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New York Entomological Society

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New Mexican and Central American Species of *Strangalia* Audinet-Serville (Coleoptera: Cerambycidae)

John A. Chemsak

Division of Entomology, University of California, Berkeley 94720

Received for Publication June 3, 1968

Abstract: Seven new species of the lepturine genus *Strangalia* Audinet-Serville are described from Mexico and Guatemala and the genus is characterized. New species are: *Strangalia* **auripilis; bicolorella; cavaventra; dolicops; gracilis; palaspina; pulchra.**

The lepturine genus *Strangalia* Audinet-Serville has not previously been reported from Mexico nor Central America. Because of the past confusion as to the identity of the genus, all of the previously described species of *Strangalia* have been placed in the genus *Ophistomis* Thomson. In 1964 Chemsak established that the correct type designation for *Strangalia* is *Leptura luteicornis* Fabricius (Thomson, 1860). On this basis all of the following new species are congeneric with *S. luteicornis* although no attempt will be made at this time to establish new combinations for other Mexican species.

Briefly, the genus *Strangalia* may be characterized as follows: Head oblique, abruptly and deeply constricted behind the eyes, front rather short, palpi unequal, apical segments cylindrical; eyes large, finely faceted, notched; antennae inserted on front at anterior margin of eyes, distinct poriferous areas usually present on distal segments, third segment longer than scape, fourth shorter than third, fifth longer than fourth. Pronotum trapezoidal, about as long as basal width, hind angles acute, sides sinuate. Elytra usually strongly cuneiform, sides narrowing at middle. Legs slender, hind femora carinate dorsally, hind tibiae often carinate along inside; posterior tarsi slender, elongate, apical segment narrow, cleft only at apex. Abdomen of males with last sternite often deeply excavated and margins expanded.

The following institutions are gratefully acknowledged for providing much of the material used in this study: Canadian National Collection, Ottawa; Chicago Museum of Natural History; University of California, Davis; and University of Kansas. The National Science Foundation through Grant GB-4944X is also acknowledged. Celeste Green assisted in the preparation of the illustrations.

Strangalia **bicolorella**, new species

(Fig. 1)

MALE: Form slender, strongly tapering posteriorly; color reddish orange except for black portions: tips of mandibles and maxillary palpi, eyes, antennae except scape, elytra except basal margin, apex of abdomen, tibiae and tarsi and apical half of hind femora. Head with front about as long as broad (measured from apex of labrum to lower edge of eyes and from outside margins of genae), vaguely punctate, inconspicuously pubescent; vertex longitudinally impressed, finely closely punctate, pubescence sparse, short, dark; antennae shorter than elytra, slender, segments six and seven with small poriferous areas at apices, areas much larger on following segments, eleventh segment strongly tapering. Pronotum with sides sinuate, not strongly impressed at apex nor base; disk convex, shallowly, densely punctate, punctures transverse; pubescence sparse, appressed, dark on disk; prosternum subglabrous, front coxal cavities essentially closed behind; meso and metasternum minutely, densely punctate, densely pubescent. Elytra over three times as long as broad, strongly narrowing before middle; base narrowly reddish; punctures rather fine, well separated; pubescence depressed, short, dark, rather sparse; apices strongly obliquely emarginate. Legs slender, hind pair elongate; hind femora carinate dorsally; hind tibiae carinate internally. Abdomen elongate, extending about two segments beyond elytra; last ventral segment excavated for its entire length, margins strongly expanded. Length, 20–22 mm.

Holotype male (California Academy of Sciences) and one male paratype from 5 miles North of Mazatlán, Sinaloa, Mexico, 28 July, 1964, on flowers of *Buddleia wrightii* (J. A. Chemsak).

Strangalia **dolicops**, new species

(Fig. 2)

male: Form slender, elongated; color black, elytra with broad testaceous, longitudinal vittae, antennae with segments 8 to 10 yellowish beneath. Head with front long, sparsely punctate and pubescent; vertex subopaque, very finely, confluently punctate, sparsely clothed with long hairs; antennae extending to about third abdominal segment, poriferous areas very small on distal segments, eleventh segment appendiculate. Pronotum with sides strongly sinuate, apex narrowly impressed; disk impressed behind middle with an irregular glabrous area; punctures at middle strongly transverse, sides confluently punctate, pubescence short, sparse, depressed; prosternum glabrous with a few punctures interspersed, coxal cavities closed behind; mesosternum finely, densely, shallowly punctate, densely clothed with pale depressed pubescence; metasternum with an elevated median carina, episternum rather coarsely, sparsely pubescent. Elytra over three times as long as broad, strongly attenuated and dehiscent; humeri obtusely angulate; pale areas surrounded by black margins with short narrow black lines often extending down middle from base, median angular black spots extending from margins but not to suture, two median dark spots at apical one third, and apices black; basal punctures fine, shallow, well separated; pubescence short, sparse, depressed; apices acuminate. Legs slender; hind femora carinate dorsally; hind tibiae arcuate near apex, vaguely carinate internally. Abdomen elongate, extending about two segments beyond elytra; last sternite excavated for its entire length, margins moderately strongly produced. Length, 19 mm.

Holotype male (Chicago Museum of Natural History) and one male paratype from Santa Clara, in interior valley of Sierra de las Minas (N. of Cabañas), Zacapa, Guatemala, 6,500 feet, 6 August, 1948 (R. D. Mitchell).

This species is distinctive by the long face, almost angulate sides of the pronotum and strongly dehiscent elytra.

Strangalia **palaspina**, new species

(Fig. 3)

male: Form moderately slender, strongly tapering posteriorly; color orange except for following black parts: tips of mouthparts, eyes, antennae, often apices of elytra, sternum

New Mexican and Central American Species of *Strangalia* Audinet-Serville (Coleoptera: Cerambycidae)

JOHN A. CHEMSAK

DIVISION OF ENTOMOLOGY, UNIVERSITY OF CALIFORNIA, BERKELEY 94720

RECEIVED FOR PUBLICATION JUNE 3, 1968

Abstract: Seven new species of the lepturine genus *Strangalia* Audinet-Serville are described from Mexico and Guatemala and the genus is characterized. New species are: *Strangalia* **auripilis; bicolorella; cavaventra; dolicops; gracilis; palaspina; pulchra.**

The lepturine genus *Strangalia* Audinet-Serville has not previously been reported from Mexico nor Central America. Because of the past confusion as to the identity of the genus, all of the previously described species of *Strangalia* have been placed in the genus *Ophistomis* Thomson. In 1964 Chemsak established that the correct type designation for *Strangalia* is *Leptura luteicornis* Fabricius (Thomson, 1860). On this basis all of the following new species are congeneric with *S. luteicornis* although no attempt will be made at this time to establish new combinations for other Mexican species.

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The following institutions are gratefully acknowledged for providing much of the material used in this study: Canadian National Collection, Ottawa; Chicago Museum of Natural History; University of California, Davis; and University of Kansas. The National Science Foundation through Grant GB-4944X is also acknowledged. Celeste Green assisted in the preparation of the illustrations.

Strangalia **bicolorella**, new species

(Fig. 1)

MALE: Form slender, strongly tapering posteriorly; color reddish orange except for black portions: tips of mandibles and maxillary palpi, eyes, antennae except scape, elytra except basal margin, apex of abdomen, tibiae and tarsi and apical half of hind femora. Head with front about as long as broad (measured from apex of labrum to lower edge of eyes and from outside margins of genae), vaguely punctate, inconspicuously pubescent; vertex longitudinally impressed, finely closely punctate, pubescence sparse, short, dark; antennae shorter than elytra, slender, segments six and seven with small poriferous areas at apices, areas much larger on following segments, eleventh segment strongly tapering. Pronotum with sides sinuate, not strongly impressed at apex nor base; disk convex, shallowly, densely punctate, punctures transverse; pubescence sparse, appressed, dark on disk; prosternum subglabrous, front coxal cavities essentially closed behind; meso and metasternum minutely, densely punctate, densely pubescent. Elytra over three times as long as broad, strongly narrowing before middle; base narrowly reddish; punctures rather fine, well separated; pubescence depressed, short, dark, rather sparse; apices strongly obliquely emarginate. Legs slender, hind pair elongate; hind femora carinate dorsally; hind tibiae carinate internally. Abdomen elongate, extending about two segments beyond elytra; last ventral segment excavated for its entire length, margins strongly expanded. Length, 20–22 mm.

Holotype male (California Academy of Sciences) and one male paratype from 5 miles North of Mazatlán, Sinaloa, Mexico, 28 July, 1964, on flowers of *Buddleia wrightii* (J. A. Chemsak).

Strangalia **dolicops**, new species
(Fig. 2)

male: Form slender, elongated; color black, elytra with broad testaceous, longitudinal vittae, antennae with segments 8 to 10 yellowish beneath. Head with front long, sparsely punctate and pubescent; vertex subopaque, very finely, confluently punctate, sparsely clothed with long hairs; antennae extending to about third abdominal segment, poriferous areas very small on distal segments, eleventh segment appendiculate. Pronotum with sides strongly sinuate, apex narrowly impressed; disk impressed behind middle with an irregular glabrous area; punctures at middle strongly transverse, sides confluently punctate, pubescence short, sparse, depressed; prosternum glabrous with a few punctures interspersed, coxal cavities closed behind; mesosternum finely, densely, shallowly punctate, densely clothed with pale depressed pubescence; metasternum with an elevated median carina, episternum rather coarsely, sparsely pubescent. Elytra over three times as long as broad, strongly attenuated and dehiscent; humeri obtusely angulate; pale areas surrounded by black margins with short narrow black lines often extending down middle from base, median angular black spots extending from margins but not to suture, two median dark spots at apical one third, and apices black; basal punctures fine, shallow, well separated; pubescence short, sparse, depressed; apices acuminate. Legs slender; hind femora carinate dorsally; hind tibiae arcuate near apex, vaguely carinate internally. Abdomen elongate, extending about two segments beyond elytra; last sternite excavated for its entire length, margins moderately strongly produced. Length, 19 mm.

Holotype male (Chicago Museum of Natural History) and one male paratype from Santa Clara, in interior valley of Sierra de las Minas (N. of Cabañas), Zacapa, Guatemala, 6,500 feet, 6 August, 1948 (R. D. Mitchell).

This species is distinctive by the long face, almost angulate sides of the pronotum and strongly dehiscent elytra.

Strangalia **palaspina**, new species
(Fig. 3)

male: Form moderately slender, strongly tapering posteriorly; color orange except for following black parts: tips of mouthparts, eyes, antennae, often apices of elytra, sternum

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often partially, parts of tarsi, apices of middle and hind femora, and most of last abdominal tergite. Head with front short, almost unpunctate, pubescence very sparse; vertex narrowly impressed, very finely, densely punctate, finely pubescent; antennae slender, shorter than elytra, segments from sixth with distinct poriferous areas, eleventh segment appendiculate. Pronotum with sides sinuate, apex feebly impressed; disk shining, strongly convex with a thin longitudinal, glabrous median line; punctures fine, shallow, transverse; pubescence moderately dense, depressed, golden; prosternum subglabrous, sparsely pubescent, front coxal cavities slightly open behind; meso and metasternum finely, densely, shallowly punctate, moderately clothed with depressed pubescence; metasternum with an acute, elevated tubercule on each side of middle. Elytra about three times as long as broad, moderately attenuated, slightly dehiscent; basal punctures fine, dense, shallow; pubescence short, depressed; apices obliquely, shallowly emarginate. Legs slender; hind femora carinate dorsally over basal half; hind tibiae arcuate, inside spur greatly expanded into a broad excavated plate, outside basal area of this structure concave with a short spine at edge of concavity. Abdomen extending about one segment beyond elytra; last sternite with a small depression at middle of apex. margins not produced. Length, 15–18 mm.

female: Form more robust, elytra not attenuated. Metasternum and hind tibiae not modified. Abdomen shorter, broader. Length, 13–16 mm.

Holotype male (Canadian National Collection) from 5 miles North Mazatlán, Sinaloa, Mexico, 24–29 July, 1964, on flowers of *Jatropha curcas* (H. F. Howden); allotype, 5 miles North Mazatlán, 28 July, 1964, on flowers of *Buddleia wrightii* (J. A. Chemsak); paratypes as follows: 3 males, 18 miles South Guamuchil, Sinaloa, 7 August, 1964, on flowers of *Croton culicanensis* (J. Powell); 1 female, 8 miles South Elota, Sinaloa, 2 July, 1963 (F. D. Parker, L. A. Stange); 4 males, 3 females, 5 miles North Mazatlán, 24–29 July, 1964, on flowers of *Buddleia wrightii* and *Jatropha curcas* (H. F. Howden), 28 July, 1964, on *B. wrightii* (J. A. Chemsak), 5–7 August, 1964 (H. F. Howden); 1 male, Mazatlán, 16 August, 1964 (J. F. McAlpine); 1 male, 9 Miles East Chupaderos, Sinaloa, 3 July, 1963 (Parker and Stange); 1 male, El Pichon, Nayarit, 25 June, 1963 (J. Doyen); 1 male, 18 miles South Tepic, Nayarit, 7 July, 1963 (Parker and Stange).

The highly modified hind tibiae of the males will immediately identify this species. Some variation in coloration is evident, primarily on the elytra. Some specimens have the apices of the elytra narrowly black. Also, one of the females possesses well developed longitudinal black fasciae. These are marginal and sutural on each elytron. The vertex of the head is often black and frequently the sides of the pronotum are black toward the apex.

Strangalia **pulchra**, new species
(Fig. 4)

female: Form slender, rather stout, strongly tapering posteriorly; color reddish, elytra yellowish and brown with black fasciae, black markings as follows: eyes, underside of head,

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Figs. 1–4. Typical elytral patterns of: (1) *Strangalia* **bicolorella** Chemsak; (2) *S.* **dolicops** Chemsak; (3) *S.* **palaspina** Chemsak; and (4) *S.* **pulchra** Chemsak.

sides of pronotum, very narrowly at apex and base of pronotum, scutellum, thoracic sterna except middle, abdominal sternites at bases, and femora for at least the basal halves. Head with front slightly long, vaguely punctate and pubescent; vertex with a fine impressed line, punctures rather fine, contiguous, pubescence inconspicuous; antennae slender, extending to about second abdominal segment, segments from sixth slightly thickened, basal five segments shining, orange, sixth and seventh dull, darker, segments eight to eleven pale yellowish, poriferous areas indistinct on segments 8 to 10. Pronotum with sides sinuate, apex barely impressed; disk shining, convex with a glabrous spot at middle in front of basal margin; punctures at middle transverse, not confluent; pubescence sparse, short, golden and depressed; prosternum subglabrous, front coxal cavities slightly open behind; meso and metasternum very densely, minutely, shallowly punctate, rather densely clothed with short appressed pubescence. Elytra less than three times as long as broad, moderately strongly attenuated; base yellowish around scutellum, humeri brownish, the brown extending dorsally back into the transverse sub-basal black chevron, a yellowish area extends from behind the dark chevron to beyond the middle, inside the yellow area are two marginal dark round spots, two dark brown spots delimit the posterior margins of the yellow area and the anterior margins of the remainder of the elytra which are brownish; basal punctures fine, separated; pubescence bicolored, short, depressed; apices acuminate. Legs slender, front femora black over basal half, middle pair black over basal three fourths, and hind pair all black; hind femora carinate dorsally at basal half; tibiae non carinate. Abdomen finely punctate and pubescent, shining; last sternite medially impressed at apex, apical margin uneven, sides subdentate. Length, 20 mm.

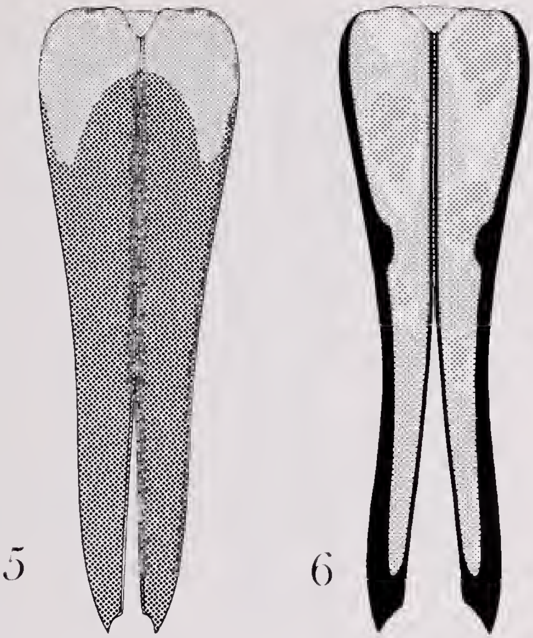
Holotype female (California Academy of Sciences) from 5 miles North Mazatlán, Sinaloa, Mexico, 27 July, 1964, on flowers of *Buddleia wrightii* (John A. Chemsak).

This species somewhat resembles *Ophistomis sallei* Bates but differs in the coloration of the pronotum, antennae, and legs. Also, the pubescence is sparser in *S.* **pulchra**.

Strangalia **auripilis**, new species
(Fig. 5)

MALE: Form slender, elongate, strongly tapering posteriorly; color black and orange, variable, head, pronotum and often elytra entirely black, antennae annulate basally, legs bicolored; pubescence golden. Head with front short, minutely, densely punctate, densely pubescent; vertex densely finely punctate, densely clothed with appressed pubescence; antennae slender, shorter than elytra, segments to fifth paler, dark at apices, segments from sixth with small poriferous areas. Pronotum with sides sinuate, apex narrowly impressed; disk convex with a narrow longitudinal glabrous line; punctures fine, dense, transverse; pubescence dense, appressed, almost obscuring surface; prosternum rugulose, densely pubescent, front coxal cavities closed behind; meso and metasternum finely densely punctate, densely clothed with appressed pubescence. Elytra over three times as long as broad, sides strongly narrowing before middle; basal punctures fine, shallow, separated; pubescence dense, short, depressed; apices obliquely emarginate. Legs slender, hind femora carinate along basal half of outside edge; tibiae not carinate. Abdomen extending at least one segment beyond elytra; sternites minutely punctate, finely pubescent; last sternite excavated for half its length, margins moderately produced, narrowly elongating at apex. Length, 16 mm.

FEMALE: Elytra much less attenuated, form more robust. Antennae extending to about second abdominal segment. Abdomen not modified, apex of last sternite impressed at middle giving a scalloped appearance. Length, 14 mm.



FIGS. 5–6. Typical elytral patterns of: (5) *Strangalia* **auripilis** Chemsak (holotype); (6) *S.* **gracilis** Chemsak.

Holotype male (Canadian National Collection, Ottawa) from 24 miles West La Ciudad, Durango, Mexico, 2 July, 1964 (H. F. Howden); allotype, 15 miles West El Palmito, Sinaloa, Mexico, 11 July, 1964 (W. R. M. Mason). Two male paratypes from 24 miles West La Ciudad, 17 July, 1964 (J. F. McAlpine), 2 July, 1964 (W. R. M. Mason). One male paratype from 15 miles West El Palmito, Sinaloa, 11 July, 1964 (W. R. M. Mason).

Considerable variation in color is evident in the type series. The type and one paratype have black elytra with an orange basal band which extends back slightly behind the humeri. In the other male the elytra are completely black and all orange in the female. The coloration of the underside and legs is also variable. This species may be recognized by the all golden, depressed pubescence, especially on the pronotum.

Strangalia **gracilis**, new species
(Fig. 6)

MALE: Form very slender, strongly tapering posteriorly; color black, each elytron with a broad longitudinal testaceous vitta and a black marginal spot before middle. Head with front short, distinctly punctate, very sparsely pubescent; vertex rather finely, subconfluently punctate, finely, sparsely pubescent; antennae slender, a little longer than elytra, poriferous areas on segments six to eleven very small. Pronotum with sides slightly sinuate; apex narrowly impressed; disk convex with a median glabrous longitudinal line; punctures rather fine, transversely ovoid; pubescence fine, appressed, pale, denser at sides and base; prosternum punctate, densely pale pubescent, front coxal cavities closed behind; meso and metasternum finely densely punctate, densely clothed with pale appressed pubescence, episternum of metathorax less densely punctate and pubescent. Elytra over three times as long as broad, strongly narrowing before middle; pale vittae completely enclosed by black margins; basal punctures moderately coarse, separated, coarser at middle; pubescence rather sparse, depressed, pale and dark; apices obliquely truncate. Legs slender; hind femora carinate on basal half of outside edge; tibiae not carinate. Abdomen elongate, extending two segments beyond elytra; sternites very finely, densely punctate over basal halves, pubescence pale, dense on basal halves; last sternite broadly excavated for its length, margins moderately strongly expanded. Length, 16–18 mm.

FEMALE: Form less attenuated, shorter. Antennae with last four segments yellow. Legs except tarsi pale. Abdomen reddish, last sternite not expanded laterally, apically impressed at middle. Length, 12 mm.

Holotype male, allotype (Canadian National Collection, Ottawa) from 15 miles West El Palmito, 5,000 feet, Sinaloa, Mexico, 11 and 8 July, 1964 (W. R. M. Mason). Five male paratypes from 15 miles West El Palmito, 11 and 25 July, 1964 (W. R. M. Mason); El Palmito, 17 July, 1964 (H. F. Howden); Potrerillos, 15 miles West El Palmito, 8 July, 1964 (J. F. McAlpine).

Strangalia **cavaventra**, new species

(Fig. 7)

MALE: Form slender, very elongated; color black, elytra usually with pale brownish longitudinal vittae. Head with front rather short, finely, densely punctate, very sparsely pubescent; vertex narrowly impressed longitudinally, finely contiguously punctate, sparsely pubescent; antennae as long as elytra, segments from sixth opaque, each with a small poriferous pit at apex. Pronotum with sides sinuate, apex shallowly impressed; disk strongly convex, median line glabrous; punctures fine, dense, transverse at middle; pubescence short, sparse, depressed, with a few long erect hairs at sides near base; prosternum with apical half finely densely punctate, coxal cavities closed behind; meso and metasternum minutely, densely punctate, middle subglabrous, pubescence pale, dense, depressed. Elytra over three times as long as broad, strongly cuneiform; margins and suture black, enclosing a pale brownish longitudinal vitta on each elytron, each side also with a narrow, short, curved black line extending back from inside of humeri; basal punctures fine, shallow, separated; pubescence sparse, short, subdepressed, pale on pale areas; apices slightly dehiscent, obliquely truncate. Legs slender; hind femora carinate; hind tibiae arcuate, strongly carinate internally, Abdomen elongate, extending two segments beyond elytra; sternites minutely, densely punctate, punctures larger and sparse toward apices; fourth sternite impressed apically, fifth sternite very deeply excavated, medially broadly carinate, margins very strongly inflated, moderately densely clothed internally with long and short erect pubescence. Length, 20–23 mm.

FEMALE: Form similar, abdomen not elongated nor modified. Elytra strongly cuneiform. Hind tibiae not carinate. Abdomen reddish, apex of last tergite strongly emarginate. Length, 15–17 mm.

Holotype male, allotype (University of Kansas) from 14 miles Northwest Tehuantepec, Oaxaca, Mexico, 26 June, 1961, on flowers of *Croton* (U. Kans.

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FIG. 7. Typical elytral pattern of *Strangalia* **cavaventra** Chemsak.

Mex. Exped.). Three paratypes (2 males, 1 female), same data. An additional male paratype from 8 miles North La Ventosa, Oaxaca, 20 July, 1963 (W. A. Foster).

The extremely developed and medially carinate last abdominal sternite distinguishes this species. The coloration of the elytra varies from the two well developed pale vittae to almost completely black.

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THOMSON, J. 1860. Essai d'une classification de la famille des cérambycides et matériaux pour servir a une monographie de cette famille. 404 pp. Paris.

Audition by *Cerura* Larvae (Lepidoptera: Notodontidae)

ALEXANDER B. KLOTS
THE AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK, N. Y. 10024

RECEIVED FOR PUBLICATION MAY 28, 1968

Abstract: Mature larvae of *Cerura scitiscripta multiscripta* Riley reacted strongly and defensively to relatively low pitched sounds of the human voice, but showed no reactions to higher pitched sounds such as those of a Galton whistle.

In August, 1967 a batch of eggs was obtained from a female *Cerura scitiscripta multiscripta* Riley caught at Putnam, Windham Co., Connecticut, and the resulting larvae were reared through to maturity. During their last instar while they were being photographed it was noticed that they appeared to react to the human voice by extruding the long stemmatopoda, expanding the prothorax and thrashing the anterior and posterior ends about. This is the normal defense reaction of larvae of *Cerura* and of the closely related European *Dicranura vinula* (L.); it is easily produced by mechanical or chemical excitation of the larvae.

To test the larval reaction to sound a simple experiment was then set up using the available materials. A dozen different larvae were tested. To eliminate, at least partially, the possibility of the larvae being stimulated by mechanical vibrations of the substrate the twig or leaf on which the larva was resting was pinned to a cork block which was rested on a stack, about 8 in. high, of extremely soft and resilient foam plastic sheets. At least 100 trials were made with the writer's voice, speaking in a moderate tone from 12–18 in. away from the larvae. The larvae invariably reacted positively. To eliminate the possibility that the breath was chemically responsible, the larvae were shielded from the breath by an interposed sheet of paper. This made no difference, the larvae reacting just the same.

The larvae were then tested with sounds of higher frequencies such as those to which adult Lepidoptera respond. No reactions were obtained by jingling a bunch of keys, a crude but effective way of producing high-pitched sounds. Nor did the larvae respond to a Galton whistle anywhere in the range of this instrument, from a shrill whistle audible to the human up to a range far supersonic to the human ear.

Relatively little work has been done on caterpillar audition, and that on relatively few species. There is good experimental evidence that the chief auditory structures are sensilla attached to body hairs, and that these are not localized but well distributed over the body. However, such an almost hairless larva as that of *Danaus plexippus* (L.) reacted well to sounds. The observations of previous authors agree well with those described here in that larvae respond well to sounds of a relatively low pitch, but not to high pitched ones.

Thus, Abbott (1927) obtained responses from larvae of *Datana ministra* (Drury) and *integerrima* Grote and Robinson, using tuning forks, with notes of 256 v/s and 512 v/s, but not of 1024 v/s. A bibliography and summary of the work done will be found in Minnich (1936). This seems to be an excellent opportunity for someone, using modern equipment and methods, to work out the nature of the auditory structures involved and the range, and perhaps the function, of caterpillar audition.

Literature Cited

Abbott, C. E. 1927. The reaction of *Datana* larvae to sounds. Psyche, **34:** 129–133.

Minnich, D. E. 1936. The responses of caterpillars to sounds. J. Exper. Zool., **72:** 439–453.

Addendum and Erratum

Mr. Joseph Miller, one of our members and, also, the Secretary of the Newark Entomological Society, has been able to furnish information for the large group picture which appeared between the histories of the New York and the Brooklyn Societies in the September, 1968 issue of the **Journal**, Fig. 1 on p. 148. He says that this same picture is in the Newark files with the notation that this was a gathering of the members of the Newark, the New York, and the Brooklyn Societies at Caldwell, New Jersey on May 30, 1908, and that the members not named in our picture are not named in theirs either. However, #7 is Otto Buchholz and not Richter, as stated.

Buchholz is also in Fig. 8, p. 155, of this series, where his name is misspelled.

Revision of the Tribe Chalepini of America North of Mexico
IV. Genus *Sumitrosis* Butte (Coleoptera: Chrysomelidae)

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Abstract: These beetles have been previously known in the genus *Anoplitis* Kirby; in this study the name is changed to *Sumitrosis* Butte, because *Anoplitis* is a junior synonym of *Chalepus* Thunberg. This synonymy is necessary because their types are congeneric. All names previously designated therefore represent new combinations. The 55 species from the Junk Catalogue, (Uhmann, 1957 and 1964) are now transferred to this genus. Six species compose the genus *Sumitrosis* in the region under consideration. These are *ancoroides* (Schaeffer), **arnetti** a new species, *inaequalis* (Weber), *lateritia* (Smith), *pallescens* (Baly) a new record in the United States, and *rosea* (Weber). Descriptions of the species are given, together with the complete list of references, and key to the species is presented. Distributional data and maps are included for each, as are illustrations of the male genitalia.

INTRODUCTION

This revision of *Sumitrosis* Butte (1968a), is the fourth[1] in a series of papers reviewing the six genera of Chalepini of America North of Mexico. The genus *Chalepus* Thunberg, 1805, is a senior synonym of *Anoplitis* Kirby, 1837. This synonymy was necessary because their type species were congeneric (Butte, 1968*b*). *Anoplitis* Kirby is monobasic, with *Hispa bicolor* Olivier, 1792, as its type. This species is not congeneric with most of the species that have been listed under *Anoplitis* by Chapuis (1875), Weise (1911a), and Uhmann (1935, 1957 and 1964). Although Chapuis adopted *Anoplitis* from Kirby, he ignored the original genotypic fixation and applied this generic name in a very different sense, selecting as his genotype ". . . les *Hispa rosea* de Weber, de Harris, et la *Hispa suturalis*[2] de Fabricius." *Anoplitis bicolor*, the type species originally fixed for *Anoplitis*, is congeneric with *Chalepus sanguinicollis* (L. 1771), which is the genotype of *Chalepus* Thunberg, as designated by Weise, (1905a: 64). *Anoplitis* as used by Chapuis is followed by Weise (1911a) who lists 38 species and accepted by Uhmann, who in 1935 discusses the South American species of this genus along with some other new genera. Uhmann (1957 and 1964) lists a total of 56 species in *Anoplitis*. Since there are no other names available for the species assigned to *Anoplitis* of authors, *Sumitrosis* was proposed as a substitute name with *Hispa rosea* Weber, 1801, as its genotype (Butte, 1968a: 46).

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[1] The third part of this series, the revision of the genus *Odontota* Chevrolat 1837, was published in the Coleopterists' Bulletin, **22**: 4: December, 1968.

[2] *Hispa suturalis* Fabricius, 1801, with *Hispa rosea* Weber, 1801, was listed as a synonym (in error).

The species of this genus closely resemble *Anisostena* Weise in their general appearance and by the presence of eight and one-half rows of punctures on each elytron. However, these two genera are easily separated by the following sets of characters in which those for *Sumitrosis* are given first, those for *Anisostena* second. Body broader, very wide at humerus: body slender, nearly cylindrical. Eyes more or less swollen: eyes feebly swollen, at least not projecting out farther than side of neck. Mesotibiae straight or feebly bent: mesotibiae strongly bent.

The measurements used here were described previously by Butte (1968a).

ACKNOWLEDGMENTS

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I wish also to express appreciation to the authorities and individuals of the following institutions for the loan of specimens for this study. The letters in parentheses indicate the abbreviations used for these institutions throughout this work. American Museum of Natural History, (AMNH), Drs. J. G. Rozen, Lee H. Herman, Jr., and Mr. J. Pallister; California Academy of Science, (CAS), Mr. H. B. Leech and Mr. J. W. Green; Canada National Collection, (CNC), Dr. W. J. Brown; Chicago Natural History Museum, (CNHM), Dr. R. L. Wenzel; Cornell University, (CU), Dr. L. L. Pechuman; Purdue University at Lafayette, (PUL), Dr. Ross H. Arnett, Jr., University of California at Berkeley, (UCB), Dr. Ray F. Smith; University of North Carolina, (UNC), Dr. D. A. Young, Jr.: United States National Museum, (USNM), Mr. O. L. Cartwright, Mr. G. Vogt and Dr. R. E. White. The abbreviation (JGB) is used for my personal collection.

Genus *SUMITROSIS*[3, 4] Butte, 1968

TYPE SPECIES OF GENUS. *Sumitrosis rosea* (Weber, 1801: 66) designated by Butte, (1968a: 46).

DIAGNOSTIC FEATURES OF GENUS. Body not elongate, very wide at humerus; eyes more or less swollen, mesotibiae straight or feebly bent.

DESCRIPTION OF GENUS. Length from 3.2 to 4.5 mm.; width from 1.4 to 2.2 mm.

HEAD slightly wider than length. Vertex finely granulose with a deep median sulcus. Frontal carina feeble and joins clypeal base. Antennae varies in length. Clypeus feebly transverse; surface varies from shining, impunctate to microgranulose. Mandibles robust, apices varies. PRONOTUM transverse; lateral margins obtusely subangulate at middle and feebly narrowing towards apex and obliquely more so towards base, dorsum transversely convex, posterior depression may be present or absent. ELYTRA elongate-ovate; apices con-

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[3] This genus is named after my mother, the late Mrs. Sumitra G. Butte.

[4] Sanskrit origin, "good friend."

jointly distinctly rounded; each elytron with eight, at the extreme base with nine rows of punctures; each elytron tricostate; outer margin may be serrulate or absent.

MALE GENITALIA. Aedeagus moderately sclerotized and showing considerable curvature from below. Basal foramen fairly large with postero-ventral border prominent and subtriangular; antero-dorsal wall of foramen from rectate to feebly convex; its shape and width varies. Median lobe tapering distally to acute or subacute point. Apical orifice fairly large and U-shaped. Apical hood large and varies in shape; lateral plates large and regular. Parameses elongate, lateral sides gradually narrowing to acute apex. Strut keeled, and varies in length and shape. Flagellum feeble and irregular. Spiculum generally U-shaped.

SPECIES INCLUDED. The Junk Catalogue (Uhmann, 1957 and 1964) has listed 56 species in *Anoplitis* Kirby. One species, *Odontota gracilis* Horn (1883) should be transferred to *Anisostena* Weise (1910), because its characteristics are similar to that genus. The remaining 55 species are now transferred to *Sumitrosis* Butte (1968a). All names previously designated therefore represent new combination.

DISTRIBUTION. The *Sumitrosis* is represented in America North of Mexico by six species: These are *S. ancoroides* (Schaeffer); *S.* **arnetti** a new species; *S. inaequalis* (Weber); *S. lateritia* (Smith); *S. pallescens* (Baly), a new record in the United States; and *S. rosea* (Weber).

CANADA, UNITED STATES, MEXICO, BRITISH WEST INDIES, GUATEMALA, NICARAGUA, COSTA RICA, PANAMA, COLOMBIA, SURINAM, FRENCH GUIANA, BRAZIL, PERU, BOLIVIA, PARAGUAY, ARGENTINA.

KEY TO THE SPECIES OF *SUMITROSIS* OF NORTH AMERICA

1. Antennae pale yellow; postero-lateral angles of elytra distinctly angulate, third costa strongly explanate at apex — *rosea* (Weber)
Antennae piceous; postero-lateral angles of elytra evenly rounded, third costa not as above — 2
2(1). Elytra uniformly rubescent — *lateritia* (Smith)
Elytra variably maculate with piceous or picinus spots — 3
3(2). Clypeus moderately convex, and strongly transversely elevated at the base, surface opaque, micro-granulose with distinct carinae along lateral margin and base (Fig. 8) — 4
Clypeus feebly convex, and not transversely elevated at the base, surface shining, impunctate, and without distinct carinae along lateral margin and base (Fig. 9) — **arnetti**, n. sp.
4(3). Pronotum entirely pale yellow — *pallescens* (Baly)
Pronotum variably maculate with black vittae, ground color testaceous — 5
5(4). Elytra parallel, not wider at apex; sutural strip picinus from scutellum to about middle of the elytra — *ancoroides* (Schaeffer)
Elytra gradually wider behind, somewhat expanded at apex; sutural strip not marked as above — *inaequalis* (Weber)

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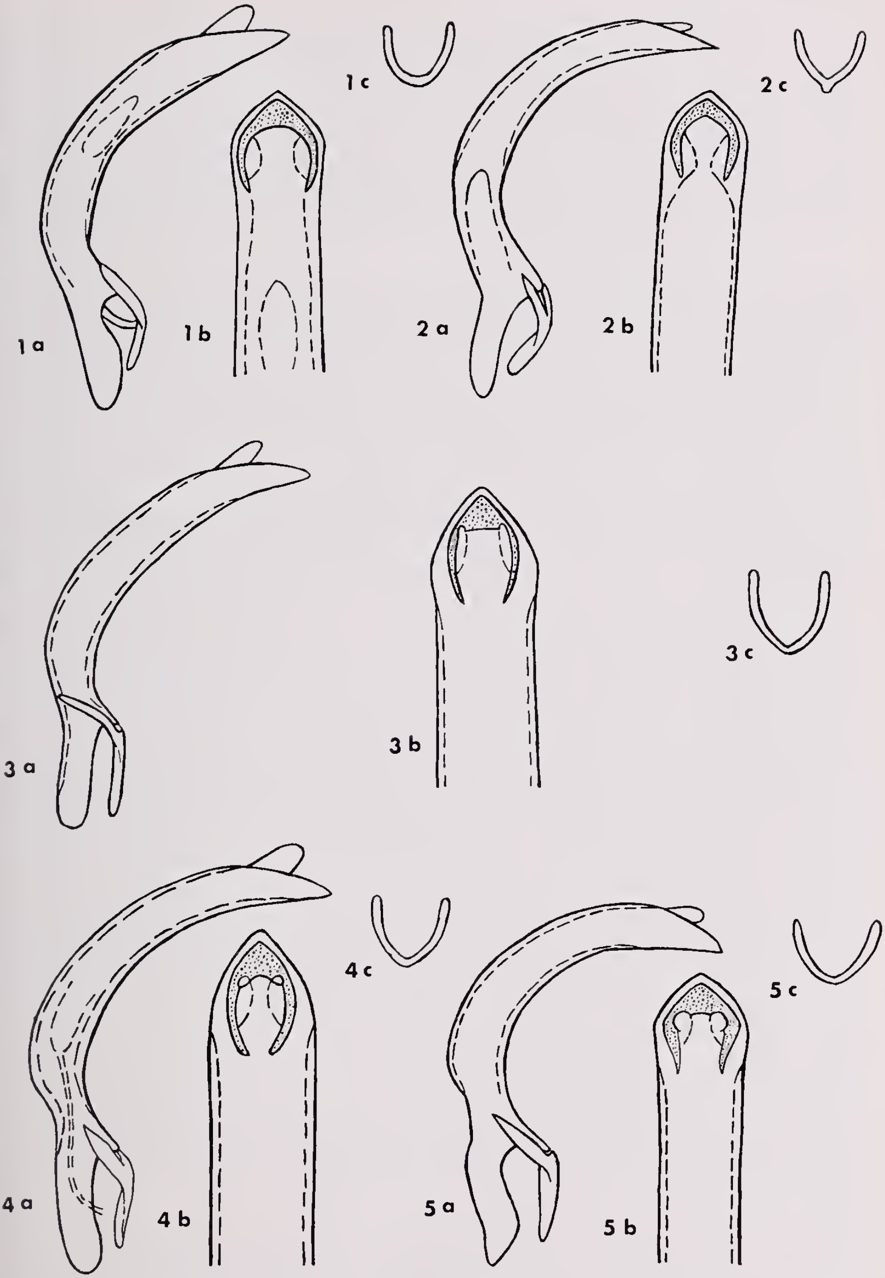
FIGS. 1–5. Drawings of the genitalia of the species of *Sumitrosis*. Similar letters designate corresponding parts in the different species: a, lateral or slightly dorso-lateral view of the



aedeagus and tegmen; b, dorsal or dorsocaudal view of aedeagus; c, dorsal or dorsocaudal view of speculum gastrale. Figs. 1a, b, c, *S. rosea*; Figs. 2a, b, c, *S.* **arnetti**; Figs. 3a, b, c, *S. pallescens*; Figs. 4a, b, c, *S. ancoroides*; Figs. 5a, b, c, *S. inaequalis.*

1. **Sumitrosis rosea** (Weber, 1801), new combination

(Figs. 1, a, b, c; and Fig. 6)

Hispa rosea Weber, 1801:66. (Location of type: Unknown to me).

TYPE LOCALITY. America.

Hispa philemon Newman, 1838:390. (Location of type: probably in the British Museum of Nat. Hist., London; or Hope Museum of Oxford, England.)

TYPE LOCALITY. Pennsylvania.

Odontota philemon (Newman), Crotch, 1873: 81, (Synonymized).

Uroplata philemon (Newman), Gemninger and Harold, 1874: 3612.

Anoplitis rosea (Weber) Chapuis, 1875: 317; Weise, 1911 (a): 23; 1911 (b): 34; Leng, 1920: 303; Schaeffer, 1933: 104; Uhmann, 1935: 232, 234; 1947: 118; Wilcox, 1954: 470; Uhmann, 1957: 80; 1964: 416.

Chalepus roseus (Weber), Baly, 1885: 49, 58.

DIAGNOSTIC FEATURES. This species resembles *S. inaequalis* in habitus, but it may be readily separated from the latter by the presence of following characteristics:

Antennae always pale. Apical angles of elytra distinctly angulate; third costa strongly explanate near apex.

DESCRIPTION OF SPECIES. Arizona, Pima Co., Santa Rita Mountains, October 5, 1936, Bryant, (CAS).

Total length 4.2 mm.; width 1.6 mm.

HEAD length/width ratio, 0.55. Vertex with a median sulcus and a small indistinct indentation on either side near eyes. Antennae 1.3 mm. in length; segments 2–6 robust; 2nd segment about .5 times shorter than 1st and 3rd; 3rd segment length/width ratio, 1.33. Clypeus moderately convex; surface opaque, micro-granulose and transverse carina present near the antennal base. Mandibles distinctly tridentate. Eye width subequal to interocular distance and smaller than clypeus. PRONOTUM length 0.7 mm.; width 0.9 mm.; widest at center; dorsum transversely convex and no traces of posterior depression; surface orbiculo-foveolate, interstices subcristate; medial line absent. ELYTRA oblong, length 2.7 mm.; lateral margins slightly dilated apically, and hinder angle angulate; sides and apex rather coarsely serrulate; third costa strongly explanate, and feebly serrulate at apical angle.

COLOR. Similar in color pattern to *S. inaequalis* (Weber), except the antennae which are always pale yellow.

MALE GENITALIA. Anterodorsal wall of foramen rectate and running into a feeble depression at one-fourth from base (Fig. 1a). Median lobe tapering distally to acute point (Fig. 1b). Apical hood subacute towards apex. Tegmen U-shaped. Strute enlongate and feebly keeled. Spiculum as shown in fig. 1c.

FEMALE. Indistinguishable from male except by dissection.

BIOLOGY. Wilcox (1954), has reported that host plants are Composits. Following information is taken from the labels: "on Locust"; "on Wild Sweet potato"; "reared from *chenopodium album* L." which is commonly known as Lambs-quarters (Chenopodiaceae).

LARVAE. Unknown.

VARIATION AND DISCUSSION. The size variations are as follows: total length 3.3–4.5 mm.; elytral length 2.5–3.5 mm.; elytral width 1.5–2.2 mm.

There are variations in the length and width of the 3rd antennal segment. The length and width is subequal in the North eastern species, it is wider than its length in the South east species, it is longer than its width in the South west species. The interocular distance is wider in North eastern species than Southeast species.

This species is extremely variable in color. The head from pale yellow to testaceous. Pronotum often pale, usually more or less maculate with piceous. The elytra sometimes pale yellow or testaceous with slight traces of black markings resembling in this respect with *S.* **arnetti** n. sp. and *S. inaequalis* (Weber), or the surface may be black with a few indistinct yellow spots and because of this color variation, *philemon* (Newman) has been synonymized with *rosea* (Weber), by Crotch (1873).

Distribution. The general distribution of *S. rosea* (Weber) is indicated in Fig. 6. This species is known from Canada southward to Florida and westward to Arizona. It has been collected from middle of May to middle of October, but mostly in June and July.

SPECIMENS EXAMINED. 123; *CANADA*: ONTARIO: Trenton, 2. (CNC). MANITOBA: Aweme, N. Criddle, May 24, 1922, 1. (CNC). *UNITED STATES*: NEW YORK: Wyoming Co., Portageville, May 30, 1888, E. P. V. Collector, 1, (CAS). Erie Co., Lancaster, E. P. V. Coll., 1, (CAS). Suffolk Co., Cold Spring Harb., July 30, 1922, H. M. Parshley, 1, (CAS). No further data, 1, (AMNH). NEW JERSEY: Warren Co., Phillipsburg, June 14, 1914, J. W. Green, 14, (CAS). Mercer Co., Trenton, August, 1905, H. B. Weiss, 3, (AMNH); Mercerville, August 24, 1910, 2, (AMNH). Hornerstown, May 14, 1910, 1, (AMNH). PENNSYLVANIA: Northampton Co., Windgap, July 7, 1936, J. W. Green, 1, (CAS). Clearfield Co., Phillipsburg, May 15, 1921, L. S. Slevin Collection, 2, (CAS). Dauphin Co., August 20, 1928, J. N. Knull, 2, (CAS). Hummerstown, June 2, 1920, J. N. Knull, 2, (CAS). MARYLAND: Baltimore Co., Baltimore, June 2, 1909, F. E. Blaisdell, 28, (CAS); Sparrows Pt., July 3, 1932, J. W. Green, 1, (CAS). Plummers, 1–V-1930, F. E. Blaisdell, 6, (CAS). NORTH CAROLINA: Buncombe Co., Black Mts., V-16-, 1, (AMNH). FLORIDA: Lake Co., Eustis, 4-6-1913, W.S.B., 2, (PUL). Enterprise, June 16, Hubbard and Schwarz, 3, (USNM). TENNESSEE: No further data, A. Fenyes collection, 1, (CAS). INDIANA: Gibson Co., Oct. 22, 1935, Montgomery, 13, on Locust, (PUL). Perry Co., May 21, 1908, W. S. B., 1, (PUL). Marion Co., May 17, 1902, W.S.B., 1; August 31, 1920, W.S.B., 2, (PUL). Morgan Co., June 28, 1932, Musgrave, 1, on wild sweet potato, (PUL). Lawrence Co., Bedford, July 26, 1932, G. Edw. Marshall, 1, reared from *Chinopodium allium*, (PUL). KANSAS: Douglas Co., Lawrence, June 1, 1922, C. H. Curran, 1, (CAS), May 20, 1951, J. G. Rozen, 1, (UCB). Ouga, May 19, 1923, Crevecoeur, 2, (CAS). No further data, Ashton collection, 2, (PUL). ARIZONA: Pima Co., Madero Cyn., Santa Rita Mts., October 18, 1936, E. P. Van Duzee, 5, (CAS); October 5, 1936, Bryant, 25, (CAS); Subbard and Schwarz, 2, (USNM). Cochise Co., Cave Crk., Chiricahua Mts., June 20, 1932, J. O. Martin, 8, (CAS); Portal, June 1, 1952, M. Casier, W. Gertach, R. Schrammel, 1, (AMNH); Huachuca Mts., July, 1936, E. S. Ross, 2, (CAS); Miller Cyn., May 12, 1932, J. O. Martin, 1, (CAS); Ramsay Canyon, July 16, 1948, C. and P. Vaurie, 1, (AMNH).

2. **Sumitrosis lateritia**[5, 6] (Smith, 1886), new combination

(Fig. 6)

Odontota lateritia Smith, 1886: 95. (Location of type: probably in the U. S. National Museum, Washington, D. C., or in the Rutgers College Collection, New Brunswick, New Jersey).

TYPE LOCALITY. Arizona, U. S. A.

Anoplitis lateritia (Smith), Weise, 1911(a): 22; 1911(b): 33; Uhmann, 1957: 79.

DIAGNOSTIC FEATURES. This species may be easily separated from other species of this genus by the presence of uniform rubescent color of the elytra.

DESCRIPTION OF SPECIES. Arizona. Total length 6 mm.

HEAD vertex with a median sulcus. PRONOTUM slightly wider at base, sides arcuate; dorsum transversely convex with a shallow posterior depression; surface coarsely and densely foveolate; medial line present. ELYTRA parallel sided; lateral margins distinctly serrulate.

COLOR. Antennae black. Dorsum uniformly rubescent. Head ventrally red else black. Prosternum red, else black; fore-legs rufo-piceous; middle-legs piceous; hind-legs black.

MALE GENITALIA. Unknown.

FEMALE. Unknown.

BIOLOGY. Unknown.

LARVAE. Unknown.

DISCUSSION. Smith (1886) has described this species from one specimen from Arizona. Dorsum rubescent color is the characteristic of this species.

DISTRIBUTION. The distribution of *Sumitrosis lateritia* is indicated in fig. 6., and it is known from Arizona.

SPECIMENS EXAMINED. Nil.

3. *Sumitrosis* **arnetti**, new species

(Figs. 2, a, b, c; 6; and 9)

DIAGNOSTIC FEATURES. This species resembles *S. inequalis* in habitus, but it may be readily separated from the latter by the presence of following characteristics:

Clypeus feebly convex, shining, impunctate and without transverse carina near antennal base (Fig. 9); mandibles tridentate.

This species is named in honor of Dr. Ross H. Arnett, Jr., with whom the writer, as a student, spent a never-to-be-forgotten summer collecting insects in the type locality.

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[5] The description of *lateritia* is taken from the literature.

[6] Dr. Sanderson has informed me in a personal communication that "I am in the process of completing a report on the Hispinae of Illinois which includes . . . a new genus for *Odontota lateritia* Smith." I have not seen any material on this species, therefore, for the present I am retaining *lateritia* (Smith) in this genus until the opportunity to study the material is presented.

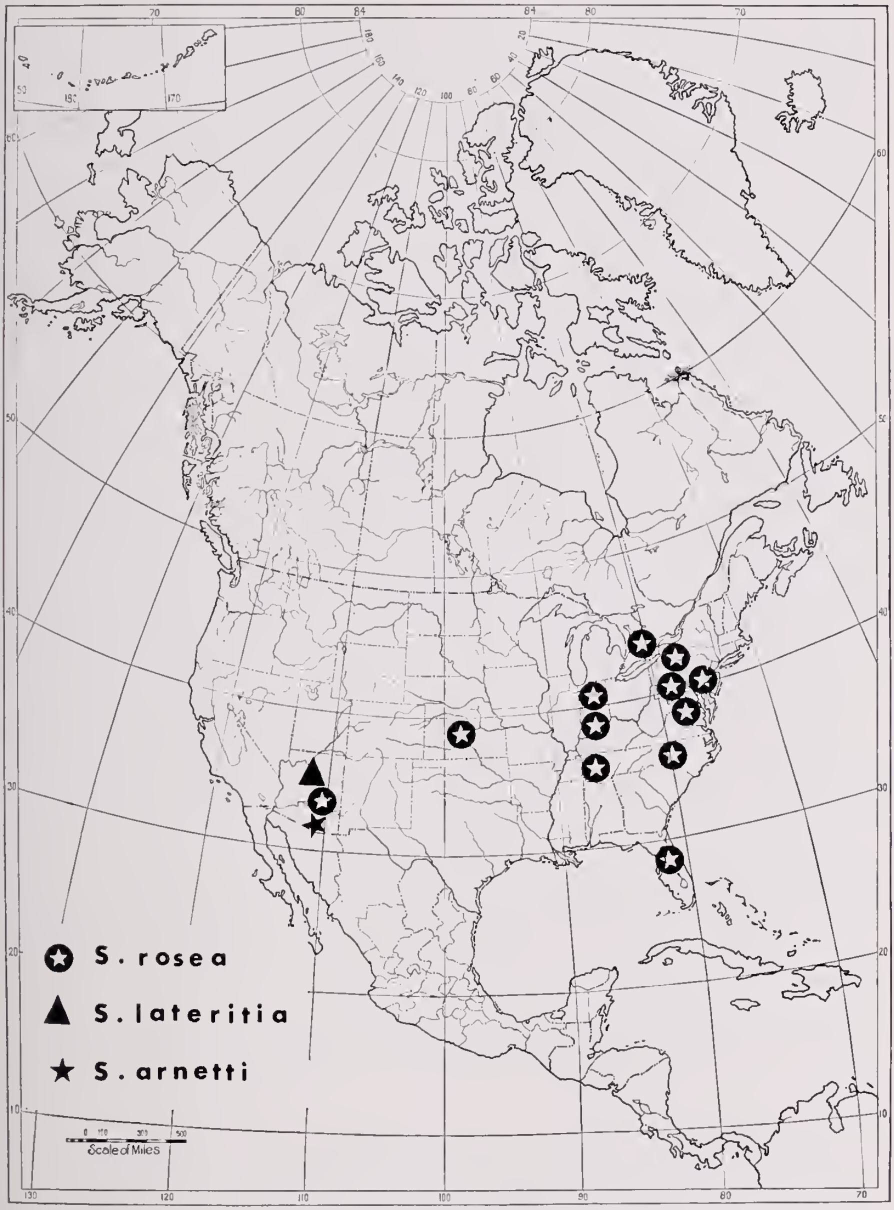


FIG. 6. Distribution of the species of *Sumitrosis, rosea, lateritia,* **arnetti**.

HOLOTYPE. ARIZONA, Santa Cruz Co., west of Nogales, Bear Canyon, June 23, 1948, Down, Lindsey and Barber collectors; male; to be deposited in the American Museum of Natural History, New York.

DESCRIPTION OF THE HOLOTYPE. Length 4.2 mm.; width 1.7 mm.

HEAD length/width ratio, 0.65; vertex with a deep median sulcus and a small indentation on either side near eyes. Antennae 1.5 mm. in length; segments 2–6 slender and irregularly sulcate and carinate; 1st and 2nd segment subequal in length. 3rd about 1.5 times longer than 2nd, and its length/width ratio, 1.6. Clypeus feebly convex, shining, impunctate, and without transverse carina near antennal base. Mandibles distinctly tridentate. Eye width wider than interocular distance and smaller than clypeus. PRONOTUM length 0.8 mm.; width 1.0 mm.; widest at one-third from base; dorsum transversely convex, feebly depressed with antescutellar transverse ridge; surface orbiculo-foveolate, interstices subcristate; medial line distinctly visible. Elytra parallel sided; length 3.0 mm.; lateral and apical margins serrulate; third costa apically broadly arcuate towards suture and connate to apex of 2nd and 1st costae.

COLOR. Antennae black. Basal and apical margins of pronotum, scutellum, and base of elytra ivory white. Lateral margins of pronotum with a narrow, irregular black vitta; a somewhat 'V' shaped piceous evanescent design at center of the disc. Elytral suture, costae and lateral margins marked with black and white as follows: Elytral suture piceous from the scutellum to about one-third of elytral length, and then small portion of apical end, in between one piceous spot. Three piceous longitudinal marks on 1st costa, alternating white and black marking on 2nd costae are so disposed that the black of the 2nd costa is mostly opposite to white of the 1st costa. A large longitudinal marking on the lateral margin and one at the outer apical angle, involving the 3rd costa. A piceous spot on humeri. Venter piceous. Legs pale yellow except the apical end of last tarsi tinged with black.

MALE GENITALIA. Antero-dorsal wall of foramen feebly convex and running into a depression at one-fifth from base (fig. 2a). Median lobe tapering distally to acute point (fig. 2b). Apical hood subacute towards apex. Tegmen V-shaped. Strut short and strongly keeled. Spiculum U-shaped (fig. 2c).

ALLOTYPE. Same data as holotype. Female. Length 4.2 mm.; width 1.7 mm. Agrees with the holotype in all essential respects except the fifth visible sternum with a small irregular patch of setae on either side of central elevation. To be deposited in the California Academy of Sciences, San Francisco.

PARATYPES. 10: Paratypes are designated from the following localities: ARIZONA, Santa Cruz Co., West of Nogales, Bear Canyon, June 23, 1948, 6, Down, Lindsey and Barber, (type locality), (USNM); near Nogales, Patagonia, June 12, 1949, 1, T. Allen, (USNM); Pena Blanca, September 14, 1947, 3, (AMNH).

BIOLOGY. The following information is taken from the specimen labels. "on *Baccharis* sp."; "on *Zexmenia* sp." These plants belong to the family Compositae.

LARVAE. Unknown

VARIATION AND DISCUSSION. The size variations are as follows: total length 3.8–4.2 mm.; elytral length 2.8–3.0 mm.; elytral width 1.5–1.7 mm.

The close relationship between *S.* **arnetti**, n. sp., and *S. inaequalis* (Weber), is indicated in their similar appearance of color, size and shape. However, these two species are easily separated by the following sets of characters in which those of **arnetti** are given first and those for *inaequalis* second: Clypeus feebly convex and not transversely elevated at the base; clypeus moderately convex

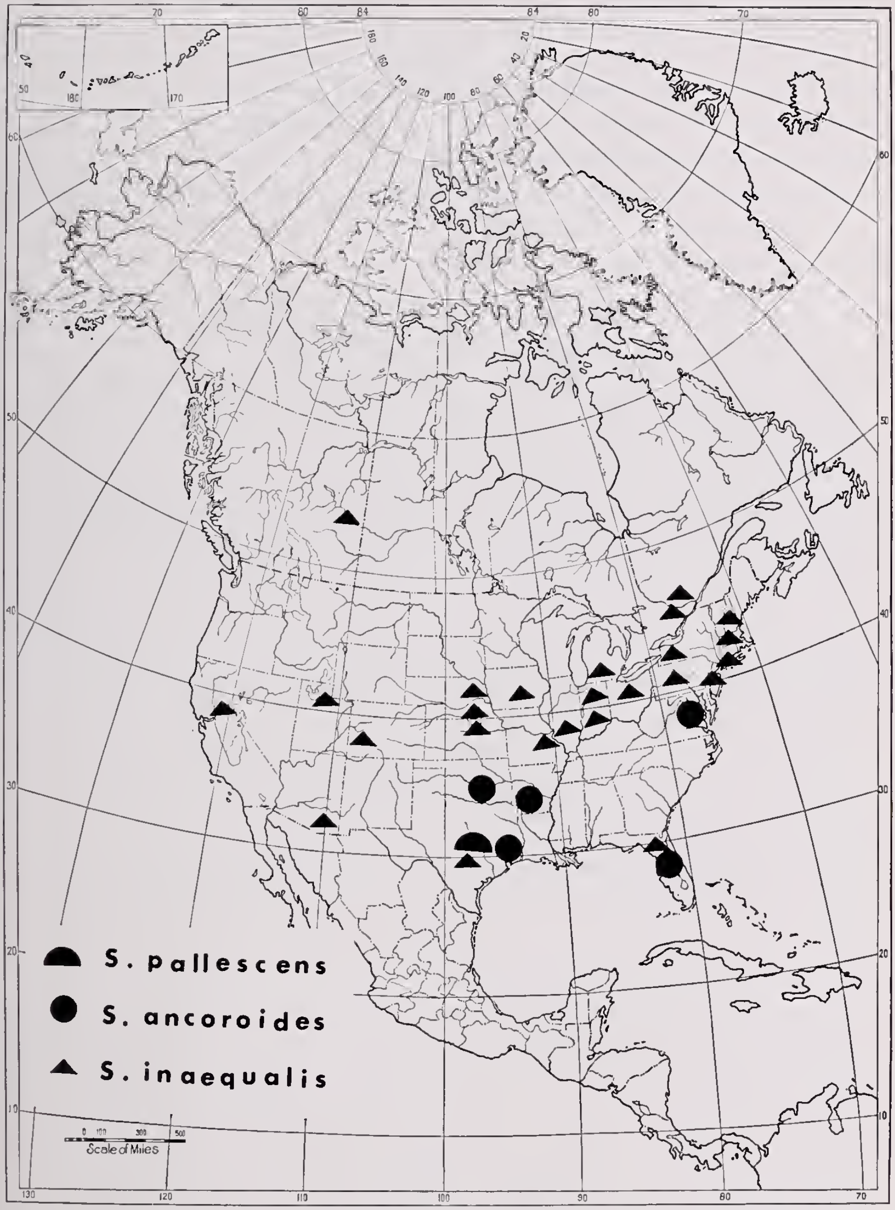


FIG. 7. Distribution of the remaining species of *Sumitrosis, pallescens, ancoroides, inaequalis.*

and strongly transversely elevated at the base. Clypeal surface shining, impunctate and without transverse carina at the base; clypeal surface opaque, microgranulose with transverse carina at the base. 3rd antennal segment distinctly longer than 2nd; 3rd antennal segment subequal to 2nd. Apical hood of aedeagus subacute towards apex; apical hood of aedeagus truncate towards apex. Strut short; strut elongate.

DISTRIBUTION. The general distribution of *S.* **arnetti**, n. sp. is indicated in fig. 6. This species is known from Arizona, and it has been collected from middle of June to middle of September.

4. **Sumitrosis pallescens** (Baly, 1885), new combination

(Figs. 3, a, b, c; and Fig. 7)

Chalepus pallescens Baly, 1885: 49, 56; Champion, 1894: 236. (Location of type: British Museum of Natural History, London, England)

TYPE LOCALITY. Bugaba, Panama.

Chalepus jansoni Baly, 1885: 49, 55; Champion, 1894: 236 (Synonymized). (Location of type: British Museum of Natural History, London, England).

TYPE LOCALITY. Chontales, Nicaragua.

Anoplitis jansoni (Baly), Weise, 1906: 238; 1911(a): 22; 1911(b): 34. Uhmann, 1930: 31, 162; 1935: 234; 1957: 79.

Anoplitis pallescens (Baly), Weise, 1906: 236; 1911(a): 23; 1911(b): 34; Uhmann, 1930: 246; 1935: 234; 1957: 79.

DIAGNOSTIC FEATURES. This species resembles *S. ancoroides* (Schaeffer) in habitus, but it may be readily separated from the latter by the presence of following characteristics:

Pronotum entirely pale yellow; elytra oblong, sutural strip is not picinus.

DESCRIPTION OF SPECIES. MALE. Texas, Leon Co., July 4, 1948, J. L. Ward, (USNM).

Total length 3.1 mm.; width 1.3 mm.

HEAD length/width ratio, 0.56. Vertex with a median sulcus. Antennae 1.0 mm. in length; segments 2–6 irregularly sulcate and feebly carinate; 1st and 3rd segment subequal in length; 2nd slightly smaller than 1st and 3rd segment. Clypeus distinctly convex; base subangulate and prominent; surface micro-granulose. Mandibles monodentate, apices obtuse. Eye width slightly larger than interocular distance and subequal with clypeus. PRONOTUM length 0.5 mm.; width 0.9 mm.; widest at one-third from base; dorsum transversely convex and no traces of posterior depression; surface coarsely and deeply foveopunctate, interstices subcristate. Medial line ill-defined. ELYTRA oblong, length 2.3 mm.; slightly arcuately broader apically; lateral and apical margins distinctly and irregularly serrulate.

COLOR. Antennae black. Dorsum uniformly pale yellow, except towards the apex of elytra a few small, ill-defined piceous spots, which form an irregular short fascia.

MALE GENITALIA. Anterodorsal wall of foramen feebly convex and running into a depression at one-fifth from base (Fig. 3a). Median lobe tapering distally to obtuse point (Fig. 3b). Apical hood truncate towards apex. Tegmen V-shaped. Strut elongate and feebly keeled. Spiculum U-shaped and symmetrical (Fig. 3c).

FEMALE. The 5th abdominal sternum with a large, irregular patch of setae on central elevation, whereas in the male it is hardly perceptible.

BIOLOGY. The following information is taken from the specimen labels. "Reared from *Cassia fasciculata* Michx." This plant is commonly known as Partridge-Pea (Leguminosae).

LARVAE. Unknown.

VARIATION. The size variations are as follows: total length 3.1–3.5 mm.; elytral length 2.3–2.5 mm.; elytral width 1.2–1.5 mm. In some specimens the elytra is uniformly pale yellow, except a small piceous spot at the center of the first costa.

DISTRIBUTION. The general distribution of *S. pallescens* (Baly) is indicated in Fig. 7, and it is a new record for the United States. This species has previously been recorded from Panama, México, Nicaragua, and Costa Rica. Six adults, agreeing with the description of *pallescens* Baly, (1885: 56), have been studied from Leon Co., Texas. They were collected from early June to middle of August.

SPECIMENS EXAMINED. 6: 3 males; 3 females. TEXAS, Leon Co., July 4, 1948, J. L. Ward, 2 males, 1 female, (USNM); August 16, 1948, J. L. Ward, 1 male, 2 females, (USNM).

5. **Sumitrosis ancoroides** (Schaeffer), new combination
(Figs. 4, a, b, c; and Fig. 7)

Anoplitis ancoroides Schaeffer, 1933: 105; Blackwelder, 1939: 64, Uhmann, 1957: 76. (Location of type: U. S. National Museum, Washington, D. C.). TYPE LOCALITY. Merchantville, New Jersey.

DIAGNOSTIC FEATURES. This species resembles *S. inaequalis* (Weber) in habitus, but it may be readily separated from the latter by the presence of following characteristics:

Elytra parallel, not wider at apex; sutural strip picinus from scutellum to about middle of the elytra.

DESCRIPTION OF SPECIES. FEMALE. Virginia, Fairfax Co., Vienna, July 25, 1942, J. C. Bridwell, (USNM).

Total length 3.3 mm.; width 1.4 mm.; subcuneiform.

HEAD length/width ratio, 0.583. Vertex with a median sulcus. Antennae 1.1 mm. in length; segments 3–6 irregularly sulcate and feebly carinate; 1st and 2nd segment subequal in length; 3rd about 0.5 times longer than 2nd. Clypeus distinctly convex; base subangulate and prominent; surface micro-granulos. Mandibles monodentate, apices obtuse. Eye width subequal to clypeus and interocular distance. PRONOTUM length 0.6 mm.; width 0.9 mm.;

widest at one-third from base; dorsum transversely convex and no traces of posterior depression; surface coarsely and deeply foveo-punctate, interstices cristate. Medial line ill-defined. ELYTRA parallel sided and not wider apically; lateral and apical margins very indistinctly and distantly serrulate.

COLOR. Antennae black. Lateral margins of pronotum with a narrow, irregular black vitta; a short, oblique, obscure black line on each side of the medial line forming a somewhat 'V' shaped design. Elytral suture bluish black from the scutellum to about middle and thence dilated at its apex on each side into a short apical branch, reaching to and involving the first costa; slightly above this branch on the second costa is a small spot which is more or less connected with apical branch producing a somewhat anchor-like design. Near apex there are three small black spots which involves the 2nd, 3rd costa and lateral margins; and below these from the first costa to the suture an oblique black line. Venter black or piceous. Legs pale with apical tarsus black near claws.

MALE GENITALIA. Anterodorsal wall of foramen feebly convex and runs into a depression at one-fourth from base (Fig 4a). Median lobe tapering distally to acute point (Fig. 4b). Apical hood as shown in Fig. 4b. Tegmen V-shaped. Strut elongate and feebly keeled. Spiculum U-shaped and symmetrical (Fig. 4c).

FEMALE. Indistinguishable from male except by dissection.

BIOLOGY. The following information is taken from the specimen labels. "Reared on *strophostyles umbellata* (Muhl.) by J. C. Bridwell in June 10–24, 1942." This plant is commonly known as Wild-Beans (Fabaceae).

LARVAE. Unknown.

VARIATION. The size variations are as follows: total length 2.9–3.7 mm.; elytral length 2.2–2.7 mm.; elytral width 1.3–1.5 mm.

In some specimens from Florida, Arkansas, and Texas, the V-shaped black design on the pronotum is absent.

DISTRIBUTION. The general distribution of *S. ancoroides* (Schaeffer) is indicated in fig. 7. This species is known from Virginia southward to Florida and westward to Texas. It has been collected from June to middle of August, but mostly in July.

