* in eastern North America, that these species of *Catocala* might tend to specialize on different hickory species. However, this is not the case among the 19 species (Gall, 1991a) that are known to specialize on *Carya* § *Eucarya*. Schweitzer (1982) and Gall (1991a-c) showed that almost all of these use shagbark hickory, *Carya ovata* (Mill.) K. Koch, in the field and have a demonstrable preference for it over other hickories. *Catocala epione* (Drury) and *C. luctuosa* Hulst are the only documented exceptions to this preference among the 14 § *Eucarya* feeders that Gall tested extensively. At least seven of these *Catocala* are specialists on *Carya ovata* according to Gall. Six or seven other *Catocala* species specialize on *Carya* § *Apocarya* and/or the genus *Juglans* (Gall, 1991a; Schweitzer, 1982).

All of Gall's and Schweitzer's data are from areas, mostly in Connecticut and Tennessee, where *Carya ovata* is common, and both authors note this

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[2] The Nature Conservancy, R.D. 1, Box 30B, Port Norris, NJ 08349

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species usually accounts for most Juglandaceae in Connecticut forests. The purpose of this paper is to report on the hickory feeding *Catocala* fauna of the Outer Coastal Plain of New Jersey south of Monmouth County (= south Jersey) where *Carya ovata* is virtually absent. South Jersey is well within the range of all of the *Catocala* species studied by Gall and Schweitzer in Connecticut, and all such species, along with a few other § *Eucarya* feeders, occur regularly on the immediately adjacent Piedmont of New Jersey and Pennsylvania where *Carya ovata* is fairly common, and all extend much farther southward. Therefore the absence of such a species in southern New Jersey can reasonably be interpreted as an indication that the available hickories there cannot sustain populations. The data below also address the question of whether or not the *Carya ovata* specialists can exploit other hickories where that species is essentially absent over a large climatically suitable area. Published data (Gall, 1991a-c) indicate that they do not do so where *Carya ovata* is present.

Sources for *Catocala* records. Since 1970 I have examined the following collections for southern New Jersey *Catocala*: American Museum of Natural History (AMNH); Academy of Natural Sciences, Philadelphia (much of their collection since moved to Carnegie Museum); Museum of Comparative Zoology, Harvard University (MCZ); Peabody Museum of Natural History, Yale University (YPM), except for the recently acquired Rutkowski collection; Rutgers University, Department of Entomology (RU); the late Joseph Muller (now at AMNH), the late John W. Cadbury III, the late C.B. Worth (now at YPM), Howard Boyd, and W.J. Cromartie (this substantial collection from eastern Atlantic County contained no Juglandaceae feeding *Catocala* as of November, 1990). I have also collected *Catocala* in the region every year since 1969. Smith (1910) was also consulted, and is believed to be reliable for the species considered here.

Major collection sites and their hickories. Juglandaceae are absent or nearly so in the natural vegetation of most of the core of the Pine Barrens (McCormick, 1970) section of south Jersey (but see Atsion below), especially north of the Mullica River. However, hickories occur occasionally to locally frequently in the southern half of the Pine Barrens, and much more regularly in the oak-pine transitional area west and south of the Pine Barrens (Stone, 1911; Moore, 1989: pers. obs.). Hickories as a group are common in much of Cumberland County where three species of § *Eucarya* occur widely. Hickories also occur in the few remnant dry woods along the immediate coast of eastern New Jersey. None of the sites from which *Catocala* are reported in this paper have *Carya ovata*.

Three § *Eucarya* hickories, *Carya tomentosa* Nutt., *pallida* (Ashe) Eng. & Graebn., and *glabra* (Mill.) Sweet are frequent at Bear Swamp East and

Bevan Wildlife Management Area in Cumberland County, where I collect regularly. Based on careful examination of hundreds of hickories from 1988 to 1990, I find the first two of these to be widespread and frequent in Cumberland County. *Carya glabra* is much less numerous, but still frequent. All three also occur at The Nature Conservancy's Eldora Preserve in nearby Cape May County where C.B. Worth (who then lived on and owned the site), Joseph Muller and to some extent myself collected extensively from about 1973 to 1983. I have collected there occasionally since. At least *Carya tomentosa* and *C. glabra* occur along the north side of Atsion Lake, Burlington County where L.F. Gall and I have collected *Catocala* frequently since 1981. *Carya tomentosa* is apparently the only hickory present at Howard Boyd's Tabernacle Twp. site (Boyd, pers. comm., 1989) where *Catocala* were collected at blacklight from 1971 to 1977. Sampling was discontinued soon after that when annual gypsy month spraying eliminated most Lepidoptera, and apparently all *Catocala*. There are a few *Carya ovata* a few miles northwest of this site around Medford. There is a single large hickory in the woods about a mile north of Batsto, probably a *Carya glabra*. I never saw any other hickories near there, and the late Annie Carter, former State Forest naturalist who lived there, knew of no others. I collected at the edge of the village regularly from 1969 to 1980. Presumably the *Catocala* recorded herein from Batsto are strays. While nearby DaCosta has not been visited, and the precise collection site for the old records (mostly from Smith, 1910) is unknown, at least *Carya pallida* and *C. tomentosa* are known to occur nearby at present. No native hickories are known to occur near Lakehurst, (pers. obs. of myself and Gerry Moore; Randy Ditier, formerly forester for Lakehurst Naval Air Station, pers. comm., 1988; Stone, 1911). Lakehurst is one of the most intensively sampled areas for moths in North America and the specimens reported herein from there were obviously strays.

Carya ovata and two other hickories, *Carya* § *Eucarya ovalis* (Wang.) Sarg. and *Carya* § *Apocarya cordiformis* (Wang.) K. Koch are native to southern New Jersey, but are virtually confined to the fragments of deciduous, Piedmont-like forests of the Inner Coastal Plain along the Delaware River Valley north and west of a line from far northwestern Cumberland County to about Medford, Burlington County and continuing up to Monmouth County (pers. obs., 1985-1989; Moore, 1989 and pers. comm.; Stone, 1911), i.e. to the west and north of all *Catocala* collecting sites reported on here. Neither myself nor Moore (pers. comm., 1989) have seen any of these three hickories in the Pine Barrens or transitional portions of the Outer Coastal Plain south of Monmouth County. *Carya pallida* is disjunct in southern New Jersey from much farther south, but the other five hickories are frequent to common on the

Piedmont of New Jersey, Pennsylvania and Delaware. Pecan (*Carya* § *Apocarya illinoiensis* (Wang.) K. Koch) is frequently planted and could be the local foodplant for *Catocala nebulosa*, a known § *Apocarya* feeder (Gall, 1990a) that is taken rarely in New Jersey.

At all sites visited, small hickories in the understory are far more common than are canopy sized trees and hickories occur in forests composed mostly of several species of oaks and pines with an ericaceous understory on dry sandy, gravelly, soils. Hickories may well be increasing due to recent fire suppression.

The pool of potential § *Eucarya* feeding *Catocala* for South Jersey. The Piedmont region adjacent to south Jersey was well collected for *Catocala* in the 1960s and 1970s by several persons, including: the late Joseph Muller and Rutgers University staff in New Jersey; myself in Chester, Delaware, Montgomery, and Berks Counties and William Boscoe in Bucks County in Pennsylvania; and records from as far back as 1880 are easily obtained from collections and the literature. However, given the temporal fluctuations in the geographic ranges of some hickory feeding *Catocala* (Sargent, 1976), species for which Piedmont records are all prior to 1960 cannot be presumed to be present now. At least three species of hickory feeding *Catocala* were taken on the New Jersey Piedmont by Muller in some numbers in the 1950s, but never since (through 1983). These were *Catocala dejecta* Strecker, *C. robinsoni* Grote and *C. angusi* Grote. I have seen a number of older specimens of *C. angusi* from New Jersey as well. I never encountered two of these species in my Pennsylvania Piedmont collecting and took only a single *C. angusi*. All three are § *Eucarya* feeders, with the latter two probably being specialists on *Carya ovata* (Gall, 1991a-c). If these three and *Catocala lacrymosa* Guenee, which Muller took once and for which Smith (1910) gives one or two records, are disregarded, the pool of regularly occurring § *Eucarya* feeding *Catocala* for the adjacent Piedmont, and thus potentially for southern New Jersey is: *epione* (Drury), *habilis* Grote, *judith* Strecker, *serena* Edwards, *residua* Grote, *obscura* Strecker, *rectecta* Grote, *vidua* J.E. Smith, *flebilis* Grote, and *palaeogama* Guenee. All of these are included in Gall's (1991a) laboratory data and most also in his field data (1991b, c) and those of Schweitzer (1982). All except *epione* prefer *Carya ovata* to some degree. Five of these ten species, *C. habilis* through *obscura*, seem to be specialists on *Carya ovata*. *Catocala flebilis* might also be a *Carya ovata* specialist based on the limited available data (Gall, 1991a-c; Tietz, 1952). The record for *Carya alba* given by Forbes (1954) could refer to either *Carya ovata* or *C. tomentosa*. The others, especially *C. epione* and *C. palaeogama*, do utilize other § *Eucarya* hickories to a significant extent in the field even where *C. ovata* is common.

Juglandaceae feeding *Catocala* records. I do not give records for the three known walnut (*Juglans* spp.) feeders (based on numerous larval collections in south Jersey): *Catocala piatrix* Grote, *C. maestosa* Guenee, and *C. neogama* J.E. Smith. Walnuts probably are not native on the Outer Coastal Plain of New Jersey. Two of the walnut feeding *Catocala* are ubiquitous around planted or escaped black walnuts (*Juglans nigra* L.), but *C. maestosa* becomes sporadic north of Cumberland and Cape May Counties. *C. neogama* apparently feeds only on *Juglans* in the wild, but the other two are known to use hickories of § *Apocarya* as well, and thus probably occasionally use planted pecans in New Jersey. None of these three are known to use § *Eucarya* anywhere (Gall, 1991a-c). All locality records of other Juglandaceae-feeding *Catocala* from the Outer Coastal Plain of south Jersey known to me are given below. Collector's names are omitted if they are identified with the particular site above.

Catocala consors sorsconi Barnes and McDunnough. Tabernacle Twp., 21 July 1971; Atsion, 13 July 1981; DaCosta (Smith, 1910; one seen by me collected by Weinzel in MCZ); Bevan WMA, Downe Two., one seen 2 July 1987; Bear Swamp East, 9 July 1989.

Catocala epione (Drury). Frequent to locally common at all sites with hickory that have been collected in very late June or July, specifically: Tabernacle Twp., Atsion, DaCosta, Bevan WMA (common at three well separated sites, Downe and Lawrence Townships), Bear Swamp East, Eldora, Belleplain State Forest, and also seen from Lakehurst, Browns Mills, and New Lisbon — Pine Barrens sites that may or may not have hickories. I collected one or two strays at Batsto in July 1969. I have also found larvae on *Carya tomentosa* at Elmer and Bevan WMA.

Catocala serena Edwards. Lakehurst (two very old specimens, J.W. Cadbury and YPM colls.); Cedarville, 29 July 1971 (RU).

Catocala judith Strecker. Two very old records Lakehurst, 19 July 1911 (AMNH) and 5-mile beach, 22 July (Smith, 1910).

Catocala retecta Grote. Two specimens only: Tabernacle Twp., 11 August 1977; Eldora, 15 August 1979 (Worth, now at YPM).

Catocala flebilis Grote. Eldora, 26 July and 21 August 1979 (Muller, both now in Schweitzer collection).

Catocala angusi Grote. One old one, certainly pre-1945, labelled Lakehurst, but with no date (Lemmer, in AMNH) and reported by Smith (1910) from 5-mile beach, 22 August.

Catocala insolabilis Guenee. "Brigantine Reserve" (= Edwin Forsythe National Wildlife Refuge near Atlantic City), 27 August 1962 (Muller, now presumably in AMNH). W.J. Cromartie did not encounter any hickory feeding *Catocala* in light trap samples on this refuge in 1989 or 1990.

Catocala vidua (J.E. Smith). Several at most of these localities: Lakehurst, Batsto, Bevan WMA (Lawrence Twp.), Bear Swamp East and Eldora (common some years); and

Erma (Schweitzer coll.). I have found larvae on *Carya pallida* at Greenbank and one on that and two on *C. tomentosa* at Bear Swamp East. Not looked for in season at Atsion.

Catocala lacrymosa Guenee. MacGuire Air Force Base, Burlington County, 11 August 1970 (RU), which could be Inner or Outer Coastal Plain.

Catocala palaeogama Guenee. New Egypt (RU), MacGuire Air Force Base (RU), Lakehurst (several), Atsion (common in 1981), New Lisbon (rare, Cadbury), West Pine Plains (one in 1981, miles from any hickory, Schweitzer), Bevan WMA (Lawrence Twp., one seen, 13 August 1988), and Eldora (frequent some years), also several larvae on *Carya tomentosa* at Cape May Point State Park in May 1987. Note the absence of this species so far (1988-1991) at Bear Swamp East. I observed a number of females ovipositing on *Carya tomentosa* and *C. glabra* at Eldora (no *C. pallida* were checked) in 1983. Smith (1910) correctly states that this species occurs throughout New Jersey.

Catocala nebulosa Edwards. Indian Mills, 20 August 1975 (RU); Eldora, 25 July, 1979 (Muller, now at AMNH).

DISCUSSION

The above data suggest that of the ten § *Eucarya*-feeding *Catocala* that regularly occur on the nearby Piedmont, only *C. epione, C. vidua* and *C. palaeogama* are long term residents on the southern New Jersey Outer Coastal Plain. *C. consors*, which does not occur on the Piedmont, also seems to be established.

The maximum number of southern New Jersey records for any species of *Carya ovata* specialist is three in about 100 years, with only one such record since 1950. Three of the combined five records for *Carya ovata* specialists that presently occur on the Piedmont are from Lakehurst where there is no hickory and another is from Cedarville, Cumberland County, just outside of the range of *C. ovata*. Three of the five *Carya ovata* specialists that occur regularly on the Piedmont have apparently never been collected in south Jersey. Of the five other § *Eucarya* feeders that occur regularly on the Piedmont, only *Catocala epione, C. vidua,* and *C. palaeogama* are taken regularly in south Jersey, and the last is rather sporadic. *C. flebilis* and *C. retecta* are known from only two specimens each (with three of these in 1979). *C. palaeogama* and *C. epione* have the broadest foodplant usage among § *Eucarya* feeding *Catocala* in Connecticut. *Catocala vidua* is currently rare in Connecticut and is absent from field data of both Gall and Schweitzer from that state, but is documented herein from two of the three indigenous Outer Coastal Plain hickories.

The failure of *Catocala retecta* to maintain large populations in southwestern New Jersey seems odd since Connecticut data suggest that it uses *Carya glabra* fairly frequently there, and it is such a common species in the northeastern USA. The single *C.retecta* taken at Tabernacle in 1977 could well have been a stray from nearby Medford, where *Carya ovata* occurs. The two records from 1979 suggest that *Catocala flebilis* did reproduce at Eldora in 1978 (which would mean it did use either walnut or a species of hickory other than *C. ovata*). *C. flebilis* is not common on the Piedmont, but occurs at most sites. Neither species has been taken in south Jersey since 1979, despite substantial collecting, and evidence is meager that either is a permanent resident there. They seem unable to persist in the absence of their preferred foodplant, *Carya ovata*, even though at least *C.retecta* does utilize other hickories.

Regardless of their foodplant preferences, *Catocala lacrymosa, insolabilis* and *angusi* are currently very rare or absent in and near New Jersey, including eastern Pennsylvania, Maryland, and Delaware. The last seems to have been resident in northern New Jersey, including the Piedmont, prior to 1960, so the two old south Jersey specimens could well have been strays from there. *C. lacrymosa* and *insolabilis* seem, in my experience, to be associated with *Carya glabra* at sites in Florida where *Carya ovata* is absent and I have actually found larvae of *C. insolabilis* on *Carya glabra* there (in Liberty County). The limited dry woods at Brigantine, where the one south Jersey specimen was taken, have considerable *Carya tomentosa* and some *Carya glabra*. The near absence of *C. insolabilis* in south Jersey as well as on the Piedmont thus cannot be explained on the basis of the hickory flora, and the same is probably true for *C. lacrymosa.*

Catocala consors sorsconi is clearly rare, and probably local, but it is largely unknown in neighboring areas (only a very few pre-1950 records for the "Orange Mountains" in northeastern New Jersey and for Long Island). Therefore there would seem to be no source of strays and I presume this species is resident. It will probably prove to occur regularly in the Bevan Wildlife Management Area and adjacent Bear Swamp East where there are over 10,000 acres of apparently prime habitat for it — and two very recent records. I believe it is a specialist on small hickories in xeric, usually sandy, scrub or open woodland, as appears to be the case with the nominate subspecies in Florida (H.D. Baggett, pers. comm.; pers. obs.). It is a known § *Eucarya* specialist.

CONCLUSION

In the absence of their preferred foodplant, five *Carya ovata* specialists of Gall (1991 a-c), as well as two of five other § *Eucarya* feeding *Catocala* (including the generally common *C. retecta*) seem unable to successfully exploit three other § *Eucarya* hickories in southern New Jersey, even though that region is well within their geographic ranges and closely proximate to portions of the Piedmont where these moths occur regularly. These results suggest that the association of many § *Eucarya* feeding *Catocala* with a single species of hickory, *Carya ovata*, is quite rigid, not only for the specialists but also for *Catocala retecta* even though it sometimes does use other hickories.

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[2] The Nature Conservancy, R.D. 1, Box 30B, Port Norris, NJ 08349

REVISED DISTRIBUTION OF THE IMMIGRANT CARABID *BEMBIDION OBTUSUM* (COLEOPTERA: CARABIDAE) IN EASTERN NORTH AMERICA[1]

E. Richard Hoebeke[2], James K. Liebherr[2], Ross T. Bell[3]

ABSTRACT: An updated distribution is presented for the Palearctic carabid *Bembidion obtusum* in eastern North America. New records for Ohio and Vermont, and additional localities in New York, Ontario, and Quebec are given. Notes on biology, wing dimorphism, mode of introduction, dispersal, and colonization are also provided.

As one of a half dozen species of *Bembidion* known to be accidentally introduced into North America (see Lindroth, 1963), *B. obtusum* Serville is expanding its range in the eastern half of the United States and Canada.

Herein, we review and summarize the few North American distribution records that have been documented in the literature for *B. obtusum*, and revise the known distribution of this adventive carabid based on our own collecting; on specimens examined in the collections of the Canadian National Collection (Ottawa, Ontario = CNCI), University of Guelph (Guelph, Ontario = GUEC), Cornell University (Ithaca, NY = CUIC), University of Vermont (Burlington, VT = UVCC), Carnegie Museum (Pittsburgh, PA = CMNH); and on specimens in the personal collection of Harry J. Lee, Jr. (Fairview Park, OH = HJLC).

Lindroth (1963: 258) was the first to report *B. obtusum* from CANADA: **Ontario: York Co.**, 16 mi. W. Bond Head, 7.IX.1956 (3 ♀♀, brachypterous) and from the UNITED STATES: **New York: New York City**, taken on board a ship (1 specimen, sex?). Additional Canadian records were later provided by Rivard (1965) who noted the collection of 1 ♀ specimen from pitfall traps in agricultural lands in **Ontario: Hastings Co.**, nr. Belleville, 7.VI.1962, and Lindroth (1969) who listed it also from **Ontario: York Co.**, Toronto. Larochelle and Lebel (1977) collected numerous specimens (119, sexes?) in southern **Quebec: Huntingdon Co.**, St.-Anicet, 13, 15.IX.1976, under leaf litter at edge of deciduous forest, while Chantal (1977) recorded it from **Quebec: Hochelaga Co.**, Dorval, 10.X.1975, ex "sifting mixture of bryophytes and grasses in partially shaded area..." (1 specimen, sex?). Through the courtesy of Stephen A. Marshall (University of Guelph, Guelph, Ontario), we also learned of a record of *B. obtusum* from Wainfleet Bog, in southeast Ontario south of Welland; this collection data resulted from a faunal

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[1] Received March 25, 1991. Accepted April 22, 1991.

[2] Department of Entomology, Cornell University, Ithaca, New York 14853

[3] Department of Zoology, The University of Vermont, Burlington, VT 05405

survey of selected Ontario bogs (unpublished data, M.Sc. thesis by D. Blades, University of Guelph). For the United States, Cooper (1976) documented additional specimens (3 ♂♂, 1 ♀, all brachypterous) from **New York: Genesee Co.**, Bergen Swamp, 29.VIII.1964, in Berlese samples of leaf litter. Shortly thereafter, Davidson and Langworthy (1978) added the following localities for **New York: Tompkins Co.**, W. Groton, 22.V.1976, treaded from wet grass at margin of small pond near pasture (1b ♂, 1b ♀), and Ithaca, Cornell Univ. Ornithology Laboratory, 23.V.1976 (1b ♂).

The new locality records that follow supplement those listed above, and are mapped in Figure 1 [For specimens examined, the sex and wing condition are noted, with the abbreviation "m" = macropterous, and "b" = brachypterous; locality records marked by an asterisk (*) were kindly provided by R.L. Davidson (*in litt.*)]:

UNITED STATES: **New York: *Onondaga Co.**, Syracuse, VIII.1979, B.G. Stevenson (4b ♂♂, 1b ♀) (CMNH). **Tompkins Co.**, Danby, 27.III.1974, 2-3.IV.1974, E.R. Hoebeke (3b ♂♂, 3b ♀♀) (CUIC); Ithaca, Savage Farm, 18.X.1970, 22.I.1967, 22.I.1968, 5.V.1968, 3.X.1967, 17-18.III.1969, 5.VIII.1969, A.G. Wheeler, Jr., ex ground ca. alfalfa, ex decaying alfalfa crowns, ex terminal stems of alfalfa (2m ♂♂, 4b ♂♂, 4b ♀♀) (CUIC); *Ithaca, 17.IV.1978, J.E. Rawlins, in rotting vines of cucurbits (1b ♂, 1m ♂) (CMNH); Town of Ulysses, N. of Jacksonville, 7.IV.1986, 19.IV.1986, 25.IV.1986, 25.XI.1986, 10.IV.1987, 13.X.1987, 12.IV.1988, 7.IX.1988, 9.IV.1990, 12.IV.1990, 14.IV.1990, 2.VIII.1990, 26.IX.1990, 29.IX.1990, 5.X.1990, 2.XII.1990, 22.XII.1990, E.R. Hoebeke, ex under flat stones on ground, ex under mats of knotweed over edge of sidewalk (2m ♂♂, 15b ♂♂, 17b ♀♀) (CUIC).**Wayne Co.**, Lyons, VII.1969, E.N. Coye (1b ♂, 1b ♀) (CUIC) **Ohio: Cuyahoga Co.**, Cleveland, Rocky River Reserve, 13.VIII. 1982, H.J. Lee, Jr., ex leaf litter at edge of floodplain pond (1m ♀) (HJLC). **Vermont: Addison Co.**, Shoreham, 18.V.1978, L. Crane, ex pitfall (1b ♂) (UVCC). **Chittenden Co.**, Burlington, 10.IX.1980, Beardsley (1m ♀) (UVCC); Burlington, Centennial Field, 26.V.1986, R. & J. Bell (1b ♂, 1b ♀) (UVCC); S. Burlington, 31.VIII.1980, R.T. Bell (1m ♀) (UVCC); Huntington, Camel's Hump, 1,000 m elev., 1990, J. Leonard (1m ♀) (UVCC). **Grand Isle Co.**, Grand Isle, 15.VIII.1983, R.T. Bell (1m ♂, 1m ♀) (UVCC).

