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This issue mailed Dec. 18, 1975

FEEDING AND REPRODUCTIVE BEHAVIOR OF *IPS AVULSUS*[1,2]

R. J. GOUGER[3], W. C. YEARIAN[4], AND R. C. WILKINSON[5]

ABSTRACT

Ips avulsus (Eichhoff) parent adults were introduced into pine inner bark-glass plate observation units where they periodically fed as follows: chips of excised inner bark were taken into the buccal cavity, compressed, and the resulting pellet of exhausted tissue was expelled from the mouth. Microscopic examination of sectioned and whole guts showed contents consisting principally of symbionts, starch grains, and small amounts of very fine material. Ventral dilator muscles of the pharynx were well-developed and the alimentary tract was of the elongate type reported in liquid-feeding insects.

Gelatinous feces were produced and deposited on the roof of the male's nuptial chamber, where they were consumed by consorting beetles or adhered to their bodies.

Adult reproductive behavior was similar to that reported for *Ips pini* (Say) and *Ips paraconfusus* Lanier. *I. avulsus* copulation lasted an average of 35 sec (range, 22-45 sec) at 30°C. Pairs mated 3 times at about 10-min intervals, after which each female isolated herself from the associated male in his nuptial chamber by packing the egg gallery behind her with boring material.

Generalized accounts of behavior in North American bark beetles (Scolytidae) have been given by Beal and Massey (1945), Blackman (1922), Chamberlin (1939), and Swaine (1918), but detailed accounts of reproductive behavior in North American *Ips* spp. have been reported for only a few species such as *Ips confusus* (LeConte) (=*Ips paraconfusus* Lanier) from California (Barr 1969), *Ips pini* (Say) from Idaho (Schmitz 1972), and *Ips calligraphus* (Germar) from Florida (Wilkinson et al. 1967).

Ips avulsus (Eichhoff) is a small species[6] which commonly infests the thinner-barked portions of *Pinus* spp. in the southeastern USA. Its reproductive habits (Beal and Massey 1945, Blackman 1922, Thatcher 1960) have been reported as follows: *I. avulsus* is polygamous, but the male alone usually initiates attacks on host material by boring an "entrance tunnel" through the outer bark and excavating a small, irregular, flattened "nuptial chamber" in the soft inner bark (phloem) next to the sapwood. He may then tunnel-out the basal portion of one or more "egg galleries", which are subsequently extended through the inner bark by the 1 to several females which join him in the nuptial chamber. The basal portions of the egg gal-

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[1]Coleoptera: Scolytidae.

[2]Florida Agricultural Experiment Stations Journal Series no. 5868. This Study was partially supported by the Southern Forest Disease and Insect Research Council, Atlanta, Georgia.

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[6]Body length of alcohol-preserved teneral adults from north-central peninsular Florida (n=50 spms/sex): $\bar{x}\pm s=2.9\pm0.1$ (2.7-3.2) mm for female; $\bar{x}\pm s=2.9\pm0.1$ (2.5-3.1) mm for male (unpublished data).

[7]Egg dimensions (n=69 eggs from 18 females): $\bar{x}\pm s=0.80\pm0.04$(0.71-0.92) mm long;$\bar{x}\pm s=0.46\pm0.03$ (0.37-0.54) mm wide (unpublished data).

leries radiate out from the nuptial chamber and commonly do not follow the grain of the underlying sapwood, but the more distal, egg-bearing portions of the egg galleries tend to parallel the wood grain. As females extend their egg galleries through the inner bark, they deposit relatively large[7] eggs singly in cup-shaped "egg niches", cut at intervals into either or both sides of the galleries. The eggs are covered and sealed in the egg niches by bits of inner bark tamped together in the form of a plug (called "phloem plugs" in our study).

Data on egg gallery construction and oviposition are given by Yearian (1966) and Yearian et al. (1972). Egg gallery construction in individual log bolts (2 females and 1 male in consort) was completed within 10 days after introduction of females, and most reproductive activity took place during the first 5 days. The average space between egg niches in the egg galleries was 5.9 mm and the mean length of 46 egg galleries was 13.5 ± 1.4 cm. In more extended tests, each of 10 females oviposited successively in 3 log bolts and consorted with a different male in each bolt. The total length of galleries constructed per female averaged 51.2 ± 5.75 cm, and females laid a mean of 77.0 ± 13.8 eggs. Females oviposited in both sides of their egg galleries when only 1 egg gallery was extended into an area of non-infested inner bark. When 2 egg galleries were concurrently extended side by side and close together, oviposition was concentrated on the opposite (farthest removed) sides of the respective galleries and not any or relatively few eggs were laid in the narrow phloem strip separating the 2 galleries. Males abandoned their nuptial chambers about 10 days after females were introduced with them, and most females left their galleries 15-20 days after introduction into the nuptial chambers.

I. avulsus larvae feed in relatively short and broad "larval galleries" which extend laterally from the egg gallery through the inner bark and are greatly enlarged at their distal ends where pupation occurs. Callow adults have been reported to feed on inner bark before leaving brood logs, but detailed accounts of parent or immature (F_1) adult feeding behavior are lacking. Adult feeding and reproductive behavior of *I. avulsus* are described here.

Methods and Materials

Behavior was studied by the use of phloem-glass plate units, a modification of the "sandwich" technique described by Hopping (1961) for rearing *Ips* spp. Each unit consisted of 3 layers; (1) a 25 X 36 X 0.95 cm glass plate which was placed on the bottom, (2) a 15 X 24 X 0.5 cm sheet of phloem from the inner bark of typical slash pine, *Pinus elliottii* Engelm. var. *elliottii* which was placed in the middle, and (3) a 25 X 36 X 0.95 cm glass plate with a 6 mm hole in the center, which was placed on top. The 3 layers were held together at their edges with no. 10 binder clips. A 6 mm plug of outer bark was inserted in the hole in the top plate and nonabsorbent cotton was packed around the edges of the phloem sheet in the middle to prevent desiccation. All observation units were held at 30°C throughout the study.

All test beetles were collected as callow adults from or near their pupal chambers and reared in isolation on inner bark until mature. It was assumed that they had not mated prior to the tests. To initiate each test, 1 male was placed on the outer bark plug and a 10mm cover slip was placed over the hole in the top plate. Males that did not become "established" by boring an entrance tunnel and constructing a nuptial chamber in the

inner bark sheet were replaced by other males, as required. Twelve hr after a male was introduced and established in a unit, a female was placed on the bark plug where the male had bored his entrance tunnel.

Feeding, mating, and oviposition behavior were observed for each of the 10 pairs of *I. avulsus,* until each female had isolated herself from the associated male in his nuptial chamber by packing the egg gallery behind her with boring material.

Ten beetles of each sex, newly-emerged from pine logs, were fixed, sectioned, and stained by a modified Gram-Weigert procedure (Gouger 1971), then sections were examined microscopically to determine whether mycangia were present and to determine contents of the alimentary canal.

Results

Feeding.—*I. avulsus* males rotated about their longitudinal axis while boring a round entrance tunnel through the plug of outer bark in the upper plate. Boring material was passed back under the beetle by means of the mandibles, maxillae, and prothoracic legs, then pushed to the rear with the meso and meta-thoracic legs. Feeding began when the inner bark was reached. Chips of bark tissue were excised from the inner bark, taken into the buccal cavity, and appeared to be compressed by squeezing action of the mandibles. After compression, the residual pellet of host tissue was expelled from the head and passed to the rear of the body as described above. Periodically, chips of inner bark were excised but passed to the rear without being taken in and compressed. Similar feeding behavior was observed in females and males.

Microscopic examination of fresh whole guts and stained sections of newly-emerged adults showed that contents of the gut consisted principally of microorganisms, starch grains, and very fine host material (Fig. 1); only small amounts of the coarser inner bark tissues were present. Asco-

Fig. 1. Contents of foregut of newly-emerged *I. avulsus* adult, showing light-colored starch grains in a matrix of very fine material. Starch grains are ca. 10μ across.

spores of the bluestain fungus, *Ceratocystis ips* (Rumbold) C. Moreau, were universally present in the gut and especially within the hind gut, but no mycangial bodies or unusual concentrations of microorganisms were detected anywhere in the adult body. The alimentary canal was of the elongate scolytid type and ventral dilator muscles of the pharynx were present and very well-developed (Fig. 2).

I. avulsus adults of both sexes produced gelatinous feces which were commonly deposited on the roof of the nuptial chamber where they were frequently eaten by consorting beetles entering the chamber or adhered to their bodies.

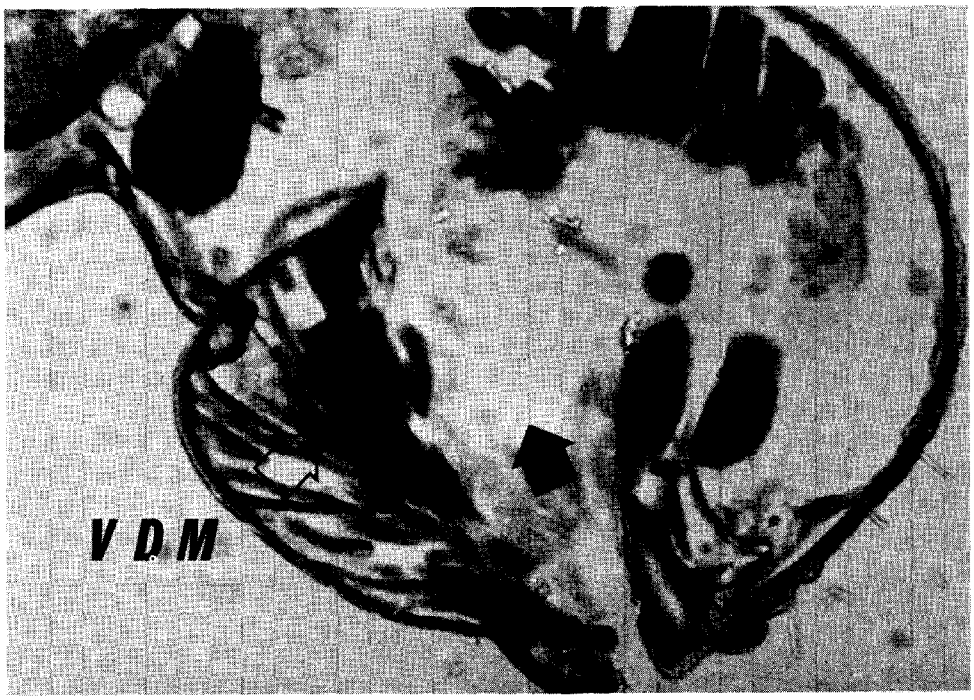

Fig. 2. Median sagittal section through *I. avulsus* adult head. Intake of inner bark (solid arrow); ventral dilator muscles of pharynx (hollow arrow-VDM). Head is ca. 1 mm across dorso-ventrally.

Mating.—An *I. avulsus* female placed on the bark plug of an observation unit became visibly excited upon contacting boring material (chips, pellets, and some gelatinous feces) expelled from the entrance tunnel by a male established in his nuptial chamber, and burrowed into this extruded material until she was at the entrance to the tunnel. The male blocked entry into the tunnel by backing into it and bringing his elytral declivity nearly even with the entrance. The female pushed vigorously against the male's declivity while forcing her way into the tunnel and stridulated with her head and pronotal organs as in other *Ips* spp. (Barr 1969, Wilkinson et al. 1967). The pushing-stridulating behavior of the female was repeated several times and the female occasionally "bit" the margins of the male elytra until the pair had reached the nuptial chamber (Fig. 3, A). The female immediately began construction of an egg gallery extending off the nuptial chamber and the male assisted by removing material produced during this

tunneling operation (Fig. 3, B, C). The female was not observed to stridulate with her head and pronotal organs after she had once begun an egg gallery.

Copulation in *I. avulsus* first occurred after the female had constructed 2.5-3.0 mm (or about 1 body length) of egg gallery. The male periodically butted the female's elytra, which apparently stimulated her to receive him, and copulation occurred at the junction of an egg gallery and nuptial chamber with the male above at an angle of ca. 100° (Fig. 3, D). Copulation lasted an average of 35 sec (range: 22-45 sec) at 30°C. Pairs mated 3 times at about 10-min intervals, ending when the female abruptly packed the tunnel behind her with boring material.

Oviposition.—The mated *I. avulsus* female extended her tunnel until it ran parallel with the phloem grain in most cases, then excised phloem tissue from the left or right side of the egg gallery with her mandibles to form an egg niche. The egg niche was cut to approximately the same size as her head capsule by rotary motion of the extended head. Tissue removed from the niche was packed into a phloem plug located at the end of the egg gallery (Fig. 3, E). She then backed out of the gallery (F), turned around in the nuptial chamber (G) and backed up to the egg niche (H) where a single egg was quickly deposited (I). She then reversed her position (J,K,L) and removed pieces of the phloem plug which were then tamped tightly over and around the egg with her mouthparts (M).

Discussion

Butts (1951) studied morphological differences between "liquid-feeding" and "solid-feeding" coccinellid beetles and other insects, and reported ventral dilator muscles were well-developed in liquid-feeding species such as the Mexican bean beetle, *Epilachnus varivestis* Mulsant, but absent in solid-feeding species. He also observed that " . . . those insects that take liquids only have a greatly elongated alimentary canal", as illustrated by *E. varivestis*. Butts did not report that *E. varivestis* also produces liquid feces, which behavior would appear to be concomitant to liquid-feeding in many insects (eg., aphids and scales).

Ips avulsus is evidently a "liquid-feeding" species at least in the adult stage, based on its feeding behavior of intake-compression- and regurgitation of inner bark from the buccal cavity, the presence of very well-developed ventral dilator muscles of the pharynx, and especially the presence of only very fine, semi-liquid material, and almost no solids in the gut. *Ips avulsus* has the elongate alimentary canal typical of liquid-feeding insects such as the Mexican bean beetle (illus. by Butts 1951), and also typical of scolytid beetles as illustrated by Hopkins (1911) in the red turpentine beetle, *Dendroctonus valens* LeConte.

Liquid-feeding, the deposition of gelatinous feces on the walls of the nuptial chamber, and consumption of feces by consorting adults was also observed by us in *Ips calligraphus* (Germ.) (unpublished), which suggests that this behavior is common in *Ips* spp. Leach et al. (1934) reported that the sticky fecal pellets of *Ips grandicollis* (Eichh.) and *I. pini* were deposited and adhered to the nuptial chamber wall. Barr (pers. comm.) reported that *I. paraconfusus* defecated principally in the nuptial chamber.

Two important consequences of this behavior would be (1) transmission of bluestain (*C. ips*) spores and other symbionts between consorting adults

and (2) concentration of the male-produced aggregating pheromone in feces deposited in the nuptial chamber, which virgin females must find and enter in order to mate and reproduce.

The universal presence of viable bluestain fungus ascospores in the gut and feces of *Ips* adults emerging from brood logs or colonizing new host material is explained by their extensive feeding on *C. ips* perithecia in the inner bark of brood logs prior to attacking new host material (Leach et al. 1934, Yearian et al. 1972). Such spores germinate in new host tissues surrounding the nuptial chamber soon after deposition of feces (Leach et al. 1934), thus ensuring establishment in new host material. Feeding on perithecia and interchange of symbionts through feeding on gelatinous feces deposited in the nuptial chamber thus ensures transmission and dispersal of

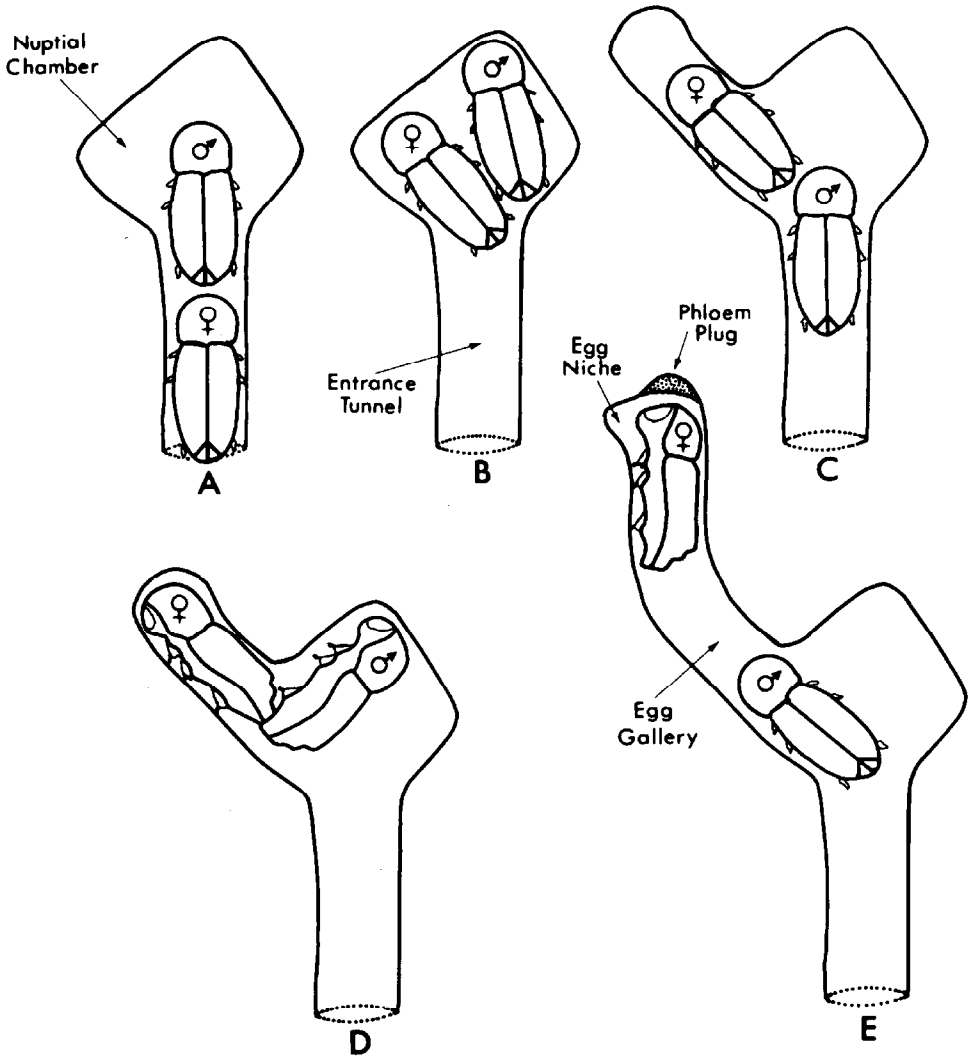

Fig. 3. Reproductive behavior of *Ips avulsus*:—A. Male *I. avulsus* preceding female into nuptial chamber; B. Female *I. avulsus* assisting male in constructing nuptial chamber; C. Male removing frass from nuptial chamber; D. Copulation in nuptial chamber; E. Female constructing egg niche in egg gallery.

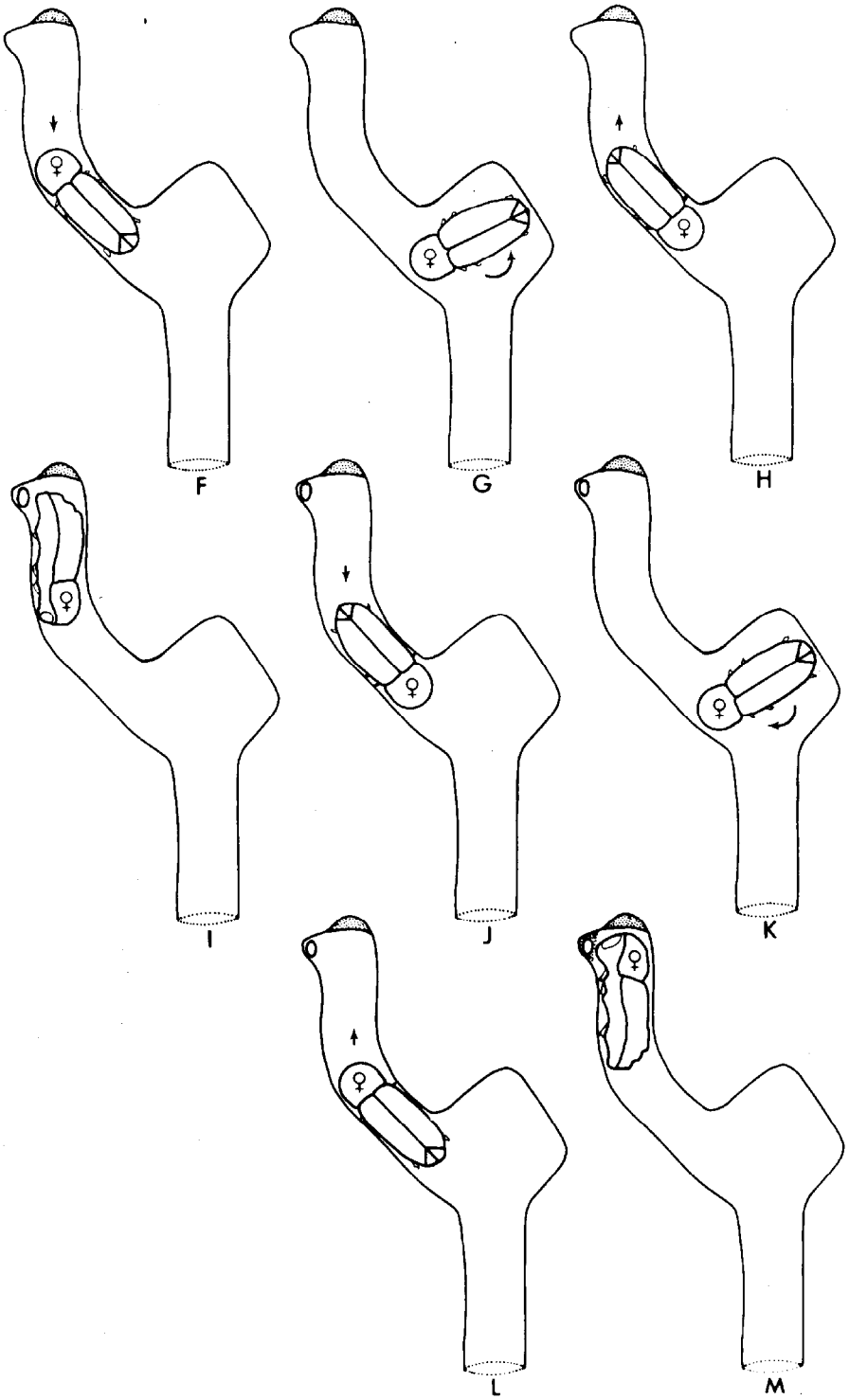

Fig. 3 (Cont'd.) F. Female backing out of egg gallery; G. Female turning around in nuptial chamber; H. Female backing into egg gallery; I. Female ovipositing in egg niche; J, K, L. Female reversing her position and re-entering the egg gallery; M. Female packing phloem around the egg.

such symbionts throughout a population of consorting adults; this would serve an important function in species such as *Ips avulsus* which lack mycangia for the transport of symbionts.

Reproductive behavior of *I. avulsus* was identical to that illustrated by Schmitz (1972) for *I. pini*, a not surprising result since both species belong to Hoppings taxonomic Group IV (Hopping 1963, Lanier 1972). Reproductive behavior is apparently quite generalized in pine-feeding *Ips* spp. from North America, since it has now been observed to be similar in species from Group IV (*pini* from Idaho and *avulsus* from Florida), Group IX (*paraconfusus* from California) (Barr 1969, pers. comm.), and Group X (*calligraphus* from Florida) (unpublished study by authors).

ACKNOWLEDGEMENTS

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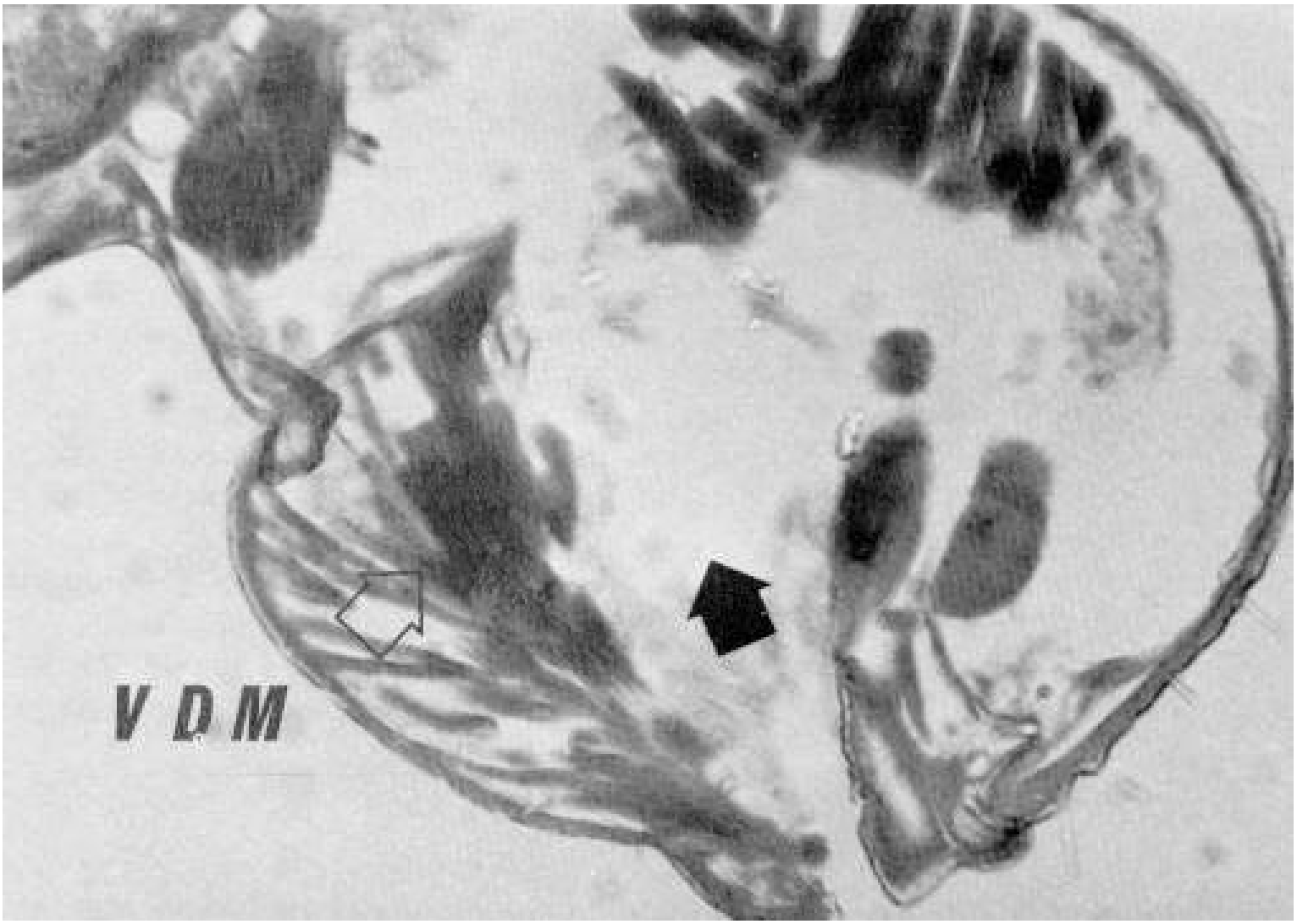
NOTICE

THE ECOLOGY OF INSECT POPULATIONS IN THEORY AND PRACTICE, by L. R. Clark, P. W. Geier, R. D. Hughes, and R. F. Morris, was first published in 1967. Halsted Press of John Wiley & Sons, New York, is now selling a paper-backed reprint of this useful book for $6.75.

(For a review of the book by E. O. Wilson, see *Science* 158:622, 1967.)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THREE NEW SPECIES OF PYGMEPHOROIDEA (ACARINA: TARSONEMIDA) FROM *FRAGARIA* IN FLORIDA[1]

GISELA RACK

Zoological Institute and Zoological Museum,
University of Hamburg, 2000 Hamburg 13, West Germany

ABSTRACT

Three new species and 1 new subspecies of the families Pygmephoridae, Microdispidae, and Scutacaridae are described and illustrated. These are: *Mahunkania secunda, Brennandania parasilvestris floridae, Scutacarus* (*S.*) *fragariae,* and *Scutacarus* (*S.*) *longipes,* all found on *Fragaria* in Florida. Males and 2 larvae of *S. fragariae* are described which constitutes only the third discovery of males in the Scutacaridae since Michael (1884). The study of the male confirms the close relationship between Pygmephoridae and Scutacaridae.