SPECIMENS EXAMINED. 21: VIRGINIA, Fairfax Co., Vienna, July 10–25, 1942, J. C. Bridwell, 3, reared on *Strophostyles umbellata* (Muhl.), (USNM). FLORIDA, Hillsborough Co., St. Petersburg, August 18–24, 1931, Bradley and Knorr, 1, (CU). ARKANSAS, Hempstead Co., Hope, July 13, 1925, L. Knobel, 1, (CU). OKLAHOMA, Marshall Co., Lake Texoma, 2 mi. east of Willis, June and July 1965, R. M. Bohart, 2, (UNC). TEXAS, Harris Co., Seabrook, August 6, J. W. Green, 5, (CAS); August 9, H. A. Wenzel, 1, (CAS). Harrisburg, July 31, J. W. Green, 8, (CAS).

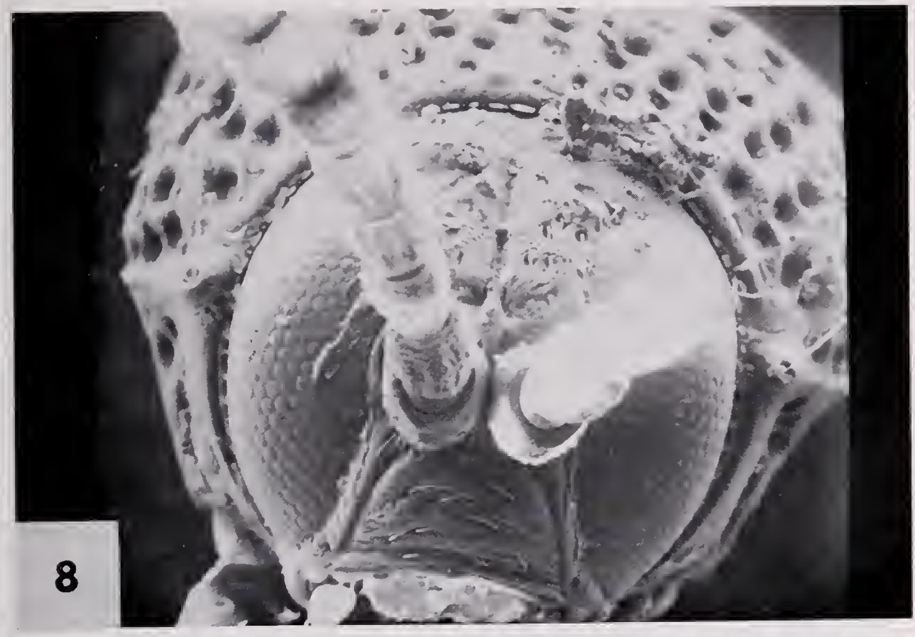
6. **Sumitrosis inaequalis** (Weber), new combination.

(Figs. 5, a, b, c; 7; and 8)

Hispa inaequalis Weber, 1801: 65. (Location of type: unknown to me.)

TYPE LOCALITY. 'North America'

Hispa suturalis Fabricius, 1801: 63; Olivier, 1808: 777; Crotch, 1873: 81, (Synonymized); Chapuis, 1875: 317. (Location of type: probably in the British Museum of Natural History, London; or Hope Museum of Oxford, England; or in the Zoologisch Museum of Kopenhagen, Denmark).



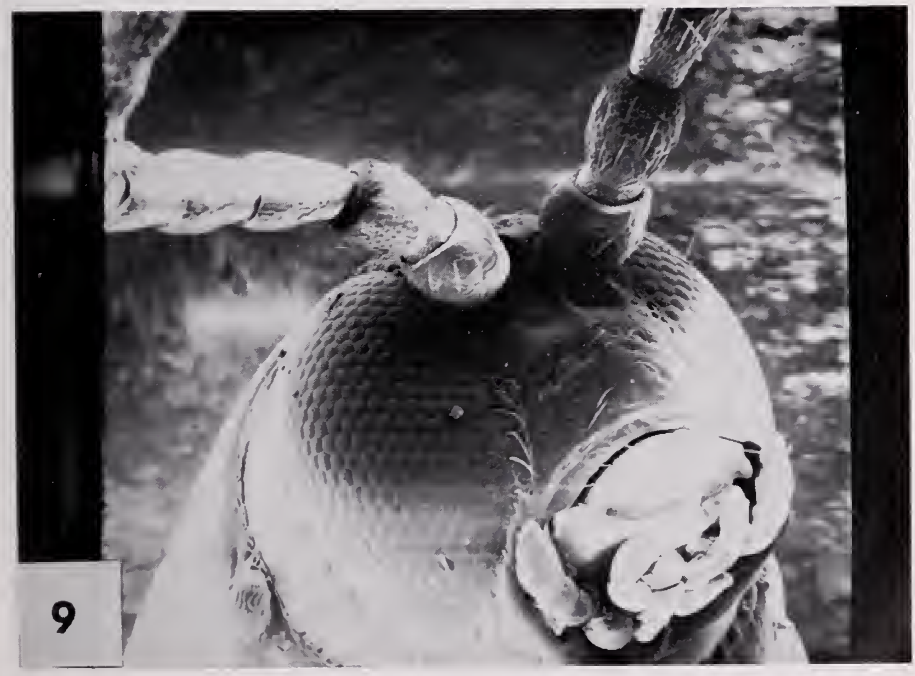


FIG. 8. Clypeus of *S. inaequalis*. × 100.

FIG. 9. Clypeus of *S.* **arnetti**, n. sp. × 100.

TYPE LOCALITY. 'Carolina,' U. S. A.

Hispa obsoleta Say, 1823: 432; Crotch, 1873: 81, (Synonymized); Leconte, 1891: 205. (Location of type: unknown to me.)

TYPE LOCALITY. 'United States of America.'

Hispa pallida Say, 1823: 432; Crotch, 1873: 81, (Synonymized); Leconte, 1891: 205. (Location of type: unknown to me.)

TYPE LOCALITY. U. S. A.

Hispa flavipes Germar, 1824: 529; Crotch, 1873: 81, (Synonymized); Leconte, 1875: 206. (Location of type: probably in the Zoologisch Museum at Berlin or in the Deutch. Entom. Institute at Berlin.)

Hispa baucis Newman, 1838: 390; 1841: 77; Crotch, 1873: 81, (Synonymized). (Location of type: Either in the British Museum (N. H.) or in the Hope Museum of Oxford, England.)

TYPE LOCALITY. Trenton Falls?

Odontota inaequalis (Weber), Crotch, 1873: 81.

Odontota nervosa Horn (not Panzer), 1883: 295, 297, Uhmann, 1964: 415, (Synonymized). (Location of type: Academy of Natural Sciences of Philadelphia).

TYPE LOCALITY. "Eastern U. S. and Arizona."

Chalepus inaequalis (Weber), Baly, 1885: 58.

Anoplitis inaequalis (Weber), Weise, 1911(a): 22; 1911(b): 34; Leng, 1920: 303; Weise, 1921: 275; Blatchley, 1924: 43; Needham, Frost and Tothill, 1928: 199; Uhmann, 1935: 234; Maulik, 1937: 136; Uhmann, 1957: 78; 1964: 415.

DIAGNOSTIC FEATURES. This species resembles *S.* **arnetti**, n. sp. in habitus, but it may be readily separated from the latter by the presence of following characteristics:

Clypeus moderately convex, and strongly transversely elevated at base, surface opaque, micro-granulose with transverse carina at the base.

DESCRIPTION OF SPECIES. MALE. CANADA. Quebec, Duparquet, 9-VII-1941, G. Stace Smith, (CAS).

Total length 4.2 mm.; width 1.8 mm.

HEAD length/width ratio, 0.55. Vertex with a median sulcus and a small indentation of either side near eyes. Antennae 1.4 mm. in length; segments 2–6 robust and feebly sulcate; 2nd segment about 0.5 times longer than 1st; 3rd about .25 times longer than 2nd and its length/width ratio, 1.25. Clypeus moderately convex, surface opaque and micro-granulose. Mandibles monodentate, cutting edges broad and sharp. Eye width subequal to interocular distance and clypeus.

PRONOTUM length 0.8 mm.; width 1.0 mm.; widest at center; dorsum transversely convex, feebly depressed posteriorly; surface orbiculo-foveorate, interstices subcristate; medial line indistintly visible.

elytra length 3.1 mm.; elongatequadrate, slightly arcuately broader apically; lateral and apical margins feebly serrulate.

color. Head testaceous—Antennae black. Lateral margins of pronotum with a narrow, irregular black vitta; an obscure black line on either side of the medial line. Elytral suture, costae and lateral margins marked with black and white as follows: three piceous longitudinal marks on elytral suture, alternating from basal black; similar alternating white and black marking on 1st and 2nd costae are so disposed that the black of the 1st costa is mostly opposite to white of the sutural line on 2nd costa. A large longitudinal marking on the lateral margin and one at the outer apical angle, involving the 3rd costa. A piceous spot on humeri. Venter piceous. Legs testaceous.

male genitalia. Antero-dorsal wall of foramen feebly convex and running into a depression at about one-fourth from base (Fig. 5a). Median lobe tapering distally to subacute point (Fig. 5b). Apical hood truncate towards apex. Tegmen V-shaped. Strut elongate and keeled. Spiculum U-shaped (Fig. 5c).

female. Indistinguishable from male except by dissection.

biology. On May 27, 1968, I have collected nearly 25 specimens of this species on *Solidago graminifolia* (L.) and *Solidago canadensis* (L.), near Glen Head, Nassau Co., New York. Most of the specimens were copulating. Needham, Frost and Tothill (1928), and Maulik (1937) has reported the following foodplants for this species: White Oak (Fagaceae); White snake root, *Eupatorium urticifolium* Banks (Compositae); Wild sensitive plant, *Casssia nictitans* Linn. (Leguminosae).

larvae. Unknown.

variation. The size variations are as follows: total length 3.4–4.2 mm.; elytral length 2.6–3.1 mm.; elytral width 1.4–1.8 mm.

This species is extremely variable in color. The head from piceous to testaceous. Pronotum often pale, usually more or less maculate with piceous. The elytra sometimes pale yellow with slight traces of black markings resembling in this respect with *S.* **arnetti**, n. sp. and *S. rosea* (Weber), or the surface may be black with a few indistinct yellow spots. The great number of variations have given this species a large synonymy.

distribution. The distribution of *S. inaequalis* (Weber) is indicated in Fig. 7. This species is known in the east from southern Canada to Florida and in the west from Alberta to California. It has been collected from late May to early November, mostly in June and July.

specimens examined. 334: *CANADA*: QUEBEC, Duparquet, July 24, 1941, G. Stace Smith, 26, (CAS); Aylmer, June 19, 1936, G. Stace Smith, 1, (CAS). ONTARIO, Sudbury, 1892, R. M. White, 2, (CNC); Ottawa, June 5, 1928, W. J. Brown, 3, (CNC); Leamington, June 14, 1940, W. J. Brown, 14 (CNC). ALBERTA, Edmonton, August 24, 1922, F. S. Carr, 1, (CAS). *UNITED STATES*: NEW HAMPSHIRE, Grafton Co., Franconia, Mrs. A. T. Slosson, 2, (AMNH). Mt. Plst., July 1, (CAS). MASSACHUSETTS, Middlesex Co., Concord, June, A. Fenyes, 1, (CAS). Norfolk Co., Framingham, August 4, 1907, C. A. Frost, 3, (CAS). Mt. Toby, July 6, 1918, 5, (CAS). CONNECTICUT, New Haven Co., New Haven, Van Duzee, 7, (CAS). Middlesex Co., Cormwell, June 10, 1920, K. F. Chamberlain, 7, (CAS). Fairfield Co., New Canaan, June 12, 1954, M. Statham, 1, (CAS). Tolland Co., Storrs, June 5, 1955, P. D. Ashlock, 3, (UCB). NEW YORK, Eric Co., Colden, June 7, 1908, M. C. VanDuzee, 1, (CAS); Buffalo, May 24, 1908, M. C. VanDuzee, 3, (CAS); Angola, June 6, 1891, M. C. VanDuzee, 1, (CAS); Lancaster, June 28, 1908, M. C. VanDuzee, 1, (CAS). Putnam Co., Cold Spring Harbor, May 10, 1931, C. H. Curran, 2, (AMNH). Bronx Co., New Rochelle, May 12, 1945, L. Lacey, 8, (AMNH). Nassau Co., Glen Head, May 27, 1968, J. G. Butte, on *Solidago* spp., 25, (JGB). Richmond Co., Staten Island, Blaisdell, 4, (CAS). Co. undet., Concord, M. C. VanDuzee, 2, (CAS); DeBruce, August 23–26, 1942, 1, (AMNH); Pelham, June 2, 1930, L. Lacey, 6, (AMNH); North Bch., June 3, 1927, F. M. Schott, 1, (AMNH); Bear Mt., Oct. 5, 1947, J. G. Rozen, 2, (UCB). No further data, Van Dyke, 2, (CAS). NEW JERSEY, Warren Co., Phillipsburg, August 2, 1914, 5, (CAS). Bergen Co., Alpine, July 28, 1946, P. Vaurie, 3, (AMNH). Englewood, June 4, 1948, J. G. Rozen, 1, (UCB). Closter, July 2, 1948, J. G. Rozen, 1, (UCB). Morris Co., Chester, July, 1916, 1, (AMNH). Lahaway, May 30, 1916, Chris. E. Olsen, 2, (AMNH); Snake Hill, 1, (AMNH). PENNSYLVANIA, Northampton Co., Easton, June 20, 1915, J. W. Green, 7, (CAS); Wind Gap, June 8, 1934, J W. Green, 1, (CAS). Snyder Co., Hummelstown, J. N. Knull, 1, (CAS). Clearfield Co., Philipsburg, May 15, 1921, L. S. Slevin, 2, (CAS). Pike Co., Milford, May 30, 1941, B. Malkin, 1, (CNHM). Aspin, July 21, H. L. Chermock, 5, (CAS); Belfast, July 30, 1937, J. W. Green, 5, (CAS); Belfast, June 20, 1952, L. Lacey, 1, (AMNH). No further data, A. Fenyes collection, 2, (CAS). MARYLAND, Baltimore Co., Baltimore, June, 1902, Van Dyke, 4, (CAS). Co., undet., Plummers Island, May 25, 1918, Van Dyke, 12, (CAS); Springfield, July 7, 1903, F. Knab, on *Solidago*, 3, (USNM). VIRGINIA, No further data, Van Dyke, 2, (CAS). WEST VIRGINIA, Harrison Co., Fairmont, June 6–22, 1927, P. N. Musgrave, 3, (CAS). NORTH CAROLINA, Buncombe Co., Black Mts., July, 1902, Van Dyke, 19, (CAS). Gray Beard Mt., 4, (AMNH); Blue Ridge, July 20, 1951, Bryant, 1, (CAS); Linnville, July 16, 1951, Bryant, 1, (CAS). FLORIDA, No further data, Mrs. A. T. Slosson, 1, (AMNH). TENNESSEE, No further data, A. Fenyes collection, 1, (CAS). OHIO, Vinton Co., Lake Alma, W. C. Stehr, 2, (CAS). Cuyahoge Co., Bedford, May 19, 1945, J. C. Pallister, 1, (AMNH); Cleveland, May 19, 1945, J. C. Pallister, 2, (AMNH). MICHIGAN, Ingham Co., Williamston, July 16, 1944, B. Malkin, 1, (CNHM). Ag. coll. June 4, 1924, L. S. Slevin collection, 5, (CAS). INDIANA, Lake Co., May 29, 1903, W. W. B. 1, (PUL). Dubois Co., May 12, 1908, W. S. B., 1, (PUL). Spiner Co., May 24, 1908, W. S. B. 1, (PUL). Tippecanoe Co., Nov. 6, 1935, 4, (PUL). Morgan Co., May 29, 1932, Musgrave, 1, (PUL). Lawrence Co., August 24, 1932, L. I. Musgrave, 1, (PUL). Poscy Co., April 26, 1908, W. S. B., 1, (PUL). Marion Co., September 5, 1927, W. S. B., 2, (PUL). Kosciusko Co., June 25, 1904, W. S. B., 1, (PUL); May 21, 1933, Geo. E. Gould, 6, (PUL). ILLINOIS, St. Clair Co., Cahokia, G. W. Bock, 3, (CAS). Randolph Co., Evansville, June 12, 1913, Van Dyke, 1, (CAS). Co. undet., Edgebrock, June 3, 1921, L. S. Slevin, 1, (CAS). MISSOURI, St. Louis Co., St. Louis, May 29, 1898, G. W. Bock, 3, (CAS). Co. undet., Roaring River St. Park, June 15, 1954, G. W. Green, 1, (CAS). IOWA, Johnson Co., Iowa City, Wickham, 2, (CAS). NEBRASKA, Lancaster Co., Lincoln, May 30, 1909, F. H. Shoemaker, 1, (CAS). Douglas Co., Omaha, Mr. Childs Point, F. H. Shoemaker, 1, (CAS). KANSAS, Pottawatomie Co., Onaga, May 26, 1923, Crevecoeur, 5, (CAS); Van Dyke, 1, (CAS). TEXAS, Bexar Co., San Antonio, May, A. Penyes, 1, (CAS); July, 1942, E. S. Ross, 1, (CAS). Uvalde Co., Uvalde, June 14, 1932, J. O. Martin, 1, (CAS). Macdona, July, 1928, J. W. Green, 1, (CAS). ARIZONA, Pima Co., Sta. Rita Mts., June 16, 1933, Bryant, 1, (CAS). COLORADO, Co. undet., Peaceful Valley, 2, (AMNH); Twin Sisters, 1, (AMNH). No further data, 1, (AMNH). UTAH, Cache Co., Logan Cyn., June 18, 1960, G. F. Knowlton, 1, (UNC) Salt Lake Co., Salt Lake City, July 15, 1925, Van Dyke, 13, (CAS). CALIFORNIA, Placer Co., Dutch Flat, Nov. 6, 1908, G. R. Pilate, 1, (CAS).

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The Species of Black Flies Found in Colombia (Diptera: Simuliidae)[1]

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Abstract: The recent discovery of the first human case of onchocerciasis in Colombia has prompted this review of the entomological literature related to simuliid black flies in this country. Fifteen named species and two other forms distinguished by letters are recorded as occurring in Colombia. For each species published data on geographic distribution and hosts are given.

In the entomological literature the references to simuliids in Colombia are scarce despite the well known importance of this group of insects as pests of man and domestic animals and also as vectors or intermediate hosts of pathogenic organisms.

The discovery of the first human case of onchocerciasis in Colombia (Assís and Little, 1965) and the subsequent field work related to the finding of this simuliid borne disease have acted as incentives for publishing the present review. The principal objective of the following list has been to gather the scattered information on black fly species known to occur in Colombia as a basis for future studies.

1. *Simulium bicoloratum* Malloch, 1912.
TYPE LOCALITY: Río Charape, Perú.
SYNONYMS: *Ectemnaspis macca* Enderlein, 1933.
Simulium molli Vargas, 1943.

Enderlein described *E. macca* from Peruvian material with distribution to "Paso Quemado," Colombia, a place name I cannot locate. Vargas and Díaz (1953a) consider *E. macca* Enderlein and *Simulium molli* Vargas as synonyms of *S. bicoloratum* Malloch. This species has been also reported from Perú, Bolivia and Venezuela (Vargas and Díaz, 1951; Briceño and Ortiz, 1957).

2. *Simulium dinellii* (Joan) 1912.
TYPE LOCALITY: Alpachiri, Tucumán, Argentina.

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SYNONYMS: *Trichodagmia miniata* Enderlein, 1934.
Simulium martinezi Vargas, 1943.

The type material of *T. miniata* consists of two female specimens collected in "Tierra caliente," Colombia, by Thieme. This species was renamed by Vargas (1943) as *Simulium martinezi*. Wygodzinsky (1950) after comparison of the types concluded that both names are synonyms of *S. dinellii* (Joan). This black fly has been collected in Argentina (many localities), Bolivia, Brazil, Ecuador, Perú and Venezuela (Briceño and Ortiz, 1957). It is an important pest of man in northeastern Argentina (Wygodzinsky, 1950).

3. *Simulium exiguum* Roubaud, 1906.
TYPE LOCALITY: Alto Sarare, Estado Lara, Venezuela.

Vargas (1945) records this species as having been obtained at Restrepo, Departamento del Meta. In describing *S. gonzalezi*, Vargas and Díaz (1953b) compared that species with one female specimen from Restrepo, Dept. del Meta, collected by P. C. Antunes in January 1935 and identified as *S. exiguum* by J. Lane in 1943. Lewis and Lee-Potter (1964) recorded this species from the following localities of the Dept. del Magdalena: Ariguaní (alt. 1,700–2,000 ft.) three female specimens taken 20 December 1963; Meollaca (alt. 10,500 ft.) one female obtained 22 December 1963 and Valledupar (alt. 1,000–1,500 ft.) two females captured 15 January 1964. All these specimens were caught while feeding on man. This species has a wide geographical distribution in South America (Briceño and Ortiz, 1957). According to Vargas (1945) *S. exiguum* also bites horses.

4. *Simulium incrustatum* Lutz, 1910.
TYPE LOCALITY: Petrópolis, Brazil.

Antunes (1937) identified as this species adult specimens taken at Caibe and Guacavía, rural localities of Restrepo, Dept. del Meta, in January–February 1935. The material which was sent to J. Lane who confirmed the presumptive identification, was later also examined by Vargas and Díaz (1953a). This species is known to be present in Brazil, Colombia, Paraguay and Venezuela (Vargas and Díaz, 1953a). It has been captured while feeding on man and horses (Vargas, 1945).

5. *Simulium lahillei* (Paterson and Shannon) 1927.
TYPE LOCALITY: Quebrada de Lules, Tucumán, Argentina.

Two males and one female from Bogotá (alt. 2,600 m.), Dept. de Cundinamarca, were reared from pupae by J. Bequaert in 1933 and identified by Vargas and Díaz (1951). This species is otherwise known only from a number of localities in Argentina where it has not been seen attacking man commonly but Wygodzinsky (1953) reports one female collected with human bait.

6. *Simulium latigiditum* (Enderlein) 1936.
TYPE LOCALITY: Muzo, Dept. de Boyacá, Colombia.

This species is known only from the type material (Vargas, 1945).

7. *Simulium lutzianum* Pinto, 1931.
TYPE LOCALITY: Río Castaño, Aragua, Venezuela.

This fly has been recorded from Cali (alt. 1,000 m.), Dept. del Valle, where adult specimens were reared from pupae collected in the Río Cali by L. Briceño. The identification of this material was confirmed by L. Vargas (Briceño, 1946). This species is said to bite man and is known to occur in Guiana (British Guiana) and Venezuela (Vargas, 1945).

8. *Simulium metallicum* Bellardi, 1859.
TYPE LOCALITY: México (exact locality not known).

This species is recorded by Lewis and Lee-Potter (1964) from two female specimens caught while attacking man at Ariguaní (alt. 1,700–2,000 ft.) and Donacuí (alt. 4,700 ft.), Dept. del Magdalena, in December 1963. *S. metallicum* has been found in México, Guatemala, Costa Rica, Panamá, Trinidad and Venezuela (Briceño and Ortiz, 1957). It is considered by Lewis and Ibáñez de Aldecoa (1962) as the main or only vector of onchocerciasis in northern Venezuela, where it was collected feeding on man and less frequently on donkeys.

9. *Simulium mexicanum* Bellardi, 1862.
TYPE LOCALITY: Tuxpango, Veracruz, México.

Adult specimens were identified from pupae collected by Briceño (1946) in the Río Cali, Cali, Dept. del Valle, 4 June 1946. Later, in the same month, Briceño again collected this species at Muzo (alt. 900 m.), Dept. de Boyacá (Vargas and Díaz, 1951). It has been captured while feeding on horses or mules (Vargas, 1945).

10. *Simulium rubrithorax* Lutz, 1909.
TYPE LOCALITY: Serra de Bocaina, Batatais, Sao Paulo, Brazil.

This species was recognized from adult specimens captured at Caibe and Guacavía, rural localities of Restrepo, Dept. del Meta, in January 1935 (Antunes, 1937). This simuliid feeds on horses and occasionally on man (Vargas, 1945). It has been recorded from Argentina, Brazil, Guiana (British Guiana) and Venezuela (Briceño and Ortiz, 1957).

11. *Simulium sanguineum* Knab 1915.
TYPE LOCALITY: Boca de Arquía, Río Atrato, Dept. del Chocó, Colombia.

Dunn (1929) identified this species at various sites along the Magdalena, Atrato and Zulia Rivers where the man-attacking flies were extremely trouble-some when present in large numbers. Vargas (1945) gives its distribution at several localities in Panamá, Guiana (British Guiana) and Venezuela.

12. *Simulium scutellatum* Lane and Porto, 1940.
TYPE LOCALITY: Restrepo, Dept. del Meta, Colombia.

The description of this species is based on 17 females collected in January 1935 by the Yellow Fever Service under the supervision of P. C. Antunes. According to Vargas (1945) it bites man. There appear to be no records other than the type collection.

13. *Simulium subnigrum* Lutz, 1910.
TYPE LOCALITY: Río Pacaembú, São Paulo, Brazil.

This species was found at Restrepo, Dept. del Meta, 6 January 1935 (Vargas, 1945). *S. subnigrum* has been collected at several localities in Brazil, Trinidad and Venezuela (Briceño and Ortiz, 1957). Vargas (1945) states it feeds on horses.

14. *Simulium tarsatum* Macquart, 1846.
TYPE LOCALITY: Nueva Granada = Colombia (exact locality not known).

The type specimen, one male, was collected in Nueva Granada, one of the several historical names applied to Colombia at the time the species was described. Apparently it is known only from this country (Vargas, 1945).

15. *Simulium violacescens* Enderlein, 1933.
TYPE LOCALITY: México (exact locality not known).

This species has been found in Venezuela and Colombia (Vargas, 1945). The Colombian record is based on one female specimen collected in March 1912 at the Sierra de San Lorenzo. According to Vargas (1945) it feeds on cattle.

Although the above list covers all the known named black flies for Colombia, it may be added that Lewis and Lee-Potter (1964) recognized two other species obtained with human bait which they designated by the letters A and B. They were taken at Meollaca and Donacuí, localities previously mentioned under *Simulium exiguum* and *S. metallicum*.

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Agent for the Sale of Back Issues of the Journal of the New York Entomological Society

The Society has recently agreed that the S-H Service Agency, Inc. of 31 East 10th Street, New York, N.Y. 10003 will be the agent to sell the back issues of our journals. Inquiries and orders for back issues and complete sets of the **Journal** should be directed to them.

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For the next two years Henry Tripp will continue to handle the sales of **A Glossary of Entomology** by Torre-Bueno.

Variation and Distribution of the Intertidal Beetle *Halocoryza arenaria* (Darlington) in Mexico and the United States (Coleoptera: Carabidae)

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Abstract: *H. arenaria* is reported for the first time from North America, with records from Florida and the Yucatan Peninsula. Among characters studied, the most important variation is in wing length. Floridian specimens are flightless and apparently well isolated from those of the West Indies and the Yucatan Peninsula. They also differ in habitat, being found in an intertidal situation rather than at or near the high tide line. Specimens from Quintana Roo are smaller, have fewer elytral setae, and have slightly reduced wings. The most probable routes of dispersal to both mainland areas have been from the Greater Antilles.

INTRODUCTION

Although the American species of *Halocoryza* have been discussed recently (Whitehead, 1966) new collections in Florida and on the Yucatan Peninsula provide valuable insight into problems of dispersal and speciation. In my earlier paper, I suggested that this genus should be present on the Atlantic coast of North America, and further that the species should be the West Indian *H. arenaria* (Darlington). These predictions proved correct. However, *H. arenaria* is much more variable than was anticipated.

NEW RECORDS

To the previously recorded distribution of *H. arenaria* in Puerto Rico and the Dominican Republic are added the following new records:

Mexico. Quintana Roo. Puerto Juarez (20 April, 1966, Ball and Whitehead, 11 specimens). Yucatan. Progreso (19 April, 1966, Ball and Whitehead, 2 specimens).

United States. Florida. Monroe County, Lower Matecumbe Key (21 July, 1967, Whitehead, 21 specimens).

Acknowledgments: I am indebted to Dr. R. E. Crabill of the United States National Museum for determinations of and information about the centipedes mentioned in this paper; to Professor G. E. Ball, Professor W. G. Evans, Mr. John R. Barron and Mr. T. L. Erwin of the University of Alberta for reading and criticizing the manuscript; and to Professor J. B. Schmitt of Rutgers University for overseeing its publication.

This study was supported in part by National Science Foundation Grant GB-3312, held by Professor Ball.

Table 1. Variation in elytral length, in millimeters.

Locality	Numbers	Range	Mean	1.5 Standard Deviations	2 Standard Errors
Florida	21	1.32–1.45	1.38	0.06	0.02
Yucatan	2	1.35–1.45	1.40	—	—
Quintana Roo	11	1.22–1.38	1.30	0.09	0.03
Puerto Rico	5	1.35–1.45	1.39	—	—

VARIATION

Differences in size and in number of elytral setae that I previously used to separate *H. arenaria* from *H. acapulcana* fail to hold true in these additional samples. In these respects, in fact, the sample from Quintana Roo is virtually identical with the *H. acapulcana* sample from Acapulco, Guerrero, Mexico.

Variation in size was determined by measuring the length of the left elytron, and is summarized in Table 1. Variation in the number of elytral setae was determined by counting the number of setae on interval three of the left elytron, and is summarized in Table 2. The Quintana Roo sample is statistically distinct from the Florida population in both of these measurements.

In my earlier paper, I stated that the wings of *Halocoryza* were fully developed and probably functional. This is not true in some of the new material. Specimens from Florida all have reduced wings, about ¾ as long as the elytra, and are certainly flightless; the elytral humeri are narrow and strongly rounded. Specimens from Quintana Roo have slightly reduced wings, about as long as or slightly longer than the elytra, and the elytral humeri are normal. The two Yucatan specimens have normally developed wings and humeri.

There is no significant variation in other reported characters, and the species *H. arenaria* and *H. acapulcana* remain readily separable by the form of the pronotum and the male genitalia.

BIOLOGICAL NOTES

During 1965–66, G. E. Ball and I visited numerous places on both coasts of Mexico in search of these beetles, but found them only at the Yucatan localities recorded above. In both cases the beetles were found at the high tide line, which

Table 2. Variation in the number of setae on interval three of left elytron.

Locality	Numbers	Range	Mean	1.5 Standard Deviations	2 Standard Errors
Florida	21	10–13	11.5	1.4	0.4
Yucatan	2	11	11.0	—	—
Quintana Roo	11	9–11	10.1	0.3	0.1
Puerto Rico	5	12–13	—	—	—

was marked by thick deposits of seaweed. At the Quintana Roo locality, well sheltered from strong surf, they were generally in fine beach sand under limestone rocks. In the seaweed drift were many specimens of a littoral schendylid centipede, *Pectiniunguis halirrhytus* Crabill (see Crabill, 1959). Since I had previously found this conspicuous centipede in Florida, I had reason to suspect that by using it as an indicator I should also find *Halocoryza* there.

By using *Pectiniunguis* as an indicator, I was able to find a suitable habitat for *Halocoryza* on the Florida Keys. Curiously, though conditions at the Florida locality were much the same as in Quintana Roo, with great mats of seaweed at the high tide line and the surf reduced by an off-shore coral reef, the beetles were found well within the intertidal zone where their habitat was inundated for several hours at each high tide. The beach was a tightly packed conglomerate of coquina, cemented by very fine silt or sand. Water drainage in this material was poor, and hence air entrapment was most probably enhanced. The entire sample was collected in an area not exceeding ten square feet, by scooping out a hole to a depth of three or four inches, filling with water, and stirring in the sides of the pool.

Associated with the *Halocoryza* were numerous small cryptopid centipedes (*Cryptops* sp.), and an unidentified pseudoscorpion (see Muchmore, 1967). No immature *Halocoryza* were found. *Pectiniunguis* was not found in this material, but only associated with drifted seaweed. The only other terrestrial arthropods found in the seaweed were a carabid larva (*Scarites* sp.) and a few staphylinid beetles.

ZOOGEOGRAPHY

Like the centipede *Pectiniunguis halirrhytus*, the carabid *Halocoryza arenaria* seems to be amphi-Caribbean in distribution, and may eventually be discovered on the northeast coast of South America. Since this new material proves my earlier prediction that this species should be found in North America (Whitehead, 1966), certain assumptions concerning the mode of dispersal are given support. These assumptions were that beetles of this genus disperse more readily overwater than over land, and therefore that a major determining factor is the nature of oceanic currents. Since currents in the Caribbean favor transport from the islands to the mainland (hurricane paths follow similar routes), I assume that the islands are probably the center of dispersal for the species.

The dissimilarity of the Yucatan and Florida populations and the apparent lack of habitat continuity along the Gulf Coast suggest genetic discontinuity; if gene exchange occurs it must be sporadic. The flightless Floridian form seems particularly isolated, and obviously cannot form a central gene pool.

Populations from the Yucatan are not as definitely isolated from the islandic populations, and may be more genetically continuous. Probably the peninsular populations are clinal, and I suspect the Progreso specimens are near the limit of the natural range since the habitat there seems marginal. If so, this might account for a greater similarity to the islandic populations, particularly in wing length, as an adaptation to a relatively poorly protected environment. Fully developed wings should be advantageous for islandic survival, even if long distance flight is relatively unimportant in dispersal.

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A Review of the Genus *Gosodesmus* Chamberlin, with the Synonymy of *Eucybe* Chamberlin (Diplopoda: Platydesmida: Androgнathidae)

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Received for Publication July 19, 1968

Abstract: The genus *Gosodesmus* Chamberlin is reviewed. With a relatively large series of *G. claremontus* Chamberlin from a number of localities in California, a more thorough evaluation of this species is presented. Until now a series of disjunct populations have been given specific rank, but our studies indicate *G. claremontus* to represent a polymorphic species. Herein, we place the genus *Eucybe* Chamberlin, including the species *E. clarus* Chamberlin (1941), *E. longior* Chamberlin (1950), and *E. auctus* Chamberlin (1954) under the synonymy of *Gosodesmus claremontus*.

The millipeds of the super-order Colobognatha are delicate animals with a thin cuticle and small mouthparts modified for specialized feeding. At the time that the first and only comprehensive work on the North American fauna was published (see Cook and Loomis, 1928), it was felt that the Colobognatha existed in the temperate zone only as localized populations of a previously widespread fauna which was largely eliminated with the recent reduction of moisture in the temperate zone. It is now evident that certain species are indeed highly localized as predicted. Certain other groups of Colobognatha, however, have successfully adapted to the new conditions and rank among the more common and widespread forest millipeds in the western United States. Among these is a very slender, pink Andrognathid which has been given the generic names *Gosodesmus* and *Eucybe*.

Found abundantly in the middle and southern Sierras and Coast Ranges, this milliped has undergone an undue amount of taxonomic confusion. Chamberlin (1922) described *Gosodesmus claremontus* from Claremont, Los Angeles County, California. The description is brief, but accurate and useful, and the drawings accurately depict the creature. Cook and Loomis (1928) include *Gosodesmus* in their basic work on the Colobognatha, drawing their treatment from the original description. Loomis (1936) added significant new distribution records from Santa Cruz, County. Then Chamberlin (1941) described the genus and species *Eucybe clarus*, from Monterey County, California, but did not compare his new genus with *Gosodesmus*, even though the descriptions of the two groups correlated very well. Later, Chamberlin (1950) described a second species in the group, *Eucybe longior*, from Tulare County, California, basing the species mainly on its greater number of segments. The third and final species, *Eucybe auctus*,

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was described by Chamberlin in 1954 and was collected in Mariposa County, California. It was distinguished by the presence of three rows of tubercles on the collum, versus two for *clarus*. In the North American Checklist of Chamberlin and Hoffman (1958), all of the above names except *E. auctus* were included as recognized species, the latter being omitted because it was published beyond the deadline date for accepting titles for the 1958 list. Buckett (1964), however, included all four names in the Annotated Checklist of the Millipeds of California.

We wish to express our sincere appreication to Mr. H. F. Loomis for making available for study the Andrognathid material in his collection.

TAXONOMIC CHARACTERS

In the Colobognatha in general, and in the Platydesmida in particular, the somatic features offer the most useful and reliable characters. Unlike the Helminthomorpha, in which the gonopods present obvious specific and generic characters, the gonopods of the Colobognatha are of relatively little use in distinguishing species.

In the western species of the Platydesmid family Andrognathidae, the numbers of segments, the shape and configuration of the body segments (of the collum in particular), and the presence or absence and nature of tergal tubercles are most useful in distinguishing taxonomic units.

The collum and its tubercle arrangement are of particular interest in the group of millipeds upon which the names *Gosodesmus* and *Eucybe* are based. The tubercles are prominent rounded projections of varying sizes and shapes, and are arranged in two or three rows. However, the arrangement is often uneven, and random tubercles are usually present. In the original diagnosis of *Gosodesmus*, Chamberlin indicated that he understood the inherent variability of this character, stating: "First tergite with six tubercles in each row, or with one or two extra ones in an indistinct third row along anterior border." However, in his later publications on *Eucybe*, Chamberlin placed particular emphasis on the number of rows of tubercles on the collum, using this character as the primary diagnostic feature in distinguishing *Eucybe auctus*.

Another character which has been used to diagnose "species" in this group is the segment number. *Eucybe longior* Chamberlin was distinguished from *E. clarus* on the basis that it possesses 70 segments as opposed to 55 for the type of *clarus*. The facts appear to indicate, however, that the number of segments is not tightly controlled genetically. For instance, adult individuals from Marin County vary from 50 to 68 segments. Hence, this character cannot be relied upon to indicate species distinctness in this group.

Genus *Gosodesmus* Chamberlin

Gosodesmus Chamberlin, 1922, Pomona Coll. J. Entomol. and Zool. **14**(1):9.

(Type species: *Gosodesmus claremontus* Chamberlin, by original designation).

Eucybe Chamberlin, 1941, Bull. Univ. Utah, biol. ser. **6**(4):3 (Type species: *Eucybe clarus* Chamberlin by original designation). **New Synonymy.**

DIAGNOSIS: *Gosodesmus* may be easily recognized by the narrow body (L/W ratio of 12) with 2 rows of tubercles on regular body tergites as well as a tuberculate colum with paranotal flanges developed.

DESCRIPTION: Body long and slender, length/width ratio about 12; color in life pink to nearly coral, often with black median dorsal stripe.

Head sub-triangular with sides strongly converging below, the labrum sharply rounded; eyes absent; antennae short, widening apically, segment 6 much the largest. Collum hardly wider than head, with paranota as well developed, proportionately, as on succeeding segments; two or three uneven rows of round or elongate tubercles present on collum, numbering from 10 to 25 tubercles total.

Following segments 2 to 7 gradually widening, on anterior segments paranota directed considerably cephalad, this anterior curvature gradually reduced and absent by segment 7. Segments fitting so that paranota are loosely spaced, a portion of prozonite exposed between metazonites; segments other than collum (with the occasional exception of segment 2) with two transverse rows of tubercles, an anterior row of 6 to 8 tubercles on each side, the outer pair of which situated on basal half of paranota, and a posterior row of 4 to 7 tubercles on each side not extending onto paranota; tubercles rounded on anterior segments, becoming longitudinally elongate in middle body segments; paranota of middle body segments angled sharply cephalad at origin, then angled laterad, the angle sharper on caudal margin; surface of paranota roughened, the margins minutely tubercled; the repugnatorial pores opening very near caudal apex of lateral margin.

Legs long, extending beyond lateral margins of body.

Gosodesmus claremontus Chamberlin.

Gosodesmus claremontus Chamberlin, 1922, Pomona Coll. J. Entomol. and Zool. **14**(1):9, 3 Figs.; Cook and Loomis, 1928, Proc. U. S. Nat. Mus. **72:**26; Loomis, 1936, Proc. U. S. Nat. Mus. **83:**364, Fig. 32c; Chamberlin and Hoffman, 1958, Bull. U. S. Nat. Mus. **212:**184; Buckett, 1964, Annot. List Diplopoda California, p. 28.

Eucybe clarus Chamberlin, 1941, Bull. Univ. Utah, biol. ser. **6**(4):3 (type locality: Monterey County, California; type: Collection of R. V. Chamberlin); Causey, 1954, Pan-Pacific Entomol. **30:**221; Chamberlin and Hoffman, 1958, Bull. U. S. Nat. Mus. **212:**183; Buckett, 1964, Annot. List Diplopoda California, p. 28. **New Synonymy.**

Eucybe longior Chamberlin, 1950, Chicago Acad. Sci. Natur. Hist. Misc. No. **68:** 4 (type locality: Tulare County, California; type: Collection of R. V.

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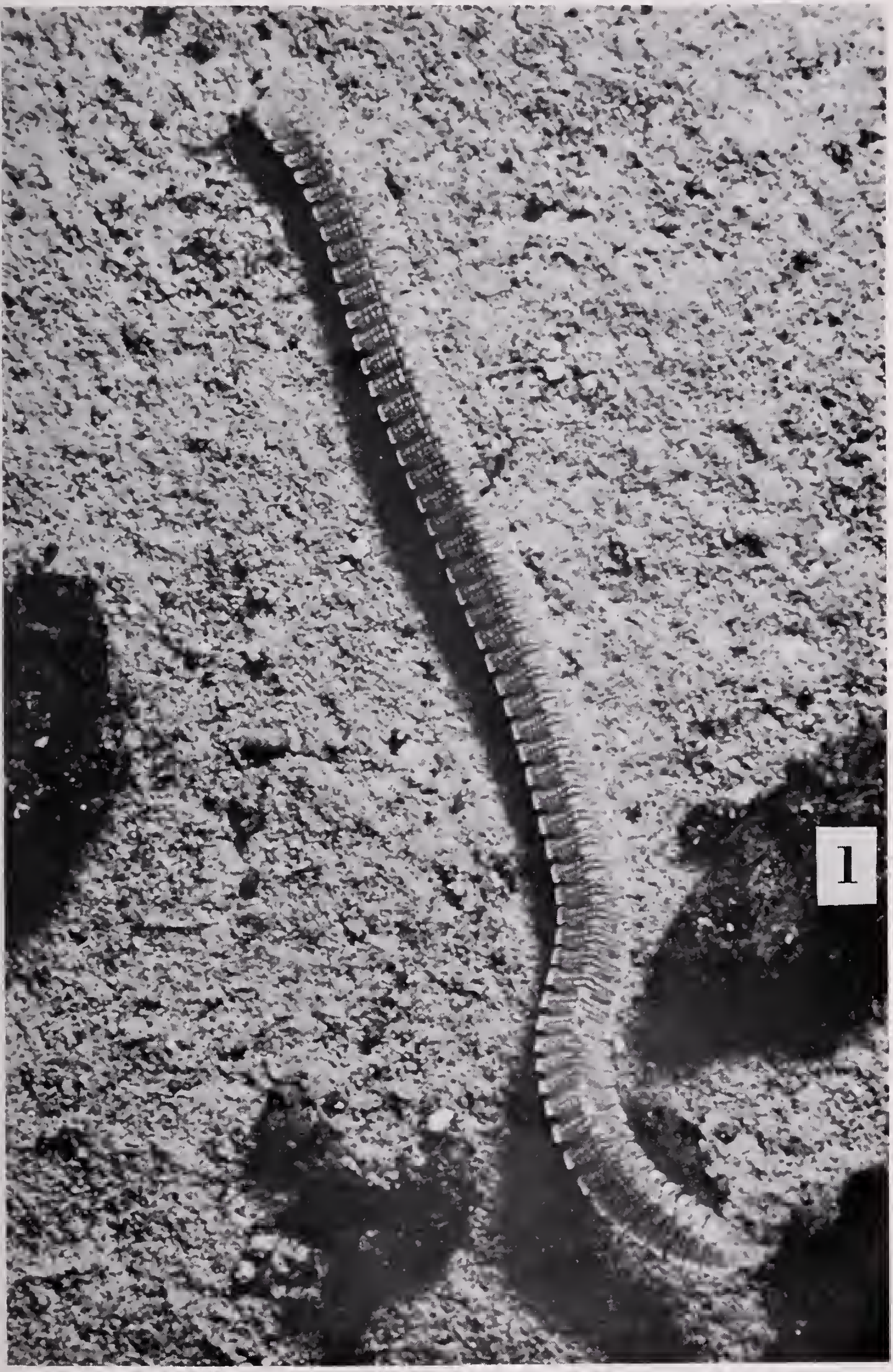
FIG. 1. *Gosodesmus claremontus* Chamberlin, adult male. Note body shape, minutely roughened tergites, and arrangement of dorsal tubercles.



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Chamberlin); Chamberlin and Hoffman, 1958, Bull. U. S. Nat. Mus. **212:** 183; Buckett, 1964, Annot. List Diplopoda California, p. 28. **New Synonymy.**

Eucybe auctus Chamberlin, 1954, Proc. Biol. Soc. Washington **67:**233 (type locality: Mariposa County, California; type: Collection of R. V. Chamberlin); Buckett, 1964, Annot. List Diplopoda California, p. 27. **New Synonymy.**

TYPE LOCALITY: Claremont, Los Angeles County, California.

TYPE: In the Museum of Comparative Zoology, Harvard University, Cambridge, Mass. Description, based on specimens from Santa Cruz County, California.: Body strikingly pink in color.

Head narrower than collum and completely uncovered by collum; frontal area flattened, covered with minute setae; coronal suture not evident, a pair of small dark brown oval areas closely situated on either side of median line about one-third distance from dorsum; antennal sockets deeply set into facial shield slightly below mid-heighth of head; head sub-triangular from frontal aspect, broadly rounded dorsally and narrowing evenly to sharply rounded labral area; antennae short, separated by distance equal to twice length of second antennal segment; first antennal segment short, cylindrical, reaching to lateral margin of facial shield; segment 2 twice length of first segment, much widened apically; segments 3 and 4 equal to 2 in width but distinctly shorter; segment 5 slightly longer than 4 and almost twice apical width of segment 4; segment 6 the largest, cylindrical; apical segment sub-equal in size and shape to segment 1, with four apical sense cones in truncate apex; antennal segments densely covered with fine setae.

Tergites with surface minutely roughened, not shining; margins of paranota with numerous minute spines and tubercles; median dorsal sulcus prominent on both prozonites and metazonites. Collum narrower but longer than following segments, with small but distinct rounded paranotal flanges, these directed slightly cephalodorsad; posterior margin of collum curved evenly convex, anterior margin concave; paranota of collum with dense, minute teeth; dorsal surface with prominent tubercles of varying shapes and sizes usually situated in 2 to 4 uneven rows; posterior row consisting usually of 6–10 large elongate tubercles, others on the collum more rounded; overall tubercle number on collum varying from 10 to 25.

Segment 2 short, with larger paranota raised 15° from horizontal and directed slightly cephalad, the apices broadly rounded; tubercles on second segment in

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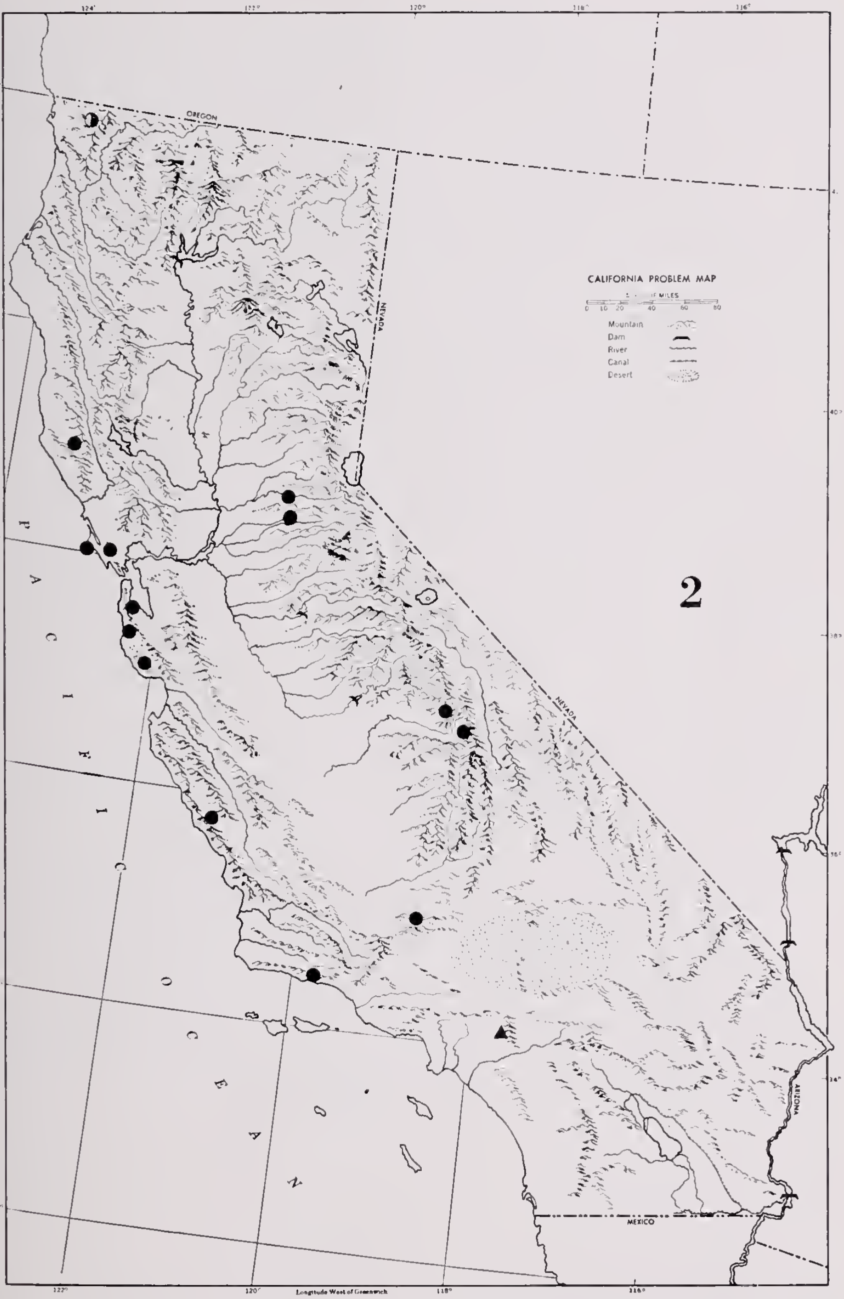
FIG. 2. Distribution map, *Gosodesmus claremontus.* The triangle represents the type locality; the half-filled circle represents a record published by Causey (1954); the full circle represents collections made by the authors.


CALIFORNIA PROBLEM MAP
MILES
0 10 20 40 60 80
Mountain
Dam
River
Canal
Desert
OREGON
NEVADA
NEVADA
ARIZONA
MEXICO
P A C I F I C
O C E A N
124°
122°
120°
118°
116°
42°
40°
38°
36°
34°
32°
122°
120°
118°
116°
Longitude West of Greenwich

2

two rows, an anterior row of 5 small tubercles on the left and 3 on the right, and posterior row of 2 large, rounded tubercles on each side; outer tubercle of anterior row on basal half of paranota flange; segments 3 and 4 similar to segment 2 in shape, but increasingly larger, each with increasingly more numerous tubercles; beginning prominently on segment 5, a sharp right-angled notch present on posterior margin of paranotal flange at juncture with margin of body cylinder, this notch increasing in size on following segments; segment 5 with 8 elongate tubercles in posterior row extending laterad to caudal notch on each side, the anterior row with 5 tubercles on the right side and 4 on the left; sixth and following segments with laterally compressed tubercles comprising both anterior and posterior rows and with paranota directed strictly laterad; sixth tergite sub-quadrate in shape, with a small notch in the center of lateral margin cephalad of location of repugnatorial pore; segments 7 through 10 with posterior corner of paranota becoming produced and sharply acute, the anterior corners rounded; tubercles on middle body segments in two rows, with 6 to 8 in the anterior row on each side of body and 4 to 7 in posterior row on each side.

Tergites of last 7 segments gradually reduced in size, the posterior corners becoming increasingly produced; last 4 segments with paranota curving increasingly caudad, the last pair of flanges with mesal margins parallel, adjacent to lateral margins of anal tergite and equalling it in length; anal segment cylindrical, covered with fine setae; 6 long setae present around caudal margin of anal tergite; anal valves smooth, bearing fine setae and produced slightly beyond anal tergite; preanal scale apparently absent.

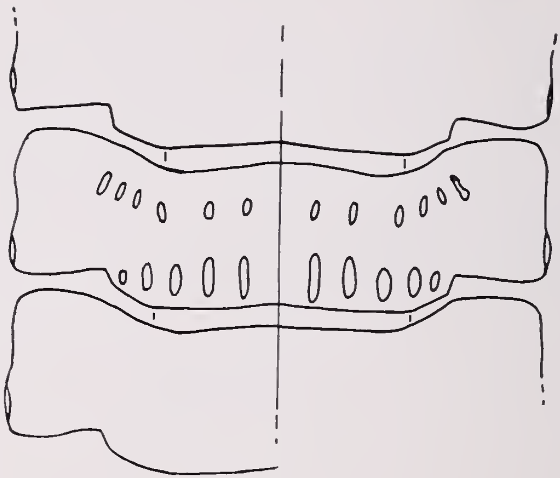
Sternal process oval, produced cephalad between coxae of each leg-pair; anterior legs of male crassate, slightly shorter and stouter than other walking legs; normal walking legs with coxae large, mesal margins almost meeting anteriorly; second leg segment very short, barely noticeable; third segment elongate, nearly twice length of coxa; fourth, fifth and sixth segments all decreasing in size, considerably shorter than third segment; seventh segment the longest, narrowing distad to width of apical claw; coxae with rounded apical protrusions on postero-ventral surface of all legs except those of last 18 segments.

Gonopods consisting of 2 pairs of segmented leg-like appendages tapered toward their apices; anterior gonopod short, sharply curved cephalad with the apical segment longest; posterior gonopod more elongate, proceeding cephalad and ending adjacent to mesal margin of anterior gonopod.

SPECIMENS EXAMINED: California: Amador County: 5 males, 2 females, 4 miles east of Fiddletown, 20 January 1968 (J. S. Buckett & M. R. Gardner); 1 female, 3 miles south-southeast of Jackson, 27 December 1965 (J. S. B., M. R. & R. C. Gardner). Calaveras County: 5 males, 10 females, 3 miles south of Westpoint, 19 January 1968 (J. S. B. & M. R. G.). Kern County: 4 males, 5 females, 1 mile north of Fort Tejon Monument, 17 December 1967 (J. S. B. & M. R. G.). Marin County: 2 males, 2 females, Inverness Ridge, 1 mile south of Inverness, 7 November 1964 (J. S. B. & M. R. G.); 1 male, 5 females, Lagunitas, 9 January 1965 (J. S. B. & M. R. G.); 3 females, Point Reyes Hill, 2 miles southwest of Inverness, 20 December 1961 (J. S. B. & G. M. Trenam). Mendocino County: 2 males, 3 females, 4 miles north of Yorkville, 21 December 1964 (J. S. B. & M. R. G.); 23 males, 21 females, 7 miles northwest of Yorkville, 21 December 1964 (J. S. B. & M. R. G.). Monterey County: 1 female, Alder Creek, 28 March 1965 (P. Richerson) San Mateo County: 7 males, 7 females, Stanford University, 29 December 1964 (J. S. B. & M. R. G.). Santa Barbara County: 1 male, Cold Spring, 1 mile north of San Marcos Pass, 19 June 1965 (J. S. B. & M. R. G.); 1 female, Jalama Beach, 9 July 1965 (M. R. G.); 2 females, Toro Canyon, 4 September 1967 (R. F. Denno). Santa Clara County: 1 male, 5.2 miles southwest of Stevens Creek Dam, 28 December 1966 (M. R. G., R. C. G., & S. E. Harrison); 3 females, 10 miles south of Woodside, 29 December 1966 (M. R. G., R. C. G. & S. E. H.). Santa Cruz County: 3 males, 8 females, Ben Lomond, 29 December 1966 (M. R. G., R. C. G. & S. E. H.); 1 male, 4 females, 2 miles northwest of Boulder Creek, 29 December 1966 (M. R. G., R. C. G. & S. E. H.). Tulare County: 1 female, 4 miles south Badger, 11 February 1967 (J. S. B. & M. R. G.); 7 males, 11 females, 3 miles north of Hospital Rock Camp Ground, Sequoia National Park, 12 February 1967 (J. S. B. & M. R. G.).

As with almost any wide-ranging species, considerable variation occurs within and between populations of *Gosodesmus claremontus*. The most obvious superficial characteristic is color. Specimens from the coast ranges north of Monterey County, California, are a bright pink color over their entire dorsal surface, sometimes with a purplish mid-dorsal stripe. The head is light tan in color. Specimens collected from the Sierras also display the bright pink color, but possess a mid-dorsal black stripe of varying widths, which may encompass from one to three tubercles of the anterior row centrally on each side of the tergite. The stripe widens cephalad to encompass the entire dorsal surface of the first 5 to 7 segments. In these specimens, also, there is a large black area encompassing the vertex of the head, this black area continuing down the middle of the frons, abruptly narrowing and ending before reaching the level of the antennae. This Sierran color form is also visible in specimens from Fort Tejon Monument, Kern County, and in specimens from localities in Santa Barbara County on the coast. Although the different color patterns are easily recognizable, they are probably not of much taxonomic significance, since some specimens from the Sierras, especially in the north, lack the black pigment almost entirely.

The number of rows of tubercles on the collum has previously been used as a character, but it is impossible to analyze because of the uneven displacement of the tubercles (See Figs. 4–7). A more objective character which can be analyzed statistically, however, is the number of tubercles on the collum. It was found that the mean number of tubercles of 18 Sierran specimens (including those from Fort Tejon) was 22, with a range of 17 to 25. Of 30 adult coastal specimens measured, the mean was found to be only 15, with the range from 10 to 19. Tested with the Student's T Distribution, the means were found to be highly significantly different; that is, the chance of the means of the populations from which these samples were taken being the same is less than 0.001. There is, then, on the average, 5 more tubercles on the collums of the Sierra specimens



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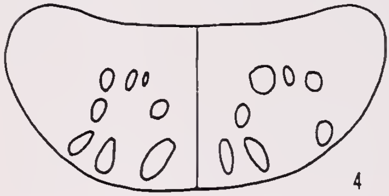

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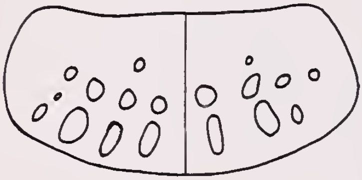

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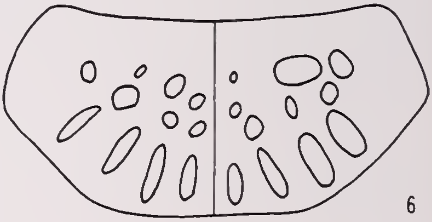

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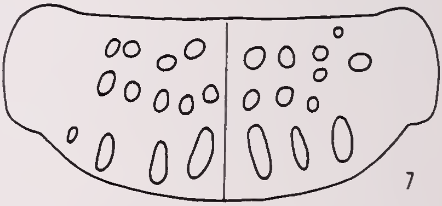

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Fig. 3. *G. claremontus.* Terga of mid body segments. Note loosely spaced segments, and arrangement and shape of tubercles.

Fig. 4. Female, Point Reyes Hill, 2 miles southwest of Inverness, Marin County, 20 December 1961 (J. S. Buckett & G. M. Trenam). Specimen composed of 55 segments.

Fig. 5. Female, Alder Creek, Monterey County, 28 March 1968 (P. Richerson). Specimen composed of 40 segments.

Fig. 6. Female, 3 miles north of Hospital Rock, Sequoia National Park, Tulare County, 12 February 1967 (J. S. Buckett & M. R. Gardner). Specimen composed of 70 segments.

Fig. 7. Male, same locality, date and collectors as in Fig. 6. Specimen composed of 81 segments.

than on the coastal specimens. Significantly, the Santa Barbara specimens which exhibited the Sierran color form averaged only 16 tubercles on the collum.

Another significant source of variation occurs in the size of the tubercles. The Sierran specimens usually have large, well-defined tubercles across all the segments, whereas in the coastal populations the tubercles diminish in size in the lateral areas of the tergites. Again, the tubercles of the Santa Barbara specimens resemble other coast specimens.

The final character of obvious importance is size, which is related to number of segments. In describing *Eucybe longior*, Chamberlin distinguished it from *E. clarus* by the fact that his specimens had from 65 to 75 segments as opposed to 55 for the type of *clarus*. Segment counts which we made revealed an average of 59.10 segments on the coast specimens with a range of 50 to 68. The average segment count of Sierran specimens was almost identical, at 59.11, with a range of 47 to 81. It is true that the largest specimens were collected from vicinity of Tulare County, although the significance in size of such specimens is reduced by the presence in the same population of adult individuals with less than average numbers of tubercles.

We have reached the conclusion in our study that the names *Gosodesmus claremontus, Eucybe clarus, E. auctus* and *E. longior* all represent a single, widespread species. In describing *Eucybe*, Chamberlin (1941) compared it with *Ischnocybe* Cook and Loomis, but ignored his own *Gosodesmus*, the diagnosis of which agreed with the diagnosis of *Eucybe* in every respect. In erecting the species *longior* and *auctus*, Chamberlin relied on characters which later proved to be too variable to indicate species integrity; namely, the number of segments in *longior* and the number of rows of tubercles in *auctus*.

Of the North American genera of Andrognathidae, *Gosodesmus* appears closely related to the genus *Ischnocybe* Cook and Loomis. Like *Gosodesmus, Ischnocybe* has about 60 body segments, a length/width ratio of about 12, 2 rows of tubercles on the body segments, well developed, loosely fitting paranota, head with obtusely angular snout and antennae with enlarged sixth segment. *Ischnocybe* differs from *Gosodesmus* mainly in the characters of the collum, in which it lacks both tubercles and the paranotal flanges.

Relationships with other groups are more obscure. From its description, *Stenocybe waipea* Chamberlin appears to be similar to *Gosodesmus* in body form. However, more must be known about the former before accurate comparisons can be made. Also, the genus *Brachycybe* Wood shares several features with *Gosodesmus*, even though *Brachycybe* has a much broader body. Both genera possess two rows of tubercles on most body segments as well as tuberculate, flanged collum, and similar numbers of segments. The European genus *Fioria* Silvestri, as pointed out by Cook and Loomis (1928), may also be related to *Gosodesmus*, as it possesses a similar pattern of dorsal tubercles, although these are apparently of a different nature.

The ecology of these animals, as far as it is known, appears to support the ideas founded on morphology. *Ischnocybe, Gosodesmus* and *Brachycybe* have all been collected in rotting wood. In fact, on one occasion in Marin County, we collected several specimens of *Gosodesmus* freely intermingling with *Brachycybe* on an oak stem. By contrast, a genus of apparently different origins, *Mitocybe*, was collected in loose, rocky soil.

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The Biology and Description of a New Species of African *Thyreus*, with Life History Notes on Two Species of *Anthophora* (Hymenoptera: Anthophoridae)

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Abstract: Information is given on the life history of the cuckoo bee *Thyreus* **lieftincki** and on its host, *Anthophora braunsiana* Friese. Biological data are also presented on *Anthophora krebsi* Friese, the nests of which are attacked by the cuckoo bee *Coelioxys* (*Liothyrapis*) *lativentris* Friese. The adults of *T.* **lieftincki**, new species, are described.

Because nothing has been recorded concerning the mode of parasitism of the melectine bee genus *Thyreus*, information on the life history of the South African *Thyreus* **lieftincki**, new species, is presented here. The biologies of its host, *Anthophora braunsiana* Friese, and *Anthophora krebsi* Friese, which nested near the latter, are also discussed and the taxonomic description of *T.* **lieftincki** is appended.

Female specimens of *A. braunsiana* were found to be conspecific with a type of the species in the Institut für Spezielle Zoologie und Zoologisches Museum, Humboldt-Universität, Berlin. This type, bearing the orange "typus" label of Friese, identified in 1904 and collected in Capeland by Krebs, is almost certainly one of the specimens examined by Friese (1905) for his description of the species. Other specimens labeled "*braunsiana*" both in the Berlin Museum and in the British Museum (Natural History) are not conspecific with either the type or the specimens discussed here. The females referred to as *A. krebsi* in the present paper are identical to a female in the Berlin Museum identified as *krebsi* by Friese in 1910. All specimens of both species of *Anthophora* and of the parasitic bees collected in connection with this study are in the American Museum of Natural History and in the Snow Entomological Museum, the University of Kansas, Lawrence.

The identification of the bees was possible because of the generous assistance of the following people and their institutions: Dr. Eberhard Königsmann, Institut für Spezielle Zoologie und Zoologisches Museum, Humboldt-Universität, Berlin; Dr. L. Vári and the late Dr. G. van Son, Transvaal Museum, Pretoria, Republic of South Africa; and Dr. I. H. H. Yarrow and Mr. Collin Vardy, British Museum (Natural History), London. I would like to express my appreciation to Dr. M. A. Lieftinck, Rijksmuseum van Natuurlijke Historie,

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Leiden, The Netherlands, for examining specimens of *Thyreus* **lieftincki** and for preparing the drawings of the male genitalia. The other illustrations are by Mr. Anthony D'Attilio and Mrs. Marjorie Favreau. Dr. Charles D. Michener, the University of Kansas, compared specimens of *T.* **lieftincki** with the type of *T. valvata* in the British Museum, and Prof. J. J. Pasteels, Université Libre de Bruxelles, kindly confirmed the identification of *Coelioxys lativentris.*

BIOLOGY

The biological aspect of this study was conducted 3 miles south of Avontuur, Cape Province, Republic of South Africa, on November 15 and 16, 1966, at an elevation of 3500 feet. The burrows of *Anthophora krebsi* were found in a vertical roadside embankment about six feet high (Fig. 1), whereas *A. braunsiana* nested in the mounds of the termite, *Amitermes hastatus* (Haviland)[2], scattered on the same bank. Because some of the nests of *A. krebsi* were only a few inches from the termite mounds, these two bees seem specific in their selection of different nesting situations. Facing north, the bank and termite mounds were exposed to the sun during most of the day, and plants growing on top of the bank did not cast a dense shadow. *Hoplitis anthodemnion* Michener was the most abundant bee nesting in the bank during the period of observations, and an anthidiine and probably a number of other anthophorines may have used the bank previously. No bee other than *A. braunsiana* nested in the termite mounds.

Nesting Activities of *Anthophora braunsiana*

Although nesting in several termite mounds, this species was studied in the mound in which it was most abundant. Approximately 30 entrances occurred on the top and middle of the north-facing surface of the mound, which was about 30 cm. across. Most burrows led to active nests though some burrows also connected to cells from previous generations. All active burrows were open and lacked tumuli and turrets. In constructing burrows, females of *A. braunsiana* had used existing cavities where they occurred, had walled-off passageways to active termite galleries, and had excavated holes between galleries. The burrows were 6.5 to 7.0 mm. at their smallest diameter and elsewhere conformed to the size of the existing termite gallery.

The main burrow generally descended moderately in a jagged course for a straight-line distance of 4 to 8 cm. Typically the cells were clustered at the end of the burrow in several linear series, sometimes with as many as four cells in a row. Cells (Fig. 2) in a series were closely connected and sometimes arranged at angles, one to another. Each cell was oriented so that its rear was lower than its front, and those closest to the burrow abutted it.