CANADA: **Ontario: Grey Co.**, Owen Sound, Inglis Falls, 24.I.1985, 23.IV.1985, 2, 5, 24, 30.VI.1985, 24, 26.X.1985, 29.XI.1985, B.J. Sinclair, ex seepage face, in moss of madicolous spring (9b ♂♂, 6b ♀♀) (GUEC). **Hastings Co.**, Stirling, 18.IX.1971 (3m ♂♂, 1m ♀, 108b ♂♂, 109b ♀♀) (CNCI). **Kent Co.**, Rondeau Pk., 2-13, 13-22.VII.1985, L. LeSage & A. Woodliffe, FIT at edge of oak forest (2m ♂♂) (CNCI). **Lambton Co.**, Thedford, 13-20.V.1983, ex pitfalls in onion field (1b ♂) (CNCI). **Leeds Co.,** 18 km. E. Gananoque, 12.V.-9.VI.1977, Dondale & Redner, old field pitfall (2b ♀♀) (CNCI). **Middlesex Co.,** London, 30.VI.1970, H.R. Thompson (1m ♂) (CNCI). **Waterloo Co.**, Oliver Bog, 3 km. S. Galt, 10-16.VII.1987, D. Blades (1m ♀) (CNCI). **Wentworth Co.**, Ancaster, 28.III.1963, J.E.H. Martin (1b ♀) (CNCI). **Prince Edward Co.**, IV.1957, 20.VIII.1961, J.F. Brimley, sifting (1m ♀, 1b ♀) (CNCI). Dunn Twp., 15.VIII., 29.VIII.1971, W.W. Judd (1m ♀, 1b ♂) (CNCI). St. Lawrence Island Nat. Pk., Thwartway Isl., 14.IX.1976, E.E. Lindquist (1m ♀) (CNCI); St. Lawrence Nat. Pk., McDonald Isl., 4.X.1976, Reid (1b♂) (CNCI). **Quebec: Gatineau Co.**, Gatineau Pk., Hull-Quest, 21-28.V.1982, E. Rickey & L. LeSage, ex pitfall in maple forest (1b ♂, 1m ♀, 8b ♀♀) (CNCI). ***Vaudreuil Co.**, Rigaud, 7.V.1982, A. Larochelle (1m ♂) (CMNH).

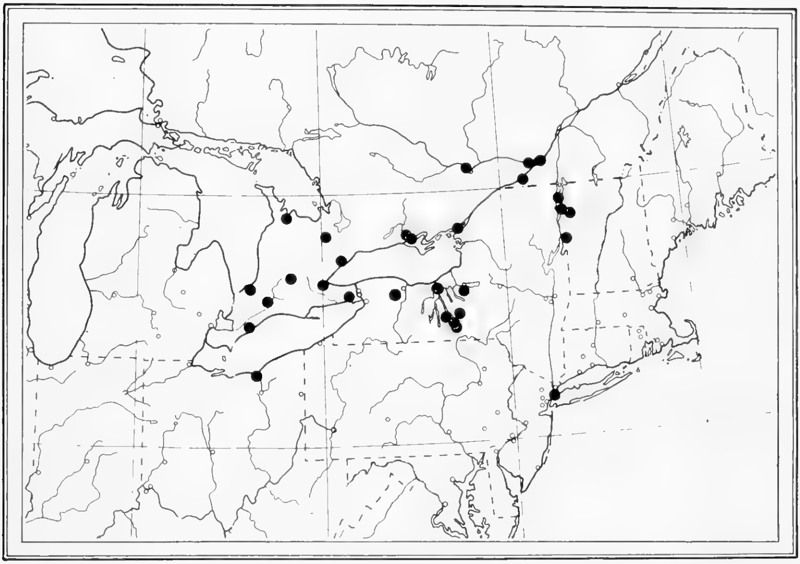

Fig. 1. Known distribution of the immigrant carabid *Bembidion obtusum* in eastern North America. These records were made available through the primary literature, our own collecting, and collaboration with other researchers (see acknowledgments).

Bembidion obtusum is a common and widespread species in western and central Europe, occurring in Ireland, England, France, The Netherlands, Switzerland, Belgium, Germany, Czechoslovakia, Poland, Hungary, Denmark, and southern Sweden (Netolitzky, 1931; Horion, 1941; Turin *et al.*, 1977; Lindroth, 1988). In its native habitat, this synanthropic species is found abundantly "on open clayish ground" (Lindroth, 1963), and is a common inhabitant of cultivated ecosystems, including arable land, open fields, and in clover and alfalfa fields (Thiele, 1977). It appears to occupy similar habitats in North America. North American specimens have been collected in close association with alfalfa crop plantings in New York - on the ground, among decaying crowns, and on terminal stems (unpublished data); in this ecosystem the species has been termed an "incidental predator" (Wheeler, 1971, 1973). Numerous other specimens at hand have been collected in pitfall traps, under stones, among various vegetative litter, in spruce-fir forest, and in moss of madicolous springs (S.A. Marshall, *pers. comm.*).

Although there are over 300 described species of *Bembidion* recorded from North America, *B. obtusum* is rather distinct morphologically and can be easily distinguished from other *Bembidion* by the following combination of characters (after Lindroth, 1963):

> Small species (2.6-3.2 mm), uniformly piceous brown with slight metallic reflection, non-converging frontal grooves of head, well-defined basal margin inside humerus of elytron, discal setae in third stria of elytron, and microsculpture lacking on pronotum and consisting of extremely dense transverse lines on elytra.

As with several other introduced *Bembidion* in eastern North America (i.e., *B. lampros* Herbst, *B. guttula* F., and *B. properans* Stephens), *B. obtusum* exhibits dimorphism with respect to the hind wings. Wing polymorphism in *Pterostichus oblongopunctatus* Illiger is under the control of a single gene, with macropters homozygously recessive, and the brachypters heterozygous or homozygously dominant (Lindroth, 1946). However, Langor and Larson (1983) discovered through breeding studies of *Bembidion lampros* that "at least three alleles or two genes are involved in controlling wing length of this species, and that there is no clear evidence of any of the wing length factors being dominant."

Presumably, wing polymorphism in a population results in individuals of two differing dispersal abilities. Langor and Larson (1983) postulated the following to occur under natural conditions: 1) in time phenotype distribution (macropterous vs. brachypterous) would be expected to follow a centrifugal cline with the frequency of the faster dispersing macropters increasing towards the limits of the range, and 2) established, founder populations would be expected to become predominantly brachypterous as the frequency of the allele(s) determining macroptery decreased due to the relatively more rapid emigration of the macropters. However, Langor and Larson did not find this pattern to hold entirely true for *B. lampros,* suggesting that dispersal of this species has been significantly aided by human activities such as transport of top soil, potted plants, or agricultural products. They also found, through rearing studies of *B. lampros,* that the number of mature eggs carried by macropterous females did not differ significantly from that for brachypterous females (AOV, $P = 0.05$). Interestingly, this latter finding deviates from the predicted case whereby the brachypterous morph is more fecund, possessing increased relative fitness (see Roff, 1986).

We suggest the strong likelihood that *B. obtusum* was accidentally introduced into North America, probably since the turn of the century via ship ballast, or perhaps with soil shipped with imported nursery stock from Europe (Brown, 1940; Lindroth, 1957). Subsequent dispersal within eastern North America has probably been strongly influenced by commerce; most of the available specimen records represent localities either at or near major ports of entry, along natural waterways, and other transportation routes (see Fig. 1). Such a mode of human-assisted dispersal would spread wing development alleles and result in a relatively homogeneous geographic distribution of allele frequencies. Conversely, active range expansion by macropters, as suggested by the single winged individuals from samples at the edge of the known range in Cleveland, Ohio, and western Vermont, would result in higher frequencies of the macropterous gene in newly colonized areas, with earlier colonized core areas having higher frequencies of the brachypterous allele. Only intensive collecting for *B. obtusum* in known areas of occurrence and elsewhere will allow rigorous analysis of wing dimorphism, possibly providing evidence of the probable point of colonization for this immigrant species in eastern North America, as Lindroth (1963a) demonstrated for *Notiophilus biguttatus* F. in Newfoundland.

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LACE BUG GENUS *ACALYPTA* IN MEXICO: KEY AND NEW SPECIES *A. LAURAE* (HETEROPTERA: TINGIDAE)[1]

Richard C. Froeschner[2]

ABSTRACT: The new species *A. laurae* is described and illustrated from a specimen intercepted on *Tillandsia inonantha* being imported into the United States from Mexico. The three known Mexican species of *Acalypta*, each based on a single specimen without further locality information, are keyed.

The holarctic genus *Acalypta* Westwood contains 40 species of which 13, including the present new one, occur in the Western Hemisphere. The two most recent comprehensive treatments of the New World species of *Acalypta* were by Drake and Lattin (1963) who treated 10 species and by Froeschner (1976) who added the eleventh species along with zoogeographic notes; subsequently a twelfth, species, *A. susanae*, was described from Arkansas by Allen *et al.* (1988). At this time ten of the New World species of *Acalypta* are known from north of the Rio Grande River and three other species, including the present new one, are known only from Mexico.

The single specimen of the present new species was intercepted on *Tillandsia inonantha* Planchon (family Bromeliaceae) being imported into the United States from Mexico. In the light of Drake and Lattin's (1963:334) comment that members of *Acalypta* are primarily muscicolous but may use other plants in the absence of suitable mosses, this specimen may have come from a moss used as packing for the flowering plant.

All three Mexican species of *Acalypta* are based on unique, brachypterous, and otherwise unlocalized type specimens intercepted on plants being imported into the United States from that country. Collectors in Mexico are urged to attempt to determine their ranges more precisely.

Acalypta laurae new species

Figure 1

Diagnosis: Known only from one brachypterous female, this species may be differentiated from all other members of this genus in the New World by the following combination of characters: Pronotum unicar-

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[2] Department of Entomology NHB-127, United States National Museum of Natural History, Washington, D.C. 20560

inate; head with a pair of long, separated frontal spines; and hypocosta uniseriate.

In Drake and Lattin's (1963:335-336) "Key to the Brachypterous Forms of American *Acalypta,*" *A. laurae* runs to *A. mniophila* Drake and Ruhoff but can be distinguished therefrom by possession of a pair of long, frontal spines. In Froeschner's (1976:267) key to the *Acalypta* known from Mexico, it runs to *A. ruhoffae* Froeschner but can be separated by any one of the following characters: the presence of long, well separated frontal spines; the wholly uniseriate hypocostal lamina; or the unicolored dark veins of the hemelytra.

Description: Measurements in millimeters. Brachypterous female holotype. Broadly ovate, widest slightly posterior to midlength. Color dark fuscous brown; veins separating discoidal and corial areas concolorous with veins within those areas. Ventrally dark with bucculae, base of hemelytron, and margins of coxal cavities noticeably paler.

Head with frontal spines long, diverging, slightly surpassing apex. Bucculae anteriorly distinctly incurved, not contiguous. Antennophore straight, blunt, attaining midlength of antennal segment I. Antennal segmental proportions, I-IV, 0.11 : 0.08 : 0.39 : 0.17; segment III slender, noticeably wider on basal sixth.

Pronotum with weakly tectate, bluntly triangular, anteromedian projection above head; paranotum almost twice as wide as an eye, triseriate, lateral margin convex; median carina irregularly uniseriate in middle third, then lower toward each end; lateral carinae absent.

Costal area cells prominent, mostly quadrate, uniseriate except for one or two divided cells at base and near apical fourth; outer limiting veins of discoidal areas coarctate in basal third, in lateral view strongly elevated and convex along anterior two-thirds; inner limiting vein of discoidal area becoming evanescent basally. Hypocostal lamina uniseriate. Length 2.07.

Holotype: Brachypterous female, "intercepted on leaf of *Tillandsia ionantha* from Mexico; Tex., Brownsville, Feb. 19, 1988, D. Riley." Deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C.

The name of this species dedicates it to Ms. Laura Torres Miller whose dissertation formed the basis for the revision of Mexican tingid genera by Brailovsky and Torres (1986).

Key to brachypterous Mexican *Acalypta*

1. Head with a pair of long frontal spines exceeding apex of head. Paranotum with 3 rows of cells 2
   Head without prominent frontal spines. Paranotum with 2 rows of cells .... *mniophila* Drake and Ruhoff
2. Frontal spines distinctly separated. Hypocosta wholly uniseriate. Outer limiting veins of discoidal area concolorous with veins in discoidal and subcostal areas .... *laurae* new species
   Frontal spines virtually contiguous for full length. Hypocosta biseriate basally. Outer limiting veins of discoidal area conspicuously darker than veins in discoidal and subcostal areas .... *ruhoffae* Froeschner

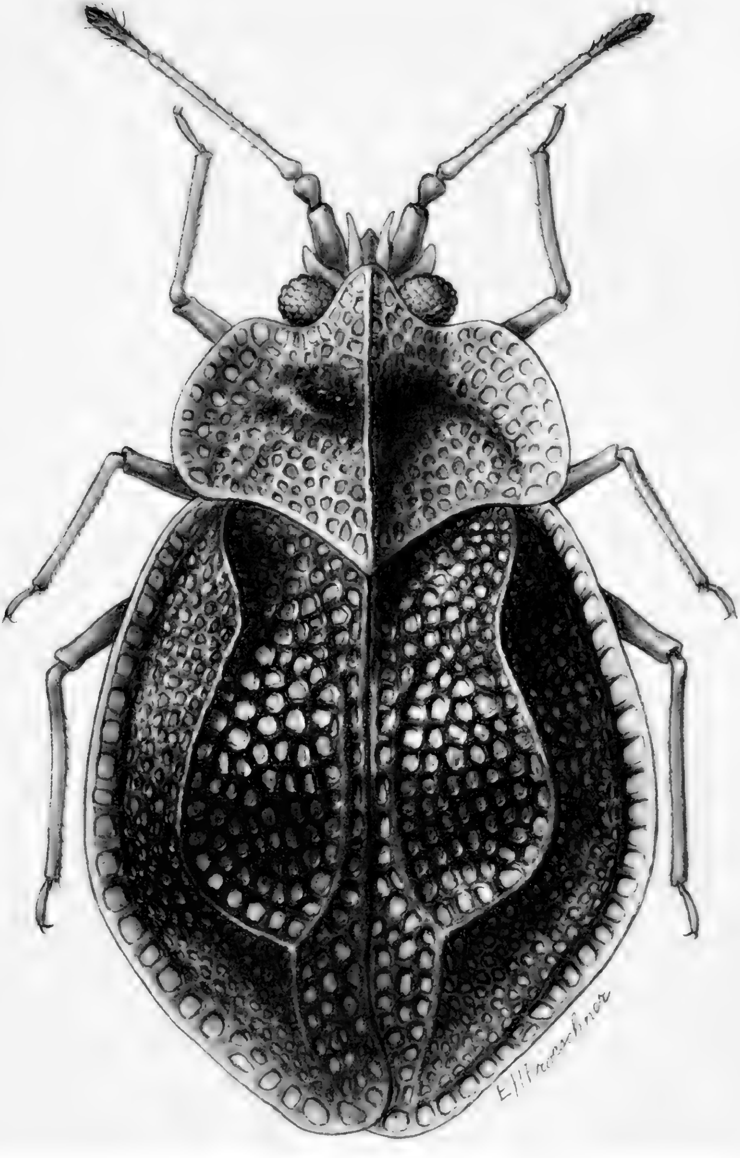

Fig. 1. Habitus of *Acalypta laurae*, n. sp.

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PREDATION BY *BEZZIA* LARVAE (DIPTERA: CERATOPOGONIDAE) ON MOSQUITO LARVAE (DIPTERA: CULICIDAE)[1]

Lawrence J. Hribar[2, 3], Gary R. Mullen[2]

ABSTRACT: Larvae of *Bezzia* spp. were observed while feeding in the laboratory. *Bezzia* sp. nr. *expolita* larvae fed on both mosquito and chironomid larvae, and killed mosquito larvae quickly. *Bezzia nobilis* larvae were not successful in subduing either mosquito or chironomid larvae.

Perhaps the least known aspect of the biology of biting midge larvae is their feeding behavior (Mullen and Hribar 1988). Food items of *Bezzia* larvae have been reported infrequently in the past, although mosquito larvae have been mentioned as food items for *Bezzia glabra* (Coquillett) and *B. varicolor* (Coquillett) (Thomsen 1937), and for unidentified *Bezzia* larvae (Weerekoon 1953). Weerekoon (1953) suggested that the latter *Bezzia* species also fed on *Chironomus* larvae since he observed red pigment in the alimentary tract of the ceratopogonid larvae. Thomsen (1937) reported that *Bezzia* larvae fed on newly hatched caddisfly larvae, and Kettle *et al.* (1975) were able to rear *Bezzia* larvae to the adult stage on a diet of nematodes. Grogan and Messersmith (1976) reported that larvae of *Bezzia glabra* (Coquillett) and *B. pulverea* (Coquillett) preyed on larvae of a smaller predaceous ceratopogonid, *Alluaudomyia paraspina* Wirth, in the laboratory. Collins (1975) and Wirth (1983) both reported that *Bezzia nobilis* preyed on the eggs of the brine fly *Ephydra thermophylla* Cresson. We report here observations on the feeding behavior and food items of larvae of two *Bezzia* species.

Larvae of *Bezzia nobilis* (Winnertz), and *Bezzia* sp. nr. *expolita* (Coquillett) were collected from sandy pond shores by sieving, salt-flotation, and agar extraction (Hribar 1990). Feeding arenas were constructed from plastic petri dishes (diam. 7.6 cm.) filled to within 0.6 cm of the top with 0.8% water agar. Larvae, subdued by chilling in a refrigerator, were introduced to the agar arenas. After covering the agar surface with spring water, a potential food item was introduced. Arenas were examined daily and food items were replaced when necessary.

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[1] Received March 18, 1991. Accepted April 29, 1991.

[2] Department of Entomology and Alabama Agricultural Experiment Station, Auburn University, AL 36849-5413

[3] Present address: Department of Entomology, 402 Life Sciences Building, Louisiana State University, Baton Rouge, LA 70803.

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Two larvae of *Bezzia* sp. nr. *expolita* were introduced into an arena and provided with larvae of *Aedes aegypti.* Another *Bezzia* sp. nr. *expolita* larva was placed into an arena and provided with larvae of *Chironomus* sp. Five *B. nobilis* larvae were provided with *Ae. aegypti*, and two were provided with *Chironomus* larvae. Arenas were examined by using a dissecting microscope. Movements of mouthparts, orientation of head capsule and body during feeding or browsing activities, and activity within the alimentary canals of larvae were observed.

Two larvae of *Bezzia* sp. nr. *expolita* were observed feeding on larvae of *Aedes aegypti.* When mosquito larvae were placed into the arena with the predaceous midge larvae, one *Bezzia* larva immediately oriented toward them. The midge larva recurved its thoracic segments, similar to a snake, and then struck at the mosquito larva, seizing it with the mandibles. The stricken larva struggled for approximately 30 seconds before it was completely immobilized. The midge larva kept its mandibles embedded in the mosquito larva until the latter was completely immobile, then penetrated the mosquito's body on the ventral aspect of the prothorax and immediately began to feed. It subsequently entered the third abdominal segment. The muscles and fat bodies were ingested without destroying the alimentary tract of the prey. The mandibles moved alternately while the epipharynx functioned with its characteristic fore and aft movements. The *Bezzia* larva appeared to suck or pump material out of the mosquito. After one hour, the *Bezzia* larva left the mosquito larva for about two minutes, during which time it did not attack any other prey. The midge larva returned to the mosquito larva and reentered the cadaver through the original feeding hole. This time it moved forward through the mosquito, feeding on the contents of cervix and head capsule including the eye pigments. The bolus was thus observed as it travelled through the midge's alimentary tract. The eye pigments stayed in discrete balls and were not mixed with any other contents of the gut as they passed by peristalsis through the alimentary tract. The *Bezzia* larva then exited the mosquito. After remaining inactive for about two minutes, it again reentered the larva and resumed feeding for about 30 seconds before abandoning its prey altogether. The mosquito larva had become blackish in color during feeding by the *Bezzia* larva.

A second *Bezzia* sp. nr. *expolita* larva attacked and fed on another *Ae. aegypti* larva. This larva seized the mosquito on the second abdominal segment. The mosquito struggled for about 20 seconds before it apparently died. The *Bezzia* larva then began to feed on the mosquito's abdominal tissues. After two hours, the larva cut a new opening in the last abdominal segment of the mosquito and continued to feed near the respiratory siphon.

In contrast to the aggressive feeding habits of *Bezzia* sp. nr *expolita*, *B. nobilis* larvae did not successfully feed on *Ae. aegypti* larvae when they were provided with them. On the few occasions when they did attack mosquito larvae, the *B. nobilis* larvae did not sustain their attack. The integument of the mosquito larvae was not punctured, and the mosquitoes were released when they struggled.

During another set of feeding trials, three *Bezzia nobilis* larvae were observed feeding on a dead conspecific adult. The larvae entered the body of the adult fly through the integument of the abdomen and the postgenal region of the head. One larva burrowed anteriorly as far as the metathoracic segment. Ingested tissue was formed into a bolus. As the bolus was swallowed, the epipharynx was adducted within the cibarium, pushing the bolus over the hypopharynx, through the mouth, and into the stomodaeum.

Larvae exhibited a characteristic behavior when feeding or searching for food. Each larva appeared to brush the anterior margin of its labrum along the substrate, often accompanied by a slow side-to-side motion of the head and thoracic segments. The manidbles moved irregularly, usually when the larva had stopped its side-to-side head movements. The mandibles were used to move food into the cibarium; the epipharynx moved fore and aft, gathering food into a bolus; and after several rhythmic cycles of alternate protraction and retraction, the epipharynx was used to move the bolus back into the mouth.

When *Bezzia* sp. nr. *expolita* larvae fed on only mosquito and chironomid larvae they pupated and produced normal adults. The aggressive feeding on mosquito larvae by *Bezzia* sp.nr. *expolita* larvae as described herein corroborates the account of Weerekoon (1953), who described similar feeding on larval mosquitoes by several species of *Palpomyia* and *Bezzia*. *Bezzia nobilis* larvae did not survive to pupation when provided with only mosquito or chironomid larvae. The behavior of mosquito larvae when attacked appeared to discourage further efforts by *B. nobilis* to feed. This species survived to pupation in other feeding arenas when offered protozoa and bacteria, and fed voraciously on dead conspecific adults, suggesting that small or immobile prey might be preferred (Hribar, unpublished obs.). Despite the difficulties of rearing predaceous midge larvae, further detailed observations of the feeding behavior of these insects should be possible under laboratory conditions. This work was supported in part by Alabama State Research Project AL-720.

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A NEW *AULACUS* (HYMENOPTERA: GASTERUPTIONIDAE: AULACINAE) FROM VIRGINIA[1]

David R. Smith[2]

ABSTRACT: *Aulacus impolitus*, n. sp., is described from Virginia and separated from related species. A list of 12 species of Aulacinae known to occur in Virginia is given.

The Aulacinae parasitize wood-boring Coleoptera and Hymenoptera. Townes (1950) revised the subfamily for the Nearctic, and included 21 species of *Pristaulacus* Kieffer (as *Aulacostethus* Philippi) and 6 species of *Aulacus* Jurine. Walkley (1952) added one species of *Aulacus*. Since, there has been little work on Nearctic Aulacinae except for the catalog by Carlson (1979). From Malaise trap collecting the past several years in Clarke, Fairfax, and Louisa counties, Virginia, I found 10 species of Aulacinae and discovered a species of *Aulacus* that is clearly separable from the described species.

Since Townes (1950), some authors, including Carlson (1979), have treated the Aulacinae as a distinct family. More recently, Gibson (1985), Rasnitsyn (1988), and Whitfield *et al.* (1989) have provided some evidence that the aulacines and gasteruptionines together comprise a monophyletic group. Therefore, I regard *Aulacus* as a member of the subfamily Aulacinae in the Gasteruptionidae.

Aulacus impolitus Smith, new species

Figs. 1, 2

Female: Length, excluding ovipositor, 7.5-9.0 mm; forewing length, 6.5-7.5 mm; ovipositor length about .8 times forewing length. Entirely dark orange with antennal flagellum blackish. Wings uniformly hyaline to very lightly smoky. Head finely granular and shagreened, dull; without occipital carina. Mesonotum finely granular and shagreened, without distinct transverse rugae. Pronotum finely punctate with short, transverse rugae in lateral depression. Sides of thorax shiny, mesopleuron with transverse to reticulate rugae. Metapleuron and propodeum shining with transverse and oblique rugae more widely spaced than those on mesopleuron. Hindcoxa without a groove and without a projecting ventral lobe; outer apical margin of midtibia wihtout toothlike projection; tarsal claw with small inner tooth near base. First sternite not cleft. Forewing with second recurrent vein present.

Male: Length, 7.0-8.0 mm; forewing length 6.0-7.5 mm. Color and structure similar to female.

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[2] Systematic Entomology Laboratory, PSI, Agricultural Research Service, U.S.D.A., c/o National Museum of Natural History, NHB 168, Washington, D.C. 20560.

Holotype: Female, Virginia, Clarke Co., University of Virginia's Blandy Experimental Farm, 2 mi. S. Boyce, V-1-13-90, Malaise trap, David R. Smith. In the National Museum of Natural History, Washington, D.C.