There are only few investigations on the Pygmephoroidea, especially the Scutacaridae fauna of North America. Therefore I am very thankful to have received this material through the kindness of H. A. Denmark, Florida Department of Agriculture & Consumer Services, Gainesville. If not otherwise mentioned, the material is deposited in the Florida State Collection of Arthropods (FSCA), Gainesville, Florida, U.S.A.

Anatomical nomenclature follows that of van der Hammen (1970).

FAMILY PYGMEPHORIDAE CROSS

Mahunkania secunda Rack, new species
(Fig. 1-5)

FEMALE: Length (without gnathosoma) 260μ; width 120μ. DORSUM (Fig. 1). Propodosoma with 3 pairs of setae. The rostral (pr) and medio-lateral prodorsal setae (pml) subequal. Setae pr smooth, pml moderately plumose. Posterior prodorsal setae (pi) longest, slightly plumose. Sensillus (Fig. 2) "pear-like" with long, finely ringed pedicel. Stigmata long. Opisthosomatic setae slightly plumose. Length of setae pc_2 nearly twice pc_1. Setae pd_1 barely longer than pc_1. Length of setae pe_1 twice pe_2. Setae pf_1 longest setae of dorsum, $pf_1$4X as long as pf_2. VENTER (Fig. 5). Apodemes 1 and 2 complete. Apodemes 3 not reaching trochanters III. Apodemes 4 incomplete. Epimeres I and II each with 3 setae, all nearly of same length and slightly plumose. All setae of hysterosoma smooth and subequal. Opisthosomatic setae ph_1 and ph_2 close together, ph_3 is separated from ph_2. LEG I (Fig. 3). Weak claw on ventral side of tibiotarsus and 4 solenidia dorsolaterally. Femur with 2 normal setae and 2 blunt spines, one of them probably equivalent to seta c. LEG II. Small solenidium on dorsum of tibia. Tarsus dorsally with larger solenidium, and distally with 2 claws and long slender pulvillus. LEG III. Small solenidium on dorsum of tibia. Tarsus with 2 claws and long slender pulvillus (Fig. 4). LEG IV. Tibia with minute solenidium and spinelike seta. Tarsus with 2 claws and slender pulvillus.

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[1]Contribution No. 320, Bureau of Entomology, Division of Plant Industry, Florida Department of Agriculture and Consumer Services, Gainesville, Florida 32602.

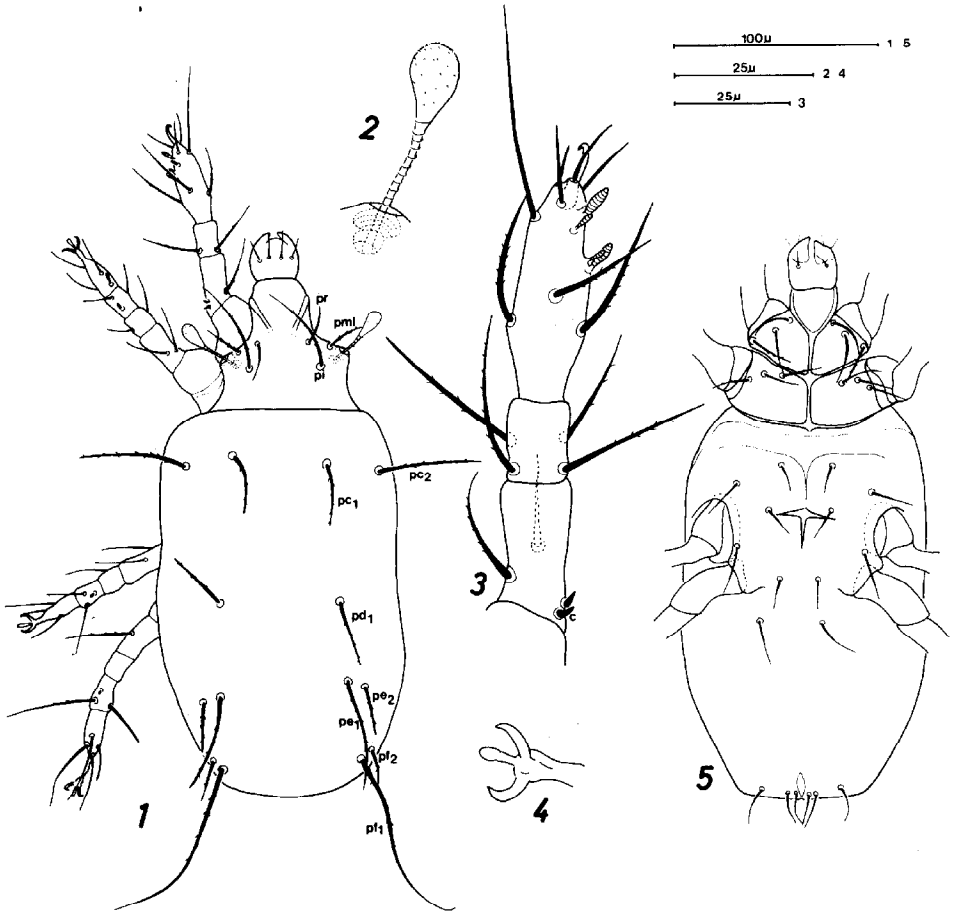

Fig. 1-5. *Mahunkania secunda* n. sp., female: 1) dorsum; 2) sensillus; 3) leg I; 4) claws and pulvillus of leg III; 5) venter.

MALE: Unknown.

MATERIAL: Holotype female, FLORIDA, Hillsborough County, Dover, 9-X-1973, (D-96-5), E. R. Fatic, on *Fragaria* sp.

DISCUSSION: This new species is the second of the genus *Mahunkania* and shows the generic characteristics distinctly: the long, finely ringed pedicel of the sensillus, the 2 blunt spines on femur I, the long, slender pulvillus on tarsus II-IV. The new species differs from the type of the genus, *M. hallensis* Rack (1972), by having setae pe_1 and pf_2 shorter, setae pf_1 longer, stigmata long, claw I inserted more distally, and the difference in size of the solenidia on tibiotarsus I.

FAMILY MICRODISPIDAE CROSS

Brennandania parasilvestris Rack, 1974

(Fig. 6)

In the material from Florida a female was found which seems to be *B. parasilvestris,* although a few differences exist. The differences do not appear to be significant enough to erect a new species, but do warrant subspecies status. Hitherto *B. parasilvestris* was known only from Europe

(DDR) as opposed to *B. silvestris,* first described by Jacot (1936) from North Carolina, U. S. A. The specimen from Florida is a subspecies which is described as follows:

Brennandania parasilvestris floridae Rack, new subspecies
(Fig. 7)

FEMALE: Length (without gnathosoma) 160μ; width 80μ. Specimen more slender than specimens from Europe. DORSUM. Number and point of insertion of setae identical to *B. parasilvestris,* but are smooth and more slender. VENTER. Setae identical to *B. parasilvestris.* All setae more slender. LEG I. Solenidia and setae approximate those in *B. parasilvestris* and both without claw. LEG IV. (Fig. 7). Conspicuous chitinous tooth at external edge of trochanter in both subspecies but not mentioned by Rack (1974). Leg IV from holotype of *B. parasilvestris* is shown in Fig. 6. Shape of Leg IV differs by proportionate length of trochanter to femur. *B. parasilvestris floridae* has a distinctly shorter femur.

MALE: Unknown.

MATERIAL: Holotype female, FLORIDA, Hillsborough County, Dover, 9-X-1973, (D-96-5), E. R. Fatic, on *Fragaria* sp.

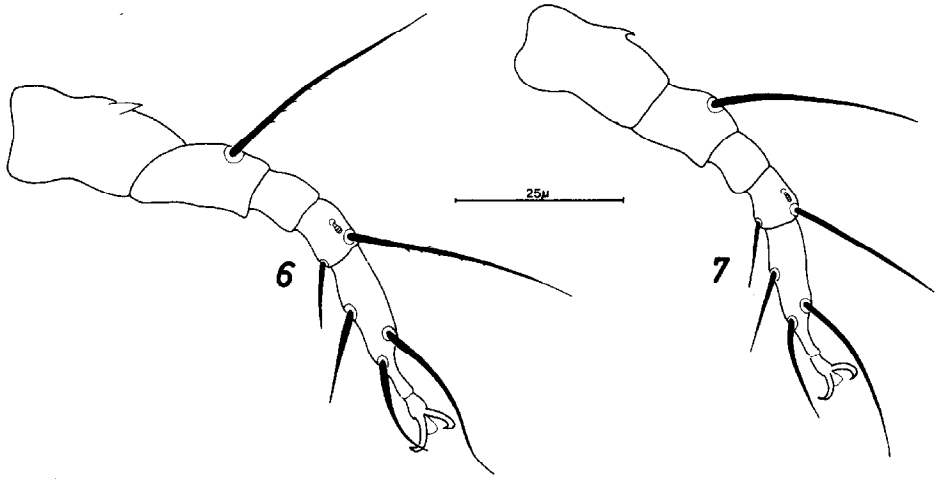

Fig. 6-7. Female, leg IV: 6) *Brennandania parasilvestris* Rack; 7) *Brennandania parasilvestris floridae* n. ssp.

FAMILY SCUTACARIDAE OUDEMANS
Scutacarus (S.) fragariae Rack, new species
(Fig. 8-18)

FEMALE: Length 140-210μ (mean of 30 specimens 180μ), holotype 180μ; width 110-150μ (mean of 30 specimens 130μ), holotype 120μ. Pale yellow, dorsally and ventrally smooth. DORSUM (Fig. 8). Setae $pc_1 > pc_2$, slightly plumose. Setae pd_1 a bit thicker than pc_1 and pc_2 also slightly plumose. Setae $pe_1 > pe_2$; pe_1 slightly plumose, pe_2 smooth. Setae $pf_1 > pf_2$; pf_1 slightly plumose, pf_2 smooth. VENTER (Fig. 9). Apodemes 2 thin, weakly developed. Sejugal apodemes strong. Apodemes 3 short, not reaching trochanters III. Apodemes 4 incomplete. Epimeres I and II each with 2 setae.

Setae 1a and 1b distinctly plumose; 1a > 1b. Setae 2a and 2b arise closely to one another; 2a > 2b; 2a slightly plumose, 2b smooth, spinelike. Epimeres III with 3 setae, all subequal and slightly plumose. Epimeres IV with 3 nearly smooth setae; 4b nearly twice as long as 4a, surpasses the end of body, if mounted specimens are not pressed too much. Setae ph_1 and ph_2 close to one another, subequal, long, slender and plumose. Base of setae ph_3 is about twice the distance apart as ph_1 and ph_2, short, and smooth. LEG I (Fig. 10 and 11). Tibiotarsus with a weak claw. Of the 4 solenidia, the ventrally arising solenidium 1 is the strongest one. Solenidium 4 is also strong. Solenidia 2 and 3 are long and slender. LEG II and III. Small solenidium on dorsum of tibia. Tarsus with a long solenidium, a spinelike seta, 2 claws and a pulvillus. LEG IV (Fig. 12). Tibiotarsus with 7 setae, seta 7 is longest.

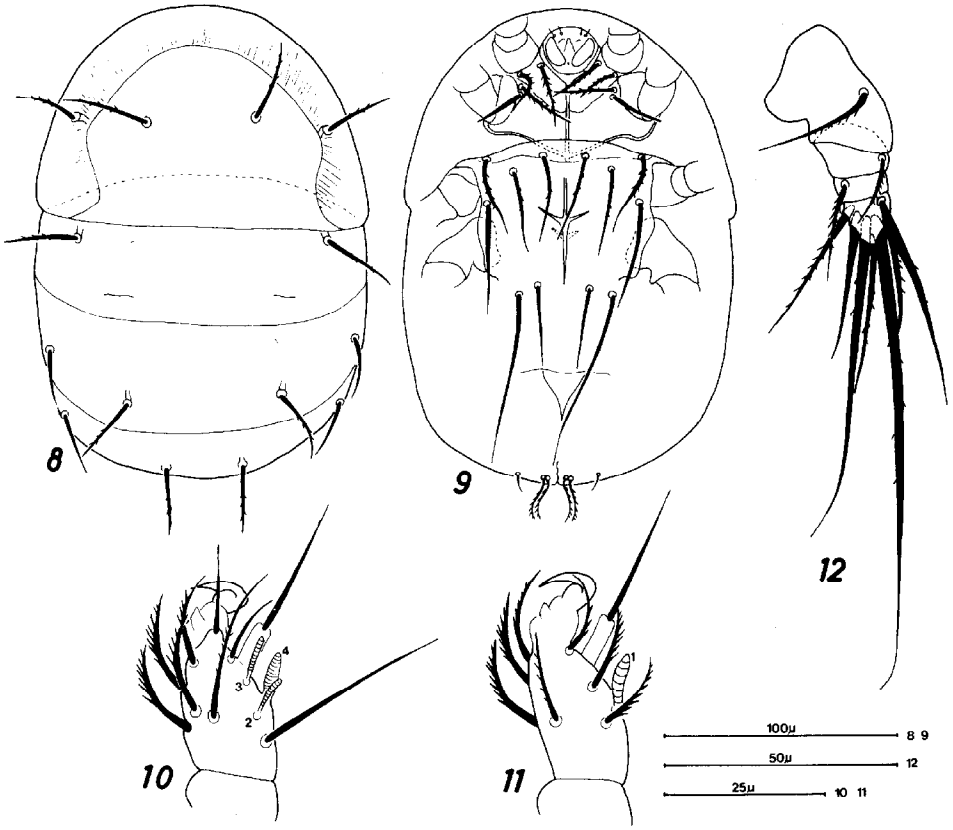

Fig. 8-12. *Scutacarus (S.) fragariae* n. sp., female: 8) dorsum; 9) venter; 10) dorsum of tibiotarsus I; 11) venter of tibiotarsus I; 12) leg IV.

MALE: Length 150-190μ (mean of 20 specimens 170μ); width 90-100μ (mean of 20 specimens 95μ). DORSUM (Fig. 13). Gnathosoma long, narrow and very reduced. Propodosoma with 3 pairs of setae. Setae pr minute, smooth, needle-like; pi are strongest, longest, and plumose. Bothridia, sensilli and stigmata absent. Opisthosomatic setae pc_1, pc_2 and pd_1 on a common shield, subequal, slightly plumose. Setae pe_1 > pe_2, thicker and more distinctly plumose than pe_2. Genital-capsule nearly completely covered with 2 fine transparent scales; it has 1 pair of cylindrical setae and 1 pair of minute spines. Penis long and strongly sclerotized. VENTER (Fig. 15). Apodemata 1

complete. Apodemata 2 not reaching anterior sternal apodeme. Sejugal apodeme weakly developed, complete. Posterior sternal apodeme incomplete. Anterior part of posterior sternal apodeme in center incomplete, reaching trochanters III. Apodemes 3 strong only near sternum. Apodemes 4 complete, strong, straight and form acute angle. Epimeres I and II with 2 pairs, epimeres III and IV with 3 pairs of setae; setae 2b smooth, spinelike. LEG I (Fig. 14). Tibia and tarsus separated. Tibia with 2 solenidia, solenidium 1 long and thin, solenidium 2 shorter and larger. Tarsus with 2 solenidia, solenidium 3 very long and broad, solenidium 4 much shorter and thinner. Tarsus with weak claw inserting on praetarsus. LEG II. Tibia with small tarsus, large solenidium and spinelike seta. Tarsus with 2 claws and short, broad pulvillus. LEG III. Tibia with small solenidium. Tarsus with spinelike seta, 2 claws and pulvillus. LEG IV (Fig. 16). Tibia with slender solenidium. Tarsus without claw, 2 very long setae, one inserted dorsally and one ventrally.

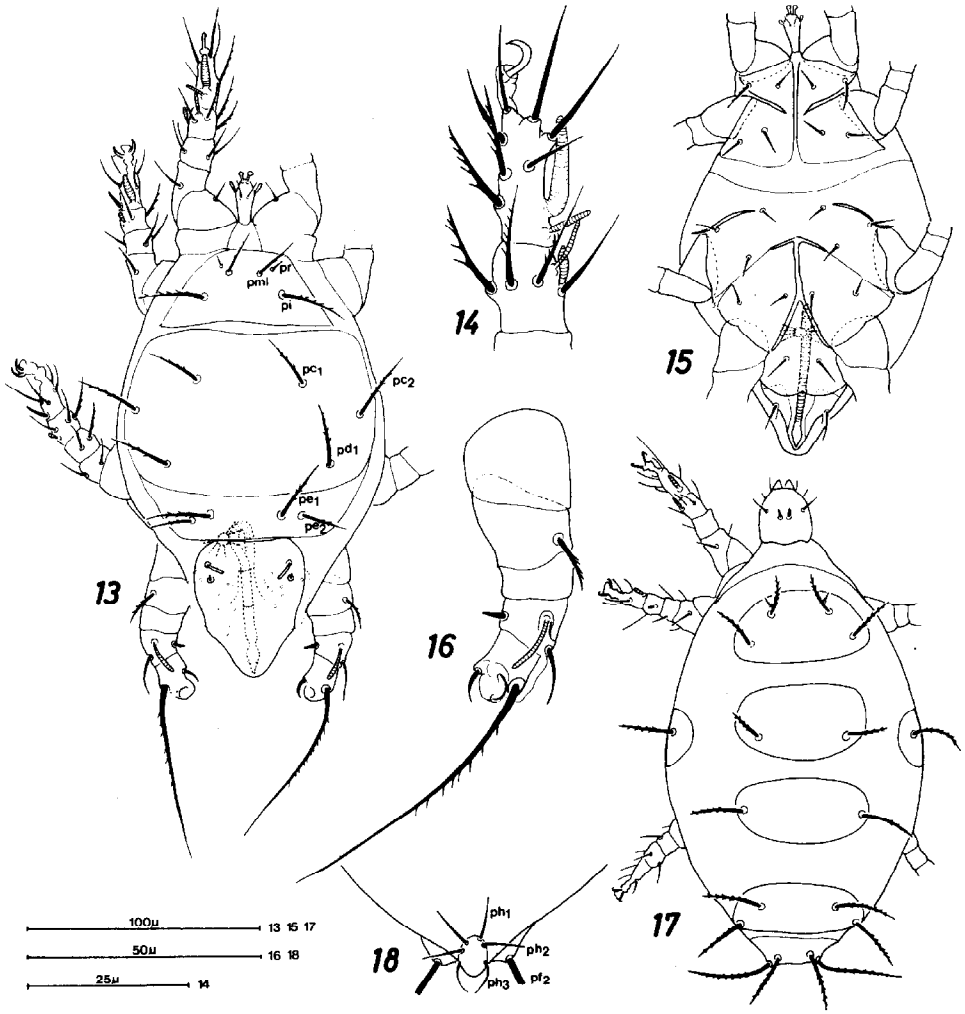

Fig. 13-18. *Scutacarus (S.) fragariae* n. sp., male: 13) dorsum; 14) tibia and tarsus I; 15) venter; 16) leg IV. Male larva: 17) dorsum; 18) venter of the end of body.

MALE LARVA: Length (without gnathosoma) 140-160μ; width 75-110μ. DORSUM (Fig. 17). Gnathosoma with 2 small, strong, spinelike setae, and 2 small setae. Shield of propodosoma with 3 pairs of setae, first pair minute, 2 others 4 times as long and plumose. First shield of hysterosoma tripartite. All setae of hysterosoma subequal and plumose. Setae pf_1 are longest ones. VENTER. Sternalapodemes absent. Epimeres I-III with 2 pairs of setae, all short and smooth. End of body distinctly narrow, mostly turned ventrally (Fig. 18). Cuticula between the epimeres closely and slightly gathered. LEG I. Tibia with thin solenidium. Tarsus with slightly broader solenidium, distally with 2 claws. LEG II. Tibia dorsally with thin and short solenidium. Tarsus dorsally with slightly broader and longer solenidium, distally 2 claws and short, broad pulvillus. LEG III. Tibia dorsally with thin and short solenidium. Tarsus distally with 2 claws and pulvillus.

FEMALE LARVA: Female larva slightly larger than male larva (length 170-220μ, width 110-185μ) and dorsal setae of body and solenidia of legs slightly stronger and longer.

MATERIAL: Holotype female, 30 females, 10 males, 10 larvae paratypes, and alcohol material at FLORIDA, Hillsborough County, Dover, 9-X-1973, (D-96-5), E. R. Fatic, on *Fragaria* sp., deposited in the Florida State Collection of Arthropods in Gainesville, Florida; 10 females, 10 males, 10 larvae paratypes and alcohol material with the same dates as holotype in the collection of the Zoological Institute and Zoological Museum, University of Hamburg, West Germany.

DISCUSSION: The new species is closest to *S. (S.) abatus* Mahunka (1967), *S. (S.) hajeki* Mahunka (1967), both from Chile, and *S. (S.) hermosillai* Mahunka (1968) from Argentina. It differs from them especially in that *abatus* has much shorter setae 4a and 4b, *hajeki* much shorter setae ph_2 and *hermosillai* fully developed apodemes 4.

Many free females and males and several larvae with a well developed female or male inside were collected together. Therefore, all larvae, males, and females surely belong to the same species. This is only the third time that males and larvae of a scutacarid have been found. The first discovery was made by Michael (1884) for *Scutacarus (S.) acarorum* (Goeze, 1780), the second by Norton and Ide (1974). Males and larvae are seldom found in most genera of other families of Pygmephoroidea, but are found more often in *Siteroptes* and *Bakerdania*. The males of *Bakerdania* (see *Bakerdania exigua* Mahunka (1969) in Rack, 1974) and *Scutacarus* are more related to each other than the males of *Bakerdania* on the one hand and *Dolichocybe, Pyemotes, Acarophenax,* etc., on the other hand (=Pyemotoidea by Mahunka, 1970). The study of the males confirms the correctness of the classification based on the study of the females into different superfamilies, Pyemotoidea and Pygmephoroidea, logically erected by Mahunka (1970).

Scutacarus (S.) longipes Rack, new species
(Fig. 19-23)

FEMALE: Length 280μ; width 200μ. Body well sclerotized. Color yellowish. Dorsum and venter finely and closely punctated. DORSUM (Fig. 19). Propodosoma at sides behind sensilli with distinct tip (Fig. 21). Setae $pc_1 = pc_2$, smooth. Setae pd_1 ¼ shorter than pc_1, smooth. Setae $pe_1 = pe_2$,

smooth; pe_1 slightly larger than pe_2. Setae $pf_1 > pf_2$, smooth; pf_1 distinctly broader than pf_2. VENTER (Fig. 20). Sternalapodemes well developed. Apodemes 3 incomplete. Apodemes 4 strong, reaching trochanters IV. Epimeres I and II each with 2 pairs of setae. Setae 1a=1b=2a, distinctly plumose. Setae 2b long and spinelike. Epimeres III and IV each with 3 pairs of setae, except for 4b all nearly the same length and weakly plumose. Setae $ph_1 > ph_2$, arising close together, plumose. Setae $ph_3 = ph_1$, distant, smooth. LEG I (Fig. 22). Tibiotarsus with medium-sized claw, arising from short pedicel. There are 4 solenidia. Solenidium 2 small and elongate. Solenidium 1 located ventrally. Solenidium 4 is strongest. LEG II. Tibia with small solenidium. Tarsus with long solenidium, 1 spinelike seta, 2 strong claws and pulvillus. LEG III. Tibia with minute solenidium. Tarsus with spinelike seta, 2 strong claws and pulvillus. LEG IV (Fig. 23). Trochanter with distinct tooth. Tibiotarsus distinctly elongate, with 7 setae as figured.

MALE: Unknown.

MATERIAL: Holotype female, FLORIDA, Hillsborough County, Dover, 9-X-1973, (D-96-5), E. R. Fatic, on *Fragaria* sp.

DISCUSSION: Only 7 of about 200 known species and subspecies of the subgenus *Scutacarus* have an elongate tibiotarsus IV; 1 of them, *S. (S.) wranoskyi* Mahunka (1970) is found in Nebraska (U.S.A.) and 5 others are

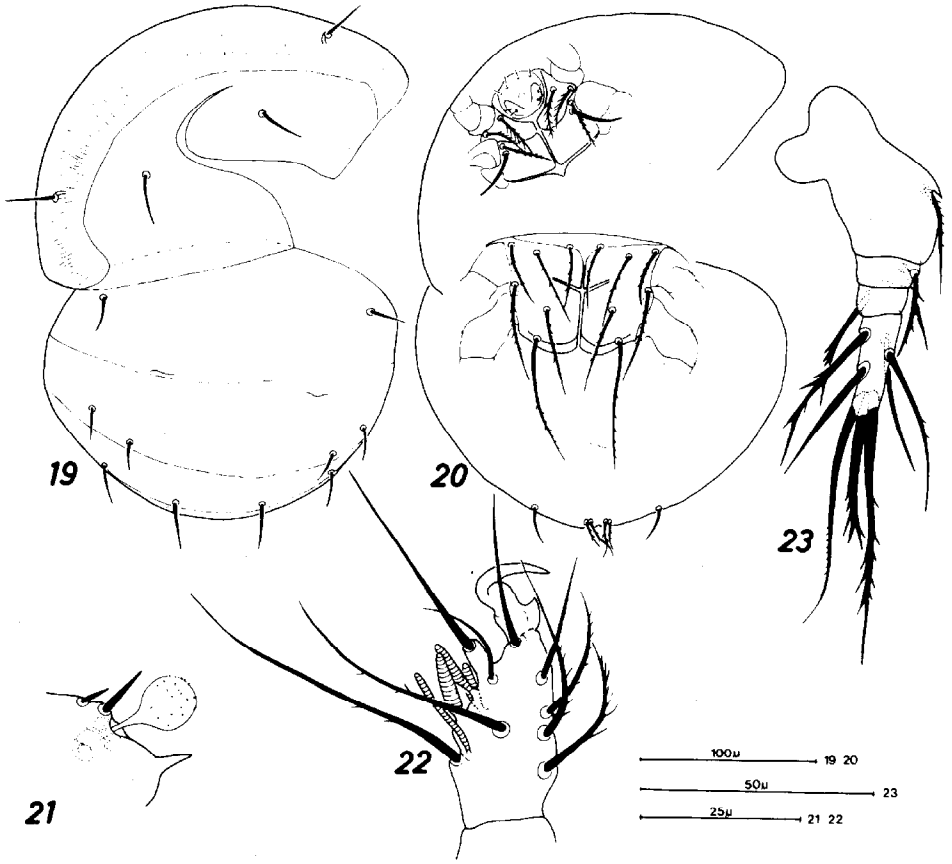

Fig. 19-23. *Scutacarus (S.) longipes* n. sp., female: 19) dorsum; 20) venter; 21) right side of propodosoma with sensillus; 22) tibiotarsus I; 23) leg IV.

found in South America. The new species is most closely related to the European *S. (S.) longitarsus* (Berlese, 1905) with 3 subspecies, 2 of them found in Africa and South America. The new species differs from *S. (S.) longitarsus* by its smaller size, the shorter tibiotarsus IV and its other setation. It differs from *S. (S.) wranoskyi* especially by the other setation of the dorsum and of the tibiotarsus IV.

ACKNOWLEDGEMENT

I wish to express my thanks to Mr. H. A. Denmark for linguistical review of the manuscript.

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A NEW SPECIES OF *FORCIPESTRICIS* BURKS, 1968 (HYMENOPTERA: ENCYRTIDAE) FROM PUERTO RICO PARASITIC ON *FORCIPOMYIA* (DIPTERA: CERATOPOGONIDAE)

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ABSTRACT

Forcipestricis portoricensis, spec. nov., is described. It and the type-species, *F. gazeaui* Burks are internal larval-pupal parasites of ceratopogonids in the genus *Forcipomyia* Meigen.

Willis W. Wirth recently gave me some encyrtid parasites of *Forcipomyia fuliginosa* (Meigen) collected by L. G. Saunders on Puerto Rico during 1953. The specimens represent an undescribed species of *Forcipestricis* Burks. The distinctive habitus of the specimens, their host association and possible negative effect on biological control attempts prompted this description.

Forcipestricis portoricensis Gordh spec. nov.

FEMALE—1.0-1.3 mm long. Body uniformly tan; antenna and legs except coxae and femora slightly paler.