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[2] Kindly determined by Dr. Kumar Krishna.

Fig. 1. Nesting site of *Anthophora braunsiana* and *krebsi*, 3 miles south of Avontuur, Cape Province, Republic of South Africa.

The female bee excavates a cavity for the cell, and, then by cementing together fine pieces of termite carton, it constructs the hard, dark gray, cell wall, approximately 1 to 2 mm. thick. If a cavity is too large for a cell, the excess space is filled first with fine uncemented carton, over which the hard wall is then cemented. The wall is lined inside all over with a thick, waterproof coating of wax, which can be easily scraped with a knife. The inside of the cell cap is concave, lined with wax, and smooth except for a central dimple, presumably where the female withdrew her tongue. The outer surface is nearly flat and smooth. The cap has a center about 1 mm. thick and a periphery 2 mm. thick. The lumen of the finished, ovoid cell is 12.0 mm. long and approximately 8.5 mm. in maximum diameter. Each cell (Fig. 2) is a complete unit encased by the hard cell wall and cap, and, therefore, cells in series can be separated without being damaged.

Though the female transports pollen dry to the nest, she adds liquid (nectar?) so that the stored provisions are a moist, homogeneous paste, deposited in the rear of the cell. The surface of the provisions of a freshly closed cell is perhaps more liquid than the rest of the provisions. Even food masses that are not yet complete have a distinct sour-milk smell, an odor different from that emanating from the cells of *Svastra* (Rozen, 1964). Fermentation apparently sets in and the provisions may swell somewhat. A white substance, presumably a yeast, coats the cap and walls of cells in which larvae are feeding. The depth of the provisions at the time the egg hatched was about 7 to 8 mm. in one case.

The egg (Fig. 2), approximately 4.4 mm. long and 1.0 mm. in maximum diameter (one measurement), is deposited on top of the food mass. White, with a dull chorion, it is slightly curved and rounded at both ends. At the time of hatching, the egg develops a shiny stripe along each side, just as was reported for *Svastra* (Rozen, 1964). The larva of *A. braunsiana* feeds as it moves around the circumference of the pollen mass. Consequently, by the time the larva grows moderately large, a center pillar of pollen projects upward and the larva surrounds it (Fig. 3).

The larva does not begin to defecate until sometime after it has consumed the provisions. Feces are applied over the entire cell wall, possibly including the cap, and no cocoon is spun. The inactive larva rests with the anterior part of its body closest to the cell closure (Fig. 4), and moves slowly from time to time. Its integument is soft, not rigid like that of the Panurginae which also do not spin cocoons. Several larvae pupated before December 10, 1966 but others still had not pupated in the laboratory by July 1, 1968.

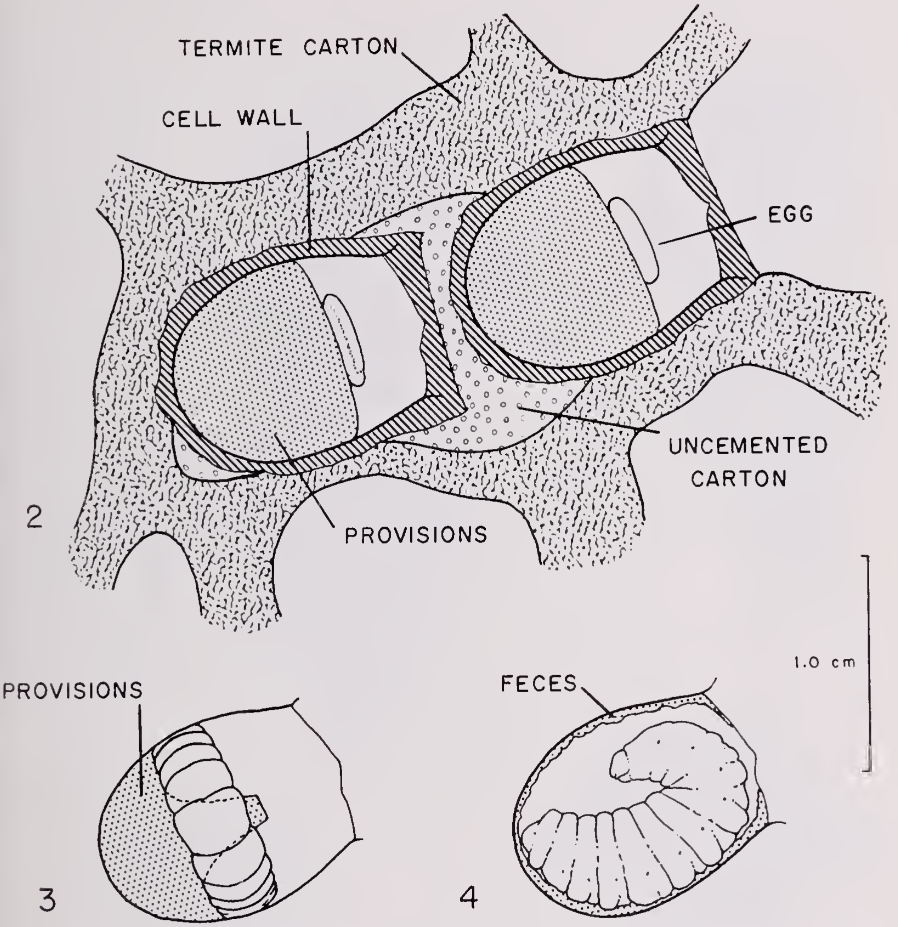
Larvae and eggs of *Thyreus* **lieftincki** were the most common nest associates encountered. However, a meloid larva and a mutillid cocoon were also discovered, and mites occurred in many cells. In some cases termites had penetrated the cell walls and killed the *Anthophora* larvae.

Nesting Activity of *Anthophora krebsi*

Several nests of *A. krebsi* were excavated from the vertical hard earth bank. The burrow, without turrets, 6.0 to 7.0 mm. in diameter, and circular in cross section, entered the bank perpendicularly and then immediately descended. It again ran nearly horizontal before reaching the horizontal to slightly tipped cells. Although the burrow usually had no special lining, either secreted or constructed, the female of *A. krebsi* had blocked a side tunnel from an older nest in one case, an act indicating that parts of old burrows could be altered and used by subsequent generations.

Like those of *A. braunsiana*, the cells of this species are provided with a special built-in lining, in this case consisting of cemented soil. The hardened wall, slightly less than 1 mm. thick, often permitted the cells to be removed intact from the bank. The wax lining is considerably thinner than the cell lining of *A. braunsiana*. The closure is identical to that of *A. braunsiana* in shape but apparently lacked a wax lining and is slightly thinner. Cells measure 11.0 to 12.0 mm. long and 8.0 to 9.0 mm. wide.

The yellow moist provisions fill the rear of the cell to a depth of about 7.0 mm. One cell, being provisioned, contained a nearly clear liquid on which floated pollen. The liquid, which emitted the sour-milk smell found in the cells



FIGS. 2–4. Cells of *Anthophora braunsiana*. 2. Containing egg; one at left about to hatch. 3. With intermediate larva feeding on provisions. 4. With postdefecating larva and feces.

of *A. braunsiana*, may inoculate provisions so that they undergo proper fermentation.

An adult of the cuckoo bee *Coelioxys* (*Liothyrapis*) *lativentris* Friese was captured while investigating the burrows of *A. krebsi*, and a mature *Coelioxys* larva, presumably of this species, was recovered from one of the cells. This is believed to be the first record of a *Coelioxys* parasitizing an *Anthophora* cell.

Habits of *Thyreus*

Adults of *T.* **lieftincki** were associated only with the nests of *Anthophora braunsiana*; they probably do not attack the nests of *A. krebsi*. One female flew from burrow to burrow on the termite mound and poked her head into each entrance before going to the next. She entered several burrows but came out in less than a minute. After examining about eight entrances, she entered one and, 15 to 20 minutes later, a female *Thyreus* flew out. When the nest was excavated, another female *Thyreus* was discovered inside; whether she was the female observed outside or one that was already in the nest could not be determined.

Eggs of this *Thyreus* are inserted through a small hole in the cell cap and apparently drop onto the provisions. None was found cemented to the cap as is the case with *Zacosmia maculata* (Cresson) (Torchio and Youssef, 1968). However, if weakly cemented, they may have been dislodged by vibrations created by my digging. In some instances it appears that the opening ("micropyle" of Torchio and Youssef, 1968) through which the *Anthophora* tongue was withdrawn is used by the *Thyreus* female, but in other cases a separate small puncture just large enough to accommodate the egg and presumably the tip of the female's abdomen, was visible on the inside. There is some suggestion that the *Thyreus* female closes such punctures on the outside, for parasitized cells often have a few raised, rough granules on the outer surface of the cell cap. Torchio and Youssef (1968) claimed that *Zacosmia* females plug the oviposition holes. As many as five eggs of *Thyreus* were found in a cell though some cells contained single eggs. They are white, nearly straight, and, in general, somewhat similar in appearance to those of *A. braunsiana*, only more slender. They measure 3.5 to 3.75 mm. long (five measurements) by 0.55 to 0.65 mm. in maximum width (four measurements).

Upon hatching, the young larva crawls from the chorion which then collapses. The first instar is slow-moving, linear in shape, and possesses a pigmented head capsule with large pointed mandibles. With these mandibles, it kills the egg, or possibly the young larva, of the host, and its siblings. The first instar will be described in a subsequent paper; however, it is similar to that of *Melecta luctuosa* (Scopoli) (Giordani-Soika, 1936), of *M. pacifica* Cresson (Torchio and Youssef, 1968), and of *Zacosmia maculata* (*ibid.*). The older larva, except for its longer antennae, is almost indistinguishable from that of its host on superficial examination. The *Thyreus* larvae, unlike those of *A. braunsiana*, begin defecating before they complete the provisions. Although they may eat a small amount of food while defecating, the provisions are not entirely consumed. The feces are applied over the entire cell wall, including the cap. The postdefecating larva curls itself tightly but can move quickly, twisting and straightening its body at the same time. In this action, it is distinct from the slow-moving larva of *A. braunsiana*. The integument of the postdefecating form, like that of *A. braunsiana*, is nonrigid. The mature larva, which is being described elsewhere, does not spin a cocoon and thereby differs from *Melecta* and *Zacosmia*.

Figs. 5–8. Schematic illustrations of adults of *Thyreus* **lieftincki**, showing distribution of white hair markings. 5. Female, dorsal view. 6. Female, lateral view. 7. Head of female, frontal view. 8. Mid-body region, male, dorsal view.

The biology of *T.* **lieftincki**, except where noted, agrees closely with the observations of Torchio and Youssef (1968) on *Zacosmia maculata.*

Thyreus **lieftincki**, new species

diagnosis: The four adult specimens upon which the following description is based are believed to represent a distinct species. Adults of previously described

South African forms have been examined in the British Museum (Natural History), London, the Museum National d'Histoire Naturelle, Paris, the Institut für Spezielle Zoologie und Zoologisches Museum, Humboldt-Universität, Berlin, and the Transvaal Museum, Pretoria, and none was found to be conspecific with *T.* **lieftincki**. This species keys to *valvata* (Brauns) in Brauns (1909) and to *vachali* (Friese) in Meyer (1921), but, according to Meyer, *valvata* is a junior synonym of *vachali*. Although the type of *vachali* has not been examined, the specimens of *T.* **lieftincki** are not conspecific with a cotype and other specimens of *valvata* in the British Museum.

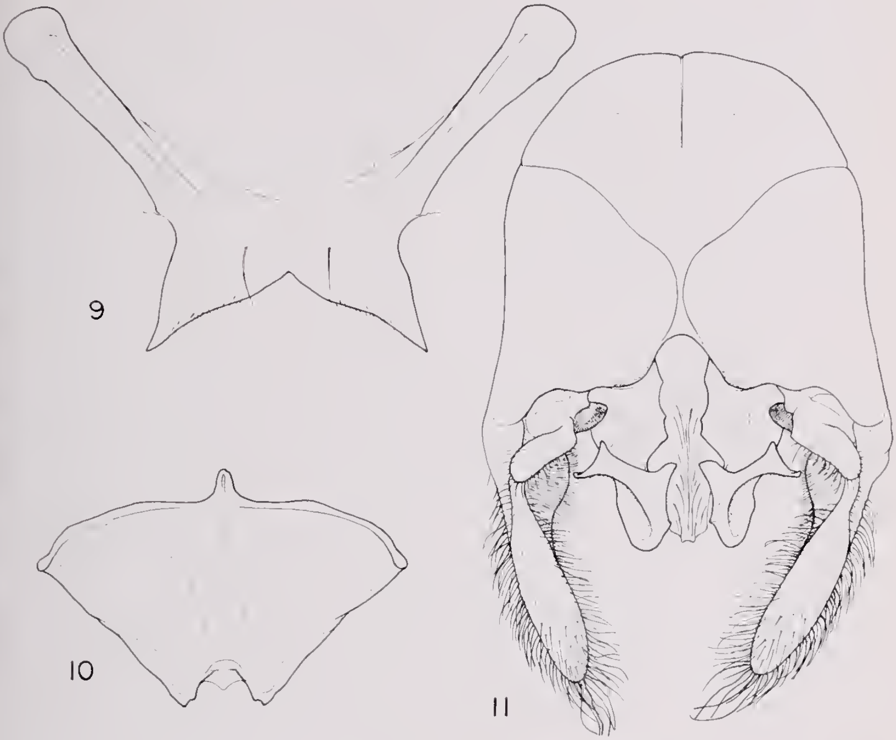
The white hair markings of *T.* **lieftincki** (Figs. 5–8) and of *valvata* are much reduced compared with those of most other South African forms, but they are even more restricted in *T.* **lieftincki**. The absence of white hairs on the genae, femora, tarsi, and anterolateral angles of the first metasomal tergum immediately distinguishes *T.* **lieftincki** from *valvata*.

Lieftinck's (1962) terminology of the thoracic white hair markings is adopted below.

FEMALE: Body size approximately 12 mm., slightly larger than that of *valvata*. Integument of body and legs black; punctation of clypeus and thoracic dorsum moderately dense but slightly coarser than that of *valvata*; punctation of dorsum of metasoma moderately dense, similar to that of *valvata*. Antennae moderately short; most flagellar segments a little wider than long. Ocelli slightly smaller than those of *valvata*; face with median, interantennal ridge somewhat less pronounced than in *valvata*; clypeus less protuberant than that of *valvata*. Legs as in *valvata* except middle and hind tibiae somewhat narrower toward apex; hind femur without tooth. Wings infuscated except for subhyaline spots beyond veins on forewing and except for more hyaline base of hind wings.

PUBESCENCE: Light hairs white. White hairs on face (Fig. 7) long, erect, suberect and restricted to two patches, each above and laterad of antennal socket; by contrast, these patches much more extensive in *Valvata* on which they also occupy part of clypeus and subantennal area; genal and postgenal hairs dark, not white as in *valvata*. Both black and white hairs of thorax erect, long, nonscale-like; thoracic white hair markings (Figs. 5, 6) reduced and either less conspicuous than those of *valvata* or absent; mediolateral scutal spots reduced to few white hairs; posterolateral scutal spots inconspicuous though present; parategular scutal spots (*plsa* of Lieftinck, 1962) narrow but elongate, extending entire length of each tegula; scutellum and axillae like those of *valvata* without white spots; tegular spots consisting, at most, of only a few white hairs; ventral episternal light hairs absent, unlike those of *valvata*. Rear coxae with small outer apical tuft of white hairs; other coxae, all trocanters, and all femora with only dark hairs; anterior tibia (Fig. 5) with posterodorsal patch of white hairs; middle tibia (Fig. 5) with white patch reduced to basal two-thirds of dorsal surface; hind tibia (Fig. 5) with white patch reduced to base of one-half to two-thirds of dorsal surface; all tarsi with only dark hairs. White hairs of metasoma decumbent but not appressed; white hair patches on each tergum small, widely separated (Fig. 5); white patches of first metasomal tergum restricted to posterolateral angle of tergum; all hairs on metasomal sterna dark.

MALE: As described for female except as follows: Antennae missing. Hind basitarsus with outer surface somewhat incurved. Genitalia and metasomal sterna VII and VIII as illustrated (Figs. 9–11).



Figs. 9–11. *Thyreus* **lieftincki**, apical metasomal sterna and genitalia of allotype, ventral view. 9. Metasomal sternum VII. 10. Metasomal sternum VIII. 11. Genitalia.

pubescence: As in female except for following: White hairs on dorsum of thorax (Fig. 8) somewhat more conspicuous so that mediolateral scutal spots moderately evident; middle coxa possibly with a few white hairs on outer side.

type material: Holotype female, one female paratype (mounted on pin), one female paratype (in alcohol), and allotype, 3 miles south of Avontuur, Cape Province, Republic of South Africa, November 15, 1966, J. G. Rozen; in collection of the American Museum of Natural History.

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TORCHIO, P. F., AND N. N. YOUSSEF. 1968. The biology of *Anthophora* (*Micranthophora*) *flexipes* and its cleptoparasite, *Zacosmia maculata*, including a description of the immature stages of the parasite (Hymenoptera: Apoidea, Anthophoridae). J. Kansas Entomol. Soc., **41:** 289–302, 21 figs.

Undescribed Species of Crane Flies from the Himalaya Mountains (Diptera: Tipulidae), XVII[1]

Charles P. Alexander
Amherst, Massachusetts 01002

Received for Publication August 5, 1968

Abstract: Six new species of eriopterine crane flies are described, all from Assam and Sikkim. These are *Trentepohlia* (*Mongoma*) **fuscogenualis**, *Teucholabis* (*Teucholabis*) **diperone**; *T.* (*T.*) **eremnopoda**; *Baeoura* **aka**; *B.* **latibasis**; and *B.* **obtusistyla**.

Part XVI of this series of papers was published in the Journal of the New York Entomological Society, **76:** 66–71, 1968. The present report continues the study of the rich collections made by Dr. Fernand Schmid in Sikkim and Assam in 1959 and 1961 and concerns species of the tribe Eriopterini, vastly developed throughout the region. I again express my thanks and appreciation to Dr. Schmid for these materials.

Trentepohlia (*Mongoma*) **fuscogenualis**, n. sp.

Size large (wing 8 mm or more); head light brown, gray pruinose, rostrum, palpi and antennae yellow; thorax almost uniformly pale yellow; legs yellow, tips of femora black, bases and tips of tibiae more narrowly darkened; wings light yellow, veins deeper yellow; cerci of ovipositor very long and slender.

MALE: Length about 7.5–8.5 mm; wing 8–9 mm; antenna 1.8 mm.

FEMALE: Length about 10 mm; wing 10 mm.

Rostrum, palpi and antennae yellow. Head light brown, heavily gray pruinose, with very long yellow setae.

Thorax almost uniformly pale yellow, praescutal stripes slightly darker. Halteres yellow. Legs with coxae and trochanters light yellow; remainder of legs darker yellow, tips of femora rather broadly black, tibiae with base more narrowly blackened, tips still more narrowly so; outer tarsal segments passing into brown; vestiture of legs short and inconspicuous, the femora with sparse longer setae over most of the length. Wings light yellow; veins deeper yellow, the outer costal border thickened, more brownish yellow.

Certain longitudinal veins beyond cord with numerous black trichia, including R_4 and distal sections of R_5 and M_{1+2}, more sparse on R_{2+3+4}, and on the fused vein R_5 plus M_{1+2}. Venation: R_2 entire but very pale; *m–cu* shortly before fork of *M*; veins Cu_1 and *1st A* at margin contiguous or shortly fused, closing the cell; cell *2nd A* very broad at near midlength.

Abdomen dull yellow. Ovipositor with cerci very long and slender, their tips gently upcurved.

HOLOTYPE: ♂, Lingdok, Sikkim, 4,000 feet, May 7, 1959 (Schmid). Allotype, ♀, Teng, Sikkim, 4,600 feet, August 1, 1959. Paratypes, ♀, pinned with allotype; 2 ♂ ♂, Tung, Sikkim, 4,500 feet, August 2, 1959; 1 ♂, Lathong, Sikkim, 6,560 feet, July 26, 1959 (all Schmid).

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[1] Contribution from the Entomological Laboratory, University of Massachusetts.

The most similar regional species are *Trentepohlia* (*Mongoma*) *horiana* Alexander, having the legs uniformly yellow, and *T.* (*M.*) *flava* Brunetti, with the femoral tips narrowly and inconspicuously infuscated, both species having cell *1st A* of the wings narrowly open by the separation of veins Cu_1 and *1st A* at margin.

Teucholabis (*Teucholabis*) **diperone**, n. sp.

General coloration of thorax yellow, the posterior praescutal disk, scutal lobes and postnotum blackened, median area of scutum, scutellum and pleura yellow; legs blackened, bases of fore femora yellowed; wings faintly tinged with brownish yellow, unpatterned except for the pale brown stigma; abdomen light brown, incisures yellowed, hypopygium dark brown; sternal pockets of male abdomen well developed; male hypopygium with outer dististyle conspicuously bispinous from a shorter base.

MALE: Length about 8 mm; wing 6.8 mm; antenna about 1.8 mm.

Rostrum dark brown, relatively long, subequal to remainder of head, palpi dark brown. Antennae brownish black; proximal flagellar segments oval, the outer ones more elongate, terminal segment oval, verticils shorter than the segments. Head dark brown.

Pronotum yellow. Mesonotal praescutum with disk polished black, including the central stripe and broad extensions to the lateral borders, humeral region and central area before suture yellow; scutal lobes polished black, the median area and scutellum light yellow; parascutella and postnotum polished black, pleurotergite slightly paler. Pleura light orange yellow. Halteres with stem brownish black, apex of the large knob yellowed. Legs with all coxae and trochanters yellow; remainder of legs brownish black, bases of fore femora yellow, including more than basal third, posterior femora uniformly darkened. Wings faintly tinged with brownish yellow, stigma pale brown; veins dark brown. Venation: Sc_1 ending far beyond origin of *Rs*; R_{1+2} and R_{2+3+4} subequal, much shorter than R_2; cell *1st* M_2 long, exceeding the distal section of M_3.

Abdomen light brown, incisures yellowed, hypopygium dark brown. Male with a conspicuous pocket on sternite five, including broad lateral setal groups, median area with seven longitudinal rows of microscopic tubercles, progressively smaller behind; sternite six with widely separated setal brushes, sternite seven with a narrowly transverse brown sclerotized plate. Male hypopygium with outer dististyle distinctive, bispinous from a shorter base; inner style with lateral arm a long narrow rod or ribbon, terminating in a long spine, margins before apex with microscopic spinulae.

HOLOTYPE: ♂, Teng, Sikkim, 4,600 feet, May 12, 1959 (Schmid).

Other regional members of the genus having the wings unpatterned or virtually so include *Teucholabis* (*Teucholabis*) *diversipes* Alexander, *T.* (*T.*) **eremnopoda**, n. sp., *T.* (*T.*) *shanensis* Alexander, and *T.* (*T.*) *solivaga* Alexander, all with the details of coloration, and especially the hypopygial structure, quite distinct. The bispinous outer dististyle of the present fly has suggested the specific name.

Teucholabis (*Teucholabis*) **eremnopoda**, n. sp.

Head polished black; mesonotum polished yellow, praescutum with a blackened saddle crossing the posterior half, pleura and pleurotergite polished yellow; halteres brownish black; posterior legs uniformly black, remaining legs with proximal half of femora yellowed; wings yellow, stigma dark brown, Sc_1 ending about opposite three-fifths *Rs*; abdomen yellow, tergites ringed with dark brown, outer segments more uniformly darkened; male hypopygium with basistyle terminating in a blackened hook, dististyle complex.

MALE: Length about 7 mm; wing 6 mm.

Rostrum and palpi black, in cases the former slightly paler basally. Antennae brownish black, proximal segment paler; flagellar segments oval, outer ones smaller and more elongate. Head polished black, slightly pruinose anteriorly.

Prothorax yellow. Mesonotum polished yellow with a major black saddle across more than the posterior half of praescutum, the median region before suture extensively yellow; each scutal lobe with a large polished black area; posterior half of mediotergite brownish black. Pleura and pleurotergite polished yellow. Halteres short, brownish black. Legs with coxae and trochanters yellow; fore and middle femora with basal halves yellow, remainder of legs black, posterior legs uniformly black. Wings with a faint yellow tinge, prearcular and costal fields clearer light yellow, stigma small, dark brown; veins brown, those at wing base yellowed. Venation: Sc long, Sc_1 ending about opposite three-fifths Rs; R_{1+2} and R_{2+3+4} subequal; cell *1st* M_2 elongate, subequal to distal section of M_{1+2}.

Abdomen yellow, proximal tergites ringed with dark brown, their bases and apices yellowed, outer segments more uniformly brown or brownish black. Male with pocket on sternite five including coarse setae in center and more delicate yellow vestiture on either side, the latter directed inward, posterior end of pocket with four narrow parallel black lines; sternite six with about 15 setae on either side, directed chiefly inward. Male hypopygium with basistyle terminating in a blackened hook, outer margin with two or three spinous points that bear axillary setae, beak slender. Dististyle subterminal, complex in structure, with three arms, including two flattened curved blades that lie superimposed, the shorter one with two strong setae on outer margin; third arm a long slender posterior spine, with a smaller lateral point on side. Phallosome a relatively slender rod, outer half with a very large flattened blade, its outer margin near base with four or five very long delicate setae.

HOLOTYPE: ♂, Dikchu, Sikkim, 2,300 feet, August 12, 1959 (Schmid). Paratopotypes, 10♂♂, with the type, mostly badly damaged by fungi.

The present fly is most similar to species such as *Teucholabis* (*Teucholabis*) *annuloabdominalis* Senior-White, differing most evidently in the extensively blackened legs, unpatterned wings, and in the quite distinct male hypopygium.

Baeoura **aka**, n. sp.

General coloration of body dark brown; legs light brown, vestiture long and conspicuous; wings strongly infuscated; male hypopygium with ninth tergite produced into a depressed glabrous median lobe, its apex truncate; sternal membrane deeply bilobed, with dense setulae and a few setae; eighth sternite terminating in an obtuse lobe; dististyle shaped like a boomerang, outer third slightly more narrowed, margined with a small flattened blade.

MALE: Length about 4 mm; wing 5–5.2 mm; antenna about 1 mm.

FEMALE: Length about 4.2 mm; wing 5.5 mm.

Rostrum and palpi brownish black. Antennae black; flagellar segments oval, the outer ones longer, all with long conspicuous verticils, those at midlength of organ longer. Head dark brown, orbits slightly paler.

Pronotum brown, pretergites paler. Mesonotum dark brown, sparsely pruinose, scutellum behind slightly paler. Pleura dark brown, dorsopleural membrane light brown. Halteres with stem brownish black, base pale, knob vaguely brightened. Legs with coxae and trochanters brown; remainder of legs light brown, outer tarsal segments darker; leg vestiture long and conspicuous. Wings strongly infuscated, stigmal region vaguely more darkened; veins dark brown. Venation: *Rs* moderately long, about one-half longer than *R*.

Abdomen dark brown. Male hypopygium with ninth tergite produced caudally into a conspicuous median depressed glabrous lobe, its apex truncate. Sternal membrane long and conspicuous, deeply bilobed, surface with short dense setulae, each lobe with four or five long setae. Apex of eighth sternite produced into an obtuse lobe. Dististyle a conspicuous blade shaped like a boomerang, outer third slightly more narrowed, tip obtusely rounded; lower margin near the point of narrowing with a small flattened blade; base of style slightly widened and produced into a spur.

HOLOTYPE: ♂, Lifakpo, Kameng, North East Frontier Agency, Assam, 3,100 feet, May 29, 1961 (Schmid). Allotopotype: ♀. Paratopotypes: 3♂♂.

The male hypopygium, especially the ninth tergite and eighth sternite is most as in *Baeoura nilgiriana* Alexander and allies, differing in other structures. The deeply bilobed ninth sternite is much as in *B. bilobula* Alexander but the tergite is quite distinct.

Baeoura **latibasis**, n. sp.

Size relatively large (wing of male about 5.5 mm); general coloration of thorax blackened, sparsely pruinose to appear plumbeous; legs brownish yellow, with very long outspreading setae; wings with R_{1+2} long, about one-half *Rs* or more; male hypopygium with posterior border of tergite trilobed, central lobe subacute to nearly acute at tip, laterals obtuse; dististyle with basal third expanded.

MALE: Length about 4 mm; wing 5.5–5.6 mm.

FEMALE: Length about 4 mm; wing 5 mm.

Rostrum yellow, palpi brownish black. Antennae brownish black; verticils of the more proximal segments nearly three times the segment. Head dark brown, heavily light gray pruinose.

Pronotum and pretergites brownish yellow. Mesonotum blackened, sparsely pruinose to appear plumbeous, posterior border of scutellum obscure yellow. Pleura chiefly blackened, metapleural region restrictedly paler, dorsopleural membrane brownish yellow. Halteres brown. Legs with coxae and trochanters brownish yellow; remainder of legs obscure yellow, segments with very long outspreading setae. Wings very faintly infuscated, prearcular and costal fields light yellow, stigma not indicated; veins brown, trichia long and conspicuous, darker brown. Venation: R_{1+2} very long, about one-half *Rs* or longer; R_{2+3+4} from about two to two and one-half times the basal section of R_5, R_{2+3} oblique in position; branches of *Rs* generally parallel to one another, cells R_2 and R_3 at margin subequal in extent or the latter slightly greater; *m–cu* shortly before midlength of M_{3+4}.

Adomen dark brown, hypopygium still darker. Male hypopygium with posterior border of tergite conspicuously trilobed, lateral lobes longer with obtuse tips, median projection about two-thirds as long, tip subacute to nearly acute. Dististyle long, basal third expanded, about three times as wide as the outer portion which is slightly dilated, truncate to feebly emarginate, with two strong spinoid setae in the notch, setae in holotype slightly longer.

HOLOTYPE: ♂, Bhairabkunda, Kameng, North East Frontier Agency, Assam, 700–1,000 feet, March 5, 1961 (Schmid). Allotopotype, ♀, pinned with type. Paratopotypes, 1♂, 1♀.

The most similar species is *Baeoura tricalcarata* Alexander, which likewise has the tergite of the male hypopygium trilobed, differing evidently in other details of venation, nature of the leg setae, and male hypopygium.

Baeoura **obtusistyla**, n. sp.

Allied to *acustyla*; general coloration of thoracic dorsum blackened, including major oval areas on sides of praescutum; antennae and legs blackened throughout; wings very faintly darkened, stigma pale brown, veins R_3 and R_4 strongly divergent, the latter terminating just before the wing tip, cell R_3 at margin about four times cell R_2; male hypopygium with a group of three or four major setae at outer end of basistyle; dististyle almost parallel-sided, apex broadly obtuse.

MALE: Length about 3.5–4 mm; wing 3.3–3.9 mm; antenna about 0.9–1.0 mm.

FEMALE: Length about 4–4.2 mm; wing 4.2–4.3 mm.

Rostrum and palpi black. Antennae black throughout, the pedicel more intensely so; flagellar segments elongate, somewhat shorter than the longest verticils. Head light gray.

Pronotum blackened. Mesonotal praescutum with central area plumbeous gray, narrowly blackened at anterior end, sides with a major opaque intensely blackened oval area; posterior sclerites blackened, gray pruinose. Pleura blackened, sparsely pruinose to appear plumbeous. Halteres dark brown. Legs blackened throughout, coxae slightly more plumbeous; vestiture of legs short and inconspicuous. Wings very faintly darkened, prearcular and costal fields more whitened, stigma pale brown; veins dark brown, conspicuous. Venation: Veins R_3 and R_4 strongly divergent, the latter outwardly deflected strongly caudad, terminating just before wing tip, cell R_3 at margin about four times cell R_2; *m–cu* about one-fourth its length beyond fork of *M*.

Abdomen brownish black. Male hypopygium with tergite broadly transverse, posterior border truncate, lateral angles produced into small triangular points. Basistyle at inner apical angle with three or four unusually long setae, approximately half as long as the dististyle. Dististyle strongly curved, beyond the slightly expanded base almost parallel-sided, apex broadly obtuse. Phallosome with the slender aedeagus long and straight, subtending apophyses narrow, their tips obtuse.

HOLOTYPE: ♂, Bhairabkunda, Kameng, North East Frontier Agency, Assam, 700 feet, March 7, 1961 (Schmid). Allotopotype, ♀ and paratopotypes, ♂, ♀, on a single pin, March 8, 1961.

The most similar species include *Baeoura acustyla* Alexander and *B. sternata* Alexander, both with the venation and general coloration much the same, differing most evidently in details of hypopygial structure.

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The following volumes have been received by this Journal from the S-H Service Agency, Inc., the distributing branch of the Hafner Publishing Co., which is located at the same address:

Insect Microbiology by E. A. Steinhaus, 763 p., (1946) reprint 1967, $15.00.
Principles of Insect Pathology by E. A. Steinhaus, 757 p., (1949) reprint 1967, $15.75.
Fleas of Eastern United States by Irving Fox, 191 p., (1940) reprint 1968, $7.00.
Fleas of Western North America by C. A. Hubbard, 533 p., (1947) reprint 1968, $12.50.

J. Forbes

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CONTENTS

Notes on the Biology of *Ctenophthalmus p. pseudagyrtes* Baker in the Northeast (Siphonaptera: Hystrichopsyllidae)

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RECEIVED FOR PUBLICATION OCTOBER 21, 1968

Abstract: *Ctenophthalmus p. pseudagyrtes* Baker occurs on a wide variety of mammals, and occasionally on birds. It occurs in greatest numbers on Cricetidae, Talpidae, and Soricidae. A population peak occurs in March–April in the northeast, but the species is taken throughout the year. Unlike most flea species, this one shows nearly equal collections of males and females except during the winter months. No habitat preference is clearly demonstrated, except that underground nests and burrows appear to be essential.

Life history studies on fleas have been restricted for the most part to a few species of public health importance. Many abundant species which are important to the ecology of their wildlife hosts remain to be studied. One of the most abundant of northeastern fleas is *Ctenophthalmus p. pseudagyrtes*, a species which shows very little host specificity and very wide distribution. The present study uses data from collected specimens, and is not based on observations of living individuals.

Most prepared slides of fleas include data on locality, date, and host. A few contain indication of elevation or habitat type. From such data, certain facts of the ecology of the species may be deduced with comparative certainty. The most serious shortcoming is that collections are often more or less random as to time and place, with collecting often concentrated in the warmer months. Thus, data on host distribution are quite dependable, while data on seasonal distribution may reflect the seasonal activity of the collector rather than that of the flea. When data on habitat are available, and when collectors sampled a wide variety of ecological conditions, such data are valuable.

The data for this study were taken from collections made by the New York State Museum and Science Service (Benton and Krug, 1956; Connor, 1960; Benton, 1966, and several unpublished lists); the Pennsylvania Game Commission (Holland and Benton, 1968); many students and friends (Cummings, 1955; Benton and Smiley, 1963; and many unpublished records); and from

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Fig. 1. Numbers of specimens of *Ctenophthalmus p. pseudagyrtes* for each month, based on 1,101 individuals.

publications on the fleas of New Jersey (Burbutis, 1956); New York (Geary, 1959); Vermont (Osgood, 1963); and New England (Parsons, unpublished MS: Main, unpublished MS).

SEASONAL DISTRIBUTION

Most species of fleas show distinct seasonal fluctuations in numbers, and many have been reported as adults during only part of the year. As shown in Fig. 1, *Ctenophthalmus pseudagyrtes* occurs in the adult stage throughout the year. There is an obvious peak in early spring, and a second peak in late summer. The latter may reflect increased collecting activity during the warmer months.

The spring peak coincides closely with the resumption of breeding by its most important hosts. Reproduction is greatly reduced or entirely stopped from late November to early February in local populations of *Microtus*, *Pitymys* and other small mammals. First litters produced in late February or early March coincide with the rise in flea specimens.

TABLE 1. Host distribution of 1,217 individuals of *Ctenophthalmus p. pseudagyrtes* from the northeastern United States.

Microtus pennsylvanicus	376	*Sorex cinereus*	3
Blarnia brevicauda	250	*Otus asio*	3
Pitymus pinetorum	146	*Tamiasciurus hudsonicus*	2
Clethrionomys gapperi	90	*Sciurus carolinensis*	2
Peromyscus spp.	89	*Ondatra zibethica*	1
Scalopus aquaticus	72	*Glaucomys volans*	1
Condylura cristata	54	*Glaucomys sabrinus*	1
Parascalops breweri	38	*Zapus hudsonius*	1
Tamias striatus	31	*Erethizon dorsatum*	1
Rattus norvegicus	20	*Sylvilagus floridanus*	1
Mustela spp.	9	*Mus musculus*	1
Synaptomys cooperi	8	*Neotoma magister*	1
Napeozapus insignis	6	*Marmota monax*	1
Didelphis marsupialis	3		
Microtus chrotorrhinus	3	Total fleas	1,217
Sorex fumeus	3	Total hosts:	29

A direct connection between the reproductive cycle of the host and that of the flea has been shown for the European rabbit flea, *Spilopsyllus cuniculi* (Mead-Briggs, 1964; Rothschild and Ford, 1964). The closely timed upsurge in numbers of both host and parasite in the present case suggests the possibility of a similar connection.

HOST DISTRIBUTION

Table 1 shows the host distribution of 1,217 specimens for which such data are available. The first three species on the list are represented in approximately the ratio in which they were taken in the collections studied. Moles of three species are relatively heavily infested in relation to the numbers taken. Deermice (*Peromyscus* spp.), on the other hand, are very lightly infested in relation to the numbers collected, and must be considered a secondary host. All others are no doubt accidental hosts, and play no important role in the ecology of the species. It seems probable, however, that the ability to feed on any of the common small mammals of the area is an important reason for the abundance of this species.

Most of the specimens from accidental hosts are females, probably an indication of the longer lives and greater food requirements of this sex.

SEX RATIO

It is axiomatic that more female fleas are collected than males. Such is not usually the case with *Ctenophthalmus*. Some of our sources did not separate males and females, but among those which did there was a ratio of about 1.2 females per male. This variation was due to a preponderance of females in winter. In all other seasons the number was approximately equal. It seems certain that the breeding season extends from March to November, thus coinciding with the breeding seasons of the most common hosts.

ECOLOGICAL DISTRIBUTION

Some species of fleas show a distinct altitudinal distribution, but *Ctenophthalmus pseudagyrtes* occurs from sea level to the Alpine zone of the Adirondacks. However, of 21 specimens collected in the vicinity of Whiteface Mountain in 1961–62, only one was from elevations above 3,000 feet. Considering the large number of mammals of suitable host species taken during these two summers, this would appear to indicate that the species is very rare at these high elevations. Since Canadian records to the north are all from southern Canada (Holland, 1949), this species is apparently not adapted to extremes of cold.

It is found on species of dry sandy land, such as *Pitymys,* and on such moisture-loving species as *Condylura.* Specimens from predominantly field-dwelling species, such as *Microtus pennsylvanicus*, are balanced by large collections from forest-inhabiting species, such as *Clethrionomys gapperi.* No association with any particular vegetational type is apparent.

It is significant, however, that all of the nine most commonly parasitized species are small mammals which utilize burrows and surface runways extensively. Cursorial species, such as the jumping mice, *Zapus* and *Napeozapus*, are seldom parasitized, while specimens from the arboreal squirrels are equally rare. The burrow-inhabiting chipmunk, on the other hand, is a frequent host. This species, like many other flea species in which the eyes are vestigial, is primarily a burrow-inhabitant species, and transfers much more readily than most species to any small mammal which may travel along these burrows. It probably breeds exclusively in underground nests.

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Erratum

In the paper *Additions to the Supplemental List of New Jersey Macrolepidoptera* by Joseph Muller, which was published in the December 1968 issue of the **Journal** (**76:** 303–306), on p. 304 under the SATYRIDAE, the line beginning 638 should read:
eurydice appalachia R. L. Chermock, 1947.

Behavioral Adaptations of Cryptic Moths. II. Experimental Studies on Bark-like Species

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Abstract: Three experiments were conducted on a variety of bark-like geometrid and noctuid moths, using an experimental apparatus which allowed a choice between black and white backgrounds. These experiments indicated that the appropriate background selections of the moths studied in this apparatus were not the result of (1) simple photo-tactic escape responses, (2) "imprinting" processes occurring shortly after emergence, or (3) reflectance-matching mechanisms, involving comparisons of wing and background reflectances. These results are viewed as additional evidence for genetically fixed reflectance preferences in bark-like cryptic moths.

Prior studies have demonstrated that a variety of bark-like geometrids and noctuids will select appropriate backgrounds in an experimental apparatus which presents a choice of backgrounds differing in reflectance (Kettlewell, 1955; Sargent, 1966; Sargent and Keiper, 1969). In addition, by painting the circumocular scales of two species, and thereby altering their reflectances, I have obtained evidence which suggests that these background preferences are genetically fixed (Sargent, 1968).

The present paper summarizes results from three additional experiments which were carried out during the summer of 1968 in Leverett, Franklin Co., Massachusetts. The first of these experiments was designed to determine whether appropriate background selections of cryptic moths in an experimental apparatus might simply be due to photo-tactic escape responses (i.e. movement toward the lightest or darkest portions of the apparatus). The second experiment was an attempt to determine whether cryptic moths might "imprint" to particular backgrounds shortly after emergence, and subsequently select backgrounds of similar reflectance. Finally, the third experiment was designed to determine whether the wings (and flight) of cryptic moths are necessary for their selection of appropriate backgrounds.

GENERAL METHODS AND MATERIALS

The apparatus used in these experiments consisted of a plywood box (15 inches square by 19 inches high), into which a cylinder (44 inches in circumference and 19 inches high) was set. This cylinder was formed of four painted sections of blotting paper (each 11 by 19 inches), two black and two white.

Acknowledgments: I thank Dr. Ronald R. Keiper and my wife, Katherine, for valuable assistance in the field.

Phigalia titea

POSITION OF MOTHS	BACKGROUNDS Black	White
Upper Half	28	64
Lower Half	24	49

Fig. 1. The distribution of individuals of *Phigalia titea* on the black and white backgrounds, in both the upper and lower halves of the experimental apparatus.

These sections were arranged vertically in an alternating black and white sequence. The entire apparatus was covered with a pane of window glass, and placed in a wooded area where a thick canopy excluded direct sunlight. Moths were introduced into the cylinder by sliding the glass top to one side.

The moths were taken at 150-watt Westinghouse outdoor spotlights at my home in Leverett, Massachusetts. Immediately after capture, and any experimental manipulation, the moths were released into the experimental apparatus. The following morning, between 0600 and 0800 EST, the positions of the moths in the apparatus were noted.

THE EXPERIMENTS AND RESULTS

EXPERIMENT 1. It has been suggested that the tendencies of light moths to select light backgrounds, and dark moths to select dark backgrounds, in experimental situations might be the result of positive and negative photo-tactic escape responses respectively. If this were the case, one would expect light moths to come to rest near the top of the white backgrounds in my experimental apparatus (i.e. close to the light source), and dark moths to rest near the bottom of the black backgrounds. To test this possibility, I noted whether resting individuals of several species were in the upper or lower half of the experimental apparatus when checking their background selections in the morning.

Results obtained with *Phigalia titea* Cramer (Geometridae), a species represented by a particularly large sample, are presented in Fig. 1. Analyses of these data reveal that (1) the total numbers of moths resting in the upper and lower halves of the experimental apparatus are not significantly different (chi-square 2.18, P greater than 0.10), and (2) the distributions of the moths on the different backgrounds in the upper and lower halves of the apparatus are not significantly different (chi-square 0.03, P greater than 0.80), both distributions revealing a highly significant preference for the white backgrounds (chi-squares greater than 8, both P less than 0.01). Similar results have been obtained with smaller samples of several other species, including the dark noctuids *Catocala*

Catocala antinympha

PRIOR HISTORY OF MOTHS	TEST BACKGROUNDS	
	Black	White
Wild-Caught	11	1
White Background	5	0

FIG. 2. The distributions of wild-caught and previously "imprinted" individuals of *Catocala antinympha* on the black and white backgrounds of the experimental apparatus.

antinympha Hübner and *Chytonix palliatricula* Guenée. In these latter species there were also slight, but insignificant, preferences for the upper half of the apparatus, and here the black backgrounds were preferred in both halves.

EXPERIMENT 2. The possibility that moths might acquire background reflectance preferences through imprinting-like processes occurring shortly after emergence (see e.g. Thorpe, 1963) has been pointed out to me by several people. This possibility, although remote in my view, does seem to warrant some consideration in monophagous or oligophagous species whose usual host-plants possess bark which is similar in reflectance characteristics to the moths' wings. Such a situation prevails with *Catocala antinympha* Hübner (Noctuidae). The usual host-plant of this extremely dark moth is sweet fern, *Comptonia peregrina* [L.] Coulter, a shrub (not a true fern) with very dark bark. *C. antinympha* normally pupates in dead leaves beneath this host-plant, and therefore might often crawl up sweet fern stems after emerging.

To test this possibility of "imprinting," an experiment with *C. antinympha* was carried out. A number of larvae were collected from local sweet fern and reared in breeding cages (Ward's 14W 7500) until pupation. The pupae were then placed in an apparatus which was identical to that used in experiment 1, except that the backgrounds were all white. When the moths emerged, they crawled up on these white backgrounds, and were allowed to rest there for at least one day (minimum of 24 hrs., maximum of 36 hrs.). These moths were then tested in the black and white experimental apparatus in the usual manner. Although the number of moths used in this experiment was small, they all selected black backgrounds (Fig. 2), revealing a preference which did not differ from that of wild-caught controls (Fisher exact probability test, P equals 0.70).

EXPERIMENT 3. In a previous study (Sargent, 1968), the reflectances of two species were altered by painting the scales around their eyes (head, thorax, and bases of forewings). The background selections of these treated moths did not differ from those of controls, a result which was interpreted as evidence for genetically fixed background preferences in these species. However, the possibility

Campaea perlata

MOTHS	BACKGROUNDS Black	BACKGROUNDS White
Controls	1	11
Wings removed	1	14

Fig. 3. The distributions of experimental (cyanide and wing removal) and control (cyanide only) individuals of *Campaea perlata* on the black and white backgrounds of the experimental apparatus.

remained that the moths might be reflectance-matching the unpainted portions of their wings with the backgrounds (perhaps in flight, when the wings could be viewed by the moths). Accordingly, another simple experiment was carried out on one of these species. *Campaea perlata* Guenée (Geometridae).

Several individuals of *C. perlata* were rendered inactive in a cyanide jar as they were collected. When the flutterings of these moths ceased, most of their wings were removed by scissors, cutting as close to the body as possible (and always removing at least three-quarters of the wing surface area). Upon recovery from the effects of the cyanide, these moths could not fly, but could crawl onto vertical surfaces. These moths were then tested in the black and white experimental apparatus, and their performance was compared to that of controls which received the cyanide treatment only (Fig. 3). The distributions of moths in the two groups on the experimental backgrounds did not differ (Fisher exact probability test, P equals 0.51), both groups exhibiting a highly significant preference for the white backgrounds (chi-squares greater than 8, both P less than 0.01).

DISCUSSION

The experiments reported here provide additional evidence for the view that background selections of cryptic moths are determined, at least in part, by reflectance characteristics of the backgrounds, and that these selections are based on genetically fixed reflectance preferences.

The results of the first experiment suggested that background selections do not result from simple photo-tactic responses. This result was expected in view of my field observations on bark-like cryptic species. For example, *Catocala antinympha*, which is very dark, almost always rests on dark tree trunks (e.g. young white pine, *Pinus strobus* L.), but often in very exposed situations.

The second experiment indicated that a moth's early adult experience does not influence its subsequent choices of backgrounds. This result was again expected in view of field observations. A relevant example is provided by *Cosymbia pendulinaria* Guenée (Geometridae) which normally feeds and pupates on sweet fern, *Comptonia peregrina*. Although the bark of sweet fern is very dark, this moth is very light and prefers to rest on light trees such as gray birch, *Betula populifolia* Marsh. The possibility of larval "imprinting" to the bark of a host-plant was not investigated, although situations like that described for *C. pendulinaria* would argue against such an event.

Finally, the results of the third experiment failed to support the view that background selections result from a reflectance-matching process, involving the moths' wings. Thus, all of the experimental results obtained to date provide evidence for genetically fixed background preferences in bark-like cryptic moths.

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Free Amino Acids and Derivatives in Eggs of *Tenebrio molitor* During Development

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Abstract: Seventeen free amino acids and three derivatives, asparagine, glutamine, and taurine, were identified in the developing eggs of the meal worm and have been quantitatively determined. Changes in concentration for these compounds showed an increase in total concentration by the fifth day of development, and a decrease in volume to the last day, the eighth, which, nevertheless, was higher than the concentration at the start of development.

Although insects are characterized by having high concentrations of free amino acids, there is no definite agreement as to the roles they play in insect metabolism (Roeder, 1953). The available literature pertains, mostly, to post-embryonic stages and shows that the common amino acids and the amides, asparagine, glutamine, and taurine, are present (Gilmour, 1961; Chen, 1962). Similar reports for the developing egg are rather sparse. The general consensus indicates that the amino acid pool in the developing egg is comparable to the adult (Chen, 1966).

Recent investigations assigning a physiological significance to the high titre of free amino acids and their fluctuations during development have been noted by Henry and Cook (1963) for the black blow fly, *Phormia regina*, and by Pant and Agrawal (1965) for the moth, *Philosamia ricini*. Metabolic responses associated with the break down of pre-existing yolk reserves and leading to the formation of tissue and organ specific proteins through free amino acid and peptide intermediates have been studied by Colombo (1962) and Chen (1967).

The present study provides data showing amino acid patterns existing for each day of the developing meal worm embryo. Studies of the amino acid history during embryogenesis will provide data necessary for interpreting the accompanying morphological and physiological events.

MATERIAL AND METHODS

Newly emergent adults were collected daily from a pupal reservoir and transferred to a bread-meal culture for a five day conditioning period. During this time they developed their black color. These adults were then placed in a glass specimen dish containing flour for the subsequent egg collections. The eggs were harvested daily by sifting the flour through a 0.45 mm. mesh sieve, sorted

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Editor's Note: Word has been received that Dr. Po-Chedley died on April 1, 1969.

according to age, stored in separate vials and incubated at 25°C., 70 per cent R.H. Under these conditions the embryological period is eight days.

The techniques of paper and thin layer chromatography were used for amino acid determinations. Fifty milligrams of eggs (about 100 eggs) were homogenized in a 15 ml. centrifuge tube and extracted with 10 ml. of 95 per cent ethanol for 30 minutes. The homogenate was centrifuged and the clear supernatant fluid collected. The residue was re-extracted with 5 ml. of 95 per cent ethanol until the supernate was negative to ninhydrin. The pooled supernates were evaporated down to a 1 ml. volume for chromatographic determinations. One to five microliters of the pooled sample were used for both one- and two-dimensional runs. The chromatogram sheets were sprayed with 0.5 per cent ninhydrin, and dried at 60°C. for 15 minutes for the development of the amino acid colors. Besides ninhydrin, other spray reagents were used to identify specific amino acids, arginine, proline, tyrosine and sulphur compounds (Pant, 1965). Quantitative determinations were made by cutting the paper into strips and measuring color intensity of individual spots by direct photometry.

OBSERVATIONS

A total of twenty free ninhydrin positive compounds were identified on all the chromatograms and their concentrations recorded for the eight days of meal worm embryogenesis (Table I). The daily changes in total concentrations for the amino acids show a diphasis response. The concentrations range from 156.7 to 196.3 mg. per cent from the first to the fifth day of growth. The values subsequently decrease to 166.7 mg. per cent by the eighth day. The high concentrations existing at the fourth and fifth days of embryology occur at the time when larval morphology has become established. This interval serves as a useful criterion for evaluating amino acid relationships to metabolic processes which provide some insight into morphological and physiological events.

The behaviour of certain amino acids and derivatives may be noted. Glycine, the most abundant amino acid, decreased steadily in concentration during the first five days of growth. Tyrosine and phenylalanine show opposing changes in concentration in that the tyrosine history is U-shaped and phenylalanine is ∩-shaped.

During the decrease of glutamic and aspartic acids for the eight days of growth there was a steady increase in the concentration of their amides, glutamine, and asparagine. Both the sulphur amino acids, cystine and methionine, increased steadily during the period of growth. The compound in lowest concentration during the entire period was taurine.

DISCUSSION

The seventeen free amino acids and three derivatives found in meal worm eggs were present in all the analysed stages. The change in total concentration during

Table I. Changes in ninhydrin positive compounds determined in the developing meal worm embryo; values expressed in mg. per cent amino nitrogen.

	days of growth							
compounds	1	2	3	4	5	6	7	8
alanine	8.5	9.2	8.4	12.6	14.2	15.1	13.2	13.1
arginine	4.8	4.6	5.0	5.6	5.1	4.3	4.7	3.0
asparagine	2.5	3.0	5.2	6.0	6.2	6.8	6.6	11.2
aspartic acid	14.2	14.7	14.0	12.1	10.5	10.1	9.8	3.1
cystine	6.5	5.5	5.8	7.2	8.0	10.0	13.2	14.5
glutamic acid	15.5	16.0	12.0	11.2	12.0	8.6	4.2	2.1
glutamine	3.3	6.1	9.2	11.6	12.2	13.1	11.0	13.2
glycine	20.5	18.6	17.1	15.1	13.2	14.9	15.0	15.0
histidine	5.1	7.6	8.2	10.1	8.7	7.9	7.0	4.9
leucines	12.2	11.5	11.9	12.9	12.1	12.7	13.8	13.8
lysine	8.0	9.1	9.2	10 1	10.4	9.8	9.2	8.6
methionine	4.6	6.2	8.3	8 4	8.4	7.5	9.1	9.2
phenylalanine	12.2	14.9	16.1	18.1	18.0	17.2	15.1	12.2
proline	8.2	10.2	13.2	15.7	16.4	13.9	12.1	9.2
serine	4.6	5.0	5.9	7.2	7.0	6.8	6.2	6.1
taurine	2.5	1.8	1.4	1.6	1.7	2.0	1.8	1.8
threonine	3.5	4.0	5.1	6.2	6.0	4.1	3.0	3.0
tryptophane	5.7	4.3	6.1	7.9	7.0	7.0	7.8	6.9
tyrosine	9.5	9.1	5.9	3.6	3.0	2.2	5.2	9.7
valine	4.8	5.1	5.9	7.9	6.2	6.7	6.5	6.1
totals	156.7	166.6	173.9	189.5	196.3	180.7	170.6	166.7

the course of embryogenesis for the meal worm has been similarly noted for the locust by Colombo (1962) and for the mosquito by Chen and Briegel (1965). It was suggested (Colombo, 1962) that such concentration changes were due to mobilization of yolk reserves for protein systhesis during the first phase of embryogenesis. During the latter part of development the decrease in amino acid concentration indicated a decline in yolk proteolysis. The amino acid pool satisfied the requirements for differentiation as the final amino acid concentrations are higher than those noted at the start of development.

An examination of changes in concentration for individual amino acids may account for certain aspects of metabolic activity prevailing during the course of development.

Glycine was present in highest concentration at the start of development. It may be that this initial effect was related to the reservoir of glycine in the yolk of the one day old egg (Colombo, 1962). The gradual increase in concentration for glycine at the end of development appears to substantiate Kutscher and Ackermann's (1933) contention that the velocity of insect metabolism prevented the acid from accumulating in high concentration.

The initially high aggregates of aspartic and glutamic acids are followed by a steady decrease in volume while the corresponding amides, asparagine, and glutamine, increase in concentration during the same period of growth. These reactions indicate an interconversion of these compounds (Kilby and Neville, 1957; Colombo, 1962; Chen, 1966).

Published data (Chen and Briegel, 1965) shows a clear correlation between tyrosine concentrations and pigmentation development. The *Tenebrio* embryo, however, shows no discernible pigmentation during its period of growth. Pigmentation occurs in the larva about three days following its eclosion. In this instance the high concentration of tyrosine accumulated at the end of embryology would act as the reserve necessary for larval pigmentation. The early decrease of tyrosine and the corresponding rise of phenylalanine and cystine occur at the time, the third through the fifth day of growth, when cuticular synthesis occurs (Golberg and DeMeillon, 1948; Colombo, 1962).

Both sulphur containing amino acids, cystine and methionine, increased in volume during the growth period. In *Melanoplus differentialis* embryos a transfer of sulphur between these compounds was reported by Fu (1957). The impression that cystine acts as a precursor for taurine is not demonstrated in the meal worm data. The constant volume of taurine and increasing concentration of cystine during the period of growth rules out such a possibility at this time.

Although the enumeration of the amino acids and derivatives present during meal worm embryogenesis does not explain physiological changes, it does provide a framework within which examination of individual compounds may be furthered. The functions of the different compounds may be more fully interpreted when different tissues are analysed (Deuchar, 1958) and when yolk and embryos are separately examined (Colombo, 1962).

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Antennal Tuft Organs of *Pediculus humanus* Linn. and *Phthirus pubis* (Linn.) (Anoplura: Pediculidae)

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Abstract: Scanning electron microscopy reveals two tuft organs each with an average of six hairs in *Pediculus humanus* Linn. Similarly located tufts of *Phthirus pubis* (Linn.) average nine hairs. Two pore organs on the fifth antennal segments of both these lice are also described.

The antennal tuft organ of *Pediculus humanus* Linnaeus was described by Keilin and Nutall (1930) as a tuft of four sensory hairs with a tube penetrating into a sensory ganglion. Only one such organ was pictured on their plate of the antenna of the first instar of *P. humanus.* Wigglesworth (1941) referred to three such structures on the dorsolateral aspect of the terminal segment and one at the apex of the fourth segment on the lateral side of the antenna. His illustration of the tuft showed it to consist of four delicate hairs on a cone which arises from within the antenna. This description has been repeated in many texts. The scanning electron microscope allows this structure to be described more accurately.

MATERIALS AND METHODS

This study is based on 96 specimens of *P. humanus* representing six different populations. Two of the populations were head lice from North America and the remaining were body lice from North America and Mexico, including one from a laboratory colony which had been reared on rabbits for many generations. Twelve specimens of *Phthirus pubis* (L.) from Europe were also examined. Males and females from each population were studied and the nymphal stages

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I am grateful to Mrs. Doris Johnson and Miss Dolores Krause for their technical assistance. My sincere thanks to Doctors John L. Duffy and Irving Abrahams of Meadowbrook Hospital, and to Dr. Janardhan G. Butte of the N. Y. State University at Farmingdale for their discussions and reading the manuscript.


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were examined from the laboratory colony. The specimens were fixed in 70% alcohol. Intact lice were mounted on metal specimen holders using aluminum paint for both adhesion and grounding. The paint was air dried and the specimens were then coated with gold in a vacuum chamber. They were studied under the scanning electron microscope, a Cambridge Steroscann Mark II, at 20KV.

OBSERVATIONS AND DISCUSSION

Ferris (1951) indicated that there is no sexual dimorphism of the antennae in either *Pediculus* or *Phthirus* lice. Scanning electron microscopy confirms this. Examination of the *P. humanus* antennae revealed only one tuft organ on the dorsolateral aspect of the fifth, or terminal, segment (Fig. 1). Contrary to Wigglesworth (1941) no other similar structures could be located despite a diligent search. However, two pore organs were seen in the approximate locations where he had reported the tufts to be. These pore organs consist of a series of slits measuring approximately 0.3 microns in length, surrounding a smaller central opening (Fig. 6). The outside diameter of the circle of slits is approximately 3 microns. Several of these pore organs showed the presence of a precipitation around the slits and central opening (Fig. 7). These structures were present in all the lice studied, and it might be that they were mistaken for tuft organs. Studies are being continued to determine the function of these pores.

A tuft organ found on the dorsolateral aspect of the fourth segment is morphologically similar to that on the terminal segment. The tuft organ is composed of a cluster of finger-like projections arising from the apex of a stalk, the base of which is not seen as it descends through an opening. This opening is 2.5 to 3.0 microns in diameter. In some of these organs the apex protrudes through the opening, whereas in others it is retracted. The number of finger-like projections, referred to in the literature as hairs, were found to vary from four to seven. Four finger-like projections were seen only on the first instars (Fig. 2) of the laboratory colony. In the adult organs, those with six hairs (Fig. 3) occurred most frequently. The four tuft organs on a single louse often exhibited a variable number of hairs present with no detectable pattern as to sex. However, the larger number of hairs usually appeared on the tufts of the fourth segment when they did differ. There is suggestive evidence that the four hairs may split to form six or seven hairs (Figs. 4 and 5). The individual intact hairs of adult lice measure approximately 2 to 3 microns in length and 0.3 microns in width. The individual hairs of the tuft of the first instar varies considerably in length from 1 to 4 microns.

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Figs. 1–5 Antennal tuft organs of *Pediculus humanus*. 1. 4th and 5th antennal segments. × 900. 2. 4 hairs of first instar. × 6,300. 3. typical 6 hairs. × 5,700. 4. splitting of 2 hairs on first instar. × 5,700. 5. splitting of a hair on adult. × 5,800.


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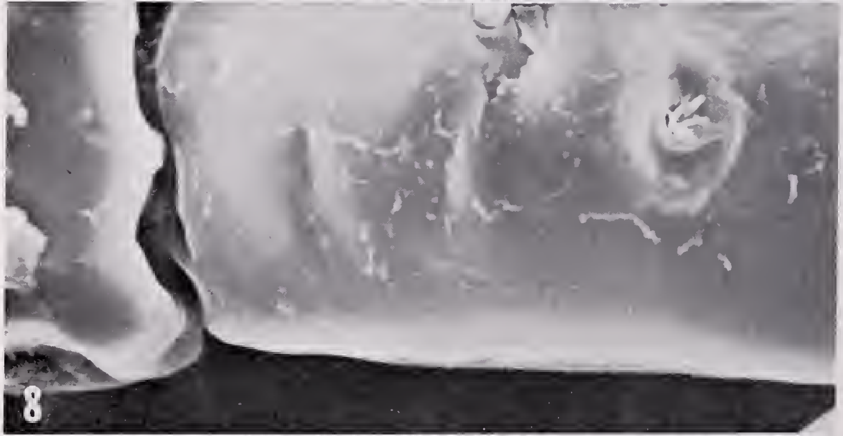
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No previous description of the tuft organ of *Phthirus pubis* was found in a review of the literature. In this species two organs were found on each antenna. One was centrally located on the dorsolateral aspect of the fifth, or terminal, segment and the second was found in close proximity to a seta on the lateral, subapical end of the fourth segment (Fig. 8). The tuft organs are morphologically similar to each other. The essential difference between the tufts in this species as compared with *P. humanus* is in the number of hairs arising from the apex of the stalk. The average number of tuft hairs is nine but this number can vary from eight to ten hairs (Figs. 9 and 10). Again the larger number of hairs was usually seen on the tuft organ of the fourth segment. Two pore organs were seen on the fifth, or terminal, segment in approximately the same location as was seen on *P. humanus*.

The two genera reported in this study are similar in the following respects: in the morphological appearance of the tuft organs, in the absence of sexual dimorphism and in the position of the tuft hairs, and in the presence of two previously undescribed pore organs on the fifth, or terminal, segment.

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Figs. 6–7 Antennal pore organs of *Pediculus humanus*. 6. pore organ on fifth segment. × 5,730. 7. precipitant covering pore organ. × 2,800.

Figs. 8–10 Antennal tuft organs of *Phthirus pubis*. 8. 4th and 5th antennal segments. × 1,200. 9. typical nine hairs. × 5,700. 10. ten hairs on adult. × 7,000.

BOOK REVIEWS

A QUINARY OF BOOKS*

Introduction to Zoology. Theodore H. Savory. Illustrated by Melchior Spoczynski. Philosophical Library Inc., New York. 1968. $6.00.

The Pocket Encyclopedia of Plant Galls. Arnold Darlington. Illustrated by M. J. D. Hirons. Philosophical Library Inc., New York. 1968. $7.50.

Earth's Bug-eyed Monsters. Alice L. Hopf. W. W. Norton & Co., Inc., New York. 1968. $4.50.

Six-legged Science. Brian Hocking. Schenkman Publishing Co. Inc., Cambridge, Mass. 1968. $4.50.

A Guide to Spiders and Their Kin. Herbert W. and Lorna R. Levi, under the editorship of Herbert S. Zim. Illustrated by Nicholas Strekalovsky. Golden Press, New York. 1968. $1.00.

The editorial office of the Journal has recently received five small books which should receive the courtesy of a review although not all of them will be of interest to the readers of **The Journal**.

The first of these, **Introduction to Zoology**, is a pocket-size text of systematic zoology. Aside from a few pages on the principles of classification it consists of an outline of the taxonomy of animals down to ordinal rank, with compact descriptive text. Since the author is an Englishman it is natural that his classification should be based on British revisions and differ somewhat from ours; but one can't help but be surprised that although the author uses the old classification of the Protozoa he makes no mention of the many revisions of that old phylum, and that he treats the Rotifera as one homogeneous group, making no attempt at ordinal division. Under the Insecta eighteen orders are briefly described. One can accept, in so small a book, the lumping of the Homoptera and Heteroptera, but not the complete omission of fourteen of the conservatively accepted thirty-two orders. For example, I can find no mention of the Plecoptera or any of the neuropteroids.

The Pocket Encyclopedia of Plant Galls, one of the natural history books in the Blandford Colour Series, is a beautiful little book that should inspire some American naturalist to do as well by our American galls for, alas, the galls here described are all from the British Isles. The general discussion of the collecting and preserving of galls, the rearing and culturing of the causative agents, and the nature of the irritants applies universally however; and the 293 color illustrations show that the majority of the galls have their nearly identical counterparts in this country and that their causative agents often differ only in species. Following the color section there are seventy pages of descriptions of representative British galls arranged in the systematic order of their host plants. The combination of all of these features makes this book valuable to anyone interested in galls from a less technical side than that presented in the publications of Kinsey or of Felt.

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* With apologies to James Lipton, author of *An Exaltation of Larks.*

The title, **Earth's Bug-eyed Monsters**, must have been selected by some office-bound editor, for the Portugese-man-of-war, the Giant Octopus, the Road Runner and the Pitcher Plant scarcely fall into such a category. The browser in the book shop will not be attracted particularly to this book; nor will today's child, bombarded by oversize, psychodelic illustrations find that the appearance of the book matches the lure of the strange and fearsome creatures mentioned in the jacket blurb. This is unfortunate because the book contains a great deal of interesting and carefully garnered information about these twenty possible prototypes of science fiction monsters. Mrs. Hopf writes easily and in a pleasant conversational manner, showing evidence on every page of her wide perusal of the popular accounts of these species. In attributing to moths the ability to hear the cry of bats she need not have shown so much caution, for as a member of the New York Entomological Society she has heard many first-hand accounts of the relationship between the two; but it is more prudent to be cautious than dogmatic. Her book should be in every Junior High and Senior High library where, once discovered, it will be in great demand. The twenty-one black and white photographs are unspectacular but, from my point of view, this is to their credit.

Six-legged Science is a small, simple, but highly literate book much of which was originally prepared for radio or television use. Kipling's Elephant Child, with its 'satiable curiosity, serves as the introduction to the use of parallels in explaining the structure, physiology and habits of insects. Teachers of children will find this book valuable, and many parents will enjoy it for the expertise it will give them in appearing knowledgeable before their science-educated children. Puns and alliteration, limerick and verse, anecdote and literary illusion enliven the book. Many times, while reading it, I said to myself: "I wish I had said that"; and "yes, my dear Professor Hocking, I will."