Paratypes: VIRGINIA: Same data as for holotype (2 ♀, 3 ♂); same except date, V-14-24-90 (3 ♀); Louisa Co., 4 mi. S. Cuckoo, Malaise trap, V-13-27-87, D.R. Smith (1 ♀). Deposited with the holotype.

DISCUSSION

Aulacus impolitus and *A. aneurus* Walkey run to couplet two in Townes' 1950 key to *Aulacus* species which includes *A. dispilus* Townes and *A. brevicaudus* Cushman. These four species are separated from the other four species of *Aulacus* by the lack of wrinkles on top of the head and in back of the head in the position of the occipital carina, lack of a projecting lobe on the hindcoxa of the female, and lack of a cleft on the first sternite of the female. Townes' second couplet is modified to include all four species:

2. Unicolorus dark orange or black and forewing without apical dark spot; head granular, dull; forewing with or without second recurrent vein 2a

\- Bicolored, orange with mesosternum and coxae black and with an apical dark spot on forewing or head and thorax black and gaster reddish; head with widely separated, coarse punctures separated by shining interspaces or shiny and smooth; second recurrent vein of forewing distinct 2b

2a. Black; top of head, mesoprescutum, and mesoscutellum with distinct coarse transverse or curved rugae; ovipositor sheath slightly longer than forewing; second recurrent vein of forewing absent; New Mexico .... *aneurus* Walkley

\- Dark orange; head and mesonotum without distinct transverse or curved rugae; ovipositor sheath about .8 times length of forewing; second recurrent vein of forewing present; Virginia .... *impolitus*, n. sp.

2b. Forewing with an apical dark spot; orange with mesosternum and coxae black; frons coarsely punctate; top of head with coarse punctures separated by flat, shining interspaces; ovipositor sheath about 1.1 times length of forewing; Texas .... *dispilus* Townes

\- Forewing without an apical dark spot; head and thorax black, gaster red; frons very finely punctate; top of head without coarse punctures; ovipositor sheath about .6 times length of forewing; California, Oregon .... *brevicaudus* Cushman

Aulacus impolitus is distinguished by the combination of the entirely dark orange coloration; fine, granular, dull sculpturation and lack of distinct transverse rugae on the head and mesonotum; lack of a dark spot at the apex of the forewing; presence of the second recurrent vein in the forewing; and ovipositor length shorter than forewing length.

Townes (1950) mentioned that *A. dispilus* and *A. brevicaudus* are parasitoids of Coleoptera, and the other species (in couplets 3-5 of his key) are parasitoids of *Xiphydriidae* (Xiphydria). However, I found no confirmed

Figs. 1-2. *Aulacus impolitus.* 1, Lateral view. 2, Dorsal view of head and thorax.

records of the former from Coleoptera. Rearing records are from twigs of woody plants, apparently presumed to contain Coleoptera. Deyrup (1984) gave some biological notes on *A. burquei* (Provancher) and *A. digitalis* Townes which are parasitoids of *Xiphydria maculata* Say. The host of *A. impolitus* is not known. Specimens were collected in Malaise traps set near a pond where willow was prevalent and from traps set in and at the edge of an 80-year-old elm-oak-hickory woodlot in Clarke County.

The species name is from the Latin adjective *impolitus*, referring to the rough, unpolished texture head of the new species.

List of Virginia species of Aulacinae

I have confirmed records of the following Aulacinae in Virginia. An asterisk (*) indicates a new Virginia record. Virginia county names are listed.

Aulacus burquei (Provancher)* - Fairfax; Louisa
Aulacus digitalis Townes* - Fairfax; Louisa
Aulacus impolitus Smith* - Clarke; Louisa
Aulacus lovei (Ashmead)* - Fairfax; Louisa
Aulacus pallipes Cresson - Arlington

Pristaulacus flavicrurus (Bradley)* - Clarke
Pristaulacus niger (Shuckard) - Fairfax
Pristaulacus resutorivorus (Westwood) - Fairfax
Pristaulacus rufitarsis (Cresson)* - Fairfax
Pristaulacus stigmaterus (Cresson)* - Clarke; Fairfax; Louisa; Montgomery
Pristaulacus strangaliae Rohwer - Clarke; Grayson; Fairfax; Louisa
Pristaulacus violaceus (Bradley) - Nelson

ACKNOWLEDGMENTS

I extend thanks to Drs. Michael Bowers and Christopher Sacchi, University of Virginia, for allowing access to the Blandy Experimental Farm for field work and to Mr. and Mrs. J.G. Kloke for allowing field work on their property in Louisa Co. Also thanks are extended to L. Masner, Agriculture Canada, Ottawa; M.A. Deyrup, Archbold Biological Station, Lake Placid, Florida; S.R. Shaw, University of Wyoming, Laramie; and R.E. White and E.E. Grissell, Systematic Entomology Laboratory, USDA, Washington, D.C., for reviewing the manuscript.

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BOOK REVIEW

THE AFRICAN HONEY BEE Marla Spivak, David J.C. Fletcher and Michael D. Breed, editors. 1991. Westview Studies in Insect Biology. Westview Press, Boulder, CO $55.00

This is the first book to comprehensively review the scientific literature on *Apis mellifera scutellata* (formerly *adansonii*), the "African" or Africanized honey bee of the Americas. This bee population, characterized as having high rates of swarming and absconding, a rapid colony population increase and prolonged and rapid expression of defensive behaviors, is also commonly called the killer bee. Their defensive reputation has resulted in negative interactions with human populations.

There are 19 chapters in this book divided into 5 sections. Nineteen authors contributed material with several such as Rinderer (4 chapters) and Hellmich (3 chapters) leading the way. Each co-editor produced a chapter in addition to collaborating on an introductory chapter. The book is heavy on text with few charts or diagrams and even fewer photographs. The references are handled at the end of each chapter rather than as one section but an author index does assist finding literature. Random checking of references and index showed a high degree of accuracy. References are consistently cited one section to the next.

The five sections are: I. Systematics and Identification (2 chapters); II. The spread of Africanized Bees and the Africanization Process (6 chapters); III. Population Biology, Ecology and Diseases (5 chapters); IV. Defensive Behavior (3 chapters); and finally V. Beekeeping in South America (3 chapters). Missing is a contribution from Orley Taylor (in introduction, co-editors state "a couple [of] important investigators were unwilling or unable to deliver promised chapters") and information on the bee in Central America/ Mexico (except chapter 7 on Costa Rica and in studies cited by various authors).

It is inevitable in a multi-authored book that there are going to be contradictory statements. Such is the case with this text. There is no consensus as to the best solution to the "Africanized bee problem." There is no single population of bees that behave in a similar manner and the points of references of the various authors are different. The co-editors cite the differences of opinion as a strength of the book in their introduction.

Even the name chosen for the bee is a contradiction. Only 1 chapter (Chapter 4 by co-editor Fletcher) used the term African bee. The population is referred to as Africanized honey bee (and the process as africanization) everywhere else in the book. The 2 chapters in the Systematics and Identification section have Howell Daly using Africanized (Chapter 2) but Glenn Hall (Chapter 3) naming bees by continents of origin. Hall uses the term africanized bees to refer to bees of "European maternal lines hybridized to African males." This reviewer believes it would have been more consistent to use Africanized in the title than "African."

Continued on page 194

DISTRIBUTIONAL RECORDS FOR SOME NORTH AMERICAN SAND FLIES, *LUTZOMYIA* (DIPTERA: PSYCHODIDAE)[1]

Chad P. McHugh[2]

ABSTRACT: Distributional records, including seven new county records, are reported for *Lutzomyia anthophora, L. diabolica, L. shannoni,* and *L. texana* collected in Texas and Arkansas.

Despite their importance as vectors of *Leishmania* Ross, phleboviruses, and *Bartonella bacilliformis* Strong, Tyzzer and Sellards, the causative agent of Carrion's disease, little is known about the distribution and natural history of phlebotomine sand flies in North America. Larval breeding sites are largely unknown, and information on host feeding patterns and seasonal activity is anecdotal or inferred from casual field observations. Young and Perkins (1984) summarized the known geographic distributions of sand fly species in North America, north of Mexico, but those records are limited in number and probably reflect the distribution of collectors more than that of the sand flies themselves. The following records from Texas and Arkansas document collections of four species of *Lutzomyia*, including seven new county records (dates preceded by an asterisk). The Texas collections were made in the southern part of the state where *Leishmania* is enzootic (Grimaldi *et al.* 1989) and where the sand fly fauna is poorly documented. All collections in Texas were made in the immediate vicinity of nests of the southern plains woodrat, *Neotoma micropus* Baird, a host for *Leishmania mexicana* (Biagi) (McHugh *et al.* 1990). The specimens from Arkansas were collected incidental to sampling for mosquitoes. Unless noted otherwise, all collections were made with solid-state army miniature light traps. Light traps were occasionally supplemented with CO_2. Identifications were confirmed by Dr. P.V. Perkins, and voucher specimens have been deposited with the Museum Support Center, Smithsonian Institution, Washington, D.C. 20560. Abbreviations for collectors used in species records are: C.L. Dieter (CLD), P.A. Hanny (PAH), S.F. Kerr (SFK), C.K. McHugh (CKM), C.P. McHugh (CPM), and C.A. Saulsberry (CAS).

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[1] Received February 25, 1991. Accepted April 8, 1991.

[2] Occupational and Environmental Health Directorate, Armstrong Laboratory, Brooks Air Force Base, TX 78235.

Lutzomyia anthophora (Addis)

Texas, ATASCOSA: *10-VI-1990, 6 mi S Jourdanton, CPM and SFK. FRIO: *23-VI-1990, 14 mi SE Pearsall, CPM and SFK. 1-IX-1990, 14 mi SE Pearsall, CPM and SFK. BEXAR [all in the vicinity of Brooks Air Force Base (AFB)]: 4-V-1988, ex *Neotoma* nest, CPM. 6-V-1988, CPM. 10-V-1988, ex *Neotoma* nest, CPM. 6-VI-1990, CPM and PAH. 26-VI-1990, CPM. 3-VII-1990, CPM and PAH. 22-VIII-1990, CPM and SFK. 7-IX-1990, ex *Neotoma* nest, CPM and SFK.

Lutzomyia anthophora is a nest associate of *N. micropus*, (Young and Perkins 1984) and is the suspected vector of Rio Grande virus among these rodents (Endris *et al.* 1983). This species also has transmitted *L. mexicana* to rodents under laboratory conditions (Endris *et al.* 1987) and is the probable vector of *L. mexicana* among woodrats (McHugh *et al.* 1990). This sand fly is probably distributed throughout south Texas and southward to Morales State, Mexico (Young and Perkins 1984).

Lutzomyia diabolica (Hall)

Texas, DIMMIT: *28-VII-1990, Chaparral Wildlife Management Area, CPM, SFK and CKM. FRIO: *23-VI-1990, 14 mi SE Pearsall, CPM and SFK. LA SALLE: *28-VII-1990, Chaparral Wildlife Management Area, CPM, SFK and CKM.

Lutzomyia diabolica has transmitted *Leishmania* to rodents under laboratory conditions (Lawyer and Young 1987) and is believed to feed on a wide variety of mammals, including humans (Young and Perkins 1984). *Lutzomyia diabolica* is not known to be associated with or feed on woodrats, but collections of this species in the vicinity of *Neotoma* nests suggest that some interaction may occur. At one collecting site southeast of Pearsall, Texas, *L. diabolica* was the predominant sand fly species collected. *Lutzomyia diabolica* occurs from Texas southward into Mexico (Young and Perkins 1984).

Lutzomyia shannoni (Dyar)

Arkansas, PULASKI: *8-VI-1989, Little Rock AFB, CLD. 15-VIII-1989, Little Rock AFB, CAS.

Lutzomyia shannoni has transmitted *Leishmania* in the laboratory (Lawyer and Young 1987), but it has not been reported from southern Texas where human cases of leishmaniasis have occurred. This species is distributed throughout the southeastern and mid-atlantic states (Young and Perkins 1984) and probably extends at least into eastern Texas.

Lutzomyia texana (Dampf)

Texas, FRIO: *23-VI-1990, 14 mi SE Pearsall, CPM and SFK. BEXAR (all in the vicinity of Brooks AFB): 3-VII-1990, CPM and PAH. 26-VII-1990, CPM and SFK. 15-XI-1990, CPM and SFK.

Lutzomyia texana has been collected from the nests of leaf-cutting ants and armadillo burrows (Young and Perkins 1984). Armadillos are common in habitat similar to that in which the collections were made. The known range of *L. texana* extends from Texas, through Mexico and into Honduras (Young and Perkins 1984).

ACKNOWLEDGMENTS

Dennis D. Pinkovsky and David E. Bowles reviewed the manuscript for this paper. Peter V. Perkins of the Walter Reed Army Institute of Research confirmed the determinations. Jaime C. Rutledge arranged access to the Chaparral Wildlife Management Area.

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Continued from page 191

The book brings together a wide range of studies, including some research not previously reviewed in English. For researchers interested in examining the population and for biologists that have heard little, or much, about the bee, this book is a valuable reference and benchmark of what we do and don't know about the "African" (africanized) bee. It is recommended reading for all.

Dewey M. Caron
Department of Entomology,
University of Delaware

ADDITIONS TO THE GENUS *CALLISCARTA* (HOMOPTERA: CICADELLIDAE)[1, 2]

Paul H. Freytag[3]

ABSTRACT: Additions to the genus *Calliscarta* include *C. richardsi* sp. n. from Brazil, the females of *C. boliviana* (Osborn) and *C. stigmata* (Nast) and the male of *C. rugosa* Freytag. Also, *C. columbiana* (Nast) and *C. stigmata* (Nast) are recorded from Panama.

Additional leafhopper specimens belonging to the subfamily Neobalinae add to our knowledge of the Genus *Calliscarta*. The material was obtained from Dr. William J. Knight, British Museum of Natural History, (BMNH), London, England; Dr. Luis J. Jolly T. and Marco Gaiani, Museo Instituto de Zoologia Agricola, Universidad Central de Venezuela, MIZA), Maracay, Venezuela; Dr. Henk Wolda, Smithsonian Tropical Research Institute, (STRI), Balboa, Panama; and Dr. K.G.A. Hamilton, Biosystematics Research Institute, Canada Department of Agriculture, (BRIC), Ottawa, Canada. I wish to thank these persons for making this material available.

The following information is added to that found in the revision of the genus *Calliscarta* Stal (Freytag, 1988):

Calliscarta columbiana (Nast)

Idiotettix columbiana Nast 1952, p. 2.

One male, collected from Panama, extends the known distribution of this species. Also, the label data gives the first host association of any of the species of this subfamily. The data is as follows: PANAMA, Canal Zone, Pipeline Road, from *Luhea scemanni*, 12-26-VII- 1976, Henk Wolda (STRI).

Calliscarta stigmata (Nast)

(Figure 11)

Idiotettix stigmatus Nast 1952, p. 2.

One female collected from Panama, extends the distribution and

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[3] Department of Entomology, University of Kentucky, Lexington, Kentucky 40546-0091.

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represents the first female associated with the males of this species. The color pattern is the same as in the male, so the female is fairly easily recognized even though it is slightly larger. The label data is as follows: PANAMA, Coclé Province, La Mesa near El Valle, 8°37' N., 80°07' W, 850 m., 21-VII- 1979, Stockwell (STRI).

Female genitalia: Seventh sternum enlarged, posterior margin with a rounded median emargination. Ovipositor extending only slightly more than its own width beyond pygofer.

Notes: This specimen is not in excellent condition, as the genitalia are somewhat damaged and shrunken. The illustration is slightly modified so that it looks symetrical. One additional male was also collected from VENEZUELA, Aragua, carret. Maracay, Chorroni, 17-VI-1975, R.E. Dietz leg. (MIZA).

Calliscarta boliviana (Osborn)

(Figure 9)

Idiotettix bolivianus Osborn 1929, p. 466.

Six additional specimens, five males and one female, collected from Chiriqui Province, Panama, includes the first female associated with the males of this species.

Female genitalia: Seventh sternum enlarged, posterior margin with relatively large rounded median emargination. Ovipositor extending twice its width beyond pygofer.

Specimen data: PANAMA, Chiriqui Province, two males, Fortuna, 1050 m., 8°44'N 82°15'W, 19-V-1978, Henk Wolda (STRI and University of Kentucky); one female, same data except 12-17-August-1976 (STRI); one male, Boquete, 1250 m., 8°48'N 82°26'W, 2-VII-1975, Henk Wolda (STRI); one male, same data except 10-X-1977 (STRI); one male, Dst. Renacimiento, Oeste Clara, 5500 m., 5-VII-1976, Engleman (STRI).

Calliscarta rugosa Freytag

(Figures 5-8)

Calliscarta rugosa Freytag 1988, p. 78.

One additional female has been collected from the type locality, with data as follows: VENEZUELA, Aragua, El Limon, 450 m., 12-XI-1976, Luz de Mercurio, F. Fernandez Y. Col. (MIZA); and one male, VENE-

ZUELA, Trujillo, Cuicas, 12-VIII-1964, E. Osuna & M. Gelbos (MIZA), which fits the color pattern of the female is here described as the male of this species.

Male with same color pattern as female. Male 9.5 mm. in length.

Male genitalia: Pygofer elongate, parallel sided to near apex, apex with sharply pointed, dorsally projecting, spine-like process. Genital plate large, long, paddle-shaped, same length as pygofer. Style long, slender, bent at right angle subapically, apex sharply pointed. Aedeagus short, stout, apex narrowed to blunt point, curved slightly dorsad, with a pair of ventral processes, each expanded at base, flattened, pointed at apex, extending nearly to base of aedeagus.

Note: The male is not from the same area as the females, but since the color pattern is so close to the females it is expected that this is the proper association.

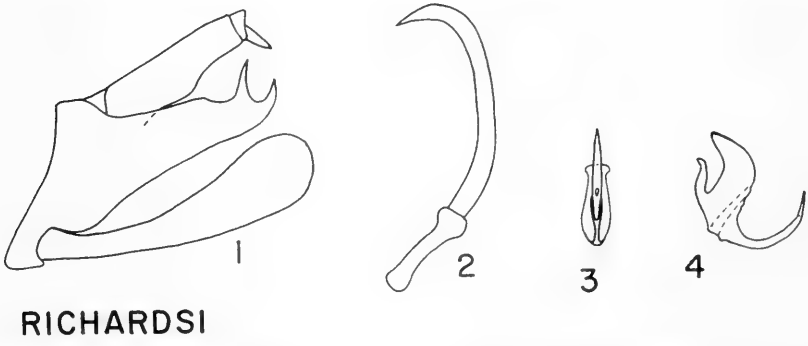
Calliscarta richardsi n. sp.

(Figures 1-4 and 10)

Length of male 9.0-9.2 mm.; female 10.0 mm.

Head wider than pronotum, crown between eyes more than four times wider than median length. Ocelli three times their own width from eyes.

Head purple brown with four transverse orange red bands, lora and postclypeus yellow, sutures below antennae margined with black. Pronotum mostly orange red, with posterior, lateral margins, median extension from posterior margin nearly to head, and anterior lateral spot on each side, purple brown. Forewings mostly smoky brown with large yellow spots, four on clavus, four on corium; apical area dark brown, with a crecent-shaped series of light brown spots. Ventral side and legs yellow, male with some brown shading on legs.



Figures 1-4. *Calloscarta richardsi* sp. n. 1. Lateral view of male genital segments. 2. Latero-ventral view of style. 3. Lateral view of aedeagus. 4. Ventral view of aedeagus.

Male genitalia: Pygofer elongate, apex with large bifurcate process. Genital plate large, paddle-shaped, same length as pygofer. Style long, narrow, sickle-shaped, pointed at apex. Aedeagus short, stout, flattened laterally, knife-shaped, pointed at apex. Aedeagus short, stout, flattened laterally, knife-shaped with a long, narrow, median ventral process with bifurcate apex (difficult to see in ventral view).

Female genitalia: Seventh sternum enlarged with a shallow rounded median emargination. Ovipositor extending its own width beyond pygofer.

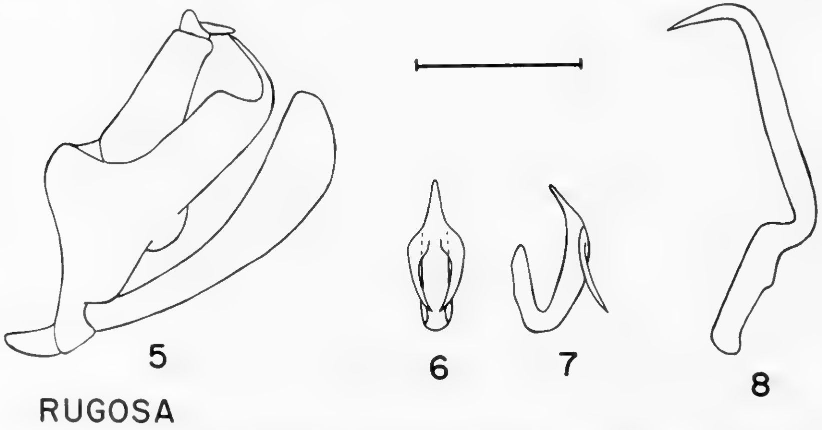
Holotype male: BRAZIL, Mato Grosso, 12°50'S., 51°47'W., Camp, 28-X-1968, O.W. Richards, Roy. Soc. & Roy. Geog. Soc. Expedition 1967-1969, B M 1968-260 (BMNH). Allotype female: Same data as holotype except, 11-XII-1968, W.J. Knight, B M 1970-192 (BMNH). Paratypes: Two males, same data as holotype except, one 11-IX-1968 (University of Kentucky).

Note: This species is similar to *boliviana* in having a bifurcate apical process on the male pygofer, however, the aedeagus is quite different with the median, long, bifurcate ventral process. In the key to species (Freytag, 1988) this species will key out to *boliviana*. It is an honor to name this species for the collector of the type, Dr. O.W. Richards a well known entomologist.

Calliscarta ornata Freytag

Calliscarta ornata Freytag 1988, p. 73.

One additional female has been collected, and is labeled: VENEZUELA, T.F. Amazonas, Dpt. Rio Negro, S. Carlos de R. Negro, 65 m., 1°55'N, 67°1'W., 4-14-III-1984, J.A. Celarijo & J. Demarmels (MIZA).

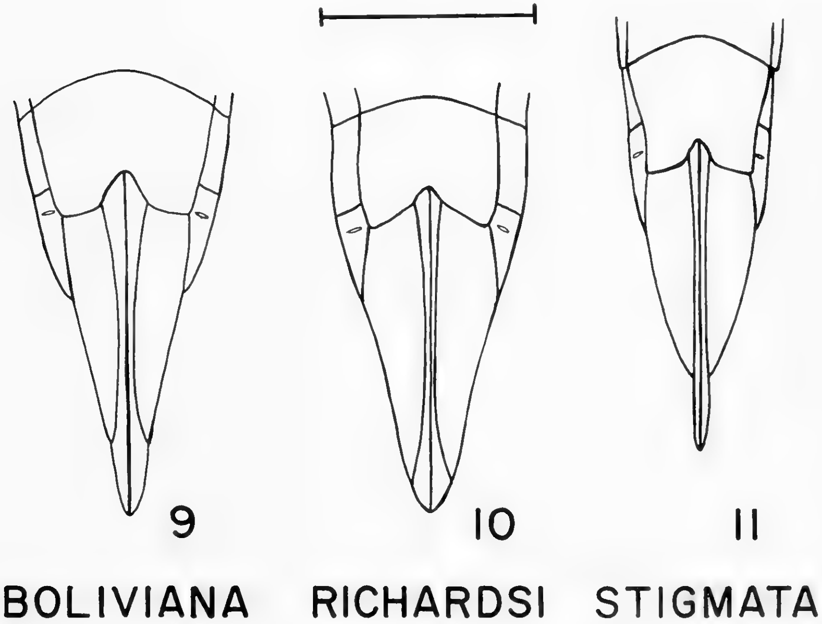


Figures 5-8. *Calloscarta rugosa* Freytag. 5. Lateral view of male genital segments. 6. Ventral view of aedeagus. 7. Lateral view of aedeagus. 8. Lateroventral view of style. All drawn to the same scale; scale equals 1 mm.

Calliscarta decora (Fabricius)

Cicada decora Fabricius 1803, p. 69.