Head in frontal aspect slightly wider than high, subtriangular; compound eye, vertex, inner margin near compound eye, malar space and region between toruli sparsely setose; head smooth, bearing few faintly incised striae on vertex and malar space. Torulus 2 times as high as wide; toruli separated by 2 times torulus diameter and 1 torulus height below imaginary line extending between ventral margin of compound eyes. Antennal scape (Fig. 1) sparsely setose, nearly smooth and not reaching vertex; pedicel sparsely setose, smooth and as long as funiculars 1-3 combined; funicular segments transverse, moderately setose, smooth, each succeeding segment uniformly increasing in size; club compact, setose, smooth; rhinaria on all funiculars and club. Clypeal margin straight; mandible tridentate, middle mandibular tooth large, conically pointed, inner and outer teeth small. Maxillary palpus 3 segmented, apical segment blunt, as long as segments 1 and 2 combined; labial palpus 2 segmented, apical segment blunt, segments subequal.

Pronotum nearly concealed from above, strongly transverse, moderately setose, with faintly incised reticulate sculpture; mesoscutum moderately setose with faintly incised reticulate sculpture; scutellum (Fig. 3) nearly smooth, with central pair of scolopophorus (?) sensilla, longitudinal mesal portion lacking setae, laterally adjacent areas with a few pale thin setae and a cluster of 7-10 horseshoe-shaped tubercles, lateral region lacking setae and sculpture; metanotum with transverse striae and small setae only along anterolateral margin. Propodeum mesally short,

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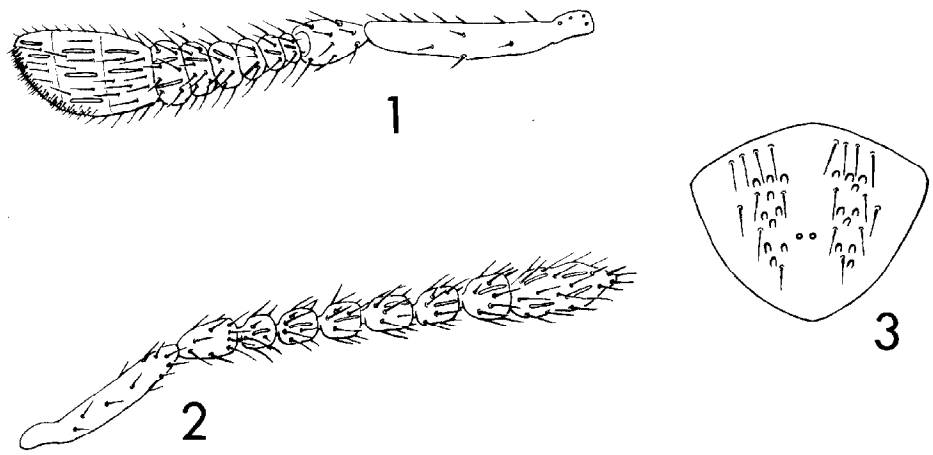

Fig. 1-3. *Forcipestricis portoricensis.* 1. Female antenna, inner aspect; 2. Male antenna, inner aspect; 3. Female scutellum.

strongly transverse and bulbous laterally to accommodate a large spiracle; with a few striae. Tegula sparsely setose and bearing a faintly incised reticulate sculpture.

Metasoma 1.1-1.3 times longer than mesosoma; cerci approximately halfway between anterior and posterior margins of metasoma; terga faintly incised with reticulate sculpture; metasomal apex moderately setose. Middle tibia 1.1-1.3 times longer than ovipositor.

Forewing hyaline; speculum present, margins poorly defined; costal cell and anterior margin setose; submarginal vein long, separated from marginal vein by hyaline break; marginal vein shorter than stigmal vein; postmarginal vein apically indistinct, approximately as long as stigmal vein; wing blade distad of speculum with uniform vestiture of small, thin setae.

MALE—1.0-1.2 mm long. Similar to the female in habitus, coloration, chaetotaxy and sculpture. Differing in the following features: antennal funicular segments (Fig. 2) moniliform, but the first distinctly smaller than the last; club as long as preceding 2 funiculars combined.

Type locality: Mayaguez, Puerto Rico.

Holotype: Female dissected and mounted in balsam; USNM Number 73409. Described from 10 females and 2 males collected at Mayaguez, Puerto Rico, on 23 March 1953 by L. G. Saunders. The host was identified by W. W. Wirth as *Forcipomyia fuliginosa* (Meigen). Eight female and 2 male paratypes deposited in USNM.

Variation: Little variation of morphological features was detected among the specimens examined. One female had funicular segments 5 and 6 partly fused and was not included in the type series.

Comparative comments: Burks (1968) erected the genus *Forcipestricis* for a single species *gazeaui* which was reared by Lionel Gazeau from pupae of *Forcipomyia (F.) simulata* Walley in Maryland. *Forcipestricis portoricensis* may be distinguished from *F. gazeaui* on the basis of the following characters: the latter species is black, the first 4 funicular segments are subannelliform and the last 2 enlarged (female only), the scutellum is boldly reticulate, and the gaster is as long as the mesosoma.

Both species bear conspicuous horseshoe-shaped tubercles on the scutellum. I have not seen these features in the Encyrtidae before and suggest that they may be diagnostic characters used in addition to those cited by Burks (1968) to separate *Forcipestricis* from all other genera of encyrtids. The denticles cannot be seen with reflected light and a dissecting microscope.

Literature Cited

Burks, B. D. 1968. A new chalcidoid parasite of a ceratopogonid midge (Hymenoptera, Encyrtidae). Ent. News 79:236-40.

PSEUDOSCORPIONS PHORETIC ON FIREFLIES II—(*Note*). Female pseudoscorpions (hereafter called ps) (*Paratemnus elongatus*) are phoretic on *Photuris sp. D* fireflies during a brief, early-summer period in Gainesville, Florida (Lloyd and Muchmore, 1974, Fla. Ent. 57:381). We have made additional observations on this phenomenon at the same site. Phoresy was found on the first night of observations, 16 June 1975 and was last seen on 24 June, though sought several evenings subsequently. Seasonal distribution of phoresy during 2 seasons, as presently delimited by observations on more than 400 fireflies, of which 8 (3 males) were encumbered with a total of 22 pss (all female apparently), is 9-24 June: *Photuris D* season is from early May to mid August. Multiple phoresy is common, and the pattern established is odd, but probably not significant: 3 fireflies had 1 ps, 3 fireflies had 3 pss each, and 2 had 5 pss. Most pss were attached to a hind tibia, usually by a single chela; other attachment sites observed in the field were the tibio-tarsal junction and tarsus of a hind leg, and mesotarsus and tibia. In captivity pss occasionally reattached at other places, including the elytral apex and an antenna.

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Experiments in which potential carriers were made to walk through the bore of a glass tube past *Paratemnus* females, or were confined up to 48 hr with them in petri dishes, demonstrated that detached pss would sometimes reattach to *Photuris D adults*. Firefly larvae, chrysomelid beetles (*Diabrotica* sp.), a *Gryllus* cricket, and an earwig were not grasped.

A firefly with 2 passengers is barely able to fly. One with 5 pss walks with difficulty. The average live-weight of the pss was 0.002 g (n=12); and of fireflies, 0.037 g (n=2), a ratio of 1:19. The firefly in Fig. 1 was carrying a payless load 29% of its own body weight (plus a parasitic mite on the right elytron). We know not why, to where or whence. Nothing yet supports a predation hypothesis, or even indicates that phoresy on fireflies is adaptive.

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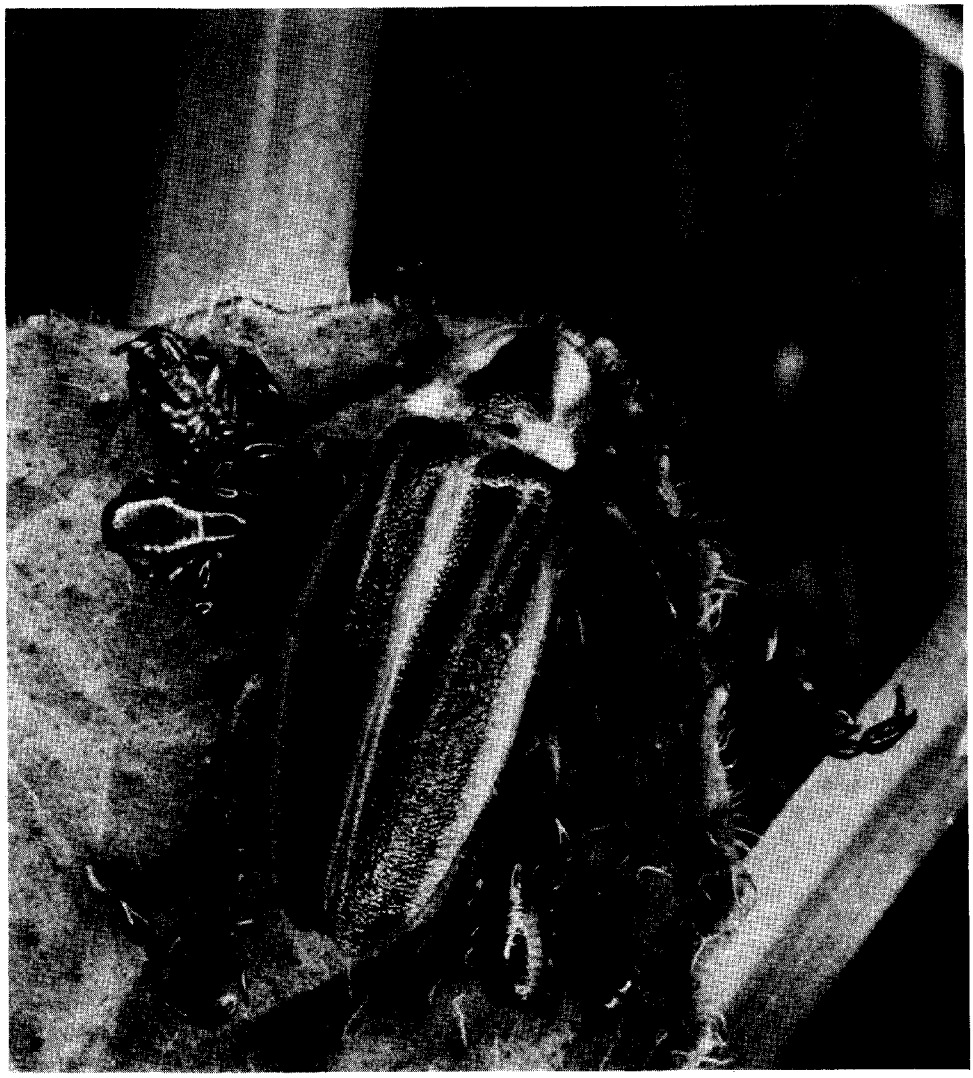

Fig. 1. Adult female firefly *Photuris sp. D* with 5 phoretic female pseudoscorpions *Paratemnus elongatus* and a parasitic mite. Photo taken in the field the night of capture. Note that the pseudoscorpion at the lower left is holding on with both chelae.

BIOLOGICAL NOTES AND NEW SYNONYMY IN *FORCIPOMYIA* (DIPTERA: CERATOPOGONIDAE)

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ABSTRACT

Biological notes are given on 2 species of *Forcipomyia* midges that are parasitized by the hymenopteran genus *Forcipestricis* Burks (Encyrtidae). *Forcipomyia (Forcipomyia) picea* (Winnertz) (synonym: *F. simulata* Walley, NEW SYN.) breeds under tree bark in Europe and North America. *Forcipomyia (Microhelea) fuliginosa* (Meigen) is worldwide in distribution, and larvae have been found under damp tree bark in Brazil, on wood in Puerto Rico, from a mossy log in Costa Rica, from bromeliads in Trinidad, from rotting leaves of *Musa* in Ghana, and from mosses, liverworts, and algae on a clay bank in Singapore. *Forcipomyia intonsa* Chan and LeRoux from Singapore is a synonym of *F. fuliginosa* (NEW SYN.).

The hymenopteran parasitic genus *Forcipestricis* was described by Burks (1968) for a single species, *gazeaui* Burks. The description by Gordon Gordh of this laboratory of a second species prompted me to review the literature on the known hymenopteran parasites of the biting midges (Ceratopogonidae) and to summarize the knowledge of the larval biology of the host of the second species, *Forcipestricis portoricensis* Gordh.

A survey of the literature revealed no instance of any hymenopterous parasite having been reared from the Ceratopogonidae, other than from the terrestrial or semi-aquatic genus *Forcipomyia* Meigen. The more aquatic genera in the subfamilies Leptoconopinae, Dasyheleinae, and Ceratopogoninae, and the predominantly aquatic genus *Atrichopogon* Kieffer in the Forcipomyiinae have no known hymenopteran parasites.

In addition to the 2 species of *Forcipestricis* in the family Encyrtidae, there are records of only 2 species of hymenopterous parasites of *Forcipomyia,* these in the genus *Entomacis* Förster in the family Diapriidae: 1) *E. longii* (Ashmead), 1902, described in the genus *Adeliopria* Ashmead, reared from pupae of *Forcipomyia wheeleri* (Long) taken in what appeared to be an abandoned ant nest in Texas; and 2) *E. californica* (Ashmead), 1883, described in the genus *Hemilexis* Förster, without reference to host, from the Santa Cruz Mountains, California, subsequently determined by C. F. W. Muesebeck and recorded by Bedard (1938) from Washington, emerged from larvae of *Forcipomyia.*

Lionel Gazeau reared *Forcipestricis gazeaui* Burks from *Forcipomyia (Forcipomyia) simulata* Walley in Maryland. Close examination of all stages of the American *F. simulata* and comparison with European material of *F. (F.) picea* (Winnertz) revealed no significant differences and I therefore place *F. simulata* as a junior synonym of *F. picea* (NEW SYNONYMY). Larvae of this widespread Holarctic species occur quite frequently under the

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bark of logs and dead trees of a wide variety of plant families. The larvae are gregarious and feed in small groups of 10-40 individuals on various fungi that grow on the rotting cambium tissue of the trees.

It was with great interest, therefore, that I discovered in the L. G. Saunders collection a number of hymenopterous parasites that were reared by Saunders from *Forcipomyia (Microhelea) fuliginosa* (Meigen) in Puerto Rico. Gordon Gordh has kindly determined these parasites as a second species of *Forcipestricis* and has described them in a companion paper in this journal.

Just before his death in 1968, Saunders donated his valuable collection of reared ceratopogonids to the U. S. National Museum in Washington, D. C. He spent a lifetime in a detailed study of the biology and immature stages of *Forcipomyia* midges; his classic publications (1924, 1956) are the best authority in the field. From 1953 until his fatal illness began in 1965 he pioneered in the study of the *Forcipomyia* midges associated with pollination of cocoa, making extensive collections and observations in Puerto Rico, Trinidad, and other Caribbean islands in 1953 and 1957, Costa Rica in 1956 and 1957, the Philippines in 1961, and Ghana in 1963. I am taking this opportunity to report some unpublished rearing records of *Forcipomyia* from his collection and manuscript notes.

Forcipomyia (Microhelea) fuliginosa (Meigen)

The extensive taxonomic literature concerning this cosmopolitan species has been summarized by Wirth (1956, 1972b). The adult females of *F. fuliginosa* attack caterpillars in small swarms, piercing the bodies of the caterpillars with their mouthparts and feeding upon the haemolymph. I (Wirth 1972a) have expressed my belief that the feeding of these midges fits them well to act as vectors of polyhedral viruses or other pathogens. In some situations it is possible that *Forcipomyia* midges may have some role in biological control, bringing a virus infection from "wild" hosts in a field or orchard margin into a caterpillar population on a crop plant. There are many records of *F. fuliginosa* feeding on a wide variety of lepidopterous larvae, but the species has been found occasionally on other unrelated hosts, including sawfly larvae, dragonflies, and meloid beetles. Field workers in biological control are especially urged to keep in mind the potential importance of *Forcipomyia* feeding on caterpillars and other insects and to look carefully for the attacks of these minute parasites. Adults of *F. fuliginosa* also have been found frequently in flowers of cocoa, where at times they may assume some importance in pollination (Kaufmann 1974).

Immature Stages.—The larva of *F. fuliginosa* was first described and figured under the name of *F. inornatipennis* (Austen) by Ingram and Macfie (1924) who reared the larvae in the laboratory in Ghana from eggs obtained from a gravid female imprisoned in a tube containing vegetable debris. Lane (1947) next described the larva and pupa under the name *inornatipennis* var. *ornaticrus* Ingram and Macfie from material which was collected from damp wood under the bark of dead, fallen, and rotting trees in Brazil. Chan and LeRoux (1971) described and figured a new species, *Forcipomyia (Forcipomyia) intonsa* from all stages reared in Singapore, Malaysia, from mosses, liverworts, and blue-green algae collected on a

clay bank. Their species belongs in the subgenus *Microhelea* Kieffer and is identical with *F. fuliginosa* (NEW SYNONYMY).

In the Saunders collection in the U. S. National Museum of Natural History are 4 lots of *F. fuliginosa* reared from larvae, as follows:

COSTA RICA: Hacienda Theobroma, Siquirres, 14 June 1956, from mossy log, L. G. Saunders, all stages (CR31).

GHANA: Tafo, 20 May 1963, from rotting *Musa* leaves, L. G. Saunders, all stages (G26).

PUERTO RICO: Mayagüez, 27 January 1953, on wood, L. G. Saunders, all stages (PR7). The *Forcipestricis* parasites emerged from the host pupae on 23 January.

TRINIDAD: Las Hermanas, 7 August 1957, from epiphytic bromeliad, L. G. Saunders, 2 males, 2 females, 2 pupal exuviae (There are also several adult *F. fuliginosa* specimens in the USNMNH collection that were also reared in Trinidad from bromeliads by R. W. Williams (no. 51, 3-10 September 1963).

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BOOK REVIEW

NATURAL HISTORY PHOTOGRAPHY. D. M. Turner Ettlinger (Ed). 1974. Academic Press, New York, 395 p. illus. $23.25 (73-19024). This book, with its broad coverage taxonomically and technically, is the last word in nature photography, instruction, and guidance. While it is too heavy and not appropriate for a guide while in the field, many of its thumb rules and techniques are worth copying into a pocket memorandum. Several problems and techniques of laboratory and controlled field photography are discussed. Chapters: Big game, Small vertebrates, Bats, Birds at the nest, Birds away from the nest, The uses of playback tape, Birds in flight, Flight photography with electronic flash, Insects and other invertebrates, Aquaria and vivaria, Plant photography, Underwater photography, Photography in caves, Stereo photography, Tropical conditions, and, under "Some technical points", camera choice, shutters, lenses, focusing, depth of field, exposure, and other topics fundamental to all specialty areas. All photographers, including the consummate connoiseur, will find something of value here!

Were you aware that taking pictures from the back of an elephant is not as easy as it looks, and not the same as shooting from a motor vehicle? This is mainly because they have a different sort of air intake system and the pumping rocks the rider. How then, from a howdah? Use a faster film and shutter, and it's worth it because with an elephant you move much closer to some subjects than you can with more prosaic perches. When working in a damp, cool cave take your photos early because the moisture you will add to the atmosphere with your breathing will flatten and wash out your images. The cave chapter also has instructions for making a stove to cook your camera to keep its optics, workings, and film dry. The text is adequately but not profusely complemented with quality illustrations. These include B&W photographs (I especially like a thistle and flying owl with prey), and line drawings (electronic circuits, camera-subject-light positioning for various situations, hide (blind) plans). Each chapter has a short, and inadequate bibliography. Among minor criticisms: through a typo error insects are considered to be vertebrates (table of contents); grasshoppers are inferred to be Lepidoptera, or leps to sing (p 153); it is hinted that natural selection works at the community level (p 310); and the political view of one contributor (p 344) would be better at Hyde Park.

As a general criticism this volume, like other recent photography guides, fails the practising biologist because it is directed at nonbiologists and devotes much space to fundamentals of nature study. For entomologists, a more serious shortcoming is that the chapter on insects is the weakest and its photos are not especially inspirational, or 'emulatable'. Its text is mostly nature-study, ethics, and conservation, and barely gets around to photography.

If you are interested in nature photography you must study this book. If you are responsible for library purchases in any field of basic, applied or hobby natural history, put this book on your list—if your institution is still buying books.

James E. Lloyd
University of Florida

A NEW FLORIDIAN *POLYCYRTIDEA* WITH COMMENTS ON ZOOGEOGRAPHY OF FLORIDA MESOSTENINI (HYMENOPTERA: ICHNEUMONIDAE)[1]

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ABSTRACT

Polycyrtidea floridana n. sp. is described from Gainesville, Florida. Our only other United States *Polycyrtidea, P. limitis* Cushman from the Lower Río Grande Valley of Texas, also is described and compared. Possible zoogeographic relationships of these and other southeastern mesostenine ichneumonids are discussed.

Through courtesy of Dr. Howard V. Weems, Jr., Curator of the Florida State Collection of Arthropods, at Gainesville, I have received for study an undescribed species of the genus *Polycyrtidea* Viereck. At the same time, under grants from the Committee for Research and Exploration of the National Geographic Society, it has been possible for me to collect a series of *Polycyrtidea limitis* Cushman, a Mexican and Central American form, which has been found in the United States only in the southern tip of Texas.

Polycyrtidea is a small, primarily Neotropical genus belonging to the Subtribe Lymeonina of the Tribe Mesostenini. According to Townes (1966: 99, 1969:288), there are 5 described species and at least 6 more awaiting description. The genus ranges on the west from subtropical northern Argentina north to the Lower Río Grande Valley of Texas and on the east to Cuba and peninsular Florida, but its center seems to lie in tropical and subtropical South America. Unlike most ichneumonids, which prefer wet forests, most *Polycyrtidea* have adapted to semiarid desert or thorn scrub habitats. Thus, I have collected it in the northwest Argentine Dry Chaco and Subandean Desert, in river valleys of the Peruvian Coastal Desert, and in subtropical thorn scrub at McAllen, Texas. Little is known about the hosts of *Polycyrtidea,* but Walkley (1958:48) reported that *P. flavopicta* Ashmead has been reared in British Guiana from the schoenobiine pyralidid moth, *Rupela albinella* Cramer.

Genus *Polycyrtidea* Viereck

Polycyrtidea Viereck, 1913:382.

Type: *Polycyrtidea gracilis* Viereck. Original description.

The following diagnosis will separate *Polycyrtidea* from all other North American mesostenine genera: front with a median conical horn; epomia strong and ending above in a prominent tubercle on dorsal edge of pronotum; hind rim of metanotum without a small tooth on each side of

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postscutellum; areolet very small and lacking second intercubitus; base of second discoidal cell usually narrowed to a point; mediella very strongly arched; first gastric tergite extremely long and slender, without longitudinal carinae.

KEY TO U. S. SPECIES OF POLYCYRTIDEA

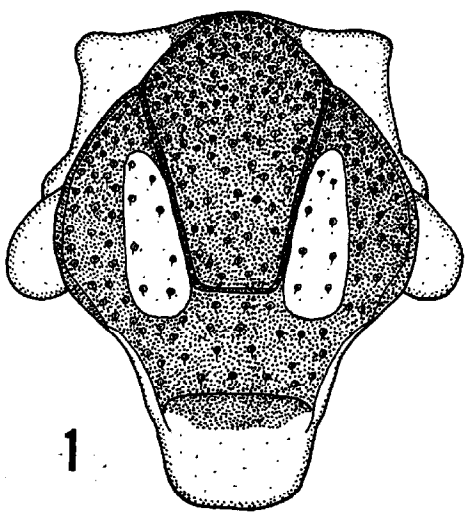
1. Mesoscutum with abundant large, coarse punctures, notauli reaching about 2/3 its length; lower metapleuron coarsely puncto-reticulate throughout; female flagellum with white band; hind tarsus marked with white ..... *P. limitis* Cushman

1'. Mesoscutum with sparse small to medium sized punctures, notauli reaching about 1/3 its length; lower metapleuron becoming smooth and largely impunctate on much of upper anterior 3/5; no white on female flagellum or hind tarsus..... ..... *P. floridana* n. sp.

Polycyrtidea limitis Cushman
(Fig. 1)

Polycyrtidea limitis Cushman, 1929. Holotype: female, USA: Brownsville, Texas (U. S. National Museum of Natural History, Washington, D. C.).

FEMALE. *Color*: scape dark brown above, white to pale yellow below; flagellum blackish with white band above on segments 6 or 7 to 10 or 11; head white to pale yellow with dark brown on apical 1/5 to 1/3 of mandible, a little dusky staining near anterior tentorial pits, more or less blackish between antennal sockets, with shining black on a broad area which reaches dorsad from antennal sockets, widens to include ocellar area, expands greatly onto occiput, reaches ventrad behind onto upper 1/2-2/3 of temple more narrowly, and finally continues rearward and below over most of postocciput; mesosoma shining black with profuse white to pale yellow markings as follows: broad band on dorsal margin of pronotum from epomia to apex, broad band on all but about median 1/4 of front margin of pronotum sometimes confluent with dorsal band, apical margin to almost all of propleuron, a pair of broad longitudinal blotches on middle of mesoscutum bordering notauli externally, sometimes a pair of yellow marks on median lobe of mesoscutum along notauli, tegula, prescutellar ridge, most of scutellum, most of postscutellum, subalarum, a pair of very large narrowly separate to confluent blotches one on upper and one on lower half of mesopleuron, usually some brownish staining in sternaulus, sometimes blotch medially on mesosternum just below sternaulus or occasionally all of mesosternum yellow with brownish suffusion, upper metapleuron and sometimes most of hind rim of metanotum, almost all of lower metapleuron, very large blotch occupying most of propodeum behind weakly traceable apical trans-carina except for apical margin and a more or less large area reaching well forward from insertion of first gastric segment; gaster dull fulvous with variably developed dusky staining, especially on base of second tergite but sometimes nearly throughout, tergite 1 pale yellow on about basal 3/5 and again on apical 1/6, tergites 2-7 with a broad pale yellow apical band that more or less fades out laterad; fore and mid legs with coxae, trochanters, and trochantelli yellowish white with a little brown staining on



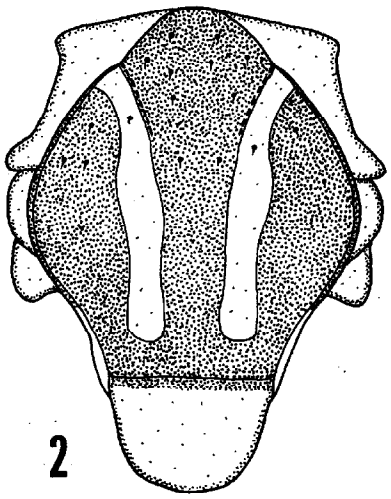


Fig. 1. *Polycyrtidea limitis,* female, McAllen, Texas. Mesonotum and dorsum of pronotum.

Fig. 2. *Polycyrtidea floridana,* female Holotype. Mesonotum and dorsum of pronotum.

apex of mid trochantellus and femora, tibiae, and tarsi fulvous with dusky staining on up to last 3 tarsomeres of fore leg and on tarsomeres 1 or 2 to 5 of mid leg; hind leg with coxa yellow with a very large black to pale brownish blotch on more than basal half of front face, a smaller black to dark brown blotch on apical half above, and a very large black to pale brownish blotch over more than basal half of hind face; trochanter and trochantellus often mostly black with yellow on apex but sometimes more extensively yellowish or brown and fulvous marked; femur fulvous, sometimes with considerable dusky staining; tibia fulvous with dusky staining briefly on base and on about apical 1/10 varying to extensively blackish with only a diffuse dull fulvous pre-basal band; tarsus blackish brown with white on apical 2/5 to 5/8 of first segment, all or almost all of second segment, sometimes in part or even throughout on third segment; wings hyaline.

Length of fore wing: 4.6-5.6 mm. *Head*: frontal horn large and high, 0.23-0.29 as long as first flagellomere. *Mesoscutum*: smooth and polished with abundant large, coarse, in part subadjacent to adjacent punctures; notauli sharply defined for about 2/3 the length of mesoscutum and with a transverse impression connecting their apices. *Metapleuron*: lower part coarsely puncto-reticulate throughout. *Propodeum*: apical trans-carina with prominent and more or less tubercular cristae, otherwise weakly and irregularly traceable. *First gastric tergite*: post petiole shining but throughout with minute wrinkling. *Second gastric tergite*: 2.7-3.4 as long as wide at apex, its surface nearly mat with very fine but strong wrinkling that becomes only a little weaker near apex.

MALE. Differs from female as follows: *Color*: flagellum without a white band.

Length of fore wing: 4.8-5.0 mm. *First gastric tergite*: postpetiole smooth and polished, largely without minute wrinkling. *Second gastric tergite*: 4.2-6.3 as long as wide at apex.

SPECIMENS EXAMINED. 8 females, 4 males, USA, *Texas*: Hidalgo Co., Valley Botanical Garden at McAllen, XII-73 in Malaise trap, 24-XII-73, I-74 in Malaise trap, 7-I-75, 12-21-I-74, III-74 in Malaise trap, C. C. Porter. (In collection of Charles C. Porter, McAllen, Texas and Florida State Collection of Arthropods, Gainesville, Florida).