Spiders, another of the Golden Nature Guide series, will make you want to run right out and find a spider to identify. If, as the authors say, there are 30,000 species of spiders in the world, we do not expect every one to be described in this vest-pocket paperback. But nearly 400 species, all looking very lively, are illustrated in color, as are 30 species of scorpions, 21 harvesters, 17 mites, 15 ticks, 26 myriopods and 8 land crustaceans—quite an array for so small a book. A few structural characters and a sampling of nests and webs are also illustrated. I haven't yet caught a spider so I don't know how easy the task of matching animal with picture will be nor what the comparative chances are that the spider I catch in New York or in Timbuctoo will be illustrated at all. Of the some two dozen species of spiders with which I am acquainted most were recognizably illustrated; only the Arctosas were disappointing. With the scorpions and myriopoda, however, I had to be content with the ordinal name. The authoritative position of the authors among arachnologists assures us of the accuracy of the tremendous amount of material capsulated here; and the attractive format will make all who see the book, adults and children alike, want to collect and learn more about spiders—and their kin.

Elsie B. Klots

Observations on the Nesting Behavior of *Crossocerus* (*C.*) *maculiclypeus* (Fox) (Hymenoptera: Sphecidae)

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Abstract: Studies on the nesting behavior of seven females of *Crossocerus maculiclypeus* in an aggregation of several hundred individuals are detailed. The wasps apparently selected pre-existing burrows in sand for use as nest sites. A female carried her prey directly into the open nest. Burrows leading to fully provisioned cells were partly filled with loose sand. The nests varied considerably in form and dimensions. The maximum number of cells per completed nest appeared to be nine; other finished nests contained from four to six cells. The small cells were constructed in clusters which were often separated by several centimeters. Fully provisioned cells contained from 9 to 20 paralyzed or dead flies. The empidid *Platypalpus holosericus* was the dominant kind of prey; other species of Empididae, Dolichopodidae, and Agromyzidae were less commonly stored. Single species each of Psilidae, Tephritidae, and Chamaemyiidae were also used as provisions. More flies were stored ventral side up, head inward than in any other position. The wasp's egg was attached by the cephalic end to the ventral side of the neck of one of these flies in each cell.

The genus *Crossocerus* contains 9 subgenera and about 40 species in the United States and Canada (Krombein, *in* Muesebeck, *et al.*, 1951; Krombein, 1958b; Krombein and Burks, 1967). Relatively little is known about the nesting behaviors of the Nearctic species. Species in the subgenera *Ablepharipus, Blepharipus, Stictoptila,* and *Epicrossocerus* nest in rotten logs, twigs and stems, and various other plant materials, frequently utilizing the abandoned burrows of small wood-boring beetles [Hamm and Richards, 1926; Davidson and Landis, 1938; Erikson, 1940; Pate, 1944 (1943); Steyskal, 1944; Krombein, *in* Muesebeck, *et al.,* 1951; Krombein, 1958a, 1958b, 1964; Krombein and Burks, 1967]. The majority of species in these subgenera provision their nest cells with small adult Diptera. As Pate [1944 (1943)] pointed out, females of species which nest in plant materials are characterized by a narrow pygidium with an apical excavation. Although lacking this structural adaptation, females of *Crossocerus* (*C.*) *planifemur* Krombein also nest in tunnels in logs (Krombein, 1952, 1958b). Other species in this subgenus exhibit similar nesting habits [Pate, 1944 (1943)]. The majority of species in *Crossocerus s. str.*, however, as well as species in the subgenera *Hoplocrabro, Microcrabro, Synorhopalum,* and

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Acknowledgments: We are indebted to K. V. Krombein and A. S. Menke, Smithsonian Institution and U. S. National Museum, for identifying the wasps; and to their associates, L. V. Knutson and G. Steyskal for determining the prey flies. (The wasps and flies have been deposited in the collection of the U. S. National Museum and bear ethology note no. labels CS-1 through CS-8).

probably *Yuchiha* nest in sandy or clay soils and stock their cells mostly with small adult Diptera [Cockerell, 1898; Peckham and Peckham, 1905; Smith, 1908; Rau, 1922; Hamm and Richards, 1926; Pate, 1944 (1943); Krombein, 1963]. Females of these species possess a broad, flat, trigonal, rather coarsely punctate pygidium [Pate, 1944 (1943)]; thus the shape of the female pygidium appears to be a good indicator of nesting habits in this genus. Virtually nothing is known about the nesting behavior of the single Nearctic species in the subgenus *Nothocrabro, nitidiventris* (Fox). Using Pate's [1944 (1943)] criterion of the shape of the female pygidium for determining nesting habits, members of this subgenus would be expected to nest in plant materials.

Among the ground-nesting species, the European *C.* (*Hoplocrabro*) *quadrimaculatus* (Fabr.) nests in sand and stocks its cells with nematocerous and brachycerous Diptera and Trichoptera (Krombein, *in* Muesebeck, *et al.*, 1951; Grandi, 1961). Females of *C. scutellatus* Say [= *C.* (*Yuchiha*) *xanthochilos* Pate] were observed by Rau (1922) entering holes in a clay bank in Kansas. He was unable to ascertain whether the wasps were foraging or nesting in the holes. Pate [1944 (1943)], observing soil particles on the legs of species of *Yuchiha*, surmised that they nested in the ground. *C.* (*Synorhopalum*) *decorus* (Fox) was observed nesting in the ground by both Cockerell (1898) and Smith (1908), but they presented little information on its nesting behavior.

Hamm and Richards (1926) reviewed the nesting behaviors of six species of European *Crossocerus s. str.* (*palmarius* Schreb., *palmipes* L., *varius* Lep., *anxius* Wesm., *wesmaeli* V. de Lind., *elongatus* V. de Lind.) and presented their own observations on five of the species. The wasps nested mostly in the ground, frequenting sandy soils, often banks. Colonies were indicated by numerous small tumuli surrounding the nest entrances. Females of *C. palmipes*, returning with prey, flew straight into their nests without hesitating. The nests of all species were rather short and shallow, and, depending on the species, either uni- or multicellular. Some tunnels of *C. varius* entered the ground obliquely, but coursed perpendicularly a few centimeters beneath the surface. The number of prey stored per cell in this species ranged from 7 to 14. As many as six or seven species were stored in a single cell. The kinds of prey varied with different species of wasps. Some species (*palmarius, palmipes, elongatus, wesmaeli, varius*) preyed only on small, often nematocerous Diptera. Other species, such as *C. anxius*, stored both Diptera and Hemiptera.

Crossocerus (*C.*) *lentus* (Fox) was observed by Peckham and Peckham (1905) nesting in the ground. One nest went obliquely downward for 6.5 cm, terminating in a cell. The incompletely provisioned cell contained "two bugs and a fly." Rau (1922) noted a female of *Crossocerus incavus* Fox [= *C.* (*C.*) *planipes* (Fox)] entering a hole in a clay bank, and later "kicking" loose dirt out of the entrance. Possibly, the wasp was renovating this hole for use as a nest site.

Fig. 1. Nesting site of *Crossocerus maculiclypeus* near Chittenango, Madison County, New York.

Krombein (1963) has presented the most detailed observations on the nesting habits of Nearctic species of *Crossocerus s. str.* He studied the nests of two females of *Crossocerus* (*C.*) *planipes* in Maryland. Both nests occupied partly shaded bare soil. One nest plunged downward at an angle of 20°–30° to the surface, bending abruptly twice, and ending in a cell, 3 cm beneath the surface. The incompletely stocked cell contained two small empidid flies of the genus *Drapetis*. A second cell in this nest, 2 cm beneath the surface, held 16 flies of the same species, of which one bore the wasp egg. Both cells were 6 mm long and ovoid in shape. In the second nest excavated by Krombein (1963) the entrance, 3 mm in diameter, was surrounded by a tumulus of sand, 15 mm wide and 25 mm long. The burrow proceeded downward at a "shallow" angle for 3 cm to a depth of about 1 cm beneath the surface, turned downward at a 60° angle to the horizon, and ended 2 cm below the surface. A cell, 2 cm from this burrow, was unearthed 2.5 cm beneath the surface. It contained 13 paralyzed, small empidids of the genus *Chersodromia*. Krombein (1963) believed that he lost the wasp egg upon removing the flies from the cell.

Our studies of *Crossocerus* (*C.*) *maculiclypeus* (Fox), a species which inhabits the northern United States and Canada, were made in a sand pit, 1 mile north of Chittenango and 7 miles west of Canastota, Madison County, New York (Fig. 1), during 3–10 June 1968. A second growth stand of mixed hardwoods, mostly oaks, and scattered white pines bordered the northern rim of the pit; the southern edge was bounded by a field. Females always nested in bare hard-packed sand, preferring slopes and ridges to flat sand. Although there were literally hundreds of nesting females, individual nests were usually spaced several centimeters apart, i.e., the wasps were not highly gregarious. Twelve nests occupied one area of about 1 square meter.

Females were not seen constructing their own burrows. The wasps were observed flying from hole to hole, entering and then exiting in flight a few seconds later. Such holes appeared to have been made by bees or other small wasps. Since females of *C. maculiclypeus* lack a foretarsal pecten (Fig. 2), we suspect that they do not construct their own burrows entirely; instead, they probably renovate the abandoned nests of other small insects, primarily hymenopterans.

One female (CS-1)[1] backed out of a small burrow, briefly removed sand from the entrance with the forelegs, flew away, and then entered three other holes nearby in rapid succession. She did not remove sand from any of the three holes. Flying in a zig-zag pattern, she entered three more holes, but abandoned each one. Upon entering an eighth hole, she emerged head first, pushing out sand, apparently using the forelegs and head. Shortly thereafter, she abandoned this burrow. Later, this wasp or another was seen backing out of an entrance to a small burrow, pushing sand backward with the legs and abdomen. A small tumulus of damp sand began forming in and around the entrance. It was not known whether this female had started to dig from the sand surface or had renovated a pre-existing burrow. Once a burrow was completed and provisioning begun, a wasp occupied the site for a period of several days, unless accidentally prevented from doing so. Two wasps (CS-4, 7) were observed provisioning their nests for at least three and four days, respectively, and probably had maintained these sites for even longer periods of time.

Several females, including CS-1, 3, 4, were observed holding their prey beneath the body and darting directly into open holes. Upon close inspection, it appeared that the wasp held the prey with the middle and hind legs. The fly was clasped tightly, ventral side up and head forward, against the ventral surface of the wasp's thorax. Females with prey flew to their nests in a zig-zag manner, many centimeters above the ground. One female (CS-3) took from 3 to 21 (mean, 11; N = 4) minutes between consecutive returns to the nest with prey. After three separate entries, this wasp stayed below the ground 10, 8, and 7 minutes, before exiting to search for the next prey. It was not determined why she spent such long periods of time inside the nest.

Females of *C. maculiclypeus* were not observed filling their burrows with sand after stocking a cell and ovipositing. However, as mentioned, partly filled

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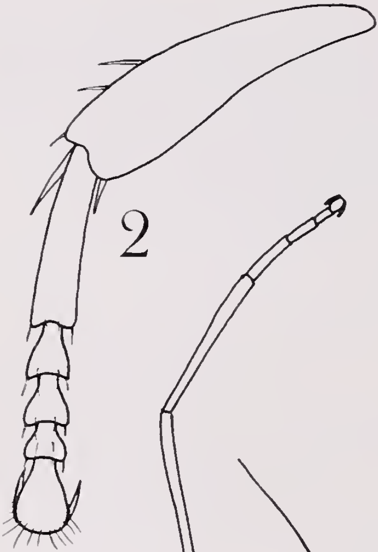
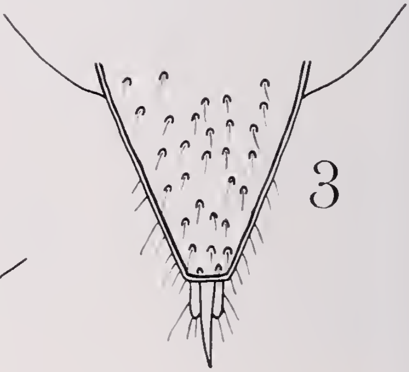
[1] Wasps and prey were given ethological note numbers to facilitate associating individual females and the contents of their nests.





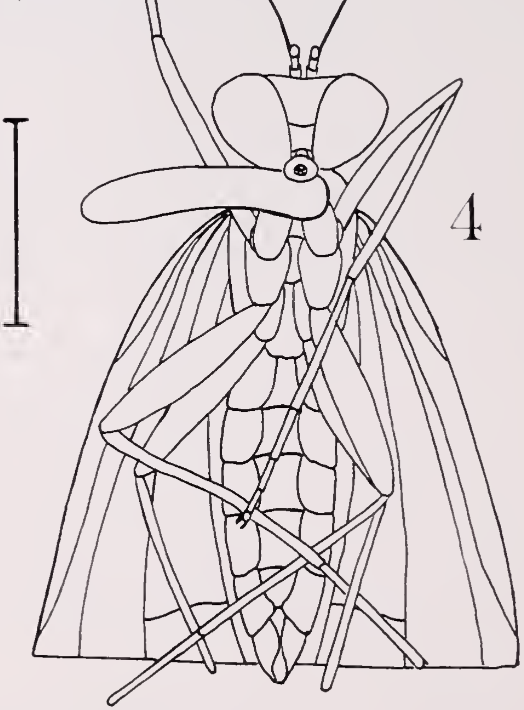


FIG. 2. Foretarsus and tibia of female of *Crossocerus maculiclypeus.*

FIG. 3. Pygidium of female of *Crossocerus maculiclypeus.*

FIG. 4. Egg of *Crossocerus maculiclypeus* in typical position on ventral side of neck of prey dolichopodid. (Scale at left equals 1 mm).

burrows led to completely provisioned cells. Open burrows terminated in incompletely provisioned cells. We believe that the female fills the burrow by packing in sand with the pygidium, either before or during the construction of a new side burrow and cell. The fact that females of *Crossocerus maculiclypeus* have a broad, flat, trigonal pygidium (Fig. 3) suggests this behavior.

We excavated and studied eight nests of *Crossocerus* (*C.*) *maculiclypeus* (CS-1 through CS-8). The nest entrances were 2–3 mm in diameter, suggesting that, if the wasps use pre-existing burrows, they are highly selective of the diameter of the tunnels in which they nest. Entrances to active nests were surrounded by tumuli, each measuring about 2.5 cm in diameter and 1 cm high. The tumuli remain intact until rainfall or an accidental disturbance obliterates them. With the construction of an additional cell, the form and dimensions of a tumulus changed slightly as sand from the new digging was brought to the surface. Only one nest (CS-6) was built in flat sand. The other seven nests were constructed into sand slopes and cliffs. The main burrows, about 2 mm in diameter, entered the sand at angles varying from about 30° (CS-6) to nearly 75° (CS-4) to the surface.

Burrows varied considerably in form and dimensions (Fig. 5). Some, such as CS-1, were rather straight. Others, for example, CS-6 and 8, curved gradually. Another burrow (CS-4) was ∪-shaped at its proximal end. Traceable burrows ranged from 5.5 (CS-1) to 11.5 (CS-4) (mean, 7.2; $N = 6$) cm in length. Such variation in the form and dimensions of these burrows further suggests the use of pre-existing insect burrows as nest sites by females of *C. maculiclypeus*. Some burrows (CS-1, 5) were entirely open or nearly so. Others (CS-2, 4, 6, 8) were filled with sand for much of their lengths, but open for a few centimeters near the entrances. Burrows filled with sand invariably led to completed cells, i.e., cells stocked with prey and a wasp egg or larva. Open burrows terminated in incompletely provisioned cells. Burrows leading to the oldest cells could not be traced with certainty. They are indicated by dotted lines in Fig. 5. These cells often contained mature larvae or cocoons.

Nests such as CS-1, 5, each with 2 cells, were undoubtedly unfinished (Fig. 5). Other nests (CS-2, 4, 6, 8), with closed burrows, were apparently completed. These nests contained 5, 6, 6, and 4 fully provisioned cells, respectively. In another area (CS-7), 14 cells were unearthed. Due to the bimodal distribution in the depths of these cells, we suspect that two nests were involved, one (CS-7a) with 5 cells, the other (CS-7b) with 9 cells. As in other species of crabronine wasps (see Hamm and Richards, 1926; Evans, 1960; Kurczewski and Acciavatti, 1968), nest cells of *C. maculiclypeus* were constructed in rather loose clusters (see, for example, CS-4, 6 in Fig. 5). Clusters of cells in a nest were often separated by several centimeters. Cells in a cluster were connected to side burrows which probably led to a main burrow, but this was impossible to confirm in older nests. Some cells (CS-2A, B, 4C, D, E, 6B, C, D, E, 8B, C, D)

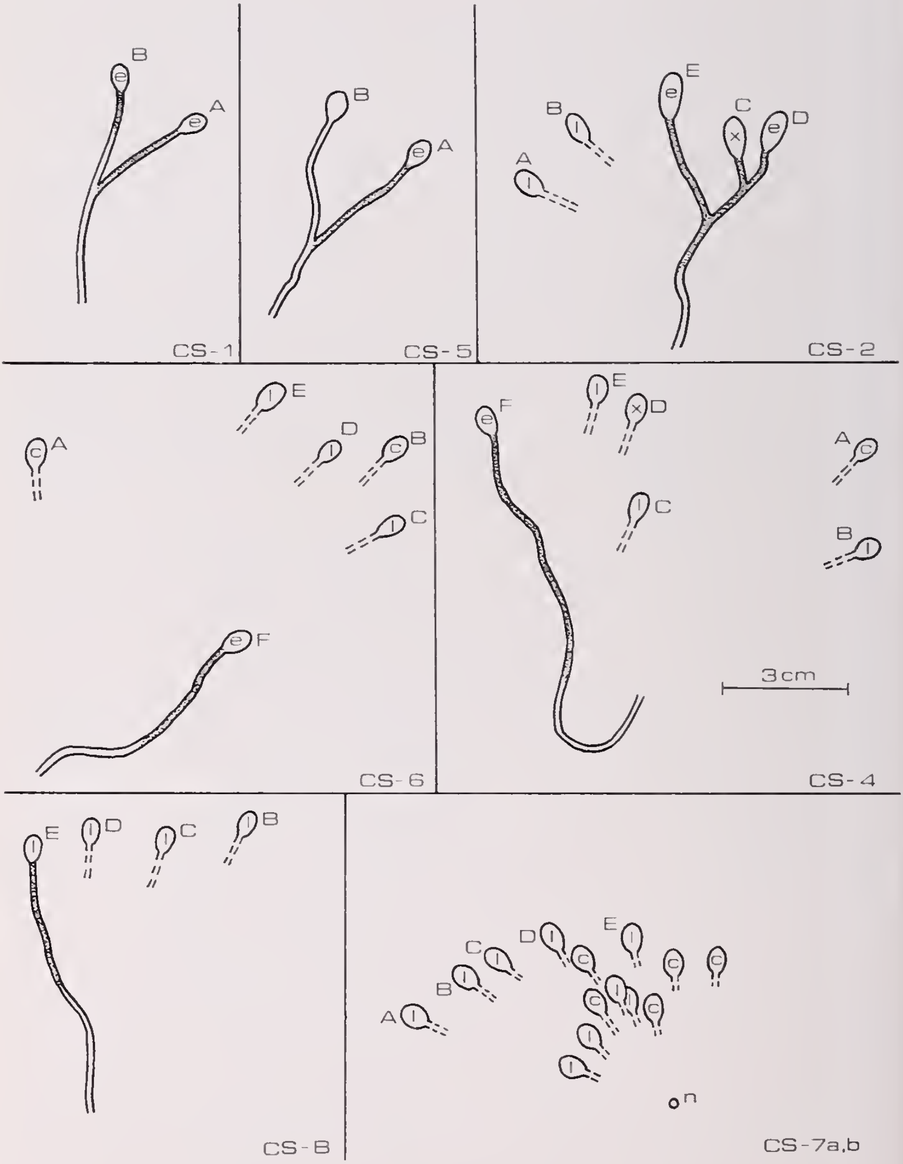


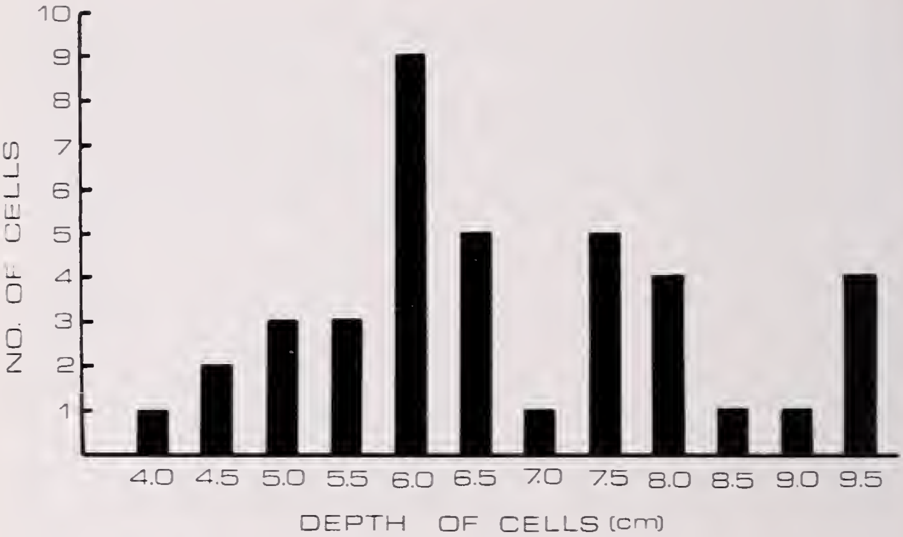
Fig. 5. Burrow and cell configurations in nests of *Crossocerus maculiclypeus*. Dotted lines indicate untraceable burrows. Burrows filled with sand are stippled. Cells are labelled with capital letters, A indicating the probable first cell made, B the second, and so on. Cell contents are as follows: e, egg, l, larva, c, cocoon, x, contents destroyed by mold or parasite; empty cell was incompletely provisioned. The entrance to nest CS-7b is indicated by n.

were unearthed several centimeters from the main burrows with which they were probably associated. Nests CS-1, 2 (cells C, D, E), and 5 indicate the structural configurations of the main burrow, side burrow(s), and associated cells. We did not find prey storage chambers in any of the nests, although we could have easily overlooked them because of the narrow confines of the burrows and the small sizes of the cells and prey. Open burrows are frequently used as storage chambers by other crabronine wasps (see Evans, 1960; Kurczewski and Acciavatti, 1968).

In species of *Crabro*, the first cells made and provisioned in a cluster are often farther from the entrance than cells made and provisioned later (Hamm and Richards, 1926; Evans, 1960; Kurczewski and Acciavatti, 1968). We were unable to clearly demonstrate this in nests of *Crossocerus maculiclypeus*, using as criteria the stages of development of the wasps in the cells and the weights of the larvae. In three nests (CS-2, 4, 6), however, older cells contained cocoons and mature larvae and were built farther from the main burrow than newer cells which contained juvenile larvae and eggs. In nest CS-7a, cells A–E showed a similar correlation. Cells D, E, nearest the entrance, contained juvenile larvae; cell C, third nearest the entrance, an older larva; and cells A, B, farthest from the entrance, nearly mature larvae ready to spin cocoons.

Nest cells of *C. maculiclypeus* were slanted downward in the sand, with the back end slightly deeper than the front. Twenty-seven cells averaged 4.3 (3–5) mm high, 4.8 (3–7) mm wide, and 6.4 (4–9) mm long. Thirty-nine cells varied in depth from 4.0 to 9.5 (mean, 6.7) cm beneath the sand surface (Fig. 6). Cells of nests CS-1, 4, and 5 were exposed at depths of only 4.0–6.5 cm, whereas cells of other nests (CS-6, 7b) were deeper, mostly 7.5–9.5 cm beneath the surface. In one area, as mentioned earlier, two nests were apparently involved, nest 7a with cells, 4.5–6.0 cm deep, and nest 7b with cells, 7–9 cm deep. Cells belonging to a single cluster were exposed at about the same depth.

Females of *Crossocerus maculiclypeus* preyed exclusively on adult flies. The majority of records were for the empidid *Platypalpus holosericus*; other species of Empididae, Agromyzidae, and Dolichopodidae were less commonly used (Table I). Single species each of Psilidae, Tephritidae, and Chamaemyiidae were also stored. Three or more species of flies were found in only 6 of the 22 cells which contained identifiable specimens. Each of only 7 of 22 cells contained two or more families of prey: CS-1B (Empididae, Dolichopodidae); CS-4A (Empididae, Agromyzidae); CS-4C (Empididae, Dolichopodidae, Agromyzidae); CS-4D (Empididae, Agromyzidae, Psilidae); CS-4E (Empididae, Agromyzidae, Tephritidae, Chamaemyiidae); CS-4F (Empididae, Dolichopodidae, Agromyzidae); and CS-5A (Dolichopodidae, Agromyzidae). However, even in these cells there was a decided preference for a particular family of prey, e.g., cells CS-4A, C, D, E, F, and 5A contained mostly agromyzids, cell CS-1B, mostly empidids. In the other 15 cells a single species of prey was almost always stored.



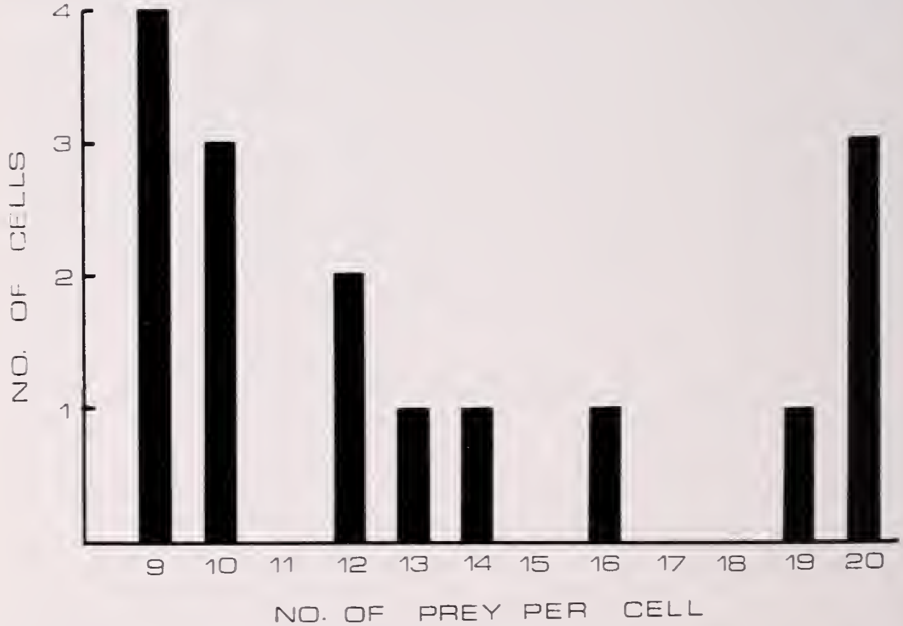


Fig. 6 (ABOVE). Depth of cells in nests of *Crossocerus maculiclypeus*.

Fig. 7 (BELOW). Number of prey per cell in nests of *Crossocerus maculiclypeus*.

TABLE I. Species of Prey of *Crossocerus maculiclypeus*

Family and species of prey	No. of individuals (cells)
Empididae	
Hilara femorata Loew	1♀ (CS-2C)
Platypalpus holosericus Melander	1♀ (CS-1); 8♀ (CS-1A); 6♀ (CS-1B); 11♀ (CS-2A); 9♀ (CS-2B); 13♀ (CS-2C); 6♀ (CS-2D); 5♀ (CS-2E); 9♀ (CS-3A); 3♀ (CS-4A); 1♀ (CS-4C); 1♀ (CS-4D); 1♀ (CS-4E); 1♀ (CS-4F); 4♀ (CS-6C); 2♀ (CS-6D); 7♀ (CS-6B); 8♀ (CS-6F); 9♀ (CS-7G); 9♀ (CS-7K); 6♀ (CS-7L);
Rhamphomyia sp.	1♀ (CS-1A); 2♂ (CS-1B); 1♂ (CS-4A); 1♂ (CS-4C)
Dolichopodidae	
Thrypticus sp.	1♀ (CS-1B); 1♀ (CS-4C); 1 (CS-5A)
Thrypticus willistoni (Wheeler)	1 (CS-4F)
Agromyzidae	
Liriomyza sp.	2 (CS-4D)
Melanagromyza spp.	5 (CS-4A); 5 (CS-4C); 11 (CS-4D); 13 (CS-4E); 14 (CS-4F)
Ophiomyia labiatarum Hering	9 (CS-5A)
Ophiomyia sp.	9♀ (CS-5D)
Phytobia sp.	1 (CS-4C)
Phytomyza sp.	1♀ (CS-4C); 1♀ (CS-5D)
Psilidae	
Psila angustata Cresson	1 (CS-4D)
Tephritidae	
Rhagoletis fausta (Osten Sacken)	1 (CS-4E)
Chamaemyiidae	
Plunomia elegans Curran	1 (CS-4E)

In 14 of these cells the empidid *Platypalpus holosericus* was nearly always or exclusively stored, and *Ophiomyia* sp. (Agromyzidae) in the other cell.

Individual females were very selective of the families and sexes of the flies on which they preyed. Some females showed a decided preference for females of *P. holosericus*—CS-1, 79%; CS-2, 98%; CS-3, 6, 7, 100% (N = 118 specimens). Females CS-4, 5, on the other hand, stored mostly agromyzids of the genera *Ophiomyia* and *Melanagromyza*—CS-4, 73%; CS-5, 90% (N = 86 specimens). The selection of certain sexes and families of prey by some females may reflect the different sizes of the wasps rather than differences in their hunting behaviors. Larger females (CS-2, 6) preferred females of *P. holosericus* and stored fewer, larger individuals per cell, whereas smaller wasps, such as CS-4, captured mostly small agromyzids and stored more flies per cell.

The number of flies stored in fully provisioned cells of *Crossocerus maculiclypeus* ranged from 9 to 20 (mean, 13.3; N = 16) (Fig. 7). The number of prey per cell could not be correlated with either the depth of cell or the distance of cell from entrance or main burrow, i.e., its relative position in the cluster. The

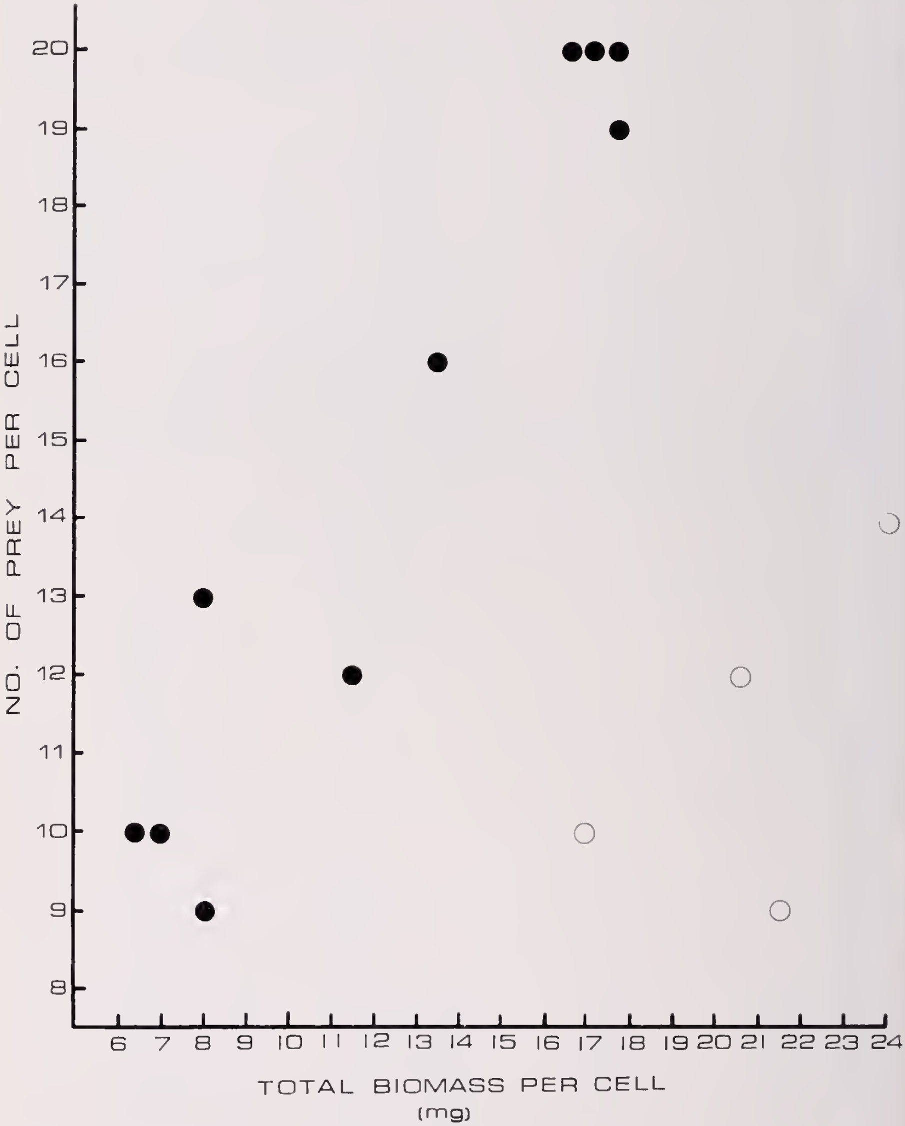


Fig. 8. Total biomass of prey per cell in *Crossocerus maculiclypeus* plotted against the number of prey per cell. (Open circles represent large females, weighing 3.5 mg, and closed circles, small females, weighing 2.5 mg.

weights of the prey individuals ranged from 0.5 to 3.5 (mean, 1.1; N = 206) mg. Larger females, such as CS-2, 6, averaging 3.5 mg in weight, stored larger flies and smaller females, for example, CS-4, weighing 2.5 mg, smaller flies. Thirty-five prey of larger wasps averaged 1.8 mg; 171 prey of smaller wasps, 1.0 mg.

Table II. Position of prey individuals in cells of *Crossocerus maculiclypeus*

Position of prey	No. of individuals
Ventral side up, head inward	64
Ventral side up, head outward	22
Dorsal side up, head inward	29
Dorsal side up, head outward	15
On side, head inward	18
Sideways, head right	10
Sideways, head left	7
Head downward, abdomen upward	4

The total biomass of prey in single cells ranged from 6.5 to 24.0 (mean, 14.7; N = 14) mg. Cells with a greater biomass usually contained more flies, except where larger females had stored larger flies (Fig. 8). An increase in the number of prey per cell did not accompany an increase in cell size.

In 11 of 14 fully provisioned cells, more flies were placed ventral side up, head inward than in any other position. One cell had the majority of individuals placed on their sides and head inward; in two cells, prey were positioned mostly dorsal side up, head outward or ventral side up, head outward. The positions in which 169 prey individuals in 14 fully provisioned cells were placed are summarized in Table II.

In most cases the egg-bearing flies, always one in each cell, were found at the bottom of the cell, either near the middle or at the back end. In 8 of 9 examples, the fly on which the wasp had laid her egg was placed ventral side up and head inward. One egg-bearer was positioned ventral side up, head outward. Egg-bearing prey were average-sized individuals. The egg was never laid on a fly that was conspicuously larger or smaller than other flies in the cell. Eggs were attached to the left or right sides of the prey in about equal numbers.

Eggs of *C. maculiclypeus* were white in color, elastic, cylindrical, curved, elongate, and, after being placed in 70% alcohol for 48 hours, measured about 1.2–1.5 mm long and 0.35–0.45 mm wide. An egg was affixed by the cephalic end to the ventral side of the neck of the fly (Fig. 4). The caudal end extended free to one side in a lateral direction.

Development and behavior of the immature stages of *Crossocerus maculiclypeus* were not studied. Since our studies were made only in early June we were unable to determine whether or not this species is multivoltine at this latitude.

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Comparative Fine Structure of Acarine Integument[1]

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Abstract: The integument shows a fundamental similarity in representatives of three suborders of mites considered in this work, despite variation in thickness and variety of organ types present.

After aldehyde fixation and mixed-resin embedding, use of the electron microscope revealed distinct divisions of the mite cuticle. A widely laminated endocuticle overlies the hypodermis, a heavily sclerotized exocuticle is present, and non-laminated epicuticle appears to be deposited outermost. Pore canals and ducts with fixed hypodermal secretions are obvious in several sections. Setae with sockets and sense organs are found at intervals in the cuticle.

Many unanswered questions exist on the subject of acarine integument, especially the structural differences in the cuticle of mites in the various suborders. Using specific techniques, the electron microscope disclosed details of integumental structures which amplify current information about the integument in relation to classification and function.

Mites from three suborders of the Acarina were considered: a) *Parasitus sp.* from the Mesostigmata, b) *Tydeus sp.* from the Prostigmata, and c) *Oppia sp.* from the Cryptostigmata. All mites sectioned were adults. Although adults are more difficult to section because of a harder cuticle, one can be sure that all formation of the integument has been completed. The posterior half of the mites was used in the sectioning because in each of the specimens used the anterior portions are more contoured and more unevenly sclerotized.

MATERIALS AND METHODS

A solution of 6.25% buffered glutaraldehyde provided rapid and adequate fixation for entire, living mites immersed directly into the fixative. Another fixative used quite successfully was a mixture of picric acid and paraformaldehyde. After fixing the specimens for approximately four hours, a post fixative of 1% phosphate-buffered osmium tetroxide (Millonig, 1961) was employed for about thirty minutes.

After fixation and rinsing in phosphate buffer, the specimens were dehydrated in a graded series of ethyl alcohols. Insufficient dehydration experienced in earlier procedures may have been caused by the sclerotized exoskeleton of the mites which allowed the water-alcohol exchange to progress slowly. Conse-

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quently, fifteen minute changes in the 35%–95% range, and two changes of 20–30 minutes for the absolute alcohol were necessary.

Propylene oxide proved to be the best transitional solvent. This solvent, combined with an embedding mixture of Epon 812 (Shell Chem. Corp., San Francisco, Calif.) and Araldite 502 (Ladd Research Industries, Burlington, Vt.), allowed sufficient infiltration of plastic into the specimen. The resin mixture consisted of one part Epon, one part Araldite, 1.5 parts DDSA (Shell Chem. Corp.), with 1.5% catalyst (Geisy, 1967). The fixed and dehydrated mites were passed through two changes of pure propylene oxide, and placed in a mixture of 3 : 1 concentration of solvent to resin for one hour; then a 2 : 2 concentration for one hour; and one part solvent to three parts resin mixture for at least fifteen hours. Specimens were then changed into solutions of pure resin for twenty-four hours at room temperature. A final change into fresh resin was made in an oven at 60°C for 2–3 days.

Sections were cut with glass knives on an LKB 'Ultratome' and Porter-Blum microtome. Usable sections varied from gold to gray in color and were probably 400–900 Å thick. Tissues were stained with uranyl acetate and lead citrate.

OBSERVATIONS AND RESULTS

Parasitus sp. (Parasitidae), Figs. 1 and 2

This amber colored mite is relatively large (800–1000μ); it is predaceous on small insects and other mites, and was collected in Colorado from predominantly mesophyllic habitats of pine and leaf litter. The thickness of the integument varies from 7–9 microns depending upon the area sectioned.

The most outstanding characteristic of the integument is the distinct laminations (Fig. 1). These laminations vary in thickness depending upon the area of integument. They are usually seen in electron micrographs as alternating light and dark bands, and appear narrower and more compressed toward the epicuticle (Fig. 1). This difference in laminar structure is explained by Richards (1951). The laminae appear to shrink considerably in thickness after formation. This is caused by sclerotization and darkening of the older cuticle due to some dehydration with subsequent increase in density, resulting in the appearance of the tightly packed laminations in the exocuticle.

The epicuticle appears to be a single, non-laminated layer, overlying the exocuticle (Fig. 1). In the mites the epicuticle is a waxy layer, probably similar to that reported by Beament (1968). In this case, it has been partially removed by dissolution in one of the preparatory solutions.

Pore canals are minute ducts extending upward from the hypodermis through the endocuticle and exocuticle (Fig. 1). They are quite small (½–1μ in diameter) and can hardly be resolved as ducts by the light microscope. These pores can be seen with the electron microscope. The entire cuticle of this Parasitidae mite appears replete with pore canals. The helical nature of the

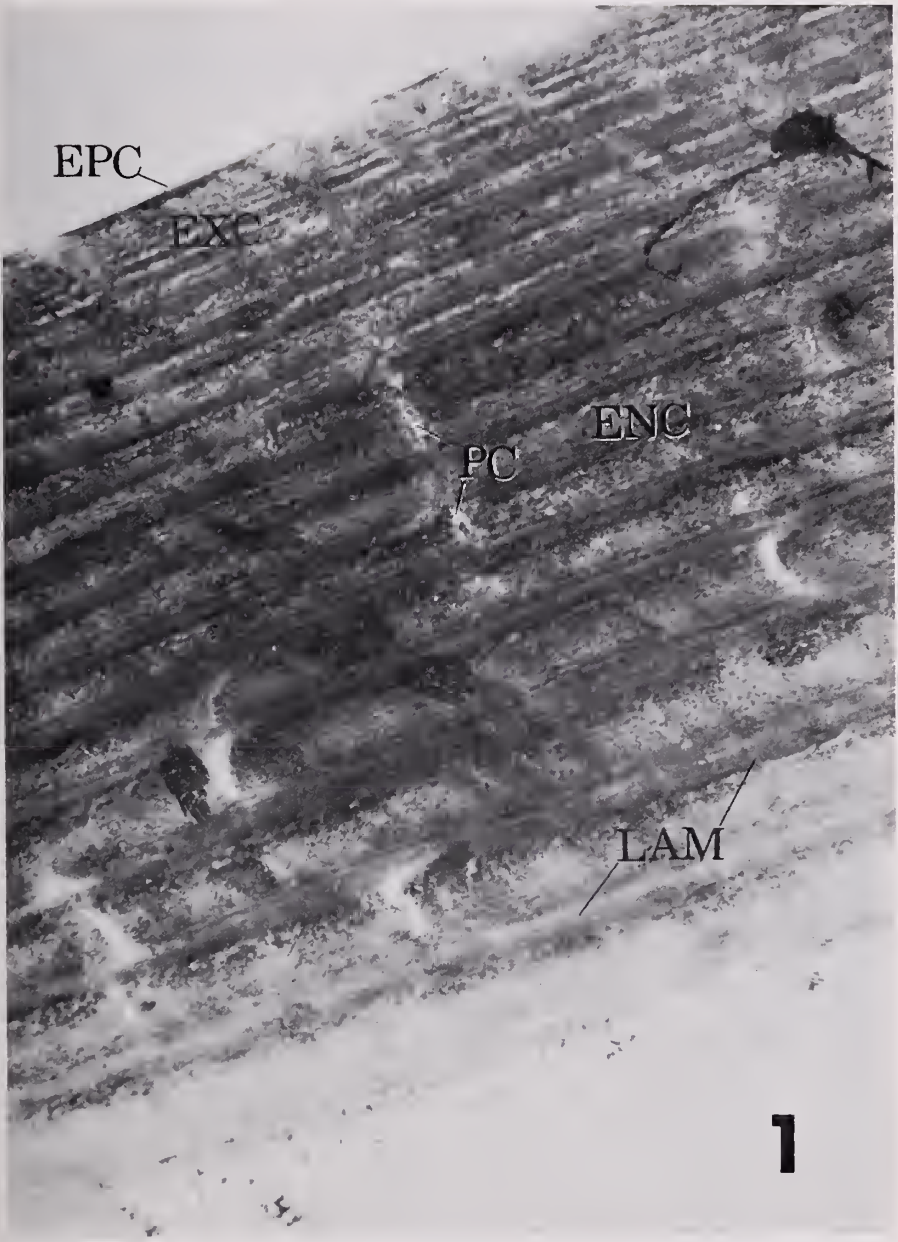

Fig. 1. Cross section through the integument of a *Parasitus sp.* mite showing laminations (LAM), divisions of the cuticle as endocuticle (ENC), exocuticle (EXC), and epicuticle (EPC), and pore canals (PC) containing secretory material. × 15,000.

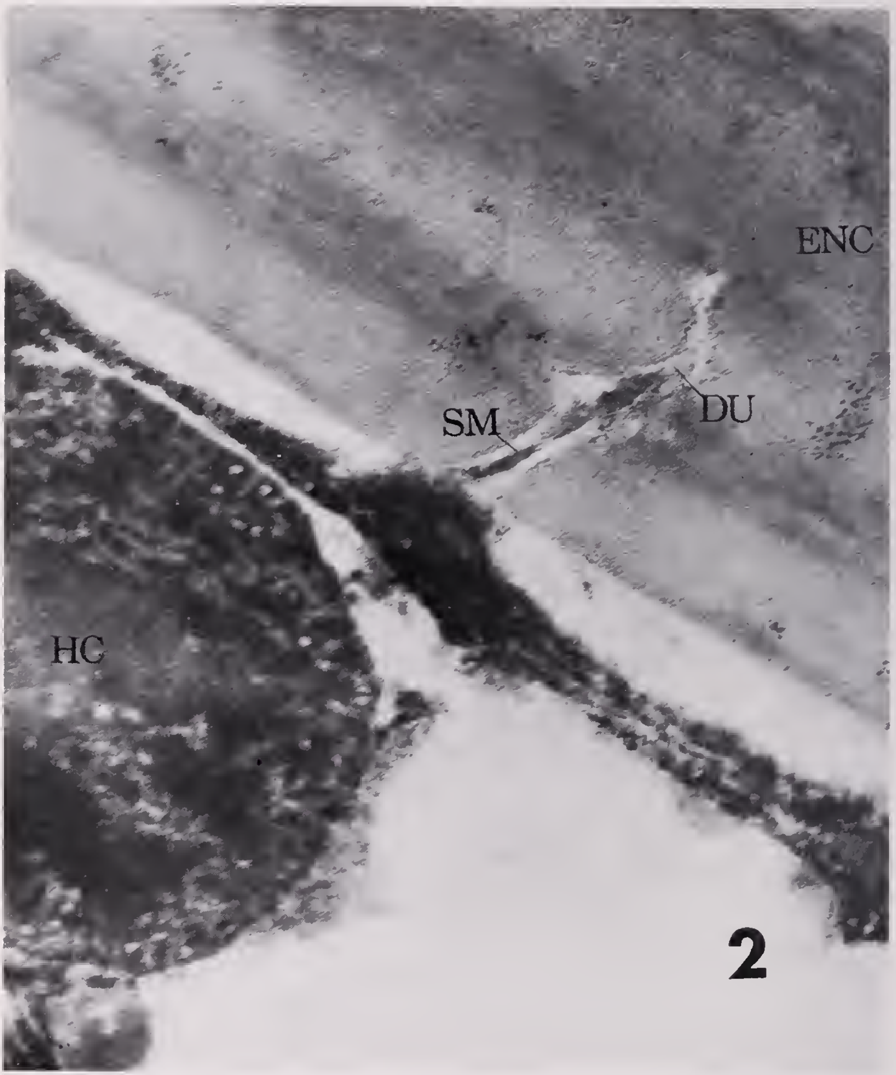

Fig. 2. Enlargement of a portion of the endocuticle (ENC) of a parasitidae mite. A duct (DU) filled with secretory material (SM) runs into the endocuticle. Portion of a hypodermal cell (HC). × 39,000.

canals is ascertained by noting their tortuous routes and intermittent areas of lighter density where the microtome knife has shaved only portions of a single, twisting pore canal (Fig. 1). The large number of pore canals suggests the constant production of waxy secretions as an outermost protective epicuticle.

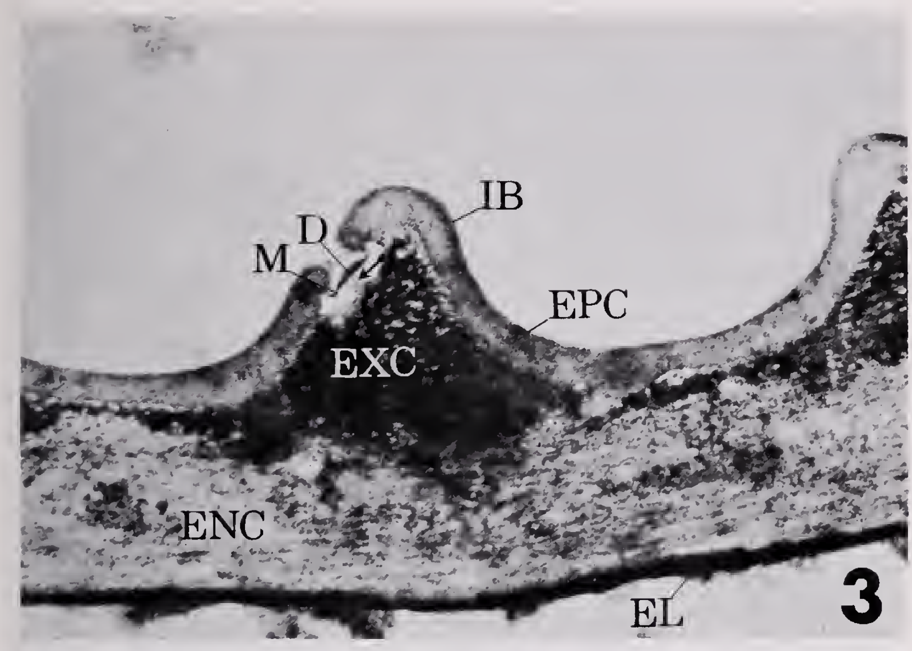

Fig. 3. Cross section through the integument of a *Tydeus sp.* mite showing distinct divisions of the cuticle as endocuticle (ENC), exocuticle (EXC), and epicuticle (EPC). Components of the "campaniform sensillus" are labeled membranous portion (M), dome portion (D), and innervating fiber (arrow). Integumental bump (IB), electron dense layer (EL). × 14,500.

The general hypodermal cells are known to secrete the cuticle (Condoulis and Locke, 1966) probably manufacturing a part of its constitutents. In this mite, the hypodermis is typically a single layer of cells, each cell with a rather extensive endoplasmic reticulum. Under high magnification, hypodermal secretions can be seen in ducts which traverse the integument (Fig. 1 and 2).

Tydeus sp. (Tydeidae), Figs. 3 and 4

This mite is rather small (200–300μ); it is generally predaceous on small insects and other mites. It has been collected from practically every habitat in Colorado where mites are found and is easily noticed because of its attractive yellow, pink, or red integument. The cuticle of this mite shows a great variety in thickness, but is generally 2–4 microns thick in cross section.

In comparison to the *Parasitus sp.* mite, the integument of this mite can hardly be termed laminated, but shows a definite endocuticle, exocuticle, and epicuticle (Fig. 3).

The endocuticle appears very lightly sclerotized, unordered, and even fibrous in some cases. The exocuticle, although more heavily sclerotized, is also un-

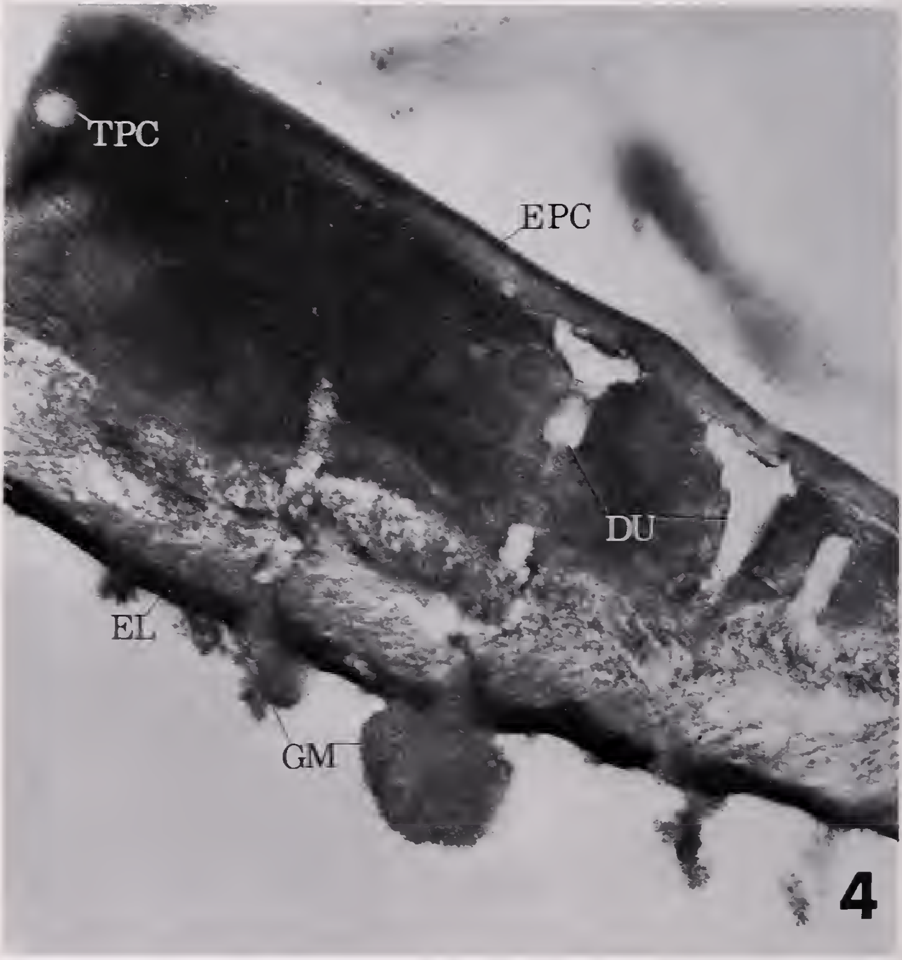

Fig. 4. Enlargment of a cross section through the integument of a tydeidae mite. Glandular material (GM) is fixed in several ducts (DU) which may branch below the epicuticle (EPC). Electron dense layer (EL), transverse pore canal (TPC). × 38,000.

ordered and fibrous. The epicuticle is unusually thick in this species. The waxy epicuticle appears as though it would provide adequate protection for the softer, fibrous portions of the cuticle below. A heavy, electron-dense layer separates the endocuticle from the underlying hypodermis (Figs. 3 and 4).

Glandular material in association with ducts is definitely visible (Figs. 2, 4, and 5). The secretion can be seen in the canals and was apparently fixed while moving toward the epicuticle. In several cases, the ducts branch just below the epicuticle (Fig. 4), and I infer that they pour glandular secretions directly

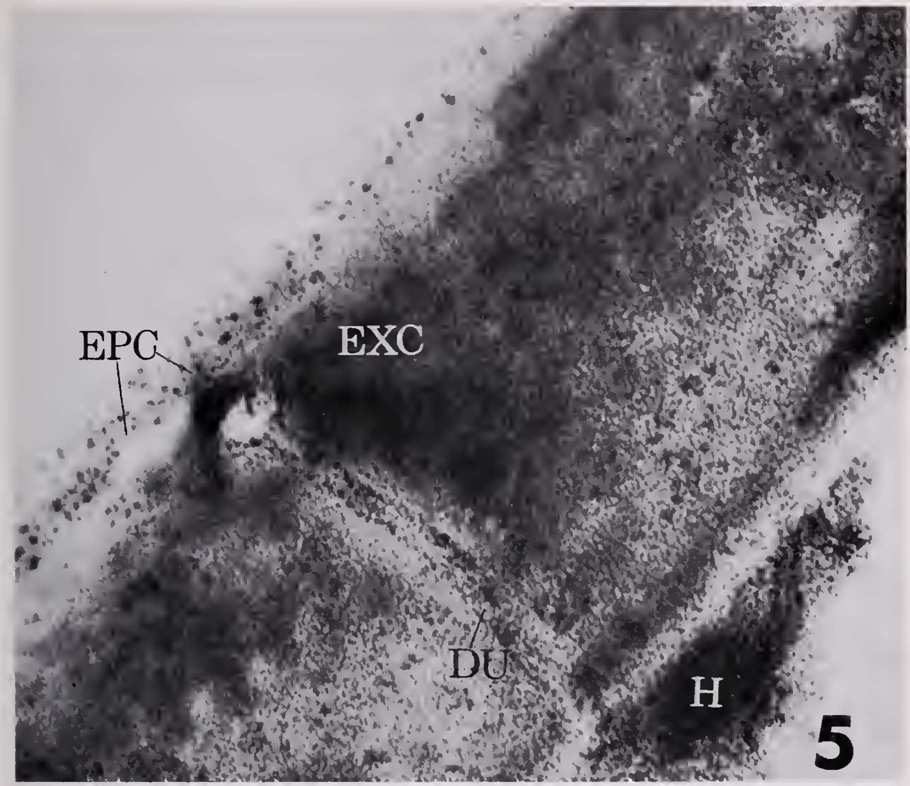

FIG. 5. Cross section through the integument of an *Oppia sp.* mite demonstrating formation of the epicuticle (EPC) after the lipid substance has emerged from a duct (DU) of the hypodermis (H) and spread over the surface of the exocuticle (EXC). × 45,500.

onto the surface of the exocuticle (Fig. 5). This situation is similar to that reported by Locke (1959, 1961, 1965) in several insects. Similar ducts have previously been reported by Wharton *et al.* (1968) in the mite *Laelaps echidnina.*

One of the more distinguishing characteristics for identifying the Tydeidae by light microscopy is a dotted integumental pattern on the dorsum of the mite. Electron microscopy has revealed the apparent reason for this pattern as a regular series of bumps and depressions which correspond respectively to the light and dark areas of the dotted design seen under the light microscope (Fig. 3). On one of these integumental bumps is a "campaniform sensillus" as described by Wigglesworth (1965). This is a sensory receptor which is thought to respond to air pressure or vibrations, and possibly to bending of the cuticle. The receptor consists of a dome portion, a thin membrane, and an innervating fiber (Fig. 3). The latter is evidence that this is a sensory structure. Because the epicuticle is interrupted in an orderly arrangement, I infer that this is not an artifact.

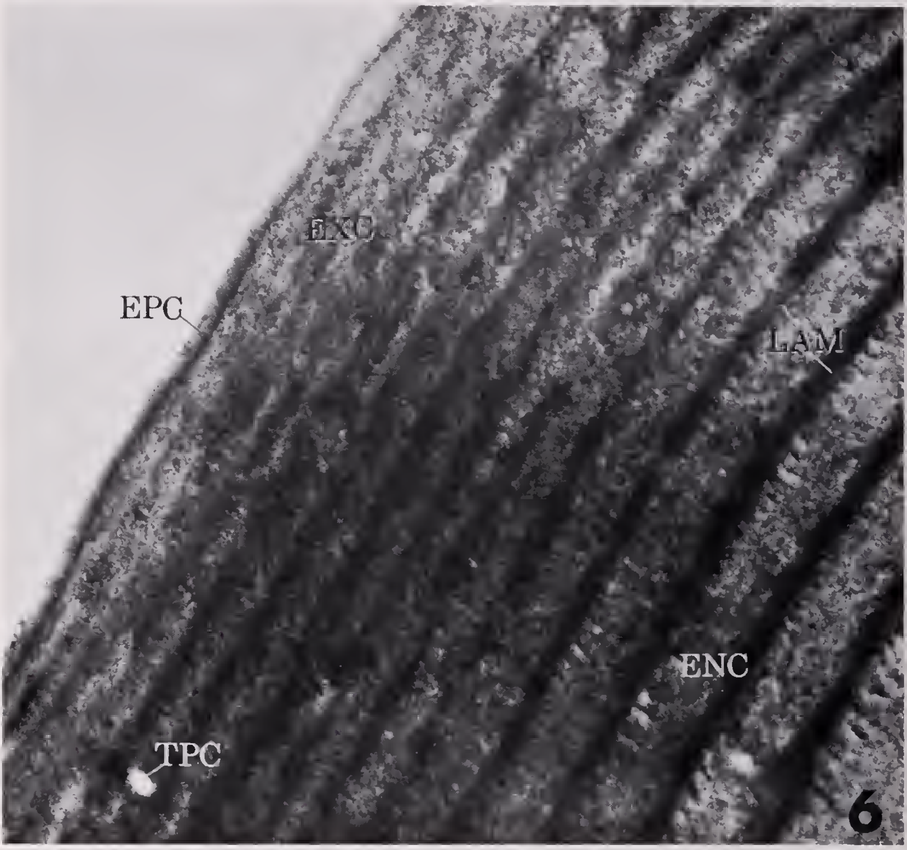

Fig. 6. Cross section through the integument of an oppiidae mite showing the laminations (LAM), the endocuticle (ENC), the compact exocuticle (EXC), and the waxy epicuticle (EPC). Transverse pore canal (TPC). × 34,000.

Oppia sp. (Oppiidae), Figs. 5, 6, 7, 8, and 9

This mite is of moderate size (400–600μ). It was collected from both hygrophyllic and mesophyllic habitats, and was raised successfully in the laboratory on a diet of fermented yeast and dextrose (Dolan, 1968).

Most oribatid mites have a heavily sclerotized and highly laminated cuticle. This oppiid is no exception (Fig. 6). Cuticle thickness varied between five and seven microns. The endocuticle and exocuticle are both laminated, but the laminae in the exocuticle are more tightly packed and not so well defined. The non-laminated epicuticle lies outermost. Transverse pore canals are quite common (Fig. 6), and are not confined to any particular area of the integument.

Setae are typically found on these and most other mites. Even though Wigglesworth (1965) has described the basic structure and formation of a typical seta,

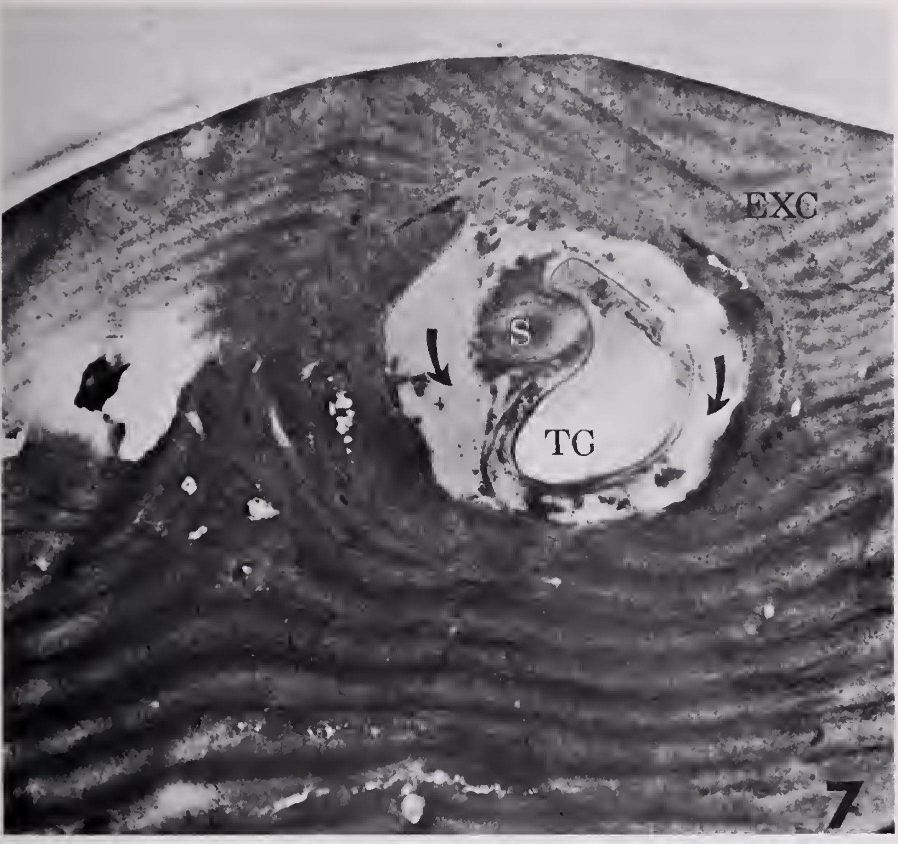

Fig. 7. Cross section through the integument of an oppiidae mite revealing a setal complex. The solid seta (S) and its tormogen cell (TC) are located in a socket filled with embedding plastic (arrows). Exocuticle (EXC). × 12,000.

nothing has been reported in the literature on its fine structure. Considering this, several pertinent points are deducible from Fig. 7. The seta is solid throughout. The tormogen or socket-forming cell lies in close proximity. Judging from the amount of embedding plastic which surrounds the seta and its tormogen cell (Fig. 7), it can be assumed that the complex is nestled in an open follicle. Note how the integument has compensated for the presence of a seta by the divergence of the laminar material around the follicle (Fig. 7).

There appears to be another form of "campaniform sensillus" in the integument of this mite (Fig. 8). Again note the dome portion, membranous folds, and obvious innervating fiber, all described as parts of a sensory receptor of this kind.

Fig. 8. A form of "campaniform sensillus" in the cuticle of an oppiide mite. Membranous portion (M), dome portion (D), innervating fiber (arrow). × 43,000.

The muscles of arthropods are united to the cuticle in several different ways (Richards, 1951). A predominant feature of the Cryptostigmata are apodemata, heavily sclerotized infoldings of the cuticle which provide areas for muscle attachment. Distinct rugosites are found on the interior surface of this apodeme of the ventral plate, and muscles are attached to them (Fig. 9).

SUMMARY

The laminated integument of mites is secreted by the hypodermal cells. Minute pore canals and larger ducts extend from the hypodermis, traverse the integument, and ultimately carry secretory material through the endocuticle to the surface of the exocuticle. These waxy secretions solidify as the protective epicuticle. Beament (1959) described the removal of this covering from various arthropods by abrasion, melting, and dissolution. These renovations exposed openings of numerous pore canals to the exterior, and demonstrated the protective function of the epicuticle since dehydration of the test animals ensued.

The electron microscope has revealed some of the fine structure of several cuticular elements. The large seta on the dorsum of an oribatid mite is nestled in a socket complete with a tormogen cell. In addition, the pressure receptors of the cuticle appear dependent on the stretchable membranous portions that

Fig. 9. This cross section through an apodeme of the ventral plate (AVP) of an oppiid mite shows rugosities (R) for muscle (M) attachment. Ventral plate (VP). × 12,000.

probably relay messages through the dome and inervating fiber when the cuticle is bent.

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Lethe eurydice (Johansson) and *L. fumosus* (Leussler), Sibling Species (Lepidoptera: Satyridae)

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Abstract: *Lethe eurydice* (Johansson), 1763, a Nearctic butterfly, has heretofore been considered a single species with four subspecies. However, two of its supposed subspecies fly at the same time and in close proximity, but they occur in different environments and have constant superficial differences. The conclusion is reached that they are sibling species and probably have different food plants. The names recognized for them are *Lethe eurydice* (Johansson) and *L. fumosus* (Leussler), 1916.

In the current Synonymic List of the Nearctic Rhopalocera (dos Passos, 1964, p. 99), *Lethe eurydice eurydice* (Johansson), 1763, *L. e. transmontana* (Gosse), 1840, *L. e. fumosus* (Leussler), 1916, and *L. e. appalachia* R. L. Chermock, 1947, are treated as one species with four recognizable subspecies; four synonyms and one form. There is now good reason to believe that this was an error carried over from earlier checklists and that two sibling species are involved, hereinafter referred to as *eurydice* and *fumosus*. A brief review of all names will be given under the respective synonymies.