Two additional males have been collected, one labeled: VENEZUELA, T.F. Amazonas, Dpt. Rio Negro, S. Carlos de R. Negro, 65 m., 1°55'N, 67°1'W, 21-23-XI-1984, E. Osuna & A. Chacon (MIZA); and one labeled: GUYANA, Itun, 29-VI-1970, B. Fenton Coll. (BRIC).



Figures 9-11. Ventral view of female genital segments. 9. *Calliscarta boliviana* (Osborn). 10. *C. richardsi* sp. n. 11. *C. stigmata* (Nast). All drawn to the same scale; scale equals 2 mm.

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BEHAVIOR OF SLUGS, *DEROCERUS RETICULATUM* (GASTROPODA: LIMACIDAE), AND CRICKETS, *GRYLLUS PENNSYLVANICUS* (ORTHOPTERA: GRYLLIDAE), ON SEEDLING ALFALFA[1]

R.A. Byers[2], B.I.P. Barratt[3]

ABSTRACT: Ten juvenile slugs, *Derocerus reticulatum* and five field crickets, *Gryllus pennsylvanicus* were confined either together or alone with or without alfalfa, *Medicago sativa* in replicated tests in a greenhouse. Surviving slugs, crickets and alfalfa plants were recorded after eight days. Defoliation was scored on a 1-4 scale for remaining alfalfa plants. Both slugs and crickets survived well, either alone or together, as long as alfalfa was present. Survival of both was reduced in the absence of alfalfa. Poorer survival was attributed to lack of alfalfa as a food source. There was no evidence that crickets had attacked or eaten the slugs or vice versa. Alfalfa was susceptible to defoliation from both *D. reticulatum* and *G. pennsylvanicus*. Survival of alfalfa plants was reduced by slugs but not by crickets. However, combining slugs and crickets significantly reduced plant survival below that of slugs alone, indicating their combined feeding was additive. Mean defoliation scores were significantly greater for slugs than for crickets and both combined significantly increased defoliation scores over either alone. Apparently neither invertebrate interfered with feeding by the other or the combination of the two would not have been additive.

We observed slugs, *Derocerus reticulatum* (Müller), and the crickets, *Gryllus pennsylvanicus* DeGeer and *Allonemobius allardi* (Alexander & Thomas) occurring together at high densities in no-till alfalfa in summer. Both slugs and crickets are recognized as serious pests during establishment of no-till alfalfa (Byers & Bierlein 1984, Grant *et al.* 1982, Rogers *et al.* 1985). However, little is known about the interactions between these groups, especially between *G. pennsylvanicus* and slugs. We noticed large numbers of adult crickets and juvenile slugs (50-100 m^2) in a one-year-old stand of no-till alfalfa while sampling slugs in July and August of 1988. Refuge traps for sampling slugs (Byers *et al.* 1989) collected adult crickets as well as immature slugs. The occurrence of both invertebrates had often been observed in previous studies using the refuge trap.

When juvenile *D.reticulatum* and *G. pennsylvanicus* adults were confined with alfalfa leaves overnight in a 100 cc closed container, the slugs disappeared, apparently consumed by the crickets. *G. pennsylvanicus* was shown to be predatory on the beetles *Hypera postica* and *Sitona hispidulus* in alfalfa by Barney *et al.* (1979). The possibility that crickets ate the slugs

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[2] USDA-ARS, U.S. Regional Pasture Research Laboratory, University Park, PA 16802.

[3] Present address Invermay Agricultural Centre, Private Bag, Mosgiel, New Zealand.

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in this case prompted the following experiment. The objective was to determine any predation by crickets or interaction in feeding behavior between species on alfalfa seedlings.

METHODS

Alfalfa *Medicago sativa(L.)* was sown in six 350 mm long rows in 20 aluminum flats 550x390x90 mm deep, three-quarters filled with a commercial potting soil, Ready-Earth.[4] Each row contained 30 seeds of 'WL316' alfalfa with 40 mm between rows. Five similar flats were left unplanted. A refuge trap composed of a 100x100 mm piece of roof shingle covered with aluminum foil was placed in one end of the flat on the soil surface. The trap was elevated slightly with stones to allow slugs and crickets to hide beneath the trap during the daytime. The flats were covered with plexiglass cages 310x470x300 mm high with a plastic mesh top. One week after planting, when alfalfa had reached the unifoliate stage, field collected *D. reticulatum* juveniles and/or *G. pennsylvanicus* adults were introduced to the cages through a hole in the screen. Densities used were similar to those encountered in the field to give the following treatments each replicated five times:

(1) alfalfa + 5 adult crickets (at least 2 of each sex)
(2) alfalfa + 10 juvenile slugs
(3) alfalfa + 5 crickets + 10 slugs (each as above)
(4) alfalfa alone, no invertebrates
(5) 5 crickets and 10 slugs (each as above, no alfalfa)

After eight days, the number of surviving slugs, crickets and alfalfa plants were recorded, and the surviving plants were scored for feeding damage on a 1-4 scale; 1 = no damage, 2 = <50% defoliation, 3 = 50% or more defoliation, and 4 = completely defoliated including growing point. Data were analyzed by Analysis of Variance Procedure and mean separation was by Waller-Duncan k-ratio T test with k = 100 (SAS 1987).

RESULTS

Both slugs and crickets survived well, either alone or together, as long as alfalfa was present (Table 1). Survival of both was reduced in the absence of alfalfa. Poorer survival was attributed to lack of alfalfa as a

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[4] Mention of a proprietary product does not constitute an endorsement or a recommendation for its use.

food source. Whenever crickets and slugs were confined together, there was no evidence that crickets had attacked or eaten the slugs or vice versa.

Survival of alfalfa plants was reduced by slugs but not by crickets (Table 2). However, slugs and crickets combined significantly reduced plant survival below that of slugs alone. Mean damage scores were significantly greater for slugs than for crickets and both combined significantly increased damage scores over either alone. Furthermore, the

Table 1. Mean number of crickets and slugs surviving after eight days.

Treatment	Mean[1] no. crickets surviving of 5 per treatment	Mean[2] no. slugs surviving of 10 per treatment
alfalfa + crickets	3.4 a	-
alfalfa + slugs	-	10.0 a
alfalfa + crickets + slugs	3.4 a	9.2 ab
crickets + slugs	2.0 b	7.6 b

[1] Mean separation by Waller-Duncan k-ratio T test. means with the same letter not significantly different at k-ratio = 100 F = 4.78.

[2] Mean separation by Waller-Duncan k-ratio T test. means with the same letter not significantly different at k-ratio = 100 F = 3.79.

Table 2. Mean number of alfalfa plants per row in caged flats with or without slugs and crickets and mean defoliation score of remaining plants.

Treatment	Mean[1] no. plants/row of 30 sown	Mean[2] defoliation score (scale 1-4)[3]
alfalfa	22.82 a	1.00 d
alfalfa + crickets	21.93 a	2.17 c
alfalfa + slugs	16.60 b	2.95 b
alfalfa + crickets + slugs	14.03 c	3.12 a

[1] Mean separation by Waller-Duncan k-ratio T test. Means with the same letter not significantly different at k-ratio = 100 F = 27.15.

[2] Mean separation by Waller-Duncan k-ratio T test. Means with the same letter not significantly different at k-ratio = 100 F = 322.25.

[3] 1 = no damage, 2 = <50% defoliation, 3 = 50% or more and 4 = completely destroyed including growing point.

percentage of plants with severe damage (score = 4) was greatest when slugs and crickets were combined (Fig. 1). Slugs alone caused more moderate damage (score 3) versus (score 2) for crickets alone.

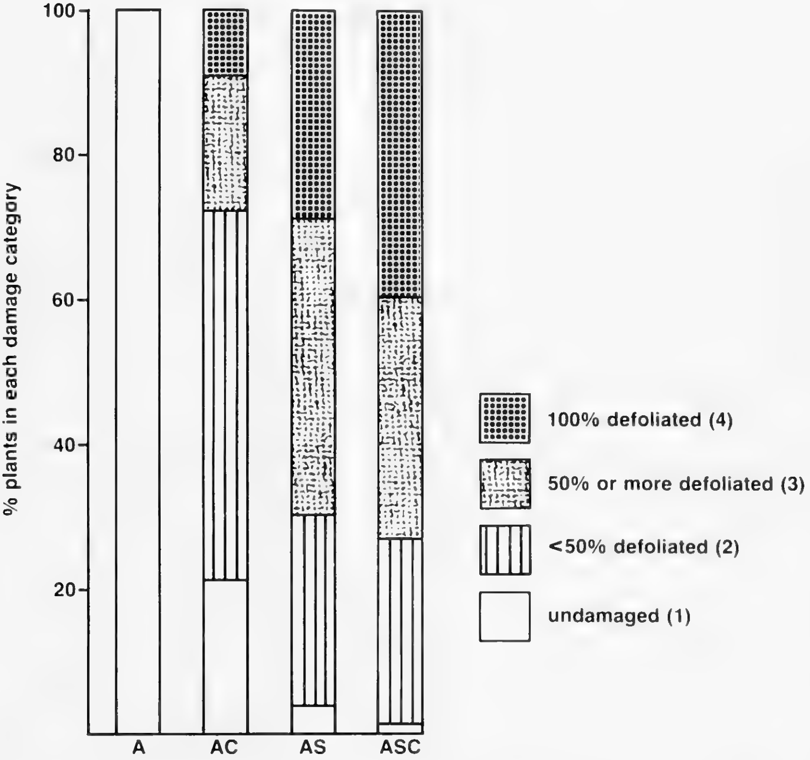

Fig. 1 Percentage alfalfa plant damaged by crickets or slugs in four treatment combination, alfalfa alone (A), alfalfa + crickets (AC), alfalfa + slugs (AS), and alfalfa + crickets + slugs (ASC).

DISCUSSION

This experiment indicated that crickets were not predatory on slugs even when no plant material was available. However, alfalfa was damaged by both *D. reticulatum* and *G. pennsylvanicus* and their combined feeding damage increased seedling mortality. Slugs were more destructive to alfalfa at the density (68.5/m^2) used in the experiment than were crickets

($34/m^2$). Slugs destroyed 0.62 plants per slug compared with 0.26 per cricket when each was caged alone on alfalfa. Therefore, one would predict the combination of crickets and slugs would destroy 0.62 + 0.26 = 0.88 plants per invertebrate. Actually when combined they destroyed 0.92 plants/invertebrate providing evidence that their combined feeding activities on alfalfa are additive. The damage scores also reinforce this theory. When either invertebrate was caged alone with alfalfa they had lower scores than when combined together. Apparently neither invertebrate interfered with feeding by the other or the combination of the two would not have been additive. On the contrary, there was a positive additive interaction between the damage caused by the two pests.

ACKNOWLEDGMENTS

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COMPARISON OF OLD AND NEW WORLD *ACANTHAMETROPUS* (EPHEMEROPTERA: ACANTHAMETROPODIDAE) AND OTHER PSAMMOPHILOUS MAYFLIES[1, 2]

W.P. McCafferty[3]

ABSTRACT: The first comparative examination of larvae of the psammophilous mayfly genus *Acanthametropus* from throughout its known Holarctic range substantiated the present classification that recognizes two species, *A. pecatonica* (Burks) from eastern North America and *A. nikolskyi* Tshernova from eastern Eurasia. Mature larvae of the two species may be differentiated on the basis of the series of sharp hooklike projections on the venter of the abdomen of *A. nikolskyi* vs. the much less developed homologous projections on the abdomen of *A. pecatonica.* Spines and processes on the head, thorax, and dorsal abdomen of larvae apparently become more pronounced with age. Similarities between Acanthametropodidae and certain other psammophilous mayfly taxa include Northern Hemisphere vicariant biogeographic patterns, predatory habits, crablike walking, speed-swimming, and low numbers of species. The relative rarity and restricted habitats of these highly specialized mayflies underscore the need for conserving riverine habitats.

Acanthametropus is a little-known Holarctic genus of mayflies that was not discovered until the mid-twentieth century (Tshernova 1948). Larvae of *Acanthametropus* develop in rivers where they are predatory and psammophilous, living on noncohesive sand substrates. Because such habitats tend to have limited and specialized benthic macroinvertebrate communities that are low in diversity [see e.g., Hynes (1970), Barton and Smith (1984), and Minshall (1984)], they tend to be neglected by ecologists and general collectors. The rarity of *Acanthametropus* and several other psammophilous mayflies in collections is at least in part a result of this. In addition, however, if *Acanthametropus* larvae are elusive speed-swimmers, as I predict, that would further explain this rarity.

Only two species of *Acanthametropus* have been named: *A. nikolskyi* Tshernova (1948) is known from the Amur Basin, eastern USSR, and *A. pecatonica* (Burks 1953) is known from the midwestern USA (northern Illinois and Wisconsin) and southeastern USA (Georgia and South Carolina). The adult stage of *A. nikolskyi* has been known since 1970 (Bajkova 1970, Tshernova *et al.* 1986); however, attempts to find adults or rear larvae in North America have thus far been unsuccessful (Lillie *et al.* 1987).

The enigmatic larval characterization of *Acanthametropus* [see Fig. 312, labeled *Metreturus* in Burks (1953) for dorsal habitus and Figs. 1 and

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[3] Department of Entomology, Purdue University, West Lafayette, IN 47907.

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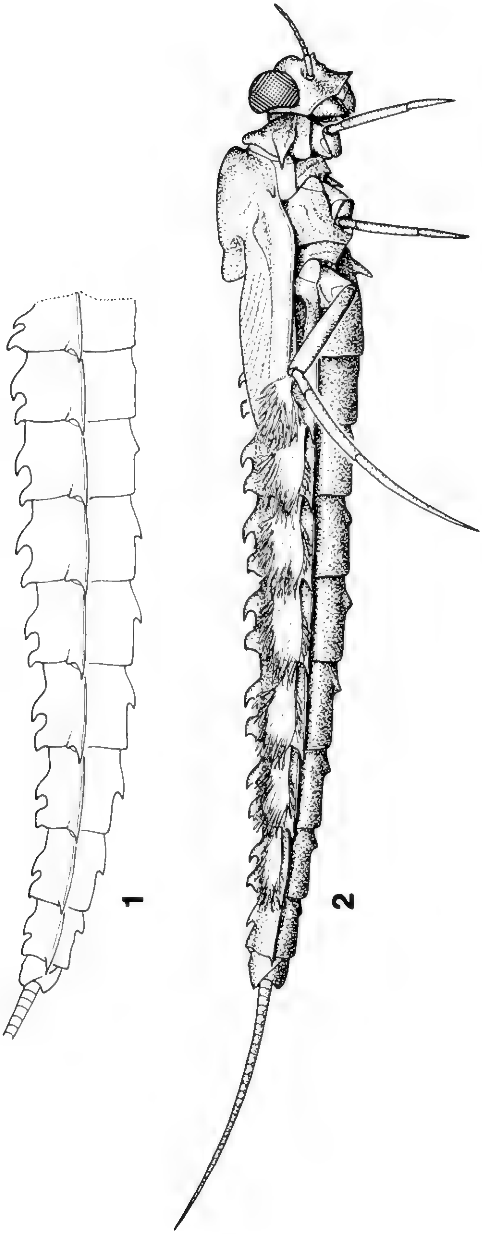

Figs. 1-2. *Acanthametropus* mature larvae, lateral view. 1, *A. nikolsky*, abdominal profile. 2, *A. pecatonica* (holotype, 25.3 mm long), detailed habitus.

2 herein for lateral habitus] led Edmunds, in Edmunds *et al.* (1963), to place the genus in a separate subfamily Acanthametropodinae of the family Siphlonuridae. The additional inclusion of three other genera (*Analetris* Edmunds, *Siphluriscus* Ulmer, and *Stackelbergisca* Tshernova) in that subfamily was discussed by Edmunds and Koss (1972). Demoulin (1974) restricted the subfamily to include *Acanthametropus* exclusively, and McCafferty (1991) has given familial rank to that latter taxonomic concept.

The number and characterization of species in *Acanthametropus* has not been adequately addressed. Edmunds *et al.* (1976) indicated that there were some differences in Illinois and South Carolina specimens but that it could not be determined whether or not the differences were of a specific nature or due to relative age of the larvae. In addition, the known larvae from Eastern and Western Hemispheres have not previously been brought together and compared to determine if indeed different species are represented. This question is germane because several Ephemeroptera populations historically thought to represent Nearctic and Palearctic species or species pairs have recently been shown to represent single circumpolar species (e.g., see McCafferty 1985, Flowers 1986). If more than one species is involved, differentiating characterization would be important to note.

The only fully mature larval specimen taken thus far in the USA is the holotype of *A. pecatonica* from the Sugar River in Illinois. A slightly younger specimen has recently been taken in the Wisconsin River, Wisconsin. The above mentioned holotype larva is comparable in size with the most mature specimen currently known from the USSR, which was taken near the type locality of *A. nikolskyi* in the Amur River, Siberia. I have examined the above specimens as well as early and middle instar larvae of *Acanthametropus* from the Flint River in Georgia, the Savannah River in South Carolina, and the Wisconsin River in Wisconsin.

Based on this comparative study, I am able to substantiate that there is one species in eastern North America and one species in eastern Eurasia. The most obvious difference in the larvae of *A. pecatonica* and *A. nikolskyi* is the relative development of the posteromedial projections on each of the abdominal sternites (Figs. 1 and 2). These projections are most developed on segments 4-8 in both species. However, whereas the projections are evident and somewhat bluntly conical in *A. pecatonica* (Fig. 2), they are sharp, spinelike, and hooked posteriorly in *A. nikolskyi* (Fig. 1). Other spination of the head, thorax, and abdomen (see especially the dorsal abdomen) is virtually identical in the mature larval specimens of the two species. There may be some specific difference in the relative development of fibrillae on the gill lamellae (appearing somewhat more profuse in *A. pecatonica),* but this character is difficult to quantify without more specimens.

In *A. pecatonica,* the relative development of spination changes slightly with age. Generally, the spines become larger, more sclerotized, and more defined as the larvae develop. If this is also true for *A. nikolskyi,* it could possibly mean that the ventral abdominal projection characterization for the two species may be less pronounced when comparing young larvae. No early instar larvae of *A. nikolskyi* were available to test this supposition; however, from the lateral drawing of the evidently very early instar type of *A. nikolskyi* (wingpads are not even apparent in the accompanying dorsal drawing) that was provided by Tshernova (1948), no ventral abdominal armature was indicated.

Although preliminary, presentation of the above conclusions at this time is justifiable because there is no prospect that any appreciable additional materials for more intensive study will become available in the near future.

Comparisons With Other Psammophilous Mayflies

Besides Acanthametropodidae, psammophilous mayfly taxa include the Behningiidae (Keffermüller 1963, McCafferty 1975), Metretopodidae (Lyman 1956; McCafferty, unpublished), Analetrididae (Edmunds and Koss 1972), Ametropodidae (Allen and Edmunds 1976, Clifford and Barton 1979), and Pseudironidae (Barton 1980, Pescador 1985). All but the Behningiidae were placed in the infraorder Arenata by McCafferty (1991); the affinity of Behningiidae is with the Leptophlebioidea and Ephemeroidea in the infraorder Lanceolata. Certain genera in other families unrelated to the Acanthametropodidae have also been associated with sand substrates. These include, for example, *Homoeoneuria* (Pescador and Peters 1980) and presumably *Oligoneurisca* in the Oligoneuriidae; some species of *Brachycercus* (Spieth 1938, Peters and Jones 1973), *Amercaenis* (Provonsha and McCafferty 1985), and *Clypeocaenis* (McCafferty, unpublished) of the Caenidae; some species of *Centroptilum* (McCafferty and Waltz 1990), *Demoulinia* (McCafferty, unpublished), *Potamocloeon* (Gillies 1990), and *Pseudocentroptiloides* (Keffermüller and Sowa 1984) of the Baetidae; and some species of *Baetisca* (Hilsenhoff 1975, 1984; Edmunds 1977) of the Baetiscidae.

The psammophilous mayflies mentioned above, with the exception of some Metretopodidae (Lyman 1956), are lotic. They have variously been reported from shifting sand, sand bars, thin layers of silt overlying sand, and marginal sand at the edge of finer or coarser substrates. Although the sand is generally noncohesive, in some cases it apparently grades to silt/sand that can be somewhat compacted. It should be pointed out, however, that in some of the reports of habitat, descriptions of the sand are qualitative or even anecdotal, and the precise habitat or the exact condition of sand in a habitat have seldom been quantified. In some cases, mature larvae may leave the sandy habitat just prior to emergence; for example, in the Metretopodidae, mature larvae become climbers in marginal vegetation prior to emergence (Lehmkuhl 1970, Hilsenhoff *et al.* 1972) and as a result have mostly been collected there.

Certain burrowing mayflies, such as species of *Anthopotamus* (Bae and McCafferty, in manuscript) in the Potamanthidae, *Ephemera* (Eriksen 1968) in the Ephemeridae, and *Ephoron leukon* (McCafferty, unpublished) in the Polymitarcyidae may be found associated with substrate containing sand, but the sand is heavily mixed with silt or gravel, or both. I do not consider them psammophilous. Still other mayfly taxa, such as *Apobaetis* and *Paracloeodes* of the Baetidae, are supposedly psammophilous (see Day 1955), but additional ecological data are needed to confirm their habitat.

Many psammophilous mayfly taxa demonstrate adaptations similar to those of the Acanthametropodidae. Predominant feeding adaptations of psammophilous mayflies include predation, passive filter feeding, and foraging fine detritus and periphyton from the sand substrate itself. The predatory habit, which has been considered relatively uncommon among mayflies in general (e.g., Edmunds 1957), is well represented in sand-dwelling mayflies, and sand-dwelling midges are evidently an abundant food source for such predators. In addition to the Acanthametropodidae, predatory psammophilous mayflies include the Behningiidae (Tsui and Hubbard 1979), Analetrididae (Edmunds and Koss 1972), and Pseudironidae (Soluk and Craig 1990). Passive filter feeding is present in the Ametropodidae (Soluk and Craig 1988), the psammophilous Oligoneuriidae(Edmunds *et al.* 1976), and presumably *Amercaenis* (Provonsha and McCafferty 1985) and *Clypeocaenis* (Soldán 1978). The other psammophilous mayflies mentioned above are bottom-feeding microvores (Aro 1910, Pescador and Peters 1974, Clifford 1976, Chaffee and Tarter 1979, Hamilton and Clifford 1983, Soldán 1986).

Above, I predicted that *Acanthametropus* larvae would be elusive and difficult to collect even when populations could be located. This is because other psammophilous mayflies of the infraorder Arenata are exceptionally swift swimmers (Leonard and Leonard 1962, Edmunds and Koss 1972, Allen and Edmunds 1976, Soluk and Clifford 1984, McCafferty and Provonsha 1986); Analetrididae (Edmunds and Koss 1972) and Pseudironidae (McCafferty and Provonsha 1986), at least, must literally be herded into very broad or deep nets since they easily escape standard kick screens. Barton and Smith (1984) have also commented on the inherent difficulty of collecting psammophilous mayfly populations.

Of the Arenata, the Acanthametropodidae, Pseudironidae, and Analetrididae have similar crablike legs, with long, somewhat curved, uniform tarsi and claws. The Pseudironidae have been seen to move deftly over the sand backwards and sideways just as sand crabs move (McCafferty and Provonsha 1986). Edmunds and Koss (1972) noted that Analetrididae could move backwards and forwards on the sand but provided no other details. Presumably, Analetrididae and Acanthametropodidae also move crablike. Ametropodidae and Metretopodidae have modified forelegs, but their middle and hindlegs have long slender claws that may enable them to move somewhat similarly on sand substrates. Details of movement in other psammophilous mayflies are not generally known, although it is known that the Behningiidae live interstitially within the sand (McCafferty 1975) and do not show any adaptations for proficient swimming or running. Legs and claws of psammophilous mayflies such as some *Brachycercus, Homoeoneuria,* and certain baetids are quite unlike those of any Arenata; they possess needlelike claws that may serve to help anchor them in sand.

Many psammophilous mayflies, particularly those that are predatory, have an Amerasian distribution pattern similar to that seen in Acanthametropodidae. The Behningiidae, for example, although unrelated, shows a similar Holarctic pattern, although it is a bit more widespread in the Palearctic, which is probably due to the fact that it is more radiated (with three genera) than Acanthametropodidae. (The nonpredatory groups Ametropodidae and Metretopodidae are also Holarctic but with ranges including western North America and western Eurasia.)