VARIATION. Townes' description (1962:406) indicates that the ground color of the mesosoma may vary from black to reddish brown.

RELATIONSHIPS. *P. limitis* ranges from the lower Río Grande Valley south to Costa Rica. In South America it is replaced by the perhaps only subspecifically distinct *P. flavopicta,* which has a somewhat different color pattern. From *P. floridana,* on the other hand, *limitis* differs in many characters of color and sculpture, as summarized under the discussion of that species. These 2 U. S. *Polycyrtidea* thus appear to have had a separate origin.

FIELD NOTES. The Valley Botanical Garden at McAllen, Texas, where I collected material of *limitis,* comprises about 15 acres of subtropical thorn scrub dominated by *Prosopis juliflora* and *Celtis pallida,* but with a considerable admixture of *Acacia farnesiana, A. greggii, Condalia obovata,* and *Celtis lindheimeri.* Hand collected specimens of *limitis* were swept from a grassy and weedy area shaded by large *Celtis lindheimeri.* The Malaise trap which caught several additional specimens also was placed in the shade of *C. lindheimeri. P. limitis* seems to fly through much of the year in south Texas, on the basis of my records for December, January, and March and Townes' data (1962:407) for July and August. It probably will be found to be most abundant in winter, as is true for most Río Grande Valley ichneumonids.

Polycyrtidea floridana Porter, new species
(Fig. 2)

FEMALE. *Color*: scape yellow with a little brownish above; pedicel pale brownish above and yellow beneath; flagellum dull pale brown; head bright yellow with dark brown on apical 1/3 of mandible and shining black on a large area which begins just above antennal sockets, reaches dorsad and expands to include ocellar region, widens out behind on occiput and about upper 1/3 of temple, and finally continues rearward and ventrad over about upper 2/3 of postocciput; mesosoma shining black with profuse yellow markings as follows: very large area covering most of dorso-lateral half of pronotum, very broad and almost contiguous band on front margin of pronotum, most of propleuron, a pair of broad longitudinal almost percurrent stripes on mesoscutum, tegula, most of prescutellar ridge, scutellum, most of postscutellum, subalarum, very large blotch over most of upper half of mesopleuron, small dull spot on mesopleuron below well in front of mid coxa, a pair of dull and obscure areas on mesosternum in front of mid coxae, upper metapleuron almost wholly, almost all of lower metapleuron, a very large blotch occupying much of propodeum behind basal trans-carina; gaster dull fulvous with considerable dusky staining, tergite 1 pale yellow on basal 3/5 and again on apical 1/6; tergites 2-5 with a broad, pale yellow apical band which fades out laterad and succeeding tergites more narrowly and diffusely yellowish on apex; fore and mid legs yellow on coxae, trochanters, and trochantelli and otherwise pale fulvous with considerable yellow staining below on basal half of femora and more or less dusky staining on last tarsomere; hind coxa yellow with a

very large black area occupying most of front face except near apex and a large brown blotch on hind face; trochanter and trochantellus brownish grading into dull fulvous below and dull yellowish on apical rims; hind femur, tibia, and tarsus dull fulvous with dusky staining on last tarsomere; wings hyaline.

Length of fore wing: 3.6 mm. *Head*: frontal horn low, 0.15 as long as first flagellomere. *Mesoscutum*: smooth and polished with very sparse small to medium sized punctures that become only moderately denser on anterior 1/3; notauli reaching only about 1/3 length of mesoscutum, without a transverse impression between apices. *Metapleuron*: lower part smooth and practically impunctate on much of upper anterior 3/5 but rearward and below with increasingly more numerous large punctures which finally become subadjacent to adjacent and mingled with weak oblique wrinkling. *Propodeum*: apical trans-carina weakly traceable laterad, where it forms obscure cristae. *First gastric tergite*: postpetiole smooth and highly polished, without minute wrinkling or shagreening. *Second gastric tergite*: 2.2 as long as wide at apex, its surface shining with well developed minute wrinkling that nearly fades out on apical 1/5.

MALE. Unknown.

TYPE MATERIAL. Known only from the holotype female: USA, Florida, Alachua Co., Gainesville (Doyle Conner Building), 4-XII-1971, H. V. Weems Jr. & C. Artaud, in Malaise trap. Holotype in Florida State Collection of Arthropods, Gainesville.

FIELD NOTES. The type locality is an area of sandy soil which supports a forest of *Pinus palustris,* various oaks, and the saw palmetto, *Serenoa repens.*

RELATIONSHIPS: *Floridana* is a distinctive species. It differs strongly from the Texan and Middle American *P. limitis* not only by those characters already mentioned in the key but also in the following details: yellow markings of mesoscutum in the form of almost percurrent stripes instead of shorter broad blotches, mesopleuron with a large yellow blotch covering most of upper half but without any yellow on lower half except for a small spot below well in front of mid coxa, gastric tergites 6-7 only narrowly and diffusely yellowish on apex, hind coxa with a very large black area occupying most of front face except near apex and a large brown blotch on hind face but without a dark area dorsally, frontal horn 0.15 (vs. 0.23-0.29) as long as first flagellomere, without a transverse depression between apices of notauli, apical trans-carina of propodeum developed laterally into obscure (rather than prominent and somewhat tubercular) cristae, postpetiole without minute wrinkling, second gastric tergite 2.2 (vs. 2.7-3.4) as long as wide at apex.

The only other *Polycyrtidea* which might approach *floridana* is the Cuban *P. pusilla* Cresson. The unique type of *pusilla* in the Gundlach collection at Havana, Cuba is not available for study. According to Townes (1966:99) this specimen has lost both the head and the abdomen. However, Cresson's original description (1865:31-32) shows that *pusilla* differs from *floridana* in the following characters: notauli "rather deeply impressed" (vs. weakly impressed in *floridana*), mesosternum pale yellowish instead of mostly dark, mesopleuron with only subalarum yellow lacking a very large pale blotch on its upper half, first gastric tergite pale yellow on basal half but without yellow on apex, succeeding tergites "honey yellow" with base of second blackish but without pale yellow bands on apex.

As to origin of *floridana* and the cause of its present geographic isolation, at least 3 possibilities may be suggested:

(1) When we know more about the Cuban *P. pusilla,* we may find it closely related to *floridana.* This would suggest that *floridana* is a remote or recent immigrant from across the water to the south. However, all available evidence indicates that ichneumonids cross water gaps rather infrequently. Of the 39 species of Mesostenini presently known from Florida (Townes, 1962), only 5 occur also in Cuba (making up about 23% of that apparently impoverished fauna). Moreover, of those 5, only *Compsocryptus fasciipennis* Brullé and *Lymeon bicinctus* Cresson are shared exclusively between Florida and Cuba, while the other 3 (*Pachysomoides fulvus* Cresson, *P. stupidus* Cresson, and *Acerastes pertinax* Cresson) also range widely in the rest of the United States and in the mainland tropics. Exchange of ichneumonids between Florida and the neighboring West Indies thus would appear minimal.

(2) *P. floridana* or its ancestor could have followed the Gulf Coastal Plain up from Middle America into Florida. However, no species closely related to *floridana* presently is known from México or Central America. If *floridana* and the Texan-Middle American *limitis* stem from a common ancestor, the degree of distinctness between them suggests that their separation must have taken place very long ago.

Among other Florida Mesostenini, only 4 species have a distribution somewhat like that outlined above. *Pachysomoides fulvus* occurs throughout the United States, in Cuba, and south into México at least to Orizaba. *Pachysomoides stupidus* ranges from North Carolina and Florida west to Texas and south through Middle America and the West Indies to Venezuela. *Acerastes pertinax* extends from Maryland south to Brasil and Paraguay. *Diapetimorpha macula* Cameron reaches from Maryland south through Texas into México at least as far as Veracruz. Note that none of these species is restricted to the Gulf Arc. All are modern, highly adaptable Neotropical elements of recent penetration in the United States. It is this adaptability which has allowed them to include the whole Gulf Arc in their ranges. During the present interglacial epoch and, indeed, most probably since the end of the Tertiary (Graham 1973:305-310) faunal and floral exchange between Mexican humid forests and those of the southeastern United States appears to have been blocked by the persistence of a wide band of desert and thorn scrub in northern México and southeastern Texas. Moisture, far more than temperature, is the prime factor governing ichneumonid distribution, and its lack probably explains why much more of the fantastically rich Mexican ichneumonid fauna has not spread into the at present climatically favorable southeastern United States. Of course *Polycyrtidea* is a relatively dry-adapted genus but one which penetrates deserts in the vegetation along river banks. As pointed out by Graham (1973:305), "drainage systems that could serve as migration routes via gallery forests tend at right angles to the required direction of migration rather than paralleling the Texas coast."

(3) *Polycyrtidea floridana* may be one of the relicts of the diverse North American Neotropic biota which existed in the Tertiary but was later decimated by Pleistocene glaciation. Until the Oligocene, a wet subtropical forest community covered most of North America. This included plant genera, such as *Philodendron* (Araceae), *Ficus, Ocotea* and *Nectandra* (Lauraceae), and *Podocarpus,* all suggestive of a mild, if not necessarily

frost-free, wet forest community not unlike that growing today in southeast Brasil and ideal for Neotropic sylvan ichneumonids (Dilcher 1973:44). At that time, the ancestor of *P. floridana* may have ranged widely over North America. With glaciation, however, tropical species retreated south, and the northern limits of their distribution were fragmented among refugia such as ravines, river valleys, and coastal plains. At glacial maxima, temperate conditions blanketed most of México, with subtropical climates beginning around 20 degrees north latitude along the coasts and genuinely tropical conditions starting at about the Nicaraguan border, while in eastern North America only the southern half of Florida enjoyed a subtropical climate (Udvardy 1969:322). During interglacials, temperatures improved but rain diminished, hampering northward dispersal of moisture-loving forms, such as ichneumonids, especially from the Middle American refugium. As already noted, the only eastern refugium of subtropical climate was Florida, and much of Florida was inundated at various times during the Pleistocene although "a number of substantial islands" (Spencer and Stegmaier 1973:9) remained above water at all times during that period. As grossly impoverished island faunas all over the world suggest, ichneumonids do not cross water with facility. Furthermore, some authors believe that the latest glaciation (the Wisconsin) may have been severe enough to "entirely eliminate" (Spencer and Stegmaier 1973:10) any genuinely tropical element from Florida. Thus, that part of the North American Neotropic Tertiary fauna which was driven southwest into México survived the glaciations in that favorable region with its open connection to the south, whereas the eastern component that was pushed toward Florida mostly became extinct from the cold and from lack of ability to escape across the water to the Florida islands or the West Indies. During the present interglacial, those species which did find refuge in what now is Florida in many cases have moved out over much of the east. Most of these today range westward only as far as the limit of the southeastern Pine-Oak forests around Houston, Texas. However, some of the more adaptable ones have attained the Río Grande Valley of southern Texas and parts of northern México, coming into contact with relatives from which they have been separated since the end of the Tertiary and from which they now are specifically distinct.

This third zoogeographic pattern is the one to which most Florida ichneumonids of Neotropic affinities seem to pertain, as illustrated by the following list:

1. *Baryceros audax* Cresson: Eastern U. S. as far west as Kansas.
2. *B. texanus* Ashmead: Maryland and Michigan west to Arkansas, Oklahoma, and Texas, with 1 record for Sonora State in northern México.
3. *Mallochia agenioides* Viereck: Eastern U. S. as far west as Nebraska.
4. *M. laevis* Townes: S. Georgia and Florida.
5. *Trachysphyrus weemsi* Porter: Florida.
6. *Lanugo retentor* Brullé: New Jersey and Illinois west to central Texas.
7. *Diapetimorpha brunnea* Townes: S. Georgia and Florida.
8. *D. picta* Townes: S. Georgia and Florida.
9. *D. rufigaster* Cushman: Maryland and Michigan to Florida.
10. *D. introita* Cresson: North Carolina to northern Nuevo León, México.

11. *Lymeon, cinctiventris* Cushman: Maryland to Lower Río Grande Valley.
12. *L. orbum* Say: Connecticut and Michigan to Lower Río Grande Valley.
13. *Polycyrtidea floridana* Porter: Florida.
14. *Cryptanura banchiformis* Megerle: New England to central Texas.
15. *Polycyrtus neglectus* Cushman: Massachusetts and Michigan to northeast Texas, with a disjunct population in the Sierra Madre Oriental of northeast México at Cola de Caballo near Monterrey.
16. *Messatoporus rufiventris* Cushman: U. S. and southern Canada.
17. *M. compressicornis* Cushman: Connecticut and Ohio west to Alabama; closely related to the Mexican *M. arcuatus* Cresson.
18. *Agonocryptus discoidaloides* Viereck: E. U. S. to Lower Río Grande Valley.

The above information, based on Townes' (1962) revision of the North American Mesostenini as well as on the Florida State Collection of Arthropods and the author's personal collection, suggests that there is a distinctive northeast North American mesostenine ichneumonid fauna of Neotropic and Sonoran (*Compsocryptus* and *Lanugo*) origins. This complex, in which *Polycyrtidea floridana* seems to fit, may constitute, in the case of its Neotropic members, the remnants of a much larger Tertiary fauna mostly extirpated by the Pleistocene glaciations (the Sonoran elements probably extended eastward during the driest parts of some of the Pleistocene interglacials).

To complete our picture of the Florida mesostenines, we should note that, besides the 22 Neotropic and 2 Sonoran species already mentioned, the state also harbors 15 mesostenines of Holarctic origin and belonging to the genera *Apsilops, Agrothereutes, Gambrus, Aritranis, Ischnus, Habrocryptoides, Trychosis, Listrognathus, Mesostenus (transfuga* group), and *Xylophrurus.*

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A CESIUM-134 TRAP FOR ISOTOPE USE[1,2]—(*Note*). To safeguard against a Cesium-134 (specific activity 2 mCi/0.5 cc) leak during a recent radioisotope experiment in Gainesville (Del Fosse, E. S., H. L. Cromroy, and D. H. Habeck. 1975. Determination of the Feeding Mechanism of the Waterhyacinth Mite. Hyacinth Contr. J. In Press.), a ^{134}Cs trap was designed to supplement a radiation-approved chemical hood (Fig. 1). The hood had a fan located at the top, which pushed ^{134}Cs-laden air out of the hood into 1.27 cm diam Tygon^{R} plastic tubing. Attached to this plastic tubing was a 10 cm length of 1.27 cm copper tubing, the free end of which was inserted into a 0.95 l glass jar containing ca. 250 ml 0.1N HCl. The end of this copper tubing extended ca. 2 cm into the HCl. To a 7 cm length of copper tubing (the end of which did not enter the HCl) was attached another length of Tygon^{R} tubing, which led back into the bottom of the hood. A precipitate, ^{134}CsCl, collected in the jar, and clean air was pulled back into the hood. The trap's efficacy was shown by absence of surface radiation contamination outside of the hood as measured with wipe tests and a NaI detector counter. Del Fosse, E. S., and H. L. Cromroy. Department of Entomology and Nematology, University of Florida, Gainesville, 32611.

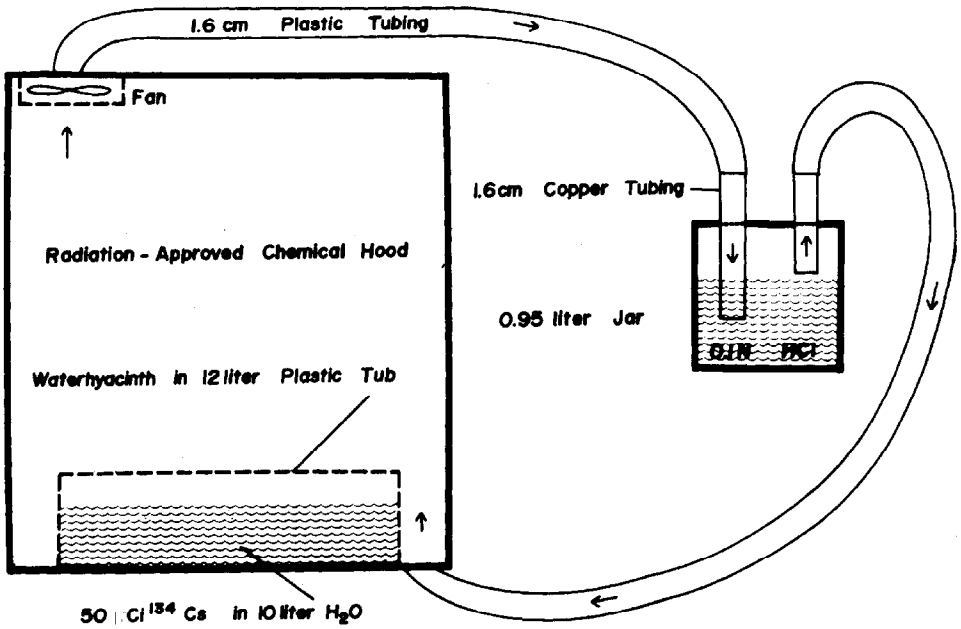

Fig. 1 Design of ^{134}Cs trap utilized in a waterhyacinth mite (*Orthogalumna terebrantis* Wallwork) experiment.

[1]Cooperative research conducted in Gainesville by Agricultural Research Service, U. S. Department of Agriculture, and the University of Florida, Gainesville, 32611.

[2]Approved as Journal Series No. 5913.

LONG TERM CAN TRAPPING FOR POPULATION ANALYSES OF GROUND-SURFACE, ARID-LAND ARACHNIDS[1]

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ABSTRACT

This investigation was designed to estimate statistically the number of can traps required to study populations of ground-surface, arid-land arachnids. Data were obtained from 16 traps operated for 1 year in the pinyon-juniper life zone of the Pinos Altos Mountains in southwestern New Mexico. The formula $N = S^2/SE^2$ (where N = number of traps, S^2 = variance, and SE = standard error of the mean) was used to estimate the number of traps required for assigned precision limits of 10, 20, 30, and 50% of the mean ($\bar{x}$) number per trap. Only precision limits within 20% or less of the $\bar{x}$ are considered meaningful.

Thus, population studies on the local scorpion, *Vejovis coahuilae* Williams, would require 67 traps, whereas 25 traps would be sufficient for similar studies on local gross solpugid populations. *Mastigoproctus giganteus* Lucas populations might be estimated using only 21 traps per area. Finally, the number of traps per study area required for estimates of local, arid-land spider populations varied from 11 for the abundant cursorial gnaphosid, *Zelotes tuobus* Chamberlin, through 12 for the abundant web-building pholcid, *Psilochorus imitatus* Gertsch and Mulaik, to 22 for the abundant wolf spider, *Schizocosa* n. sp. (nr. *avida* Walckenaer). Data on less common species indicated that 20-70 traps per area might be required for study, even of male cursorial activity.

This evaluation of can trap population estimates suggests that a knowledge of the life cycle, food habits, ecological requirements, and behavior of target species, and the use of this and other methods of population estimation should be combined for valid population studies.

An investigation was designed to determine if long term operation of can traps of the type proposed by Muma (1970) could be utilized for quantitatively analyzing ground-surface, arid-land, non-acarine, arachnid populations (Williams 1968; Muma 1973, 1974). This report is concerned primarily with calculating the necessary number of traps per study area for the production of a repeatable mean number of specimens per trap, per year within certain limits of precision.

Baited and unbaited pitfall devices buried flush with the surface of the soil have been used as a qualitative survey tool by arthropod taxonomic specialists for many years. Fichter (1941) first suggested their use for quantitative research. His alcohol pitfall was large, expensive, and difficult to install and maintain. However, Muma and Muma (1949) discussed prairie

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spider populations on the basis of specimens collected in the Fichter pitfall, and Rhoades (1962) did the same with insect and spider populations in northwestern Florida. Other workers have utilized sheltered or unsheltered, sunken metal, glass, or plastic containers for both qualitative and quantitative studies (Southwood 1966). Reports have indicated considerable variation in trap size, killing-preserving agents, number used, time of operation, animals studied, and purpose of investigation. These variations for 12 recent studies are cited in Table 1.

Prior to presentation of the present research, it seems apropos to discuss the nomenclature of ground-surface arthropod trapping devices. As indicated in Table 1, 4 different names have been applied to such devices. The extra-large, 1 m-wide trap constructed to force arthropods into a much smaller alcohol-filled container (Fichter 1941; Muma and Muma 1949; Rhoades 1962) has consistently been referred to as an *alcohol pitfall.* Small, dry, similar-sized jars (Hensley et al. 1961; Duffey 1962; Mitchell 1963; Greenslade 1964; Hayes 1970) have also been referred to consistently as *pitfall traps.* Duffey hyphenated the term pitfall and Hensley et al. used a killing agent, but all workers applied the same name to essentially the same device. Variation in trap nomenclature has occurred among workers who utilized moderate to large-sized cans. Allred et al. (1965) referred to theirs, which they operated dry, as can pit-traps; although they and other workers later referred to them as can traps. Williams (1968 and 1970) referred to his, also operated dry, as pitfall traps, and Muma (1963, 1970, 1973, 1974) consistently referred to his, whether operated dry or with a killing-preserving agent, as can traps. Since the terms alcohol pitfall and pitfall trap have been consistently applied to similar devices, operated in a similar manner, a comparable name needs to be developed only for moderate to large cans operated dry and similar cans operated with a killing or killing-preserving agent. I suggest that large, dry cans be referred to as *pit traps,* a term used by Schmid et al. (1973), and large cans with a killing-preserving agent as *can traps.*

Two reviews (Southwood 1966, Turnbull 1973) have questioned the validity or reliability of such traps for quantitative evaluation of arthropod populations. Both reviews cited apparent reasons for this lack of efficiency and value. Several workers have taken the opposite position.

Duffey (1962) concluded that small, dry pitfalls produced valid spider population data often comparable to those obtained by Tullgren aparatus processing of turf samples and by hand picking. Williams (1968, 1970) concluded that large, dry pitfalls produced numbers of scorpions comparable to those of the natural community observed with the ultraviolet light method. Schmoller (1971) believed that small, dry pitfalls produced good data on diurnal versus nocturnal ground-surface arthropods. Muma (1970, 1973, 1974, 1975) maintained that large pitfalls, despite numerous hypothetical objections, produced valid spider and solpugid population data. Gist and Crossley (1973) found small pitfall and hand sorting estimates of ground surface arthropods on isolated grids to be highly comparable. And finally, Uetz and Unzicker (in press) indicated that pitfall trapping is a valid, useful ecological method.

These differences of opinion concerning usefulness and validity of the pitfall principle in population studies may be reduced to 6 factors.

1. Large species may damage or devour small species. This is unquestionably true for dry pitfalls, but a killing-preserving agent (Fichter 1941;

TABLE 1. SIZE AND USE OF PITFALL DEVICES FOR ARTHROPOD STUDIES.

Worker and Citation	Trap Diameter	Killing Agent	Number Used	Time Operated	Name Applied	Arthropods Studied	Purpose of Study
Fichter (1941)	1 m	70% C_2H_5OH	3	9 mos.	Alcohol Pitfall	Misc. Arthropods	Long-grass prairie populations.
Hensley et al. (1961)	1 qt freezer jar	70% C_2H_5OH & Kerosene	2/plot	7 mos.	Pitfall Trap	Insects and Arachnids	Predaceous fauna, sugar cane fields.
Duffey (1962)	6.5 cm	None	23	14 mos.	Pit-fall Trap	Spiders	Limestone grassland populations and trap study.
Rhoades (1962)	1 m	70% C_2H_5OH	12	36 mos.	Alcohol Pitfall	Misc. Arthropods	Effects of heptachlor on populations.
Allred et al. (1963)	17.7 cm	None	Several 100	36 mos.	Can pit-trap	Misc. Animals	Biotic community surveys.
Whitcomb et al. (1963)	6-7 cm	70% C_2H_5OH	30	2.5 mos.	Pitfall Trap	Spiders	Comparison of populations.
Mitchell (1963)	6.5 cm	None	50 and 100	4 mos.	Pitfall Trap	Carabidae	Population make-up, density and activity
Greenslade (1964)	6.5 cm	None	21	2 mos.	Pitfall Trap	Carabidae	Trap evaluation.
Williams (1968)	15.3 cm	None	100	5 mos.	Pitfall Trap	Scorpions	Population make-up and density.
Hayes (1970)	6.0 cm	None	24	1 night	Pitfall Trap	Isopods	Trap evaluation.
Muma (1973)	9.5 cm	Alcohol & Glycol	16	48 mos.	Can trap	Spiders	Population make-up and density.
Muma (1974)	15.3 cm	Alcohol & Glycol	48	24 mos.	Can trap	Solpugida	Population make-up and density.

Hensley et al. 1961; Muma 1970, 1973; Schmid et al. 1973) prevents such activity.

2. An alcohol preservative may repel species. Until comparative studies have been conducted with pitfall devices containing water, water and detergents, alcohol, and other preservatives, possible repellence can neither be assumed nor denied. However, the data of Muma (1973, 1974, 1975, this paper, and unpublished) indicate that many insect and arachnid arthropods are not repelled by an alcohol (ethyl or iso-propyl)-ethylene glycol mixtures. In fact, the common to prevalent collection of grasshoppers, ants, crickets, beetles, flies, spiders, and scorpions indicates a degree of attraction. The use of picric acid suggested by Southwood (1966) may be hazardous, since dry picric acid and its derivatives are known to be explosive, and Frank A. Enders (unpublished) has found picric acid to be less useful than ethylene glycol in a desert.

3. Trap and removal may reduce populations. Tretzel (1955), Greenslade (1964), Williams (1968), and Muma (1973, 1974, 1975) have found that this is not true, at least for spiders, carabids, scorpions, and solpugids.

4. Placement of traps may influence trap catches. The lip of the trap may be above ground-surface among dense grasses and herbs, above ground-surface in duff or leaf litter, and at ground-surface in natural or artificially cleared areas. As stated by Muma and Muma (1949), placement of traps should be based on a knowledge of the habits and life histories of the target animals.

5. Animal activity may influence trap catches. Activities vary from species to species, from habitat to habitat, from dry to night, with weather, temperature, and according to attractiveness of the trap to the target animals. Here again, quantitative analyses of trap records not guided by a knowledge of the biology of the species under study could be misleading.

6. Abundance of the study animal is the least influential factor. This may be true but such a generalization is subject to criticism, particularly since the influence of trap size, trap number, and duration of trap operation on the stability of the mean number of target animals collected is not known.

I have used (Muma 1974, 1975) and am presently using the large can trap proposed by Muma (1970), so only this trap is evaluated here.

Methods

Sixteen can traps were emplaced in the pinyon-juniper life zone of the Pinos Altos Mountains in Grant County, New Mexico. Emplacement was in 3 transects; traps 1-5 oriented in an east-west line, spaced at 5 m intervals; traps 6-11 oriented in a north-south line at 5 m intervals, and traps 12-16 oriented in an east-west line at 10 m intervals. Transects 1-5 and 12-16 were separated by about 50 m.

The traps were operated from 1 April 1972 to 2 April 1973. Specimens were collected from the traps at 2-week intervals. To reduce evaporation, the killing-preserving agent used was 200 ml of a 1:1 mixture of 70% commercial grade isopropyl alcohol and commercial grade ethylene glycol. The killing-preserving agent was reconstituted at each visit with a 3:1 mixture of alcohol and glycol.

At each collection date, specimens were removed from each trap, sorted, identified, recorded, and maintained separately. Only adult specimens were

identified to species. Sub-adults, when possible, were identified to genus and spiderlings (first, second, and third instars) to family. All immatures, with few exceptions, are reported here at the family level. A few adults could not be identified to species and are reported here at the generic level. Dr. Willis J. Gertsch, Portal, Arizona either identified or confirmed identifications of most of the spiders. Michael Soleglad, San Diego, California identified the scorpions.

The standard error of the mean was utilized in the formula $SE = S/\sqrt{n}$ or $n = S^2/SE^2$ to analyze the numbers of collected specimens of common species, those representing 1 or more percent of the total recorded specimens. In these formulas SE = standard error, S = standard deviation, n = number of traps and S^2 = variance. Variance was determined for precisions of 10, 20, 30, and 50% of the mean number of specimens per trap, per year. The mean ($\bar{x}$) number of specimens per trap, per year and the standard deviation (S) of the yearly trap totals and means were computed in the usual manner. Dr. Tom R. Ashley, ARS, USDA, Gainesville, Florida, and his associates examined accumulated raw data, and suggested this statistical treatment. Dr. Ashley also assisted in evaluating statistical review comments and suggestions.