This problem is somewhat similar to that pointed out by Rawson and Ziegler (1950, p. 74) that two species of *Mitoura* had been included in the species *gryneus* Hübner, "1816" [1819], and they described the second species as *hesseli.* In that case it was found that the food plant of *gryneus* is Virginia cedar, which grows in dry ground, and that of *hesseli* is white cedar, which is found in swampy areas. Both species are so close in appearance that their slight differences had passed unnoticed thus far. In the present problem we have species that are not quite so similar yet have not been detected as different heretofore.

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Klots (1951, p. 68) has written concerning *Lethe eurydice appalachia* (= *fumosus*) as follows: ". . . West Virginia to Georgia in the mountains, to northern Florida (swamps?), not typical in piedmont in the South; darker ground color, coloration less contrasty, postmedian band straighter, less jagged and irregular." Since that publication, Muller (1968, p. 304) has recorded *eurydice* (*recte appalachia* = *fumosus*) from New Jersey, which extends its range considerably northward, while this paper extends its range farther northwest to Nebraska.

Interesting facts about the discovery of *fumosus* in New Jersey by Muller and Frank Rutkowski are that while *eurydice* and *fumosus* fly at the same time in close proximity to each other, they are found in different environments, the former occurring in open meadows, sometimes wet or dry and even on dry hillsides, while the latter is restricted to boggy or swampy areas close to or in open woods. This, coupled with the differences in appearance of the two insects as pointed out by Klots (1951), leads the present author to believe that two distinct but closely related species are involved and to suggest the following synonymies:

Lethe eurydice (Johansson)

Papilio eurydice Johansson
  1763 Amoen. Acad., vol. 6, p. 406, no. 65
  Type locality: Philadelphia
  Type deposited: collection De Geer, probably destroyed
?*Papilio canthus* Linnaeus
  1767 Systema Naturae, 12th ed., vol. 1, p. 768, no. 129
  Type locality: America septentrionale
  Type deposited: not in Linnean Society, probably destroyed
?*Satyrus cantheus* Godart
  "1819" [1824] Encyclopédie Méthodique, vol. 9, p. 493, no. 56
  Type locality: l'Amerique septentrionale
  Type deposited: not in Paris Museum, probably never existed
?*Hipparchia transmontana* Gosse
  1840 Canadian Naturalist, p. 247, 1 fig.
  Type locality: Compton, Quebec
  Type deposited: not in Canadian National Collection nor in British Museum (Natural History), probably destroyed
Hipparchia boisduvali Harris (*emendatio*)
  1862 Insects Inj. to Veg., p. 305, fig. 128
  Type locality: northwestern Massachusetts
  Type deposited: not in Museum of Comparative Zoology, probably destroyed
Satyrodes eurydice transmontana ♀ form *rawsoni* Field
  1936 Pomona Jour. Ent. & Zool., vol. 28, p. 22
  Type locality: Bloomfield, Michigan, August 12, 1928
  Type deposited: U. S. National Museum

The types of *eurydice*, *canthus*, *cantheus*, *transmontana* and *boisduvali* are difficult to trace. The two first might be expected to be in the Linnean collection, but Verity (1913, pp. 173–190), who studied that collection carefully, did not report finding either of them. This author also examined that collection in 1937 with the same result. The type of *cantheus* according to Dr. Pierre Viette is not in the Paris Museum, as he has kindly advised the author (*in litt.*). The type of *transmontana* is not in the Canadian National Collection according to Dr. Thomas N. Freeman who kindly searched for it nor is it in the British Museum (Natural History) according to Mr. T. Graham Howarth who did likewise. The Thaddeus W. Harris collection is in the Museum of Comparative Zoology but does not contain the type of *boisduvali* according to Dr. Howard E. Evans who kindly looked for it. Presumably all of these types are lost or destroyed.

The upperside of the wings of *eurydice* are a pale brown in the basal and discal areas. The limbal area is much lighter so that the wings are contrasty, thus making the submarginal rows of spots on both primaries and secondaries stand out prominently. On the underside of both wings, the colors are paler with similar results. The postmedian band on both wings is outlined by narrow lines of darker color. The outer lines of this band are irregular and show some sharp points. This is especially true near the anal angle of the secondaries. The ocelli on both wings consist of a white pupil in a black ground which is set in a light buff circle surrounded by another of paler buff. Good comparative figures of *eurydice* and *fumosus* will be found in Leussler (1916, figs. 1–4).

There were early differences of opinion as to the proper name to use for the eyed brown butterfly, and unfortunately such differences still exist. However, the name in general use at present is *eurydice*. In the synonymy of *eurydice* there is usually placed *canthus, cantheus, transmontana,* and *boisduvali*, although Harris (1862, p. 306), in proposing the latter name, claimed that both *canthus* and *cantheus* referred to another insect. He does not appear to have been aware of the names *eurydice* and *transmontana*. Harris' objection to *canthus* and *cantheus* was that there was no mention in the original descriptions of "eye-spots" on the upperside. If his objection is valid, *eurydice* would be ruled out also. But this author is not inclined to discard a name that has been in general use since at least 1926. He has, however, questioned both *canthus* and *cantheus* in the synonymy. If *eurydice* must eventually be replaced, the inadequately described and, also, questioned in the synonymy *transmontana* as a junior subjective synonym would take its place; before this is done, an application should be made to the International Commission on Zoological Nomenclature to conserve *eurydice*.

Compton, Quebec, the type locality of *transmontana*, is a small village near which Gosse had a farm and taught school during the winter. This information was offered by Dr. Freeman, who also kindly furnished a small series of *eurydice* from Georgeville and Waterville between which Compton lies.

It should be noted that the original spelling "*boisduvallii*" of Harris' was erroneous; Boisduval wrote his name with one "l" only. It has been emended in this paper to read *boisduvali*. Harris' description and figure of this insect are adequate.

Morris (1862, p. 75, no. 6) ascribes *cantheus* (not *canthus*) to Fabricius, but the reference is incorrect as Fabricius never used that name. The first author to use *cantheus* was Godart in 1824, so the name must be ascribed to him. He too refers the name to Fabricius. The only apparent differences between *canthus* and *cantheus* according to Godart is that the former has four ocelli on the underside of the primaries and five on the secondaries, while the latter has three small indistinct ocelli on the underside of the primaries and six, the fifth very large and the sixth very small, at the anal angle. Such variations in spots are well known in species of Satyridae. It is this author's conclusion that these names are synonymous. Strictly interpreted, neither description applies very well to *eurydice* any more than Johansson's does.

The authorship of *eurydice* and *boisduvali* has fluctuated between Linnaeus and Johansson for the former and Morris and Harris for the latter. The paper in which the name *eurydice* was proposed was a thesis written by Johansson although published by Linnaeus, and this name has been ascribed to the former. In the case of *boisduvali*, the name was published by both Morris and Harris in the same year. But Morris' use of *boisduvali* was in the synonymy of *canthus*, a method of publication no longer considered valid under the Code. Therefore, *boisduvali* is ascribed to Harris who gave a good description and a figure of the insect.

Lethe fumosus (Leussler), new combination

Satyrodes canthus Linnaeus, n. v. *fumosus* Leussler
1916 Ent. News, vol. 27, p. 99, pl. IV, figs. 1, 2
Type locality: Sarky County, Nebraska
Type deposited: Ohio State University
Satyrodes canthus ab. *boweri* F. H. Chermock
1927 Bull. Bklyn. Ent. Soc., vol. 22, p. 119
Type locality: Port Hope, Ontario, July 29, 1921
Type deposited: Carnegie Museum
Lethe (*Enodia*) *eurydice appalachia* R. L. Chermock
1947 Ent. News, vol. 58, p. 33
Type locality: Conester Falls, near Brevard, North Carolina, June 27, 1941
Type deposited: Collection of the author

While Leussler described *fumosus* as a new variety, the name was given subspecific standing by McDunnough (1917, p. 6, no. 100a) and has been so used ever since. The types of *fumosus*, ab. *boweri*, and *appalachia* are all in existence and accounted for in the synonymy listed above.

The upperside of the wings of *fumosus* is brown, especially on the males. There is little contrast between the limbal area and other parts of the wings, but there is more contrast in the females than in the males. Thus the rows of ocelli on both primaries and secondaries do not stand out prominently, especially not on the upperside. On the underside of the primaries and secondaries, the lines bounding the postmedian band are straighter, and the basal line seems to terminate before the anal angle. The ocelli on both wings consist of a white pupil in a black ground which is set in a yellow circle surrounded by another of brown.

Leussler wrote in his original description: "The habitat of this variety is a spring-fed marsh . . . where wild rice, rushes and tall coarse grasses flourish," and added, "It seems quite probable that this form of *canthus* has been developed as a result of geographical isolation." From this it may be gathered that Leussler himself considered his variety as synonymous with subspecies. This insect is found in partly wooded bogs and swamps and not in dry, open fields. Its preferred food plant is probably a species of rough grass or sedge.

Since *fumosus* and *appalachia* occur at opposite ends of a cline, there appears to be no reason for not using both in a varietal sense; minor differences must exist between them.

As a result of this study the following arrangement of the names in checklist form is proposed:

eurydice (Johansson), 1763
  a) *e. eurydice* (Johansson), 1763
    ?*canthus* (Linnaeus), 1767
    ?*cantheus* (Godart), "1819" [1824]
    boisduvali Harris, 1862 (*emendatio*) *boisduvallii* Harris, 1862
  b) ?*e. transmontana* (Gosse), 1840 form ♀ *rawsoni* (Field), 1936

fumosus (Leussler), 1916
    canthus Boisduval & Le Conte, "1833" [1834] (*nec* Linnaeus, 1767, *nec* Fabricius, 1775)
  a) *f. fumosus* (Leussler), 1916
    ab. *boweri* (F. H. Chermock), 1927
  b) *f. appalachia* R. L. Chermock, 1947

The *Satyrus canthus* of Boisduval & Le Conte, although only figured, is not the *canthus* of Linnaeus or Fabricius because of the presence of ocelli on the upperside of both wings, but it is the *fumosus* of Leussler and a good figure of that species. We do not know to whom those authors would have ascribed the name if they had published any letter press for that plate.

The life history of *eurydice* as *Satyrodes canthus* will be found in Scudder's *Butterflies of the Eastern United States* (1889, vol. 1, pp. 193–198) and in Edwards' *Butterflies of North America* (1890, vol. 3, pp. 193–202, pl. *Satyrodes* I). These may involve also the life history of *fumosus*, since these species thus far have been considered conspecific, but it is impossible to tell unless one has a description of the females that laid the eggs or of the environment in which they were taken. Doubtless when fully studied, slight differences will be found in the preparatory stages of *eurydice* and *fumosus*—they may even hybridize—and most probably they feed on different species of grasses due to the different environments in which they are found.

The genitalia of *eurydice* and *fumosus* are substantially similar, although long series of dissections might show minor differences. This fact is not surprising because there is no apparent difference between the genitalia of the two other Nearctic species of butterflies presently referred to *Lethe*, although superficially they are quite distinct in appearance.

The distribution of *eurydice* is somewhat wider than that of *fumosus*. It extends from Manitoba, Ontario, and Quebec south to Colorado and east of the Rocky Mountains to Georgia and Florida. On the other hand, *fumosus* has a more restricted range from Nebraska southward to Georgia and northern Florida. Doubtless both ranges have been somewhat confused by the failure of collectors to properly determine their specimens.

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Behavioral Adaptations of Cryptic Moths. V. Preliminary Studies on an Anthophilous Species, *Schinia florida* (Noctuidae)

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Abstract: Experiments were conducted on an anthophilous noctuid, *Schinia florida* (Guenée), which rests by day in blossoms of the evening primrose, *Oenothera biennis* L. These experiments involved presenting *S. florida* with choices of various plants to rest upon in a simple experimental apparatus. The results indicated that *S. florida* is able to recognize the primrose plant by olfactory cues, and that the attractive emanation is effectively restricted to the blossoms of this plant. No evidence for an attraction of *S. florida* to yellow substrates was found, but indirect evidence suggested that reflectance characteristics may play a role in attracting these moths to primrose blossoms. It is postulated that the attractive emanation from primrose blossoms may trigger the eclosion of adult *S. florida* in nature.

The primrose moth, *Schinia* (= *Rhodophora*) *florida* (Guenée), is an anthophilous species which rests by day in the flowers of its food plant, the evening primrose (*Oenothera biennis* L.). At first glance, this pink and yellow moth might seem to be warningly colored, but observation of its habits in nature reveal its cryptic adaptations. The moth ordinarily rests folded-up and head-down in a primrose blossom (Fig. 1). In this position, the yellow tips of the moth's fore wings resemble the petals of the blossom, particularly when the blossom partially closes. The pink portion of the moth's fore wings closely matches the color of dying primrose blossoms, and so the moth is easily overlooked, even when resting in an open blossom, or among the blossoms, on the head of this plant.

Further evidence for the cryptic, rather than aposematic, nature of the primrose moth's coloration has been obtained using two caged Pekin robins, *Liothrix lutea* (Scopoli). These birds readily and repeatedly ate *S. florida*, but rejected *Anisota rubicunda* Fabricius (Citheroniidae), which displays similar colors, after one trial. The earlier "experiments" of Jones (1932, 1934), showing a relatively low acceptability of *S. florida* to wild birds, cannot be taken as evidence for any unpalatability of this moth. His results can be equally well interpreted in terms of predator avoidance of novel insects, or generalization from prior experiences with a distasteful species, perhaps *A. rubicunda*.

Descriptions of the life history stages of *S. florida*, and observations regarding the anthophilous habits of the adults, have been contributed by several

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Fig. 1. The typical resting attitude of *S. florida* in a blossom of the evening primrose. Shaded portions of the moth are pink, and unshaded portions are yellow. Life size.

authors (e.g., Fitch, 1867; Saunders, 1869, 1871; Hardwick, 1958, 1967). The only prior behavioral study of a heliothidine moth, to my knowledge, is that of Brower and Brower (1956) on the resting attitudes of *Schinia* (= *Rhododipsa*) *masoni* (Smith) on blossoms of the composite *Gaillardia aristata* Pursh.

The present paper summarizes several preliminary experiments which were designed to shed light on the nature of the attraction of *S. florida* to primrose blossoms.

MATERIALS AND METHODS

Individuals of *S. florida* were collected from primrose blossoms in central Massachusetts (Franklin and Hampshire counties) during the summers of 1967 and 1968. These moths were then tested for plant preferences in a very simple experimental apparatus.

A plywood box (15 inches square by 19 inches high), containing four 12-ounce beer bottles which served as vases for cuttings of various plants, constituted the basic apparatus. The plant cuttings were taken daily in the local area, they were trimmed to approximately 14 inches in height, and they were placed into the bottles; two stalks of one plant species to each bottle. The

EXPT.	PLANTS & SELECTIONS OF THE MOTHS				P
1.	BLOSSOMING STALKS				
	Evening Primrose	St. Johnswort	Goldenrod	Mullein	
	20	5	7	2	★★★
2.	BLOSSOMING STALKS, CLOTH-COVERED				
	Evening Primrose	St. Johnswort	Goldenrod	Mullein	
	15	2	5	7	★★
3.	STALKS, BUDS & BLOSSOMS REMOVED				
	Evening Primrose	St. Johnswort	Goldenrod	Mullein	
	10	9	4	5	ns
4.	BLOSSOMING STALKS				
	Goldenrod	Joe-pyeweed	Queen-Annes-lace	Yarrow	
	13	5	7	7	ns
5.	BLOSSOMING STALKS, PRIMROSE SCENT				
	Goldenrod	Joe-pyeweed	Queen-Annes-lace	Yarrow	
	8	5	9	3	ns

FIG. 2. A summary of the experiments with *S. florida,* showing the numbers of moths selecting the various plants in each experiment. Chi-square tests gave probabilities (P) of less than 0.001 (three stars), less than 0.01 (two stars), and greater than 0.05 (ns = not significant).

experimental box was covered with a pane of window glass, and it was set out in a wooded area. Moths were introduced into the box at night by sliding the glass top to one side, and the selections of the moths (i.e., the plants on which they were resting) were noted on the following morning.

Five experiments were carried out over a series of nights, using from two to ten moths in the experimental box per night. Each moth was used only once in any particular experiment. The data in all of these experiments were analyzed by chi-square tests (goodness-of-fit of the moths' observed distributions to random distributions on the plants).

EXPERIMENTS AND RESULTS

Five experiments, each involving choices among four plants, were conducted with *S. florida*. The data from these experiments are summarized in Fig. 2.

EXPERIMENT 1. The apparatus was initially tested by presenting *S. florida* with a choice among evening primrose (*Oenothera biennis* L.) and three other plants having yellow blossoms, St. John's-wort (*Hypericum perforatum* L.), goldenrod (*Solidago* sp.), and mullein (*Verbascum thapsus* L.). In this case, the distribution of resting moths on the plants differed significantly from random, there being an obvious perference for primrose. This result indicated that the experimental apparatus was suitable for testing the moths' abilities to discriminate among various plants.

EXPERIMENT 2. In order to determine whether *S. florida* could locate primrose without visual or tactile clues to its identity, Experiment 1 was repeated, but now each plant was loosely wrapped in a double layer of cheesecloth. The distribution of moths on the plants again differed significantly from random, and again primrose was obviously preferred. This result indicates that *S. florida* is able to locate primrose on the basis of olfactory stimuli.

EXPERIMENT 3. Since *S. florida* is almost invariably found in or near the blossoms of primrose in nature, the moths were presented with a choice among the four plants previously used, but all buds and blossoms were removed from the experimental cuttings. In this case, the distribution of moths on the plants did not differ from random. This result, in view of the previous evidence for the moths' olfactory recognition of primrose, suggests that an attractive emanation is effectively restricted to the blossoms of this plant.

EXPERIMENT 4. In order to determine whether *S. florida* would exhibit a preference for another yellow flower, should primrose be unavailable, the moths were given a choice among goldenrod, *Solidago* sp., (yellow); joe-pye-weed, *Eupatorium* sp., (pink); queen-Anne's-lace, *Daucus carota* L., (white); and yarrow, *Achillea ptarmica* L., (white). The distribution of moths on these plants did not differ from random.

EXPERIMENT 5. It might be argued that *S. florida* would not seek yellow blossoms unless exposed to the attractive emanation from primrose. Accordingly, Experiment 4 was repeated, but a blossoming head of primrose was wrapped in cheesecloth and placed on the bottom of the experimental box. The distribution of moths on the plants again did not differ from random. In addition to the 25 moths recorded in Fig. 2, nine moths were found resting on the cloth-covered primrose on the bottom of the box. The results of Experiments 4 and 5 suggest that *S. florida* is not attracted to yellow blossoms as such when seeking a resting place.

DISCUSSION

The experiments reported here indicate that the attraction of *S. florida* to evening primrose is based on olfactory stimuli emanating from primrose blossoms. The data also suggest that *S. florida* is not attracted by yellow stimuli when seeking a resting place.

Further evidence for the ineffectiveness of yellow substrates in attracting *S. florida* has been obtained in another experiment. In an apparatus allowing a choice of a yellow background among several gray backgrounds, described in detail in Sargent and Keiper, (1969), none of 11 *S. florida* selected the yellow background. Some evidence suggests, however, that this moth is attracted to substrates of high reflectance. In an apparatus allowing a choice between black and white backgrounds, described in detail in Sargent, (1968), 11 out of 14 *S. florida* selected the white backgrounds. This result suggests that reflectance characteristics may interact with olfactory characteristics to bring *S. florida* to the blossoms of primrose plants.

The apparent restriction of an attractive emanation to the blossoms of evening primrose tempts one to postulate that this emanation may actually trigger the eclosion of adult *S. florida* in nature. At any rate, it is certainly true that *S. florida* is only cryptic on blossoming primrose plants.

Several factors that undoubtedly influence the anthophilous habits of *S. florida* were not investigated in the present study, and these should provide opportunities for further work. One such factor is the apparent tendency of these moths to seek out the apical portions of plant stalks when coming to rest. In addition, the role of tactile stimuli in determining the moths' final resting positions in primrose blossoms would seem particularly amenable to experimental analysis.

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New Honorary Members

A happy event of the year 1968 was the consolidation of the Brooklyn Entomological Society with the New York Entomological Society. As a special mark of this event a member was chosen from each of the groups to receive an Honorary Membership in the Consolidated Society. The eminent scientists elected in recognition of their contributions to entomology at the October 1st meeting were Charles P. Alexander of the New York Society and Rowland R. McElvare of the Brooklyn Society. These elections were announced at the Anniversary Dinner celebrating the 75th Anniversary of the Incorporation of the New York Society and the official launching of the new Consolidated Society, held on October 29th at the American Museum of Natural History.

Charles P. Alexander is preeminent in the taxonomy and systematics of the Crane Flies of the world. Since his visit in 1906 with Dr. E. P. Felt, then the New York State Entomologist, and correspondence with other prominent entomologists of the day to get help with the identification of some crane fly specimens, his interest in these insects was aroused. He has been "working out" the crane flies ever since. He has traveled extensively to collect these insects, and collectors and correspondents from all corners of the world send specimens to him. His personal collection now contains over 11,000 species, and he has published more than 800 papers with descriptions of about 9,000 new species. In 1912 he joined the New York Society, and the same year one of his papers first appeared in our **Journal**. Since then 56 of his contributions have been published in the **Journal**; an average of one per year. Over an almost similar period he had 50 papers published in the **Bulletin of the Brooklyn Entomological Society**. Professor Alexander joined the staff of the University of Massachusetts in 1922 and served there continuously as Professor, Chairman of the Zoology and Entomology Department, and Dean of the School of Science. His influence through his numerous undergraduate and his many graduate students has been vastly important, too. He retired from the University in 1959 with the title, Emeritus Professor of Entomology, but his research is still in progress. Our hope is that he will be our active Honorary Member for many years to come.

The interest of **Rowland R. McElvare** in insects goes back to his boyhood when he discovered the Brooklyn Children's Museum. At that time George P. Engelhardt was the Staff Naturalist and the close association which they formed continued during the lifetime of the latter. Throughout his subsequent banking career, Mr. McElvare devoted much of his free time to Lepidoptera. Becoming a member of the Brooklyn Entomological Society in 1917, he served as President in later years, and, upon the death of Mr. Engelhardt, he assumed the treasurership, a position he held for a quarter of a century. He was Honorary President of the Society at the time of its consolidation with the

New York Society. For many years he has been interested in the Heliothiinae, a subfamily of noctuid moths to which little attention has been paid except for a few species of economic importance. Lack of available material for study has entailed considerable field collecting in the Southwest. A number of his papers have appeared in the **Bulletin of the Brooklyn Entomological Society** and more recently in the **Journal of the Lepidopterists' Society.** Currently, he is retired and lives in the North Carolina Sandhills near Southern Pines where he is continuing his studies of heliothid moths.

On February 4, 1969 the Society elected Alexander B. Klots and Asher E. Treat to Honorary Membership. Although their scientific contributions more than qualify them for this honor, each has had long, active membership in the Society and has served as its President.

Dr. Alexander Klots has published extensively on the biology and taxonomy of Lepidoptera, including his well-known *Field Guide to the Butterflies of North America, East of the Great Plains.* Together with his wife, Dr. Elsie B. Klots, he has published several books of popular interest. Of special importance to many of Dr. Klots' students at City College was his course in field biology. In an atmosphere of increasing emphasis on molecular biology in the College's curriculum, this course was unique. While students were training to peer through electron microscopes, Dr. Klots showed them the value of peering through binoculars at mallards flying overhead. While students were rolling up their sleeves to dissect cats, Dr. Klots showed them how much could be learned by rolling up their pants and wading out on a quaking bog mat. Those students who have pursued professional careers in biology utilizing field studies continually express their gratitude to him. Long before formal course work in ecology was made an integral part of the City College biology curriculum, Dr. Klots' students left his course with a deep appreciation of the interactions between populations and their physical and biotic environments.

The scientific endeavors of **Dr. Asher Treat** are known to all biologists, as well as to entomologists. His studies include papers on taxonomy, morphology, neurophysiology, behavior, and cytology, and each is a major scientific contribution. His studies on the social behavior of mites infesting the ears of certain moths and his collaborations with Dr. Kenneth Roeder on hearing in moths today stand as classics in biology. Those of us who were students at City College and knew Dr. Treat are genuinely grateful for having had the opportunity to study under him, and were regretful upon his recent retirement. To the undergraduate students he was an outstanding teacher and coordinator of General Biology. To the graduate students he was a skillful and perceiving experimental biologist, and they regretted his leaving when the graduate program was expanding. We are pleased his research and publishing are continuing, and we are happy that the Society is honoring him.

BOOK REVIEW

Pogonomyrmex Harvester Ants. Arthur C. Cole, Jr. The University of Tennessee Press, Knoxville. 1968. 222 p., 12 pls. $7.50.

During the noisy infancy of the *New Systematics* we were often told that subjective taxonomy must be thrown out of the window. The old duffers and the subjective species with which they had cluttered up the literature were both thoroughly discredited. It was held that, once these pathetic antiques had been disposed of, modern taxonomy could begin setting up species by purely objective methods. This last is a highly laudable idea and it might be wished that our brave new taxonomists would stick more closely to it. But it would be awkward for them to do so. Any completely objective approach to a species must include an exhaustive acquaintance with that species in the field. It is far from easy to make such an acquaintance and, when a large and widely distributed genus is involved, to do so may require years of field work. Faced with this difficulty the most ardent advocate of the *New Systematics* is usually willing to settle for something less than complete objectivity in his taxonomic studies.

Dr. Arthur C. Cole appears to be a notable exception to the above rule. During the past forty years he has taken the time and the trouble to acquire a unique field acquaintance with the North American species of *Pogonomyrmex*. Of the twenty-two species treated in the volume only two have been able to elude Dr. Cole in the field. But it should be remembered that this enviable record required more than a dozen summers of intensive collecting in the western United States and northern Mexico. It appears that Dr. Cole spent about five years in the field before he was satisfied that he had a field knowledge of *Pogonomyrmex* that was good enough to permit him to begin his laboratory analysis. One wonders how many of our brave new taxonomists would willingly spend that much time and effort for the sake of gaining an objective view.

With such a background it is not surprising that Dr. Cole has produced what is, by very long odds, the best study of our *Pogonomyrmex* yet published. But it is surprising that his objective treatment of our species has caused remarkably little damage to the previously existing taxonomic structure of the group. It is heartening to discover that eight of the nine species of North American *Pogonomyrmex* which W. M. Wheeler listed in 1910 are still in good taxonomic standing. This is not to say that Dr. Cole has made no revisionary changes. Several forms hitherto considered subspecies have been raised to specific rank and an even larger number of subspecies have been placed in the synonymy of their respective species. Dr. Cole has shown that Kusnezov's proposal to treat *Ephebomyrmex* as a separate genus is unacceptable and he has also given reasons why *huachucanus* should be transferred to the subgenus *Ephebomyrmex*. Dr. Cole has recognized four species groups or complexes in the subgenus *Pogonomyrmex*. This arrangement is very helpful from a taxonomic standpoint for by keying the complexes the subgenus is broken up into small, easily handled groups of species.

Perhaps the best index of the thoroughness with which Dr. Cole pursued his field studies is the fact that he was able to secure the sexual castes of nineteen of the twenty-two species studied. As things stand in ant taxonomy today this is a surprisingly large proportion and the benefits are clearly apparent, for he has been able to back up differences in the worker caste with others derived from the male and female castes.

Most of the key characters are illustrated, and a glossary covering the contractions used in the diagnoses is supplied. Each species is furnished with a distribution map or a locality list. When Dr. Cole sent me the typescript of his book a year or so ago I wrote him that, while I understood that the number of stations collected was far too large to include all of them, I was disappointed that this should be true. There is a peculiar pleasure in coming on a station in a locality list which you know lies at the end of a particularly ghastly stretch of road. The response is always, "By George! He got in there!" I am sure that Dr. Cole's omission of the full list of locality data has deprived those who know the areas which he worked of many such pleasures. But this is the only thing about the book which is to be regretted.

In conclusion, it may be emphatically stated that no one interested in the taxonomy of *Pogonomyrmex* can afford to be without Dr. Cole's book.

Wm. S. Creighton
La Feria, Texas

ENTOMOLOGICA AMERICANA

The President and the Trustees of the newly consolidated *New York Entomological Society, Incorporating the Brooklyn Entomological Society, Inc.* are happy to announce that the next issue of the ENTOMOLOGICA AMERICANA is now in preparation. It is anticipated that it will be issued during the first half of 1969. Dr. James Slater will continue as Editor.

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Organized June 29, 1892—Incorporated February 25, 1893
Reincorporated February 17, 1943

The Brooklyn Entomological Society

Founded in 1872—Incorporated in 1885
Reincorporated February 10, 1936

The meetings of the Society are held on the first and third Tuesday of each month (except June, July, August and September) at 8 P.M., in the AMERICAN MUSEUM OF NATURAL HISTORY, 79th St. & Central Park W., New York, N. Y. 10024.

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CONTENTS

Ecological Studies of Carrion Beetles in Hutcheson Memorial Forest

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RECEIVED FOR PUBLICATION OCTOBER 1, 1968

Abstract: Carrion-baited ground cans were used to collect carrion beetles during the summers of 1961 through 1965. Fresh chicken legs were used as bait and were left in the cans for two-week periods of time. Practically all of the flesh was eaten or decomposed by the end of this period. All collected beetles were identified to family, all Silphidae to species, and all Leptodiridae to genus or species. The members of the Silphidae, Leptodiridae, Histeridae, and Staphylinidae were consistently attracted to carrion and accounted for the bulk of the beetles that were trapped. The Silphidae was the dominant family and the seven species collected accounted for almost half of all the beetles collected. The numbers of individuals of this family were maintained at about the same level throughout the seasonal periods of study in 1961 and 1963. There was no apparent succession of Silphidae species on carrion during the period of time required for total decomposition. The carrion seemed to be most attractive to these beetles from the fifth to the tenth days when it was in the fresh-bloated, bloated, and decay stages. There was a seasonal pattern of change in dominant populations of Silphidae during the six-week summer periods of study. *Silpha noveboracensis*, the dominant species of early summer, decreased steadily and virtually disappeared by middle summer. *Nicrophorus* sp., on the other hand, was present in small numbers in early summer but increased steadily and became the dominant species in middle summer. *Silpha noveboracensis* was the dominant species in three shrub areas during early summer. It was most abundant in the Maple-leaved Viburnum shrub area.

INTRODUCTION

Many beetles are attracted to carrion and one family in particular, the Silphidae, are commonly called carrion beetles. This family of beetles contains some fairly large, brightly colored individuals which have been made famous through the writings of Jean Henri Fabre (1899). Much is known about these beetles, yet more is to be learned. It has been my hope to contribute to this information. This study was conducted in The William L. Hutcheson Memorial Forest, near East Millstone, in Somerset County, New Jersey.

Acknowledgments: I wish to express my sincere gratitude for the direction, guidance, and encouragement given to me by Dr. Paul G. Pearson throughout this investigation and for the suggestions and assistance of Dr. John B. Schmitt. I am indebted to Doctors Murray F. Buell, Leslie A. Stauber, and Jeff Swinebroad for reviewing this paper, and to my wife, Mary, for typing the manuscript. Dr. H. P. Andrews, Associate Professor of Statistics, kindly reviewed the statistics employed in the study. The William L. Hutcheson Memorial Forest Committee provided financial assistance to help defray the expenses of this research.

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Several studies dealing with various aspects of carrion decomposition and the arthropods associated with it have appeared during the last three or four decades. Payne (1965) conducted a summer study in South Carolina using baby pigs for carrion. He found that insect-free carrion decomposed very slowly and retained its form for many months. Carrion exposed to insects, however, was completely eaten within six days. As a result of this study, the Oak Ridge National Laboratory published a complete list of animal species associated with pig carrion (Payne and Crossley, 1966).

Walker (1957) studied the arthropods associated with decaying fish, cantaloupe and corn meal in four habitats in Tennessee. The differences in species collected, he noted, were due to the courses of carrion decay within the habitats, which in turn were caused by differences in microclimate.

Reed (1958) studied the animal communities associated with dog carcasses in Tennessee. He used paired carcasses, in wooded and pasture areas. The insect populations were found to be smaller in the pasture but succession was faster as a result of the greater heat. Reed also listed the earliest and last days for insect species collected during the course of a full year.

Bornemissza (1957) studied arthropod succession on carrion in Australia along with the effect of carrion decomposition on soil fauna. He found that the various stages of decomposition affected the soil below the carrion differently. This effect persisted, at least to some extent, for over a year.

Fuller (1934) also studied insect inhabitants of carrion in Australia. Although Fuller's efforts were concentrated on blowflies, her paper included some general discussion on Coleoptera. She made note of the great destruction of blowfly eggs and larvae by beetles, ants, and earwigs.

Howden (1950) studied the succession of beetles on carrion in North Carolina and Maryland. She found 14 families of beetles on carrion. One-half of the species present were primarily predators of fly larva and pupa, whereas the other half were necrophagous or of uncertain food habits. The typical succession, as she found it, started with oviposition by flies, followed by invasion of Staphylinidae and Histeridae, and finally the arrival of Silphidae and a number of other families associated with them.

In a previous paper (Shubeck, 1968) I discussed the results of orientation studies. However, this present paper contains the results of studies directed toward three objectives: A survey of beetles associated with carrion; the succession of the families of beetles and the species of the Silphidae on carrion; and the succession of carrion beetles in three different shrub areas within the oak-hickory climax forest.

METHODS

The observations here reported were made between July 1 and August 15 during the summers of 1961 through 1965. The beetles were trapped in gallon cans buried with the open end flush with the surface of the soil (Shubeck, 1968). Each of the traps was baited with an uncooked chicken leg or "drum stick."

Most collections were made between 2:00 and 4:00 o'clock in the afternoon. The beetles present in the traps on collecting days were removed with large forceps and placed in small jars containing 75% alcohol. Thus, all collections made over the five year period have been preserved. The jars were labeled so that the collecting day, the location, and the individual trap were recorded when the beetles were identified. All beetles were identified to their family designation, all Silphidae were identified to species, and all members of Leptodiridae to genus and, when possible, to species using references by Arnett (1963), Dillon and Dillon (1961), and Lutz (1918). A series of identified specimens have been deposited at the Department of Entomology Museum of the College of Agriculture and Environmental Science, Rutgers—The State University.

The study designed to compare succession by families of beetles and by species of family Silphidae was conducted during the summers of 1961 and 1963. A station was set up in the Maple-leaved Viburnum (*Viburnum acerifolium*) shrub area of Hutcheson Memorial Forest. Twelve ground cans were arranged in a circle so that each can was ten feet away from each neighboring can (Walker, 1957). The baiting of the cans was arranged so that there were three replicates, each containing a series of baits. The first can contained a chicken leg, the second can a fresh, peeled potato, the third can corn meal, and the fourth can was left empty. Although I had originally planned to look into the succession of insects on corn meal and potato, so few insects were attracted to these baits that they, along with the empty cans, served as controls to the carrion-baited trapping-cans.

Freshly baited traps were set up in two-week cycles. In this way the chicken legs went through cycles of decomposition until little flesh was left. For the sake of convenience, since I collected in three two-week cycles, "seasonal" labels were given to these periods of time; Early summer, July 1 to July 15; Early-middle summer, July 16 to July 31; Middle summer, August 1 to August 15. These dates varied only slightly in 1961 and 1963 since a given cycle always started on a Saturday with the setting of the traps. Collecting trips were made on Tuesdays, Thursdays, and Saturdays, so that for each cycle insects were collected on the 3rd, 5th, 7th, 10th, 12th, and 14th days after the baits had been set. During the 1963 study a record was kept of the condition and approximate degree of decomposition of the carrion on each collecting day.

In 1962 only one cycle was run but it was set up in three distinct shrub layers some distance apart from each other. The Maple-leaved Viburnum station was the same one used in the 1961 and 1963 study. A second station was set up in an Arrowwood-Greenbrier (*Viburnum dentatum-Smilax rotundifolia*) shrub area which was about 250 meters W.S.W. of Station 1. The third station was set up in a Black-haw (*Viburnum prunifolium*) shrub area and was about 200 meters N.W. of Station 1. This experiment was designed to see if there was any difference in carrion beetle species or succession in relation to different shrub areas within a given forest. Two one-gallon cans were left on the ground at each of the three stations to measure rainfall, and the temperature was recorded on the soil surface at each of the three stations during the collecting trips.

RESULTS

TAXONOMY. Four families of Coleoptera were consistently attracted to the carrion-baited ground cans. They are: Silphidae, the Carrion Beetles; Leptodiridae, the Small Carrion Beetles; Histeridae, the Hister Beetles; Staphylinidae, the Rove Beetles. These families made up the bulk of the Coleoptera collected. In 1961 they accounted for 97% of all beetles taken and in 1963 they accounted for 89% of all beetles collected; they are very important members of the carrion community.

Two genera and seven species of Silphidae were present, *Silpha americana, S. noveboracensis, S. surinamensis, S. inaequalis, Nicrophorus orbicollis, N. pustulatus,* and *N. tomentosus.* Tables 1 through 3 show that four of these species, *S. americana, S. noveboracensis, N. orbicollis,* and *N. tomentosus,* were collected in modest to abundant numbers, and for convenience I referred to these as the "common" species. On the other hand, *Silpha surinamensis, S. inaequalis* and *N. pustulatus* were collected in very low numbers, and for convenience I referred to these as "rare" species.

SUCCESSION. In terms of this study, succession might be defined as the predictable, sequential appearance and relative abundance of carrion beetle species on a chicken leg during a two-week cycle of decomposition. The presence and abundance of individuals of the families Silphidae, Staphylinidae, Histeridae, and Leptodiridae during six-week periods of observations is recorded in Table 1 (1961) and Table 3 (1963). The Silphidae were the most abundant in terms of numbers of individuals and comprised 46.51% of the four families during 1961 and 1963 (Table 4). The numbers built up to a peak on the fifth to seventh days of each cycle and dropped off to zero by the 12th to 14th days. The numbers of individuals in this family were maintained at about the same level throughout the six-week period of time (Table 4 and Fig. 1).

The numbers of Staphylinidae usually exhibited peaks at about the same time as the Silphidae although their numbers were much lower (Tables 1 and 3). The numbers of Histeridae and Leptodiridae did not describe a definite pattern.

EARLY SUMMER. *Silpha noveboracensis* was the most abundant species present at this time and an acute peak was present on the fifth day of the cycle in 1961 and 1963. A second, smaller peak was present on the tenth day in 1961. A total of 200 individuals was collected during the early summer cycle in 1961 and 1963 (Table 5).

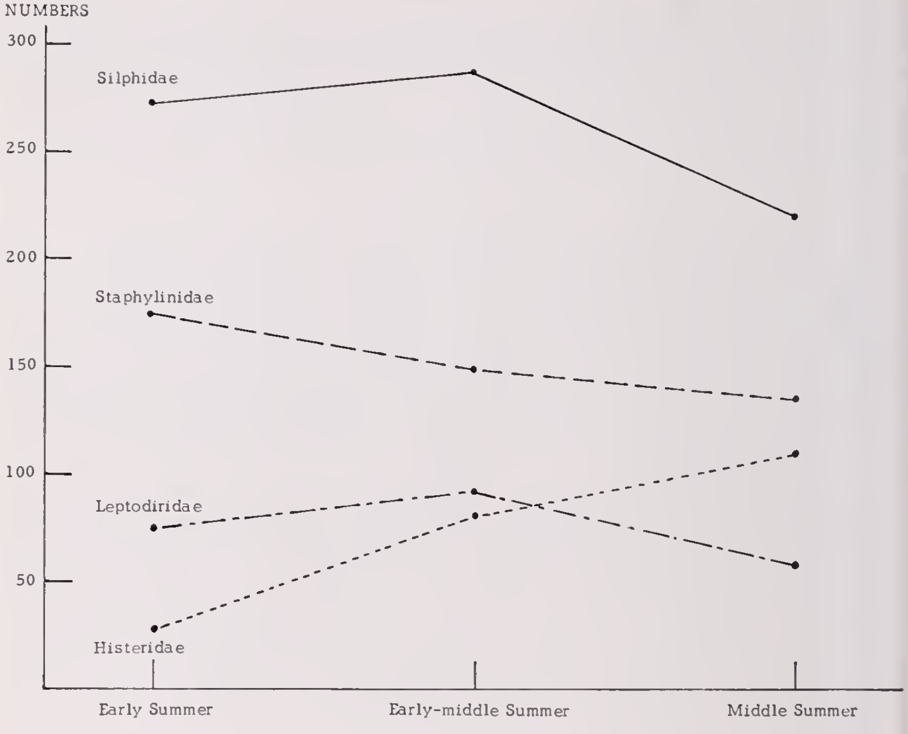

Fig. 1. Total numbers of four families recorded by season in 1961 and 1963.

The number of *Nicrophorus* sp. present during this cycle was only about 25% of the above species and it also manifested a peak, although a modest one, on the fifth day. I found it practical when examining and discussing results of these studies to combine the numbers of *Nicrophorus orbicollis* and *tomentosus* and to refer to these individuals in terms of one taxon, *Nicrophorus* species.

Few individuals of *Silpha americana* were present during this cycle (Table 5) although one or two appeared on several collecting days (Tables 1 and 3).

Prionochaeta opaca (Leptodiridae) was present in small numbers from the third day. In 1961 this species increased to 19 individuals on the seventh day when the other species dropped off considerably for some unexplainable reason (Table 1). In 1963 this species increased in numbers during the second week when the other species were no longer present (Table 3).

early-middle summer. The numbers of *Silpha noveboracensis* dropped to about 25% of the early summer level (Table 5). There was but one peak at this time and it fell on the fifth or seventh days (Tables 1 and 3).

Nicrophorus sp. showed a two-fold increase in numbers over the early summer period (Table 5), and a modest peak was again evident but it was present on the seventh and not on the fifth day.

TABLE 1. Carrion beetles collected in 1961.

	Early Summer 7/1/61–7/15/61							Early-middle Summer 7/15/61–7/29/61							Middle Summer 7/29/61–8/12/61							
Days	3	5	7	10	12	14	Total	3	5	7	10	12	14	Total	3	5	7	10	12	14	Total	Summer Total
Silphidae																						
Silpha americana	1	1	–	3	1	–	6	1	43	23	8	11	–	86	–	–	2	2	–	–	4	96
S. noveboracensis	20	46	13	26	1	–	106	1	17	7	–	–	–	25	–	–	1	–	–	–	1	132
S. surinamensis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. inaequalis	–	–	1	2	2	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5
Nicrophorus orbicollis	5	4	4	4	–	5	22	2	10	16	3	12	–	43	–	42	56	18	1	–	117	182
N. pustulatus	–	–	–	–	–	–	–	–	–	1	–	1	–	2	–	–	1	–	–	–	1	3
N. tomentosus	1	7	1	4	–	2	15	1	5	5	8	2	–	21	–	1	3	–	–	–	4	40
Leptodiridae																						
Prionochaeta opaca	2	3	19	–	–	–	24	–	–	2	–	–	–	2	–	–	–	1	–	–	1	27
Catops spp.	–	–	3	1	19	–	23	–	–	–	–	–	–	–	–	1	1	–	–	–	2	25
Staphylinidae	12	20	26	11	16	4	89	3	25	19	7	7	–	61	1	12	11	8	9	–	41	191
Histeridae	1	1	2	3	2	–	9	–	6	3	5	2	–	16	–	–	–	6	1	–	7	32

Table 2. Carrion beetle species collected in 1962.

	Maple-leaved Viburnum Shrub Area							Arrowwood-Greenbrier Shrub Area							Black-haw Shrub Area						
	Early Summer 6/30/62–7/14/62							Early Summer 6/30/62–7/14/62							Early Summer 6/30/62–7/14/62						
Days	3	5	7	10	12	14	Total	3	5	7	10	12	14	Total	3	5	7	10	12	14	Total
Silphidae																					
Silpha americana	1	1	–	–	–	–	2	–	–	1	14	9	2	26	1	–	3	7	7	–	18
S. noveboracensis	24	45	21	26	6	1	123	8	20	9	83	22	5	147	5	13	18	74	43	12	165
S. surinamensis	–	–	1	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. inaequalis	1	–	–	–	–	–	1	–	1	–	2	1	–	4	–	–	–	–	–	–	–
Nicrophorus orbicollis	4	3	6	2	1	–	16	–	4	2	2	–	–	8	5	5	3	4	–	2	19
N. pustulatus	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	1	–	–	–	–	1
N. tomentosus	3	3	1	–	–	–	7	–	6	3	10	6	–	25	5	–	2	11	1	–	19
Leptodiridae																					
Prionochaeta opaca	1	–	1	–	2	3	7	2	2	7	7	–	5	23	1	1	3	–	–	2	7
Catops spp.	3	3	2	1	10	10	29	1	6	17	15	3	14	56	–	–	–	4	–	2	6

Table 3. Carrion beetles collected in 1963.

	Early Summer 7/6/63–7/20/63							Early-middle Summer 7/20/63–8/3/63							Middle Summer 8/3/63–8/17/63							Summer Total
Days	3	5	7	10	12	14	Total	3	5	7	10	12	14	Total	3	5	7	10	12	14	Total	
Silphidae																						
Silpha americana	1	1	–	–	–	–	2	4	12	6	2	–	–	24	–	3	24	3	–	–	30	56
S. noveboracensis	5	76	13	–	–	–	94	2	–	14	2	–	–	18	–	2	8	–	–	–	10	122
S. surinamensis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1	1
S. inaequalis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nicrophorus orbicollis	–	–	–	–	–	–	–	–	1	18	3	2	–	24	7	–	15	3	1	3	29	53
N. pustulatus	–	–	1	–	–	–	1	1	–	1	–	–	–	2	–	2	–	–	–	–	2	5
N. tomentosus	–	–	1	–	–	–	1	–	–	9	–	–	–	9	1	–	12	3	3	–	19	29
Nicrophorus sp.	6	14	–	–	–	–	20	16	17	–	–	–	–	33	–	4	–	–	–	–	4	57
Leptodiridae																						
Prionochaeta opaca	2	–	1	3	7	7	20	8	2	2	4	30	39	85	–	–	8	–	7	4	19	124
Catops spp.	3	–	–	2	2	1	8	5	–	–	–	–	1	6	4	10	10	–	5	6	35	49
Staphylinidae	15	26	23	13	5	3	85	46	22	9	4	3	4	88	18	24	13	26	5	6	92	265
Histeridae	2	11	–	1	3	2	19	12	36	11	3	1	1	64	12	30	22	22	1	15	102	185

Table 4. Changes in total numbers of important beetles by season, during 1961 and 1963, and percentages of major families for entire season, 1961 and 1963.

Families	Early Summer	Early-middle Summer	Middle Summer	Totals	%
Silphidae	272	287	222	781	46.51
Leptodiridae	75	93	57	225	13.40
Staphylinidae	174	149	133	456	27.15
Histeridae	28	80	109	217	12.92
Totals	549	609	521	1,679	99.98

Silpha americana was now found in much larger numbers and there was a definite peak on the fifth day of the cycle.

Prionochaeta opaca barely made its appearance during this season in 1961. In 1963 it was present in very small numbers during the first ten days and then increased very sharply on the 12th and 14th days when the other species all but disappeared.

MIDDLE SUMMER. The number of *Silpha noveboracensis* was now insignificant (Table 5 and Fig. 2). In 1961 one individual was taken on the seventh day of the cycle (Table 1). In 1963 two individuals were taken on the fifth day, eight on the seventh day and none thereafter (Table 3).

Nicrophorus sp. was now the dominant carrion beetle (Table 5 and Fig. 2). A peak of 59 individuals was reached on the seventh day in 1961 (Table 1). In 1963 a peak of 27 individuals was present on the same day of the cycle (Table 3).

Silpha americana was present in very small numbers on the seventh and tenth day of the cycle in 1961. In 1963 this species was present on days five, seven and ten with a conspicuous peak on the seventh day.

Prionochaeta opaca was barely present during this season in 1961. In 1963 it was present in larger numbers and once again was quite conspicuous during the second week of the cycle when the other species had all but disappeared (Table 3).

Table 5. Total numbers of species recorded by season in 1961 and 1963.

	Early Summer	Early-middle Summer	Middle Summer	Totals
Silpha americana	8	110	34	152
S. noveboracensis	200	43	11	254
Nicrophorus sp.	58	130	173	361
Opaca prionochaeta	44	87	20	151
Totals	310	370	238	918

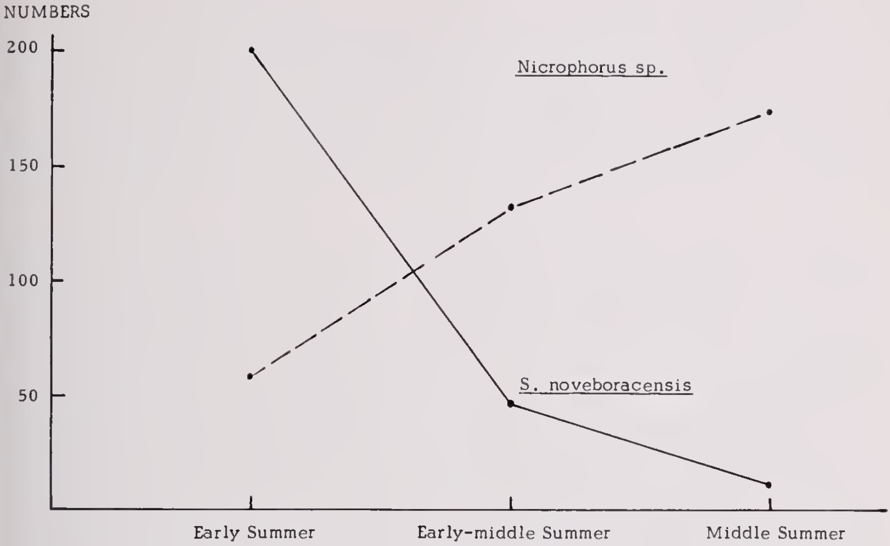

FIG. 2. Total numbers of two species recorded by season in 1961 and 1963.

In Reed's study (1958) of dog carcass communities he identified four stages of decomposition. These stages, as determined in our study, and the characteristics of each are shown in Table 6. The chicken legs were still fresh on the third day of each cycle. On the fifth day the carrion was not completely bloated so it was designated as fresh-bloated. On the seventh day the carrion was clearly bloated. On the tenth day it was in the decay stage and in the dry stage on the twelfth and fourteenth days.

SUCCESSION IN THREE DISTINCT SHRUB AREAS. The general similarity of the three shrub areas with respect to the presence and abundance of carrion beetles is evident in Table 2. *Silpha noveboracensis* manifested a primary peak on the fifth day and a secondary peak on the tenth day in the Maple-leaved

TABLE 6. Characteristics of carrion (chicken leg) during two-week periods of decomposition in the summer of 1963.

	3rd Day	*5th Day*	*7th Day*	*10th Day*	*12th Day*	*14th Day*
Color	Clear	Darker	Black	Black	Black	Black
Odor	Slight	Moderate	Strong	Slight	Slight	Slight
Consistency	Firm	Firm	Mushy	Moist	Dry	Dry
Maggots	Few (small)	Many	Many	Few (large)	None	None
	FRESH	FRESH-BLOATED	BLOATED	DECAY	DRY	DRY

Table 7. Chi Square data for Maple-leaved Viburnum shrub area.

	Expected	Observed	X²
3rd Day	12.3	24	$\frac{(24-12.3)^2}{12.3} = 11.1$
5th Day	26.0	45	$\frac{(45-26)^2}{26} = 13.8$
7th Day	16.0	21	$\frac{(21-16)^2}{16} = 1.6$
10th Day	61.0	26	$\frac{(26-61)^2}{61} = 20.1$
12th Day	23.7	6	$\frac{(6-23.7)^2}{23.7} = 13.2$
14th Day	6.7	1	$\frac{(1-6.7)^2}{6.7} = 4.8$
d.f. = 6 − 1 = 5			$X^2 = 64.6$

Viburnum area. In the Arrowwood-Greenbrier and Black-haw areas a very high peak was present on the fifth day.

Nicrophorus sp. shows a plateau on days three to seven in Area 1. In Areas 2 and 3 a modest peak is evident on the tenth day. *Silpha americana* does not show a uniform pattern in this study. *Prionochaeta opaca* was present in low numbers in all three areas; however, no clear pattern was discernible.

Although it was apparent that there was general similarity in presence and abundance of carrion beetles in the three shrub areas, and it was also apparent that the numbers of *Silpha noveboracensis* and *Nicrophorus* sp. approximated the numbers for the same species in 1961 and 1963 (Tables 1 and 3) during early summer, careful observation seemed to indicate that the numbers of *Silpha noveboracensis* in the Maple-leaved Viburnum area might be somewhat different than the same species numbers in the other two areas. There was no question that *Silpha noveboracensis* was clearly the dominant species in all three shrub areas. However, the question remained, was there a significant difference in abundance of this species in the three shrub areas? The Chi Square statistic was used to help make this determination. The expected figure for each collecting day was the mean number of *Silpha noveboracensis* trapped in the three shrub areas. The observed figure was the number collected in the Maple-leaved Viburnum area.

Null hypothesis: There is no effect of shrub type on the abundance of *Silpha noveboracensis*.

Since the derived Chi Square of 64.6 (Table 7) is much greater than the theoretical Chi Square of 12.83, with 5 degrees of freedom, we must reject the null hypothesis and we must conclude, at the .05 level of significance, that the Maple-leaved Viburnum shrub area, in some manner, affected the abundance of *Silpha noveboracensis* differently than did the other two shrub areas tested

The temperature and rainfall observations were very similar in all three shrub areas. No rainfall was recorded in any of the three areas on any of the six collecting days and the temperature differences were very slight. On the third day of the cycle there was but one degree Fahrenheit difference in one of the areas. On days five, seven and 12 there was a range of two degrees and on days ten and 14 there was a spread of three degrees.

DISCUSSION

It would seem that the seven species of Silphidae found in Hutcheson Memorial Forest form a representative group of this family which are found in a large region of the U.S. roughly east of the Dakotas to the eastern seaboard and north of Georgia and Alabama to Canada. Payne and Crossley (1966) collected the same species near Clemson, South Carolina. Howden (1950) collected all but *Nicrophorus orbicollis* and *N. pustulatus* in North Carolina. Between Walker (1957) and Reed (1958) all seven species were recorded in Tennessee. All but *Silpha noveboracensis* and *Nicrophorus pustulatus* were recorded at Cedar Point, Ohio by Jaques (1915). Hatch (1927) recorded all but *Silpha inaequalis* for the State of Minnesota but he states that it may also be present in the State. Milne and Milne (1944) recorded all seven species as far north as Irondale, Ontario.

SUCCESSION. I was surprised to find that there was very little succession within any given two-week cycle. The species that were present were usually present during most of the two weeks although it was true that the populations would build up and then drop off (Tables 1 and 3). Carrion seemed to be most attractive to carrion beetles from the fifth to the tenth days when it was in the fresh-bloated, bloated, and decay stages. Since this is the period of time during which the maggots were present (Table 6), it is possible that they are in some way involved in making the carrion habitat attractive to carrion beetles. It is probable that *Silpha* and *Nicrophorus* are predaceous on the maggots. Bell (1873), Clark (1895), Davis (1915), and Selous (1911) have reported observational evidence to this effect.

Although no succession was evident within any given cycle, there was on the other hand a very definite seasonal pattern of change in dominant populations of Silphidae through the six-week period of study. Whereas *Silpha noveboracensis* was the dominant species in early summer, it dropped off to a much lower level in early-middle summer and virtually disappeared in middle summer. *Nicrophorus* sp. was present in very small numbers in early summer but increased steadily during the summer. Its numbers rose above those of the former species during early-middle summer and increased sharply to make it the dominant species during middle summer when *Silpha noveboracensis* was all but gone (Table 5 and Fig. 2).

Since *Nicrophorus* sp. increased steadily as the former decreased, the high numbers of individuals in family Silphidae were maintained so that this family persisted in being the dominant family in the carrion community during the six-week study period (Table 4 and Fig. 1). Families Staphylinidae and Histeridae are apparently predaceous on other insects on carrion (Arnett, 1963). Although the numbers depicting the presence and abundance of Staphylinidae rose and fell as did the numbers of Silphidae (Tables 1 and 3), the former were about one-half as abundant.

The disappearance of *Silpha noveboracensis* in middle summer was puzzling. Reed (1958) was apparently troubled by a similar experience. When speaking of the above species and of *Silpha inaequalis* he said, "This species, and the following species abruptly disappeared from the carcasses early in the season, a fact which I cannot explain." The last date which he gave was June 22. Howden (1950) likewise indicated that *Silpha noveboracensis* was not taken after June in her studies. As a result of these observations, along with my own findings, I am convinced that this species reproduces and terminates its activities relatively early during the summer.

To determine that the disappearance of *S. noveboracensis* was not a result of my collecting activities, I rechecked data obtained in 1964 and 1965. These data were taken from orientation studies (Shubeck, 1968) and were very important because few beetles were removed from the forest during the studies conducted these summers. It is true that the beetles that had been marked and recaptured were then destroyed but this was a relatively small portion of those present. It amounted to 50 individuals of *Silpha noveboracensis* in 1964 and 112 individuals of this species in 1965.

It was interesting to note that on several occasions, during the early summer and early-middle summer seasons, the tiny *Prionochaeta opaca* (Leptodiridae) increased in numbers as the other carrion beetles decreased. This usually occurred during the latter phase of decomposition when the carrion was in the dry stage. This was the one species that seemed to have a fixed position, when present, among the beetles present during carrion decomposition. Although members of this family are commonly referred to as the Small Carrion Beetles, many of its species feed on fungus (Arnett, 1963). It is possible that *Prionochaeta opaca* was feeding on fungus growing on the carrion.

Although Silphidae were usually present on most collecting days during decomposition of carrion, the greater numbers were taken on days five, seven and ten. The carrion was in the fresh-bloated, bloated, and decay stages on these days (Table 6). Reed (1958) found that Silphidae were frequently present in large numbers during the bloated and decay stages but in very small numbers during the fresh and dry stages of decomposition. Payne and Crossley (1966), on the other hand, found the Silphidae virtually limited to the decay stage.

SUCCESSION IN THREE DISTINCT SHRUB AREAS. The fact that the results were basically the same in all three shrub areas seems to indicate that specific shrub areas, having similar microclimates, within a forest region have only a minor effect on the presence and abundance of carrion beetles. Walker (1957) attributed the differences that he noted in his study to different microclimates. The Silphidae that are present in a given forest region probably cruise through the area until they detect the odor of carrion and are able to locate it.

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Additional Observations on the Nesting Behaviors of *Crabro advenus* Smith and *C. latipes* Smith (Hymenoptera: Sphecidae)

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Abstract: A review of information associated with the nesting behaviors of *Crabro advenus* and *C. latipes* is presented. Our observations on the nesting ethologies of these two species are detailed. Behavioral components examined included habitat selection, burrow construction, prey transport and other provisioning activities, form and dimensions of nests, and analysis of cell contents (kinds of provisions, number of prey per cell, weights of flies, total biomass of prey per cell, position of prey flies, oviposition data). An interpretation of interspecific differences in an attempt to find behavioral characters at the subgenus level is made. Seasonal and local variation in the nesting behavior of *C. advenus* is discussed.

In 1968 Kurczewski and Acciavatti reviewed information associated with the nesting behaviors of 10 Nearctic species of *Crabro* and presented observations on the nesting behaviors of *C.* (*Synothyreopus*) *advenus* Smith and *C.* (*Crabro*) *latipes* Smith. The present paper is a continuation of the studies on these two species of digger wasps.

Patton (1897) published the first observations on *C. advenus.* He found females nesting in the ground and stocking their nest cells with adult flies belonging to the familes Sarcophagidae, Muscidae, and Tachinidae. Evans (1960) studied the nests of two females of this species in early July, 1958, near Ithaca, New York. He reported that the wasps nested in bare hard ground, left their nest entrances open during provisioning trips, and carried prey flies to the nests in flight. Evans (1960) presented details on prey transport and final closure in this species. He excavated one nest which contained a branched burrow, with 4 cells near each branch. The cells, each about 7 × 14 mm, varied from 6 to 12 cm in depth from the surface. Older cells were found to be farthest from the entrance. A first "branch" burrow was filled with soil before the construction of a second was begun. Fully provisioned cells contained 4–7 apparently dead flies. The first fly placed in each cell was found to be the egg-bearer. Evans (1960) also provided details on the positioning of the prey and wasp egg. The majority of prey flies belonged to the family

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Muscidae, but species of Rhagionidae, Tabanidae, Otitidae, Calliphoridae, and Sarcophagidae were also used as provisions.

Kurczewski and Acciavatti (1968) studied the nests and nesting behavior of two females of *C. advenus* under different conditions of soil and surrounding vegetation and at a different time of year (mid-September, 1967). They presented information on the construction of additional nest cells, provisioning activity, and prey transport. Two unfinished nests which were excavated contained 5 and 16 cells, averaging 7 × 13 mm in size. Clusters of from 3 to 7 cells were unearthed near the horizontal burrows. Cells belonging to a cluster were uncovered at about the same depth. Cells in more loosely-packed sand were constructed farther beneath the surface than cells in hard-packed sand. Based on evidence from the stages of development of the wasps in the cells and weights of the wasp larvae, they concluded that cells built first in a series are usually farther from the entrance than cells built later. Open burrows were used as prey storage chambers by the wasps. Older burrows and accompanying side burrows leading to completed cells were filled with sand.

Kurczewski and Acciavatti (1968), also, found that females of *C. advenus* stored from 2 to 6 adult flies in a cell. These flies, often of mixed species, belonged to the families Otitidae, Anthomyiidae, Muscidae, Calliphoridae, and Sarcophagidae. An average prey weighed about 19 mg or slightly less than the average weight for the female wasps (26 mg). Cells with a greater biomass of prey usually contained more flies, but an increase in the number of prey per cell did not accompany an increase in cell size. Most flies were placed in the cells or storage chambers head inward and ventral side up. Invariably, the wasp laid her egg on a fly in this position. The egg was rarely laid on the heaviest individual in the cell. A description of the egg and its placement on the prey is given.

Practically nothing is known about the nesting behavior of *C. latipes*. The first published note on this species comprised a prey record, *Musca domestica* L. (Muscidae) (Krombein, *In* Muesebeck, *et al.*, 1951). Kurczewski and Acciavatti (1968) observed a female of *C. latipes*, weighing 29 mg, flying with her prey, *Musca autumnalis* De Geer (Muscidae) (weight, 30 mg), near a sand cliff.

Our observations on the nesting behaviors of *C. advenus* and *C. latipes* were made in late May and early June, 1968. Those on *C. advenus* enable us to draw comparisons with the previous studies which were made at different times of the year and thus elucidate seasonal variation in the nesting behavior of this species; such information is often lacking in published studies on digger wasp behavior. Our data on the nesting behavior and prey preferences of *C. latipes* is the first of its kind for this species. Because both species were nesting more or less side by side at the same locality we were able to compare the behaviors of two members of different subgenera under the same conditions.

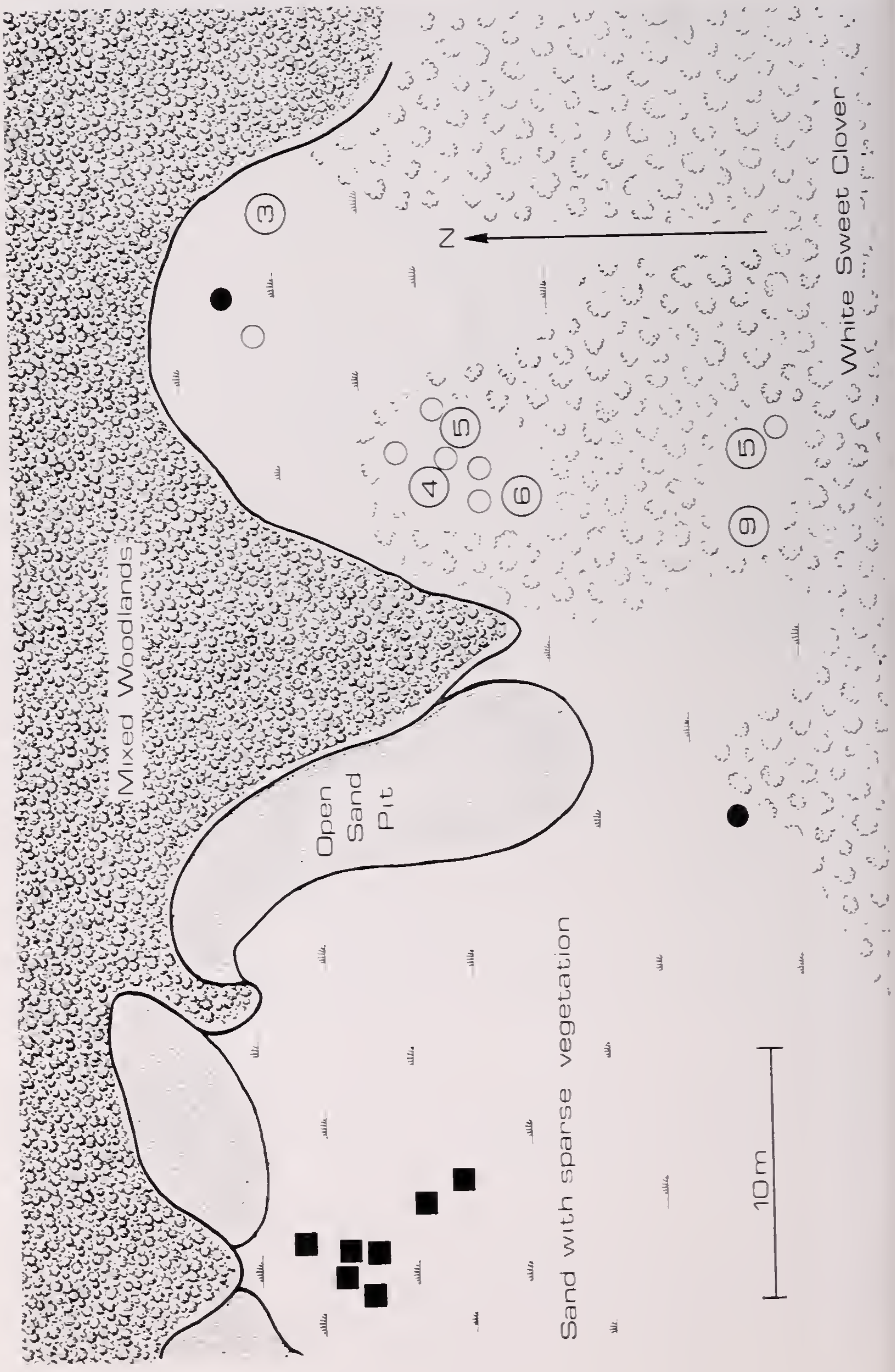
Mixed Woodlands
Open Sand Pit
Sand with sparse vegetation
White Sweet Clover
N
10m
3
4
5
5
6
9

Fig. 2. Entrances (indicated by white arrows) and tumuli of nine nests of *Crabro advenus* in an area of sand surrounded by white sweet clover.