In North America, distribution patterns of the predatory, psammophilous mayfly species tend to be broadly disjunct and to involve the upper Osage and Great Plains in central North America and the Southeastern Coastal Plains. Unique characteristics of these systems and pertinent aspects of their general ecology have been treated, for example, by Patrick *et al.* (1966), Peters and Jones (1973), Barton and Lock (1979), and Matthews (1988). Disjunctions similar to the distribution of *Acanthametropus pecatonica* given above are found in *Dolania americana* (Behningiidae) (Edmunds *et al.* 1976, Jacobs 1990) and *Pseudiron centralis* (Pseudironidae) (Pescador 1985). Such disjunctions are probably a function of vicariance, related to the geologic events that have affected the continuity of drainage systems providing adequate sand habitats.

The predatory, riverine mayflies *Raptoheptagenia cruentata* (Heptageniidae: Heptageniinae), and *Anepeorus simplex* (Heptageniidae: Anepeorinae) [see McCafferty and Provonsha (1988) for the current nomenclatural application of these names] have a basically similar North American distribution pattern. Any possible ecological relationship with sand substrates in these predatory heptageniids is not clear at this time since they have been predominantly taken in deep drift and dredge samples. However, Edmunds *et al.* (1976) stated that *Raptoheptagenia* larvae [incorrectly known as *Anepeorus* larvae at that time] "show a preference for rocks over sand substrate, and they move very rapidly."

Similar to *Acanthametropus,* the other predatory, psammophilous mayfly genera are all relatively very distinct and evidently monospecific in North America. Those that are Holarctic consist of only a very few species. This perhaps indicates an old origin but low rate of speciation. They are also restricted to the Northern Hemisphere, and some lineages of Arenata are possibly of Laurasian origin. Of the other taxa having psammophilous mayflies, Baetiscidae is restricted to the Nearctic, but psammophilous baetids, caenids and oligoneuriids, are known from the Southern Hemisphere.

Given the many similarities among psammophilous mayflies, it is important to decipher which of the similarities reflect a common evolutionary ancestry and which are in fact parallelisms that have resulted from adaptations to similar environmental circumstances. Thus, the special ecological relationships as well as cladistics of these mayflies need to be carefully studied. I cannot be optimistic about such a prospect, however, because the actual survival of many of them may be in serious jeopardy.

McCafferty *et al.* (1990) stressed the need for conserving riverine habitats, citing in particular the rarity and specialized nature of psammophilous, riverine mayflies in North America and the fact that much of this habitat is already altered or threatened. For example, areas of the White River in Indiana that are unpolluted and have shifting sand substrates are disappearing (McCafferty, unpublished), many streams and rivers with shifting sand substrates in the Southeast, although relatively common, are disturbed (Peters and Peters 1977), and prairie streams, which are often typified by sandy substrates such as in the Platte system, are possibly "mere remnants of former systems, having been ravaged by pump, plow, and pollution" (Matthews 1988). The exploitation of U.S. rivers continues at an alarming rate, and natural riverine ecosystems in general continue to decline (see Benke 1989). This will have dire consequences for riverine mayflies that are psammophilous or predatory or both. For example, one such predatory and possible psammophilous species, *Anepeorus rusticus,* from the Green River in Utah is probably extinct and another, *Acanthomola pubescens,* from the Saskatchewan River may be nearly extinct as the result of regulating such rivers (see McCafferty and Provonsha 1985, Whiting and Lehmkuhl 1987, and McCafferty *et al.* 1990).

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BEHAVIORAL OBSERVATIONS ON THE MYRMECOPHILE *FUSTIGER KNAUSII* (COLEOPTERA: PSELAPHIDAE: CLAVIGERINAE) WITH A DISCUSSION OF GRASPING NOTCHES IN MYRMECOPHILES[1, 2]

Richard A. B. Leschen[3]

ABSTRACT: *Fustiger knausii* is a well integrated myrmecophile in the nest of its host, *Crematogaster cerasi*. Laboratory observations show that adult beetles spend most of their time associated with the ant brood. Most common behaviors include feeding, mounting, and phoresy on ant workers. Integrated behaviors include grooming and possible trophallaxis.

A basal abdominal depression on the body of *Fustiger* appears to be used by ants to grip beetles during portage.

One of the most fascinating features of pselaphid beetle evolution is the repeated independant origins of social insect inquilinism. Pselaphid inquilines include species that are facultative and obligate myrmecophiles and termitophiles (Park 1964; Kistner 1982). Members of the Clavigerinae are all obligate myrmecophiles. This subfamily, which includes *Fustiger* LeConte, is certainly one of the most taxonomically diverse groups of myrmecophiles and contains about 60 genera (Newton and Chandler 1989).

Despite the generic diversity of clavigerines, behavioral observations have been made exclusively upon North American species of *Adranes* LeConte (*A. lecontei* Brendel, Park 1932; *A. taylori* Wickham, Akre and Hill 1973), European *Claviger* Preyssler (mainly *C. testaceus* Preyssler, for a review see Donisthorpe 1927), the South American species *Fustiger elegans* Raffray (San Martin 1968) and the Japanese *Diartiger fossulatus* Sharp (Kistner 1982). Information on *F. elegans* is incomplete. Reviews of clavigerine behavior are given in Park (1942) and Kistner (1982). In this paper I present behavioral observations on the inquiline *Fustiger knausii* Brendel and its host *Crematogaster cerasi* (Fitch), collected together in the Chiricahua Mountains of southeastern Arizona.

Adults of *Fustiger* are similar in form to other clavigerine genera. They are small beetles (about 1-2 mm in size) that posses a variety of features

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[2] Contribution number 3057 from the Department of Entomology, University of Kansas, Lawrence.

[3] Snow Entomological Museum, University of Kansas, Lawrence Kansas, 66045, U.S.A.

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typical of obligate myrmecophiles: reduced eyes, winglessness, reduced number of antennal segments, and presence of secretory trichomes.

Clavigerine trichomes have been studied in detail by Krüger (1910), Hill *et al.* (1976), and Cammearts (1973, 1974, 1977). Trichomes are typically associated with large glands that have been previously referred to as Wasmann glands. Among clavigerines the number and distribution of trichomes on the bodies appear to be of taxonomic importance. The trichomes of *F. knausii* are restricted to the basal laterotergal areas of the abdomen; the conspicuous ventral trichomes of *Adranes* (Akre and Hill 1973; Hill *et al.* 1976) are lacking.

Laterotergal trichomes of *Fustiger* and other clavigerines are associated with a dorsal abdominal basal depression. The lateral portions of the depression are delimited by a distinct wall connecting the dorsal abdominal tergites and by the trichomes (Fig. 1). The significance of this region is discussed later.

METHODS

Field collections of *F. knausii* and its host *Crematogaster cerasi* were made in the Chiricuauha Mts., Cochise Co., Arizona, 20 May 1990. Beetles and their ant hosts were collected in a dry ravine draining toward the northeast in an oak/juniper/pine vegetation zone at an elevation of 2600 m. Stones were overturned along a 100 m trail within the arroyo. Specimens were preserved in 70% alcohol or kept alive for observations. Beetles and ants were observed in a petri dish on slightly moist filter paper. The laboratory colony of ants consisted of approximately 30 workers and brood (70 eggs, 20 pupae). Twelve beetles were monitored within this colony. The colony was fed 30% sugar solution daily.

Observations through a dissecting microscope were made for up to 4 hr periods during all times of the day for three weeks. Activities were monitored at 15 min intervals. Total observation time was 42 hr. Some behaviors were photographed.

Some beetle specimens were cleared in 10% KOH (potash) and slide-mounted. Specimens are deposited in the following collections: D. S. Chandler Collection, University of New Hampshire, Durham; University of Arkansas Insect Collection, Fayetteville; Snow Entomological Museum Collection (SEMC), University of Kansas, Lawrence; R.A. Leschen Collection.

RESULTS

Field observations. The 100 m transect yielded 19 beetles from a number of *Crematogaster cerasi* nests. The number of adults from each

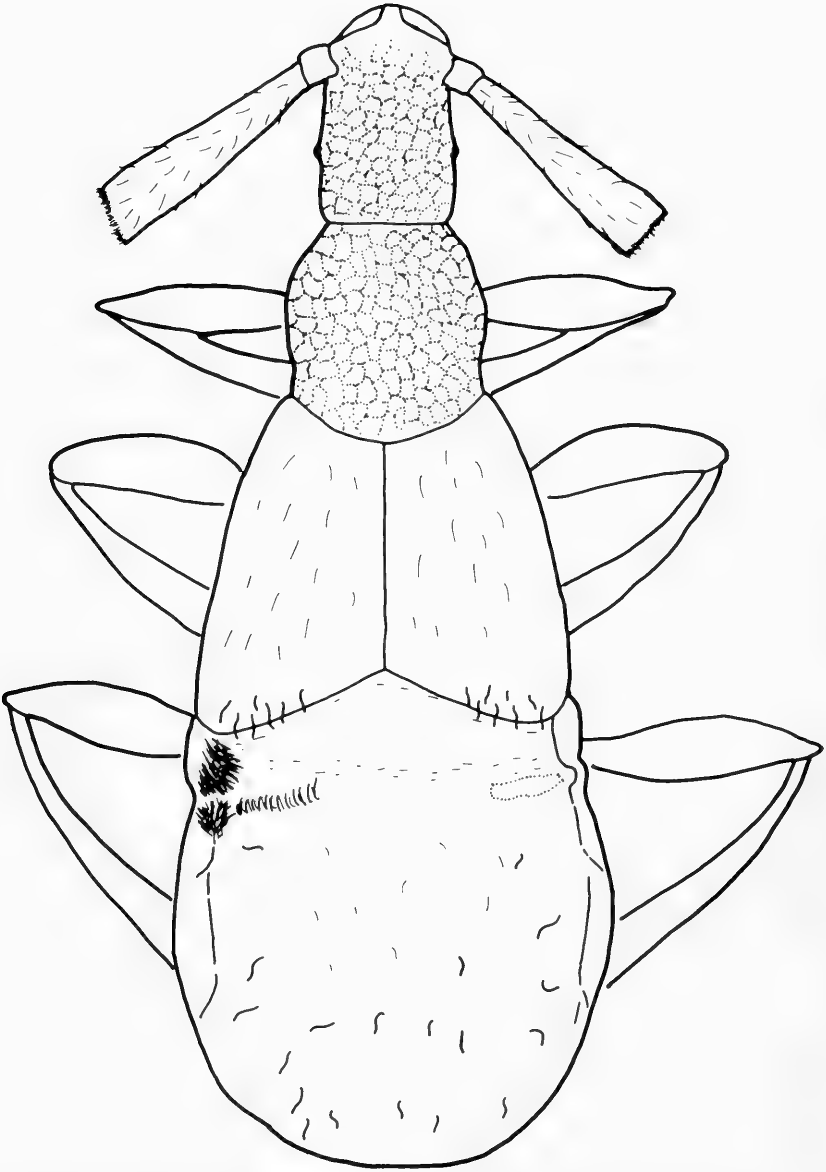

Fig. 1. Habitus of *Fustiger knausii.* The trichomes on the right side of the dorsal terga are removed to show detail of cuticular structure. The Wasmann gland appears as an oblong reservior indicated by a dotted outline.

nest ranged from 1 to 11. The majority of individuals were collected from tunnels within ant nests, but a few were found clinging to ventral surfaces of the overturned rocks. All individuals were found associated with workers, but none were found with brood. One pair of beetles was collected in copula in a tunnel.

Individual behavior. Individuals spent more of their time resting on the ant brood than searching on or below the filter paper. During periods of search, beetles walked the perimeter of the petri dish. Antennae were constantly moving in circular motions during periods of rest and at faster rates when active.

Mating behaviors. Attempts at mating were frequent throughout the investigation. Since males were never observed to insert their genitalia into the female, this mating behavior is referred to as mounting. Mounting occurred at a variety of locations, but most commonly near or on the brood. Mounting while females were phoretic on the dorsum of ants occurred three timess. Males were observed stacked two high on top of a single female on two occasions. Necrophilia was observed once.

Prior to mounting, males contacted the females with the antennae then either moved away or immediately mounted the female. During mounting, males placed their forelegs on the females pronotum, while the middle and back legs grasped her abdomen. On one occasion a male was observed to tap a female's pronotum repeatedly with the right foreleg while mounted.

Subsequent to mounting, females either tolerated or immediately rejected the males. Rejection was characterized by rapid dorsoventral flexing of the abdomen until the male was "bucked" off. Durations of time from mounting to successful male removal were up to 4 min. Tolerated males remained mounted for 4 min to 2.5 hr until termination. Termination of mounting was caused by intervening males, female bucking, ant intervention, or most commonly by observer disturbance. Worker ants commonly investigated mating pairs and pried off males, especially when ant workers were attracted to female bucking.

Despite a high incidence of mounting, aedeagal intromission was never observed even though the aedegus was frequently observed moving in and out the males' genital sheath.

Interspecific behavior. Ants walking to and from the brood investigated the beetles. Investigation almost always led to a period of grooming. Grooming was observed 25 times and lasted for up to 1 min. Up to four workers were observed grooming a single beetle simultaneously. Ants groomed all parts of the beetle, but gave special attention to the antennae and trichomes.

Ants removed the males from mounting pairs of beetles on 6 occasions. Workers engaged in grooming or feeding the brood removed beetles from the brood on 15 occasions, and carried them to areas away from the brood or to the refuse pile. On one occasion a worker removed a mated pair and took them to the refuse pile. When the whole colony was placed into a clean petri dish, workers picked up beetles and placed them on the brood. This behavior was observed 8 times.

Ants grasped beetles with their mandibles at three locations on the bodies of the beetles: the head (usually at the neck), the pronotum, and most commonly at the base of the abdomen. Duration of portage ranged from 25 sec. to 1.5 min.

Possible trophallaxis was observed 9 times. This occurred when a worker approached a beetle or when a beetle was groomed, and the mouthparts of the insects came into contact. No fluid exchange was observed.

Ants were groomed by beetles on 3 occasions, with attention directed to several areas of the ants' body. Once a larva was strigilated by a beetle, but this did not illicit a regurgitation of fluid by the larva. On one occasion a beetle was observed feeding upon a dead ant, in movements similar to that of grooming. Commonly beetles would groom the brood.

Duration of phoresy ranged from 20 min to 2 hr. Beetles were oriented anteriorly on the worker dorsum (observed 17 times) or posteriorly (observed 8 times). Beetles mounted ants by moving slowly over them into a dorsal position. Preceeding phoresy there were no interactive behaviors between the approaching beetle and ant, and the ant did not respond negatively to a phoretic beetle. Usually ants that carried beetles were not active.

DISCUSSION

Some data for clavigerines is summarized in Table 1. Clavigerines are usually associated with ant brood, often for long periods of time (Hetschko 1896; Donisthorpe 1927; Park 1932; San Martin 1968; Akre and Hill 1973; Kistner 1982). The most likely reason for this is that the brood is a location for food. In contrast to the laboratory study, *F. knausii* collected in the field were not found in association with the brood.

Ants groom the entire body of a *F. knausii* and are especially attracted to the trichomes. Adult ants are usually attracted to the clavigerine trichomes (Donisthorpe 1927; Akre and Hill 1973; Kistner 1982). *Lasius* ant larvae are more strongly attracted than adults to the trichomes of *A. taylori* (Akre and Hill 1973). The integument of living *Fustiger* and *Adranes* appears oily as if covered with secretions (Akre and Hill 1973). Trichomes and their associated glands secrete fluids in clavigerines and other myrmecophiles. Kistner (1982) attributed an appeasement function

Table 1. Habitats, ant hosts, and behaviors of some clavigerine Pselaphidae[a].

	Claviger spp.	*Adranes* spp.	*Fustiger knausii*	*Diartiger* sp.
Habitat	under rocks	rotting wood	under rocks	?
Ant hosts	*Lasius* *Crematogaster*	*Lasius*	*Crematogaster*	*Lasius*
Associated with brood	+	+	+	+
Frequent mating	+	+	+	?
Ant grooming	+	–	+	+
Trophallaxis with adult ants	+	+	+	+
Phoresy	+	+	+	+

+=present, -=absent, ?= unknown.

[a] Compiled from: Hetschko 1896, Donisthorpe 1927, Park 1932, Akre and Hill 1973, Kistner 1982, Paulian 1988.

to these fluids with respect to their host ant, but Cammearts (1977) suggested that *C. testaceus* secretions act as a chemical releaser initiating ant regurgitation for trophallaxis and also mimicing the odors of dead insects. The odor mimicry presumably functions as a chemical cue for ants to carry beetles to various locations within the nest (e.g. brood and refuse pile).

Food of clavigerines include the following: regurgitated food from ants, dead insects, larval excretions and body fluids, and brood (Donisthorpe 1927; Park 1932; Akre and Hill 1973; Kistner 1982). The observations of *F. knausii* suggest similar habits of fluid feeding. The mouthparts are reduced in clavigerines and are contained within a capsule formed by lateral closure of the head (Akre and Hill 1973; Cammaerts 1974; Kistner 1982). In *Fustiger*, each lacinea bears elongate setae that appear to be the principal food collecting device. These setae may act as a capillary sponge to obtain fluids and other small particles from the surfaces of living and dead ants, and are also important for feeding on liquid regurgitants from ants.

Phoresy has been previously observed in clavigerines (Hetschko 1896; Donisthorpe 1927; Park 1932; Kistner 1982). Akre and Hill (1973) noticed a high attraction of beetles to winged females, and based upon earlier reports of phoresy on winged adults (see Hetschko 1896 and Donisthorpe 1927), suggested that this phenomenon may be associated with an anticipation for dispersal to new colonies. Phoresy of *F. knausii* may be similar, however no winged adults were present in the laboratory colony or were present in the field during the time of collection.

Grasping Notches- Among the variety of morphologies that have evolved in assocation with myrmecophily, structures that have not been clearly documented are what I propose to call "grasping notches". These are constricted, invaginated or evaginated areas of cuticle on the bodies of many myrmecophilous beetles. Ants may use these locations for grasping myrmecophiles with their mandibles during particular behaviors. Previous studies (Donisthorpe 1927; Cammearts 1977; Kistner 1982) report that ants carry clavigerines by the body in a variety of locations, including regions where the "grasping notches" occur.

In clavigerines, the grasping notch occurs as a broad transverse depression at the base of the abdomen directly behind the elytra (Fig. 1). Associated with this depression are trichomes and Wasmann glands. The trichomes are regions of the highest concentration of secretions, and it seems reasonable to suggest that secretions attract ants to this location to lead to grasping for portage. As stated earlier, ants groomed beetles at the trichomes, and then picked the beetles up at the lateral portions of the abdominal depression. The beetles were carried to a variety of locations within the nest.

However, these depressions in Clavigerinae may not be adapted exclusively for ant grasping. Other pselaphids, including some myrmecophiles and free living species, bear similar depressions but lack trichomes. The abdomen of pselaphids are typically rigid, and the presence of the depression may be associated with a modified ability to dorsoventrally flex the abdomen. In clavigerines the abdominal terga forms a broad dorsal shield. That the grasping notches are indeed used by ants to move beetle inquilines is suggested by their occurence in other inquilines. Many myrmecophilous histerid beetles of the subfamily Hetaeriinae, possess a lateral pronotal notch in association with trichomes (see photographs in Helava *et al.* 1985). A common hetaeriine in eastern North America, *Hetaerius brunneipennis* LeConte, was observed being carried by ants grasping the notches with their mandibles (personal observation). In their work on myrmecophilous Ptinidae, Lawrence and Reichardt (1969) distinguished features shared by all beetle myrmecophiles from those shared by ptinid myrmecophiles and their free-living confamilials. Pronotal pits and grooves are features that occur in the latter group. These structures may serve as grasping notches.

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Fustiger knausii and other organisms inhabiting the Chiricahua Mts. are currently threatened by private gold mining interests. Inquiries regarding saving this fragile habitat should be sent to the American Museum of Natural History, The Southwestern Research Station, Portal, Arizona, 85632.

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DROSOPHILA CANARYANA TAKADA AND YOON, 1989 (DIPTERA: DROSOPHILIDAE), A JUNIOR SYNONYM OF *DROSOPHILA GUANCHE* MONCLÚS, 1976[1]

David Grimaldi[2]

ABSTRACT: *Drosophila canaryana* Takada and Yoon, 1989 is a junior synonym of *Drosophila guanche* Monclús, 1976, both reported from Tenerife Island, Canary Islands. A new diagnosis is provided for the species, some morphological variation is noted, and the male genitalia illustrated in detail. Comments on relationships are reviewed.

Very recently in this journal there appeared the descriptions of three unrelated drosophilid species from widely separate areas, one of which was *Drosophila canaryana*. The main purpose of that report was to describe the undescribed species that occur in the National Drosophila Species Stock Service (NDSSC) at Bowling Green State University, Ohio. Dr. William B. Heed (Univ. Arizona) called to my attention the likelihood that *D. canaryana* was synonymous with *D. guanche* Monclús, also known only from the island of Tenerife in the Canary Islands. Dr. Marie Monclús (Univ. of Barcelona) provided copies of correspondence that Professor A. Prevosti (Univ. of Barcelona) sent to Prof. Marshall Wheeler (Univ. of Texas) in 1972 with some cultures of an undescribed *obscura* group species from Tenerife Is. Later, Prof. Prevosti recognized that the stock listed in the 1984 NDSSC catalogue from the Canary Islands was probably the culture of *D. guanche* which was originally sent to Prof. Wheeler. When the NDSCC was moved to Bowling Green St. Univ., this species was later re-described by Haruo Takada and Yong Sik Yoon, the latter director of the DNSCC. Thus, it is likely that the stocks on which the two descriptions are based are actually from the same culture!

Drosophila guanche Monclús, 1976

Drosophila guanche Monclús, 1976: 205.
Drosophila canaryana Takada and Yoon, 1989: 115. NEW SYNONYM.

Diagnosis: Color ranging from yellowish to dark brownish-black (see below); carina low, with narrow ridge; a single pair of vibrissae (subvibrissae slightly longer than one-half the length of vibrissae); arista with three dorsal and 1-2 ventral branches, plus terminal fork; male foretarsomere one with row of 24-29 stout black teeth, foretarsomere two with 18-26 (fig. 1); male genitalia as illustrated (figs. 2 and 3).

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[1] Received May 24, 1991; Accepted June 30, 1991

[2] Department of Entomology, The American Museum of Natural History, Central Park West at 79th St., New York, New York 10024-5192

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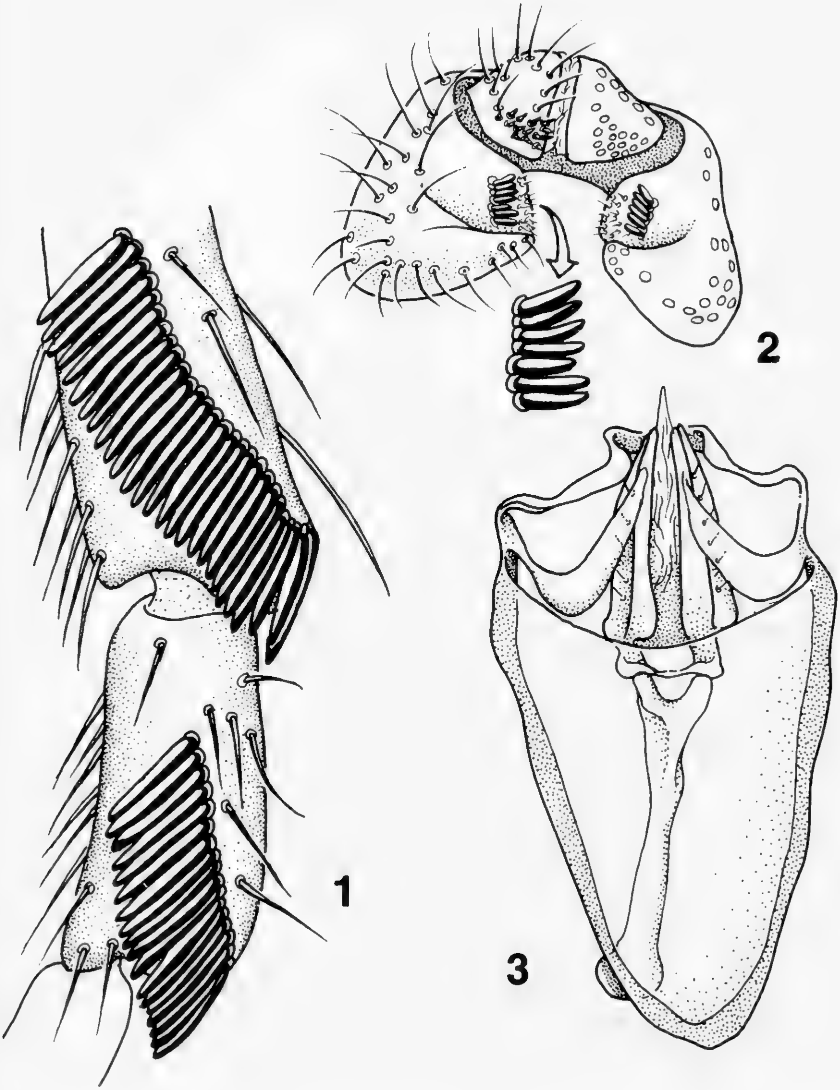

Figs. 1-3. Structures of male *Drosophila guanche*. 1. Comb of teeth on first and second foretarsomeres. 2. Epandrium and surstyli. 3. Hypandrium, aedeagus and associated structures.