Results

Altogether 956 arachnid specimens, representing 4 orders and 15 families, were collected in the traps during the study. The Scorpionida was represented by 1 family and 1 species, the Pedipalpida by 1 family and 1 species, the Solpugida by 2 families and 6 species, and the Araneida by 11 families and 64 species. For taxonomic and zoogeographic purposes all species collected are listed in Table 2. The only statistical data presented in the table are those pertaining to families and species representing 1 or more percent of the total recorded arachnid population.

The statistical approach used indicated that large series of traps are required at each study station if a sampling precision within 10% of the mean is desired for most of the local common arachnid forms representing less than 20% of the total studied population. On the other hand, if less sampling precision is tolerable, a few traps can be operated on each study area to produce meaningful population data for most common southwestern New Mexico arachnids collected during this study.

No differences were detected between the arachnids trapped in the east-west and north-south transects, so the tabulated figures represent the totals for 16 traps.

Discussion and Conclusions

Many of the arachnids collected by the can traps were not true, ground-surface cursorial forms. For instance, most Pholcidae, Agelenidae, Dictynidae, Theridiidae, and Linyphiidae are web-builders. They stay on their snares to capture prey that vibrate or become entangled in the silken strands. Further, most of the misumenine Thomisidae are known to be ambush predators (Gertsch 1949). Regular occurrence of such sedentary forms in can traps is difficult to explain in some cases and relatively easy in others.

TABLE 2. ARACHNIDA COLLECTED IN 16 CAN TRAPS IN THE PINYON-JUNIPER LIFE ZONE OF THE PINOS ALTOS MOUNTAINS AT SILVER CITY, NEW MEXICO BETWEEN 1 APRIL 1972 AND 2 APRIL 1973. COMMON FORMS, THOSE REPRESENTING 1.0% OR MORE OF THE POPULATION, ARE STATISTICALLY EVALUATED FOR THE NUMBER OF TRAPS (N) REQUIRED FOR SAMPLING PRECISION WITHIN 10, 20, 30, AND 50% OF THE MEAN ($\bar{x}$).

Arachnids Collected	No. Spms. Trapped	% of Population	$\bar{x}$±SE/ trap/year	No. traps (n) needed for sampling precision within:			
				10%$\bar{x}$	20%$\bar{x}$	30%$\bar{x}$	50%$\bar{x}$
Scorpionida							
Vejovidae							
Vejovis coahuilae Williams	14	1.5	0.88±0.34	265	62	22	10
Pedipalpida							
Thelyphonidae							
Mastigoproctus giganteus Lucas	26	2.7	1.63±0.38	87	21	10	4
Solpugida							
Eremobatidae (Juveniles, young and adults)	29	3.0	1.81±0.45	97	25	11	4
	9						
Eremobates n. sp. (*palpisetulosus*-group)	2						
Eremobates pallipes (Say)	3						
Eremochelis sp. (*imperialis*-group)	1						
Hemerotrecha fruitana Muma	3						
Hemerotrecha sp. (*banksi*-group)	1						
Ammotrechida (juveniles, young and adults)	1						
Ammotrechula peninsulana (Banks) (young)	1						

TABLE 2–*Continued.*

Arachnids Collected	No. Spms. Trapped	% of Population	$\bar{x}$±SE/ trap/year	No. traps (n) needed for sampling precision within:			
				10%$\bar{x}$	20%$\bar{x}$	30%$\bar{x}$	50%$\bar{x}$
Araneida							
Pholcidae (immatures and adults)	144	15.1	9.00±2.04	83	21	10	4
Psilochorus imitatus Gertsch and Mulaik	99	10.3	6.19±1.07	48	12	6	2
Lycosidae (immatures and adults)	284	29.7	17.75±1.90	19	5	3	1
Allocosa sp. (immature)	1						
Hesperocosa unica (Gertsch and Wallace)	4						
Lycosa coloradensis Banks	4						
Lycosa n. sp. (nr. *coloradensis*)	5						
Lycosa n. sp.	12	1.3	0.75±0.27	227	52	23	9
Pardosa sp. (*lapidicina*-group)	1						
Pardosa sternalis (Thorell)	3						
Schizocosa n. sp. (nr. *avida* Walckenaer	67	7.0	4.19±0.96	87	22	10	4
Schizocosa mimula Gertsch	22	2.3	1.38±0.32	84	21	10	4
Tarentula kochi Keyserling	24	2.5	1.19±0.33	127	32	14	5
Gnaphosidae (immatures and adults)	239	25.0	14.94±1.61	19	5	3	1
Callilepis gosoga Chamberlin and Gertsch	1						
Drassodes celes Chamberlin	1						
Drassodes gosiutus Chamberlin	2						
Drassodes robinsoni Chamberlin	5						
Drassyllus mephisto Chamberlin	13	1.4	0.81±0.26	183	43	19	7

TABLE 2—*Continued.*

Arachnids Collected	No. Spms. Trapped	% of Population	$\bar{x}$±SE/ trap/year	No. traps (n) needed for sampling precision within:			
				10%$\bar{x}$	20%$\bar{x}$	30%$\bar{x}$	50%$\bar{x}$
Drassyllus mormon Chamberlin	6						
Drassyllus orgilus Chamberlin	1						
Gnaphosa sericata (L. Koch)	4						
Haplodrassus sp. (nr. *signifer* Koch)	13	1.4	0.81±0.33	295	68	30	11
Herpyllus propinquus Keyserling	2						
Herpyllus sp. (nr. *hesperolus* Chamberlin	2						
Micaria sp. #1	4						
Micaria sp. #2	2						
Micaria sp. #3	5						
Micaria sp. #4	1						
Micaria sp. #5	1						
Poecilochroa pananus Chamberlin	2						
Zelotes n. sp. (large)	32	3.3	2.00±0.60	144	36	16	6
Zelotes tuobus Chamberlin	82	8.6	5.13±0.84	43	11	5	2
Anyphaenidae (immatures and adults)	7						
Anyphaena coloradensis Banks	3						
Clubionidae (immatures and adults)	21	2.2	1.31±0.30	85	22	10	4
Agroeca trivittata Keyserling	1						
Castianeira variata Gertsch	1						
Corinna bicalcarata Simon	2						
Piabuna n. sp.	3						

TABLE 2—*Continued.*

Arachnids Collected	No. Spms. Trapped	% of Population	$\bar{x}$±SE/ trap/year	No. traps (n) needed for sampling precision within:			
				10%$\bar{x}$	20%$\bar{x}$	30%$\bar{x}$	50%$\bar{x}$
Phrurotimpus borealis (Emerton)	1						
Phrurotimpus mormon Chamberlin and Gertsch)	1						
Scotinella schwarzi (Gertsch)	5						
Agelenidae (immatures and adults)	15	1.6	0.99±0.34	225	52	23	9
Agelenopsis longistylus (Banks)	1						
Cicurina nr. *varians* Gertsch and Mulaik	9						
Dictynidae (immatures and adults)	17	1.8	1.06±0.36	189	48	21	8
Dictyna n. sp. (nr. *saltona* Chamberlin and Gertsch)	1						
Dictyna cholla Chamberlin and Gertsch	2						
Dictyna oasa Ivie	3						
Dictyna personata Gertsch and Mulaik	5						
Tricholathys n. sp.	3						
Theridiidae (immatures and adults)	15	1.6	0.94±0.19	74	17	8	3
Euryopis sp. (small light female)	1						
Euryopis scriptipes Banks	8						
Steatoda medialis Banks	2						
Linyphiidae (immatures and adults)	16	1.7	1.00±0.29	135	34	15	6
Cochembolus sp.	1						

TABLE 2—*Continued.*

Arachnids Collected	No. Spms. Trapped	% of Population	$\bar{x}$±SE/ trap/year	No. traps (n) needed for sampling precision within:			
				10%$\bar{x}$	20%$\bar{x}$	30%$\bar{x}$	50%$\bar{x}$
Eperigone eschatologica Crosby	3						
Erigone sp. (poss. *blaesa* Crosby and Bishop)	2						
Meioneta sp.	4						
Tennesseellum formicum (Emerton)	3						
Thomisidae (immatures and adults)	118	12.3	7.38±0.89	24	6	3	1
Apollophanes margareta (Lowrie and Gertsch)	1						
Apollophanes texanus (Banks)	4						
Ebo pepinensis Gertsch	1						
Thanatus sp. (nr. *coloradensis* Keyserling)	2						
Tibellus sp. (immature)	1						
Xysticus aprilinus Bryant	1						
Xysticus cunctator Thorell	64	6.7	4.00±0.95	91	23	11	4
Xysticus lassanus Chamberlin	13	1.4	0.81±0.32	273	63	28	10
Xysticus locuples Keyserling	1						
Xysticus paiutus Gertsch	1						
Salticidae (immatures and adults)	11	1.2	0.69±0.18	126	27	12	5
Metaphidippus sp.	1						
Pellenes sp. (nr. *wrighti* Lowrie and Gertsch)	1						
Phidippus n. sp. (nr. *coccineus* Peckham)	2						

Common occurrence of misumenine crab spiders in can traps primarily represents sexual cursorial activity of males searching for females (Muma and Muma 1949). In this study 83% of the collected misumenines were males, whereas only 60% of the cursorial philodromine crab spiders were males. Other explanations are needed for the regular occurrence of web-building species.

Among the theridiids, females were 4 times as numerous as males. They may have been trapped either while changing web sites (Turnbull 1964) or while repelling intruders (Riechert 1973). Also conceivably some theridiids could be cursorial species taxonomically classified among web-builders.

In this study, the most prevalent species was *Psilochorus imitatus* Gertsch and Mulaik, a pholcid. Abundance of pholcids probably was due to the spiders' use of the can traps as web-building sites. This species and other southwestern pholcids normally use mammal, especially rodent, burrows, hollow yucca "logs", and crevices in and under other ground-surface debris as web-building sites. It can be assumed that the sunken cans merely added additional micro-habitats to the environment. Since more than 1 male of this species often live in the web of 1 female under natural conditions, it is not surprising that 64% of the collected adults were males. Some males also may have been trapped while searching for females.

The common occurrence of agelenid, dictynid, and linyphiid spiders in the can traps cannot presently be explained, especially since nearly equal proportions of the sexes of each species were collected. Many linyphiids also have been taken in other studies (Barnes 1953; Walker 1969). As stated by Muma and Muma (1949), behavioral and life history studies must be conducted on local, arid-land species before their cursorial activity can be explained.

The above discussions suggest biological reasons for the occurrence of non-cursorial forms in the can traps. In addition, surprisingly, analyses of trapped specimens indicate that such traps may be useful in comparative population studies on such species. This is especially true for the abundant *P. imitatus,* whose populations may be investigated to a precision within 20% of the mean, using 12 traps per study area. To a limited extent, the same is true for the ambush predator, *Xysticus cunctator* Thorell, if precision limits are extended to 30% of the mean and deductions and conclusions are confined largely to activity of the male population.

Among the true cursorial spiders collected during the study, the Lycosidae and Gnaphosidae were by far the most abundant. In fact, the only common cursorial spiders taken in the traps were representatives of these families. The cursorial Anyphaenidae were uncommon and the Clubionidae and Salticidae were common only as families. Therefore, in any local, arid-land studies involving populations of running or jumping spiders, deductions and conclusions should be confined to the family level for precision within 20% of the mean using 27 traps per study area.

The most common cursorial spider taken in the can traps was *Zelotes tuobus* Chamberlin. It was more than twice as abundant as the next three most common gnaphosid, a large undescribed *Zelotes,* and more than 6 times as numerous as *Drassyllus mephisto* Chamberlin and a species of *Haplodrassus* near *signifer* C. L. Koch. Although the wolf spiders as a family were more numerous than the wandering gnaphosids, the most common lycosid, *Schizocosa* n. sp., was distinctly less abundant than *Z. tuobus.* However, it

was 3 times as numerous as either *Schizocosa mimula* Gertsch or *Tarentula kochi* Keyserling and 5 times as abundant as *Lycosa* n. sp., the other 3 common wolf spiders.

Although only 5 traps per study area would be required to obtain precision within 20% of the mean for evaluation of local lycosid and gnaphosid populations at the family level, the number of traps would have to be increased to 30 to obtain precision within 30% of the mean if analyses of common local species populations were desired.

As discussed above for the non-cursorial spiders, other factors must also be considered in the comparative estimation of arid-land, cursorial, spider populations with can traps. For instance, increased confidence in the mean number of wandering gnaphosids trapped apparently is somewhat related to the abundance of the several species under investigation. Only 11 traps are required to obtain precision within 20% of the mean for the very abundant *Z. tuobus*. A much larger number of traps is required for the less common gnaphosids. Furthermore, the sex ratios of trapped common gnaphosids varied from only 31% males for *D. mephisto* to only 63% males for *Z. tuobus* which indicates that both gnaphosid sexes are cursorially active. The same is not true for the lycosids. In the first place, increased confidence in the mean number of lycosids trapped is not related to the abundance of the investigated species. More traps were required to obtain the same level of confidence for the abundant undescribed species of *Schizocosa* than for the much less common *S. mimula*. Since the sex ratios of trapped wolf spiders varied from 73% males for *Schizocosa* n. sp. to 86% males for *S. mimula*, the occurrence of wolf spiders in can traps must be assumed to be largely an expression of male sexual cursorial activity (Hollander 1967). These data show that can trap evaluation of wolf spider populations should be combined with careful biological and behavioral studies prior to the drawing of specific conclusions.

Among the other orders of arachnids trapped, the data on the scorpion, *Vejovis coahuilae* Williams, perhaps are the most interesting since Williams (1968, 1970) has collected and published data on a closely related species, *Vejovis spinigerus* Wood. In his first study, Williams (1968) operated 100 pit traps in a desert valley and concluded that *V. spinigerus* was not sufficiently abundant to determine the effects of trap cover and the trap and removal method. Habitat data collected by Williams (1970), using 20 pit traps per habitat, corroborated his 1968 findings by demonstrating that *V. spinigerus* was primarily a rocky, habitat species.

Present data also confirm Williams' conclusions since *V. coahuilae* is closely related to *V. spinigerus* and was the only scorpion collected in can traps in the rocky, pinyon-juniper life zone of the Pinos Altos Mountains. The limited number of specimens recorded here indicate that either Williams' pit traps were more efficient in collecting scorpions than can traps or, as indicated by Beatty (1961) and Frank A. Enders (unpublished), the scorpion population during the present study was much smaller than that sampled by Williams. In either case it appears that use of fewer than 62 can traps per study area will invalidate such traps for the study of local scorpion populations. Further, current studies (Muma 1975, and unpublished) indicate that scorpions are highly discontinuous in distribution and "colonies" should perhaps be located before trapping is attempted.

Data on *Mastigoproctus giganteus* Lucas, the only pedipalpid trapped during the present study, indicate that local populations of this whip-

scorpion can be studied with as few as 21 traps per station. Current studies (Muma, unpublished) indicate that this whip-scorpion may also be highly discontinuous in distribution and "colonies" should perhaps be located before trapping is attempted.

The data on solpugids were somewhat disappointing. Although the family Eremobatidae represented 3% of the total, trapped, arachnid population, the Ammotrechidae were not common, and none of the 6 recorded solpugid species achieved common status. Even analyzed at the family level, the data indicate that use of fewer than 25 can traps per plot greatly decreases the sampling precision of such traps for estimating local solpugid populations. For instance, local, gross solpugid populations can be compared only to a precision within 30% of the mean, using 11 can traps per study area. Since a single field worker cannot effectively operate 25 traps per study area, additional methods studies are required for analyzing solpugid populations. Muma (1974) indicated the need for such studies for *Eremochelis bilobatus* (Muma).

Several conclusions can be drawn concerning the use of can traps, and possibly also alcohol pitfalls, pitfall traps, and pit traps, for the estimation of ground-surface and cursorial arachnid populations. Prior to trapping, an investigation should be made to determine whether or not the species or group to be studied is subject to collection by the pitfall principle. During this study, absence of Loxoscelidae, Diguetidae, Sparassidae, and Oxyopidae and collection of relatively few Salticidae indicate that all ground-surface forms may not be susceptible to collection by pitfalls. After susceptibility to can trap collection has been determined, habitats with low population levels should be investigated with perhaps more can traps than were utilized here to determine the sexual activity and precision limits of the mean number of individuals trapped. Finally, can traps apparently can produce only data on community or habitat species composition, relative data on abundance, and some information on seasonal adult incidence and activity. Therefore, can trap population data should be considered complementary and supplementary to other population estimates and to a knowledge of the biology and behavior of the forms under study.

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DEVELOPMENT OF *DIAPREPES ABBREVIATUS* ON POTTED CITRUS SEEDLINGS

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ABSTRACT

Adult *Diaprepes abbreviatus* (L.) were recovered from citrus seedlings 132 through 168 days after infestation of the plants with 0- to 24-hour old larvae. Pupae were recovered 98 through 238 days after infestation. The number of larval instars could not be determined from the frequency distribution curves of head capsule measurements.

The so-called sugarcane rootstalk borer weevil, *Diaprepes abbreviatus* (L.), a serious pest of sugarcane and citrus in the West Indies, was first found infesting citrus in the vicinity of Apopka, Fla., in 1964. Later a quarantine area of ca. 6500 acres that included an uninfested border zone was established (Woodruff 1964, 1968). In a recent review of the status of this pest in Florida, Selhime and Beavers (1972) found that the known area of infestation entailed ca. 7200 acres of citrus within an area of ca. 15,000 acres.

Little is known about the development of *D. abbreviatus,* especially in Florida. In the Barbados, Watson (1903) reported the egg stage as 10 days, the larval stage as 312, the pupal stage as 15, and the adult lifespan as 20, a total of 357 days. Ballow (1912) and Jones (1915) also indicated a life cycle of ca. 1 year. Nowell (1913) reported larval periods of 261, 326, and 334 days before pupation.

In more detailed studies in Puerto Rico, Wolcott (1933) successfully reared 3 larvae to the pupal stage on corn and bean seed. Larval periods were 202, 238, and 268 days, and pupation occurred after the 10th, 6th, and 9th instars, respectively. He indicated that the larval period was extended to ca. 1 year by a resting period before pupation. Later, Wolcott (1934) arbitrarily chose the 8th instar as the transitional period from active growth to the period before pupation, an interval he called active diapause. This active diapause lasted less than 2 and more than 13 months (Wolcott 1936). Adults remained in the ground from 11 to 126 days before emergence, but some completed their life cycle in 8 to 18 months.

The earlier studies thus indicated a high degree of variability in the development of *D. abbreviatus.* Also, we have little information about the development of the weevil in Florida. A study was therefore made of the larval development of *D. abbreviatus* at the USDA Citrus Root Weevil Research Unit at Apopka, Fla. The information may be helpful in determining the age of new larval infestations, in predicting the number of generations occurring in Florida, in timing the application of control measures, and in determining the feasibility of rearing this weevil on artificial diets.

METHODS AND MATERIALS

Two tests were made. In the first test, each of 150 sweet orange seedlings (0.5 m tall) planted in 4-liter plastic pots was infested with 5 neonatal

D. abbreviatus (0-24 hr old) by placing the larvae in a small hole adjacent to the tree trunk and covering them with soil. Then, at least 3 seedlings were uprooted each week, and the larvae were recovered by sifting the soil through various sized screens. Head capsule widths of the recovered larvae were measured with an ocular micrometer, and were placed in K.A.A.D. solution (Peterson 1962) for 24 hr; then they were preserved in 70% alcohol until the test was completed. The larvae were so small during the first 4 weeks of this test that additional seedlings grown in 0.35-liter cans were infested. Weevils could then be recovered from the soil by placing the soil in small dishes and flooding them with water so the small larvae were floated off. All trees were held in a building under artificial lighting at ca. 25°C and 60-65% RH.

In the second test, 93 plants in 4-liter plastic pots were each infested with 10 neonatal larvae as before. These plants were held outdoors in an 8 X 8 X 7-ft screen cage (16 mesh/in.) covered with a corrugated fiberglass roof. Plants were uprooted only after they had been killed by larval feeding. The head capsules of the recovered larvae were not measured to avoid undue stress on the larvae. Larvae were transferred onto fresh plants.

Results and Discussion

The first test was run from 5 May to 8 November 1971. Six adults (0.8%), 6 pupae (0.8%), and 107 larvae (14.3%) were recovered, a total of 15.7% of the larvae originally infested. Most larvae were recovered from 35 to 70 days after infestation. Head capsule measurements ranged from 0.33 mm for neonatal larvae to 2.58 mm for 175-day-old larvae. We were unable to determine the number of larval instars from the frequency distribution of head capsule widths because individual variation in growth prevented definite separation of instars. Pupae were recovered at 98, 126, 140, 154, 161, and 175 days after infestation. Adults were recovered at 154(2), 161(2), and 168(2) days. Larvae were recovered each week through 175 days. The test was discontinued at 182 days because all plants had been uprooted.

In the second test, 5 May 1971, to 9 March 1972, four adults were recovered at 132, 133(3), and 144 days after infestation, and 8 pupae were recovered (while larvae were being transferred onto fresh plants) at 102, 129(2), 132, 221, 234, 236, and 238 days after infestation. During the test, 64 larvae were transferred to fresh plants.

In all other attempts to establish a colony of *D. abbreviatus* on citrus (seedlings), larval mortality was high. Although over 1,100 potted seedlings, cultivars of pineapple orange, Carrizo citrange, rough lemon, Murcott orange, sweet lime, Cleopatra mandarin, Succory orange, and sweet orange were infested with about 16,000 larvae, only 90 adults were recovered from 140 to 297 days after the infestation.

Results of these tests indicate that the developmental period of *D. abbreviatus* in Florida is highly variable, as reported for the West Indies, and that natural mortality of the immature forms due to unknown factors is also high. An extended diapause (Wolcott 1936) is not a prerequisite for the development of all these weevils because adults were first obtained at 154 and 132 days in the first and second test, respectively. This occasional absence of diapause may make it possible to rear the weevil in the laboratory on artificial media by selecting eggs from those weevils that mature in the shortest period.

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BOOK REVIEW

MY WEAPONS HAD WINGS. Hubert W. Simmonds. Percy Salmon, Wills, and Grainger, Ltd. Auckland, N.Z. 1964. 164 p. (Published privately by the author under patronage of the Fiji Society).

One of the benefits of travel is the opportunity to see and acquire items of interest that are not readily available at home. Curio vendors the world over assiduously endeavor to assure that no traveler returns home empty handed. All too often the treasured objet d'art excavated from the tomb of third dynasty Pharoah proves to have come from a factory production line in some enterprising center of modern industry. Fortunately, not all travelers are losers. After chasing fireflies in New Guinea some five years ago Dr. James Lloyd returned home with a book—in addition to an ample store of knowledge about the life and behavior of New Guinea fireflies.

Being something of a bibliophile he had visited the only bookstore in the port city of Madang. Among the Bibles and religious literature he found an entomological book with the jingoistic title "My Weapons Had Wings." For the price of $2.75 (Australian) he acquired a book that appears to have escaped the attention of scientific literature abstracting services as well as new book lists and reviews. He recently mentioned the book to me as one that contained a lot of interesting information concerning biological control. He then retrieved the book from his overloaded shelves and I was surprised to find it to be the autobiography of Hubert W. Simmonds.

Mr. Simmonds spent 17 years as Government Entomologist of Fiji and during these years organized and personally conducted explorations to find natural enemies of pests that had invaded the Fiji Islands. As a result of this work the coconut scale, coconut leaf moth as well as the noxious weed known as Koster's curse were controlled and constitute classic examples of biological control through introduction of natural enemies. After retiring in 1937 he interested himself in the problem caused in Fiji by an enormously abundant housefly population. In Java he found a histerid beetle, *Platylister chinensis,* that preyed on fly larvae. Imported into Fiji and Samoa it proved phenomenally successful and all but eliminated the housefly from these islands.

Interesting as this book is to entomologists—at least those of the biological control persuasion—it deserves a much wider audience. The author and his wife were keen naturalists and dedicated conservationists who worked to establish nature reserves long before ecology and endangered species became household words. In addition to entomology and natural history, Mr. Simmonds' comments on the social customs of peoples living on the islands and lands bordering the Pacific Ocean. Few pages lack some fascinating information of scientific or human interest. For example on page 93 we learn how a weed acquired the name of "Koster's curse." A young man surnamed Koster was asked where the weed first appeared. He replied, "On Parr's Place." Erroneously interpreted as pa's place the weed became known as Koster's Curse! So, if you can find a copy of this book—read it!

R. I. Sailer
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PSEUDOSCORPIONS FROM FLORIDA. 4. THE GENUS *DINOCHERNES* (CHERNETIDAE)[1]

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ABSTRACT

The genus is redefined on the basis of a redescription of the type species, *Dinochernes vanduzeei* (Chamberlin). A new species from Florida, *D. wallacei,* is described.

Several years ago I received a number of pseudoscorpions collected by Dr. H. K. Wallace in Florida. One of these has proved to be a representative of the genus *Dinochernes,* previously known only from Coronados Island, Gulf of California, Mexico. Because the original description of the type species, *Chelanops vanduzeei* Chamberlin (1923), is incomplete, I have redescribed that species from the holotype and have revised the generic diagnosis, in addition to describing the new species.

Genus *Dinochernes* Beier

Dinochernes Beier, 1933:99.

Type species: *Chelanops vanduzeei* Chamberlin, 1923.

DIAGNOSIS (revised, based on females only): A genus of the family Chernetidae. Characterized especially by very heavy palpal chelae and restriction of all trichobothria except *t* and *et* to proximal halves of fingers. Body and appendages stout; carapace and palps fairly heavily sclerotized, brown, surfaces granulate; legs, especially femora, scaly. Carapace longer than broad; with a single, shallow transverse furrow just behind middle; 2 large, distinct eyespots present. Tergites 1-10 and sternites 3-10 divided. Posterior part of carapace, all tergites, and all sternites poorly sclerotized, such that some scuta are only small plaques in midst of extensive, scaly interscutal membranes; setae not confined to sclerotized areas; most dorsal setae terminally denticulate, most ventral ones acuminate; setae of spiracular plates acuminate; 11th tergite with 2 and 11th sternite with 4 long, tactile setae; setae of anal plates denticulate. Genital opercula not unusual; spermathecae comprising 2 smaller, proximal, cribrate, ovoid sacs and 2 larger, distal, thin-walled, spherical sacs. Chelicera with 3 setae in flagellum; hand with 5 setae, *b* and *sb* terminally denticulate, *es* long, acuminate. Palps quite robust, especially chela, where hand is nearly as deep as long, and fingers are shorter than hand. Chelal fingers with 35-50 contiguous marginal teeth, and 10-15 external and 0-1 internal accessory teeth. Movable finger with well developed venedens and venom duct reaching about to level of trichobothrium *t*; fixed finger with terminal tooth

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much reduced and no apparent venom duct. Only trichobothrium *t* on movable finger and *et* on fixed finger in distal halves of fingers; *it, ist* and *est* grouped just proximad of middle of finger; all others located in basal thirds of fingers. Legs rather short and robust; each tarsus with elevated slit sensillum just proximad of middle; tarsus IV (and III) with long, prominent tactile seta just distad of middle.

REMARKS: Males of this genus are still unknown. It is hoped that continued collecting, especially in Florida, will turn up some specimens soon. Also, from the wide geographic separation of the 2 known species (Mexico and Florida), it appears likely that representatives of the genus will be found at various places along the Gulf of Mexico and perhaps into Central and South America.

Dinochernes vanduzeei (Chamberlin)

Chelanops vanduzeei Chamberlin, 1923:378; 1931:fig. 69.
Dinochernes vanduzeei; Beier, 1933:99.

The holotype female (California Academy of Sciences, Type 1296) from Coronados Island, Gulf of California, Mexico, has been studied and compared with the specimen from Florida mentioned below. Because this species is the type of the genus, it deserves a more complete description than that given by Chamberlin.