The studies on *C. advenus* and *C. latipes* were made in a partly overgrown sand pit, 1 mile north of Chittenango and 7 miles west of Canastota, Madison County, New York (see Fig. 1, Kurczewski, Burdick, and Gaumer, 1969). The northern rim of the pit was bordered by a second growth stand of mixed hardwoods, mostly oaks and scattered white pines; the southern edge was bounded by a field. Only two nests of *C. latipes* were discovered at the periphery of a rather dense nesting aggregation of perhaps 50–75 females of *C. advenus* (Fig. 1). Seven nests of a third species, *C.* (*Crabro*) *monticola* (Packard) were located about 30 meters west of this aggregation in more loose, almost bare sand. *C. monticola* is larger than either of the other two species and its nests are easily recognizable by the rather large entrances and surrounding tumuli. Nests of *C. advenus* were frequently sheltered beneath overhanging

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Fig. 1. Nesting sites of *Crabro advenus* (open circles), *Crabro latipes* (closed circles), and *Crabro monticola* (closed squares) near Chittenango, New York. Areas where nests of *Crabro advenus* were close together are shown by large open circles with the number of nests inside.

vegetation, particularly white sweet clover, whereas nests of *C. latipes* were situated in open areas with sparse vegetation. As mentioned, nests of *C. advenus* were often close together (Fig. 1). In one small area, for example, only 2–42 cm separated any two of nine entrances (Fig. 2). In another area five entrances were only 4–60 cm apart. Similar dense nesting aggregations have been reported for *Crabro argus* Packard by Evans (1960).

Initiation of a burrow was seen for the first time in *C. advenus*. One female (CR-5) was made to construct a new burrow after one of us (NAB) accidentally stepped on her old nest entrance. Beginning from the sand surface, she used her forelegs and mandibles for digging. The wasp occasionally kicked sand backward with the middle legs, bracing herself in the entrance with the hindlegs. Penetrating the sand at a steep angle, she practically stood on her head. As she dug deeper the female twisted from side to side, using the mandibles to loosen the soil. Periodically, she backed up and shoved sand out of the hole with the end of the abdomen. After 11 minutes of digging she pushed damp sand up the burrow, completely plugging the entrance for the first time. Upon subsequent sand removals she pushed out the plug, distributing it on the tumulus surrounding the entrance. The tumulus enlarged in height and diameter following each sand removal. Until completion of the burrow which took 79 minutes from start to finish the female was not seen again in the entrance; rather, new plugs of damp sand continuously appeared in the entrance as the old plugs became incorporated into the tumulus. After constructing the burrow the female made a lengthy orientation flight above the area of the entrance before flying away to search for prey. Her nest entrance remained open throughout provisioning, but was plugged with sand from inside after each day's activities. Kurczewski and Acciavatti (1968) presented brief observations on the addition of new cells to the nest in this species.

We observed provisioning females of both *C. advenus* and *C. latipes*. The observations on *C. latipes* are the first to be recorded for this species. One female of *C. latipes* (CR-4) spent 16, 19, 8, and 33 minutes between consecutive returns to the nest with prey on 1 June 1968 at an ambient air temperature of 29.5° C and under conditions of almost complete cloud cover. This wasp spent from 1 to nearly 5 minutes beneath the surface between entering with the prey and exiting. Similar long periods of time spent inside the nest were recorded for *C. advenus* by Kurczewski and Acciavatti (1968). They believed such durations were related to the long distances inside the nest to which the wasp had to proceed with the flies. A female of *C. advenus* (CR-5) took 4 and 8 minutes between consecutive returns with prey on 3 June 1968. Periods spent beneath the surface by this wasp were not recorded, although another female of this species spent more than 15 minutes inside between entering and exiting. This period may have been spent in rearranging the provisions or in transferring the flies from a storage chamber to a rearing cell.

Provisioning females of *C. latipes* transported prey in a manner similar to that of provisioning females of *C. advenus.* The fly, held with the legs, was carried in flight. It was clasped against the venter, ventral side up and head forward. Upon landing the wasp used the middle pair of legs in holding the fly. Unless distracted or disturbed, she plunged into the entrance without pausing.

Females of *C. advenus* and *C. latipes* spent at least one week in provisioning up to eight and six cells, respectively, or, an average of about one cell per day. Since not more than two clusters of cells were involved in any of these nests we believe that some females of *C. advenus* spend two or more weeks in provisioning a nest. This estimate is based on the fact that Kurczewski and Acciavatti (1968) found 16 cells in one unfinished nest of this species.

Females of *C. advenus* provisioned nearly continuously during the morning hours from 0900 to 1100 hours (E. S. T.). However, many wasps stopped bringing in flies by 1100 or at least 1130 hours. Such individuals, after entering with a prey, closed the nest from inside by plugging the entrance with damp sand. The entrance remained plugged until 1500–1600 hours when many wasps reopened their nests and resumed their provisioning activities. Time of day seemed to be more important than air or sand temperature in determining when the wasps stopped provisioning and plugged their entrances. On hot days entrances were plugged between about 1100 and 1200 hours at air temperatures of 30°–32° C and sand surface temperatures of 38°–45° C. On cool days entrances were closed at approximately the same time (1110–1215) but at air temperatures of 19°–21° C and sand surface temperatures of 32°–36° C. One entrance was reopened and provisioning resumed at 1555 hours at an air temperature of 27° C and a sand surface temperature of 38° C. Pechuman (1963) found that nests of *C. monticola* were open in the morning but closed in the afternoon. The wasps may close their nests during mid-day because they rely on pronounced shadows to facilitate their hunting behavior.

Three nests of *C. advenus* (CR-5, 6, 7) and two of *C. latipes* (CR-3, 4) were excavated and studied (Fig. 3). These nests were all in rather early stages of development, as indicated by the small number of clusters, total number of cells, and stages of development of wasps in the cells—mostly eggs and juvenile larvae. Older nests contain several clusters, each with many cells, of which the oldest contain cocoons, newer ones, larvae, and the most recent ones, eggs (see Fig. 5, Kurczewski and Acciavatti, 1968). Except for one nest of *C. advenus* (CR-5), which had a cell containing a cocoon, none of the nests gave evidence of being more than about a week old. The females of both species had apparently emerged the last week in May during a period of unusually warm weather and had constructed and stocked their nests during the latter part of this week and the first week in June. Even nest CR-7 (*C. advenus*) which was excavated on 8 June and contained eight cells was relatively

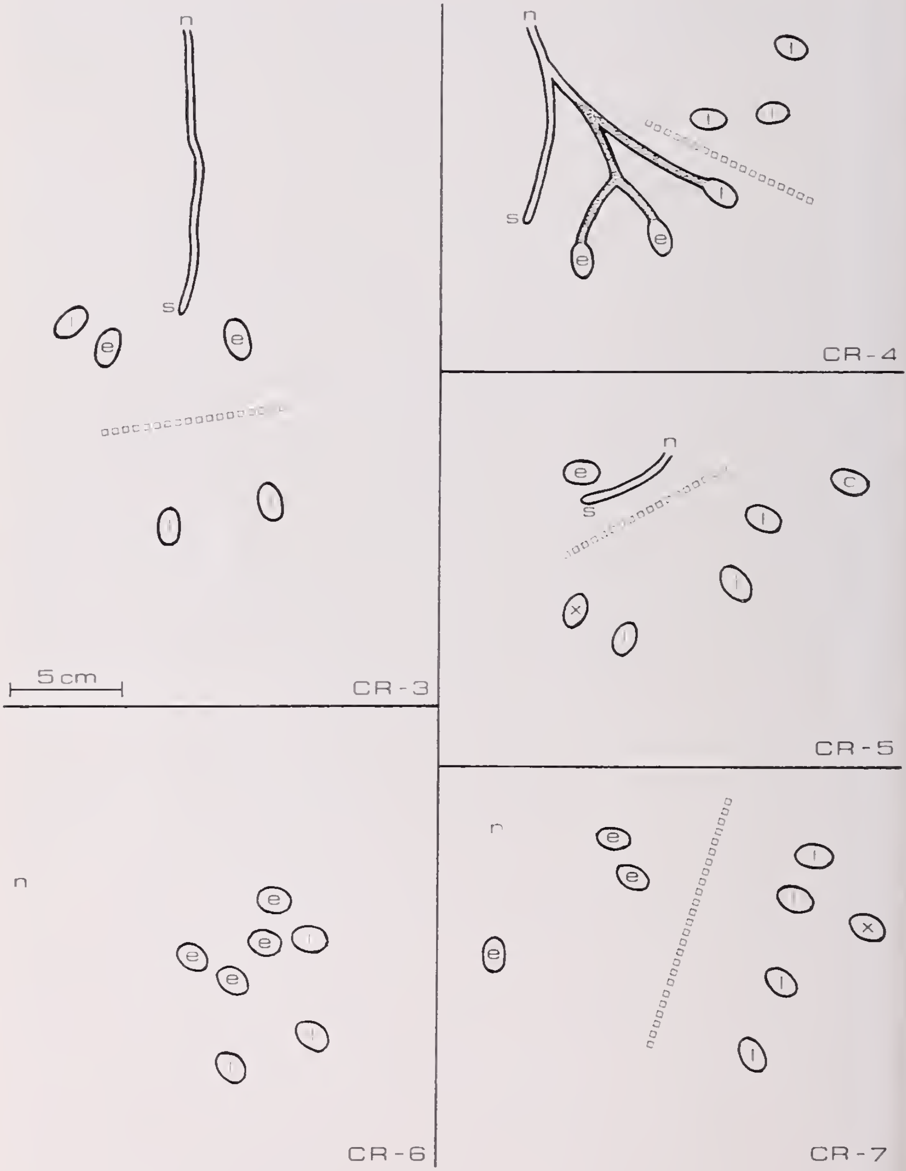


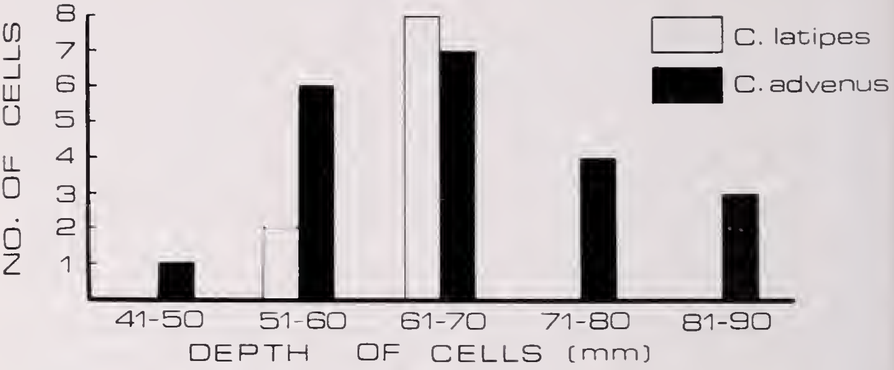
FIG. 3. Structure of nests of *Crabro latipes* (CR-3, 4) and *Crabro advenus* (CR-5, 6, 7), as seen from above. Apparent clusters of cells are separated by dotted lines, the first clusters made containing the older cells (see text). Cell contents are as follows: e, egg; l, larva; c, cocoon; x, contents destroyed. Nest entrances are indicated by n, storage areas by s. Stippled burrows are filled with sand. The scale below Nest CR-3 refers to all nests.

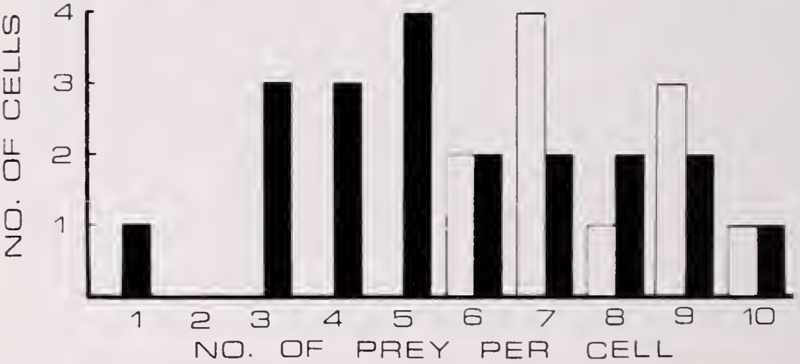
"young," as judged by the stages of development of wasps in the cells, the oldest of which contained a 4 mm long larva.

Nests of *C. advenus* and *C. latipes* were similar in form and dimensions. Nests of both species were easily recognizable by conspicuous tumuli surrounding the entrances (Fig. 2). The shapes and sizes of these tumuli varied with the development of the nest, particularly the addition of new cells, weather conditions, and accidental disturbances. An entrance to one *C. advenus* nest (CR-5), 4.5 mm in diameter, was surrounded by a "fresh" tumulus of damp sand, 7 cm in diameter and 2 cm high. Entrances to nests of *C. latipes* varied from 4 (CR-4) to 4.5 (CR-3) mm in diameter. The open entrances of nests of both species led to rather straight burrows the ends of which were used as storage chambers for the recently captured flies (Fig. 3, s). Two such burrows in nests of *C. latipes* were 13 (CR-3) and 9 (CR-4) cm long. A burrow in nest CR-5 (*C. advenus*) was 5 cm long. The lengths of the open burrows vary considerably in this species (see Figs. 4, 5, Kurczewski and Acciavatti, 1968), as well as in other species of *Crabro* (see Fig. 1, Evans, 1960). The burrows of both *C. advenus* and *C. latipes* penetrated the sand at various angles to the surface and then coursed somewhat horizontally. No abrupt curvatures such as Kurczewski and Acciavatti (1968) found in one nest of *C. advenus* were discovered in burrows of either species at this locality.

Similar to the findings of Hamm and Richards (1926), Evans (1960), and Kurczewski and Acciavatti (1968) for species of *Crabro*, we found that cells built first in a cluster in both *C. advenus* and *C. latipes* were usually farther from the entrance than cells built later, as indicated by the stages of development of wasps in the cells and the weights of the larvae (Fig. 3). We recorded not more than two clusters of cells in any of these incomplete nests. The maximum number of cells per cluster in *C. latipes* was three, and in *C. advenus*, five. Evans (1960) and Kurczewski and Acciavatti (1968) recorded up to seven cells per cluster in nests of *C. monticola* and *C. advenus*, respectively. Cells in a single cluster of *C. advenus* or *C. latipes* were separated by from 1 to 5 cm of sand. In one nest of the latter species (CR-4) it was possible to trace side burrows filled with sand to three cells. Other cells in nests of *C. advenus* and *C. latipes* could not be associated with side burrows. Different clusters in a nest were separated by from 3 (CR-4; *C. latipes*) to 6 (CR-3, 7; *C. latipes, C. advenus*) cm of sand, the closeness of these clusters possibly reflecting the fact that these nests were in rather early stages of development.

Although some cells in nests of *C. advenus* (CR-5, 6, 7) were deeper than cells in nests of *C. latipes*, other cells in the same nests were found at approximately the same depths (Fig. 4). Means for depth of cells in nests CR-3, 4 (*C. latipes*) and CR-5, 6, 7 (*C. advenus*) were almost identical: 7.0, 6.7, 6.7, 6.9, and 7.0 cm, respectively. There appears to be no seasonal variation in





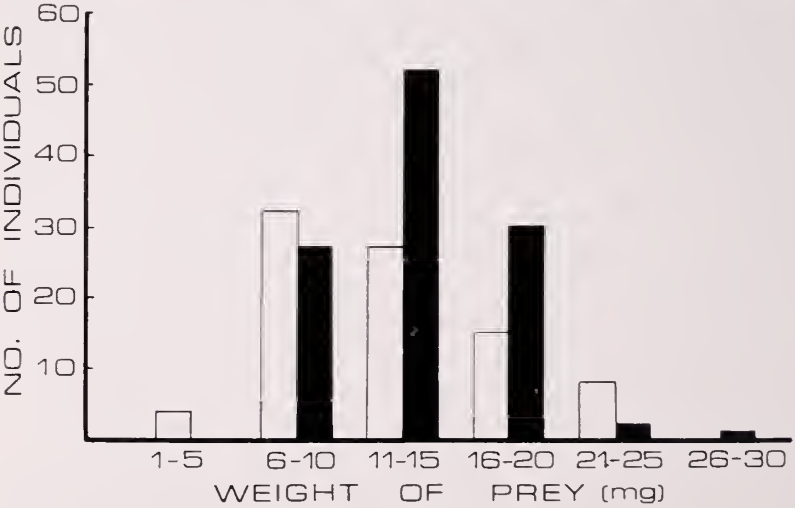


Fig. 4 (ABOVE). Depth of cells in nests of *Crabro advenus* and *C. latipes*.

Fig. 5 (MIDDLE). Number of prey per cell in nests of *Crabro advenus* and *C. latipes*.

Fig. 6 (BELOW). Weights of individual flies in nest cells of *Crabro advenus* and *C. latipes*.

the depth of nest cells of *C. advenus* when our June studies are compared with those of Kurczewski and Acciavatti (1968) made in mid-September. Cells in a cluster were more nearly equivalent in depth than cells from different clusters. There was some variation in the depth of cells in a single nest. For example, nest CR-5 (*C. advenus*) had cells which ranged from 5 to 8.5 cm in depth. The deepest end of the cell in nests of both *C. advenus* and *C. latipes* was found to be the end farthest from the entrance. Some cells of *C. advenus* were declined at an angle of nearly 45° to the surface. Kurczewski and Acciavatti (1968), on the other hand, found that the front ends of cells of *C. advenus* were slightly deeper than the back ends. According to Fig. 1 in Evans (1960), nest cells of *C. advenus* are more or less horizontal to the surface. The reasons for these discrepancies are not known, but apparently are related to the wasps' underground orientation in relation to local conditions. Cells of *C. latipes* averaged 7.1 (6–8) × 12.5 (10–15, N = 11) mm in size; those of *C. advenus*, 7.2 (5–9) × 14.0 (9–19, N = 19) mm. Both sets of figures compare well with those given by Evans (1960) [7 × 14 mm] and Kurczewski and Acciavatti (1968) [approx. 7 × 13 mm] for the latter species, indicating that there are few, if any, interspecific or seasonal differences in cell size.

Females of *C. advenus* and *C. latipes* provisioned their nest cells with adult flies (Table I). Generally speaking, both species of wasps captured a wide variety of average-sized flies of rather stocky build, excluding only the nematocerous and acalypterate muscoid Diptera. Digger wasps belonging to the genus *Oxybelus*, various crabronines, including even *C. advenus* at a different time of year, and numerous bembicines and mellinines prey on these and other flies, so that only a very few Diptera are probably "safe" from the predations of solitary wasps. Although our studies indicated that both *C. advenus* and *C. latipes* preyed mostly on the same families of flies, e. g., Rhagionidae, Syrphidae, Anthomyiidae, Muscidae, and Tachinidae, there appeared to be a certain amount of prey specificity exhibited by these species, particularly in the use of Dolichopodidae by *C. latipes*. Seasonal and local differences in the provisions of *C. advenus* were, however, much more marked than interspecific differences. With one exception, none of the species of flies which we recovered from the cells is the same as those which Kurczewski and Acciavatti (1968) recorded in their studies on this species. Furthermore, the species of provisions we found in the cells were entirely different from those recorded by Evans (1960) for *C. advenus*. Species of Muscidae, Calliphoridae, and Sarcophagidae were prevalent among the nest contents studied by both Evans (1960) and Kurczewski and Acciavatti (1968). Patton (1897) observed females of this species preying on Sarcophagidae, Muscidae, and Tachinidae. Evans (1960) found that rhagionids, tabanids, and otitids were rarely

Table I Species of Prey of *Crabro advenus* and *C. latipes*

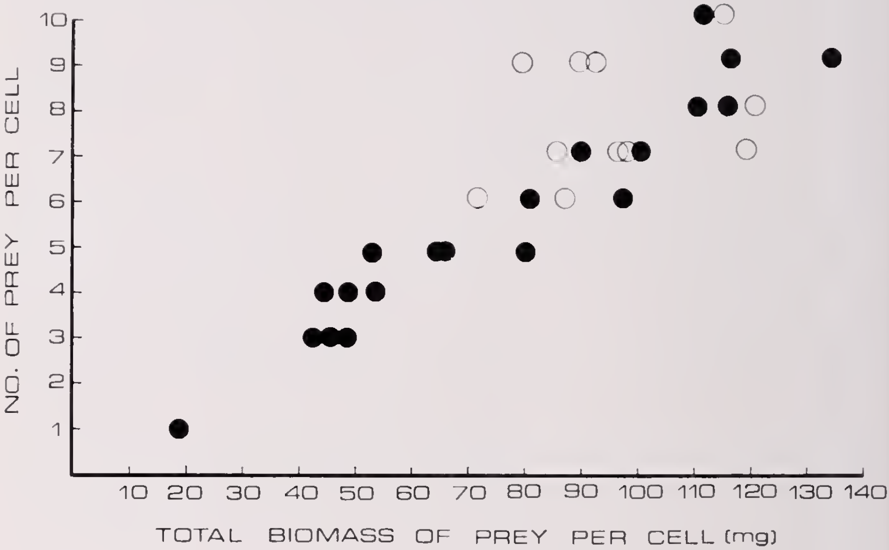
	Nest cells	
Family, species, and no. of prey	*C. advenus*	*C. latipes*
Rhagionidae		
Symphoromyia pluralis Curran, 36	CR-5B, 6A, B, C, D, F, 7B, C, G	CR-3C, 4B
Dolichopodidae		
Dolichopus adultus Van Duzee, 5		CR-4A, B, E
Dolichopus nigricornis Meigen, 1		CR-4F
Dolichopus nodipennis Van Duzee, 1		CR-3A
Dolichopus remus Van Duzee, 3		CR-3E, 4A, C
Dolichopus socius Loew, 2		CR-4C, E
Gymnopternus spectabilis Loew, 1		CR-4A
Rhaphium armatum Curran, 3		CR-4B, C
Rhaphium crassipes (Meigen), 2		CR-4B, D
Syrphidae		
Platycheirus peltatus (Meigen), 8		CR-3B, E 4C, D, F
Syrphus rectus Osten Sacken, 1	CR-7E	
Anthomyiidae		
Hydrophoria conica (Wiedemann), 95	CR-5A, C, E, 6C, D, E, G, 7A, B, D, E, F, H	CR-3A, B, C, D, E, 4A, B, C, D, E, F
Hylemya setigera (Johannsen), 2		CR-4E
Hylemya stratifrons Huckett, 2		CR-4F
Pegomya affinis Stein, 3		CR-4A, B, E
Pegomya lipsia (Walker), 2		CR-4A, D
Muscidae		
Fannia maniceta (Meigen), 2		CR-3C
Muscina assimilis (Fallen), 20	CR-5A, B, C, 6B, C, D, F 7B	CR-3A, E, F, 4C, D
Phaonia bysia (Walker), 2		CR-4C, F
Calliphoridae		
Lucilia illustris (Meigen), 1		CR-3D
Tachinidae		
Aplomyiopsis sp., 3 ♀ ♀	CR-5E	CR-3E, 4E
Ictericophyto tibialis (Curran), 1		CR-3A
Oswaldia assimilis (Tns.), 1		CR-3B
Genus & sp. Blondeliini, 1	CR-7B	

used as prey by *C. advenus*, while Kurczewski and Acciavatti (1968) recorded species of Otitidae and Anthomyiidae as being occasionally preyed upon. We found, on the other hand, that species of Anthomyiidae and Rhagionidae, in addition to Muscidae, were most commonly preyed on by *C. advenus*. We also recorded species of Tachinidae and Syrphidae as prey, neither of which family was listed by Evans (1960) or Kurczewski and Acciavatti (1968). We found no sarcophagids, otitids, or calliphorids.

The species, genera, and families of flies were well-mixed in the cells of *C. latipes,* but less so in the cells of *C. advenus.* In 11 completely provisioned cells of *C. latipes,* 2 cells contained two families of flies, 4, three families, 4, four families, and 1, five families. In contrast, only 1 fully provisioned cell of *C. advenus* contained four families, only 2, three families, 7, two families, and 9, one family. To underline this specificity, in nest CR-7 (*C. advenus*), five of the six cells with only a single family of prey contained as many as 7–10 flies! These data suggest that females of *C. advenus* are more selective of the flies they capture and store in cells than females of *C. latipes.* Perhaps, they condition more easily during hunting than females of *C. latipes,* i. e., they continue to return to an area where there is an abundant source of readily available prey, often a single sex of one species. Kurczewski and Acciavatti (1968) also reported that females of *C. advenus* were somewhat selective of their prey, although the species of flies were often "mixed" in the cells. They found that one female preferred the sarcophagid *Sarcophaga scoparia* Pand., whereas another often used the calliphorid *Pollenia rudis* (Fabr.). They related this selectivity to either the wasps' individuality or limitation in the number of species of available prey. Evans (1960), too, found that *P. rudis* was frequently captured and stored by *C. advenus,* but that *Fannia scalaris* Fabr. (Muscidae) comprised more than half the records in the nest cells.

The number of flies stored in the nest cells of *C. advenus* and *C. latipes* ranged from 1 to 10 (mean, 5.6; $N = 20$) and from 6 to 10 (mean, 7.7; $N = 11$) per cell, respectively (Fig. 5). These mean differences are significant at the 5 percent level, using the F test (see Steel and Torrie, 1960). Comparison of our mean value for *C. advenus* with that of Kurczewski and Acciavatti (1968) [4.3 prey/cell] made in September does not reveal significant differences at the 5 percent level, using the same test, but, at first glance, does suggest seasonal variation in this facet of the nesting behavior. If one examines the mean values of the individual nests, however, this difference is not so clear-cut. For example, the means for nests CR-5, 6, and 7 were 3.4, 4.9, and 7.6 prey per cell, respectively, compared to means of 4.2 and 4.3 prey per cell recorded by Kurczewski and Acciavatti (1968). The mean value of nest CR-7 compares nicely with the means of 7.6 and 7.8 prey per cell for nests CR-3, 4 (*C. latipes*)! Evans (1960) recorded from four to seven flies per cell for *C. advenus* in July. We found no correlation between the number of flies stored per cell and the depth of cell, nor between the number of prey per cell and the distance of cell from entrance, i. e., its relative age.

The weights of the individual flies ranged from 6 to 26 (mean, 13.7; $N = 112$) and from 4 to 23 (mean, 12.6; $N = 86$) mg in *C. advenus* and *C. latipes,* respectively (Fig. 6). These mean differences are not significant. However, these differences become exaggerated when one considers the average sizes of the



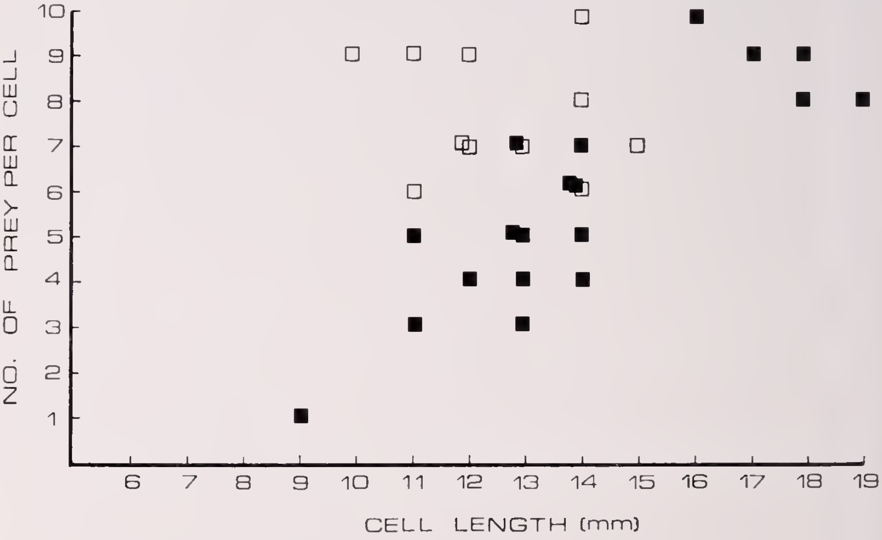


FIG. 7 (ABOVE). Total biomass of prey per cell in *Crabro advenus* (closed circles) and *C. latipes* (open circles) plotted against the number of prey per cell in these species.

FIG. 8 (BELOW). Cell length in *Crabro advenus* (closed squares) and *C. latipes* (open squares) plotted against the number of prey per cell in these species.

female wasps. Females of *C. advenus* averaged only 25 (23–29; N = 3) mg in body weight, females of *C. latipes*, 29 (26–32; N = 2) mg. Thus, females of *C. advenus* provision with slightly larger flies in relation to their body size than do females of *C. latipes*. As mentioned, the former species stores about two fewer individuals per cell than the latter species. This relationship between sizes of flies and number of prey per cell is not a direct one because the total biomass of prey in cells of *C. latipes* is greater than that in cells of *C. advenus*. The biomass in individual cells of *C. latipes* averaged 96.4 (71–122; N = 11) mg, in *C. advenus*, 76.5 (19–135; N = 20) mg. Cells with a greater biomass of prey usually contained more flies in *C. advenus* (Fig. 7).

There appears to be little seasonal variation in the total biomass of prey per cell when comparing our mean value for *C. advenus* with that of Kurczewski and Acciavatti (1968) for this species [80.6 mg]. However, the considerably broader range in biomass per cell which we give for this species compared to that of Kurczewski and Acciavatti (1968) [55–117 mg; N = 11] indicates more variation in this behavior in June than in September. Even more striking is the seasonal variation in the sizes of the individual flies. Kurczewski and Acciavatti (1968) found that the weights of individual prey from September, 1967 nests of *C. advenus* ranged from 4 to 38 (mean, 18.9; N = 55) mg. Not only is this range greater and the mean considerably higher than the ones we present for this species, but the mean differences are significant at the 5 percent level, using the T test approximation for unequal variances (see Guenther, 1964).

The results we obtained by plotting the number of prey per cell against cell size are contradictory (Fig. 8). An increase in the number of prey per cell did accompany an increase in cell size in *C. advenus*, but not in *C. latipes*. Moreover, Kurczewski and Acciavatti (1968) reported that an increase in the number of prey per cell did not accompany an increase in cell size in *C. advenus*! We cannot explain this discrepancy, except to state that our positive correlation in *C. advenus* possibly reflects a greater range in the number of prey per cell.

Fifty-nine of 115 (51%) prey flies of *C. advenus* and 40 of 83 (48%) of *C. latipes* were placed in the nest cells in a head inward, ventral side up position. Thirty-three (29%) prey individuals of *C. advenus* and 30 (36%) of *C. latipes* were put in the cells on their left or right sides and head inward. Nineteen (16%) flies in cells of *C. advenus* and 12 (14%) in cells of *C. latipes* were positioned head inward and dorsal side up. Only one prey of *C. latipes* was placed head outward and ventral side up. Four prey of *C. advenus* were in an oblique position, head upward, against the back end of the cell. Evans (1960) and Kurczewski and Acciavatti (1968) also found that the majority of prey flies of this species were placed in the cells head in and venter up, and only occasionally in other positions.

The fly on which the wasp laid her egg was rather horizontal in position with the ventral side up and the head inward in 12 of 18 cells of *C. advenus* and, also, in 5 of 8 cells of *C. latipes.* In one cell of each species the egg-bearing prey was placed dorsal side up, head inward, and in one cell each, on the side and head inward. Four egg-bearing prey of *C. advenus* and one of *C. latipes* were positioned obliquely, head upward, against the back end of the cell. In fact, in all 18 cells of *C. advenus* and in 7 of 8 of *C. latipes* the pedestal fly was against or near the back end of the cell, usually near the ceiling or floor. One egg-bearing prey of *C. latipes,* however, was found near the front end of the cell, on top of the other flies. Kurczewski and Acciavatti (1968), too, reported that the flies on which the females of *C. advenus* laid their eggs were positioned venter up and head in, near the back ends of the cells. They believed that such a placement might reduce the amount of parasitism. Evans (1960), observing this species, found that the egg-bearing prey was the first fly placed in the cell, "obliquely against the deep end." We support Evans' observations regarding the egg-bearers being the first flies put in the cells. In four examples of egg-bearing prey of *C. advenus* and in three of *C. latipes* one of the wings was noticeably extended laterally, as has been recorded for some egg-bearing flies of species of *Bembix* by Iwata (1942), Tsuneki (1956), Evans (1957, 1966), and others. Possibly, females of *C. advenus* and *C. latipes,* like those of *Bembix,* use the mandibles in bending the fly wing laterally which, in turn, facilitates oviposition.

In *C. advenus* only 4 of 19 eggs were laid on the heaviest fly in the cell, and one of these individuals was the only prey in the cell. In this species 3 eggs were laid on the second heaviest fly in the cell, 1 on the third heaviest, 2 on the fourth heaviest, and 9 on the lightest. In *C. latipes* none of 10 eggs was laid on the heaviest or second heaviest fly in the cell, 4 on the third heaviest, 2 on the fourth heaviest, 1 on the fifth heaviest, 2 on the sixth heaviest, and 1 on the eighth heaviest (lightest). The mean weight of the egg-bearing prey individuals was 12.4 (8–19; N = 19) mg in *C. advenus* and 12.3 (8–19; N = 10) mg in *C. latipes.* These mean values are close to those recorded for the weights of all fly individuals in the cells—13.7 (*C. advenus*) and 12.6 mg (*C. latipes*). Kurczewski and Acciavatti (1968) recorded 20.3 (14–32; N = 9) mg as the mean weight of egg-bearing flies of *C. advenus* in September, a distinct difference from our June mean values. The mean weight of the egg-bearing flies which Kurczewski and Acciavatti (1968) reported was close to the mean weight they recorded for all prey individuals [18.9 mg]. Thus, it appears that the wasps select the egg-bearing flies at random rather than by specific sizes.

Eggs of both *C. advenus* and *C. latipes* were white or cream in color, elastic, cylindrical, and elongate. Five examples of *C. advenus* eggs averaged 2.5 (2.1–

2.9) mm long and 0.55 (0.45–0.70) mm wide. Four examples of *C. latipes* eggs also averaged 2.5 (2.2–2.7) mm long and 0.55 (0.5–0.6) mm wide. Two eggs of a *C. advenus* female, weighing 23 mg, both measured 2.5 × 0.6 mm, whereas two eggs of a *C. latipes* female, weighing 26 mg, measured 2.6 × 0.6 and 2.3 × 0.5 mm. Kurczewski and Acciavatti (1968) found the eggs of two females of *C. advenus*, weighing 23 and 29 mg, to average 2.5 × 0.5 mm. Evans (1960), evidently observing smaller females, found the egg of this species to be about 2 mm long. In both species the egg was attached by the cephalic end to the ventral side of the neck of the fly (see Fig. 11, Kurczewski and Acciavatti, 1968). The egg extended obliquely backward across the prosternum and mesopleuron. Kurczewski and Acciavatti (1968) found that one female of *C. advenus* usually attached her eggs to the left sides of the flies, whereas another female preferred the right sides for the attachments. This was the case in females of *C. latipes,* with 4 of 5 eggs being attached to the right sides. In *C. advenus,* on the other hand, no such stereotypy was evident in any of the nests. Seven eggs were glued to the left and seven to the right sides.

DISCUSSION

The importance of the external morphological characters used in separating certain Holarctic subgenera of *Crabro* is often overestimated. This is especially true of females in the subgenera *Crabro s. str.* and *Synothyreopus* where the differences are rather subtle. Evans (1960), in discussing the nesting behaviors of species of *Crabro,* implied by omitting subgeneric designations that they are not well-founded. Nevertheless, he found differences in the nesting behaviors of species belonging to different subgenera, including nest site selection, hunting localities, manner of flight, and kinds of provisions. He observed that differences in depth of nests reflected differences in soil types and wasp sizes. Otherwise, Evans (1960) found the species to be similar in their nesting behaviors. Kurczewski and Acciavatti (1968) reported difficulty in characterizing the behavior patterns of the Nearctic species of *Crabro* at the subgenus level. They felt that lack of information on the Nearctic species was partly responsible for this. Kurczewski and Acciavatti (1968) were able to differentiate subgeneric and species distinctions in nest site selection, prey selectivity, number of prey stored per cell, and average sizes of prey flies. They found no clear-cut differences in eleven other behavioral components, particularly between species of *Crabro s. str.* and *Synothyreopus.* Our recent studies substantiate the findings of Evans (1960) and Kurczewski and Acciavatti (1968). Somewhat detailed observations of nesting females of *C.* (*Crabro*) *latipes* and *C.* (*Synothyreopus*) *advenus* revealed few significant differences at the subgenus level. In fact, our data indicate more variation in the nesting behavior of *C. advenus* during different times of the year and at different localities than between that of *C. advenus* and *C. latipes*. Our studies, along with those of Evans (1960) and Kurczewski and Acciavatti (1968), suggest that the most reliable behavioral characters in this genus are nest site selection and prey selection. However, neither of these criteria can be used to separate *C. advenus* from *C. latipes*.

Females of *C. advenus* and *C. latipes* may nest in the same areas, but the nests of the latter are often more peripherally situated. There is also much intraspecific variation in the selection of nesting sites. For example, Evans (1960) found nests of *C. advenus* in bare hard ground. Our studies and those of Kurczewski and Acciavatti (1968) indicate that this species prefers sand pits, albeit areas of well-packed sand. *C. latipes* nests in sand cliffs (Kurczewski and Acciavatti, 1968), as well as in flat sand. One of us (FEK) has even observed *C. latipes* in Pennsylvania nesting in hard-packed gravel at the edge of an overgrown field. Burrow construction and the making of additional cells have been observed only in *C. advenus*. Prey transport and other provisioning activities are similar in the two species.

The nests of *C. advenus* and *C. latipes* are similar in form and dimensions. Nests of both species are characterized by conspicuous tumuli of loose sand with the entrances, 4–6 mm wide, in the center, open burrows the ends of which are used as storage chambers for the captured flies, and clusters of provisioning cells. In both species the first cells made and provisioned in a cluster are usually farther from the entrance than cells made later. This is apparently the case in all species of *Crabro* and many other crabronine wasps. Four, five, six, or seven cells per cluster is common in *C. advenus,* whereas only two or three cells per cluster were found in nests of *C. latipes*. Fewer cells per cluster in *C. latipes* suggest fewer cells per nest in this species than in *C. advenus*. Females of the latter species may construct up to 20 cells per completed nest. Nest cells of *C. advenus* and *C. latipes* are found at about the same depth. There is little seasonal or local variation in the depth of cells of *C. advenus*. This is surprising when one considers that Evans' (1960) studies were made in hard ground and other studies in sand. Variation in cell depth in other digger wasp species is often related to differences in soil texture or friability. The average sizes of the nest cells of the two species are similar. Cell dimensions for *C. advenus* given by Evans (1960) and Kurczewski and Acciavatti (1968) are nearly identical to our measurements, indicating no seasonal or local variation in cell size in this species.

C. advenus and *C. latipes* prey upon a variety of average-sized, stockily-built, adult flies, usually of muscoid families. In June both species captured a preponderance of anthomyiids and a lesser number of muscids. In addition *C. advenus* used a large number of rhagionids, whereas *C. latipes* preyed only rarely on these flies. On the other hand, *C. latipes* captured more tachinids and syrphids than *C. advenus. C. latipes* also stored calliphorids and eight dolichopodid species, although neither of these families was preyed on by *C. advenus* in June. Seasonal and/or local variation in the provisions of *C. advenus* is striking. As mentioned, there was only a single duplication in the species of prey of this wasp in June and September. Furthermore, in September, *C. advenus* stored calliphorids, sarcophagids, and muscids, in order of decreasing frequency, and only rarely took otitids and anthomyiids (Kurczewski and Acciavatti, 1968). Evans (1960) found a similar selection of the same families of prey by this species in July, except for the exclusion of anthomyiids and the rare use of rhagionids and tabanids. The species of flies in the cells of *C. advenus* in June, July, and September were less mixed than those in the cells of *C. latipes.* In June we recorded an average of 3.4 families of flies per cell for *C. latipes* but only 1.7 families per cell for *C. advenus.*

The average number of flies stored per cell was about 8 for *C. latipes* and 6 for *C. advenus* in June. However, as mentioned, an examination of individual nests of *C. advenus* revealed that one female stored, on the average, almost 8 prey per cell. Differences between the two species cannot be related to differences in the average sizes (weights) of the prey flies (*C. latipes,* 12.6 mg; *C. advenus,* 13.7 mg). The total biomass of prey per cell, therefore, was somewhat higher in *C. latipes,* whose range was only half (71–122 mg) that of *C. advenus* (19–135 mg). These data are distorted by the fact that females of *C. latipes* were slightly larger than females of *C. advenus.* Kurczewski and Acciavatti (1968) found only about 4 prey per cell in September nests of *C. advenus.* An average prey was much larger in size (weight, 19 mg) than we recorded in June, indicating not only a certain amount of seasonal variation in this behavior but a close relationship between the number of prey per cell and average size of prey in this species. An examination of individual nests of *C. advenus* in June, however, revealed females which stored about 3 and 5 flies per cell, or close to the average number recorded by Kurczewski and Acciavatti (1968). The total biomass of prey per cell they recorded in September averaged only 4 mg higher than we recorded in June, although the range (55–117 mg) was close to that of *C. latipes.* The results we obtained by plotting the number of prey per cell against cell size are contradictory. An increase in the number of prey per cell accompanies an increase in cell size in *C. advenus* in June but not September, nor in *C. latipes.*

The placement of prey flies in the cells and position of the fly on which the wasp laid her egg are similar in *C. advenus* and *C. latipes.* No difference between these species could be found in the relative sizes of the flies on which the eggs were laid. The mean weights of the egg-bearing flies were practically identical. As might be expected, Kurczewski and Acciavatti (1968) found the average weight of the egg-bearing fly of *C. advenus* to be much greater in September than in June, corresponding to the larger average weights of the flies at this time of year. The description and sizes of the eggs of females of *C. advenus* and *C. latipes* are identical. The egg is attached in the same position on the fly. This position of egg attachment is probably characteristic for the genus and was termed the "*Crabro*-type" of oviposition site by Iwata (1942).

In summary, differences in the nesting behaviors of *C.* (*Synothyreopus*) *advenus* and *C.* (*Crabro*) *latipes* do not warrant separation of the species at the subgenus level. Seasonal and local variation in certain components of the nesting pattern of *C. advenus* are much more pronounced than interspecific variation between the nesting behaviors of these two species. It is difficult to draw conclusions about the nesting patterns of species of *Crabro* because so few species have been studied in any detail.

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Association of the Mite *Blattisocius tarsalis* with the Moth *Epizeuxis aemula*

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Abstract: Females of the ascid mite *Blattisocius tarsalis* (Berlese), known chiefly as a predator on the larvae of insects in stored grain, have been found on the widely distributed herminiine noctuid *Epizeuxis aemula* (Hübner). Incidence in small samples has been as high as 32 percent. The mites usually occupy the dorsal thoraco-abdominal region. They appear to be phoretic upon the adult moths, possibly taking food parasitically on occasion. With a single exception, this mite was not found on other species of *Epizeuxis* in a large museum collection.

This paper reports the frequent finding of females of the ascid mite *Blattisocius tarsalis* (Berlese, 1918) on adults of the herminiine noctuid moth *Epizeuxis aemula* (Hübner). Mites of this species (for synonymy, see Chant, 1963) are common in many parts of the world. Chant says that the species "seems cosmopolitan in distribution and has been collected many times in North America." As representative collection records he gives "sugar and rolled oats, Vancouver, British Columbia; stored wheat, Corvallis, and stored barley, Brownsville, Oregon (G. W. Krantz); roach cultures, Berkeley, California (C. A. Hanson); wheat dust, Ithaca, New York (G. W. Krantz); on lily bulbs, Toronto, and on 'equipment'; *Tribolium* cultures, and clothes moth cultures, Ottawa, Ontario." A. M. Hughes (1961), who gives the distribution as England, Italy, Switzerland, U. S. A., and Australia, says that she has found the mite "only . . . in stored food infected with species of corn [i.e. grain] moths: *Anagasta*, *Sitotroga*, and *Plodia*." Nesbitt (1951) records it from cultures of *Tribolium confusum* J. du V., *T. castaneum* Hbst., *Attagenus piceus* Oliv., and *Tineola bisselliella* (Hummel), and adds that at the time of his writing there were as yet "no records of its having been found in the wild state out of buildings." Berlese gave the type locality as "*in detritus foeni, in presepibus, Florentiae*." According to A. M. Hughes, "The mite eggs are laid on the webbing covering the [grain moths'] caterpillars and the larvae appear to feed on these. The adult females are carried by the moths, hanging on to the body particularly at the bases of the wings."

The host here reported, *Epizeuxis aemula,* is very common in the wild state. Forbes (1954) gives its range as Nova Scotia and Mattagami River, Ontario, to Florida, west to British Columbia and New Mexico. Riley (1891) mentions the larvae as having been found in Virginia feeding on dead leaves of hickory. Forbes gives the food as "dead leaves, usually on the forest floor," but adds that the larvae may also be a "semi-scavenger," having been reared from a squirrel nest. The moth is not commonly known to infest stored grains, although according to Crumb (1934), it has on occasion been injurious to corn fodder in Mississippi. Crumb implies that Packard's account of the rearing of larvae beaten from spruce means that they were probably feeding "in a webbed-up mass of dead needles." Forbes states that the moths fly (in New York) "from May to August, rarely again in late fall (probably a false brood)." Forbes credits Françlemont with the observation that the pupae are "essentially like *Palthis*, in a slight cocoon, largely of frass," and says that the various species of the genus are "partly double-brooded, hibernating as caterpillars." He suggests that the species that feed on dead leaves are "probably getting their chief nourishment from fungi."

My first collection of an *E. aemula* carrying *B. tarsalis* was in Tyringham, Massachusetts, on 30 July, 1953. At that time I overlooked the mite, spread the moth, and placed it in the collection of The American Museum of Natural History. It was not until nearly 16 years later that I discovered my oversight. Although *E. aemula* is common in Tyringham, for several years I examined only an occasional specimen as a somewhat desultory spot check, finding no mites. The earliest record of the mite on this moth in my notes is dated 8 July, 1965. Two female mites, one with red gastric contents, were found on that date on the metascutellum of an *E. aemula* male taken in copula at 12:30 AM the previous night. As later proved typical, the mites were facing toward the moth's head, with their mouthparts hidden under the scutal or metascutellar scales. They were easily removed, and no feeding scars were seen.

The next finding of these associates was on a female moth taken at about 11 PM on 1 August, 1966. The moth had just recovered from brief CO_2 anesthesia and was being held by the upraised wings for routine examination under the microscope, when five mites were seen creeping about upon the abdomen, some entering the ventral thoraco-abdominal cleft, some probing the dorsal thoraco-abdominal area, and one moving rearward to the base of the partly exserted ovipositor, finally getting trapped in a fecal droplet from the moth's anal tube. The mites moved rather slowly, even when prodded with a bristle. The moth showed no signs of being disturbed by the actions of the mites, and the mites did not appear to change their behavior when, on occasion, the moth's body was vibrated by attempted flight movements. The mites were light brown and semitransparent, with the reddish brown fore tarsi characteristic of their species. All were females. Three were easily lifted from the host with a needle, while two were allowed to remain on the living moth, which was left unrestrained overnight in a moist chamber. One of these mites was still on the moth at 1:20 PM the following day; the other was not found.

Although an occasional *Epizeuxis* of this and other species was examined thereafter, it was not until 9 October, 1967, that the next infested specimens were discovered. On this warm, rainy night, *E. aemula* were unusually abundant at the "black light." Of the 18 collected, seven carried from one to six *B. tarsalis*, a total of 18 mites. Eight of the moths were not examined immediately but were kept overnight in the refrigerator. On two of these, mites were found at 3 PM the next day. On the other hand, an infested moth which was kept overnight at room temperature had lost its mite by the following day.

Most of the moths observed on this occasion carried their mites on the abdominal dorsum, but one mite was found under the right tegula, and one on the moth's head. Some of the mites had round crimson globules of various sizes in their digestive tracts, while others from the same host showed none of these. The globules retained their color after overnight clearing in warm lactic acid and mounting in Hoyer's medium. They are still visible in these specimens 17 months after mounting. They were found in mites taken from hosts of both sexes.

On 16 October, 1967, a week after the last previous collection, two *E. aemula* females were taken, one carrying a single mite, the other bearing two. The first of these I watched continuously under the microscope for about 45 minutes. During all this time the mite remained on the dorsum of the first abdominal segment, moving about with only brief pauses. It kept probing under the scales dorsal to the metascuta, palpating the cuticle, and pausing now and then with the mouthparts in contact with it. It was not possible to see whether any actual feeding took place, but dark spots resembling feeding scars were found on the following day in the area dorsal to the base of the left alula, where the probing had been observed. Defecation did not occur, but among the moth's scales were a few small white objects resembling dried fecal droplets. The moth was kept alive overnight at room temperature, and on the next day, the mite could not be found.

On the following night, 17 October, two of the nine *aemula* females that came to the light carried each a single *B. tarsalis*. One of these moths (and a few others collected subsequently) had also a whitish tydeid mite (*Pronematus* sp.) under each hood. One moth which had no *Blattisocius* carried nine hypopes of *Histiogaster* sp. under the proboscis. On 18 October, the season's last two *E. aemula* were taken, both mite-free. The incidence of infestation since 9 October was thus 11 out of 31, or about 32 percent.

In 1968, out of 62 *E. aemula* collected at Tyringham between 14 July and 18 October, 14 (about 23 percent) carried from one to eight *B. tarsalis* each. Only three had mites of other kinds, all tydeids. Of these three moths, only one carried both tydeids (one in each tympanic recess) and *Blattisocius* (four on the dorsum of the first abdominal segment).

Though well known in association with various stored grain pests, *B. tarsalis* has seldom been noticed on noctuid moths of any kind. Except for those on *Epizeuxis,* my collection and records include only a single female mite taken from a male of *Crymodes devastator* (Brace) which was collected by Harold Higgins in Salt Lake City, Utah, in August, 1955. The finding of the frequent association of the mite with an *Epizeuxis* in Tyringham raised questions of whether this was a purely local phenomenon, and of whether other moths of the same genus might also act as hosts. At least three other species of *Epizeuxis* occur in Tyringham, but have not as yet been found to carry the mite. For partial answers to these questions, I examined the dorsal surfaces of all of the more than 1,500 *Epizeuxis* specimens, representing 12 species, in the general study collection of the American Museum of Natural History. With the exception of a single female on one of the 15 specimens of *E. majoralis* Smith (male, "July, C. [?Chicago], Ill., J. B. Smith Collection"), *B. tarsalis* was found only on *E. aemula,* 29 out of 375 (7.7 percent) of this species showing one or more mites. Since only the dorsal surfaces were examined, and since some of the moths may have lost mites during collection or preparation, it is likely that the incidence is higher than the above figure suggests. A total of 57 mites, all female, was recovered from the 29 moths. Many of the mites were gravid. With the exception of three found on the metathorax, one in the right tympanic recess, one ventrally between thorax and abdomen, and one on the right hind wing, all of these mites were on the dorsum or pleurae of the first abdominal segment. Most were easily detached: possible feeding scars were noted in only one instance. Detailed collection records are given below, arranged alphabetically according to state or province.

Connecticut: Putnam, Windham Co., 6 July, 1954, A. B. Klots, F. and P. Rindge, ♀, 2 mites. *Florida*: Monticello, 4–8 October, 1914, ♀, 5. *Kansas*: Ottawa, 3 October, 1949, Wm. H. Howe, ♂, 2. *Massachusetts*: Cohasset, 3 September, J. B. Smith Collection, ♂, 1; Lee, Highfield Farm, 16 September, 1939, Collection of Grace H. and John L. Sperry, ♀, 1; Tyringham, Berkshire Co., 30 July, 1953, A. E. Treat, ♀, 1. *Mississippi*: Biloxi, Harrison Co., 6 August, 1964, R. and B. Taylor, ♀, 2; Clinton, Hinds Co., 1 October, 1961, M. and E. Roshore, ♀, 3; 26 June, 1965, M. and E. Roshore, ♂, 1. *New Jersey*: Chester, August, J. B. Smith Collection, ♀, 1 (with 4 *Pronematus* sp.); Cranford, 5 July, O. Buchholz Collection, ♀, 2; Merchantville, 29 June, 1896, J. B. Smith Collection, ♀, 1; Orange, April, 1930, ♀, 2; August, 1930, ♀, 3; Orange Mountains, 20 July, O. Buchholz, ♀, 2; Ramsey, 25 July, 1935, W. J. Gertsch, ♀, 2. *New York*: Lewisboro, Westchester Co., 16 June, 1966, M. and T. M. Favreau, ♀, 3; Rye, 22 October, 1934, Ghika, ♀, 3. *North Carolina*: Southern Pines, 3 June, 1954, R. R. McElvare, ♀, 2. *Ontario*: Toronto, 12 October, 1958, J. C. E. Riotte, ♂, 1; 11 June, 1959, ♀, 1; 27 June, 1959, ♂, 2; 2 July, 1961, ♀, 1; 12 August 1959, ♀, 2. *Texas*: Montague Co., L. H. Bridwell, 28 May, 1940, ♀, 2; 15 June, 1940, ♀, 4; 20 June, 1940, ♀, 1; 20 June, 1940, ♀, 1.

The ecological nature of the association of *B. tarsalis* with *E. aemula* is unclear. It is certainly in contrast with the relationship between the mite's close relative *B. patagiorum* and its noctuid hosts (Treat, 1966). Despite the occasional finding of what look like feeding scars, it seems quite unlikely that *B. tarsalis* regularly parasitizes the adult moths. The ease with which living or dead mites can be removed from the insects, the tendency of living mites to leave captive hosts within a few hours, and the fact that only adult females, often gravid, have been found on the moths all suggest phoresy rather than true parasitism. The dates of collection, however, ranging from April to October even in the same latitude, show no pronounced peak of seasonal infestation. From what is known of the habits and life cycle of the mite in other contexts, it seems plausible to speculate that some similar relationship prevails in the association with *Epizeuxis*. Crumb's statement already noted, that the insect has been known to damage corn fodder, together with the usual abundance of the moths, suggests that *aemula* (perhaps in contrast with other species) may breed, at least occasionally, in concentrations which could account for its relatively high incidence of infestation with *B. tarsalis*. Experimental attempts at rearing the two species together are surely in order.

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Studies on the Behavior of the American Copper Underwing Moth *Amphipyra pyramidoides* Guenée

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Abstract: Experiments were conducted to investigate the stimuli used by the American Copper Underwing moth *Amphipyra pyramidoides* Guenée in selecting its daytime resting place. Light seemed to be the primary factor and tactile stimuli are important, also, because the moths preferred to rest in a dark crack, offering positive tactile stimuli, over a dark flat surface. Likewise, grouping in the same crack, or under the same substrate, occurs.

The American Copper Underwing moth *Amphipyra pyramidoides* Guenée is a common late summer species which during the day conceals itself under the loose bark of trees (Holland, 1968) or under the eaves or porches of houses. In the latter resting place, I have found 20–30 moths within an area of a few feet. The following experiments were designed to gain information as to the stimuli which determine the moth's selection of its daytime resting place and their relative importance.

MATERIALS

The experimental box used in these experiments was constructed of plywood (24 inches square × 19 inches high), and the floor was equally divided into 4 quadrates (each 12 × 12 inches). The box was rotated nightly to eliminate any "position" effect. The substrates consisted of white cardboard squares (3 inches by 3 inches) which were presented in 4 different shapes: flat squares, squares folded in the middle and set on end ("tent"), squares folded in the middle and set on a side ("right angle") and squares set on top of a nail ("leaf") with the nail passing through the center of the substrate square and, thus, raised off the floor of the box. The box was covered with a pane of window glass and placed in a wooded area where a thick canopy excluded direct sunlight. Moths were introduced into the box by sliding the glass top to one side.

The moths were collected at "sugar" in a woodlot in Leverett, Massachusetts and immediately introduced into the box. The following morning, between

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0600–0800 Eastern Standard Time, the box was checked and the selection of the moths noted.

OBSERVATIONS AND RESULTS

Physical Stimuli

In an attempt to determine the importance of light in the selection of a resting place, moths were released into the experimental box and presented with a choice of substrates, only one of which effectively shielded the moths from the light.

Of 26 moths presented with these substrates all of the moths were found resting under the "tent" substrate. Analysis of these results by chi-square tests indicate a high degree of significance ($P < 0.001$).

In a second experiment designed to investigate the importance of tactile cues, the substrates were removed from the bottom of the box, and one corner was pulled apart so that a 1 inch crack was formed for about 6 inches down the length of the corner. Clear tape was applied to the outer surface to prevent the moths from escaping. Of 13 moths presented with the above situation all were found resting in the cracks, generally either with the head facing outward (i. e. into the crack) and the body horizontal, or with the head and body pointly downward within the crack itself. Once again, analysis by chi-square revealed a highly significant deviation from the expected results ($P < 0.001$).

In an attempt to determine which of the stimuli (light or touch) was more important to the moth in making its selection, moths were presented with 2 cracks (formed in the same way as described previously) which were located at opposite corners of the box. However, a small lamp was positioned outside the box so that one of the cracks was fully illuminated while the other remained dark. Of 25 moths presented with the above situation, 21 moths were found resting in the dark crack, only 1 moth was observed in the lighted crack, while 3 moths were located in a corner of the box ($P < 0.01$).

In another experiment designed to obtain the same kind of information, 23 moths were placed in the box containing both the paper substrates and the crack. However, after all the moths had been placed into the apparatus, several layers of a dark colored blanket were thrown over the top of the box so that all light was prevented from entering the box. Observation of the resting moths indicated that none of the moths were found either in the crack or under the substrates, but instead rested haphazardly on the plywood sides of the box ($P > 0.01$).

All these results suggest that light is the primary stimulus used by the moth in making its selection of a resting place (the animal responding in a negatively phototaxic way). Tactile stimuli seem only to be used after the animal has responded appropriately with respect to light.

Social Stimuli

Since these moths had been observed resting in rather large groups, an experiment was also designed to determine if there was a tendency to rest with other moths or to rest alone.

Twenty moths were captured, and simultaneously placed into the box containing 4 "tent" substrates. If no grouping tendency occurred, 5 moths should be expected under each of the substrates. However, observation revealed that 13 moths were found under 1 substrate, 5 under another, 2 under the third, and 0 under the fourth "tent."

To assure that the results were consistent, a second trial was run on the following night after the box had been rotated. Twenty-eight moths were released into the box. Half of this number were found resting under the same substrate, while the remaining 14 moths were distributed as follows: 7, 5, and 2. In both cases, the difference between the observed and expected results is great enough so that the difference does not seem to be due to chance (chi-square tests: $P < 0.01$). It should also be pointed out that 13–14 moths seems to be close to the maximum which could fit under under the substrate. Even at this concentration, some moths were resting on the top of others and the posterior ends of many of the moths were extending out from under the substrate.

Therefore, it does appear that the Copper Underwing moth is attracted by the presence of other moths of the same species. What causes the method of attraction is unknown, although it might be due to the secretion of a pheromone.

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Notes on *Dyschirius* Bonelli and *Akephorus* LeConte, with a Peculiar New *Dyschirius* from Texas (Coleoptera: Carabidae: Scaritini)

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Abstract: *Dyschirius* Bonelli and its close relatives are placed in the subtribe Dyschiriina. The *marinus* group (= *Akephorus* LeConte) is the oldest and most divergent group of American *Dyschirius*. No described South American species are related to the *marinus* group, and the species described as *Akephorus bruchi, A. bryanti, A. darwini,* and *A. ogloblini* by Kult are new combinations in *Dyschirius* closely related to the *tridentatus* group. All North American *Dyschirius* which lack discal elytral setae are keyed and discussed. *D.* **exochus** is a new species from Texas, and is placed in a separate group. *D. dentiger* LeConte is reduced to synonymy with *D. aratus* LeConte. Species reported from Mexico for the first time are *D. aratus, D. erythrocerus,* and *D. sublaevis.* The *criddlei,* **exochus**, *filiformis, politus,* and *sellatus* groups are a monophyletic unit. Sister-group relationships proposed are: **exochus**-*filiformis* and *criddlei-politus-sellatus*; and *criddlei-politus* and *sellatus.*

INTRODUCTION

The isolated position of *Dyschirius* has been noted by Bruneau de Miré (1952), who treated the genus and its relatives as a subfamily of the family Scaritidae. In line with contemporary classifications of North American Carabidae, I am placing these genera in a separate subtribe, the Dyschiriina. I here follow Lindroth (1961) in recognizing a single North American genus divided into a series of species groups, with the reservation that once a full study of the world genera has been undertaken, the *marinus* group (= *Akephorus*) will probably be recognized as a distinct genus. Such nominate Old World genera as *Clivinopsis* Bedel, *Cribrodyschirius* Bruneau de Miré, and *Torretassoa* Schatzmayr and Koch seem to be relict groups roughly equivalent to the *marinus* group in terms of divergence from typical *Dyschirius.*

Specialized characters of the subtribe (or "subfamily") include the very peculiar structure of male abdominal segments eight and nine, which is not matched elsewhere among the more primitive Carabidae and which hence cannot

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be regarded as primitive as done by Bruneau de Miré; the flagellum of the median lobe of the male genitalia, which does not appear to be homologous with the "stylets" or basal sclerites in other Scaritini or in the Elaphrini; the interruption of the lateral series of umbilicate elytral punctures, which is unique in the Scaritini; and the presence of eight elytral striae, which is not known in other members of the so-called Clivinina but which does occur in at least *Pasimachus* (in some groups the eighth stria is secondarily reduced or absent except at the apex of the elytra).

The *marinus* Group

As noted by Lindroth (1961), this group of two Pacific Coast species is the most bizarre element of North American *Dyschirius.* The group may be characterized briefly as follows: labrum deeply, sharply emarginate; mentum deeply cleft, with broadly rounded epilobes and a sharp median tooth; clypeal margin without prominent median projections; clypeal suture indistinct; vertex and frons entirely rugose; entire body surface with dense granulose microsculpture; legs large, hind femora extending to middle of sternum six; first article of hind tarsus twice as long as second; elytra fused, hind wings greatly reduced; discal setae of interval three not fixed, variable in number and position; basal fovea of elytron present, lateral margin with one subhumeral and two subapical foveae, eighth stria without preapical foveae; elytral striae very shallow, impunctate; elytra ovate, humeri oblique, base distinctly margined to peduncle; metasternum and metepisternum short; ventral carinae of visible sternum two very widely separated; sterna three to five often with more than single pairs of ambulatory setae, particularly in males; four setae on sternum six, distant from margin; median lobe of male genitalia very large, with relatively broad apex; parameres grossly unequal, without distal setae, right paramere rudimentary.

All workers since Putzeys (1863) except Kult (1950) have placed *Akephorus* in synonymy with *Dyschirius.* Indeed, many of its characters may be found in various typical *Dyschirius*, but the combination of characters is very highly distinctive. The sum of the differences, the unusual habitus, and the structural modifications associated with the loss of wings imply a long separation from other *Dyschirius.* The punctures of interval three are variable rather than fixed, unlike any other Dyschiriina, and the absence of preapical punctures in the eighth stria is unique to the group.

Kult (1950) assigned to the genus *Akephorus* certain South American forms with elongate appendages. I have studied a specimen of *Dyschirius* labelled "BRAZIL. Rio Grande do Sul. Sinambu, IX. 60. Fritz Plaumann" (DRW), which closely matches Kult's description of *Akephorus bryanti* except for having a premedian pair of discal elytral setae. This specimen, and the original descriptions of Kult's species, confirm that none of the characters employed by Kult to distinguish *Akephorus* from *Dyschirius* are relevant. The tarsi of these species are short, especially in comparison with the length of the tibiae, and they are thereby much closer to the *tridentatus* group of *Dyschirius* than to the *marinus* group (= *Akephorus*). The proportions of the tarsal articles do not support Kult's arguments, since the basal article is about twice as long as the second in both the *tridentatus* and *marinus* groups as well as in the South American *Akephorus*; and similarly, the elytral base is margined in all of these groups. All of these South American specimens have three subhumeral, three subapical, and two preapical foveae, and on this basis alone are excluded from the *marinus* group. In these and all other observed characters, these species are quite close to the *tridentatus* group (subgenus *Dyschiridius* Jeannel). Thus, whether *Akephorus* is recognized as a separate genus or not, the species *Akephorus bruchi, A. bryanti, A. darwini,* and *A. ogloblini* Kult are NEW COMBINATIONS in *Dyschirius*, and the species *A. pampicola* Putzeys and *A. minarum* Putzeys belong there as well.

Changes In Lindroth's Key To *Dyschirius*

Lindroth (1961), in his fine review of the genus, supposed that North American *Dyschirius* might eventually prove to number nearly 100 species. To date, only two new species have been added to Lindroth's list of 45 recognized species (Larson, 1968). I am adding seven species, including one from Mexico, one new species from Texas, and one new synonymy. This treatment covers all of the known North American species which lack discal elytral setae. These are arrayed in four groups, one of which is new.

Remaining for future study are five North American species not included by Lindroth, and three described Central American species. These are: *D. basalis* LeConte (California), *D. dejeani* Putzeys (North America), *D. desertus* Fall (California), *D. guatemalenus* Bates (Guatemala), *D. hintoni* Kult (Veracruz), *D. planiusculus* Putzeys (Mexico), *D. transmarinus* Mannerheim (Alaska), and *D. unipunctatus* Fall (California). The Mexican fauna is rich in members of the *analis* group, to which belong *D. guatemalenus* and *D. hintoni. D. planiusculus* evidently belongs to the *integer* group, and may be the only endemic member of that group in Mexico. The *politus* group is represented in Mexico, so far as known, only by *D. erythrocerus* LeConte, which together with *D. sublaevis* Putzeys has also been reported from Cuba (Darlington, 1934). I have seen six Mexican specimens of *D. erythrocerus* as follows: Yucatan: seabeach at Progreso, and marsh 1.8 miles south of Progreso (UASM). The Peruvian *D. weyrauchi* Kult may also belong to the *politus* group, and is in any case the only described South American species in which the elytra are not margined basally.

In addition to the changes in Lindroth's key required for the added species treated below, I have included *D. laevifasciatus* Horn which was inadvertently omitted from his key. Other changes were made by Larson (1968).

1. Elytra fused along suture; preapical setae of eighth stria absent .... 2.
Elytra not fused along suture; one or two preapical setae on eighth stria .... 3.

* * * * * *

8 (3). Elytral striae effaced by two polished transverse bands .... *D. laevifasciatus* Horn.
Elytra without polished transverse bands .... 8a.
8a (8). Intervals three, five, and seven of elytra with numerous discal setae .... 9.
Discal setae, if present, restricted to interval three .... 10.