Material Examined: Numerous laboratory-reared males and females from two stocks, both derived from Tenerife Island, Canary Islands. Specimens from the NDSSC at Bowling Green derived from culture number 1410-1211; details of the stocks from Barcelona are given in Monclús (1976). Pinned specimens of both lots are in the AMNH. The holotype of *D. "canaryana"* is in the AMNH (Takada and Yoon, 1989); the holotype of *D. guanche* is in the Genetics Department of the University of Barcelona, but was not examined by myself.

DISCUSSION

The two original descriptions are sufficiently ambiguous and different enough as to make identification difficult. Although the descriptions do agree in some respects, obvious discrepencies are the following (in italics are the conditions as I have found them): Number of aristal rays: 7 in Monclús, 5 in T&Y (I found 6-7). Illustrations of male genitalia: with no paraphysis, *large lateral gonopods*, median gonopods smaller than the paraphysis, a *long thin aedeagal apodeme*, and *narrow hypandrum* in Monclús; with a pair of *paraphyses each bearing a row of 8 sensilla,* small lateral gonopods, median gonopods equal in length to paraphyses, a stout aedeagal apodeme, and a wide rounded hypandrum in T&Y. Monclús (1976) mentioned that much of the body, such as the antennae, mesonotum, and pleura, were yellowish, which contrasts with the description of Takada and Yoon that the flies were mostly dark brown. The color is consistently different between cultured flies that I received from Drs. Monclús and Yoon, as reported. However, the flies from Barcelona were also considerably smaller, indicating that the color difference is probably due to differences in the temperature at which larvae were reared. It is known that cooler temperatures prolong larval development, resulting in larger individuals, and, in at least some species such as *Drosophila testacea,* cooler tempertures result in darker adults.

Monclús (1976), Takada and Yoon (1989), and Lakovaara and Saura (1982) all agreed that *guanche* is most closely related to *D. subobscura.* The range of *D. subobscura* extends from England to Iran, northern Africa, also on Tenerife and Madeira Islands, and it has even been introduced to Chile. Most recently, Monclús (1984) discovered *Drosophila madeirensis* from Madeira Island (32°38′N, 16°54′W), which now appears to be the closest relative of *guanche.*

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PARASITIC HYMENOPTERA COLLECTED FROM A PEAR ORCHARD UNDER ORGANIC MANAGEMENT IN WASHINGTON STATE[1]

G.S. Paulson, R.D. Akre[2]

ABSTRACT: During the summers of 1986-1989 parasitic Hymenoptera were collected from a pear orchard under organic management through the use of pitfall traps, a beating tray, and vegetation samples. More than 94 species of Hymenoptera were collected with representatives from 24 families and 72 genera. Four species were added to the *C. pyricola* parasitoid complex: *Psyllaephagus* sp. (Encyrtidae), *Dilyta rathmanae* Menke and Evenhuis (Charipidae), *Pachyneuron albutius* (Walker) and *P. siphonophorae* (Ashmead) (Pteromalidae).

During a study of the biological control of pear psylla, *Cacopsylla pyricola* (Foerster), a great deal of information relating to the parasitic Hymenoptera fauna of a pear orchard under organic management was collected. Collection records are presented here in tabular form. This information will contribute to our knowledge of the dynamics of parasitoid populations in agricultural systems.

METHODS

Studies were conducted during the summers of 1987-1989 (June - August) in an organic Bartlett pear orchard located near Peshastin, Washington (Chelan Co.). The orchard was ca. 1 ½ ha in size, with 6m x 6m tree spacing. Ground cover was predominantly grasses, kept short (<10cm) by regular mowing. Undertree irrigation was carried out on a weekly basis.

Pitfall traps were used in 1987-1989 to monitor ground activity of parasitoids. Traps were constructed from 12 oz plastic cups. Approximately 20 ml of diluted antifreeze (1:5 antifreeze:water) were poured into the cups which were then buried up to their rim in the orchard. Pitfalls were collected after 24 h, and the contents examined under a dissecting microscope in the laboratory. Parasitoids in the traps were counted and identified. Pitfall traps were rotated throughout the study area with 40-60 traps placed during each 24 h period. In 3 years 865 traps were examined.

A beating tray was also used to collect parasitoids. This method utilized a 45 cm x 45 cm beating tray held under a pear limb while the limb was

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[1] Received February 23, 1991. Accepted August 3, 1991.

[2] Dept. of Entomology, Washington State University, Pullman, WA, 99164-6432

struck three times with a 35 cm length of rubber hose. Parasitoids which landed on the tray were collected for identification. Beating tray samples were collected from 32 pear trees/week. Three beating tray samples were collected from each tree.

Parasitized pear psylla were collected from vegetation, placed in separate shell vials, and held in the laboratory for emergence of parasitoids.

RESULTS

The pear orchard supported a diverse parasitoid fauna including more than 94 species from 24 families and 72 genera (Table 1). The greatest number of species were collected from beating tray samples. Seventeen species were collected only in pitfall traps, and only a few specimens (< 10) with the following exceptions: Encyrtidae - *Trechnites* sp. (123), *Psyllaephagus* sp. (47), and *Litomastix* spp. (150); Charipidae - *Dilyta rathmanae* (23); and Scelionidae - *Scelio* spp. (23), *Telenomus* spp. (30), and *Idris* spp. (30). The abundance of these taxa is probably due to their host range. *Trechnites* sp., *Psyllaephagus* sp., and *D. rathmanae* are part of the *C.pyricola* parasitoid complex. The other genera were represented by more than one species and are parasitioids of relatively abundant hosts such as Lepidoptera larvae (*Litomastix* spp.) and grasshoppers (*Scelio* spp.).

This study revealed new information concerning the pear psylla parasitoid complex. *Trechnites* sp., *Psyllaephagus* sp., *Pachyneuron siphonophorae* (Ashmead), *P. albutius* (Walker), and *D. rathmanae* Menke and Evenhuis were reared from pear psylla in the laboratory and collected from beating trays. *C. pyricola* is a new host for all of these species except *Trechnites*. Psyllidae is a new host family record for *Pachyneuron*. Biological information from Krombien *et al.* (1979) indicated that *P. albutius* and *P. siphonophorae* are probably hyperparasites of pear psylla while *Trechnites* sp. and *Psyllaephagus* sp. are primary parasitoids of pear psylla. *D. rathmanae,* a hyperparasitioid of pear psylla (Rathman and Paulson 1991), was a new genus record for North America and a new species described by Menke and Evenhuis (1991).

Although hosts of most parasitoids collected in this study were not determined, there appeared to be a correlation between the microhabitat preferences of reported hosts of the parasitioids and the microhabitat from which the parasitoids were collected (method of collection). For example, spider egg sac parasitoids *Gelis* (Ichneumonidae) and *Baeus* (Scelionidae), and carabid egg parasitoid *Trimorus* (Scelionidae) were only collected in pitfall samples. Similarly, Weseloh (1986) reported correlations between patterns of parasitoids caught on sticky traps in various forest microhabitats and parasitoid host preferences. These studies indicate that method and microhabitat of collection may reveal important information about parasitoid host range. Host range of many taxa listed in Table 1 can be found in Krombein *et al.* (1979).

Table 1. Parasitic Hymenoptera collected from a pear orchard under organic management in Washington State. Specimens were collected through the use of a beating tray (BT) and/or pitfall traps (PF).

	BT	PF
Parasitica		
Ceraphronoidea		
Ceraphronidae		
Ceraphron spp.	+	+
Unknown Genus	−	−
Megaspilidae		
D. niger	+	−
Dendrocerus sp.	+	−
Chalcidoidea		
Aphelinidae		
Coccophagus sp.	+	−
Neodusmetia sp.	−	+
Chalcididae		
Invreia sp.	−	+
Encyrtidae		
Trechnites sp.	+	−
Psyllaephagus sp.	+	−
Litomastix spp. (2)	+	−
Zarhopalus sp.	+	−
Procheiloneurus sp.	+	−
Metaphycus spp. (2)	+	−
Cerchysius sp.	+	−
Isodromus sp.	+	−
Paralitomastix sp.	+	−
Unknown Genera (6)	+	−
Signophoridae		
Signiphora sp.	+	−
Thysanus sp.	−	+
Eulophidae		
Chrysocharis sp.	+	−
Diglyphus sp.	+	−
Elachertus sp.	+	−
Euplectrus sp.	+	−
Chrysonotomyia sp.	+	−
Tetrastichus spp. (2)	+	−
Hyssopus sp.	+	−
Pnigalio sp.	+	−
Eupelmidae		
Eupelmella sp.	+	+
Eurytomidae		
Eurytoma spp.	+	−
Sycophila sp.	+	−
Harmolita sp.	+	−
Eudecatoma sp.	+	−
Mymaridae		
Unknown Genus	−	+
Perilampidae		
Perilampus hyalinus Say	+	−
Pteromalidae		
Gastrancistrus sp.	+	−
Asaphes sp.	+	−
Pachyneuron sp.	+	−
P. albutius (Walker)	+	−
P. siphonophorae (Ashmead)	+	−
Homoporus sp.	+	−
Tritneptis sp.	+	+
Mesopolobus sp.	+	−
Halticoptera sp.	+	−
Spalangia sp.	−	+
Torymidae		
Monodontomerus sp.	+	−
Cynipoidea		
Charipidae		
Dilyta rathmanae	+	−
Alloxysta sp.	+	−
Cynipidae		
Unknown Genus	+	−
Stephanoidea		
Stephanidae		
Schlettererius sp.	+	−
Ichneumonoidea		
Braconidae		
Praon sp.	+	−
Trioxys sp.	+	−
Mirax sp.	+	−
Orgilus sp.	+	−
Hormius sp.	+	−
Chelonus sp.	+	−

	BT	PF
Ichneumonidae		
Othocentrus spp. (3)	+	–
Stenomacrus spp. (2)	+	–
Gelis spp. (7)	–	+
Proctotrupoidea		
Diapriidae		
Trichopria spp.	+	+
Platygastridae		
Amblyaspis spp.	+	–
Platygaster sp.	+	–
Synopeas spp.	+	–
Inostemma sp.	+	–
Scelionidae		
Scelio spp.	+	–
Telenomus spp.	+	+
Idris spp.	+	+
Anteris sp.	+	–
Trimorus sp.	–	+
Baeus sp.	–	+
Aculeata		
Chrysidoidea		
Bethylidae		
Goniozus spp. (3)	+	–
Epyris spp. (2)	–	+
Chrysididae		
Unknown Genus	+	–
Dryinidae		
Aphelopus sp.	+	–

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Specimens were identified by J.B. Johnson (Dept. of Soil, Plant and Entomological Sciences, Univ. of Idaho, Moscow, ID) and the following USDA-ARS, Systematic Entomology Laboratory taxonomists: R.W. Carlson, E.E. Grissell, A.S. Menke, P.M. Marsh, and M.E. Schauff. Voucher specimens have been placed in the James Entomological Museum, Washington State University, Pullman, WA and the Barr Entomological Museum, Univ. of Idaho, Moscow, ID.

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POTENTIAL HOST RANGE AND PERFORMANCE OF A REPORTEDLY MONOPHAGOUS PARASITOID, *PTEROMALUS CEREALELLAE* (HYMENOPTERA: PTEROMALIDAE)[1]

John H. Brower[2]

ABSTRACT: Larvae or prepupae of 12 species of beetles were tested as possible hosts of *Pteromalus cerealellae*, a reportedly monophagous parasite of *Sitotroga cerealella* (Lepidoptera: Gelichiidae). This parasitoid attacked and developed successfully in 12 species of beetles in the families: Anobiidae, Bostrichidae, Bruchidae and Curculionidae. This extension of the host range of this parasitoid greatly increased its utility as a biological control agent for stored-product pests.

A cosmopolitan parasite of the Angoumois grain moth, *Sitotroga cerealella* (Olivier), was described in 1902 as *Catolaccus cerealellae* Ashmead from a culture of *S. cerealella* originating in Philadelphia, PA (Ashmead 1902). Girault (1917) placed this species in the genus *Habrocytus* Thomson where it generally remained until Boucek (1977) lumped this genus under *Pteromalus* Swederus because no clear character enables separation of the two groups. This species has been reported from many parts of the U.S. and from many countries of the world (Peck 1963, Graham 1969, Krombein *et al.* 1979), but only two studies of its biology have been published (Noble 1932, Fulton 1933). In all of these reports, the specimens were obtained from cultures of *S. cerealella* or from infested grain where this species was present. In fact, this parasitoid is always listed as being monophagous on *S. cerealella* (Krombein *et al.* 1979, Boucek 1988), except for one early report by Flanders (1930).

It is not particularly unusual for a parasitoid to be monophagous, but most of the other parasitoids of stored-product pests appear to be more habitat specific than host specific. It was with this in mind that a study of the host range of *Pteromalus cerealellae* (Ashmead) was undertaken. The results of that study are reported here.

MATERIALS AND METHODS

The culture of *P. cerealellae* originated as a field collection on *S. cerealella* in wheat from Eagle Pass, Texas in 1984. It has been cultured since that time in the laboratory on *S. cerealella* reared in wheat. In

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[2] Stored-Product Insects Research Lab, ARS, USDA, P.O. Box 22909, Savannah, GA 31403.

general, rearing conditions were 27°C ± 2°C, 60 ± 5% RH, and a 12 h photophase:12 h scotophase. New stock cultures of *P. cerealellae* were established three times a week by aspirating about 50, 0 to 2-day-old adults (25 males, 25 females), briefly exposing them to CO_2, and placing them in 1 liter jars containing a 14 - 18-day-old culture of *S. cerealella* in ca 380 g of wheat. All *P. cerealellae* adults were removed after one week by sifting. Cultures were incubated at the controlled conditions, and emergence usually started ca. 14 days after setup. Most adult emergence was completed within one week.

The species of parasitoid used in these tests was determined by Dr. E.E. Grissell, Systematic Entomology Laboratoy, ARS, USDA to be *Pteromalus cerealellae* (Ashmead). The culture was identified in 1984 before host range testing began and then reconfirmed in 1989 after the test was terminated. In 1989 separate cultures reared for many generations on *Callosobruchus maculatus* (Fab.) and on *Sitotroga cerealella* were both identified as *P. cerealellae* by Dr. E.E. Grissell. Voucher specimens of these cultures have been deposited in the USNM.

Hosts were obtained from laboratory stock cultures, and the species tested are shown in Table 1. These cultures were started with clean grain or legumes inoculated with 100, 1-week-old adults of each species. Adults were left on the rearing medium for 5-7 days and then removed. Differences in reproductive rate among potential host species resulted in cultures with very different host densities. The medium was then incubated at the aforementioned controlled conditions until both mid-and late-instar larvae were present. The time interval was dictated by the developmental rate of each species (Hill 1990). The rearing medium was then thoroughly mixed and weighed into 100 g samples that were placed in 250 ml jars with filter paper tops. Normally ten samples of each potential host species were prepared and half were randomly assigned to be infested with ten pairs of *P. cerealellae*. One to 7-day-old adults of *P. cerealellae* were collected from stock cultures reared on *S. cerealella* and ten males and ten females were selected using a dissecting microscope. The adult *P. cerealellae* were removed from the host samples after 7 days and counted to ensure recovery of all of the parental adults. The samples were then incubated as before until parasitoids or hosts started to emerge. Adults were removed and counted three times a week until emergence ceased or until a second generation of insects started to emerge. Counts were terminated after the first generation.

RESULTS AND DISCUSSION

The results of this test were unexpected. Out of 12 species of stored-product beetles tested, each of them were attacked by the parasitioid and each sustained the development of the parasitoid to the adult stage (Table 2). Not ony did *P. cerealellae* develop on each of the hosts tested, it developed very well on several of the species. Most notable was the success of this parasitoid on high density populations of the cowpea weevil (Table 2). On groups of pupae and mature larvae of this host, an average number of 488 and 278 parasitoids emerged per culture, and the emergence of beetle adults was reduced by 89 and 97%, respectively. High density populations of the lesser grain borer also yielded over 100 parasites per culture, although the beetle populations were reduced only about 26% (Table 2). The parasite also developed well on the granary weevil and reduced populations of this pest by 66% (Table 2), and this may be of practical importance for biological control efforts.

Because it is now obvious that *P. cerealellae* is not monophagous, the observation by Flanders (1930) that this parasitoid also attacks the potato tuberworm, *Phthorimaea operculella* (Zeller), another species of gelechiid, should be considered valid.

The different potential host species varied in age from mid stage larvae to pupae at the time they were presented to the parasitoid, and cultures of the various species also varied widely in host density. Thus, no firm conclusions can be drawn on the relative host suitability of each species in comparison to others. However, the fact that *P. cerealellae* attacked and developed successfully on a wide range of host beetles is of great significance to biological control efforts in stored grain (Brower & Cogburn 1989). For example, if *P. cerealellae* are released into grain storages that don't contain *S. cerealella*, then the parasitoid may attack species of beetles present and perhaps maintain its population until *S. cerealella* migrants move into the storage. Or conversely, if the parasitoid is released and it successfully suppresses or eliminates a resident population of the *S. cerealella*, then it may transfer to alternate beetle hosts and help to suppress their populations. Because published reports never list this species as a beetle parasitoid, the indication is that this species of parasitoid probably prefers *S. cerealella* as a host. However, the data presented here indicates that if released into grain bins it would probably transfer to alternate hosts in the absence of its primary host.

Table 1. Species of beetles tested as alternative hosts for the monophagous parasitoid, *Pteromalus cerealellae* (Ashmead)

Family	Scientific Name	Common Name	Ages Tested (days)
Anobiidae	*Lasioderma serricorne* (Fab.)	Cigarette Beetle	13-20
Anobiidae	*Stegobium paniceum* (L.)	Drugstore Beetle	21-28
Bostrichidae	*Rhyzopertha dominica* (Fab.)	Lesser Grain Borer	17-24
Bostrichidae	*Prostephanus truncatus* (Horn)	Larger Grain Borer	21-28
Bruchidae	*Acanthoscelides obtectus* (Say)	Bean Weevil	16-23
Bruchidae	*Callosobruchus analis* (Fab.)		13-20
Bruchidae	*Callosobruchus chinensis* (L.)		18-26
Bruchidae	*Callosobruchus maculatus* (Fab.)	Cowpea Weevil	13-20
Bruchidae	*Callosobruchus rhodesianus* (Pic)		12-19
Curculionidae	*Sitophilus granarius* (L.)	Granary Weevil	9-16
Curculionidae	*Sitophilus oryzae* (L.)	Rice Weevil	9-16
Curculionidae	*Sitophilus zeamais* Mots.	Maize Weevil	8-15

Table 2. Mean number of parasitoid progeny (± SE) when various factitious hosts were exposed to 10 pairs of *P. cerealellae* for 1 week and % reduction compared to untreated checks

	Checks	*P. cerealellae* (10 pairs)		
Factitous hosts tested	**$\bar{x}$ No. Beetles** (± SE)	**$\bar{x}$ No. F_1 Parasites** (± SE)	**$\bar{x}$ No. Beetles** (± SE)	**% Reduction**
L. serricorne	93.0±4.2	32.0±18.2	78.6±32.0	15.5
S. paniceum	50.0±4.3	6.4±2.1	43.6±13.7	12.8
R. dominica	1338.8±24.0	104.0±10.9	987.4±45.0	26.2
P. truncatus	165.3±17.6	2.8±1.0	66.6±16.3	59.7
A. obtectus	21.0±3.1	0.8±0.4	21.0±2.2	0
C. analis	113.6±5.5	4.0±1.1	102.0±4.1	10.2
C. chinensis	68.8±1.6	32.2±3.6	22.8±4.2	66.9
C. maculatus	500.0±9.3	278.4±10.0	17.2±4.5	96.6
C. rhodesianus	27.0±1.1	6.0±2.5	11.0±4.6	59.3
S. granarius	175.6±12.9	58.4±15.3	77.2±36.8	66.0
S. oryzae	609.4±25.4	5.4±2.8	561.8±14.3	7.8
S. zeamais	110.0±3.8	2.0±1.38	93.8±6.8	14.7

ACKNOWLEDGMENTS

I am indebted to E. Eric Grissell, Research Entomologist, Systematic Entomology Laboratory, ARS, USDA, Beltsville, MD for identification of the parasitoid, and to Timothy Foard, Biological Aid, for helping with all phases of these tests.

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ELMIDAE OF TAIWAN PART I: TWO NEW SPECIES OF THE GENUS *STENELMIS* (COLEOPTERA: DRYOPOIDEA) WITH NOTES ON THE GROUP OF *STENELMIS HISAMATSUI*[1]

Ming-Luen Jeng, Ping-Shih Yang[2]

ABSTRACT: Two new species of Elmidae: *Stenelmis wongi* and *Stenelmis formosana*, belonging to the group of *Stenelmis hisamatsui*, are described and illustrated. Descriptions of their habitats and ecological information are also included. A key and checklist to the species of *hisamatsui* group are given.

Elmidae is one of the major components in stream coleopteran fauna. More than 120 genera and about 1200 species are known from the world.

Most of the genera of Elmidae are endemic. In fact, not any genus can be considered truly cosmopolitan. *Stenelmis* is the elmid genus most nearly cosmopolitan and with the largest number of species. There are 146 species known from the whole world except Neotropical Region (Brown, 1981). *Stenelmis sauteri* Kôno 1936 is the only recorded species of this genus from Taiwan. The authors obtained this species from the neighborhood of its type locality. However, it is more similar morphologically to genus *Ordobrevia* than to *Stenelmis*. Its status will be discussed in another paper. Two new species of *Stenelmis* from Taiwan, belonging to *hisamatsui* group, are reported in this paper.

MATERIALS AND METHODS

The elmid materials available for this study were collected since 1987 by the authors and their colleagues from the laboratory of Insect Conservation of the Department of Plant Pathology and Entomology, N.T.U. The samples were captured by the modified Surber net sampler (50 cm x 50 cm x 50 cm), D-frame aquatic net (diameter 39 cm, depth 47 cm), and light trap.

The measurements used in the article are shown in Fig. 1. Coloration was observed under a white light source, and the specimens were deposited in 75% ethanol. The type specimens are preserved in 75% ethanol with a little glycerol.

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[1] Received February 16, 1991. Accepted April 30, 1991.

[2] Laboratory of Insect Conservation, Department of Plant Pathology and Entomology, National Taiwan University, Taipei, Taiwan 10764, R.O.C.

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The following abbreviations are used for depository institutions:

EMNTU	Entomological Museum of National Taiwan University, Taipei, Taiwan, R.O.C.
NMW	Naturhistorisches Museum Wien, Austria
NMNH	National Museum of Natural History, Smithsonian Institution, Washington D.C., U.S.A.
OMNH	Oklahoma Museum of Natural History, University of Oklahoma, Norman, U.S.A.
TARI	Department of Applied Zoology, Taiwan Agricultural Research Institute, Taichung, Taiwan, R.O.C.

Stenelmis Dufour s. lat.

Stenelmis Dufour, 1835: 158.