DESCRIPTION OF FEMALE: Carapace and palps heavily sclerotized. Carapace about 1.25 times as long as broad; surface granulate; with 1 shallow, indistinct, transverse furrow about 0.7 length of carapace from anterior margin; 2 large, distinct eyespots. Abdomen elongate; tergites 1-10 and sternites 3-10 divided; tergal chaetotaxy 8:10:10:12:12:12:14:15:14:14:10:2; sternal chaetotaxy 15:(3)9(3):(1)5(1):14:16:16:16:15:19:T3T2T3T:2. Spermathecae not in best position for observation, but obviously similar to those of *D. wallacei* described below (see Fig. 2). Chelicera 0.28 as long as carapace; hand with 5 setae, *b* denticulate, *sb* broken, *es* long, acuminate; flagellum of 3 setae; galea broken; serrula with about 25 blades. Palp "extremely heavy; very striking is the great *depth* of the claw which is more than the length of fingers" (Chamberlin, 1923:378); trochanter 1.85, femur 2.6, and tibia 2.1 times as long as broad (chela in poor position for observation); hand (without pedicel) 0.95 as long as deep; movable finger about as long as hand. All surfaces granulate. Fixed chelal finger with 46 and movable finger with 51 contiguous, marginal teeth; each finger with 1 internal and 12 external accessory teeth. Movable finger alone with venedens and venom duct. Trichobothria as shown by Chamberlin (1923: plate II, Fig. 23); only *t* on movable finger and *et* on fixed finger definitely in distal halves of fingers. Legs rather stout; leg IV with femur 2.6, tibia 3.05 and tarsus 3.1 times as long as deep. Surfaces of femora scaly. Each tarsus with a prominent, slit sensillum just proximad of middle; tarsus IV with a prominent, long seta 0.6 length of segment from proximal end; subterminal tarsal setae curved, simple.

MALE: Unknown.

MEASUREMENTS (mm): Body length 4.20. Carapace length 1.07. Chelicera 0.37 by 0.16. Palpal trochanter 0.54 by 0.295; femur 0.94 by 0.36; tibia 0.89 by 0.42; chela (without pedicel) 1.42 by (indet.); hand (without pedicel) 0.76 by 0.80; movable finger 0.75 long. Leg IV: entire femur 0.86 by 0.33; tibia 0.615 by 0.20; tarsus 0.435 by 0.14.

Dinochernes wallacei Muchmore, new species
(Fig. 1-4)

DIAGNOSIS: Distinguishable from *D. vanduzeei*, the only other species in the genus, by the slightly smaller size (palpal femur 0.85 versus 0.94 mm long), fewer teeth on fingers of palpal chela (37 and 43 versus 46 and 51), and relatively shorter palpal tibia (0.89 versus 0.95 as long as femur).

DESCRIPTION OF FEMALE: Carapace and palps rather heavily sclerotized, brown; other parts lighter. Carapace 1.4 times as long as broad; surface granulate; with shallow, but distinct transverse furrow 0.6 length of carapace from anterior margin; posterior tenth of carapace (behind setae) poorly sclerotized, scaly and directly continuous with interscutal membrane; with 2 large, conspicuous eyespots; about 50 terminally denticulate vestitural setae, including 4 long ones at anterior and 7 near posterior margin. Tergites 1-10 and sternites 3-10 divided; sclerotized portions of tergites restricted, with extensive interscutal membranes; surfaces scaly; sclerotization of sternites poor, anteriorly restricted to small plaques in center of each sternal half; setae not confined to sclerotized areas; interscutal and pleural membranes scaly. Tergal chaetotaxy 9:9:9:11:11:13:14:14:15:15: T11T:2; sternal chaetotaxy 23:(3)9(3):(1)8(1):16:17:19:15:19:20:T2T4T2T: 2; dorsal setae terminally denticulate; ventral ones often acuminate; anterior genital operculum as shown in Fig. 1; setae of spiracular plates acuminate, those of anal plates denticulate. Spermathecae as shown in Fig. 2. Chelicera about 0.33 as long as carapace; hand with 5 setae, *b* and *sb* terminally denticulate, *es* long, acuminate; flagellum of 3 setae, anterior 1 serrate on distal quarter, posterior 1 short, straight; galea short, stout, with 8-9 terminal rami; serrula exterior with 24 blades. Palp quite robust (Fig. 3 and 4); trochanter 1.7, femur 2.6, tibia 1.95, and chela (without pedicel) 2.25 times as long as broad; hand (without pedicel) 1.1 times as long as deep; movable finger 0.88 as long as hand. All surfaces granulate except chelal fingers. Fixed finger with about 37 contiguous, marginal teeth, and 1 internal and 11 external accessory teeth; movable finger with 43 marginal teeth and no internal but 14 external accessory teeth. Movable finger with well developed venedens and venom duct, nodus ramosus distal to level of trichobothrium *t*; fixed finger with terminal tooth much reduced, no visible venom duct. Trichobothria positioned as shown in Fig. 4; only *t* on movable finger and *es* on fixed finger definitely in distal half of fingers; *it, ist* and *est* grouped just proximad of middle of finger; all others located in basal thirds of fingers. Legs generally typical of Chernétidae but rather stout; leg IV with entire femur 2.6, tibia 3.1, and tarsus 3.3 times as long as deep. Surfaces of femora scaly; each tarsus with an elevated slit sensillum just proximad of middle; tarsus IV (and III) with prominent, long seta 0.55 length of segment from proximal end; subterminal tarsal setae curved, simple.

MALE: Unknown.

MEASUREMENTS (mm): Body length 5.4. Carapace length 1.05. Chelicera 0.34 by 0.19. Palpal trochanter 0.50 by 0.29; femur 0.85 by 0.33; tibia 0.755 by 0.385; chela (without pedicel) 1.325 by 0.59; hand (without pedicel) 0.73 by 0.665; pedicel 0.12 long; movable finger 0.64 long. Leg IV: entire femur 0.805 by 0.31; tibia 0.57 by 0.185; tarsus 0.415 by 0.125.

MATERIAL: Female holotype (WM 593.01001), FLORIDA, Alachua County, 5 miles west Gainesville on Archer Road, 8-IV-1949, (H. K. Wal-

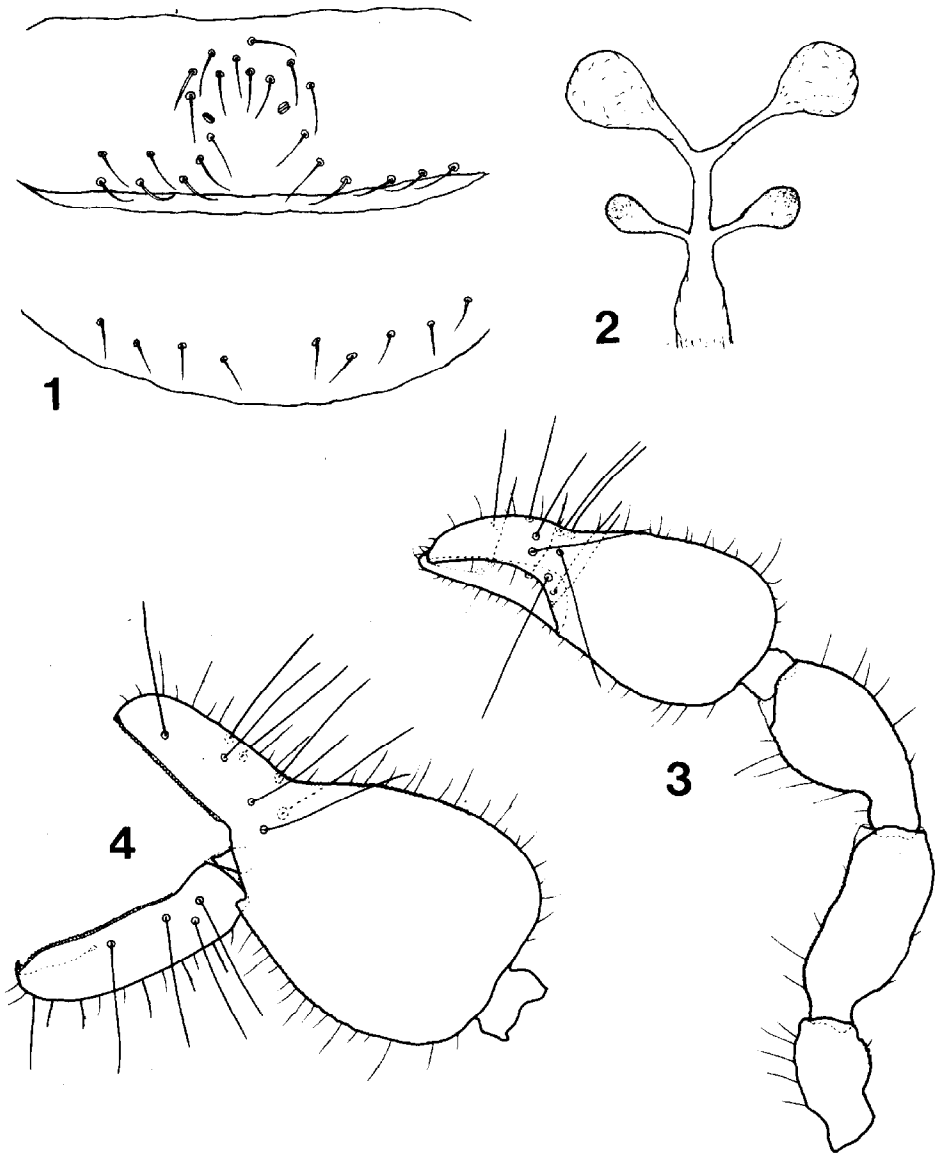

Fig. 1-4. *Dinochernes wallacei* new species, holotype female: 1) Genital opercula; 2) Spermathecae; 3) Dorsal view of right palp; 4) Lateral view of left chela.

lace), "mesophytic hammock west of Hogtown Sink on J. C. Dickinson Ranch on trunk of smooth-barked tree in hammock-hackberry?" The specimen is in the Florida State Collection of Arthropods, Gainesville.

ETYMOLOGY: The species is named in honor of Dr. H. K. Wallace, renowned entomologist of the University of Florida, who collected the type specimen.

ACKNOWLEDGMENTS

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NOMURAEA RILEYI ATTACKING THE VELVETBEAN CATERPILLAR, *ANTICARSIA GEMMATALIS*[1], IN PARANÁ, BRAZIL—(*Note*).

Anticarsia gemmatalis Hübner and other lepidopterous larvae attacking soybeans are commonly infected by *Nomuraea rileyi* (Farlow), although there are no quantitative data on the occurrence of this fungus in Brazil. An experiment was therefore carried out to investigate the effect of *N. rileyi* on population levels of *A. gemmatalis* in soybeans.

A ½ ha plot of 'Hardee' soybeans sown 16 November 1973 in Ponta Grossa, Paraná was sampled. Thirty randomly-chosen plants were removed and inspected weekly from 4 December 1973 to 24 April 1974; twice-weekly sweep-sampling was done from 27 January to 1 May. The total number of *A. gemmatalis* larvae and the percentage infected with *N. rileyi* were noted.

Larvae of *A. gemmatalis* were found from the end of December until early April. They were most abundant at the end of the soybean flowering period, with means of 29 larvae per 30 plants (= 1 m), found by plant inspection on 13 February, and 19 per 100 m of row by sweeping on 7 February. The first larvae infected with *N. rileyi* were recorded on 13 February by both sampling methods. The proportion of infected larvae increased rapidly until by the pod-filling stage in early March, 94% of the larvae on inspected plants and 71% of those in the sweep samples showed disease symptoms. From 20 March until 3 April, after which no more larvae were seen, all larvae on inspected plants were infected with *N. rileyi*; in the sweep samples only 1 larva, which was infected, occurred after early March.

The total number of larvae per plant sampled by plant inspection was greater than the number found by sweeping. The percentage of infected larvae was 41.5% of the total of 142 sampled by plant inspection and 18% of the total of 96 sampled with the sweep net. Plant inspection was the most efficient of the 2 methods used, doubtless due to dead larvae adhering firmly to the plants and those on the lower part of the plant remaining untouched by the sweep net.

The mean temperature in the period from January to April was about 20°C, the relative humidity varying between 76 and 80%, thus approximating conditions considered ideal for the development of *N. rileyi.*

The percentage of infected larvae represent only those showing disease symptoms at the time of sampling; undoubtedly many larvae not showing symptoms were also infected, and had all the larvae been examined again at a later date, a higher percentage of infection would have been likely.

Although *N. rileyi,* because of its late appearance, is sometimes considered ineffective in controlling Lepidoptera, it appeared to be responsible in this experiment for maintaining populations of *A. gemmatalis* below the level at which insecticidal control is recommended.

We thank the Director of 'IPEAME', Ponta Grossa for providing research facilities and Dr. G. E. Allen and Dr. G. L. Greene, University of Florida, for identification of *N. rileyi* and for criticism of the manuscript respectively. Beatriz S. Corrêa, and Judith G. Smith. Departamento de Zoologia, Universidade Federal do Paraná, Caixa Postal 756, Curitiba 80.000, Paraná, Brasil.

[1]Lepidoptera: Noctuidae.

WITHIN-CROWN DISTRIBUTION OF CONE AND SEED INSECT DAMAGE TO SLASH PINE FLOWERS, CONELETS, AND CONES

GARY L. DEBARR, LARRY R. BARBER, AND R. C. WILKINSON[1]

ABSTRACT

From 76 to 87% of the total cone crop was located in the upper half of the tree crowns of slash pines, *Pinus elliottii* Engelm. var. *elliottii,* in Baker County, Florida. The east and south quadrants supported significantly larger crops than the north and west quadrants. The numbers of female strobili attacked by the slash pine flower thrips, *Gnophothrips fuscus*; coneworms, *Dioryctria* spp.; or seedworms, *Laspeyresia* spp., did not differ significantly among the quadrants. Significantly greater numbers and percentages of cones in the upper crown were infested by *Dioryctria* spp. More cones in the upper crown were infested by *Laspeyresia* spp., but the percentage of cones infested, as well as the average number of *Laspeyresia* larvae per cone, did not vary significantly between levels or among quadrants. The proportion of full, empty, and seedbug damaged seed did not differ significantly among quadrants or crown levels.

To insure early detection of insect pest problems in pine seed orchards it is essential to know where infestations are most likely to occur. Within the crowns of individual trees the host structures and insect attacks upon them are not always evenly distributed. Therefore, when collecting data on insect populations or impact in seed orchards, it may be advantageous to select sampling methods which take into account the distribution of host material and/or insect attacks within various sectors (i.e. quadrants and levels) of the crown. In addition, control measures should be directed to the area of the crown where the crop is concentrated or where the greatest losses are anticipated.

MATERIALS AND METHODS

Field layout.—Twelve slash pines, *Pinus elliottii* Engelm. var. *elliottii,* located on the Olustee Experimental Forest, Baker County, Fla., were selected on the basis of being open-grown, with well-developed crowns similar in form to seed orchard trees (Barber 1968). The trees ranged from 43 to 55 ft in total height, and 9 to 13 in. DBH. The lowest limbs were 10 to 17 ft above ground level. Three trees were chosen in each of 4 old-field stands, growing on well-drained flatwoods sites with both slash and longleaf pine, *P. palustris* Mill., present.

The tree crowns were divided into north, east, south, and west quadrants with the aid of plastic ribbon radiating out from the base of the trunk, along N. E., S. E., S. W., and N. W. compass bearings. A ribbon tied around the trunk divided the live crown into upper and lower crown levels. The locations of all female flower, conelet, and cone clusters were deter-

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mined, and each cluster was identified as to quadrant and level by a small numbered tag.

Two-foot-wide bands of aluminum placed around the trunk of each tree prevented squirrels from destroying cones.

The study was begun by tagging conelets and cones in June 1967. In 1968, all female flower clusters were tagged early in January. Each month from June 1967 through September 1968, except November and December 1967, the number of surviving conelets and cones, as well as those lost to mortality factors, was recorded.

Mortality categories.—Because only a few conelets became infected with southern cone rust, *Cronartium strobilinium* (Arthur) Hedgcock and Hahn, or were killed by attacks of coneworms, *Dioryctria* spp., insufficient data were available for analysis of within-crown distribution of these losses (DeBarr and Barber 1974). However, 2 types of conelet mortality occurred in sufficient abundance to analyze statistically.

The slash pine flower thrips, *Gnophothrips fuscus* Morgan, feeds upon female slash pine strobili from twig-bud stage until pollination. While feeding ceases once the strobili are pollinated, mortality of thrips-damaged conelets continues for several months (DeBarr 1969). Therefore, cumulative totals (January-April 1968) of the numbers of thrips-killed conelets were used in the analysis of variance. The 1967 thrips data were not analyzed because the study was begun after many of the thrips-killed conelets had fallen from the trees.

The second category of conelet mortality was damage by *Dioryctria* larvae tunneling vegetative shoots; conelets growing on infested shoots usually died. The numbers of dead conelets resulting from shoot attacks were subjected to an analysis of variance.

Coneworms, *Dioryctria* spp.; seedworms, *Laspeyresia* spp.; the leaf-footed pine seedbug, *Leptoglossus corculus* (Say); and the shieldback pine seedbug, *Tetyra bipunctata* (H.-S.), were the principal insects destroying the seed in slash pine cones. *Dioryctria* attacks were marked by loosely twisting a small piece of colored wire around the cone stalks. Thus, monthly records contained only data on infestations that occurred since the previous tally. A cumulative total of cones infested by *Dioryctria* for 1967 (June-October) and 1968 (January-October) was obtained by combining the monthly records. These yearly totals were analyzed for differences in the number or percentage of cones infested with *Dioryctria* among trees, quadrants, and crown levels.

In September of 1967 and 1968, all cones undamaged by *Dioryctria* spp. were collected by quadrant and level to provide data on the incidence of seedworm, *Laspeyresia* spp., infestation. Following seed extraction, the cones were bisected with a cone cutter (DeBarr and Proveaux 1969) and the number of larval galleries per cone axis recorded. Analyses of variance were used to examine the quadrant and level variation in number and proportion of cones infested by *Laspeyresia,* as well as the mean number of *Laspeyresia* larvae per cone. Seed condition was determined by a radiographic procedure (DeBarr 1970). These data were also subjected to analyses of variance.

Data analysis.—The data were summarized with a PL/I computer program. The mortality percentages for each category were based upon the total number of conelets or cones present in each octant on the first obser-

vation date each year. Analyses of variance to test for statistically significant differences in the distribution of conelets and cones, and for losses in each mortality category among trees, quadrants, and levels were run, utilizing Statistical Analysis System (SAS) programs. Duncan's New Multiple Range test (DNMRt) was used to determine the statistical significance of quadrant differences.

Where sufficient data were available, an analysis of variance was run on the mortality for a single month. In some analyses, missing plots made it necessary to combine data from upper and lower crown levels into quadrant totals, or calculate level totals by combining the quadrant data for each level. These quadrant or level totals were then used in a simplified analysis of variance.

Results and Discussion

Among-tree variation of insect attacks.—Analyses of variance of infestation or strobili mortality showed significant differences among trees for the following factors: conelets killed by thrips ($p=0.01$), conelets indirectly killed by *Dioryctria* shoot attacks ($p=0.01$), and cones infested with *Dioryctria* ($p=0.001$) or *Laspeyresia* ($p=0.0001$). These differences may reflect local environmental effects, but apparent differences in inherent susceptibility of individual trees to *Dioryctria, Laspeyresia,* and thrips (DeBarr *et al.* 1972, Merkel *et al.* 1965, Merkel 1967a) have been reported.

Highly significant differences ($p=0.01$) in the proportion of full, seedbug-damaged, and empty seed occurred among trees in 1967 and 1968. DeBarr *et al.* (1972) previously reported clonal differences in susceptibility of slash pines to seedbug damage. Furthermore, the amount of self-pollination varies from tree to tree, and this affects the proportion of empty vs. full seeds per cone (Franklin 1969).

Within-crown distribution of female strobili.—In the analyses of variance of numbers of conelets or cones present at several different times during female strobili development, all F-tests showed highly significant differences ($p=0.0001$) among trees and between the upper and lower crown levels. From 76 to 87% of the total conelet or cone crops were found in the upper crown (Table 1). Cone production is generally greatest in the upper crowns of conifers, as reported for Douglas fir, *Pseudotsuga menziesii* (Mirb.) Franco, (Kozak *et al.* 1963, Winjum and Johnson 1964); red pine, *Pinus resinosa* Ait., (Hard 1964); longleaf pine, *P. palustris* Mill., (Coyne 1968); and shortleaf pine, *P. echinata* Mill., (Coulson and Franklin 1968).

The numbers of conelets differed significantly ($p=0.05$) among the quadrants in both years. Numbers of cones differed significantly ($p=0.05$) among quadrants in 1967, but not in 1968. The DNMRt showed that in 3 out of 4 tests, the east and south quadrants supported significantly larger ($p=0.05$) crops than the north and west quadrants (Table 2). Our findings substantiate the report of a strong non-random east over west distribution of cone initiation on slash pine trees observed by Goddard and Strickland (1965) in a clonal seed orchard at Gainesville, Florida. Later, Smith and Stanley (1969) also found a preponderance of cone initiation on the east crown face for open-grown trees in 3 slash pine stands near Gainesville. They postulated that this distribution was related to the intensity of morning sunshine received on the east crown face during the period (July and August) when flower primordia are initiated. Similarly, branches in the south quadrant

TABLE 1. PERCENTAGE OF TOTAL CONELETS AND CONES BY QUADRANTS AND LEVELS WITHIN THE CROWNS OF 12 SLASH PINES. BAKER CO., FLA.

Cone Crop	Date	Stage of ♀ Strobili Development	No.	Quadrants				Levels	
				S	E	N	W	Upper	Lower
1967	June 1967	Cones	1928	29	31	21	19	76	24
1967	Sept. 1967	Cones	1523	32	27	20	21	76	24
1968	June 1967	Conelets	3820	32	27	20	21	84	16
1968	Jan. 1968	Cones	2829	30	26	21	23	87	13
1968	Sept. 1968	Cones	2103	30	28	22	20	85	15
1969	Jan. 1968	Conelets	5119	30	27	22	21	86	14
1969	Sept. 1968	Conelets	3689	29	29	22	20	87	13

TABLE 2. MEAN NUMBER OF CONELETS OR CONES PER QUADRANT ON 12 SLASH PINES—BAKER CO., FLA.—1967 AND 1968.

Cone Crop	Time	Stage of ♀ Strobili Development	Mean Number of Conelets and Cones Per Quadrant*			
1967	June 1967	Cones	49 E	46 S	34 N	31 W
	June 1967	Conelets	101 S	84 E	68 W	65 N
1968						
	Jan. 1968	Cones	71 S	61 E	54 W	50 N
1969	Jan. 1968	Conelets	127 S	116 E	95 N	89 W

*Any 2 quadrant means not underscored by the same line are significantly different ($p = 0.05$).

are reportedly the most prolific flower producers on other species of conifers, including red pine (Mattson 1972), Douglas fir (Winjum and Johnson 1964), and shortleaf pine (Coulson and Franklin 1968).

Within-crown distribution of insect attacks by quadrant.—There were no statistically significant differences in the numbers of female strobili attacked by thrips, *Dioryctria,* or *Laspeyresia* among the quadrants. Neither did the proportion of the strobili per quadrant damaged or destroyed by *Dioryctria, Laspeyresia* (Table 3), or seedbugs (Table 4) differ significantly.

TABLE 3. QUADRANT AND LEVEL MEANS FOR *Dioryctria* AND *Laspeyresia* INFESTATIONS—12 SLASH PINES—BAKER CO., FLA.

Year	Crown Level or Quadrant	*Laspeyresia* spp.			*Dioryctria* spp.	
		Cones Infested*		Larvae/Cone	Cones Infested**	
		Number—Percent		Number	Number—Percent	
1967	Lower	12.6	30.4	0.44	16.3	26.8
	Upper	25.6	35.3	0.50	36.4	30.0
	East	11.6	32.8	0.50	16.6	29.2
	North	9.6	33.3	0.50	11.3	25.0
	South	10.9	37.8	0.49	18.4	31.4
	West	9.6	29.6	0.41	10.7	21.9
1968	Lower	11.5	27.3	0.31	1.5	4.9
	Upper	34.5	23.0	0.30	22.8	12.1
	East	15.0	28.6	0.36	6.3	7.8
	North	13.8	25.9	0.36	5.3	7.4
	South	10.9	20.6	0.23	7.4	8.5
	West	13.6	23.6	0.29	5.9	10.4

*Based upon the number of *Dioryctria*-free cones collected in Sept.
**Based upon the number of cones present at the first observation date of each year.

Analyses of variance of *Dioryctria* cone attacks run on individual monthly data gave results similar to the analyses based upon yearly totals (accumulated cone mortality June–September 1967 and January–September 1968). While tree differences were again significant, there were no significant differences in *Dioryctria* infestation among quadrants.

Our observations agree with previous reports on the distribution of insects in the crowns of other host species. Coulson and Franklin (1968) found that insects (primarily *Dioryctria*) infesting the conelets and cones of shortleaf pine congregated in the upper crown and that the south side (which had the most cones) did not harbor a disproportionate number of insects. Yates and Ebel (1972) found no significant differences in conelet mortality caused by the Nantucket pine tip moth, *Rhyacionia frustrana* (Comstock), among quadrants. Coyne (1968) reported that the longleaf pine seedworm, *Laspeyresia ingens* Heinrich, also did not favor any particular crown direction on longleaf pine.

TABLE 4. QUADRANT AND LEVEL MEANS FOR SEED QUALITY—12 SLASH PINES—BAKER CO., FLA.

Crown Level or Quadrant	Seed Condition*					
	1967			1968		
	Full	Seedbug Damaged	Empty	Full	Seedbug Damaged	Empty
Lower	79.8	10.1	10.1	79.3	12.6	8.1
Upper	84.1	7.0	8.9	80.1	10.0	9.9
East	82.7	8.5	8.8	77.9	11.8	10.3
North	77.4	9.2	13.4	80.1	9.3	10.6
South	83.8	8.3	7.9	83.2	8.1	8.7
West	87.2	6.4	6.4	79.9	10.6	9.5

*All figures are percents.

Within-crown distribution of insect attacks by crown level.—Yates and Ebel (1972) reported that the Nantucket pine tip moth killed a significantly greater percentage of the shortleaf pine conelets in the upper crown than in the lower crown. In our study, there were no significant differences between crown levels for the percentages of conelets killed by thrips. The proportion of full, seedbug-damaged, and empty seeds also did not differ significantly between crown levels in either 1967 or 1968 (Table 4).

A significantly greater number and percentage of cones ($p=0.001$) were infested by *Dioryctria* in the upper tree crown (Table 3).

Significantly greater numbers of cones ($p=0.001$) were infested with *Laspeyresia* in the upper tree crown, but the percentage of infested cones, as well as the mean number of *Laspeyresia* larvae per cone, did not differ significantly between crown levels (Table 3). Abrahamson and Kraft (1965) found the highest population densities of the eastern pine seedworm, *L. toreuta* Grote, on the lower 10 ft of the tree crowns of jack pine, *Pinus banksiana* Lamb. Coyne (1968) also observed that *L. ingens* favors cones in the lower crown of longleaf pine for oviposition. The slash pine seedworm, *L. anaranjada* Miller, is the predominant species infesting slash pine cones (Merkel 1967b), with occasional attacks by *L. ingens*. Perhaps *L. ingens* prefers the lower tree crown, while *L. anaranjada* seeks oviposition sites in the upper crown.

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MAJOR AND TRACE ELEMENT ANALYSIS IN RED IMPORTED FIRE ANT QUEENS BY ION INDUCED X-RAY FLUORESCENCE[1]

R. LEVY[2], H. A. VAN RINSVELT[3], AND H. L. CROMROY[2]

ABSTRACT

Analysis of red imported fire ant queens, *Solenopsis invicta* Buren, by ion induced X-ray fluorescence indicated that concentrations of P, S, Cl, K, Ca, Ti, Cr, Mn, Fe, Ni, Cu, Zn, Pb, Rb, Sr, and Mo could be detected in their tissues. In general, results indicated that red imported fire ant queens contained lower total body levels of P, S, Cl, K, Ti, Cr, Fe, Ni, Cu, Zn, Pb, Rb, Sr, and Mo than major and minor workers. However, higher concentrations of Ca and Mn were noted in queens when compared to workers.

Ion induced X-ray fluorescence data have been presented showing the relative total body concentration of major and trace elements (P, S, Cl, K, Ca, Ni, Cr, Ti, Mn, Fe, Cu, Zn, Pb, Sr, Mo, Rb) in the tissues of major and minor workers, larvae, and pupae of the red imported fire ant, *Solenopsis invicta* Buren (Levy et al. 1974). Their results indicated that adult red imported fire ants contained a higher total body concentration of major and trace elements than the immature stages, with the following trend being noted: workers > pupae > larvae. The aim of the present paper is to determine the total body concentration of major and trace elements in red imported fire ant queens. This data could then be used to compare the relative major and trace element content among several developmental stages of a single ant species, i.e. the red imported fire ant.