* * * * * *

11 (10). External-lateral teeth of front tibia rudimentary .... 12.
External-lateral teeth of front tibia well developed .... 13.
12 (11). Margin of elytron without subhumeral foveae; color mainly testaceous .... *D. pallipennis* Say.
Margin of elytron probably with a single subhumeral fovea; color piceous; size very large (7 mm.) .... *D. edentulus* Putzeys.
13 (11). Pronotum and elytra with dense granulose microsculpture; front angles of pronotum strongly produced; lateral margin of elytron with two subapical setae .... *D.* **exochus**, n. sp.
Pronotum and elytra without conspicuous microsculpture; front angles of pronotum not strongly produced; lateral margin of elytron with three subapical setae .... 13a.
13a (13). Lateral margins of pronotum not extended far behind anterior setae; lateral margin of elytron with three subhumeral foveae; eighth elytral stria obsolete except at apex .... 13b.
Lateral margins of pronotum extended to hind angles; eighth elytral stria represented by at least a few punctures in front half .... 13c.
13b (13a). Elytral striae with punctures not reaching middle of elytron; seventh stria with only four or five large punctures .... *D. darlingtoni* Kult.
Elytral striae evidently punctate to beyond middle of elytron; seventh stria with six or more large punctures .... *D. abbreviatus* Putzeys.
13c (13a). Lateral margin of elytron with two or three subhumeral foveae .... *D. pumilus* Dejean.
Lateral margin of elytron with one subhumeral fovea .... 13d.
13d (13c). Clypeal field triangular, clypeal suture interrupted at middle .... *D. montanus* LeConte.
Clypeal field truncate or at most slightly triangular, clypeal suture not or hardly interrupted at middle .... 13e.
13e (13d). Eighth elytral stria with one preapical fovea .... 13f.
Eighth elytral stria with two preapical foveae .... 13g.
13f (13e). Elytral striae not abbreviated apically .... *D. filiformis* LeConte.
Elytral striae generally evanescent apically .... *D. sublaevis* Putzeys.
13g (13e), Pronotum elongate, sides nearly straight; elytral striae sharply engraved toward apex .... *D. curvispinus* Putzeys.
Pronotum subglobose; outer elytral striae obsolete toward apex .... *D. aratus* LeConte.

From a study of original descriptions and papers by LeConte (1879), Lindroth (1961), and Putzeys (1868), I have been able to identify all but one of the species keyed in material at hand. From its description, it is clear that *D. edentulus* Putzeys belongs in the *criddlei* group as recently defined by Larson (1968); it is very likely a senior synonym of *D. colossus* Larson but either erroneously described as without a seta on interval three, or a variant. *D. pallipennis* was placed in the *sellatus* group by Lindroth, and requires no further discussion. The remaining nine species belong to two distinct groups, and are treated in greater detail below.

The **exochus** Group

Small species without metallic coloration; clypeal margin truncate medially; frons not rugose; mentum truncate medially, with no trace of a median tooth; pronotum with two pairs of marginal setae, front angles strongly produced, margin entire and relatively broad in front, form elongate; elytron without basal tubercle, humeral denticle, discal setae, or basal margin, but with a basal fovea, one subhumeral and two subapical marginal foveae, and two preapical foveae on stria eight; all eight elytral striae sharply and evenly engraved, impunctate; most of body including pronotum and elytra with dense granulose microsculpture; front tibia armed with conspicuous external-lateral teeth, distal spur very large and strongly arcuate; abdomen with single pairs of ambulatory setae on sterna three to five, and two pairs of marginal setae on sternum six; male genitalia with flagellum longer than median lobe, parameres without apical setae; elytra not fused.

The prominently developed front angles of the pronotum are unique in the genus, presenting a *Clivina*-like habitus. In its technical characters, however, the single known species is a typical *Dyschirius*.

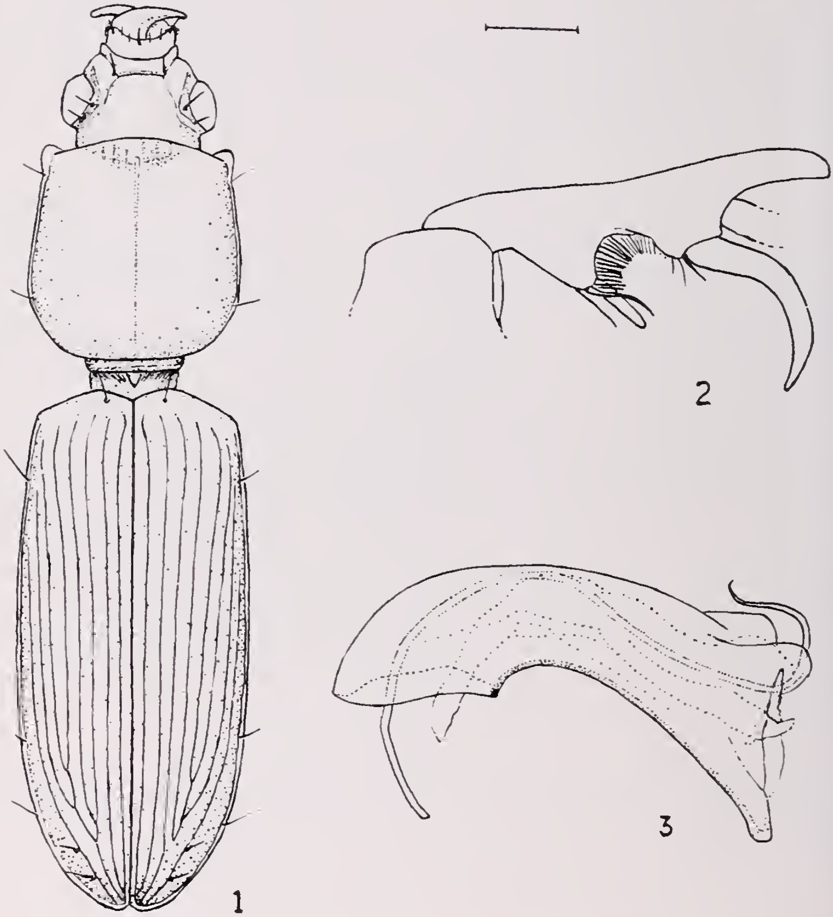
Dyschirius **exochus**, n. sp.

The prominently developed pronotal front angles, and the combination of lack of discal elytral setae and granulosely microsculptured pronotum and elytra, are known in no other Dyschiriina of the world.

HOLOTYPE. MALE (Fig. 1), labelled "Cedar Lane, Tex 8-9-28 J. G. Shaw," deposited in the University of Kansas. With the characters of the **exochus** group. Total length (length of head from base of eye to apex of clypeus, plus length of pronotum along midline, plus maximum length of left elytron) 2.73 mm.; length pronotum/width pronotum 1.22; length pronotum/width elytra 1.06. Body cylindrical. Color castaneous, opaque, without metallic luster. Entire body surface with dense, slightly flattened granulose microsculpture, reduced or absent only on dorsum of head, gula, posterior surfaces of front and middle legs, and anterior surfaces of front legs.

HEAD. Labrum concavely emarginate, armed with seven apical setae and six pairs of lateral setae. Clypeus with lateral lobes small, without median teeth. Clypeal suture deep and sharp behind median field of clypeus, median field not triangular. Frons and vertex smooth, convex. Eyes large, prominent, globose. Mentum deeply incised at middle, epilobes broadly rounded, median tooth absent. Labial palpus with penultimate article bisetose, terminal article fusiform and with a large concave sensory area. Terminal article of maxillary palpus with a small sensory depression near apex. Antennae very short, articles four to ten transverse; pubescence normal.

THORAX. Pronotum convex, elongate; sides nearly straight in front of middle, weakly convergent, hind angles obsolete; margins well developed, extending to behind posterior



Figs. 1–3. *Dyschirius* **exochus**, n. sp. Line scale represents 0.30 mm. for Fig. 1, and 0.10 mm. for Fig. 2 and 3.

Fig. 1. Holotype, habitus, dorsal aspect.

Fig. 2. Allotype, left front tibia, anterior aspect.

Fig. 3. Holotype, median lobe of male genitalia, lateral aspect.

setae, widened in front to form prominent front angles; median longitudinal and anterior transverse impressions weakly engraved, the latter with conspicuous longitudinal rugae. Legs very short; front tibia (Fig. 2) with distal spur relatively enormous and strongly arcuate, proximal spur quite short; distal lateral-external tooth (not shown) well developed, proximal tooth rudimentary. Elytron with striae sharply engraved to apex, impunctate; basal fovea present, basal tubercle absent, discal setae absent; umbilicate series divided into one subhumeral and two subapical foveae; stria eight with two preapical foveae. Wings well developed.

abdomen. Paramedian carinae of visible sternum two normal. Sterna three to five each with a single pair of ambulatory setae. Sternum six with two pairs of marginal setae. Median lobe of male genitalia as in Fig. 3. Lateral lobes without apical setae.

ALLOTYPE. FEMALE, same label data as holotype (UKL), differs from male only in having simple labial and maxillary palpi without sensory areas on the terminal articles. The elytra of this specimen are broken off behind the middle.

REMARKS. *D.* **exochus** is known only from the holotype and allotype from coastal Texas. I have seen specimens of *D. sublaevis* Putzeys and *D. colossus* Larson with the same label data, and consequently suspect that the species is a halophile. The name is derived from the Greek "exochos," meaning "projecting," in reference to the prominent front angles of the pronotum.

The *filiformis* Group

Small to medium sized species; clypeal margin truncate at middle; frons not rugose; mentum with a sharp median tooth; pronotum with two pairs of marginal setae, front angles not strongly produced, margin entire or abbreviated basally, form globose to elongate; elytron without basal tubercle, humeral denticle, discal setae, or basal margin, but with a basal fovea, one to three subhumeral and three subapical marginal foveae, and one or two preapical foveae on stria eight; elytral striae punctate, at least the eighth reduced; pronotum and elytra without conspicuous microsculpture, color piceous and generally aeneous; front tibia armed with conspicuous external-lateral teeth, distal spur often large and recurved at apex but not arcuate; abdomen with single pairs of ambulatory setae on sterna three to five, and two pairs of marginal setae on sternum six; male genitalia with flagellum short to moderately elongate, parameres without apical setae; elytra not fused.

Two species in this group have abbreviated pronotal margins. *D. abbreviatus* Putzeys was described from Texas. My study is based on 51 specimens of this species from Florida: De Soto County, Arcadia (UASM); Highlands County, Archbold Biological Station (TLE); Manatee County, Oneco (UASM); Sarasota County, Myakka River State Park (TLE, DRW). All of these have a sharply incised transverse pronotal impression. *D. darlingtoni* Kult was based on a single specimen from Jalapa, Veracruz, Mexico. I have seen a single specimen from a nearby locality, Fortin de las Flores (UASM), which matches the description of the type perfectly except that the anterior transverse impression of the pronotum is obsolete. It is very close to *D. abbreviatus* and may not be specifically distinct.

D. pumilus Dejean from "Amer. sept." and *D. falciger* LeConte from Florida were indicated as probable synonyms by Lindroth. I have seen 52 specimens of this species from Florida: Clay County, Goldhead Branch State Park (TLE); Dade County, 18 miles northwest Hialeah (TLE); De Soto County, Arcadia (UASM); Hardee County, Zolfo Springs (UKL); Hendry County, La Belle (UKL); Highlands County, Archbold Biological Station (TLE), Highlands Hammock (TLE, DRW) and Lake Placid (UKL); Manatee County, Bradenton (UKL) and Oneco (UASM); Marion County, 23 miles east Ocala (TLE); Sarasota County, Myakka River State Park (TLE). This species is easily distinguished from all others in the group by having more than one subhumeral marginal fovea on the elytron, together with a globose pronotum with complete lateral margins. Thus, it is probably the most primitive member of the group.

D. montanus LeConte was well described by Lindroth, and I have no new records to add.

D. filiformis LeConte and *D. sublaevis* Putzeys are the only species in the group having a single preapical fovea in the eighth stria. The nomenclatural synonymy of *D. rufiventris* LeConte from Louisiana with *D. sublaevis* from Texas was tentatively suggested by Lindroth, and I have found no objection to it. I have examined two specimens of *D. filiformis*, from Rockaway Beach and Long Beach, Long Island, New York (UASM). Twenty-nine specimens of *D. sublaevis* were studied from the following localities. UNITED STATES. Texas: Aransas County, Goose Island State Park (TLE, DRW); Brazoria County, Brazoria (UKL), 32.1 miles southwest Galveston (salt marsh, TLE); Matagorda County, Cedar Lane (UKL). MEXICO. Yucatan: sea-beach at Progreso (UASM).

D. curvispinus Putzeys is quite similar to *D. sublaevis*, and is most easily distinguished by having two preapical foveae in the eighth stria; further, the elytral striae are more sharply engraved apically. I have seen 9 specimens of this species from Texas: Aransas County, Goose Island State Park (TLE, DRW); Brazoria County, 32.1 miles southwest Galveston (pond in dunes, TLE).

D. aratus, described from the Gila River of Arizona, is the most widespread species of the *filiformis* group. The names *D. aratus* LeConte 1852:196 and *D. dentiger* LeConte 1857:79, described from New York, are synonyms. This is a NEW SYNONYMY. I have studied 94 specimens from the following localities. CANADA. Alberta: Empress (UASM, male determined as *D. dentiger* by Lindroth). UNITED STATES. Arizona: Cochise County, Palominas (UASM); Gila County, Salt River Canyon (UASM); Graham County, Gila River near Geronimo (UASM); Pima County, Quitobaquito (UASM); Yuma County, Colorado River near Martinez Lake (UCB), and 4 miles west Dome (TLE, DRW). California: Riverside County, Blythe (UKL). New Mexico: Otero County, 25 miles west Tularosa (UKL). MEXICO. Chiapas: Puerto Arista (UASM). Guanajuato: Lake Yuriria (UASM). Sinaloa: El Camaron (UASM), Mazatlan (UASM), 5 miles north Mazatlan (UCB). There may be more than one species involved in this material. In particular, specimens from coastal Mexico (Chiapas and Sinaloa) are much larger and lack the small patch of microsculpture in front of the basal elytral fovea that characterizes the other specimens, but there are no important differences in the male genitalia.

Specimens from Arizona are variable in body form and in the depth of the elytral striae, but there are no important differences between them and the specimen of *D. dentiger* from Alberta, either in external morphology or in the male genitalia.

DISCUSSION

The *criddlei,* **exochus**, *filiformis, politus,* and *sellatus* groups include those species which do not have the anterior and middle discal elytral setae simultaneously present, lack distal setae on the parameres, and lack a distinct basal margin on the elytron. Each group includes one or more halophiles, so that such similarities as pronotal elongation and a reduction in the standard setae may be convergences resulting from similar habits and habitat. However, I am assuming that the characters given above for these five groups indicate a monophyletic unit, and am analyzing their relationships accordingly. The common ancestor of this unit probably lacked the anterior discal setae; *D. perversus* Fall of the *politus* group, which has anterior rather than middle setae, most likely represents just a minor shift in this character.

Based on a comparison with other typical *Dyschirius*, such a common ancestor should have had the following additional characters: color piceous, aeneous; integument without distinct microsculpture; mentum with a sharp median tooth; pronotum globose, lateral margins complete, front angles not produced; front tibia with external-lateral teeth well developed, apical spur moderately elongate and weakly curved; elytral striae punctate; and elytron with a basal fovea, median and postmedian discal setae, two preapical foveae in the eighth stria, and three subhumeral and three subapical setae in the umbilicate series.

Selected characters of the five groups are given in Table 1. I have used a slightly simplified version of the system of notation employed by Ball and Erwin (1969). Each character is noted by a different letter, and each character state by a variation of that letter; the characters are treated in either two or three states. The character states are classified as primitive or derived by inference, on the assumption that convergence occurs less often than divergence in evolution. The following discussion is based on this table.

Two groups are reasonably conservative in these characters. In the *politus* group, all but the following criteria are met by at least some of the included forms: none have more than a single subhumeral fovea, the pronotum is not strongly globose, and the external-lateral teeth of the front tibia are rudimentary. In the *filiformis* group, no known species has discal setae, and the apical spur of the front tibia tends to be elongate and strongly recurved apically; most of the species are further specialized in having an elongate pronotum and a reduction in the number of subhumeral foveae, but *D. pumilus* Dejean is specialized in no important way other than in the loss of discal elytral setae.

TABLE 1. Selected characters and inferred character states in some species groups of *Dyschirius*.

Character	Species group				
	exochus	*filiformis*	*politus*	*criddlei*	*sellatus*
X. Character state: primitive-x derived (2 state)-X derived (3 state)-X′					
A. Integument: piceous, metallic-a pale, unmetallic-A	A	a	a	aA	A
B. Microsculpture: not granulose-b granulose-B	B	b	b	b	b
C. Body length: under 5 mm.-c over 5 mm.-C	c	c	cC	C	cC
D. Mental tooth: well developed-d reduced or absent-D	D	d	d	D	d
E. Outer antennal articles: moniliform-e transverse-E	E	e	e	e	e
F. Pronotum: globose-f elongate-F	F	fF	F	F	F
G. Pronotal margins: complete-g abbreviated-G	g	gG	gG	g	g
H. External-lateral tibial teeth: well developed-h rudimentary-H	h	h	H	H	H
I. Pronotal front angles: not prominent-i prominent-I	I	i	i	i	i
J. Distal tibial spur: short, weakly curved-j long, apex curved-J long, arcuate-J′	J′	jJ	j	j	j
K. Elytral striae: punctate-k impunctate-K	K	k	k	k	kK
L. Discal Setae: two-l one-L none-L′	L′	L′	lL	LL′	lLL′
M. Preapical foveae: two-m one-M	m	mM	m	m	mM

Table 1 (Continued)

Character	Species group				
	excohus	*filiformis*	*politus*	*criddlei*	*sellatus*
N. Subhumeral foveae:					
three-n					
one-N					
none-N′	N	nN	N	N	N′
O. Subapical foveae:					
three-o					
two-O	O	o	o	o	oO
P. Distribution:					
boreal-p					
temperate-P	P	P	pP	P	P
Q. Habitat:					
not halophilic-q					
halophilic-Q	Q	qQ	qQ	Q	qQ

The *criddlei* and *sellatus* groups both agree with the *politus* group in having rudimentary external-lateral tibial teeth, and both can be derived from it in their other specializations. The *criddlei* group differs significantly only in a reduction of the mental tooth; the loss of this tooth is a convergence in the **exochus** group, which cannot be derived from the *politus* group, and in the unrelated *quadrimaculatus* group. Some members of the *sellatus* group are highly specialized, with characters which are shared by *D.* **exochus** and which suggest only a remote common ancestry with the *politus* and *criddlei* groups. But the more primitive forms in the *sellatus* group, *D. sellatus* LeConte and *D. salivagans* LeConte, differ importantly from the *politus* group only in having a pale integument and in lacking subhumeral foveae. The rudimentary tibial teeth and the short, weakly curved distal spur of the front tibia therefore indicate a true relationship among the *criddlei, politus,* and *sellatus* groups.

Sister-group relationships (Hennig, 1966) among these three groups are unclear, however, since they don't share definitively synapomorphic characters. There is no reason to suggest a common ancestry between the *criddlei* and *sellatus* groups, since the specialized characters of these groups are divergent. To which of these two groups is the *politus* group most closely related? I cannot make a definite statement on this question. However, the *sellatus* group looks like it may be the older group since it is the more diverse and distinctive, and therefore it probably is the sister group of a *politus-criddlei* lineage.

The **exochus** group is specialized as follows: integument pale (as in *D. criddlei* and in the *sellatus* group) and with granulose microsculpture; tooth of mentum obsolete (as in the *criddlei* group); antennae very short; pronotum elongate (as in at least some members of all four other groups) and with prominent front angles; apical spur of front tibia grossly enlarged and evenly

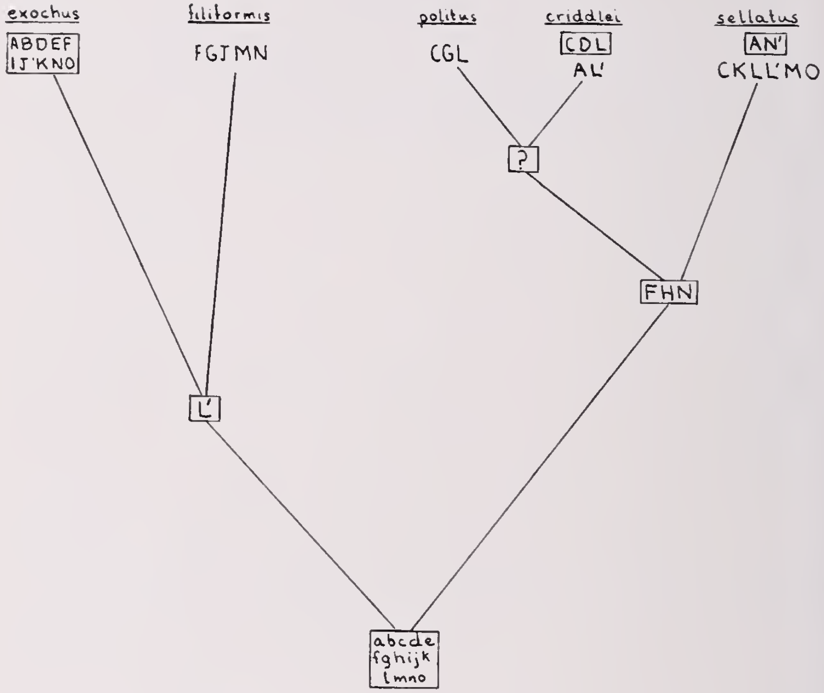


Fig. 4. Suggested phylogeny of the *criddlei*, **exochus**, *filiformis*, *politus*, and *sellatus* groups of *Dyschirius*. See text for explanation.

arcuate (unique, but most like the *filiformis* group); elytral striae impunctate (punctures reduced or absent in some members of the *sellatus* group); discal setae absent (as in some members of all but the *politus* group); subhumeral setae one (as in some members of all but the *sellatus* group, in which the subhumeral setae are absent); subapical setae two (as in some members of the *sellatus* group). Because of the well developed external-lateral tibial teeth, the form of the distal tibial spur, and the lack of discal elytral setae, this group can be readily derived only from the *filiformis* group. Of these characters, however, probably only the third is synapomorphic. I therefore think that the **exochus** and *filiformis* groups are distantly related sister groups. There is no evidence of a close relationship with the *politus*, *criddlei*, or *sellatus* groups.

Thus, the following sister-group relationships are proposed: first, an early *filiformis*-**exochus** and *criddlei-politus-sellatus* dichotomy; and second, a later dichotomy for the *criddlei-politus* and *sellatus* groups. These relationships are summarized in Fig. 4, in which the symbols are equivalent to those used in Table 1 except that the non-morphological characters of halophily and distribution are omitted. Definitive apomorphic characters which pertain to all members of a group or lineage, and which may therefore be considered as ancestral, are enclosed in a box. Characters which are found in the apomorphic state in some but not all members of a group are not so enclosed.

Many characters have originated independently two or more times. If my conclusions on phylogeny are correct, the following apomorphic character states have been achieved independently: pale integument, three times; large body size, probably at least twice, but small size in the *sellatus* and *politus* groups may be secondary; pronotum elongate, three times; pronotal margins abbreviated, twice; distal tibial spur elongate, twice; elytral striae impunctate, twice; discal elytral setae absent, three times; one preapical fovea, twice; one or no subhumeral foveae, three times; and two subapical foveae, twice.

Only the *politus* group is Holarctic, with at least one circumpolar species, *D. politus* Dejean. This is also the most widespread group in the Americas, extending southward at least to Mexico and possibly to South America. The remaining groups all are best represented in temperate North America. I suspect that the ultimate ancestry of the entire complex was boreal, not only because there are Holarctic elements in the complex, but because related elements of *Dyschirius* such as the *integer* group are Holarctic. By extension, the first sister-group pair may have originated in the northern part of North America. However, the predominantly halophilic *criddlei*, **exochus**, and *sellatus* groups must have had their origins in temperate North America, as judged from their present patterns of distribution.

I am well aware that this analysis is not entirely satisfactory, since alternative evolutionary pathways are possible. As shown in Fig. 4, neither the *politus* group nor the *filiformis* group is certainly defined as monophyletic by definitive apomorphic characters. This suggests a possibility, for example, that the *filiformis* group is paraphyletic, and that *D.* **exochus** could be derived from some relatively specialized member of the *filiformis* group having the apomorphic characters F, J, and N. The great dissimilarity of *D.* **exochus** from members of the *filiformis* group, however, implies a long period of separation, and I have therefore interpreted these shared characters as convergences. Similarly, the *criddlei-politus* lineage is not supported by definitive apomorphic characters, and is merely a supposition based on plesiomorphic similarity. In short, my suggested phylogeny is purely tentative, but it should serve as a springboard for future investigations in the complex phylogeny of *Dyschirius*.

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Siphonaptera from Northern New York

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Abstract: Data are presented on 28 species of Siphonaptera which have been collected in the counties of Clinton, Essex, Franklin, Hamilton, St. Lawrence, and Warren in northern New York.

During the last five years, extensive collections in northern New York have been made available to us for study. Dr. Paul Connor, collecting for the New York Museum and Science Service, secured 278 specimens in 1964 and 1965. From 1965 to 1967, Tucker collected occasionally, and in 1967 he and G. N. Mathewson collected 112 fleas in St. Lawrence county. Benton and Cerwonka (1964) reported on a collection of 515 fleas from Essex county, but since this report was not widely circulated their data have been included here. Since 1967, a few additional specimens have been collected by Tucker, so that we have a rather full selection of specimens from this area.

Figure 1 shows the area covered by the present paper. It includes the counties of Clinton, Essex, St. Lawrence, Franklin, Hamilton, and Warren. Ecologically, this area includes the St. Lawrence valley, a largely cleared area with numerous swamps and abandoned farms; the Champlain valley, a somewhat similar area which meets the St. Lawrence valley near the extreme northeast corner of the state; and the Adirondack Mountain region, which includes peaks up to 5,000 feet above sea level and is still largely forested. This highly variable terrain provides habitat for most of the species of mammals known from New York State, and as a result it has an unusually rich flea fauna.

We are grateful to Dr. Paul Connor and G. N. Mathewson for assistance in securing many of the specimens on which this paper is based. Dr. James N. Layne kindly supplied information on his collections from Essex county, some of which have not previously been reported in print.

SPECIES LIST. Nomenclature of the Siphonaptera in the following list follows the British Museum catalog (Hopkins and Rothschild, 1953 and following). For mammalian nomenclature, we follow Hall and Kelson (1959).

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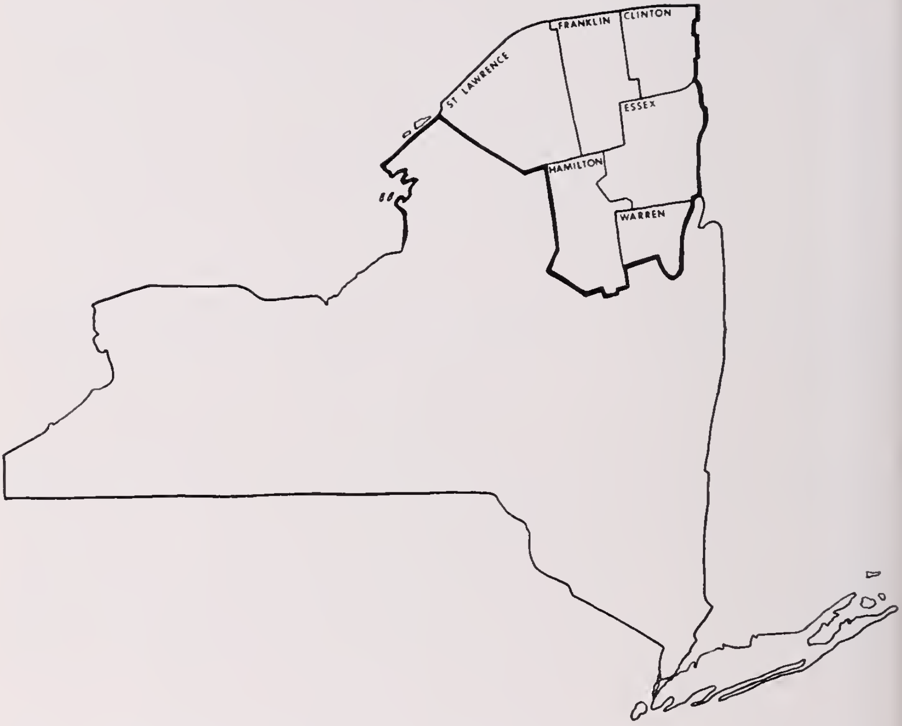

Fig. 1. Counties of northern New York included in this study.

FAMILY PULICIDAE

Ctenocephalides f. felis (Bouché)
Franklin county: Tucker
Hosts: *Canis familiaris, Felis domestica*

Cediopsylla simplex (Baker)
Warren county: State University of New York collection, Albany, New York, fide Benton
Hosts: *Sylvilagus floridanus, Sylvilagus transitionalis, Lepus americanus.* May be expected on *L. europaeus* where that species occurs.

FAMILY VERMIPSYLLIDAE

Chaetopsylla lotoris (Stewart)
Franklin county, Hamilton county: Geary, 1959
Hosts: *Procyon lotor, Martes pennanti*

FAMILY HYSTRICHOPSYLLIDAE

Hystrichopsylla tahavuana (Jordan)
Essex county: Type collection from Lake Placid, Jordan, 1929; Benton and Cerwonka, 1964.
St. Lawrence county: Connor
Hosts: *Parascalops breweri, Condylura cristata, Blarina brevicauda, Microtus pennsylvanicus*

Epitedia wenmanni wenmanni (Rothschild)
Essex county: Jordan, 1929; Benton and Cerwonka, 1964
Franklin county: Mathewson and Tucker
Hamilton county: Geary, 1959
St. Lawrence county: State University College, Fredonia, collection
Hosts: *Peromyscus leucopus, P. maniculatus, Napeozapus insignis, Blarina brevicauda, Clethrionomys gapperi, Parascalops breweri.*

Catallagia borealis (Ewing)
Essex county: Jordan, 1929
Host: *Blarina brevicauda* (the more usual host is *Clethrionomys gapperi*)

Tamiophila grandis (Rothschild)
Essex county: Jordan, 1929; Benton and Cerwonka, 1964
Franklin county: Mathewson and Tucker
St. Lawrence county: Connor
Hosts: *Tamias striatus, Tamiasciurus hudsonicus*

Ctenophthalmus pseudagyrtes pseudagyrtes Baker
Essex county: Jordan, 1929; Stewart, 1928; Stewart, 1933; Fox, 1940; Benton, SUC, Fredonia, collection
Franklin county: Mathewson and Tucker
Hamilton county: Stewart, 1933; Geary, 1959
St. Lawrence county: Connor
Hosts: *Blarina brevicauda, Parascalops breweri, Condylura cristata, Peromyscus leucopus, P. maniculatus, Microtus pennsylvanicus, M. chrotorrhinus, Clethrionomys gapperi, Microtus pinetorum, Synaptomys cooperi, Napeozapus insignis, Rattus norvegicus, Tamias striatus, Sorex cinereus, Mustela erminea, Glaucomys sabrinus*

Doratopsylla blarinae (C. Fox)
Essex county: Benton and Cerwonka, 1964
Franklin county: Mathewson and Tucker
Hamilton county: Geary, 1959
St. Lawrence county: Connor
Hosts: *Blarina brevicauda, Peromyscus maniculatus*

Corrodopsylla curvata curvata (Rothschild)
Essex county: Benton and Cerwonka, 1964; Jordan, 1929
St. Lawrence county: Connor
Hosts: *Blarina brevicauda, Sorex cinereus*

Nearctopsylla genalis genalis (Baker)
Essex county: Benton and Cerwonka, 1964
Host: *Blarina brevicauda*

FAMILY CERATOPHYLLIDAE

Ceratophyllus riparius riparius (Jordan & Rothschild)
Essex county: Benton and Cerwonka, 1964
Franklin county: Tucker
Host: *Riparia riparia*

Ceratophyllus idius (Jordan & Rothschild)
Franklin county: Benton, SUC, Fredonia, collection
Host: *Iridoprocne bicolor*

Ceratophyllus gallinae (Schrank)
Essex county: Jordan, 1929; Geary, 1959
Hosts: *Passer domesticus* (nest), chicken house, *Tamias striatus*

Ceratophyllus diffinis (Jordan)
  Hamilton county: Parkes, 1954
    Host: *Turdus migratorius*

In the collection of the State University College of Forestry at Syracuse University, two females from Newcomb, Essex county, are labelled as *C. diffinis*. These specimens differ in several respects from specimens in our collection, and until additional material is available we consider it inadvisable to assign them to this species.

Megabothris acerbus (Jordan)
  Essex county: Jordan, 1929; Benton and Cerwonka, 1964
  Franklin county: Mathewson and Tucker
  Hamilton county: Geary, 1959
  St. Lawrence county: Connor
    Hosts: *Tamias striatus, Tamiasciurus hudsonicus*
Megabothris asio asio (Baker)
  Essex county: Benton and Cerwonka, 1964
  St. Lawrence county: Connor
    Hosts: *Microtus pennsylvanicus, M. chrotorrhinus, Clethrionomys gapperi, Mustela erminea*
Megabothris quirini (Rothschild)
  Essex county: Jordan, 1929; Benton and Cerwonka, 1964; Layne
  Franklin county: Mathewson and Tucker
  Hamilton county: Geary, 1959
    Hosts: *Clethrionomys gapperi, Microtus chrotorrhinus, Microtus pennsylvanicus, Napeozapus insignis, Peromyscus leucopus, P. maniculatus*
Monopsyllus vison (Baker)
  Essex county: Layne; Benton and Cerwonka, 1964
  Franklin county: Layne
  Hamilton county: Geary, 1959; Stewart, 1933; Layne
    Hosts: *Tamiasciurus hudsonicus, Tamias striatus, Peromyscus maniculatus, Procyon lotor*
Opisodasys pseudarctomys (Baker)
  Essex county: Benton and Cerwonka, 1964
  St. Lawrence county: Connor
    Hosts: *Glaucomys sabrinus, Tamiasciurus hudsonicus*
Oropsylla arctomys (Baker)
  Essex county: Benton and Cerwonka, 1964; Stewart, 1933
  Franklin county: Geary, 1959
  St. Lawrence county: Connor; Geary, 1959
    Hosts: *Marmota monax, Canis latrans*
Orchopeas caedens durus (Jordan)
  Clinton county: Stewart, 1933
  Essex county: Benton and Cerwonka, 1964; Stewart, 1933; Layne
  Franklin county: Mathewson and Tucker
  Hamilton county: Stewart, 1933; Benton, 1955
  St. Lawrence county: Connor
    Hosts: *Tamiasciurus hudsonicus, Tamias striatus*
Orchopeas howardii howardii (Baker)
  Essex county: Stewart, 1933

Franklin county: Layne
St. Lawrence county: Connor
Hosts: *Glaucomys sabrinus, Tamiasciurus hudsonicus, Tamias striatus, Myocastor coypu, Peromyscus maniculatus*

Although we have not seen the specimens reported by Stewart, and later from the same area by Fox (1940), there is a strong possibility that they may be misidentified specimens of *O. leucopus*. All are from deermice, and all are from a mountainous area where gray squirrels do not occur. However, there is no doubt that *O. howardii* occurs in and around villages where gray squirrel populations exist and that, in those areas, it occurs on a variety of hosts.

Orchopeas leucopus (Baker)
Essex county: Jordan, 1929; Benton and Cerwonka, 1964; Layne; Geary, 1959
Franklin county: Mathewson and Tucker
St. Lawrence county: Connor; Geary, 1959
Hosts: *Peromyscus leucopus, P. maniculatus, Microtus pinetorum, Clethrionomys gapperi, Glaucomys sabrinus*

FAMILY LEPTOPSYLLIDAE

Peromyscopsylla hamifer hamifer (Rothschild)
St. Lawrence county: Connor; Benton, 1967
Host: *Synaptomys cooperi*

This record, a single male, is the first New York State record. A winter flea, this species is seldom collected, although it appears to be a parasite of voles, particularly the abundant meadow vole, *Microtus pennsylvanicus*. Its apparent rarity is probably due to ecological factors which make its collection difficult, rather than to any actual rarity.

Peromyscopsylla hesperomys hesperomys (Baker)
Essex county: Benton and Cerwonka, 1964
Hosts: *Peromyscus leucopus, P. maniculatus, Tamiasciurus hudsonicus*

Peromyscopsylla catatina (Jordan)
Essex county: Jordan, 1929; Benton and Cerwonka, 1964
St. Lawrence county: Connor
Hosts: *Clethrionomys gapperi, Microtus chrotorrhinus, M. pennsylvanicus, Microtus pinetorum, Blarina brevicauda, Parascalops breweri*

FAMILY ISCHNOPSYLLIDAE

Myodopsylla insignis (Rothschild)
Essex county: Geary, 1959
Host: *Myotis lucifugus*

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Undescribed Species of Crane Flies from the Himalaya Mountains (Diptera: Tipulidae), XVIII[1]

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Abstract: Seven new species of eriopterine crane flies from Nepal, Sikkim, and Assam are described, all belonging to the genus *Cheilotrichia* Rossi, subgenus *Empeda* Osten Sacken. These are *Cheilotrichia* (*Empeda*) **apemon**, *C.* (*E.*) **cheloma**, *C.* (*E.*) **fuscoapicalis**, *C.* (*E.*) **fuscostigmata**, *C.* (*E*). **melanostyla**, *C.* (*E.*) **nigristyla**, and *C.* (*E*). **tumidistyla**.

Part XVII of this series of papers was published in the Journal of the New York Entomological Society, **77:** 61–65, 1969. In the present paper I am describing further new species belonging to the genus *Cheilotrichia* Rossi, subgenus *Empeda* Osten Sacken, from Nepal, Sikkim, and Assam, collected by Dr. Fernand Schmid and Dr. Edward I. Coher. I wish to express my deepest thanks to the collectors for these materials.

Cheilotrichia (*Empeda*) **apemon**, n. sp.

Size medium (wing of male 4 mm); general coloration gray; antennae black throughout; halteres yellow; legs brown, without scales; wings weakly tinged with brown, very restrictedly patterned with darker; vein Sc long, Sc_1 ending opposite midlength of the long Rs, Sc_2 not apparent; cell M_2 open by atrophy of m; male hypopygium with both dististyles pale, outer style deeply forked.

MALE: Length about 3 mm; wing 4 mm.

Rostrum dark gray, palpi black. Antennae black, proximal segments more pruinose; pedicel large, first flagellar segment subglobular, succeeding ones more oval, outermost elongate, verticils of more basal segments exceedingly long, pale. Head light gray.

Pronotum brown, obscure yellow behind, the narrow pretergites clearer yellow. Mesonotal praescutum dark gray with a vague brownish central area, scutal lobes similarly darkened, pseudosutural foveae black; posterior sclerites of notum dark gray, scutellum narrowly reddened behind. Pleura dark gray, posterior sclerites somewhat paler, dorsopleural region dusky. Halteres pale yellow. Legs with fore coxae infuscated, remaining coxae and all trochanters brownish yellow; remainder of legs brown, femoral bases obscure yellow, outer tarsal segments blackened; legs without scales. Wings weakly tinged with brown, prearcular and costal fields pale yellow, stigma narrow, vaguely darkened; bases of anal cells weakly suffused; veins yellowish brown, clearer yellow in costal region. Venation: Sc long, Sc_1 ending opposite midlength of the long Rs, Sc_2 not evident; R_{2+3+4} about one-half longer than R_2; veins R_3 and R_4 moderately divergent, cell R_3 at margin about twice cell R_2; cell M_2 open by atrophy of m; m-cu close to fork of M.

Abdomen dark brown, hypopygium yellow. Male hypopygium with the basistyle relatively long, outer lobe with very long setae, the longest exceeding the dististyles, inner

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[1] Contribution from the Entomological Laboratory, University of Massachusetts.

apical lobes with fewer setae but with abundant delicate setulae. Both dististyles pale throughout, outer style deeply forked, stem subequal to the longer or outer branch, inner branch miscroscopically roughened at apex; inner style a simple pale blade that widens gently outwardly, tip obtuse. Gonapophyses appearing as broadly flattened plates.

HOLOTYPE: ♂, Simbhangang Pass. Mahabharat Range. Nepal, 8,197 feet, June 24. 1957 (Coher).

The most similar species is *Cheilotrichia* (*Empeda*) *microdonta* Alexander, of Kashmir, which has the hypopygial details distinct. Two other allied species, *C.* (*E.*) *accomoda* Alexander, and *C.* (*E.*) *simplicior* Alexander, both of South India, differ in venation and in hypopygial structure, as the heavily blackened outer dististyles.

Cheilotrichia (*Empeda*) **cheloma**, n. sp.

Size medium (wing of male 4 mm); general coloration of mesonotum brown, posterior sclerites and pleura gray; legs brown, vestiture including flattened scales as well as setae; wings with Sc_1 ending about one-third the length of Rs; veins R_3 and R_4 long, generally parallel to one another; male hypopygium with outer dististyle heavily blackened, deeply forked, the narrower outer arm divided at near midlength into two slender slightly unequal rods, inner arm dilated into a spatula; inned dististyle unusually broad.

MALE: Length about 4 mm; wing 4 mm; antenna about 1 mm.

FEMALE: Length about 5 mm; wing 5 mm.

Rostrum and palpi brownish black. Antennae with scape and pedicel brownish black, flagellum dark brown. Head light gray.

Pronotum obscure yellow, disk weakly more darkened. Petergites, with extreme border of praescutum, light yellow. Mesonotal praescutum with four nearly confluent brown stripes, humeral and lateral regions gray; posterior sclerites of notum light gray, scutal lobes brown. Pleura gray, dorsopleural membrane yellowed. Halteres with stem dull yellow, knob clear light yellow. Legs with fore coxae and trochanters dark brown, remaining coxae and all trochanters yellow; remainder of legs brown, femoral bases narrowly yellowed; legs with flattened appressed scales additional to delicate setae. Wings weakly darkened, prearcular and costal regions light yellow; veins light brown. Venation: Sc long, Sc_1 ending about opposite one-third the straight Rs; veins R_3 and R_4 long, generally parallel to one another.

Abdominal tergites dark brown, sternites obscure yellow, hypopygium yellow. Male hypopygium with outer dististyle heavily blackened, deeply forked, outer arm narrow, at near midlength divided into two slender, slightly unequal rods, inner arm dilated into a spatula, tip obtuse; inner style unusually broad, appearing as a yellow cleaverlike blade, the tip obtuse.

HOLOTYPE: ♂, Sirhoi Kashong, Manipur, Assam, 7,500 feet, June 10, 1960 (Schmid). Allotopotype, ♂, with type. Paratopotype, ♂.

The present fly is readily distinguished from other regional species by the structure of the male hypopygium, including both dististyles. Other regional species having the dististyles heavily blackened include *Cheilotrichia* (*Empeda*) *accomoda* Alexander and *C.* (*E.*) **melanostyla**, n. sp., these being smaller species with vein Sc shorter and with the hypopygial details quite different, especially the dististyles.

Cheilotrichia (*Empeda*) **fuscoapicalis**, n. sp.

Size medium (wing about 4 mm); general coloration yellow, mesonotal praescutum and scutum with large polished black areas; femora yellow, tips narrowly but conspicuously black; wings yellowish gray, stigma not indicated; vein Sc_1 ending about opposite one-fourth *Rs*, vein R_{3+4} longer than R_1.

sex ?: Wing 4 mm.

Rostrum yellow, palpi brownish yellow, terminal segment slightly darker. Antennae with basal segments brownish black, flagellum slightly paler, especially outwardly; basal flagellar segments subglobular, slightly larger than the pedicel, densely covered with short stiff setulae, verticils subequal in length to the segments. Head dark brown.

Pronotum yellow. Mesonotal praescutum yellow, with three major polished black areas, including a broad central mark on anterior half of sclerite that narrows behind into a delicate line; lateral borders before suture with a slightly smaller similar area; scutum brownish yellow, each lobe largely covered by a polished black mark; scutellum obscure yellow; mediotergite infuscated, pleurotergite more yellowed. Pleura yellow, ventral pteropleurite gray pruinose. Halteres destroyed by fungi. Legs with fore coxae infuscated, remaining coxae and all trochanters yellow; femora yellow, tips narrowly but conspicuously blackened, involving about the outer fifteenth of the segment; tibiae and basitarsi yellow, tips more narrowly infuscated, remainder of tarsi black; no scales on legs, femoral setae large but sparse. Wings faintly tinged with yellowish gray, costal region light yellow, stigma not indicated; veins light brown, more yellowed in costal field, especially *Sc*. Macrotrichia on most longitudinal veins beyond level of origin of *Rs*, lacking on *Sc* and *1st A*, present on all but the proximal fifth on *2nd A*. Venation: *Sc* moderately long, Sc_1 ending about opposite one-fourth *Rs*, Sc_2 not evident; R_{2+3+4} and R_{1+2} long, nearly twice R_3; R_{3+4} long and straight, exceeding vein R_1; cell M_3 about twice its petiole, *m-cu* close to fork of *M*.

Abdomen with proximal five segments yellow; outer segments destroyed by fungi.

holotype: Sex ? Nanga, Sikkim, 5,000 feet, August 3, 1959 (Schmid).

Cheilotrichia (*Empeda*) **fuscoapicalis** is distinct from all described regional members of the subgenus in the coloration of the thorax and legs. It most nearly resembles species such as *C.* (*E.*) *minuscula* Alexander and *C.* (*E.*) *nigroapicalis* Alexander, of Formosa and southern Japan, which differ in the details of coloration including the broad blackened femoral tips.

Cheilotrichia (*Empeda*) **fuscostigmata**, n. sp.

General coloration of head and thorax clear blue-gray, without pattern; halteres pale yellow; legs light brown; wings entirely light yellow, including the veins, only the long-oval stigma and its included veins dark brown; *Sc* long, R_2 very oblique, exceeding R_{2+3+4}.

male: Length about 3.5 mm; wing 4 mm.

Rostrum and palpi black. Antennae black; pedicel greatly enlarged; proximal flagellar segments of male with very long verticils. Head light gray.

Thorax almost uniformly clear blue-gray, without pattern; pretergites and dorsopleural region more testaceous; pseudosutural foveae more darkened, very small. Halteres pale yellow. Legs with coxae and trochanters obscure yellow; femora light brown, terminal tarsal segments slightly darker. Wings entirely light yellow, including the veins, only the long-oval stigma and its included veins dark brown. Venation: *Sc* long, Sc_1 ending about opposite two-thirds *Rs*; R_2 very oblique, exceeding R_{2+3+4}.

Abdomen broken.

HOLOTYPE: ♂, Rongne, Sikkim, 6,200 feet, August 21, 1959 (Schmid).

The present fly is very distinct in the coloration of the wings, the most similar regional species being *Cheilotrichia* (*Empeda*) *vamanta* Alexander which has the coloration and wing pattern quite different.

Cheilotrichia (*Empeda*) **melanostyla**, n. sp.

Size small (wing of male less than 3 mm); mesonotum medium brown, posterior sclerites and pleura more yellowed; femora brownish yellow; wings brownish yellow, prearcular and costal fields more yellowed; Sc_1 ending about opposite one-fourth to one-fifth *Rs*; male hypopygium with outer dististyle heavily blackened, large and complex in structure, outer arm of outer style extended into a slender point.

MALE: Length about 2.5 mm; wing 2.7 mm.

Rostrum, palpi and antennae black. Head darkened.

Pronotum and pretergites yellowed. Mesonotal praescutum and scutal lobes medium brown; scutellum light brown, posterior border yellow; mediotergite brownish yellow. Pleura and pleurotergite chiefly yellow, restrictedly patterned with brown, dorsopleural membrane light yellow. Halteres with stem yellow, knob brown. Legs with coxae and trochanters yellow; femora brownish yellow, the darkened color produced by setae and abundant appressed scales; tibiae brownish yellow, tarsi darker brown. Wings brownish yellow, prearcular and costal regions light yellow; veins pale brown. Venation: Sc_1 ending about opposite one-fourth to one-fifth *Rs*; R_{2+3+4} and R_2 subequal; cell R_3 at margin about one-half more extensive than cell R_2.

Abdominal tergites brown, sternites and hypopygium yellow. Male hypopygium with outer dististyle heavily blackened, large and complex in structure, outer arm flattened, its inner apical angle extended into a slender point, inner arm unequally bifid into obtuse lobes.

HOLOTYPE: ♂, Thingsat, Mizo District, Lushai Hills, Assam, 2,000 feet, September 9, 1960 (Schmid).

Cheilotrichia (*Empeda*) **melanostyla** is most readily told from other generally similar regional species by the hypopygial structure, particularly the outer dististyle. Other species that have this style heavily blackened but of different conformation include *C.* (*E.*) *accomoda* Alexander and *C.* (*E.*) *brevior* (Brunetti).

Cheilotrichia (*Empeda*) **nigristyla**, n. sp.

General coloration of thorax dark gray; halteres clear light yellow; legs brown; wings very faintly darkened, Sc_1 ending about opposite one-third *Rs*; male hypopygium with outer dististyle heavily blackened, unequally bifid, the longer outer arm a simple rod, inner arm expanded into a flattened oval blade.

MALE: Length about 3.5 mm; wing 3.8 mm.

Rostrum dark gray, palpi black. Antennae black, scape more pruinose. Head light gray.

Pronotum brown, pretergites light yellow. Mesonotal praescutum and scutal lobes dark gray, sides of the former light gray; posterior sclerites of notum gray. Pleura dark brown, gray pruinose; dorsopleural membrane yellowed. Halteres clear light yellow. Legs with fore coxae dark brown, remaining coxae and all trochanters yellowed; femora and tibiae light brown, tarsi darker brown; leg vestiture including abundant black setae and dense paler scales. Wings very faintly darkened, stigma scarcely indicated; veins brown. Venation: *Sc* moderately long, Sc_1 ending about opposite one-third *Rs*; veins R_3 and R_5 slightly divergent, cells R_2 and R_3 at margin subequal in extent; *m-cu* close to fork of *M*.

Abdomen dark brown, sternites and hypopygium somewhat more yellowed. Male hypopygium with outer dististyle heavily blackened, unequally bifid, outer arm a longer simple rod, tip narrowly obtuse; inner arm expanded at apex into a flattened oval blade; inner style yellowed, outer half more expanded, apex broadly obtuse.

HOLOTYPE: ♂, Chingsao, Manipur, Assam, 3,800 feet, June 13, 1960 (Schmid).

Cheilotrichia (*Empeda*) **nigristyla** differs from *C.* (*E.*) *brevior* (Brunetti) and some other generally similar regional species chiefly in hypopygial structure, especially the outer dististyle.

Cheilotrichia (*Empeda*) **tumidistyla**, n. sp.

Size small (wing of male about 3 mm); mesonotal praescutum and scutum brownish gray, scutellum, pleurotergite and pleura extensively yellowed; fore coxae dark brown; wings faintly tinged with brownish gray, costal field yellow; male hypopygium with the dististyles large, pale, unusually stout and tumid, their tips obtuse.

MALE: Length about 2.5 mm; wing 3 mm.

Rostrum brown, palpi brownish black. Antennae brownish black. Head dark gray; eyes large.

Pronotum and pretergites light yellow. Mesonotal praescutum and scutum brownish gray, without evident pattern; scutellum brownish gray, posterior border broadly obscure yellow; mediotergite gray, sides, together with the pleurotergite, yellow. Pleura yellowed, anepisternum more pruinose, sternopleurite slightly suffused with brownish black, dorsopleural membrane light yellow. Halteres yellow. Legs with fore coxae dark brown, remaining coxae and all trochanters yellow; femora and tibiae obscure yellow, tarsi dark brown. Wings faintly tinged with brownish gray, prearcular and costal fields yellow; veins light brown, more brownish yellow in the brightened fields. Venation: Sc_1 ending about opposite one-third *Rs*.

Abdomen brown, hypopygium light yellow. Male hypopygium with the dististyles distinctive, appearing as large fleshy pale lobes that are scarcely darker in color than the basistyle; outer style deeply bifid, both lobes stout, tips obtuse; inner style similarly stout, nearly as broad as the inner arm of outer style, tip obtuse.

HOLOTYPE: ♂, Thingsat, Mizo District, Lushai Hills, Assam, 2,000 feet, September 9, 1960 (Schmid).

Cheilotrichia (*Empeda*) **tumidistyla** is generally similar to *C.* (*E*). **melanostyla**, n. sp., differing evidently in hypopygial structure.

A Simple Notation for the Naming of Segments of Complex Dendroids in Insect Wing Venation

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Abstract: A new notation is proposed for the naming of complex venational dendroids in insect wings, in which is incorporated an objective summary of structural branching characteristics. The notation is designed for statistical comparison of fragmental and whole specimens. Although developed for use with fossils, the notation may facilitate determination of insects in modern fecal and stomach samples, and may prove useful for primary description in some taxa.

In order to identify the veinlets in fragments of fossil blattoid (cockroach-like) insect wings, a simple notation has been devised, which objectively summarises the branching characteristics of any vein segment, terminal or discal. The basal segment of the vein is assigned a symbol representing the estimate of homology of the major vein, if in fact this homology is obtainable; thus Sc for subcosta. After the first bifurcation the vein consists of two segments: Sca and Scp, the first anterior and first posterior branches. Where the veinlet is terminal the notation may be closed; thus Sca]. Where there is a succession of branches in the same direction their number may be written as a superscript for brevity; thus Scp^5 for Scppppp, the fifth posterior fork of the subcosta. Using this notation it is convenient for comparative purposes, to list all the terminal veinlets of a major vein, and at the same time retain within the notation all information pertaining to the relative branching pattern of the vein; thus Sca, pa, p^2a^2, p^2ap, p^3a^2, p^3ap, p^4a, p^5, represents the branching system of an anteriorly pectinate, marginally furcate vein of eight terminal veinlets, the first anterior, the first anterior of the first posterior, the second anterior of the second posterior, the first posterior of the first anterior of the second posterior, the second anterior of the third posterior, the first posterior of the first anterior of the third posterior, the first anterior of the fourth posterior, and the fifth posterior forks. This new notation has the advantage of preserving all the relative data pertaining to the ramification pattern, in a short symbolism, and should be readily adaptable to mechanical or "computer" methods of pattern comparison and structure analysis. When measurements are made for individual veinlets, whether terminal or discal, the measured veinlet or segment may be referred to by its symbol and may be easily located in the complex dendroid by another investigator. This notation appears to have greater practical potential than the one proposed by Cockerell (1916).

Several parameters are suggested here for the description of the branching pattern of a major vein or its sectors. The BIFURCATION INDEX, i, for a dendroid is taken as the greatest number of consecutive bifurcations to be found within the dendroid. Hence i is the highest sum of superscripts for a terminal veinlet, to be found in the listing of terminal veinlets of that vein or sector. Within the constraint of the venational field, i is an estimate of the maximum branching potential of the dendroid. A major vein is considered to be a dendroid with potential minimum branching producing $i + 1$ terminal veinlets and a potential maximum branching of 2^i terminal veinlets. In order to compare the degree of development of the same vein in different wings, a ratio, the RAMIFICATION INDEX, R, is proposed. $R = (t - Tmin)/(Tmax - t)$, where t is the number of terminal veinlets, $Tmin$ is $i + 1$, and $Tmax$ is 2^i. R is zero for minimum branching and is very large for maximum branching. The wing venation dendroid grows confined in a plane between the dorsal and ventral epidermis, in paths along tracheal precursors[1]. The limits of the dendroid are affected both by wing edge conditions and by proximity to adjacent venational dendroids. The actual developmental control of these locations may be linked to the increased velocity or change in direction of the circulating blood in the field boundary zone. The result of these effects on the developing dendroid, is the production of a certain amount of asymmetry. Terminal asymmetry may be expressed as an INDEX OF PERIPHERAL SKEWNESS, P. $P = (a/ - p/)/(i - 1)$, where $a/$ and $p/$ are the numbers of terminal anterior and posterior veinlets, and $i - 1$ is the absolute value of $a/ - p/$ in a perfect pecten of bifurcation index i. Positive values to 1 are anteriorly pectinate, zero shows terminal symmetry, and negative values to -1 show posterior pectination. P ignores discal symmetry which is probably determined early in the dendroid development and is expressed as uneven development of the sectors of the vein. This internal asymmetry may be accounted for by a WEIGHTED INDEX OF SKEWNESS, S. $S = (wa - wp)/(1 - Sum\ 1\ to\ i)$, where wa and wp are the respective sums for a and p terminal veinlets of J^f in which J is the superscript in the notation and f is the frequency of listing of that superscript of the terminal veinlets of the direction a or p being summed, for all symbols mentioned in the listing, and $1 - Sum\ 1\ to\ i$ is the value of $wa - wp$ for a perfect anterior pecten. Thus anterior internal pectination is repre-

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[1] Carpenter (1966) argues against this theory; however both viewpoints seem still to be in need of additional evidence. Too little is known yet concerning the histology of the developing wing tissues, but it appears probable that anlagen are present or extended into the wing for all components of the developed vein. If this is so, the appearance of tracheal sclerotization in place, in the blood spaces or lacunae, as shown by Holdsworth (1940), rather than as outgrowths from the wing base does not necessarily contradict the Comstock-Needham theory of vein development. The tracheae may grow out as their unsclerotized anlagen, before formation of lacunae, but may not become optically differentiated until the sclerotization is laid down by the tracheal wall cells, after the formation of lacunae.

sented by positive values of S to 1. Internal symmetry and perfect pectination is indicated by an S of zero, and posterior internal pectination appears as negative values of S to -1. Effects due to change in field size, following marginal developmental allometry, as in brachyptery, or following injury; or the effects of increase in neighbouring vein ramification, may show as a change in R. However if R is modified too slowly, crowding effects may occur as interference between the veinlets and at the margin of the field. These effects may be expressed as an INTERFERENCE INDEX, X. $X = x/t$, where x is the number of anastomoses, confluences, or crossings over of the vein, involving veinlets within that field or between fields, and t is the number of terminal veinlets of the venational dendroid of this field. In the modern Cuban roach—*Byrsotria fumigata* (Guérin-Méneville) of the Blaberidae, x is higher for the veins of the brachypterous variety of males than it is for those of the long winged variety.

The phenomenon of vein "capture" presents problems if it is thought of as a capturing process. Vein "capture" is a phylogenetic phenomenon, not a developmental process. In the initial phase of "capture," one or more of the branches, of one venational field may lie across the major stem of an adjacent field and terminate amongst the branches of that field. This situation is perhaps selected for initially under conditions of venational crowding or as a functional solution for maintaining planar stability of the wing, a function approximating that of true crossveins. Because the developmental patterns and locations of the venational elements of blood lacunae and tracheae are probably controlled by many gene loci, variational shift in location, or non-development of a trachea need not be accompanied by lacunar modification. This in fact, is found to be the case in some Plecoptera in which the venation is persistently different in wings of the right and left side. The presence in the wing of a lacunar segment, without trachea, connected to two major veins through inheritance from ancestors in which these veins were frequently crossed presents a potential branching location for the tracheae of either of the adjacent veins. If the empty lacunar system is taken over by tracheae of the vein associated ancestrally with the formation of this lacunar segment there is apparent return again to the ancestral condition. If, however, the trachea of the other vein occupies the lacunar space we arrive at the situation in which the first vein is said to have been "captured" by the second. It should be recognized that at no time is there any break in connection of parts of the trachea, and rarely, probably never, is there a true confluence of tracheae of different major veins. The most frequent situation in which vein "capture" occurs, seems to be the close approach of the anterior ramus of one vein to another anterior vein. In the earlier fossil representatives there is close approximation only. In later fossil representatives a major branch of the anterior trachea occupies the approximated lacuna. Some situations may be found in which tracheal branches

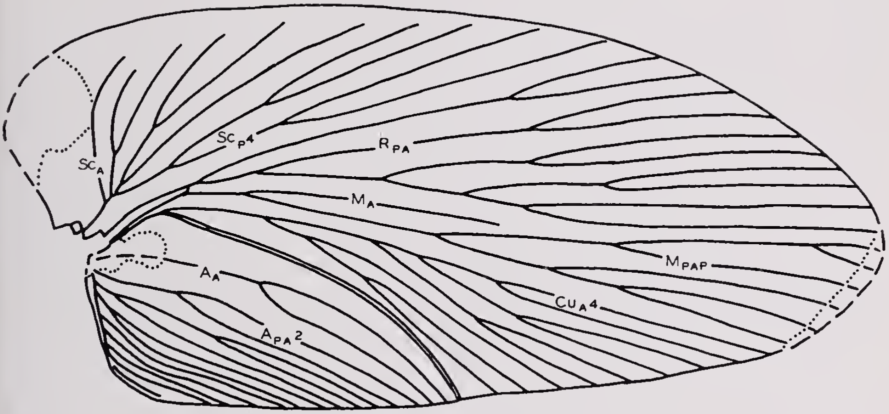

Fig. 1. An example of application of the venational notation to the vein segments in a fossil insect wing; *Mylacris anthracophila* Scudder Syntype, Univ. of Illinois, x-499.

from both stems may enter at least part of the "captured" vein as is found in some of the anisopterous Odonata.

The phenomenon of venational "capture" is widely distributed amongst insects, occurring in the Odonata, Saltatorial Orthoptera, Lepidoptera, and other orders. The notation for a captured vein should be derived from the tracheal system rather than from the lacunal system, for the practicality in determination of homology.

As an example of the new notation proposed here the system is applied to the type of *Mylacris anthracophila* Scudder 1868 (Mylacridae; Pennsylvanian), from the Francis Creek Shale, Carbondale Group, Pennsylvanian of Colchester, McDonough County, Illinois, Fig. 1.

Listing of terminal veinlets: Sca, pa^2, pap, p^2a^3, p^2a^2p, p^2ap, p^3a^2, p^3ap, p^4a, p^5; Ra^2, ap, pa^2, pap, p^2a^2, p^2ap, p^3a^2, p^3ap, p^4a, p^5; Ma, pa^3, pa^2p, pap, p^2a, p^3a, p^4; Cua^4, a^3p, a^2pa, a^2p^2, apa, ap^2, pa, p^2a, p^3; Aa^2, ap, pa^2, pap, p^2a^3, p^2a^2p, p^2ap, p^3a^2, p^3ap, p^4a, p^5a, p^6a, p^7.

Venational parameters: Sct = 10, Rt = 10, Mt = 7, Cut = 9, At = 13; Sci = 5, Ri = 5, Mi = 4, Cui = 4, Ai = 7; RSc = 0.28, RR = 0.28, RM = 0.44, RCu = 0.86, RA = 0.06; PSc = 0, PR = 0, PM = 0.33, PCu = 0.33, PA = 0.17; SSc = –0.71, SR = 0.07, SM = –0.22, SCu = 0, SA = –0.11.

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Incorporated May 21, 1968

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Journal of the New York Entomological Society

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CONTENTS

The Arthropod Fauna of Bovine Dung in Central New York and Sources on Its Natural History

IVAN VALIELA*

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RECEIVED FOR PUBLICATION JUNE 9, 1969

Abstract: The arthropod fauna of bovine manure in the vicinity of Ithaca, N. Y. is described. In addition, a list of the most useful references for the biology and natural history of dung arthropods is presented.

This report deals with the complex of species encountered during studies on the population dynamics, predator-prey relations and community structure of dung arthropods.

The collections were carried out during three summers (1965–1967) of research on a dairy farm in the vicinity of Ithaca, New York. During the summer of 1966, standard amounts of cow dung were set out in an open pasture and collected one, two, three and five days after exposure. These samples were then extracted using Tullgren funnels. A detailed description of the whole sampling procedure is provided in Valiela (1969). Other arthropods, especially adult flies, were collected around droppings with nets and suction devices.

Samples were collected only from an open pasture during the summer in an effort to simplify the system under study. Collections around shady areas, as well as during cooler parts of the season, would have provided greater taxonomic diversity, especially among the muscoid flies.

After an initial determination, specimens of a majority of the species were sent to specialists for identification.

A study of various aspects of the population dynamics of some important species has been published (Valiela, 1969). Reports dealing with the bulk of the prominent species in the community are in preparation, but since these papers center around the more abundant species, it seemed useful to record here as complete a list as could be compiled (see Table 1). Many species, particularly immatures, proved impossible to identify. However, since they could in general be determined to genus and separated from other specimens, an estimated number of these undetermined species is given in parentheses (Table 1). Voucher specimens of the prominent species are deposited in the care of the Curator of the Insect Collection at Cornell University. A large number of specimens of the listed species are available from the author for study by anyone interested.

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Table 1. Arthropods found in bovine dung in a pasture in Central New York. The occurrence code is 1) abundant; 2) common; 3) rare; 4) accidental. These categories are not intended as rigorous frequency classifications. In some instances it was not possible to assign a code number. All species except "accidentals" are thought to be members of the community. Abundant species are invariably found in all samples while rare ones in very few. Where no determiner is indicated, the identification is the author's. In virtually all cases the species listed occur both as adults and larvae ("accidentals" are an exception). Adults and larvae are mentioned when the determination included both. Determinations were made on adults unless otherwise indicated.