Type species: *Elmis canaliculata* Gyllenhall

Characterization - Adult: Body elongate, subparallel, moderately convex and finely pubescent dorsally. Body length 2-4 mm. Head globose, retractable within prothorax. Antennae slender, each 11-segmented. Maxillary palpi with apical segment oval and often largest. Pronotum with median longitudinal groove and sublateral carinae or lateral tuberculi, but without transverse impression. Elytra elongate and subparallel, each bearing 8 punctate striae, with or without accessory striae; humeri not very prominent; lateral margins serrate; epipleura extending to near apex of elytron; apices rounded and often converged at apex. Venter and legs except tarsi covered with plastron setae. Granules on venter and legs round. Prosternum occupies about 2/3 area of prothorax from vental view; anterior portion deflected to permit retraction of head; lateral sides sinuate. Procoxae, mesocoxae and metacoxae moderately broadly separated. Mesosternum with a anteromedian excavation to accommodate prosternal process. 1st and 2nd visible abdominal sterna normal or with shallow impression on disk; the first three sterna with conspicuous lateral teeth attaching to epipleura. Protibiae without a fringe of hairy tomentum on the inner margin. Tarsi 5-segmented, tarsal claws with or without basal teeth. Male genitalia elongate, moderately broad; median lobe longer than parameres and usually longer than basal piece which is asymmetric.

The species occurs commonly in streams, lakes or ponds (Sanderson, 1953). Adults are positively phototactic and can be attracted by light traps during flight periods occurring from summer to autumn (Seagle, 1980).

Group of *Stenelmis hisamatsui*

Characterization: Body length 2.2-3.1 mm in known species. Color reddish brown to black. Interspace between pronotal longitudinal groove and sublateral carinae irregularly undulated. Elytra without accessory stria. Prosternal process subparallel, with round or slightly emarginated apex. The first two visible abdominal sterna impressed shallowly on disk and with carinae laterally beside the impression. Legs stout, hind tibiae of males more strongly curved, and with serial denticulations on inner side from basal 1/4 to apices; hind tibiae of females normal and with inside smooth. Apicoventral margin of tarsomere 5 with an elongate rounded process; tarsal claws without basal claws. Male genitalia with a closely pubescent projection on each paramere at about apical 1/5 dorsally.

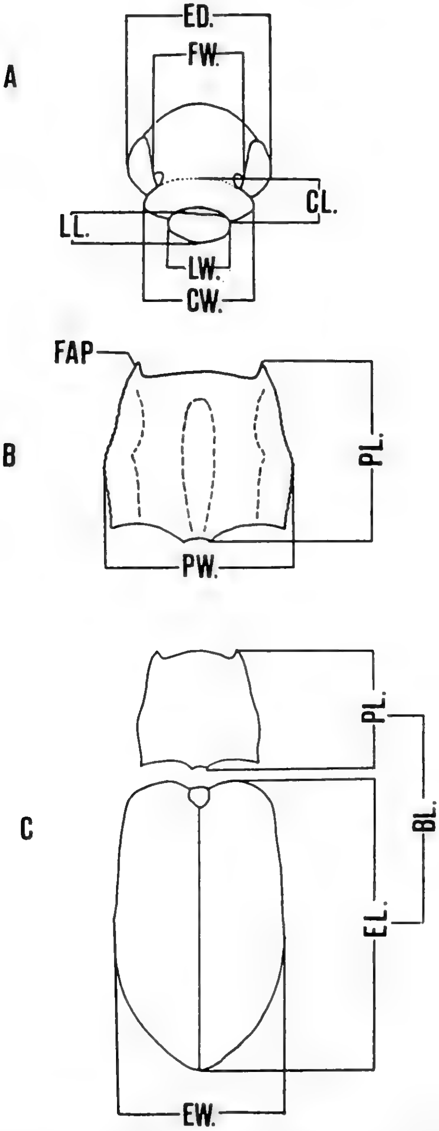

Figure 1. Morphological terminology: A. head; B. pronotum; C. pronotum and elytra. FW.: width of frons; ED.: distance across eyes; CW.: width of clypeus; CL.: length of clypeus; LW.: width of labrum; LL.: length of labrum; PW.: width of pronotum; PL.: length of pronotum; FAP.: frontal angle of pronotum; EL.: length of elytron; EW.: width of elytra; BW.: width of body (EW. = BW.); BL.: length of body (BL. = PL. + EL.).

Type species: *Stenelmis hisamatsui* Satô, 1960

Nomura first mentioned this group, including 6 species serially distributed from Japan to Southeast Asia in his letter to Satô (Satô, 1964b). But he did not define the group. This group now, at least, contains 7 species including 2 new Taiwanese species: *Stenelmis formosana* sp. nov. and *Stenelmis wongi* sp. nov. *S. birmanica* Grouve., another species in this group according to Nomura, is ignored here because of insufficient morphological data. A distribution map is shown in Fig. 8. It is clear that these species are distributed around mainland China and we infer that they split from a common ancestor distributed in China. It is a pity that we still do not know this ancestor since the study about elmids of mainland China is not complete. On the other hand, four species: *S. aritai* Satô, *S. ishiharai* Satô, *S. formosana* sp. nov., and *S. wongi* sp. nov. are more similar morphologically than the other members of the group. In addition, their distributions (the first two in Sakishima Is. and the other two in Taiwan) are very close. We suspect that they may have had a recent ancestor living in this area while land bridges existed between these islands during glacial periods of the Pleistocene epoch. Speciation among these four species occurred after these islands and Taiwan were isolated when glacial periods finished, and they may have diverged later than the other species in this group.

The following key, partially based upon characters extracted from the literature, is presented to separate species in this group.

Key to the adults of the *S. hisamatsui* species group

1. **Frontal angles of pronotum truncate laterally; middle tibiae of male with serial denticulations on inner side ---------- *metatibialis* (Vietnam)**
   Frontal angles of pronotum not truncate laterally; middle tibiae of male without serial denticulations on inner side ---------- 2
2. Body size 2.4-2.8 mm ---------- 4
   Body size smaller or larger ---------- 3
3. Body size smaller (under 2.4 mm) ---------- *hisamatsui* (Ryukyu)
   Body size larger (above 2.8 mm) ---------- *nipponica* (Japan)
4. Pronotum bi-sinuate laterally; narrowest at apical 2/5; prosternal process with apex round ---------- *ishiharai* (Ryukyu)
   Pronotum less sinuate laterally, broadest at basal 1/3 and thence gradually narrowed anteriorly; prosternal process with apex mostly emarginate ---------- 5
5. Surface of pronotum somewhat densely granulate (Fig. 5); frontal angles of pronotum less than 60° ---------- *formosana* (Taiwan)
   Surface of pronotum sparsely granulate (Fig. 4); frontal angles of pronotum more than 60° ---------- 6
6. Granules on pronotum finer than those on head; frontal angles with apex dully pointed ---------- *aritai* (Ryukyu)
   Granules on pronotum not finer than those on head; frontal angles with apex somewhat sharp (Fig. 4) ---------- *wongi* (Taiwan)

Stenelmis wongi, sp. nov.

Fig. 2, 4, 6

Body length (PL. + EL.): 2.5-2.8 mm, width (EW.): 1.0-1.1 mm.

Coloration: Reddish brown to dark brown, ventral surface lighter; covered with black granules throughout all the body and legs (except tarsi); epicranium dark brown except occiput lighter; antennae, mouthparts, tarsi and genitalia translucently yellowish brown.

Head (Fig. 2E): Subparallel behind eyes from dorsal view; vertex and occiput retractable within pronotal collar; cuticle covered with granules, on clypeus and frons denser than elsewhere; labrum, clypeus, and frons rather finely punctate; labrum subrectangular, about 2 times broader than long, but looks like long elliptic when retracted in clypeus; clypeus moderately convex in center, lateral margins round; ratio of length between clypeus and labrum (CL.:LL.) about 1.3; of width about 1.7; frontoclypeal suture not distinct; eyes round, width across the eyes (ED.) about 1.6 times as broad as frons width (FW.); surface of antennae reticulate under SEM, and with sparse sensory hairs apically, the first segment dilated and distal one strongly pointed at apex; the ratios of segments (1-11) are: 1.0 : 0.6 : 0.6 : 0.5 : 0.5 : 0.6 : 0.7 : 0.8 : 0.7 : 0.8 : 1.3.

Pronotum (Fig. 2E, F): Subquadrate as seen from above; slightly broader than long by about 1.2 times; widest at basal 2/5; base about 1.3 times as broad as apex; lateral side crenulate but not distinctly sinuate; frontal angle conspicuous, about 75° by dorsal view; about 85° by basal angle; surface coarsely granulated, more densely in lateral sides of median longitudinal groove and sublateral carina area, but very sparsely in median groove; median longitudinal groove more deeply impressed at center of pronotum, extending from base to apical 1/6; sublateral carina convex, sinuate, extending from base to apical 1/7; two small round deep depressions beside base of median groove. Scutellum subpentagonal, granulated sparsely.

Elytra: about 1.7 times as long as broad, wider than pronotum by about 1.2 times, broadest at about apical 1/3; lateral sides subparallel anteriorly and tapering arcuately posteriorly to round apex; lateral margins finely serrate; surface covered with minute and close granules and fine pubescence; each elytron bearing 8 complete punctate striae, strial punctures on disk rather large, deep, subcircular, and separated from one another by less than their own diameters, but becoming smaller and more shallow posteriorly; strial intervals with one or two irregular rows of coarse granules, slightly elevated, the 5th one narrowly carinate from humerus to apical 1/9; epipleura (Fig. 2J) narrowed gradually from basal 2/5 to apex.

Prosternum: Prosternal process (Fig. 2G.) with sparser and larger granules than on anterior portion, margins elevated, slightly expanded posteriorly, apex round or moderately emarginated.

Mesosternum: Coarsely granulate; hind angle (Fig. 2H) beside mesocoxal cavity with apex sharp.

Metasternum: (Fig. 6): Coarsely and sparsely granulated, median impressed line distinct, extending from posterior margin to anterior 1/4; transverse metasternal suture distinct.

Abdomen: Surface coarsely granulated on first visible sternum and progressively less coarse posteriorly, but on disk sparser than on lateral area; the 5th sternum (Fig. 2I) sinuate laterally and slightly emarginate at apex in both sexes.

Legs: Closely granulate except on tarsi; tibiae subequal to femora, and with small apical spurs; hind tibia (Fig. 2K) of male distinctly dilated at basal 1/3 on inner side; tarsi 5-segmented, last segment longer than others; the first four segments each with a short apical tuft of setae on ventral side; tarsal claws large, without basal teeth.

Male genitalia: (Fig. 2A, B, C): convex dorsally; median lobe about 1.2 times as long as

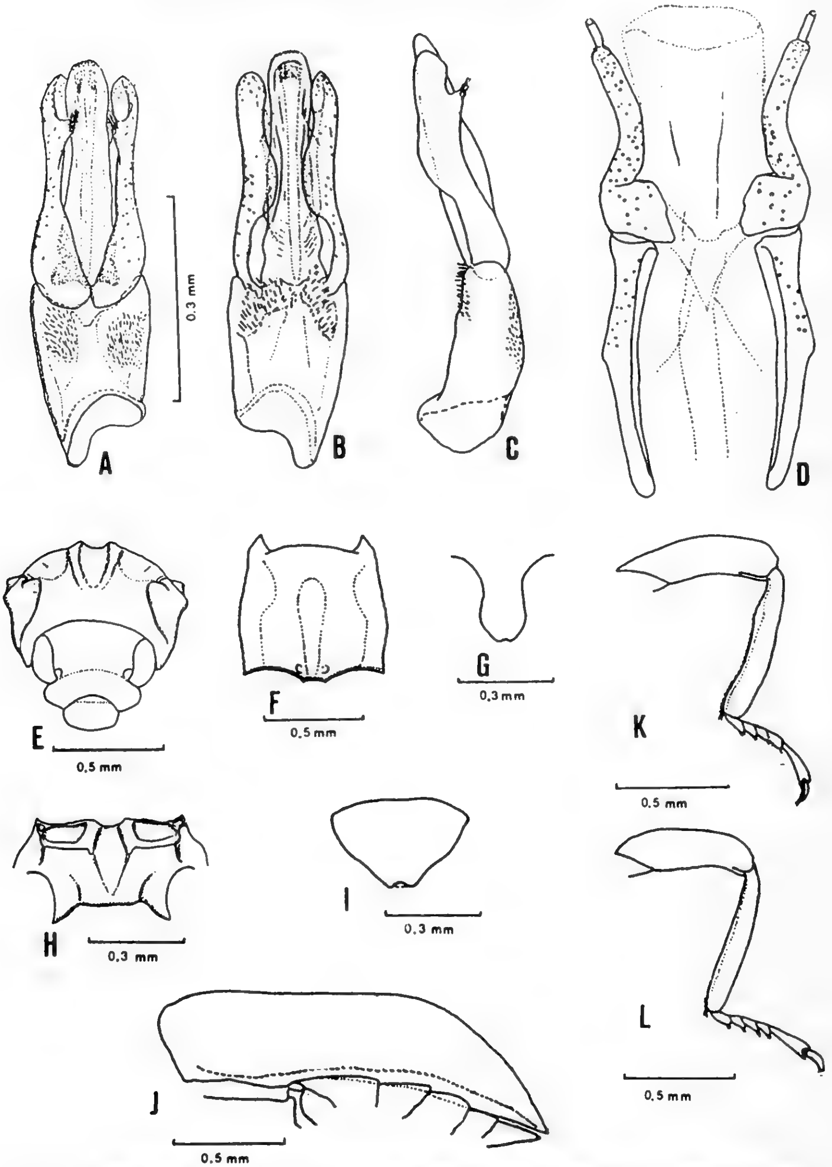

Figure 2. *Stenelmis wongi* n. sp.: A. male genitalia (dorsal view); B. ditto (ventral view); C. ditto (left lateral view) D. female genitalia (ventral view); A-D are drawn to same scale; E. head and pronotum (frontal view); F. pronotum (dorsal view); G. prosternal process; H. mesosternum (ventral view); I. the 5th abdominal sternum (♀); J. elytron (lateral view); K. hind leg (♂); L. hind leg (♀).

basal piece, expanding posteriorly; paramere with many setae at apex and median portion, shorter than median lobe, with a dorsal, densely pubescent tooth or projection at apical 1/6 of paramere, and expanded medially at apical 2/3 ventrally; basal piece asymmetric, convex dorsally, with close pubescence on dorsal and ventral surface.

Female: Body size larger than male in general (male 2.5-2.6 mm; female 2.6-2.8 mm in our material); hind tibia more slender and not dilated on inner side (Fig. 2L); genitalia as in Fig. 2D.

Variations: Color of young adults is lighter than the older ones (Maybe the old adults' surface is dirty and looks darker than the young.). The prosternal process is not emarginated apically in local population of Nuannuan, Keelung city. Frontal angles of pronotum ranged from 60° - 83°, mean ± SD = 73° ± 7 (n = 30).

Specimens examined: Holotype ♂, Keelung city, Nuannuan, 20-VIII-1990, Jeng M.L. leg.. Paratypes: 3 ♂♂, 4 ♀♀, same data as holotype; 2 ♂♂, Taipei Hsien, Pinglin, 21-VI-1989, Wong K.C., Jeng M.L., and Hsieh S.H. leg.; 1 ♀, Taipei Hsien, Pinglin, 22-XI-1989, Wong K.C. leg.; 2 ♂♂, 4 ♀♀, Taipei Hsien, Pinglin, 26-VIII-1986, Wong K.C. and Hsieh S.H. leg.; 1 ♀, Taipei Hsien, Pinglin, 19-II-1990, Wong K.C. and Lee C.W. leg; 1 ♀, Taipei Hsien, Pinglin, 7-VII-1989, Wong K.C. leg.; 2 ♀♀, Taipei Hsien, Tongho, 28, 29-VIII-1989, Wong K.C. leg.; 2 ♀♀, Taipei Hsien, Tongho, 28, 29-VIII-1989, Wong K.C. and Jeng M.L. leg.; 1 ♀, Ilan Hsien,Chaoshih, 16-XII-1989, Jeng M.L. leg.; 1 ♀, Taipei city, Waishung-shi, 27-VIII-1987, Wong K.C. leg.; 1 ♀, Taipei Hsien, Wulai, 27-VIII-1990, Jeng M.L. leg.; 3 ♀♀, Taipei Hsien, Sanshah, 13-VIII-1990, Jeng M.L. leg.; 1 ♀, Sanshah, 14-X-1990, Jeng M.L. leg.; 3 ♀♀, Taipei Hsien, Teng-liao, 20-X-1990, Jeng M.L. leg.; 2 ♂♂, Taoyuan Hsien, Dashi, 6, 7-XII-1990, Hsu I.S. leg.. Most of the specimens were captured by modified Surber net sampler and D-frame water net, and the last collection data were by mercury lamp light trap.

Holotype and some paratypes are deposited in EMNTU; other type series will be deposited in NMW, NMNH, OMNH, TARI, and Dr. M. Satô's collection, Nagoya, Japan.

Etymology: The specific name is in honor of Mr. K.C. Wong who gave us so much help in many ways.

Diagnosis: This species is closely related to *Stenelmis aritai* from Ryukyu archipelago. These can be separated from each other by characters in the key.

Distribution and habitats: This species is distributed in north Taiwan as shown in Fig. 9. Most of the localities are branches of Tamsui River. These habitats are all the upstreams and are often the shaded stream in the forest. Their elevations are lower than 500 m. Most of the type series were collected from gravels and pebbles in shallow riffles in the stream like the microhabitats of *Zaitzevia* species. A few were taken from cobbles. All of the habitats have minimum pollution.

Stenelmis formosana sp. nov.

Fig. 3, 5, 7

Body length (PL. + EL.): 2.4-2.8 mm, width (EW.): 1.0-1.1 mm.

Coloration: Reddish brown to dark brown dorsally, pronotum and central line of elytra lighter in newly emerged specimens; ventral surface lighter; body surface covered with dark granules; appendages of head, tarsi and genitalia translucently yellowish brown.

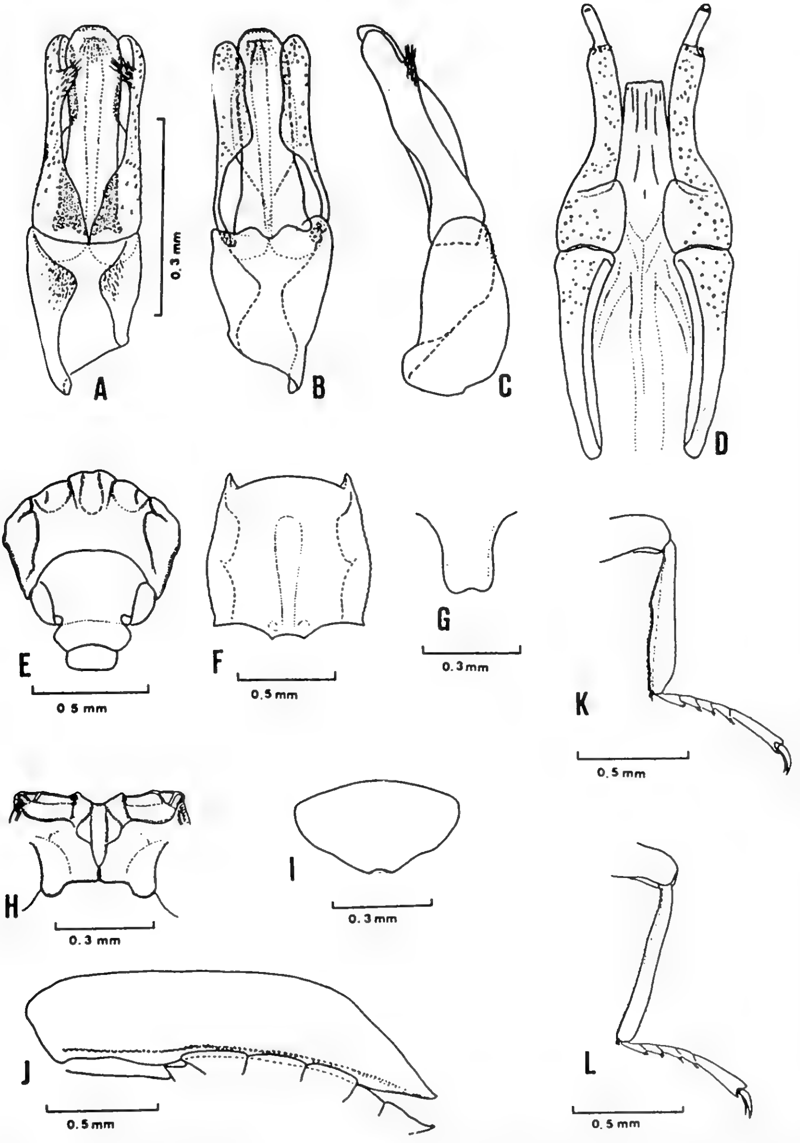

Figure 3. *Stenelmis formosana* n. sp.: A. male genitalia (dorsal view); B. ditto (ventral); C. ditto (left lateral view); D. female genitalia (ventral view); A-D are drawn to same scale; E. head and pronotum (frontal view); F. pronotum (dorsal view); G. prosternal process; H. mesosternum (ventral view); I. the 5th abdominal sternum (♀); J. elytron (lateral view); K. hind leg (♂); L. hind leg (♀).

Head (Fig. 3E): Subparallel behind eyes from dorsal view; distance across eyes broadest; labrum subrectangular, about 2 times as broad as long, but looks like long elliptic when retracted in clypeus; clypeus broader than labrum by 1.5 times; eyes slightly prominent, distance across eyes (ED.) about 1.6 times as broad as frons (FW.); antenna 11-segmented, with sensory hairs apically, the first segment dilated and distal one strongly pointed at apex; the ratios of segments (1-11) are: 1.0 : 0.7 : 0.6 : 0.5 : 0.4 : 0.6 : 0.5 : 0.6 : 0.7 : 0.7 : 1.1.

Pronotum (Fig. 3E, F): Slightly broader than long by about 1.1 times; widest at basal 1/3; base about 1.3 times as broad as apex; lateral side crenulate, round or slightly sinuate; frontal angle conspicuous, about 45° in dorsal view; about 85° to 90° by basal angle; surface somewhat densely granulated, more densely in lateral sides of median longitudinal groove and sublateral carina area, but very sparsely in median groove; median longitudinal groove extending from base to apical 1/5, groove more deeply impressed at central pronotum; sublateral carina convex, sinuate, extending from base to apical 1/6; two small round depressions besides the base of median groove. Scutellum subpentagonal, granulated sparsely.

Elytra: About 1.8 times as long as broad, 1.3 times broader than pronotum, broadest at about apical 1/3; thence subparallel anteriorly and tapering arcuately posteriorly to round apex; lateral margins finely serrate; surface covered with minute and close granules and fine pubescence; punctures on disk rather large, deep, subcircular, and separated from one another by equal or slightly less than their own diameters, but becoming smaller and more shallow posteriorly; strial intervals with one or two irregular rows of coarse granules, slightly elevated, the 5th strial interval narrowly carinated from humerus to near apex; epipleura (Fig. 3J) narrowed gradually from basal 2/5 to apex.

Prosternum: Prosternal process (Fig. 3G.) with larger and sparser granules than on anterior deflect portion, margins elevated, lateral sides subparallel or slightly expanded posteriorly, apex moderately emarginate.

Mesosternum (Fig. 3I): Apex of hind angle beside mesocoxal cavities bluntly rounded.

Metasternum (Fig. 7): More coarsely and closely granulated than the preceding species; median impressed line distinct and complete; transverse metasternal suture distinct.

Abdomen: Surface coarsely granulate on first visible sternum and progressively less coarse posteriorly, but on disk sparser than on lateral area; the 5th sternum (Fig. 3I) sinuated laterally and slightly emarginate at apex in both sexes.

Legs: Closely granulate except on tarsi; tibiae with small apical spurs; hind tibia of male (Fig. 3K) distinctly dilated at basal 1/3 on inner side; distal tarsal segment longer than others; the first four segments each with a short apical tuft of setae ventrally; the apex of last segment with a process ventrally; tarsal claws without basal teeth.

Male genitalia (Fig. 3A, B, C): Median lobe expanded posteriorly, about 1.3 times as long as basal piece; paramere shorter than median lobe, with bluntly rounded apex, and with a dorsal pubescent tooth or projection at apical 1/5, and bearing many fine setae at apex and median portion; basal piece asymmetric, each side provided with close pubescence ventrally at base.

Female: Body size usually larger than male (male 2.4-2.6 mm; female 2.5-2.8 mm); hind tibia (Fig. 3L) more slender and not dilated on inner side; genitalia as in Fig. 3D.