METHODS AND MATERIALS

Field collected red imported fire ant queens (i.e. 2-3g collected during a mating flight) were obtained from the Insects Affecting Man Research Laboratory, ARS-USDA, Gainesville, Florida. These queens were freeze-killed and dried by lyophilization, ashed in a low temperature radiofrequency furnace, and analyzed for total body major and trace element concentration according to the ion induced X-ray fluorescence techniques of Van Rinsvelt et al. (1973).

RESULTS AND DISCUSSION

Results of ion induced X-ray fluorescence indicated that significant concentrations of P, S, Cl, K, Ca, Ti, Cr, Mn, Fe, Ni, Cu, Zn, Pb, Rb, Sr, and Mo can be detected in the tissues of red imported fire ant queens (Fig. 1). In addition, stage-specific concentrations of these major and trace elements have been shown between major and minor workers, pupae, and larvae of the red imported fire ant (Levy et al. 1974). Data by Levy et al. (1974) indicated that P, S, Cl, K, Ti, Cr, Fe, Ni, Cu, Zn, Pb, Rb, Sr, and Mo were less concentrated in the tissues of queens than in major and minor workers. How-

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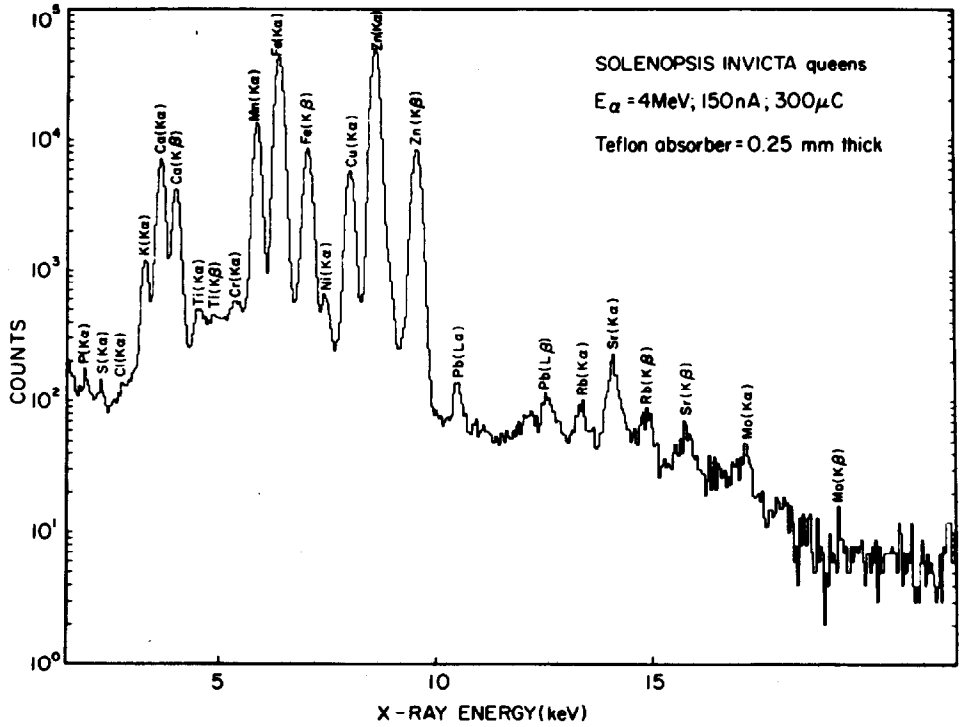

Fig. 1. Analysis of red imported fire Ant queens by ion induced X-ray fluorescence.

ever, total body levels of Ca and Mn were found to be greater in queens than in workers. The generally high concentration of major and trace elements in the workers when compared to queens could indicate the importance of major and minor workers in supplying nutrients to the colony. Furthermore, the greater concentration of Ca and Mn in imported fire ant queens could reflect egg development and metabolic activity of the female reproductive system.

In general, ion induced X-ray fluorescence is an excellent tool for studying the relative concentration of biologically active elements (e.g. Ca, K, Cu, Fe, Zn) as well as environmental contaminants (e.g. Pb, Sr) which have accumulated in insect tissues.

Acknowledgment

The authors wish to thank D. P. Jouvenaz from the Insects Affecting Man Research Laboratory, ARS-USDA, Gainesville, Florida for supplying the insects used for the analyses. This research was partly supported by Cooperative Agreement Grant No. 12-14-100-10, 951(33) entitled Toxicants For Control of Imported Fire Ants.

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RECAPTURE OF VIRGIN FEMALE CARIBBEAN FRUIT FLIES[1] FROM TRAPS BAITED WITH MALES[2]

A. J. PERDOMO[3], R. M. BARANOWSKI[4], AND J. L. NATION[3]

ABSTRACT

Field tests in Homestead, Fla., during spring and summer, 1972, demonstrated that virgin male Caribbean fruit flies, *Anastrepha suspensa* (Loew), caged in sticky board traps attracted virgin females. Apparently much of the attraction was related to release of a volatile sex attractant. More females were trapped in the late afternoon than during other parts of the day.

Traps baited with 10 live males were as effective as the McPhail traps currently used and were substantially more effective when baited with 20 or 40 males. The pure pheromone, when available, may be easy to use in traps and may be a more sensitive survey tool than those presently available.

Five day old male caribflies, *Anastrepha suspensa* (Loew), have been shown to attract female flies in a laboratory bioassay (Nation 1972). Extracts prepared from males indicated that some or possibly all of the attraction was due to 1 or more chemicals released by the males. To establish whether the attraction of virgin females to males was significant under field conditions, we developed a field bioassay at the University of Florida Agricultural Research and Education Center at Homestead, Florida.

MATERIALS AND METHODS

All experiments were conducted in an avocado grove. Avocados are not a host of caribfly and the nearest grove of host trees consisted of guavas approximately 300 m away. No wild flies were observed in the avocado grove, and between the avocado and the guava grove there was only open ground. Survey traps were placed in the avocado grove before and after most of the experiments. The trapping results consistently indicated an absence of wild flies. In 1 test with marked flies, all flies captured were marked.

Cotton boll weevil traps baited with live caribfly males supplied with dry sucrose, yeast hydrolysate paste, and water, and coated with stickem[5] were used. Control stickem-coated traps contained food only. Males were placed in screen mesh cylinders 16 cm long X 6 cm diam. All flies used in these experiments were laboratory reared. Sexes were segregated before sexual maturity was reached.

A Latin square 4 x 4 design was used for trap location. The avocado trees in the release area were spaced 6 m apart. The traps were suspended from a branch approximately 2 m above the ground in every 4th tree. Virgin females were released at 25 sites, each approximately 13 m from any trap.

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[5]A glue-like trapping agent (Michel Pelton Co., Oakland, California).

Attraction of females to 0, 1, 5, and 10 live males was compared in the first experiment. Both sexes were 8 days old when first put into the field and recaptures were recorded between 2-6 days. The experiment was replicated 4 times in successive weeks; a total of 6,250 females was released. A second experiment was designed to compare the attraction of the McPhail trap with the attraction of 10, 20, and 40 live males in the same traps and release sites as before. The flies were again 8 days old when first put into the field. The aqueous suspension of yeast hydrolysate used in the McPhail traps was always prepared 3 days in advance of the experiment date. This comparison was run 4 times in successive weeks with a total release of 8,650 females. Female flies were always released between 1500 and 1700 h. Captures were recorded over a period of 3-6 days.

Results were transformed to percentage of recovery and evaluated by analysis of variance and Duncan's multiple range test.

Results

Traps without males captured 2.25 females per trap, traps with 1 male attracted 5.31 females per trap, 5 males attracted 14.19 females per trap, and 10 males attracted 43.44 females per trap (Table 1). The recovery of released females in each experiment varied from 6.5 to 28% between replicates. Traps with 10 males attracted significantly more females than traps with 0, 1, or 5 males, and traps with 5 males attracted more than traps containing 0 males. The difference between traps with 0 and 1 male was not significant. Variation in percentages of recovery among replicates may have been caused by variable weather conditions prevailing when replicates were performed. In the test started on 3 May 1972 the low total recovery of 6.45% was possibly related to the fact that females were held in much smaller cages prior to release than used in subsequent replicates. Crowding could have weakened the flies.

TABLE 1. Recapture of released *A. suspensa* adult virgin females with male-baited sticky traps from tests in a non-host avocado grove at Homestead, Florida. A Latin square 4 × 4 design was used in each test.

Treatments	Dates				Total no. of females recaptured	Mean no. recaptured trap*
	5-3-72	5-12-72	5-16-72	5-26-72		
0 Male	11	3	9	13	36	2.25a
1 Male	16	13	30	26	85	5.31ab
5 Males	21	51	84	71	227	14.19 b
10 Males	81	204	170	240	695	43.44 c
Total recapture	129	271	293	350	1043	
No. of females released	2000	1000	2000	1250	6250	
% Total recovery	6.45	27.10	14.65	28.00	16.69	

*Values followed by the same letter are not significantly different at 0.01 level.

The McPhail trap captured an average of 14 females per trap, traps with 10 males captured an average of 17 females per trap, and traps with 20 and 40 males captured an average of 32 and 60 females per trap, respectively (Table 2). In this series of experiments the total percentage recovery of released females varied from 12 to 38% between replicates.

TABLE 2. RECAPTURE OF RELEASED *A. suspensa* ADULT VIRGIN FEMALE FLIES WITH STICKY TRAPS BAITED WITH 10, 20, AND 40 LIVE MALES AS COMPARED WITH RECAPTURE BY THE MCPHAIL TRAP FROM TESTS IN A NON-HOST AVOCADO GROVE AT HOMESTEAD, FLORIDA. A LATIN SQUARE 4 × 4 DESIGN WAS USED IN EACH TEST.

Treatments	Dates				Total no. of females recaptured	Mean no. recaptured trap*
	5-30-72	6-7-72	6-13-72	6-20-72		
McPhail	97	71	26	31	225	14.06a
10 Males	75	52	57	95	279	17.44ab
20 Males	155	108	63	186	512	32.00 b
40 Males	356	170	93	349	968	60.50 c
Total recapture	683	401	239	661	1984	
No. of females released	2900	2000	2000	1750	8650	
% Total recovery	23.55	20.00	11.95	37.77	22.94	

*Treatments followed by the same letter were not significantly different at the 0.01 level.

Statistical analysis shows that traps with 40 males attracted significantly more females than McPhail traps or traps with 10 or 20 males. Traps with 20 males attracted more females than McPhail traps; but traps with 10 males were not significantly different from the McPhail traps. On 2 occasions traps with 10 males captured fewer females than McPhail traps.

Recapture of females at intervals of time after release was recorded for the test of 26 May (Fig. 1). Most of the females recaptured were caught during the first 48 h and during the daylight hours. From 1945 h of 26 May to 0615 h of 27 May only 24 flies were recaptured which represents only 0.29 flies per trap per hour, but during the daylight hours on 27 May substantially more females were recaptured (though not as many as during the daylight hours of 26 May) indicating that caribflies are not particularly active at night.

The recapture percentages at the end of 48 h, and the total recapture percentage for 6 experiments are shown in Fig. 2. Data from 2 experiments are not included because no observations were made at 48 h. Almost all flies recaptured were caught during the first 48 h following release.

DISCUSSION

We conclude from these experiments with *A. suspensa* that virgin males attract virgin females under field conditions. It seems reasonable to con-

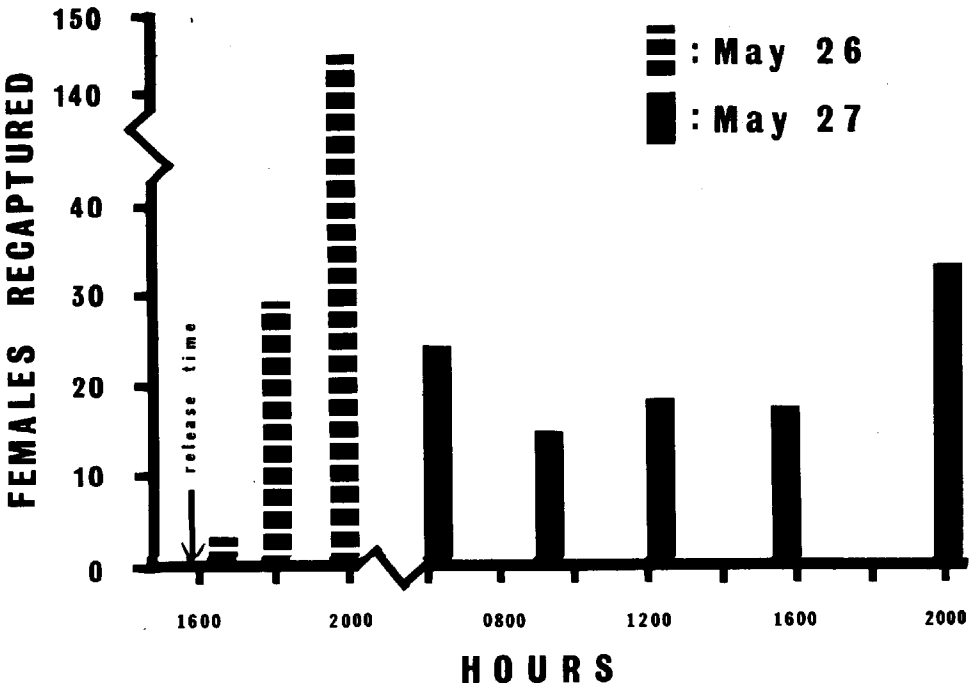

Fig. 1. Number of *A. suspensa* adult virgin females recaptured at intervals of time with 4 sticky traps with 5 males and 4 with 10 males each in a non-host avocado grove.

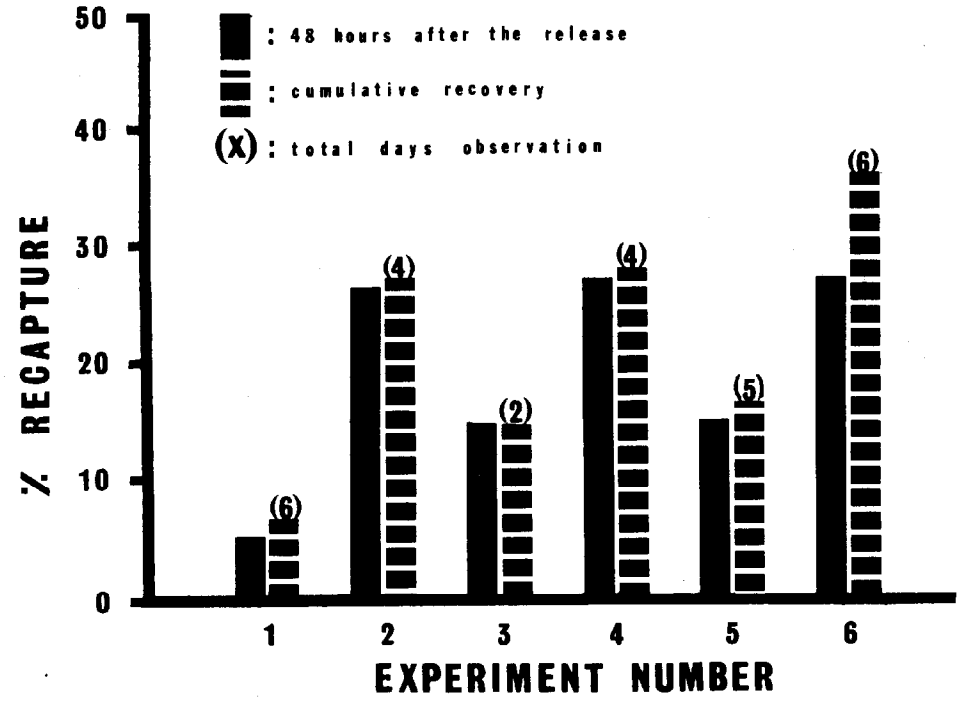

Fig. 2. Recapture of virgin female *A. suspensa* adults in 48 h, and cumulative recovery for total observation period with sticky traps baited with males.

clude that much of the field attraction is related to release of a volatile sex attractant. Although extracts of male bodies have not been field tested, such extracts do attract females in laboratory bioassays (Nation 1972). The field data show that more females are trapped in the later afternoon than during other intervals of the day.

Preliminary data on observations of the behavior of wild flies in the field indicate that mating occurs during the afternoon hours. No mating has been observed in the morning. A related paper will be prepared detailing this information.

AliNiazee (1971) showed that about 80-90% of the omnivorous leaf roller, *Platynota stultana* Walsingham (Lepidoptera), males caught were attracted between 1800 h-2000 h and no males were trapped between midnight and 1800 h. AliNiazee attributed this to a rhythm of sexual behavior in the males or as a response to a rhythm of a female pheromone release or a combination of both factors. Very little, however, is known about the behavior of *A. suspensa* in the field.

Although sticky traps with 20 or 40 males were substantially more effective than McPhail traps, the use of these traps is more cumbersome and time consuming than use of McPhail traps, and probably could not replace McPhail traps in practice. Possibly the pure pheromone, when available, would be easier to use and be a more sensitive survey tool than those presently available.

Good recoveries of released virgin females in some experiments suggest that substantial population reduction might be possible with pheromone baited traps. Much more data are needed, however, on the effectiveness of pheromone baited traps in host areas. The avocado grove was selected for these experiments because avocado is a non-host fruit and the grove was isolated from host fruit groves. In a host grove we would expect competition from wild males and oviposition odors. Nakagawa et al. (1970) showed that when males were scarce or absent, sperm-deficient, sexually mature female Mediterranean fruit flies were attracted by trimedlure, medlure, and angelica seed oil, but when sexually mature males were introduced into field populations, virgin females stopped their response to the lures.

The effect of age and mating of the flies in influencing attraction in the field also must be evaluated. Since females begin producing fertile eggs when they are 7 days old (Baranowski 1968) a pheromone trap likely would have to attract younger females than those used in these experiments and also non-virgin females in order to provide satisfactory control.

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SOUTHERN CORN ROOTWORM EGGS IN SOYBEAN FIELDS.[1]—(*Note*). During studies of the bean leaf beetle in 1974 we found eggs of the southern corn rootworm (SCRW), *Diabrotica undecimpunctata howardi* Barber, in soil from 2 Illinois soybean fields. These are, to our knowledge, the first hard data showing that SCRW adults oviposit in soybean fields although the adults are often common there.

SCRW adults and larvae feed on a wide variety of plants of diverse families (F. H. Chittenden. 1905. USDA Bur. Ent. Circ. 59, F. S. Arant. 1929. Alabama Polytech. Inst. Agr. Exp. Sta. Bull. 230, and D. Isely. 1929. Univ. Arkansas Agr. Exp. Sta. Bull. 232), including some legumes, i.e., peanuts (W. V. Campbell and D. A. Emery. 1967. J. Econ. Ent. 60:1675-8).

We used the method of Waldbauer and Kogan (1973. Environ. Ent. 2: 441-6 and 4:375-80) to extract SCRW eggs from soil cores cut through soybean roots in Coles and Mason Co. fields. We found 10 eggs in cores collected in the Mason Co. field on 5 August. Cores taken in the Coles Co. field on 30 July yielded 11 eggs, those taken on 26 August yielded 1, and those taken on 11 September yielded 2. The cores may actually have contained more eggs; because SCRW eggs are larger than bean leaf beetle eggs, some may have been lost because they did not pass through the 40-mesh screen used to remove debris in extracting bean leaf beetle eggs.

We identified the eggs by the descriptions of W. T. Atyeo, G. T. Weekman and D. E. Lawson (1964. J. Kansas Ent. Soc. 37:9-11) of the chorion sculpturing of *Diabrotica* eggs, and by collections and photographs of eggs made by one of us (J.V.M.). We did not rear adults from the eggs since there is no doubt about the identification.

Ten sets of 50 sweeps made in each field on each of 10 days between 5 August and 24 September showed adults to be abundant—overall means of 2.5 and 1.4 per 50 sweeps at Mason and Coles Cos., respectively. The populations reached maxima in both fields on 18 September—8.3 and 3.9 per 50 sweeps in Mason and Coles Cos., respectively. Mark A. Mayse, G. P. Waldbauer, and Joseph V. Maddox. Illinois Natural History Survey, Illinois Agricultural Experiment Station, and Department of Entomology, University of Illinois, Urbana, 61801.

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THE LIFE HISTORY OF *CRASPEDUCHUS PULCHELLUS*, A LYGAEID NEW TO THE UNITED STATES (HEMIPTERA:LYGAEIDAE)[1,2]

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ABSTRACT

Craspeduchus pulchellus (F.), a widespread neotropical species is first reported from the United States. In this country it is known only from Key Largo, Florida where it is found on *Corchorus siliquosus* L. Eggs are deposited on the ground in loose clusters. The nymphs and adults are found on plants of *C. siliquosus* feeding on the seedpods or they may be found beneath the plants feeding on fallen seeds.

The immature stages are described and figured.

Craspeduchus pulchellus (F.) is a widespread neotropical species previously known from the West Indies, Central and South America (Slater 1964). Although, as noted below, there is a previous erroneous report from Canada and several quarantine interceptions, the species has not previously been known to be present as a breeding species in the United States.

On 3 December 1969, Mrs. Perrie Krieter (formerly laboratory technician, AREC, Homestead) collected several specimens from Key Largo, Florida. Subsequently we have, over a period of several years, collected additional material at several locations on Key Largo, always on the seedpods or at the base of *Corchorus siliquosus* L. A breeding population is definitely present.

Provancher (1871) reported this species from Quebec, but this is certainly in error. It has been intercepted at ports of entry in California, Texas, Louisiana, and Florida on 7 occasions since 1951 (Wheeler 1951; Hunt 1956, 1958; Mumford 1965, 1966). Included in these was a single specimen intercepted in a shipment of copra from the Philippines! None of these records, of course, established the species as a member of the fauna of the United States.

Pulchellus was placed in the genus *Ochrostomus* Stal in the 1964 Slater Catalogue. Most of the literature records place it in the old omnibus genus *Lygaeus* and it has been cited in 2 subgenera of *Lygaeus, Ochrostomus* Stal and *Craspeduchus* Stal. Both of these latter were described by Stal in the same work. Slater (1964) has elevated both *Craspeduchus* and *Ochrostomus* to generic status. Van Duzee (1916) fixed *pulchellus* (F.) as type species of *Ochrostomus* and *xanthostaurus* H.S. as type species of *Craspeduchus*. Ashlock (1975) has discussed the matter, pointed out that *pulchellus* and *xanthostaurus* are congeneric and since both generic names appear first in the same paper either can be selected by the first revisor. Ash-

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lock (1975) in the capacity of first revisor has selected *Craspeduchus* Stal as the senior synonym and reduced *Ochrostomus* Stal to junior synonymy. *Pulchellus* (F.) therefore becomes properly *Craspeduchus pulchellus* (F.) as indicated in the title.

Pulchellus will key in Torre Bueno (1946) to *Lygaeus* sg. *Craspeduchus* and poorly to the species *uhleri* Stal, to which *pulchellus* is closely related. From *uhleri, pulchellus* is readily distinguishable by the longer labium which extends to the posterior margin of the metacoxae or onto the first visible abdominal sternum, whereas in *uhleri* the labium extends posteriorly only between the mesocoxae. The abdominal sternum in *uhleri* is nearly uniformly orange-red with the seventh and succeeding segments a strongly contrasting dark brown to black. In *pulchellus* the abdominal sternum is predominately dark chocolate brown to black with the connexival area broadly flavescent and the posterior margins of sterna 4 to 7 pale margined. These pale areas usually are suffused with reddish coloration.

The only previous biological information of which we are aware are records by Wolcott (1936, 1941, 1950) of mating pairs on *Corchorus hirsutus* in Puerto Rico. Wolcott's 1936 paper indicates a tentative identification of the plant, although his 2 subsequent citations do not have a qualifying statement. In view of our host findings we feel that Wolcott's host identify requires verification. Gibson and Carrillo (1959) report *pulchellus* "en maiz" in Mexico.

We have taken *C. pulchellus* only upon or below specimens of *Corchorus siliquosus* L. and only on Key Largo. There *C. siliquosus* occurs in open roadside sites in full sunlight, growing on an overdrained limestone substrate together with a variety of roadside weeds. We also have found *pulchellus* associated with the above host in Jamaica.

Graptostethus servus (F.) a widespread species of lygaeine in the eastern hemisphere, is reported by Golding (1947) as breeding upon *Corchorus capsularis* L. and *C. olitorius* L. in Africa. This species is known to breed upon a variety of other plants (see Slater & Sperry 1973 for summary).

Three species of *Corchorus* are found in Florida, *aestuans* L., *orinocensis* HBK, Jutes and *siliquosus* L. All of the plants that we recognized as *Corchorus* proved to be *siliquosus*. We therefore assume that the other species are relatively rare. Long and Lakela (1971) state *C. siliquosus* is found in hammocks and disturbed sites in south Florida. We do not believe it to be a true hammock plant, but on occasion it may occur along the edges of hammocks if the area is open. It is quite common along roadsides and in cleared fields where plant growth has been unchecked for a few years.

We have examined *C. siliquosus* in many areas on the mainland in south Dade County especially in the Homestead area and also in the Everglades National Park from the entrance to the Flamingo Prairie area without finding *C. pulchellus. C. siliquosus* is rare in the lower Florida Keys; however, 1 plant was observed on Key West, but *C. pulchellus* was not present. We have been able to collect *C. pulchellus* along the entire length of Key Largo and are sure that, at present, it is limited to this area.

In view of the limited distribution of the insect, and despite the widespread occurrence of the host plant, it seems likely that *pulchellus* has only recently established itself in North America. There is a single specimen of *pulchellus* in the Division of Plant Industry, Florida Dep. of Agriculture and Consumer Services Collection at Gainesville taken on Key Largo 2 May 1961 (B. K. Dozier). It should be noted that in the years immediately

prior to 1961, severe hurricanes had struck the southern Florida area. It seems likely to us that *pulchellus* could have been introduced at that time.

Eggs are deposited on the ground in loose clusters. When the host plants are growing vigorously, nymphs and adults will be found up on the plants feeding on the seedpods and occasionally early instars will be found in open, partially dried pods still remaining on the plants. When plants are not actively growing, breeding populations can often be found in the debris directly under the plants; however, they do not move very far from the host plants.

Craspeduchus pulchellus

Fifth instar nymph: Key Largo (in alcohol), Fig. 1

Head, central area of pronotum, scutellum, wing pads a rich reddish brown; suture between tylus and juga, a broad anteriorly diverging irregular stripe within epicranial arms on either side of midline, area immediately behind eye, pronotal calli and antero-lateral region of scutellum contrastingly black; pronotum broadly margined anteriorly and posteriorly with white, darkened central area suffused with rose-red; scutellum with a pale white, posteriorly broadening median longitudinal stripe; abdomen pale testaceous with a wide median and a pair of very broad vivid sublateral red longitudinal stripes extending from base to tergum 8; eighth and ninth terga mesally black, scent gland sclerites dark brown, small, with SGA on both segments 4-5 and 5-6 rounded and larger that SGP (Slater & Wilcox 1973); legs and antennae nearly uniformly dark brown, distal ends of femora and 1st antennal segment paler, femora irregularly spotted with black; head below with a large pale yellow blotch below eye; pleura reddish brown with broad white or pale yellow margins, abdomen pale yellow to testaceous with a broad longitudinal red vitta sub-laterally, sterna 8 and 9 black mesally.

Head convex dorsally, moderately declivent anteriorly, tylus not quite attaining distal end of first antennal segment, epicranial stem present but very short; length head 1.0[3], width 1.25, interocular space 0.75; pronotum short, broadly transverse, anterior margin conspicuously concave, posterior margin nearly straight, length pronotum 0.75, width 1.45; wing pads extending midway on abdominal terga 3, length wing pads 1.75; length abdomen 2.75; labium reaching well between or slightly beyond mesocoxae, length labial segments I 0.60, II 0.60, III 0.65, IV 0.55; antennae slender, terete, 4th segment narrowly fusiform, length antennal segments I 0.30, II 0.75, III 0.65, IV 1.05, total length 4.70.

NOTE: There is some variation in color. In some individuals the dark areas including the appendages are nearly uniformly black rather than reddish brown, and the rose-red pronotal coloration is confined to the lateral margin centrally beyond the dark central quadate marking.

Fourth Instar: (as above) Fig. 2

General form and color as in preceding; pronotal central coloration predominately red and contrasting markedly with a dark calli "bar"; mesothoracic wing pads small and lobate, not extending caudad of distal end of metathoracic pads; length head 0.95, width 1.10, interocular space 0.70; length pronotum 0.55, width 1.20; length wing pads 0.85; length abdomen

[3]All measurements are in millimeters.

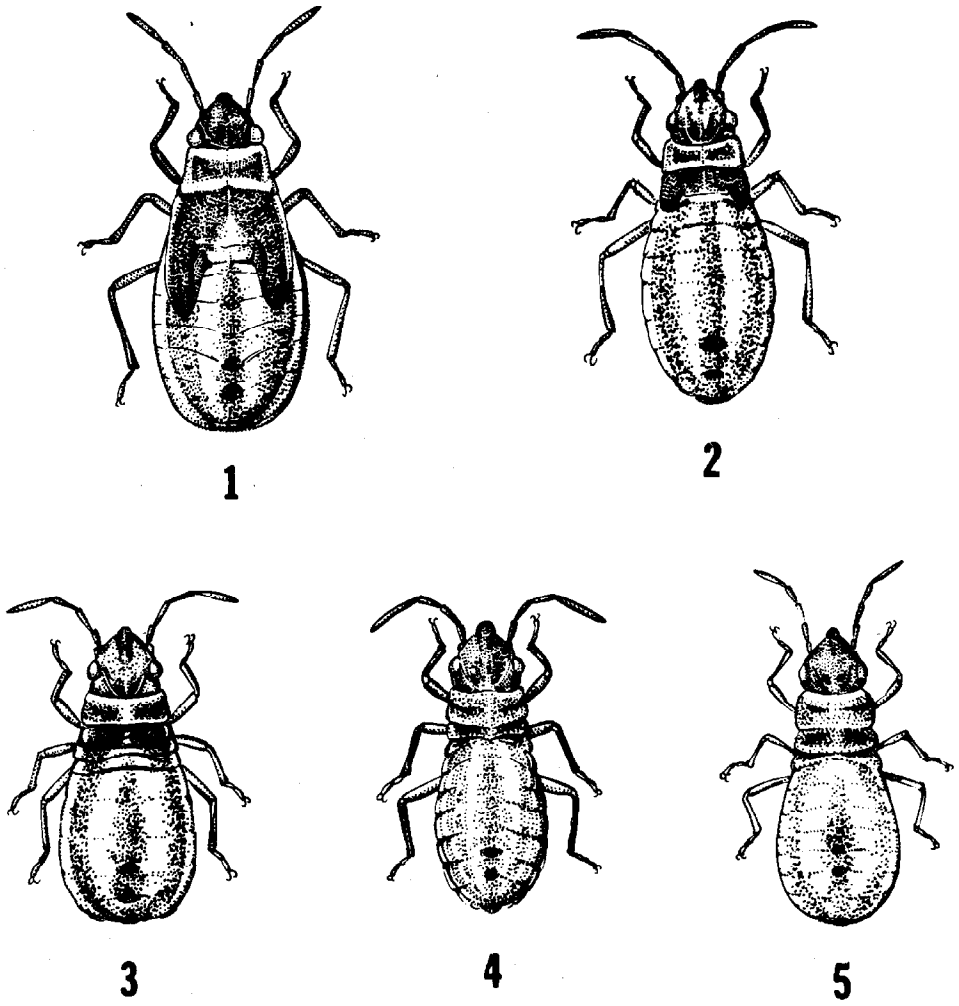

Fig. 1-5 *Craspeduchus pulchellus* nymphs. 1. Fifth instar. 2. Fourth instar. 3. Third instar. 4. Second instar. 5. First instar.

2.15; length labial segments I 0.50, II 0.55, III 0.55, IV 0.55; length antennal segments I 0.25, II 0.55, III 0.50, IV 0.85; total length 4.4.

Third Instar: (as above) Fig. 3

General form and color as in preceding; reddish central coloration of pronotum extending completely over lateral margin except for extreme anterior corner; mesonotum including wing pads dark brown with exception of a median reddish stripe that widens posteriorly and extends laterally along posterior margin to inner angle of wing pads; median and sublateral red longitudinal abdominal stripes strongly differentiated from orange ground color.

Length head 0.65, width head 0.90, interocular space 0.65; length pronotum 0.35; width 0.90; length abdomen 2.25; length labial segments I 0.40, II .40, III .45, IV .40; length antennal segments I .20, II .40, III .35, IV .60; total length 3.75.

Second Instar: (as above) Fig. 4

Very similar in form and color to instar 1; pronotum with pale anterior

marginal color much broader and more conspicuous than posterior; dark sclerotization of mesonotum covering greater part of notum; abdomen and thoracic nota chiefly red so that longitudinal red stripes are only obscurely differentiated from remainder of coloration, abdomen narrowly orange laterally; length head .60, width .70, interocular space .50; length pronotum .30, width .75; length abdomen 1.45; length labial segments I .30, II .35, III .35, IV .35; length antennal segments I .20, II .40, III .40, IV .65; total length 2.90.

First Instar: (as above) Fig. 5

Head reddish brown with dark markings very conspicuous, pronotum reddish slightly paler anteriorly and posteriorly with transverse calli "bar" nearly black and very strongly contrasting; mesonotum with a prominent brown transverse sclerite on either side of midline, covering anterior one-half of notum and extending nearly to lateral margins, a short transverse dark "bar" in middle of lateral one-half of above sclerite; metanotum with a similar but much smaller sclerite along anterior margin, strongly tapering to a point near meson; ground color of thoracic nota and abdomen orangish with a broad median and 2 sublateral longitudinal red stripes; appendages as in later instars.

Head relatively large, strongly convex, tylus exceeding distal end of antennal segment 1; length head .45, width .50, interocular space .40; all thoracic nota short and strongly transverse, length pronotum .25, width .55; no evidence of wing pads present; abdomen large ovoid, length abdomen 1.15; labium elongate, exceeding metacoxae and reaching visible abdominal sternum 2; length labial segments I .25, II .25, III .25, IV .25; length antennal segments I .15, II .20, III .20, IV .35; total length 1.95.

Egg

Oval in shape with 8-10 micropylar processes arranged in a circle 0.25 mm in diameter at the anterior end; length 1.1 mm, width 0.6 mm, pearl white in color.

Development

Under room temperatures varying from 23 to 26°C the average development time of the egg was 12 days; 1st instar 10; 2nd instar 8; 3rd instar 10; 4th instar 12; and 5th instar 13 days. Adults can be maintained several weeks in the laboratory on sunflower seeds.

Acknowledgements

We thank Dr. C. W. Campbell, University of Florida AREC, Homestead for his identification of *Corchorus siliquosus* L.

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NEW RECORDS FOR *ZETHUS* FROM TEXAS (HYMENOPTERA:EUMENIDAE)[1]

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ABSTRACT

Recent collecting at McAllen in the Lower Rio Grande Valley of Texas has revealed 3 species of *Zethus*: *Z. aztecus* and *Z. montezuma,* here recorded for the first time from the United States, and *Z. miscogaster,* previously unknown from the state of Texas. All the U. S. *Zethus* are keyed and ecological data are provided for the Texas species.

The solitary vespoid genus *Zethus* has 187 species in tropical America but is poorly represented in the United States. *Z. spinipes* Say occupies most of the Upper and Lower Austral Zones. *Z. slossonae* Fox inhabits subtropical Florida. *Z. miscogaster* Saussure extends from southern Arizona to Argentina, and *Z. guerreroi* Zavattari has been reported from Arizona and New Mexico to El Salvador. These 4 species constitute the entire Nearctic fauna, as cited in Bohart and Stange's (1965) recent monograph of the New World *Zethus.*

During the last two years, I have been surveying the Hymenoptera of the Valley Botanical Garden at McAllen, Texas. Among material collected are series of *Z. aztecus* Saussure, *Z. montezuma* Saussure, and *Z. miscogaster. Z. montezuma* and *Z. aztecus* have not been recorded previously from north of Mexico. *Z. miscogaster* is cited for the United States by Bohart and Stange on the basis of a single specimen from the Baboquivari Mountains of Arizona.

These additions to our *Zethus* fauna are not surprising. Few entomologists have sampled the Hymenoptera of the Lower Rio Grande Valley. Furthermore, that region harbors the richest Neotropical biota of any part of the United States. Indeed, the plant community at the Valley Botanical Garden is subtropical thorn scrub resembling that which grows in suitably arid places from Mexico south to Argentina. The dominant large angiosperm genera are *Acacia, Baccharis, Celtis, Condalia, Opuntia, Parkinsonia,* and *Prosopis.* This same element forms a prominent part of Chaco communities in northern Argentina at the other extreme of the Neotropics.

The following contribution offers a revised key to the United States *Zethus* and field notes on the species newly recorded from Texas.

KEY TO UNITED STATES *Zethus*

1. Third gastric sternite with a conspicuous translucent apical lamella or flange that is truncate abruptly on each side before attaining lateral margin of sternite (Fig. 1) 2

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1′. Third gastric sternite with apical flange weakly to conspicuously differentiated but not especially abbreviated toward lateral margin of sternite 3

2. Hind margin of 2nd gastric tergite evenly convex, hardly membranous; only 1 well developed mid-tibial spur; interocellar area without tubercles ..... *aztecus* Saussure

2′. Hind margin of 2nd gastric tergite divided into 3 sections by translucent lateral lobes; 2 mid-tibial spurs; interocellar area with broad, more or less polished tubercles separated by a narrow line of punctures ..... *guerreroi* Zavattari

3. Female clypeus mat with very minute regular longitudinal striae, as well as numerous large punctures; male flagellum rolled toward apex; mid-tibia with 1 well developed apical spur; gaster mostly red ..... *slossonae* Fox

3′. Female clypeus shining with strong punctures and/or coarse striations but without minute wrinkling; male flagellum hooked toward apex (Fig. 2, 4); mid-tibia with 1 or 2 apical spurs; gaster mostly black 4

4. Stem of 2nd gastric tergite definitely longer than that of 1st (Fig. 3); notaulus weakly impressed or absent .... *miscogaster* Saussure

4′. Stem of 2nd gastric tergite definitely shorter than that of 1st (Fig. 5); notaulus distinct at least over apical 0.5 of mesoscutum 5

5. Apical propodeal lamella produced into a rounded lobe above valvula (Fig. 5); 2 well developed mid-tibial spurs; petiole slender ..... *montezuma* Saussure

5′. Apical propodeal lamella scarcely distinguishable from rest of submarginal carina; only 1 well developed mid-tibial spur; petiole very stout ..... *spinipes* Say

Zethus aztecus Saussure
(Fig. 1)

SPECIMENS EXAMINED: 1 female, 8 males, TEXAS, Hidalgo Co., Valley Botanical Garden, McAllen, C. C. Porter. On 12-VI-1973, 2 males were swept from flowers of *Acacia greggii* A. Gray. The other 7 specimens, including the only female, were taken between 27-VIII and 8-IX-1973, on flowers of *Baccharis halimifolia* L.

Outside the United States *aztecus* ranges from Tamaulipas and Sonora in Mexico south to Guatemala and El Salvador.

I am indebted to Dr. Lionel Stange of the Instituto Miguel Lillo (Tucumán, Argentina) for determination of this material.

Zethus guerreroi Zavattari

No specimens of *guerreroi* were available for examination. Bohart and Stange (1965:177) recorded it from southern Arizona, southwestern New Mexico, most of the Mexican states, and Quetzaltepeque in El Salvador.

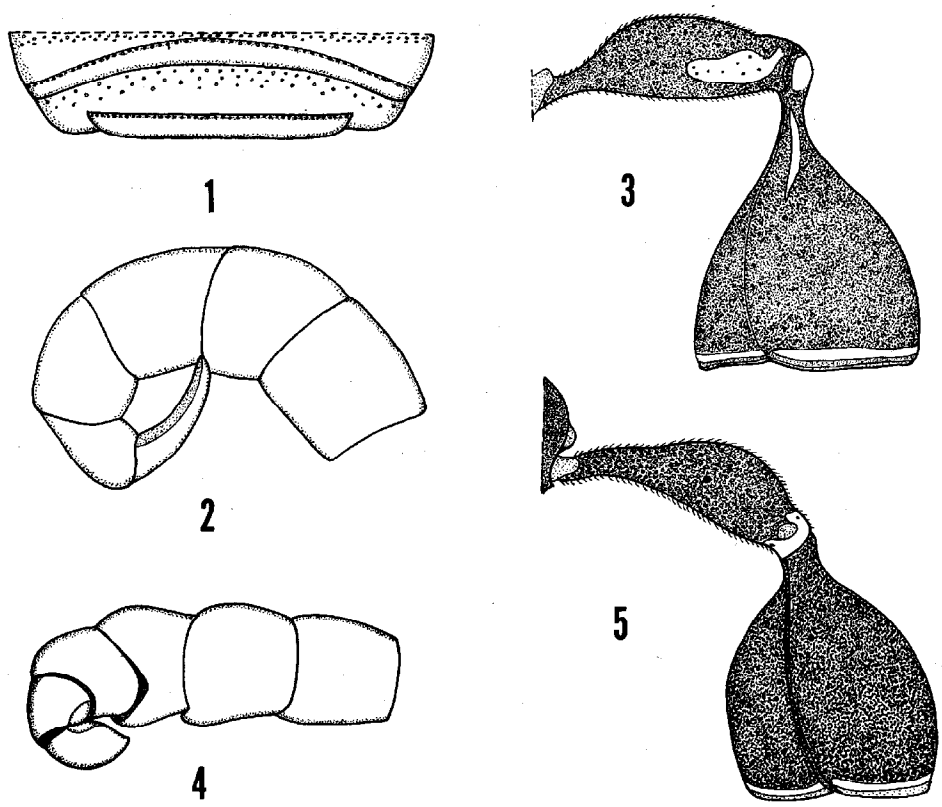

Fig. 1-5. *Zethus* species. 1) *Z. aztecus,* ventral view 2nd and 3rd gastric sternites, showing laterally truncate apical flange of 3rd. 2) *Z. miscogaster,* male, apex of flagellum. 3) *Z. miscogaster,* lateral view of 1st and 2nd gastric segments. 4) *Z. montezuma,* male, apex of flagellum. 5) *Z. montezuma,* lateral view of apex of propodeum and 1st 2 gastric segments.

Zethus slossonae Fox

SPECIMENS EXAMINED: 1 female, FLORIDA, nr. Everglades, 26-VI-1972, C. C. Porter.

Z. slossonae is confined to the subtropical part of Florida. Its closest relatives are West Indian and South American.

Zethus miscogaster Saussure
(Fig. 2, 3)

SPECIMENS EXAMINED: 2 females, 2 males, TEXAS, Hidalgo Co., Valley Botanical Garden, McAllen, C. C. Porter. On 11-VI-1973, 1 male was collected from flowers of *Acacia greggii.* The other 3 specimens were found on flowers of *Baccharis halimifolia* between 27-VIII and 8-IX-1973.

Bohart and Stange (1965:74) reported *miscogaster* from Arizona and outside the United States from Mexico, El Salvador, Panama, Colombia, Venezuela, Brasil, Paraguay and Argentina.

Zethus montezuma Saussure
(Fig. 4, 5)

SPECIMENS EXAMINED: 4 females, 2 males, TEXAS, Hidalgo Co., Valley Botanical Garden, McAllen, C. C. Porter. A single female appeared on

flowers of *Baccharis* between 27-VIII and 8-IX-1973. Between 20-27-XII-1973, 2 more females were collected on foliage of *Prosopis juliflora* DC. From 12-21-I-1974, 1 female and 2 males were found on foliage of *Condalia obovata* Hook and *Baccharis halimifolia* L.

Zethus spinipes Say

SPECIMENS EXAMINED: 1 female, 1 male, MARYLAND, Dorchester Co., Hudson, 1-VIII-1972, C. C. Porter.

Z. spinipes ranges over most of the eastern United States from Massachusetts and Kansas south to Florida and Texas.

MATERIAL

One female each of *Z. aztecus, miscogaster,* and *montezuma* has been donated to the Florida State Collection of Arthropods at Gainesville. Other material herein cited remains in the collection of Charles C. Porter at McAllen, Texas.

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EFFECT OF IRRADIATION WITH ^{60}Co ON TRANSFER AND MOTILITY OF SPERM AND ON MATING OF THE TOBACCO BUDWORM[1]

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ABSTRACT

Adult tobacco budworms, *Heliothis virescens* (F.), irradiated as pupae within 24 hr of adult eclosion with 20 or 40 krad gamma irradiation were paired singly in all possible combinations. The effects of treatment on the quantity and motility of sperm were generally related to dose. However, the quantity and motility of sperm and mating frequency of irradiated males were affected by 20 or 40 krad at 5 days after adult eclosion but not after 10 days. The mating frequency of irradiated females was not affected by either dose at either time, but fecundity was affected. A dose of 40 krad completely sterilized both sexes; a dose of 20 krad caused 64 and 98% sterility in males and females, respectively. Both doses of irradiation increased longevity of males, but female longevity was increased with 20 krad.

Field tests involving releases of sterile male tobacco budworms, *Heliothis virescens* (F.), on the Island of St. Croix, U.S. Virgin Islands, were unsuccessful because laboratory-reared males were not sexually competitive with males of the natural population for the native females. Basic information on the overall reproductive capacity of an insect is essential to develop a control method based on the sterile male technique. Some of this information is lacking for the tobacco budworm.

Flint and Kressin (1969) suggested that the presence of normal quantities of sperm in the spermatheca of the tobacco budworm, rather than frequency of mating, is basic to normal oviposition; they also found that sperm from irradiated (I) or unirradiated (U) males was equally effective in stimulating oviposition. The effect of gamma irradiation on the motility of tobacco budworm sperm has not been determined, though it has been for the bollworm, *H. zea* (Boddie) (Snow et al. 1972). A study was therefore conducted to determine the effects of ^{60}Co irradiation on mating frequency, the amount of sperm transferred and its motility in the spermatheca, and the fecundity, fertility, and longevity of treated tobacco budworm moths.

MATERIALS AND METHODS

The budworms used were taken from our laboratory colony (Guerra et al. 1971). Male or female pupae were irradiated with 20 or 40 krad within 24 hr of adult eclosion at a rate of 815.2 rad/min with SD 8% of mean. These doses were chosen because they are considered to be a substerilizing (Guerra

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et al. 1974) and a sterilizing dose—a 97% reduction in hatch was obtained with 30 krad (Wolfenbarger and Guerra 1971). Only moths that eclosed within 24 hr of irradiation were paired. The females from the single-pair replicates were dissected at 5 or 10 days after pairing or upon death. Each test was replicated 4 times during a 2-month period in 1973, with 40-50 pairs/cross.

Female spermathecae were dissected by holding and applying a little pressure to the female abdomen with the thumb and index fingers of the left hand and pulling out the protruded oviscaptum with a fine pair of forceps until the entire sexual organs were completely removed. These organs were then placed on a glass slide and the spermatheca was separated, placed on another slide in a drop of 0.25 m sucrose, and covered gently with a cover glass for microscopical examination.

The relative amounts and motility of eupyrene sperm in the spermatheca were determined by the rating system developed by Holt and North (1970) and modified by Snow et al. (1972); we used the methods of Snow et al. (1972) to determine motility of eupyrene sperm. Thus when 60% or more of the visible eupyrene sperm were motile in the spermatheca, we assumed that the spermatheca contained a normal quantity of motile sperm and that these females successfully mated. Spermatophores (an indicator of mating frequency) and eggs were counted by the methods of Wolfenbarger and Guerra (1970), and longevity was recorded as described by Guerra et al. (1971). Sterility was based on the observed difference in egg hatch of the I X U moths and the check.

Binomial confidence limit techniques were used to test the differences between the check and irradiation treatments in the percentage of females with no sperm or with normal quantities in the spermathecae. These techniques were also used to compare the differences in sperm motility. All differences were compared at the 5% level of probability.

Results and Discussion

The proportion of females with normal quantities of sperm after 5 days was reduced 37% from the check when males were irradiated with 20 krad and 94% when the males received 40 krad (Table 1); reductions were significant. After 10 days, the quantity was equal among females paired with males irradiated at 20 krad, and that of females paired with males irradiated with 40 krad was reduced 67%, a significant difference. However, 32 and 20% of the check females had less than normal quantities of sperm (between 1 and 59% of eupyrene sperm) after 5 and 10 days, respectively. For the purpose of this work, we reported only females with normal or no sperm at all. We suggest that this difference among the check females in quantity of sperm at 5 and 10 days results because female budworms oviposit, reabsorb, or expel unused sperm. For example, Flint and Kressin (1969) found that 15-20% of their strain of tobacco budworms failed to transfer a normal quantity of sperm. Also, Taylor (1967) and North and Holt (1968) indicated that when sperm was not transferred in normal quantities, the female budworm remated (as determined by spermatophores per female) more often than when she received normal quantities.

When males were irradiated at 20 krad, the number of females with sperm of normal motility was reduced 50%, a significant difference, after 5 days compared with females placed with U males and 100% after 10 days

TABLE 1. EFFECTS OF GAMMA IRRADIATION ON REPRODUCTION OF TOBACCO BUDWORMS IRRADIATED AS PUPAE AND PAIRED 0-24 HR AFTER ECLOSION (40-50 SINGLE PAIR REPLICATES).

Cross* (Female X Male)	Irradiation dose (krad)	After 5 days					After 10 days				
		% Females with quantity of eupyrene sperm in spermatheca		% Females with indicated motility of sperm		No. of spermatophores/Female††	% Females with quantity of eupyrene sperm in spermatheca		% Females with indicated motility of sperm		No. of spermatophores/Female††
		None**	Normal†	None**	Normal†		None**	Normal†	None**	Normal†	
U X U		4	64	4	60	2.96 abc	32	48	40	28	5.28 a
U X T	20	32 s	40 s	39 s	30 s	3.32 ab	40	50	100 s	0 s	3.24 b
T X U	20	0	72	0	74	2.68 bcd	8 s	50	13 s	58 s	4.32 ab
T X T	20	8	44 s	21 s	38 s	3.52 a	32	32 s	92 s	8 s	3.60 b
U X T	40	44 s	4 s	91 s	0 s	2.52 cd	64 s	16 s	96 s	0 s	4.24 ab
T X U	40	0	72	0	64	2.52 cd	8 s	60	0 s	54 s	3.52 b
T X T	40	55 s	10 s	80 s	0 s	2.44 d	40	30 s	87 s	0 s	3.68 b

*U = untreated; T = treated.

** s indicates percent significantly different from check at 5% probability level based on binomial confidence limits of 0-14% for 4% females in check with condition, 20-47% for 32% females and 25-57% for 40% males.

† "Normal" quantity of sperm as described by Flint and Kressin (1969). "Normal" motility of sperm based on numerous observations at this laboratory of sperm transferred by untreated males. s indicates percent significantly different from check at 5% probability level based on binomial confidence limits of 49-77% for 64% females in check with condition, 34-63% for 48% females and 16-42% for 28% females.

†† Means followed by same letter are not significantly different at 5% level by analysis of variance and Duncan's multiple range test.

(both were significant); at 40 krad, no motile sperm were present in the females after either period. These results are similar to those reported by Snow et al. (1972) for the bollworm.

When I females were paired with U males, the proportion with normal motility was equal to the check at 5 and 10 days after pairing. This finding is especially important if sterile tobacco budworm females are to be used in a release program. Such females receive motile sperm in their spermathecae, and they also receive normal quantities and mate as often as untreated females. Thus I females of this species are completely "normal" in terms of sperm transfer.

Irradiation with 40 krad completely sterilized both sexes; 20 krad caused 64, 83, and 98% sterility in I male X U female, I female X U male, and I male X I female crosses, respectively (Table 2). These results are similar to those shown by others for the same crosses at ca. the same doses (Flint and Kressin 1967, El Sayed and Graves 1969, Wolfenbarger and Guerra 1970). Likewise, frequency of mating was generally similar to that determined in other tests for the lifetime of the insects, regardless of dose or sex irradiated.

Fecundity was significantly affected whenever one or both sexes were irradiated, regardless of dose. However, it is much more important that the increased motility of sperm and the presence of presumably normal quantities of sperm did not cause normal fecundity in I females. Moreover, since all the U females were equally fecund when equal amounts of sperm were transferred, we conclude that the dose of irradiation affected egg laying and fertility more than it affected any other factor.

Mating frequency (Table 1) during these tests was comparable between treatments (including the check) in the 5-day group (2-3 spermatophores/female). When adult pairs were permitted to stay together 10 days, mating frequency was somewhat greater in the check (5 spermatophores/female),

TABLE 2. EFFECT OF GAMMA IRRADIATION ON REPRODUCTION OF TOBACCO BUDWORMS (IRRADIATED AS PUPAE) WHEN 24-HR-OLD MOTHS WERE PAIRED DURING THEIR LIFE (40-50 SINGLE PAIR REPLICATES).

Cross* (Female X Male)	Irradiation dose (krad)	% sterility**	No./Female†		Longevity†	
			Spermatophores	Eggs	Female	Male
U X U			4.92 a	796 a	13.0 b	13.2 b
U X T	20	64	2.85 b	466 b	12.7 b	12.1 b
T X U	20	83	3.85 ab	449 b	15.9 a	16.3 a
T X T	20	98	2.85 b	307 bc	12.5 b	12.4 b
U X T	40	100	3.83 b	277 e	11.8 b	11.8 b
T X U	40	100	3.92 ab	108 d	14.8 b	15.5 a
T X T	40	100	3.57 ab	101 d	12.8 b	13.2 b

*U = untreated; T = treated.

**Based on 61% hatch of the check.

†Means followed by same letter are significantly similar by Duncan's multiple range test at 5% level of probability.

but mating frequency was comparable in the rest of the treatments (3-4 spermatophores/female). Similar results were obtained when pairs were permitted to mate their entire lifespan (Table 2).

Irradiation significantly increased male longevity at both doses of irradiation; female longevity was significantly increased with 20 krad. Also, the percentage of females that mated in all treatments (data not shown) was 92-100% after 5 days and 96-100% after 10 days, therefore it appears that in the laboratory the majority of the matings for the lifespan took place during the 1st 5 days after adult emergence.

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DISTASTEFUL FIREFLIES SOMETIMES EMETIC, BUT NOT LETHAL.—(*Note*). *Photinus umbratus* fireflies are distasteful to fence lizards (*Sceloporus undulatus*) and skinks (*Eumeces laticeps*). An attacking lizard vigorously spits out the firefly, wipes its snout with its forefeet or against the substrate, and sometimes makes gaping or yawning movements of the mouth. A single experience will usually prevent further attacks for several weeks or months; when a firefly is presented to a lizard days later, the animal sometimes, without approaching the firefly, makes gaping, yawning movements (J. E. Lloyd, 1973. Coleop. Bull. 27:91-106).

We presented *P. umbratus* to 9 fence lizards in a total of 45 trials; none were eaten though 6 attacks were elicited. Four lizards never attacked (prior experience?); 3 attacked only on the first presentation and not during 4 remaining weeks of trials; 1 attacked on the second trial, and not again; and 1 attacked on the first 2 trials but not subsequently. (A feeding regimen of mealworms and crickets at 2-day intervals was established during the month preceding the tests; tests were performed in lieu of regular feeding. In all cases reported, animals that did not attack fireflies ate mealworms.)

We stuffed the gutted abdomens of live crickets with 3-7 fireflies (killed by freezing), and presented them to 5 lizards. The stuffed crickets walked and elicited attacks. In 4 attacks, by 2 fence lizards, crickets were taken headfirst partway (up to the abdomen) into the mouth and then suddenly disgorged; in 3 separate attacks and disgorgements a skink swallowed then vomited crickets smuggling 5-7 fireflies each; another skink swallowed 6 crickets containing a total of 28 fireflies and 4 hr later disgorged all and a mealworm she had eaten after refusing the seventh cricket—3 weeks later she swallowed more than 15 fireflies in 3 crickets, disgorged the third with its 6 fireflies, ate another with 6, refused the next, and during 7 subsequent hours of observation did not further disgorge or exhibit unusual behavior. A fence lizard swallowed 3 crickets with a total of 15 fireflies and in the subsequent 8 hr exhibited no unusual behavior or disgorgement, but when tested 18 days later ran from a cricket and jumped and clawed at the glass wall of the cage. Three weeks later it ate a cricket with 6 fireflies and refused 2 more and a mealworm; in 6 subsequent hours it exhibited no unusual behavior or disgorgement. Both skinks commonly pushed partially swallowed, stuffed crickets through the sand and when swallowed these were well-covered with sand.

The gaping-yawning of experienced lizards, when viewing a firefly, may be an indication of recall activity in their central nervous system, and the flight of the lizard that had previously eaten but not vomited 15 fireflies suggests that the meal produced internal discomfort. Susanne L. Sydow, and James E. Lloyd, Depts. of Zool. and Entomol., respectively, Univ. of Florida, Gainesville 32611.

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