Variations: Color of newly emergent adults collected by light trap is lighter than the older ones; prosternal process sometimes asymmetric at apex; the frontal angle of pronotum ranged from 30° to 60°, mean ± SE = 45° ± 5° (n = 30).

Specimens examined: Holotype male, Taipei city, Waishung-shi, 20-VI-1987, Wong K.C. leg.; paratypes: the same locality and collector as holotype: 7 adults, 25-VII-1987; 5 adults, 28-VIII-1987; 3 adults, 17-IX-1987; 1 adult, 4-X-1987; 5 adults, 18-X-1987; 1 adult, 8-XI-1987; 1 adult, 13-XII-1987; 1 adult, 28-V-1988; 11 adults, 20-VI-1988; 1 adult, 30-VII-1988;

Figure 4. *Stenelmis wongi* sp. nov.: ♂, dorsal view, younger adult.

Figure 5. *Stenelmis formosana* sp. nov.: ♂, dorsal view, younger adult.

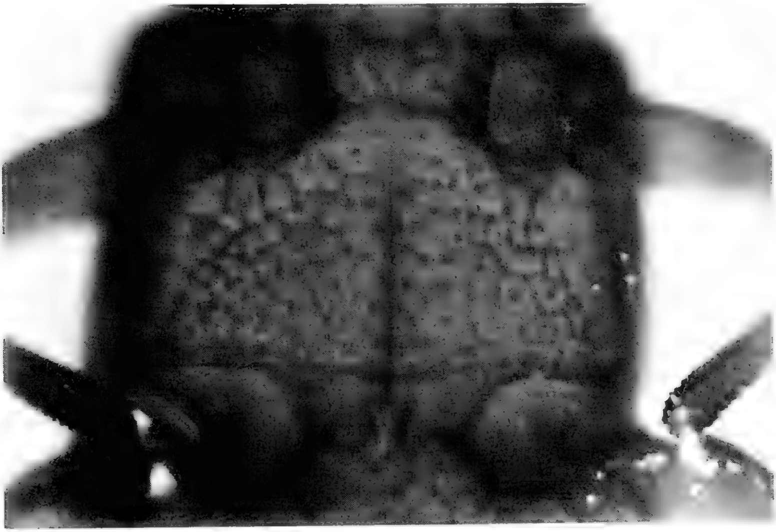

Figure 6. Metasternum of *Stenelmis wongi* sp. nov.

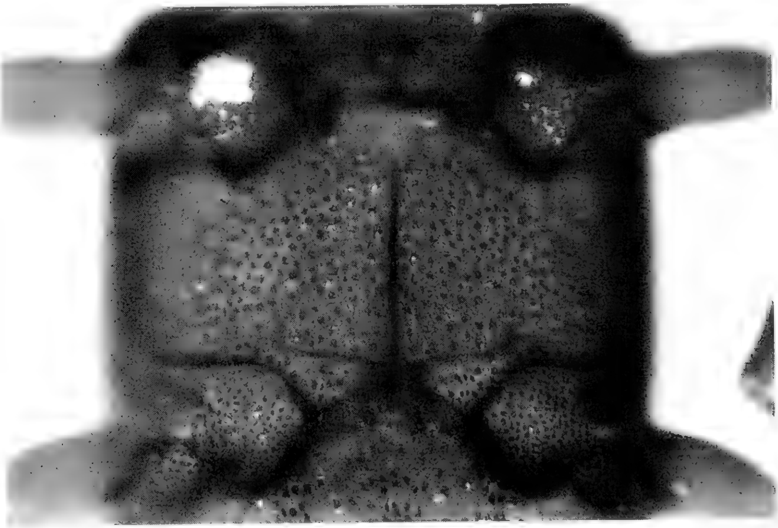

Figure 7. Metasternum of *Stenelmis formosana* sp. nov.

2 adults, 27-VIII-1988; 3 adults, 19-I-1989, Jeng M.L. leg.; 3 adults, 28-VII-1990, Jeng M.L. leg.. The following paratypes were collected around Taiwan: 14 adults, Taipei Hsien, Sanji, 25-VII-1990, Jeng M.L. leg.; 6 adults, Taipei Hsien, Wanli, 13-VII-1990, Jeng M.L. leg.; 1 adult, Taipei Hsien, Wulai, 27-VI-1990, Jeng M.L. leg.; 1 adult, Taipei Hsien,Sanshah, 16-VII-1990, Jeng M.L. leg.; 2 adults, Taipei Hsien, Sanshah, 14-X-1990, Jeng M.L. and Lin Y.J. leg.; 11 adults, Taipei Hsien, Shungshi Shang, 11-VIII-1990, Jeng M.L. leg.; 2 adults, Taipei Hsien, Teng-liao, 20-X-1990, Jeng M.L. leg.; 26 adults, Taoyuan Hsien, Dashi, 27, 28-XI-1990, Hsu I.S. leg.; 1 adult, Nantou Hsien, Puli, 5-IX-1989, Jeng M.L. leg.; 4 adults, Chiayi Hsien, Fanlu, 9-IX-1989, Jeng M.L. leg.; 20 adults, Kaohshung Hsien, Liogwai, 26, 28-V-1989, Jeng M.L. leg.; 6 adults, Kaohshung Hsien, Shanping, Hsu I.S. leg.; 11 adults, Pintong Hsien, Suchung-shi, 21-I-1990, Jeng M.L. leg.; 2 adults, Pintong Hsien, Suchung-shi, 30-VII-1990, Jeng M.L. leg.; 2 adults, Pintong Hsien, Kenting, 14-VIII-1990, Chang S.J. leg.; 26 adults, Pintong Hsien, Shinjung, 22-I-1990, Jeng M.L. leg.; 10 adults, Taitong Hsien, Chulu, 21-VIII-1989, Jeng M.L. leg.; 89 adults, Taitong Hsien, Peiyuan, 11-VIII-1989, Luo T.G., Wong K.C. and Jeng M.L. leg.; 5 adults, Taitong Hsien, Chikwai-tsuo, 31-I-1991, Jeng M.L. leg.; 8 adults, Taitong Hsien, Chengkong, 12-VIII-1989, Jeng M.L. leg.; 22 adults, Hwalien Hsien, Shitsuo, 11-VIII-1989, Jeng M.L., Luo T.G. and Wong K.C. leg.; 8 adults, Hwalien Hsien, Fuhyuan, 22-VIII-1989, Jeng M.L. leg.. Other specimens examined by Satô: 215 adults, Hwalien Hsien, Antong Spa, 12-VIII-1968, M. Nishikawa leg.

Holotype and some paratypes are deposited in EMNTU; other type series will be deposited in NMW, NMNH, OMNH, TARI, and Dr. M. Satô's collection, Nagoya, Japan.

Etymology: The specific name is derived from Taiwan because the species is widely distributed around Taiwan.

Diagnosis: This species is allied to *Stenelmis nipponica* Nomura, 1958 and *Stenelmis ishiharai* Satô, 1964; these can be separated by the key. This species is also similar to the preceding species, but the frontal angle of the pronotum is sharper and the granules of the metasternum are much denser than in *S. wongi* n. sp. (fig. 6, 7).

Distribution and habitats: This species is very common in lower altitude streams around Taiwan. The known localities are shown in Fig. 9. These streams are only slightly polluted. In contrast with *S. wongi*, the majority of the specimens were collected from cobbles, boulders, and blocks. Sometimes we found the adults clinging tenaciously to algae on submerged rocks in large numbers. These habitats are also favored microhabitats of *Grouvellinus* species. We think this species has greater tolerance limits to various pollutants.

Ecological Remarks: We have used light traps combining mercury lamp and black light to attract adults in the late summer. We obtained more females than males by the trap, and this is similar to American *Stenelmis* species (Seagle, 1980). Black light seems more effective than mercury lamp for attracting the species. Furthermore, we have observed that very few adults collected from the stream flew to fluorescent lamps when they were placed on dry land. We suspect that some adults have spent a bit of time under water before they began the flight period.

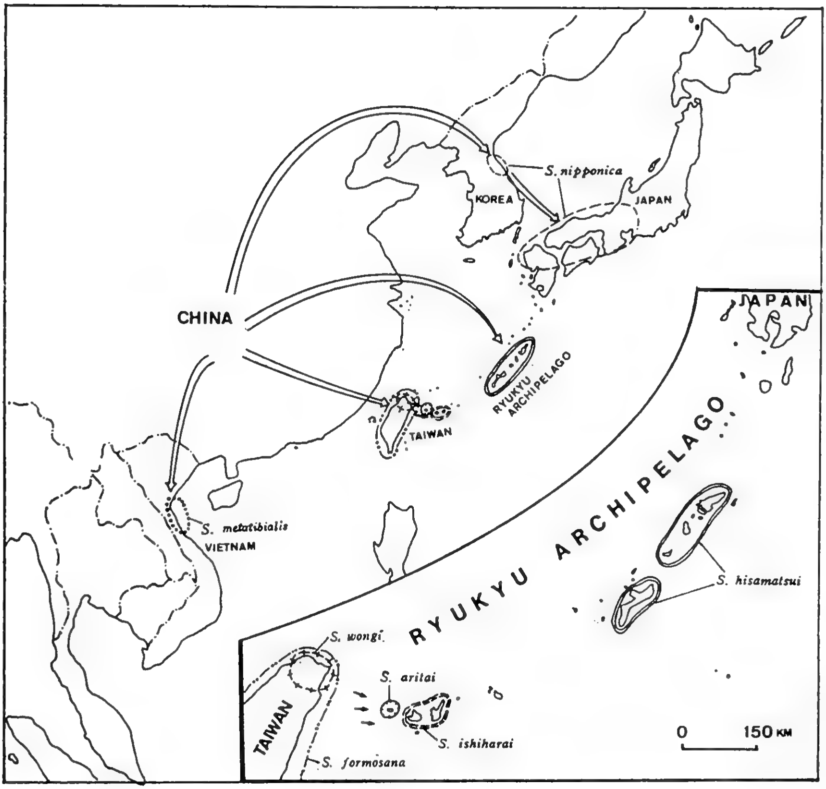

Figure 8. Distribution map of *Stenelmis hisamatsui*-group species. The arrows present the inferred pathways that the species of the group spread.

— — — — *S. nipponica* Nomura

═══════ *S. hisamatsui* M. Satô

= = = = *S. ishiharai* M. Satô

-•-•-•- *S. aritai* M. Satô

-+- -+- -+- *S. wongi* sp. nov.

—••—••— *S. formosana* sp. nov.

••••••••• *S. metatibialis* Delève

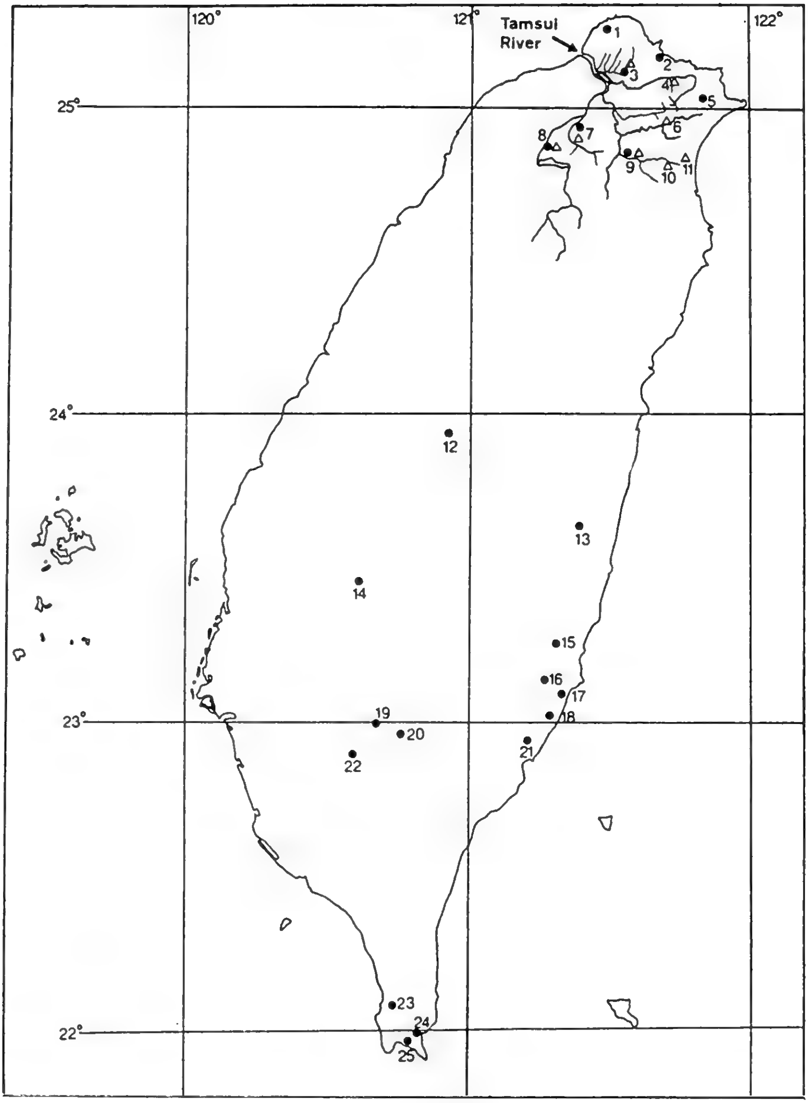

Figure 9. Distribution of *Stenelmis wongi* (△) and *Stenelmis formosana* (●) on Taiwan. The collection sites are: 1. Sanji, 2. Wanli, 3. Waishung-shi, 4. Nuannuan, 5. Shungshi Shang, 6. Pinglin, 7. Sanshah, 8. Dashi, 9. Wulai, 10. Tongho, 11. Chiaoshi, 12. Puli, 13. Fuhyuan, 14. Fanlu, 15. Antong Spa, 16. Shitsuo, 17. Chengkong, 18. Peiyuan, 19. Liogwai, 20. Shanping, 21. Chikwai-tsuo, 22. Meinong, 23. Suchung-shi, 24. Shinjung (Kangko), 25. Kenting

Hinton (1976) stated that he never saw any elmids collected from streams or rivers attempt to fly, even when they were placed on dry land. This should be just a common condition but not absolute. Our observations support the statement of Brown (1987) that a fair number of light-trapped elmids have almost certainly spent time submerged in water before flying.

Checklist of the species of the group of *Stenelmis hisamatsui*

aritai M. Satô, 1964a, p. 32, no figure.
  Holotype female in Dr. M. Satô's collections.
  Male is unknown at the present time.
  Distribution: Japan (Ryukyu: Sakishima Is.).
formosana Jeng and Yang, sp. nov.
  as "*Stenelmis* sp." in Nomura's letter to Satô (Satô, 1964b)
  Holotype male in EMNTU, Taiwan.
  Distribution: Taiwan.
hisamatsui M. Satô, 1960, p. 253, Fig. 1, 2; maxillary palpus and
  male genitalia in Satô1965, Fig. 4, 12; found in cave (Satô, 1964b); collected from Is. Guam (Satô, 1983, p. 41)
  Holotype male in Dr. M. Satô's collections
  Distribution: Japan (Ryukyu: Amami-Ôshima Is.,
  Toku-no-shima Is., Okino-erabu-shima Is., Okinawa-honto), Guam.
ishiharai M. Satô, 1964, p. 31, no figure; male genitalia in Satô 1965, Fig. 11.
  Holotype male in Dr. M. Satô's collections.
  Distribution: Japan (Ryukyu: Sakishima Is.).
metatibialis Delève, 1968, p. 161,Fig. 21-23.
  Monotype male in Musée Hongrois d'Historie Naturelle à Budapest.
  Female is still unknown.
  Distribution: Vietnam (Prov. Nghe-An).
nipponica Nomura, 1958, p. 41, Fig. 1.
  Holotype male in Natural Science Museum, Tokyo, Japan.
  Distribution: Japan (Honshu, Shikoku, Kyushu), Korea (Satô, 1978)
wongi Jeng and Yang, sp. nov.
  Holotype male in EMNTU, Taiwan.
  Distribution: north Taiwan.

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We express our greatest appreciation to Professor M. Satô (Biological Laboratory of Nagoya Women's Univ., Nagoya, Japan) for sending us allied Japanese elmid specimens to make comparative notes. We also thank our colleagues: Wong Kwok-Ching, Luo Tzi-Gwei, Hsu I-Shin, Lee Chang-Way, Lee Chi-Feng, Lee Chun-Lin, Hsieh Sen-Her and Lin Yi-Jiao for collecting materials and helping us in many ways during field collections; Dr. H.P. Brown (Dept. of Zoology, Oklahoma Univ., Norman) and Dr. M.A. Jäch (Naturhistorisches Museum Wien, Austria) who helped us in many ways and revised the English manuscripts; Dr. Chang Hwei-Yu (Dept. of Plant Pathology & Entomology, National Taiwan Univ.) and lecturer Yang Jeng-Tze (Dept. of Entomology, National Chung Hsing University, Taiwan, R.O.C.) who gave us much valuable advice.

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BOOK REVIEW

THE CONSERVATION OF INSECTS AND THEIR HABITATS. Collins, N.M. and J.A. Thomas, eds. Academic Press. 1991. 450 pp. $79.00.

In a comprehensive overview of the status of, and urgent need for, insect conservation in today's rapidly disappearing natural world, this book brings together a series of 15 papers on this subject, authored by 26 leading entomologists, presented at the 15th symposium of the Royal Entomological Society of London, September 14 and 15, 1989. Although somewhat over half (9) of the chapters were written and/or presented by British (English) entomologists, most of whom supported their papers with English examples, due consideration is given to world-wide conditions with papers on the status and need for insect conservation in North America (Opler), Australia (Greenslade and New), island insects - Hawaii and New Zealand (Howarth and Ramsay), northern Europe - Fennoscandia (Mikkola), Mediterranean region - Italy (Balletto and Casale), European grasslands - Switzerland (Erhardt), and Neotropical insects - Brazil (K. Brown). References are listed at the end of each chapter.

The stated purpose of this symposium was "to bring together a series of papers which reflect the diversity of entomological habitats and ecological roles around the world, emphasize the value of insects to humanity, and set out some practicle proposals for conservation, especially in tropical forests and on islands, where their diversity is greatest".

In spite of inevitable contradictory statements in a multi-authored work, the many contributors generally agree and zero in on several important points, some of which I briefly summarize:

The largest single cause of changes in the distribution and abundance of insects over the past 50-100 years is loss of habitat resulting from changes in land use by humans. In temperate zones, major declines of saproxylic invertebrates have occurred concurrently with the woodland clearances that have taken place as a result of man's activities beginning with the Neolithic and continuing through the present.

Man's current abuses of natural ecosystems with chemical fertilizers, insecticides, herbicides, and particulate pollution usually leads to strong reduction in diversity (especially in soil organisms and arthropods in general), breakdown of community structure and services, and irretrievable loss of genetic heritage.

Some of this earth's greatest wealth is contained in natural ecosystems and the biological communities that inhabit them. While insects are rarely, if ever, the main focus in resource exploitation, they support the stability of these communities by their genetic diversity and their complex web of ecological interactions.

Conservation of insects forms a major sector of general conservation of terrestrial habitats, genetic diversity, and species interactions since well over half the genes, biomass, and energy transfers in many terrestrial ecosystems probably involve insects. The need is urgent to conserve this bio-diversity.

Although the faunas of islands appear to be more sensitive to environmental changes and more prone to extinction than continental areas, islands really are microcosms of continents and ecological and evolutionary processes are identical in both. Only the relative areas of ecosystems, taxonomic diversity, endemism, isolation from potential colonists, and historical development are different. However, even for these characteristics, island-like situations occur frequently on continents. What is happening now on islands is a preview of coming attractions for continents.

From one third (Brown) to 95% (Sutton and Collins) of the world's insect species occur in the vast expanses of the Neotropics, strongly concentrated in forest and woodland biomes where they are critical to the function of these ecological systems. Not only are insects concentrated in the tropics, more importantly their concentrations are in the wet tropics.

The primary aim of tropical forest insect conservation must be to establish a network of effective protected areas in pristine habitats. A secondary aim must be to save as many as possible of the insects able to survive in disturbed habitats.

Since only about one million (Wolf, 1987) of an estimated 30 million (Erwin, 1982) insects have been described to date, there is a tremendous challenge facing taxonomic entomologists as well as a great need to stimulate more entomologists to apply their talents in taxonomic research. It is imperative we have greater knowledge of current insect diversity before many species become lost and it is too late. In the tropics, very few insect groups have over half their species described.

The current conservation strategy of protecting relatively small areas of lands as nature preserves has proven far less successful for insects than for long-lived plants and vertebrates.

Entomologists must not delay in supporting measures to establish large reserves of self-perpetuating, high-carrying capacity habitats - principally in tropical rain forests where there is the greatest wealth of insect species.

Taken together, these papers provide a review of the impact humans have had, and are continuing to have, upon the abundance and diversity of insects through deforestation, agriculture, drainage programs, and other alterations of the natural environment. Further, they offer a variety of recommendations for much needed programs aimed at conservation of viable insect and arthropod populations throughout the temperate regions of the world, and especially in island and tropical ecosystems.

H.P.B

BOOK REVIEW

REPRODUCTIVE BEHAVIOR OF INSECTS: INDIVIDUALS AND POPULATIONS.

Bailey, W.J. and J. Ridsdill-Smith, 1991. Chapman & Hall, New York & London. 339 pp. $95.00

This book is based on a symposium held in Perth, Australia, with considerable additions. There are 11 chapters by 13 authors, 62% of whom are Australians. Emphasis is on the evolutionary significance of insect behaviors, especially reproductive behavior.

Contents of the chapters are as follows: 1) Introduction; 2) Evolution of mating systems; 3) Mate-finding; 4) Location of, and oviposition on animal hosts; 5) Location of, and oviposition on plant hosts; 6) Location of, and oviposition on hosts by tephritid fruit flies; 7) Host selection in Heliothinae (Noctuidae); 8) Reproduction and host selection by aphids; 9) Oviposition and defense by social wasps; 10) Competition between dung-breeding insects; and 11) Contribution to fitness by leaf-feeding larvae. Coverage of North American literature appears adequate. Proofreading was unusually good; I did not detect any typos.

W.H. Day
Beneficial Insects Research Lab., USDA
Newark, DE 19713

BOOK REVIEW

THE BIOLOGY OF THE HONEY BEE. Mark L. Winston. 1987 Harvard Univ. 281 pp. $29.95 cloth. $17.95 pbk.

Anyone with an interest in honey bees, whether as a beekeeper focusing on hive management or from a natural history standpoint, will benefit from reading this book. It presents the most up-to-date and complete introduction to the biology and behavior of the honey bee that is available. Winston, who is well versed in the biology and social behavior of this organism, presents the information in a very interesting and authoritative manner. He appropriately includes evolutionary relationships throughout. References are cited for those who may want to pursue a subject in more depth.

Beekeepers with the primary goal of managing honey bees for honey production or pollination will find this book of great value for understanding the intricate dynamics of honeybees as individuals and as a highly organized colony much as a super organism. Beekeepers who can relate the biology and behavior of the honey bee to the basis for sound management practices will be at an advantage when selecting management alternatives. Likewise, a beekeeper who has a thorough knowledge about the biology of bees can make wise decisions on management when unpredictable situations arise for which little or no management information is available. Winston's book is one that beekeepers will find fascinating, highly valuable, and easy to read.

For the person who is strictly interested in the natural history of honey bees, this book is one that will be very rewarding. It covers the details of anatomy and physiology that relate to the biology, social organization, and behavior. These are the heart of the book and are discussed in some detail. Of particular interest are the chapters on nest architecture, chemical association, communication, swarming, and the biology of temperate versus tropical honey bees. Winston and his colleagues have extensively researched the latter subject, thus his book reflects a great deal about the biological features involved in making comparisons between honey bees that have evolved in the temperate and tropical climatic zones. Also, he nicely summarizes the research studies of the past 15 years on honey bee orientation, particularly those associated with the bee's ability to sense the magnetic field.

This is a book highly recommended for reading regardless of one's level of interest in bees, whether it is new or with extensive experience. The book is well written, free of errors in text and fact, well illustrated to enhance explanation of key concepts, and comprehensive in coverage of honey bee biology. It represents the best general work available at present and will serve as a key reference on honey bee biology and social behavior for years to come.

Charles E. Mason
Dep't. Entomology & Applied Ecology,
University of Delaware.

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3	May & June	113-164	June 27, 1991
4	Sept. & Oct.	165-204	Sept. 26, 1991
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