	Occurrence Code	Determined by:
ACARINA		
Acarine sp. (9 species?)	2	
Macrocheles glaber		R. C. Axtell
M. muscaedomesticae	1	"
M. sp.		"
Parasitus sp. (3 sp.?)	1	"
Uropodid sp.	3	
COLLEMBOLA		
Entomobryidae		
Seira platani	2	D. L. Wray
Poduridae		
Hypogastrura glasgowi	1	"
MALLOPHAGA		
Damalinia bovicola	4	
PSOCOPTERA		
Lachesillidae		
Lachesilla pedicularia	4	E. L. Mockford
Liposcelidae		
Liposcelis sp.	4	"
COLEOPTERA		
Staphylinidae		
Aleochara bipostulata	1	H. Dietrich
A. imbricata	3	"
Aleocharine sp. n. *Aleochara* (3 sp.)		
Atheta sordida	1	H. Dietrich
Aleocharine sp. n. *Atheta* (2 sp.)		
Creophilus maxillosus	2	
Falagria dissecta	1	H. Dietrich
Hyponygrus obsidianus	2	"
Oxytelus tetracarinatus	1	"
Philonthus cruentatus	1	"
P. rectangulus	3	"
P. varius		"
P. sp. (2 sp.)		
Platystethus americanus	1	H. Dietrich
Staphilinid adults (9 unidentified sp.)	3	
" larvae (2 " sp.)	2	
Trogophloeus (arcifer?)	3	H. Dietrich
Ptiliidae		
Acrotrichis sp. (n. *sericans*)	1	H. Dybas
Nephanes sp. (n. *titan*)	3	"
Histeridae		
Hister abbreviatus	3	R. L. Wenzel
Saprinus sp.	2	

TABLE 1. *Continued.*

	Occurrence Code	Determined by:
Hydrophilidae		
Cercyon sp. adults (10 sp.)	1	
Cercyon sp. larvae (unidentified)		
Sphaeridium bipostulatum	1	W. J. Brown
S. lunatum	1	"
S. scarabaeoides	1	"
Nitudulidae		
Carpophilus brachypterus	4	
Omosita colon	4	
Chrysomelidae		
Longitarsus sp.	4	R. White
Elateridae		
Melanotus sp. larvae	4	T. J. Spilman
Scarabaeidae		
Aphodius erraticus	1	O. L. Cartwright
A. fimetarius	1	D. M. Anderson, O. L. Cartwright
A. fossor	1	O. L. Cartwright
A. granarius	2	"
A. haemorrhoidalis	1	D. M. Anderson, O. L. Cartwright
A. prodromus	2	O. L. Cartwright
A. ruricula	3	"
A. stercorosus	2	"
Aphodius larvae (unidentified)		
Onthophagus hecate	3	
O. nuchicornis	3	O. L. Cartwright
O. pennsylvanicus	3	
DIPTERA		
Psychodidae		
Psychoda alternata		L. W. Quate
P. pusilla		"
Psychoda sp. (larvae)	1	A. Stone
Ceratopogonidae		
Forcypomyia bipunctata		W. W. Wirth
F. brevipennis		"
Scatopsidae		
Psectrosciara sp.	4	
Rhegmoclema sp.	4	
Scatopse fuscipes		A. Stone
Sciaridae		
Bradysia coprophila (adults & larvae)	4	A. Stone
Bradysia sp.	4	"
Cecidomyiidae		
Unidentified adults	4	
Phoridae		
Phorid sp.	4	
Sphaeroceridae		
Leptocera sp.	1	C. W. Sabrosky
Syrphidae		
Eristalis tenax (larvae & adults)	4	
Stratiomyidae		
Microchrysa polita (adults & larvae)	2	
Sargus cuprarius (" ")	1	W. W. Wirth
Anisopodidae		
Sylvicola punctatus	3	A. Stone

Table 1. *Continued.*

	Occurrence Code	Determined by:
Sepsidae		
Saltella sphondylii (adults & larvae)	1	G. Steyskal
Sepsis biflexuosa		"
S. neocynipsea	1	"
S. punctum		"
S. vicaria		"
Sepsis sp. larvae	1	
Piophilidae		
Piophilid sp.	4	
Drosophilidae		
Unidentified adults	4	
Chloropidae or Milichidae		
Unidentified adults	4	G. Steyskal
Anthomyidae		
Scatophaga stercoraria	2	
Muscidae		
Haematobia irritans (larvae)	2	C. W. Sabrosky
Hydrotaea tuberculata (larvae)	3	G. Steyskal
Hylemya (?) sp. (larvae)	3	"
Morellia sp.		
Musca autumnalis (adults & larvae)	1	
M. domestica (larvae)	4	R. Gagné
Muscina stabulans		
Orthellia caesarion (adults & larvae)	2	
Calliphoridae		
Phaenicia sp. (larvae)	4	R. J. Gagné
Sarcophagidae		
Ravinia l'herminieri (adults & larvae)	1	W. L. Downs
Sarcophaga sp. (s.l.) (larvae)	1	R. J. Gagné
Sarcophaga sp. (s.l.) (adults)	1	
HYMENOPTERA		
Formicidae		
Lasius flavus	4	
Scelionidae		
Telenomus sp.		P. M. Marsh
Diapriidae		
Basalis sp.		"
Pteromalidae		
Spalangia nigripes		B. D. Burks
Braconidae		
Aphaereta pallipes	1	P. M. Marsh
Asobara sp.		"
Blacus sp.		B. D. Burks
Pentapleura sp.		P. M. Marsh
Cynipidae		
Cothonaspis sp.		B. D. Burks
Figitidae		
Xyalophora quinquelineata	2	

Much biological information has accumulated about the arthropods of dung and has been compiled by several authors. It therefore seems redundant to describe here the natural history of each species encountered. This is particularly the case in view of the fact that in general dung faunas are cosmopolitan. Many species and virtually all genera, listed in this paper, can be found in widely distant geographical locations (cf. Bogdanow, 1901; Duffield, 1937; Hafez 1939; Hammer, 1942; Mohr, 1943; Snowball, 1944; Laurence, 1954; Sanders & Dobson, 1966; Poorbaugh *et al.*, 1968). However, it seems useful to provide a guide to the relevant literature. Table 2 presents a list of the main sources of information on the natural history of the arthropods involved. In general, the purely taxonomic works are not included. For the face fly few of the many papers are cited since a partial bibliography is already available (Smith *et al.*, 1966; 1967).

Table 2. List of the more useful sources on the biology and natural history of dung arthropods. The more general papers which deal with entire faunas or large groups of dung arthropods are included in the references section rather than in this table.

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Table 2. *Continued.*

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TABLE 2. *Continued.*

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As a pertinent aside, the affinities of dung faunas with those of sea wrack (Backlund, 1945; Ardö, 1957), carrion (Fuller, 1934; Reed, 1958; Payne, 1965) and other decaying substrates (Walker, 1957; Bornemissza, 1957) should be noted. This phenomenon suggests similarities in the environments provided by such accumulations of organic matter. The study of such similarities in environments of diverse origin would be of interest to the student of comparative community ecology. Dung insects also offer very interesting opportunities to zoogeographical studies because of their relationships to the spread of cattle and since many documented cases of animal invasions are known (cf. Brown, 1940 for example). A study of some aspects of the invasion of North America by the face fly is being prepared.

Dr. E. J. Hansens of Rutgers University first suggested this topic a number of years ago. The aid of Dr. W. H. Anderson and his staff at the Insect Identification and Parasite Introduction Research Branch, U.S.D.A., is acknowledged, and the names of the taxonomists responsible for the determinations are included in Table 1. This research was conducted under a predoctoral fellowship from the National Institute of Health at Cornell University. The manuscript was completed with the support of N.I.H. Postdoctoral Fellowship 1 TO1 GM01751-01 at Michigan State University.

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The Genus *Kaestneriella* (Psocoptera: Peripsocidae)[1]

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Abstract: Nine species and a possible tenth are now known in the genus *Kaestneriella*. Eight of these are here described as new and are named as follows: *K.* **guatemalensis**, *K.* **maculosa**, *K.* **mexicana**, *K.* **minor**, *K.* **obscura**, *K.* **occidentalis**, *K.* **pacifica**, *K.* **setosa**. An augmented diagnosis of the genus is presented. Figures of genitalic and forewing characters for all of the new species are included. A key to the known species is presented. The taxonomic treatment is based on examination of 185 adult specimens. The location of the major types of each new species is mentioned in its description. A brief discussion of phylogenetic relationships within this genus is included and is summarized with a dendrogram. The genus *Kaestneriella* is now known to occur from Costa Rica north to southern Arizona.

The genus *Kaestneriella* was established by Roesler (1943) on the basis of a single male specimen with *Peripsocus*-like venation (i.e., simple vein Cu_1, three-branched median, pterostigma constricted basally), forewing veins well ciliated and forewing margin ciliated except at its tip. The figure of the phallosome showed it to be essentially as in *Peripsocus* but wide basally. The radula appeared to be composed of two sclerites, bilaterally symmetrical.

The present study is based on examination of 185 adult specimens of *Kaestneriella*, including eight species new to science, herein described. This investigation has allowed some clarification and modification of the original diagnosis of the genus, as follows:

1. In addition to forms with well-ciliated forewings, the group includes some species in which ciliation is very poorly developed, so that the individual setae cannot be noticed at magnifications less than 70×.
2. The phallosome is somewhat constricted basally in some species but never as much as is commonly found in *Peripsocus*.
3. As in *Peripsocus*, the pore-bearing (presumably external) parameres are median in position.
4. The clunial comb is broad, straight or slightly curved, and set on a quadrate posterior extension of the clunial margin.
5. The forewing is usually gray or grayish-brown in color over most of its

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Table 1. Measurements (in mm), Ratios and Ctenidial Counts for species of *Kaestneriella*. IO/D, least head width between eyes divided by greatest antero-posterior diameter of an eye in dorsal view of head; PO, transverse eye diameter divided by greatest antero-posterior eye diameter in dorsal view of head; refer to text (page 225) for further information.

	Forewing length	Length of hind tibia	Length of hind tarsal segment 1	Length of hind tarsal segment 2	Number of ctenidia, hind tarsal segment 1	IO/D	PO
Kaestneriella **guatemalensis**, n. sp. ♂							
Sample size	8	8	8	8	8	8	8
Minimum	3.93	1.20	0.34	0.15	14	1.24	0.79
Maximum	4.35	1.35	0.37	0.17	19	1.77	0.90
Mean	4.17	1.26	0.35	0.16	16.4	1.54	0.84
S.D.	0.161	0.052	0.011	0.010	1.60	0.196	0.034
Kaestneriella **guatemalensis**, n. sp. ♀							
Sample size	14	14	14	14	14	14	14
Minimum	1.57	0.91	0.27	0.15	0	2.79	0.62
Maximum	2.31	1.10	0.30	0.17	1	3.20	0.70
Mean	1.81	1.02	0.28	0.16	0.1	2.98	0.65
S.D.	0.189	0.052	0.009	0.008	0.27	0.126	0.023
Kaestneriella **maculosa**, n. sp. ♂							
Three	2.28	0.84	0.25	0.12	16	1.67	0.57
Specimens	2.23	0.83	0.25	0.11	16	1.83	0.60
	3.12	1.01	0.28	0.13	15	1.82	0.79
Kaestneriella **maculosa**, n. sp. ♀							
One Specimen	1.90	0.84	0.23	0.11	12	2.64	0.57
Kaestneriella **mexicana**, n. sp. ♂							
Sample size	16	16	16	16	16	16	16
Minimum	2.77	1.09	0.30	0.12	11	0.74	0.54
Maximum	3.46	1.28	0.36	0.14	21	2.07	1.03
Mean	3.03	1.17	0.33	0.13	16.3	1.25	0.70
S.D.	0.181	0.054	0.016	0.004	3.03	0.389	0.142
Kaestneriella **mexicana**, n. sp. ♀							
Sample size	16	16	16	16	16	16	16
Minimum	2.24	0.91	0.24	0.08	3	2.09	0.47
Maximum	2.94	1.19	0.31	0.14	16	2.88	0.69
Mean	2.50	1.02	0.27	0.12	9.2	2.52	0.58
S.D.	0.179	0.089	0.024	0.016	5.29	0.173	0.050
Kaestneriella **minor**, n. sp. ♂							
Sample size	4	4	4	4	4	4	4
Minimum	1.74	0.71	0.19	0.09	11	1.08	0.68
Maximum	2.30	0.78	0.28	0.11	16	1.48	0.81
Mean	2.04	0.75	0.23	0.10	14.3	1.27	0.75
S.D.	0.255	0.028	0.041	0.011	2.22	0.184	0.055

Table 1 (*Continued*)

	Forewing length	Length of hind tibia	Length of hind tarsal segment 1	Length of hind tarsal segment 2	Number of ctenidia, hind tarsal segment 1	IO/D	PO
Kaestneriella **minor**, n. sp. ♀							
Sample size	9	9	9	9	9	9	9
Minimum	1.62	0.67	0.17	0.08	2	2.33	0.47
Maximum	1.83	0.77	0.20	0.11	12	2.84	0.65
Mean	1.75	0.71	0.19	0.10	5.7	2.61	0.55
S.D.	0.064	0.035	0.011	0.010	4.03	0.154	0.066
Kaestneriella **obscura**, n. sp. ♂							
Sample size	16	16	16	16	16	16	16
Minimum	2.78	0.95	0.28	0.10	12	0.80	0.56
Maximum	3.27	1.15	0.32	0.14	18	1.04	0.91
Mean	3.03	1.05	0.30	0.13	15.6	0.91	0.69
S.D.	0.160	0.050	0.015	0.009	2.19	0.062	0.093
Kaestneriella **obscura**, n. sp. ♀							
Sample size	10	10	10	10	10	10	10
Minimum	1.98	0.82	0.21	0.12	5	1.90	0.45
Maximum	2.42	1.01	0.27	0.15	21	2.67	0.58
Mean	2.23	0.93	0.24	0.13	7.8	2.45	0.51
S.D.	0.117	0.058	0.016	0.010	6.91	0.237	0.043
Kaestneriella **occidentalis**, n. sp. ♂							
Sample size	5	5	5	5	5	4	4
Minimum	2.71	0.86	0.25	0.12	15	0.48	0.59
Maximum	3.13	1.06	0.32	0.14	20	0.63	0.72
Mean	2.85	0.98	0.30	0.13	17.4	0.56	0.63
S.D.	0.164	0.073	0.032	0.009	2.07	0.078	0.060
Kaestneriella **occidentalis**, n. sp. ♀							
Sample size	19	19	19	19	19	19	19
Minimum	2.17	0.81	0.24	0.11	4	1.94	0.48
Maximum	2.44	1.05	0.30	0.14	16	2.40	0.75
Mean	2.29	0.90	0.27	0.13	10.3	2.17	0.66
S.D.	0.074	0.052	0.014	0.006	3.04	0.11	0.070
Kaestneriella **pacifica**, n. sp. ♂							
Sample size	4	4	4	4	4	3	3
Minimum	1.95	0.69	0.19	0.10	8	1.39	0.63
Maximum	2.11	0.83	0.23	0.10	14	1.48	0.69
Mean	2.02	0.77	0.22	0.10	11.5	1.44	0.65
S.D.	0.068	0.061	0.022	0.003	2.65	0.045	0.034
Kaestneriella **pacifica**, n. sp. ♀							
Sample size	4	4	4	4	4	4	4
Minimum	1.93	0.73	0.19	0.10	8	2.47	0.45
Maximum	2.90	0.79	0.22	0.12	13	2.78	0.60
Mean	1.86	0.76	0.20	0.11	10.5	2.59	0.51
S.D.	0.054	0.026	0.013	0.009	2.38	0.131	0.064

TABLE 1 (*Continued*)

	Forewing length	Length of hind tibia	Length of hind tarsal segment 1	Length of hind tarsal segment 2	Number of ctenidia, hind tarsal segment 1	IO/D	PO
			Kaestneriella **setosa**, n. sp. ♂ (?)				
Single specimen	2.00	0.83	0.25	0.11	18	0.70	0.66
			Kaestneriella **setosa**, n. sp. ♀				
Sample size	17	17	17	17	17	17	17
Minimum	1.57	0.63	0.17	0.09	4	2.13	0.49
Maximum	2.28	0.90	0.26	0.14	15	2.70	0.70
Mean	1.96	0.80	0.23	0.12	11.7	2.43	0.61
S.D.	0.151	0.062	0.025	0.011	3.00	0.192	0.074

surface, but there is generally a pattern of colorless regions, one such region above, one below, and one immediately distal to the R-M junction. This color pattern is best developed in females.

6. The female external genitalia are of the *Peripsocus* type, but the third ovipositor valvulae tend to be larger relative to the other valvulae than is generally seen in *Peripsocus*.

7. The cell R_5 of the forewing tends to be relatively wider than in *Peripsocus*. This may be shown quantitatively by the following technique (Fig. 54): on a tracing of the wing a line is drawn passing through the anterior margin of the wing base and bisecting a line drawn between the marginal ends of veins R_{4-5} and M_1: three perpendiculars are drawn through this line, one passing through the point where R, and M branch apart, one passing through the point where M_3 branches from the main M stem, and one passing through the two points furthest apart on the veins delineating cell R_5. The length between the first two perpendiculars (a) is divided by the greatest width of cell R_5 measured along the third perpendicular (b). The resulting index, herein called the R_5 index is recorded for a representative individual of each sex of each species included in this paper. The range of R_5 indices for males of *Kaestneriella* is 1.11 to 1.38. For males of five species of *Peripsocus* it is 1.38 to 1.70. The R_5 index has a much greater range in *Kaestneriella* females (1.15–1.63), and was not determined for *Peripsocus* females, as a wide overlap was anticipated.

In all species observed there is at least some sexual dimorphism in forewing length, the males having relatively longer ones than the females. This situation reaches an extreme in *K.* **guatemalensis**, n.sp., in which females are brachypterous. In this species the females are smaller in general than males. Also, in all species observed the pigmented area of the subgenital plate covers the median apical lobe, a broad region basal to the lobe, and extends forward as a pair of slender, antero-laterally directed arms. Generally a more pigmented central region or pair of regions may be noted within the pigmented area.

Measurements (Table 1) were taken on whole specimens mounted temporarily in glycerine on a well slide. Forewing lengths were taken at 42×, at which the micrometer unit equals 17.4 μ. All other measurements were taken at 120×, at which the micrometer unit equals 6.2 μ.

Material examined is principally from the collection of the senior author. Material was also borrowed from the Canadian Department of Agriculture, Ottawa, Ontario, Canada.

KEY TO SPECIES OF *Kaestneriella*

1. Forewing ciliation consisting of minute sparse setae on veins, anterior margin, and surface of pterostigma; the marginal setae visible above 70×; large setae, if any, limited to vein R and the part of R_1 forming posterior margin of pterostigma 5
Forewing ciliation distributed as above but consisting of abundant setae readily visible at 70× 2

2. Clypeus marked with a conspicuous large pair of spots formed by the striations .... **maculosa**, n.sp.
Clypeus with no conspicuous marking 3

3. Small species, forewings about 2.0 mm; known mostly from females in southern Mexico and Guatemala (coastal plain to 7,000 ft.) .... **setosa**, n.sp.
Males frequent, species from higher elevations of Guatemala or from further south 4

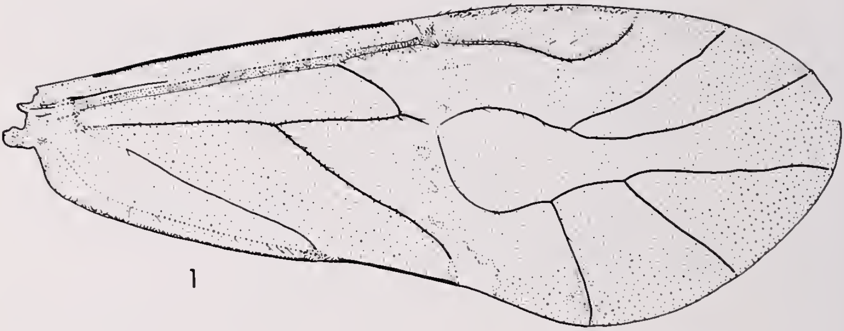
4. Large species, male forewings 4.0 mm; species from over 9,000 ft. in Guatemala .... **guatemalensis**, n.sp.
Small species, male forewings 2.5 mm; species from Costa Rica .... *pilosa* Roesler

5. Radular sclerites (♂) a simple pair of hook-shaped structures with a pair of small rounded sclerites lateral to bases of hooks (figs. 14, 17, and 21) 6
Radular sclerites three pairs of prongs 8

6. With a distinct pair of large spots on clypeus formed by lineations; setae conspicuous at 70× on vein R and on R_1 bordering pterostigma posteriorly .... **minor**, n.sp.
Clypeus with no distinct marks; setae of veins R and R_1 inconspicuous at 70× 7

7. Female forewing uniformly tawny brown in distal one-third; three colorless spots around R-M junction large (fig. 9). Male forewings 2.10 mm or less in length .... **pacifica**, n.sp.
Female forewing with darker regions in distal portions of cells R_1, R_3, R_5, M_1, M_2, and M_3. Male forewings 2.78 mm or more in length .... **obscura**, n.sp.

8. Middle pair of prongs of radular sclerites developed same as basal pair, being long and slender; a distinct dark spot just distad of colorless spot in base of cell R_5 .... **occidentalis**, n.sp.
Middle pair of prongs of radular sclerites much shorter and stouter than basal pair; region just distad of colorless spot in base of cell R_5 concolorous with surrounding tawny cuticle .... **mexicana**, n.sp.



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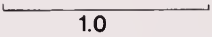

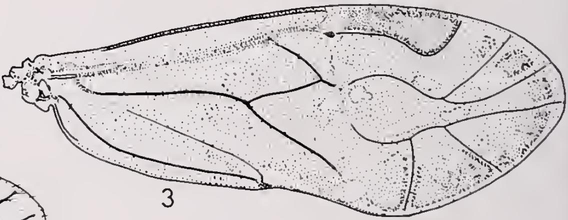

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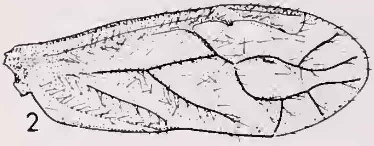

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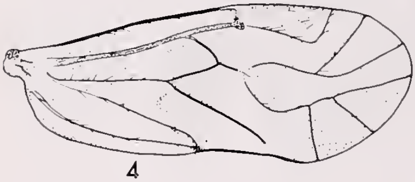

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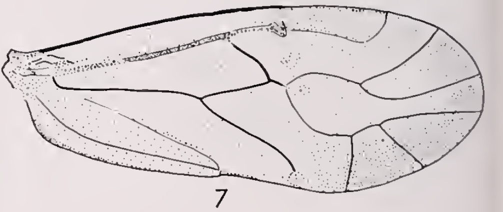

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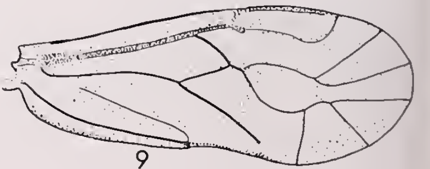

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Kaestneriella **guatemalensis**, n.sp.

DIAGNOSIS. Forewing ciliation very conspicuous in females, much less so in males, but in latter readily visible at 70×. Male radular sclerites consisting principally of a pair of elongate, curved structures each terminating posteriorly in a narrow, bent, acuminately pointed hook. Females brachypterous, the forewings not reaching tip of abdomen.

MALE. Measurements, Table 1.

MORPHOLOGY. R_5 index = 1.17. Phallosome (Fig. 12) broad and of approximately equal width near basal and near distal end; pore-bearing parameres indistinct at their bases, their tips falling well short of apical beak of phallosome, the pores very sparse and seen mostly in distal half of paramere. Apical beak of phallosome rather long and slender. Radular sclerites (Fig. 11) a pair of elongate structures curving toward mid-line at bases and outward posteriorly, each ending posteriorly in a narrow, bent, sharply pointed hook; to side of each of these a rounded sclerite. Clunial comb (Fig. 10) straight with several small denticles forming submarginal row and scattered smaller denticles before that; larger denticles of marginal row 14 and 20 in number on two specimens counted.

COLOR (in alcohol). Body coloration essentially same as in *K.* **obscura** but darkened areas of vertex showing slight spotting. Forewings (Fig. 1) uniformly washed with grayish-brown except for very slight development of colorless areas around R-M junction of forewing and large colorless area at distal end of vein Cu_1; membrane bordering vein M_3 of forewing with slightly darker pigmentation.

FEMALE. Measurements, Table 1.

MORPHOLOGY. Brachypterous; forewings extending to seventh abdominal segment at rest. Rs fork about even with stem in length. Subgenital plate (Fig. 32) with a slender, transverse darkly pigmented central area somewhat constricted mesally; median apical lobe of subgenital plate decidedly longer than its width at base, decidedly tapering from base to apex, the apex truncated and bearing a few long setae toward each of its lateral angles. Ovipositor valvulae (Fig. 31): first valvula slender, slightly bent upward at apex, the subapical region beset on medio-ventral side with rather sparse, minute setae. Second and third valvulae typical of the genus. Sensory cusion of paraproct with 12 and 19 trichobothria in two specimens counted; one trichobothrium decidedly larger than others and issuing from a larger basal rosette.

COLOR (in alcohol). Body essentially same as in male, but darkened areas of vertex much more discretely spotted. Forewings with colorless spots around R-M junction greatly en-

←

Figs. 1–9. Forewings of *Kaestneriella*, all drawn at scale shown.

Fig. 1. *K.* **guatemalensis**, n.sp. ♂.
Fig. 2. *K.* **guatemalensis**, n.sp. ♀.
Fig. 3. *K.* **mexicana**, n.sp. ♀.
Fig. 4. *K.* **maculosa**, n.sp. ♀.
Fig. 5. *K.* **occidentalis**, n.sp. ♀.
Fig. 6. *K.* **minor**, n.sp. ♀.
Fig. 7. *K.* **obscura**, n.sp. ♀.
Fig. 8. *K.* **setosa**, n.sp. ♀.
Fig. 9. *K.* **pacifica**, n.sp. ♀.

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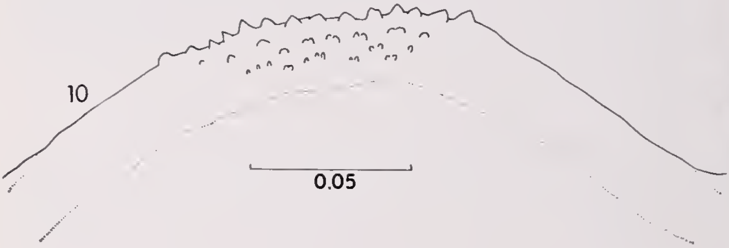

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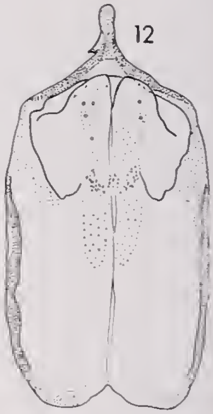

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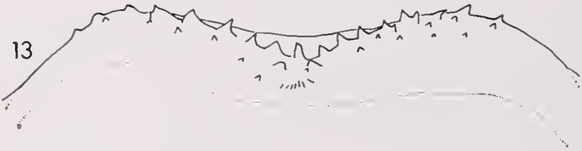

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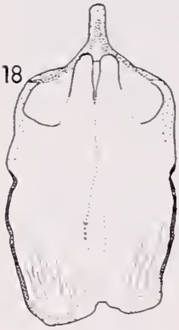

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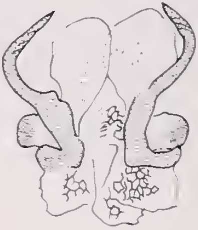

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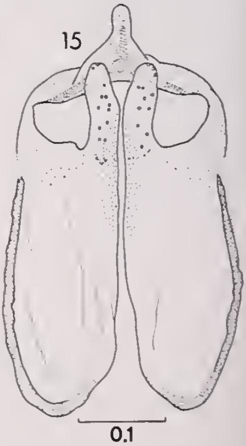

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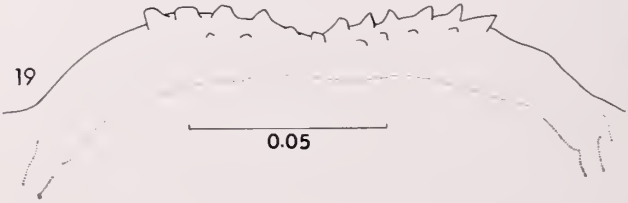


larged, the anterior one covering most of width of cell R_1, the middle one covering most of width of basal region of cell R_5, the posterior one extending from region immediately posterior to R-M junction back to wing margin at distal end of vein Cu_1.

VARIATION. In addition to the marked sexual dimorphism in wing length, males are in general decidedly larger than females. The sexual dimorphism in compound eye diameter is not very pronounced. Observed color variation in age-related.

RANGE. Highlands of Guatemala, taken at two localities, one at 9,500 feet and the other at 12,000 feet in elevation.

TYPE LOCALITY. 17 miles north of Huehuetenango (Hwy. 9), Dept. of Huehuetenango, Guatemala, September 2–3, 1968, E. L. Mockford and A. Garcia Aldrete collectors, holotype ♂, allotype ♀, 4 ♂ and 12 ♀ paratypes. Types are in the collection of the senior author.

RECORDS. Guatemala: 34 miles northwest of Sololá (Inter-Amer. Hwy., Dept. of Totonicapan).

HABITAT. Foliage of *Cupressus*.

Kaestneriella **maculosa**, n.sp.

DIAGNOSIS. Forewing ciliation abundant and conspicuous. Male radular sclerotization in form of pair of sclerites each bearing three postero-mesally directed blades. Clypeus marked by conspicuous pair of large brown spots formed by the striations.

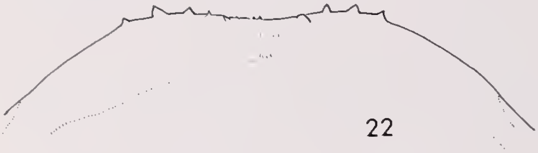
MALE. Measurements, Table 1.

MORPHOLOGY. R_5 index = 1.32. Phallosome (Fig. 24) broadest near its posterior end, tapering somewhat towards base. Pore-bearing parameres long, slender, diverging somewhat, with pores only in their distal halves. Apical beak of phallosome long, pointed at tip. Radula (Fig. 23) of two sclerotized regions each giving rise to three slender, posteriorly-directed blades; anterior pair of blades very slender, directed somewhat mesally; middle pair of blades shortest and somewhat stouter than anteriors, also directed somewhat mesally; posterior pair of blades pointing directly posteriorly, about same length as anteriors but stouter. Clunial comb (Fig. 22) of 13 small denticles on single specimen observed.

←

FIGS. 10–19. Genitalia of *Kaestneriella.*

FIG. 10. *K.* **guatemalensis**, n.sp. ♂, clunial comb.
FIG. 11. *K.* **guatemalensis**, n.sp. ♂, radular sclerites (twice scale of Fig. 15).
FIG. 12. *K.* **guatemalensis**, n.sp. ♂, phallosome (scale of Fig. 15).
FIG. 13. *K.* **obscura**, n.sp. ♂, clunial comb (scale of Fig. 19).
FIG. 14. *K.* **obscura**, n.sp. ♂, radular sclerites (twice scale of Fig. 15).
FIG. 15. *K.* **obscura**, n.sp. ♂, phallosome.
FIG. 16. K. **pacifica**, n.sp. ♂, clunial comb (scale of Fig. 19).
FIG. 17. *K.* **pacifica,** n.sp. ♂, radular sclerites (twice scale of Fig. 15).
FIG. 18. *K.* **pacifica**, n.sp. ♂, phallosome (scale of Fig. 15).
FIG. 19. *K.* **minor**, n.sp. ♂, clunial comb.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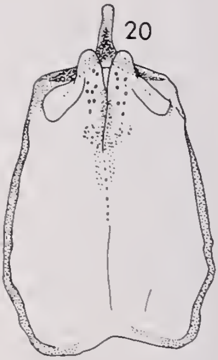
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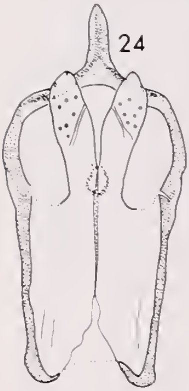
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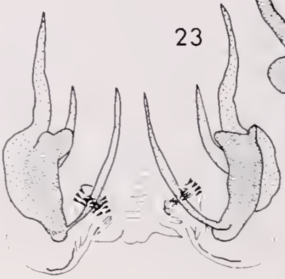
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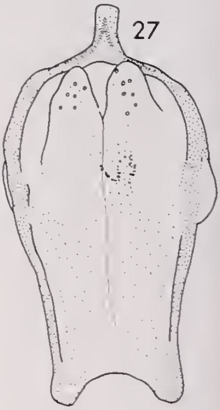
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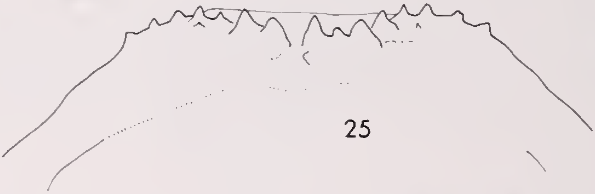
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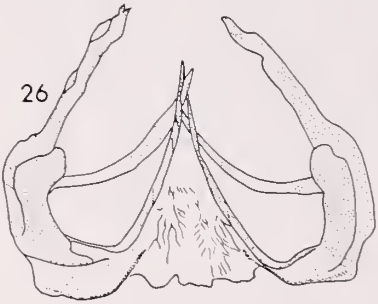
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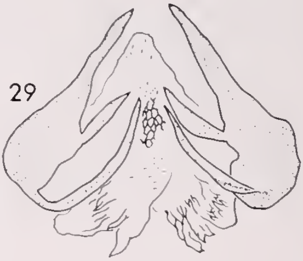
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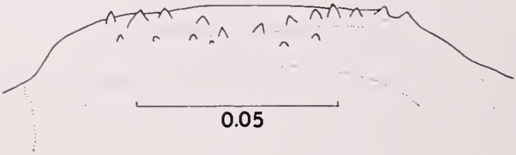
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COLOR (in alcohol). Head and thorax chiefly dull yellowish-white, marked by medium brown cuticular pigment as follows: three pairs of spots on vertex of head—one pair behind compound eyes, one pair mesad of compound eyes and behind level of ocellar interval, one pair bordering epicranial suture; one pair of spots on post-clypeus, formed by the striations; a spot along ventral margin of each gena. Thoracic tergal lobes marked with medium brown, the brown areas separated by broad areas of dull yellowish white bordering sutures; thoracic pleura lacking brown markings. Antennae and legs pale brown. Preclunial abdominal segments colorless in cuticle, each segment with a ring of subcuticular purplish-brown pigment, the rings appearing double due to partial inclusion of a narrow white ring within each colored ring. The rings interrupted along dorsal and ventral midlines. Clunium pale brown in cuticle, marked with a dorsal and two lateral purplish brown subcuticular pigment spots. Phallosome medium brown; epiproct and paraprocts pale brown. Wings faintly washed with grayish-brown. Ocellar interval dark brown; compound eyes black.

FEMALE. Measurements, Table 1.

MORPHOLOGY. Rs fork in forewing slightly longer than stem. R_5 index = 1.38. Subgenital plate (Fig. 39) with slightly darkened central region below median apical lobe; median apical lobe decidedly longer than broad, its distal angles rounded and each bearing three long setae and two or three shorter ones. Ovipositor valvulae (Fig. 38): first valvula broadened in middle, slightly upcurved at tip, subapical region beset with a few minute setae. Second and third valvulae typical of the genus. Sensory cushion of paraproct with 20 and 22 trichobothria on two sides of single specimen counted.

COLOR (in alcohol). Same as in male, but brown marks somewhat darker; ventral interruption of abdominal color rings wide; forewings (Fig. 4) marked as follows: wide cloudy brown band bordering distal margin from vein R_{2+3} nearly to Cu_1, cloudy brown spot in basal region (not covering extreme base) of cell R_5, cloudy brown spot covering base of R-M junction and extending well back into cell M_3, pale cloudy brown spot in cell Cu_1 anterior to nodulus, another such spot in base of cell Cu_1 extending posteriorly into bases of cells Cu_2 and IA.

VARIATION. There appears to be sexual dimorphism in forewing length. Geographic variation in size is suggested by the data, the single male from Oaxaca being considerably larger than the two males from San Luis Potosi.

RANGE. Known from only three localities, two in central and one in southern Mexico, at elevations of from 4,500 to 7,000 feet.

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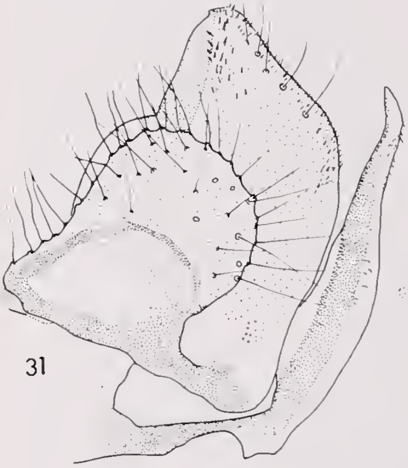
FIGS. 20–30. Genitalia of *Kaestneriella*.

FIG. 20. *K.* **minor**, n.sp. ♂, phallosome (scale of Fig. 30).
FIG. 21. *K.* **minor**, n.sp. ♂, radular sclerites (twice scale of Fig. 30).
FIG. 22. *K.* **maculosa**, n.sp. ♂, clunial comb (scale of Fig. 28).
FIG. 23. *K.* **maculosa**, n.sp. ♂, radular sclerites (twice scale of Fig. 30).
FIG. 24. *K.* **maculosa**, n.sp. ♂, phallosome (scale of Fig. 30).
FIG. 25. *K.* **mexicana**, n.sp. ♂, clunial comb (scale of Fig. 28).
FIG. 26. *K.* **mexicana**, n.sp. ♂, radular sclerites (twice scale of Fig. 30).
FIG. 27. *K.* **mexicana**, n.sp. ♂, phallosome (scale of Fig. 30).
FIG. 28. *K.* **occidentalis**, n.sp. ♂, clunial comb.
FIG. 29. *K.* **occidentalis**, n.sp. ♂, radular sclerites (twice scale of Fig. 30).
FIG. 30. *K.* **occidentalis**, n.sp. ♂, phallosome.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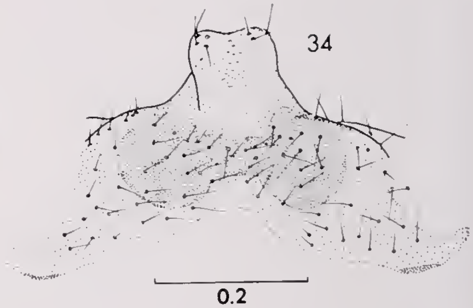
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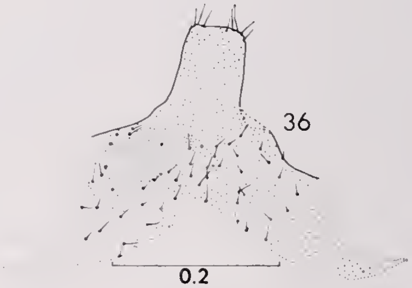
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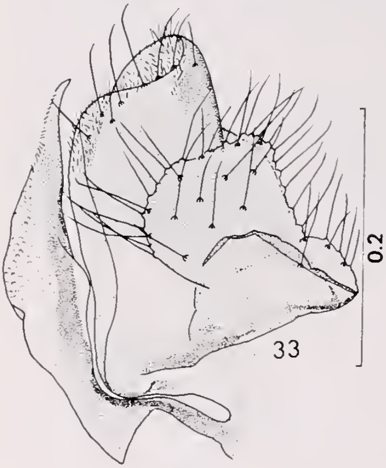
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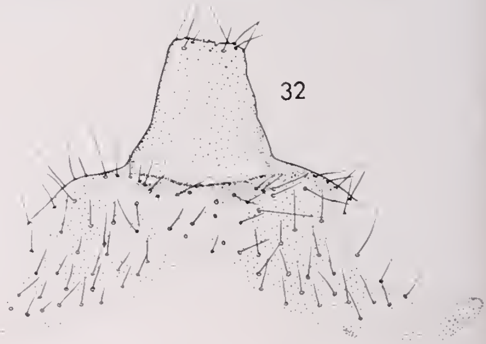
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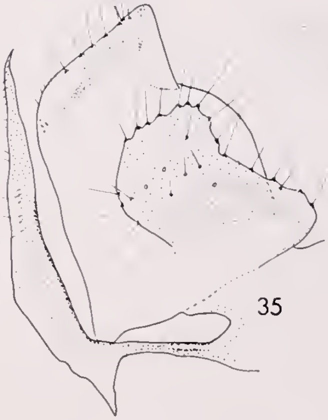
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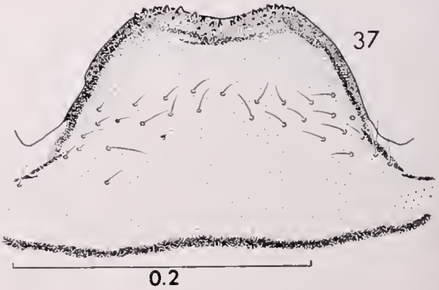
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TYPE LOCALITY. Hidalgo, San Luis Potosi, Mexico, September 2, 1958, E. L. Mockford collector, holotype ♂ and 1 ♂ paratype. Types are in the collection of the senior author.

RECORDS. Mexico: Oaxaca: 5 miles south of Nochixtlan. San Luis Potosi: 8 miles east of Huizache (Hwy. 80) (allotype).

HABITAT. This species has been taken on various desert shrubs.

Kaestneriella **obscura**, n.sp.

DIAGNOSIS. Forewing ciliation inconspicuous. Male radular sclerites consisting principally of a pair of hooks. Clypeal striations not coalescing to form a pair of spots. Female forewings (except for usual pale areas) tawny brown with darker brown markings in distal one-third. Male forewings 2.89 mm or more in length.

MALE. Measurements, Table 1.

MORPHOLOGY. R_5 index = 1.21. Phallosome (Fig. 15) broad and approximately as wide basally as distally; pore-bearing parameres distinct at their bases, their tips falling short of apical beak of phallosome, the pores scattered along entire length of each paramere. Membranous area bordered by side of aedeagal arch and pore-bearing paramere approximately triangular, small; apical beak short. Radular sclerites (Fig. 14) a pair of hook-shaped structures pointed distally, with a small pair of rounded sclerites, one attached laterally to the base of each hook-shaped sclerite. Clunical comb (Fig. 16) incurved mesally, with at least a few minute denticles forming a submarginal row; the larger denticles of the marginal row 17 and 18 in number on two specimens counted.

COLOR (in alcohol). Ground color (probably from underlying muscles showing through cuticle) dull yellowish-white overlain by dusky brown cuticular pigment on head, thorax, appendages and tip of abdomen in pattern as follows: on head a broad band bordering epicranial suture, posterior margin of vertex and orbits from posterior margin of vertex to level of ocellar interval; postclypeus faintly striated with dusky brown. Labrum, ocellar interval, and spot in front of ocellar interval dark brown. Antennae, maxillary palpi and legs except tibiae and ventral surfaces of femora dusky brown. Tibiae dark brown; ventral surfaces of femora dull yellowish-white. Thoracic notal lobes dusky brown except of ground color along sutures and in central part of metascutum. Thoracic pleura pale dusky brown, darkening somewhat ventrally. Abdomen with broad annulations of purplish-brown subcuticular pigment, except dusky brown (cuticular pigment) on clunium, phallosome, epiproct, and paraprocts. Wings uniformly washed with dusky brown. Compound eyes black.

FEMALE. Measurements, Table 1.

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FIGS. 31–37. Genitalia of *Kaestneriella*.

FIG. 31. *K.* **guatemalensis**, n.sp. ♀, ovipositor valvulae (scale of Fig. 33).
FIG. 32. *K.* **guatemalensis**, n.sp. ♀, subgenital plate (scale of Fig. 36).
FIG. 33. *K.* **obscura**, n.sp. ♀, ovipositor valvulae.
FIG. 34. *K.* **obscura**, n.sp. ♀, subgenital plate.
FIG. 35. *K.* **pacifica**, n.sp. ♀, ovipositor valvulae (scale of Fig. 33).
FIG. 36. *K.* **pacifica**, n.sp. ♀, subgenital plate (slightly damaged in mounting).
FIG. 37. *K.* **obscura**, n.sp. ♂, clunium in dorsal view showing comb.

MORPHOLOGY. Rs fork in forewing somewhat longer than stem. R_5 index = 1.21. Subgenital plate (Fig. 34) with single broad, darkly pigmented central area somewhat constricted mesally; median apical lobe of subgenital plate somewhat longer than wide, each of its distal angles beset with three long setae and one or two shorter ones. Ovipositor valvulae (Fig. 33): first valvula somewhat broadened in middle, very slightly upcurved at apex, the subapical region beset on medio-ventral side with numerous minute setae. Second and third valvulae typical of the genus. Sensory cushion of paraproct with more or less 21 trichobothria.

COLOR (in alcohol). Body and appendage coloration differing from that of male only in that darkened areas of vertex not continuous but broken up into numerous discrete spots, and those around orbits extending more anteriorly. Forewings (Fig. 7) largely dusky brown but with usual colorless areas around R-M junction and a colorless spot at distal end of Cu_1. Darker brown pigmentation present in submarginal regions of Cells R_1, R_3, R_5, M_1, M_2 and M_3.

VARIATION. Sexual dimorphism in wing length and compound eye size is pronounced. Variation is noted in extent of development of the dark submarginal pigmentation of the forewing. Paler individuals lack this pigment.

RANGE. Middle elevation in central Mexico.

TYPE LOCALITY. 6 miles east of Tulancingo, Highway 130, Hidalgo, Mexico, June 24, 1962, E. L. Mockford, J. M. Campbell, and F. Hill, collectors, holotype ♂, allotype ♀, and 5 ♂ paratypes. Types are in the collection of the senior author.

RECORDS (Fig. 58). Mexico: Guanajuato: 25 miles south of San Luis de la Paz (Hwy. 57). Hidalgo: 15 miles west of Huachinango (Hwy. 130); 4 miles southwest of Rancho Viejo (Hwy. 85); 10 miles west of Jacala (Hwy. 85). Michoacan: 4 miles east of Carapan (Hwy. 15); 17 miles east of Zacapu (Hwy. 15). Puebla: 5–6.3 miles southwest of Teziutlan. Veracruz: 4 miles west of Jalacingo (Hwy. 131).

HABITAT. This species has been taken principally on branches of oaks (*Quercus* spp.) and alder (*Alnus* sp.), but also on other broadleaved trees and on juniper (*Juniperus* spp.), and pine (*Pinus* spp.).

Kaestneriella **mexicana**, n.sp.

DIAGNOSIS. Forewing ciliation inconspicuous; male radular sclerotization in form of two elongate sclerites each giving rise to three blades, all directed posteromesally. The basal two pairs of blades slender, curving toward and meeting at mid-line. Cell R_5 in forewing with several pale or colorless spots distad of basal one.

MALE. Measurements, Table 1.

MORPHOLOGY. R_5 index = 1.11. Phallosome (Fig. 27) widest near distal end, tapering toward base; pore-bearing parameres indistinct at their bases, the pores apparently not extending to their bases; these parameres not attaining base of apical beak of phallosome; apical beak short. Radular sclerites (Fig. 26) as described in diagnosis, the distal pair of blades straight and somewhat stouter than other two pairs. Clunial comb (Fig. 25) very slightly indented toward mid-line, with break in sclerotization in middle; a few minute submarginal denticles present (2, 3, and 5 in three observed specimens): 13, 15, and 15 denticles in marginal row of three observed specimens.

COLOR (in alcohol). Essentially same as in *K.* **obscura**, n.sp., but brown markings in general somewhat lighter, tibiae decidedly lighter, band bordering epicranial suture mottled and forewings marked exactly as in female (see below).

FEMALE. Measurements, Table 1.

MORPHOLOGY. Rs fork in forewing about same length as its stem, R_5 index = 1.15. Subgenital plate (Fig. 50) with small, compact, darkly-pigmented central area; median apical lobe about as long as broad, each of its distal angles beset with several setae of various lengths. Ovipositor valvulae (Fig. 49): first valvula slender, slightly upcurved at tip, subapical region on medio-ventral side with numerous minute setae; second and third valvulae typical of the genus. Sensory cushion of paraproct with more or less 23 trichobothria.

COLOR (in alcohol). Essentially as in male. Forewing (Fig. 3) washed over most of surface with reddish-brown, darkest in pterostigma and in submarginal band from cell R_1 through cell M_3. Usual trio of colorless spots around R-M junction. Cell R_5 with, in addition to its basal clear spot, one or two clear spots about half-way along its length near its posterior border. Pale region anterior to point of R_5 fork. Colorless spot at distal end of vein Cu_1.

VARIATION. Sexual dimorphism exists in forewing length and compound eye diameter. Males show considerable variation in compound eye diameter, those from higher elevations tending to have smaller compound eyes than those from lower elevations (Fig. 55).

RANGE. Mountains of central Mexican states of Mexico, Morelos, Puebla, Durango, Sinaloa, and Michoacan at elevations of 7,000 to 10,000 feet.

TYPE LOCALITY. Mexico-Tlaxcala State Line on Highway 136 (Continental Divide), Mexico, Mex., July 3, 1962, E. L. Mockford, J. M. Campbell, and F. Hill, collectors, holotype ♂, allotype ♀, 2 ♂ and 6 ♀ paratypes. Same locality, August 20, 1958, 2 ♀ paratypes.

RECORDS (Fig. 57). Mexico: Durango: 20 miles west of Cd. Durango (Hwy. 40); 20 miles east of El Salto (Hwy. 40); 4 miles west of El Salto (Hwy. 40). Mexico: 9.6 and 12 miles west of Rio Frio (Hwy. 190). Michoacan: 10 miles west of Zinapicuaro (Hwy. 15). Morelos: mountains outside Cuernavaca. Puebla: 34 miles west of Acultzingo (Veracruz, Hwy. 150). Sinaloa: 12 miles east of Santa Lucia (Hwy. 40).

HABITAT. This species has been taken primarily on branches of oaks (*Quercus* spp.), but also on madrone (*Arbutus* sp.), other broad-leaved trees and shrubs, piñon pine (*Pinus cembroides*), cypress (*Cupressus* sp.), and firs (*Abies* sp.).

Kaestneriella **minor**, n.sp.

DIAGNOSIS. Forewing ciliation inconspicuous except for large setae on vein R and on posterior margin of pterostigma. Male radular sclerites consisting of a pair of curved hooks with a pair of small, rounded sclerites to the sides of the hooks. Clypeal striations forming a pair of large spots.

MALE. Measurements, Table 1.

MORPHOLOGY. R_5 index = 1.27. Phallosome (Fig. 20) broad and approximately as wide near base as near apex; pore-bearing parameres indistinct at their bases, their tips reaching base of apical beak of phallosome, the pores occurring not quite to tip of each paramere;


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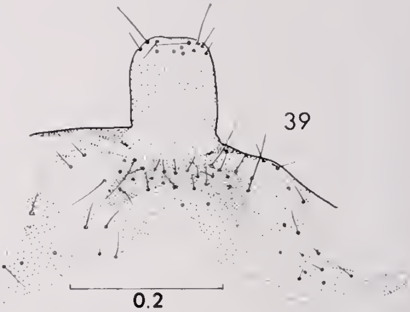
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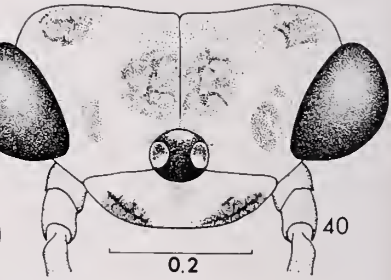
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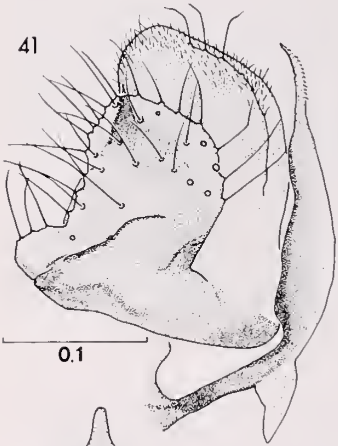
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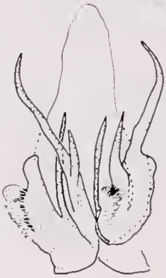
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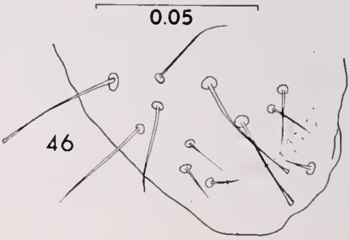
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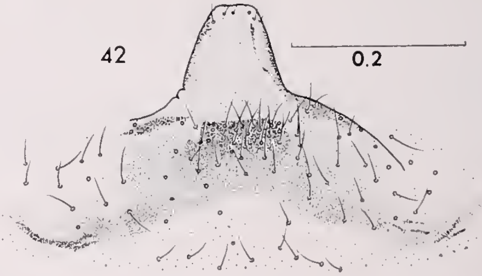
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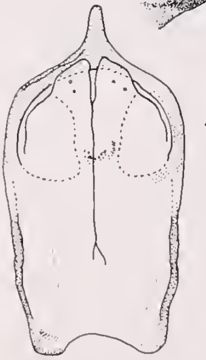
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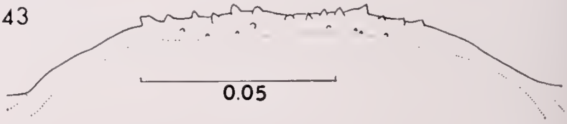
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membranous area bordered by side of aedeagal arch and pore-bearing paramere rather long and narrow, somewhat widened near its base; apical beak long. Radular sclerites (Fig. 21) a pair of hook-shaped structures pointed distally, with a pair of small rounded sclerites, one lateral to the base of each hook-shaped sclerite and probably attached to the hook-shaped sclerite by a membrane. Clunial comb (Fig. 19) incurved mesally, with a few small denticles forming submarginal row, the longer denticles of the marginal row 12 and 17 in number in two specimens counted; lateral denticle of each side directed outward.

COLOR (in alcohol). Ground color of body as in *K.* **obscura**. Vertex with pair of dark brown spots, one on each side of, not touching, epicranial suture. Ocellar interval and area immediately bordering it dark brown. Post-clypeus bearing pair of dorso-ventrally elongated medium brown spots within which darker brown striations visible. Each gena with a pale brown spot along its ventral margin. Clypeus dark brown. Antennae, maxillary palpi and legs pale brown. Mesoprescutum medium brown except for ground color bordering its posterior suture and narrow band of ground color along its dorsal mid-line. Lateral lobes of mesoscutum dark brown, separated by ground color along mid-line, this ground color continuous anteriorly with that along suture delimiting prescutum and posteriorly with ground color covering entire mesoscutellum. Prescutum and scutellum of metatergum of ground color, the lateral lobes of scutum dark brown. Thoracic pleura of ground color except for purplish-brown spot below each wing. Preclunial abdominal segments colorless except for narrow purplish-brown bands of subcuticular pigment over dorsal surface of each segments 1 through 6, three spots of same color on segment 7 marking lateral limits of band of other segments and dorsal mid-line, a dorso-ventrally elongated spot of same color around each spiracle of segment 2 through 7, and a narrow ventral band connecting lateral spiracular spots on segments 4, 5, and 6. Clunium and epiproct dark brown, paraprocts and phallosome medium brown. Forewings uniformly washed with pale gray except for very small colorless areas in usual positions around R-M junction and small colorless area at distal end of vein Cu_1. Compound eyes black.

FEMALE. Measurements, Table 1.

MORPHOLOGY. Rs fork in forewing very slightly longer than stem. R_5 index = 1.63. Subgenital plate (Fig. 52) with pair of darkly pigmented central areas narrowly separated along mid-line; median apical lobe of subgenital plate about as long as wide, rounded distally, bearing laterally at apex a few setae, the lateral ones (3 each side) longer than mesal pair. Ovipositor valvulae (Fig. 51): first valvula slender, bent upward at apex, the subapical region beset on medio-ventral side with numerous minute setae. Second and third valvulae typical of the genus. Sensory cushions of paraproct with 15 and 18 ctenidiobothria on two sides of single specimen counted.

COLOR (in alcohol). Body color differing from that of male only in having somewhat wider

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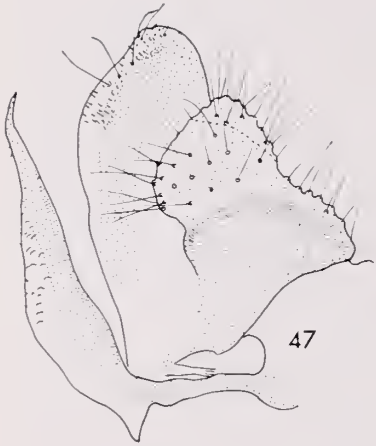
FIGS. 38–46. Genitalia and other parts of *Kaestneriella*.

FIG. 38. *K.* **maculosa**, n.sp. ♀, ovipositor valvulae.
FIG. 39. *K.* **maculosa**, n.sp. ♀, subgenital plate (slightly damaged in mounting).
FIG. 40. *K.* **maculosa**, n.sp. ♂, head, dorsal view.
FIG. 41. *K.* **setosa**, n.sp. ♀, ovipositor valvulae.
FIG. 42. *K.* **setosa**, n.sp. ♀, subgenital plate.
FIG. 43. *K.* **setosa**, n.sp. ♂ (?), clunial comb.
FIG. 44. *K.* **setosa**, n.sp. ♂ (?), radular sclerites (twice scale of Fig. 42).
FIG. 45. *K.* **setosa**, n.sp. ♂ (?), phallosome (scale of Fig. 42).
FIG. 46. *K.* **occidentalis**, n.sp. ♂, ventral end of paraproct showing clubbed setae.



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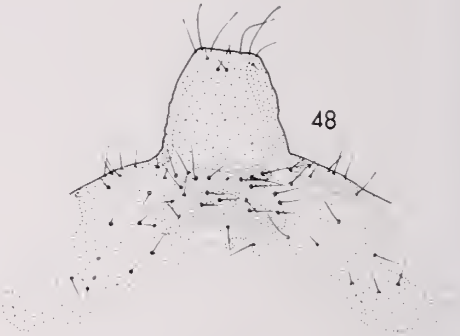

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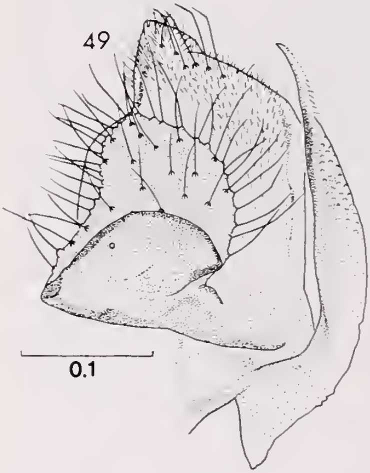

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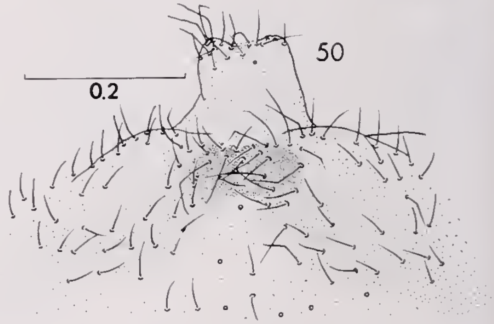

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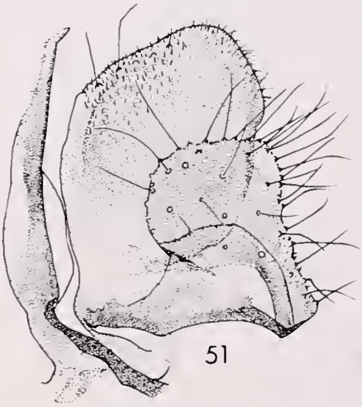

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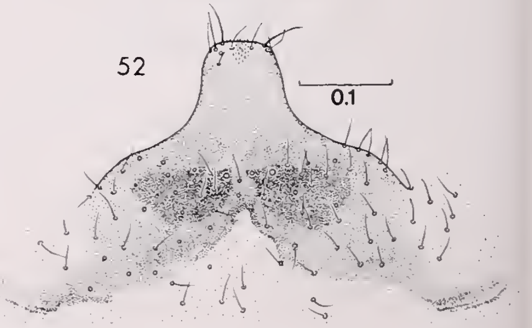

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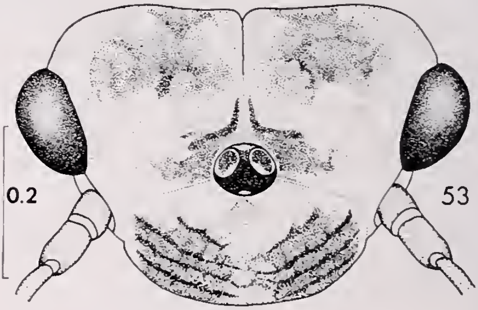

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bands of purplish brown on dorsal surfaces of abdominal segments 1 through 6, such a band present on segment 7 instead of three spots; these bands at least narrowly joined to spots around spiracles except on segment 7; these bands continuous ventrally beyond spiracles on segments 2, 3, 4, and 5, but broadly interrupted along mid-line. Pigmented area of subgenital plate dark brown. Forewings with larger colorless areas around R-M junction.

VARIATION. Sexual dimorphism is pronounced in compound eye size and forewing length. Variation is noted in coloration of seventh abdominal segment of females, some specimens having three pigment spots, as in males, instead of a band.

RANGE. Central Mexico and Pacific slopes from Chiapas to Nayarit.

TYPE LOCALITY. 9 miles south of Izucar de Matamoros (Hwy. 190), Puebla, Mexico, August 17, 1968, A. Garcia Aldrete collector, holotype ♂ and 1 ♂ paratype. Types are in the collection of the senior author.

RECORDS (Fig .58). Mexico: Chiapas: 2.3 miles west of Las Cruces (Hwy. 190); 8 miles south of Las Cruces Junction (Hwy. 195). Guerrero: Mexcala to 10 miles north of Mexcala (Hwy. 95); 8 miles north of Zumpango del Rio (Hwy. 95). Nayarit: 21 miles southeast of Tepic. Oaxaca: 40 miles south of Oaxaca City (Hwy. 190) (allotype). San Luis Potosi: Hidalgo.

HABITAT. This species has been taken from shrubs and small trees in arid and semi-arid areas.

Kaestneriella **occidentalis**, n.sp.

DIAGNOSIS. Forewing ciliation inconspicuous. Male radular sclerotization in form of two elongate sclerites each produced into a slender blade posteriorly and each giving rise near its base to two blades on the median side directed postero-medially. The more basal of these two blades slender and curved, the more distal blade short, straight, and stout. Cell R_5 in forewing with only one pale spot, the basal one; generally with a dark spot immediately apicad of the pale spot.

MALE. Measurements, Table 1.

MORPHOLOGY. R_5 index $= 1.22$. Phallosome (Fig. 30) essentially same as in *K.* **mexicana** but pore-bearing parameres somewhat shorter and anterior margin not emarginate. Radular sclerites (Fig. 29) as described in diagnosis, the distal pair of blades straight and somewhat

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FIGS. 47–53. Genitalia and other parts of *Kaestneriella*.

FIG. 47. *K.* **occidentalis**, n.sp. ♀, ovipositor valvulae (scale of Fig. 49).
FIG. 48. *K.* **occidentalis**, n.sp. ♀, subgenital plate (scale of Fig. 50).
FIG. 49. *K.* **mexicana**, n.sp. ♀, ovipositor valvulae.
FIG. 50. *K.* **mexicana**, n.sp. ♀, subgenital plate.
FIG. 51. *K.* **minor**, n.sp. ♀, ovipositor valvulae (scale of Fig. 49).
FIG. 52. *K.* **minor**, n.sp. ♀, subgenital plate.
FIG. 53. *K.* **minor**, n.sp. ♀, head, dorsal view.

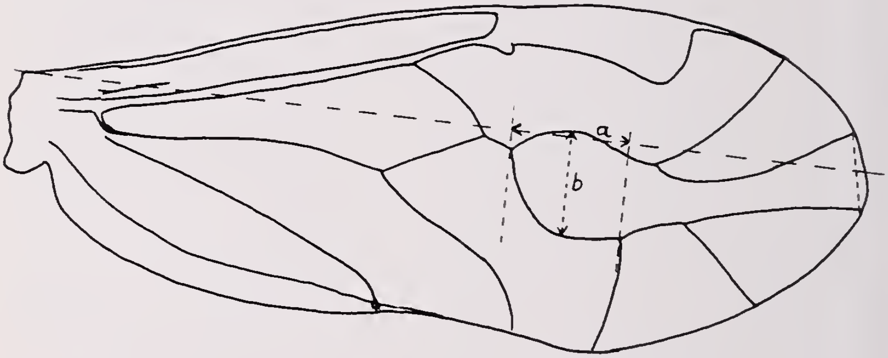

Fig. 54. Outline of forewing venation of *Kaestneriella* **obscura**, n.sp. ♀, showing lines constructed for determination of the R_5 index. Line segments a and b are measured.

stouter than other two pairs. Clunial comb (Fig. 28) curving inward toward mid-line, with a submarginal row of small denticles: 12 and 17 denticles in marginal row of two specimens observed.

COLOR (in alcohol). Not differing from *K.* **mexicana** except in forewing markings; the latter as described for female (see below).

FEMALE. Measurements, Table 1.

MORPHOLOGY. Essentially identical with *K.* **mexicana**, only differences noted being fewer minute setae near tip of first valvula and constriction near base of third valvula. R_5 index = 1.27.

COLOR (in alcohol). Essentially as described for *K.* **mexicana**, but brown regions of body reddish-brown instead of dusky; subcuticular pigment rings of abdomen reddish-brown instead of purplish-brown. Forewings (Fig. 5) essentially as described for *K.* **mexicana** differing as mentioned in diagnosis.

VARIATION. Females show variation in intensity of color of wings and body in the brown areas, probably related to age. Males on hand have decidedly lighter wing markings than in most females. Males from Durango (three specimens) are paler in brown areas of body than darker females but same as paler females; the single male from Oaxaca is dusky in brown areas. Sexual dimorphism exists in wing length and compound eye size.

RANGE. Known from the Mexican states of Durango, Michoacan, and Oaxaca.

TYPE LOCALITY. 20 miles west of Durango City on Hwy. 40, Durango, Mexico, July 16, 1963, E. L. Mockford and F. Hill, collectors, holotype ♂, allotype ♀, 1 ♂ and 15 ♀ paratypes. Types are in the collection of the senior author.

RECORDS (Fig. 57). Mexico: Durango: 19 miles northeast of Durango City (Hwy. 40). Michoacan: 4.5 miles east of Carapan (Hwy. 15). Oaxaca: 5 miles south of Nochixtlan (Hwy. 190).

HABITAT. This species has been taken on pines and on desert trees.

Kaestneriella **pacifica**, n.sp.

DIAGNOSIS. Forewing ciliation inconspicuous. Male radular sclerites consisting principally of a pair of hooks. Clypeal striations not coalescing to form a pair of spots. Female forewings uniformily tawny brown in distal one-third. Male forewings 2.11 mm or less in length.

MALE. Measurements, Table 1.

MORPHOLOGY. R_5 index = 1.38. Phallosome (Fig. 18) broad and approximately as wide basally as distally; pore-bearing parameres weakly sclerotized, the pores minute and indistinct; these parameres falling short of apical beak of phallosome; membranous area bordered by side of aedeagal arch and pore-bearing paramere rounded anteriorly, tapering posteriorly; apical beak long. Radular sclerites (Fig. 17) a pair of acuminately pointed hook-shaped structures each with a broadened base. Clunial comb (Fig. 16) incurved mesally with or without scattered submarginal denticles; 13 marginal denticles in each of the two specimens counted.

COLOR (in alcohol). Color pattern generally same as in *K.* **obscura**, but cuticular pigment generally lighter brown; clypeal striations dark brown and very narrow; purplish-brown subcuticular rings of abdomen somewhat narrower, hence wide colorless rings bordering each intersegmental line.

FEMALE. Measurements, Table 1.

MORPHOLOGY. Rs fork in forewing somewhat longer than stem. R_5 index = 1.54. Subgenital plate (Fig. 36) apparently with pair of darkly pigmented areas just basal to median apical lobe; the lobe much longer than broad and each of its distal angles beset with several short hairs. Ovipositor valvulae (Fig. 35): first valvula only very slightly broadened in middle, slightly upcurved at apex, the subapical region beset on medio-ventral side with a few minute setae. Second valvula typical of the genus. Third valvula somewhat longer and less wide than in most other species. Sensory cushion of paraproct with more or less 21 trichobothria.

COLOR (in alcohol). Same as in male except brown regions of vertex mottled; striations of post-clypeus indistinct, pale brown; forewing with usual pale spots around R-M junction, the spot above and the spot below junction relatively larger than in *K.* **obscura**; forewing otherwise uniformly washed with grayish-brown except for pale area at distal end of Cu_1.

VARIATION. Slight sexual dimorphism exists in wing length and compound eye size.

RANGE. Known only from Nayarit and western Jalisco.

TYPE LOCALITY. 21 miles southeast of Tepic, Nayarit, Mexico, July 20, 1963, E. L. Mockford collector, holotype ♂, allotype ♀, 3 ♂, and 3 ♀ paratypes. The types are in the collection of the senior author.

RECORDS (Fig. 58). Mexico: Jalisco: 13 miles west of Guadalajara (Hwy. 15).

HABITAT. This species has been taken on various broad-leaved trees and shrubs, including oaks (*Quercus* spp.), and on pines (*Pinus* spp.).

Kaestneriella pilosa Roesler (♂)

Kaestneriella pilosa Roesler, 1943:10.

DIAGNOSIS. Forewing ciliation conspicuous. Male radular sclerites consisting

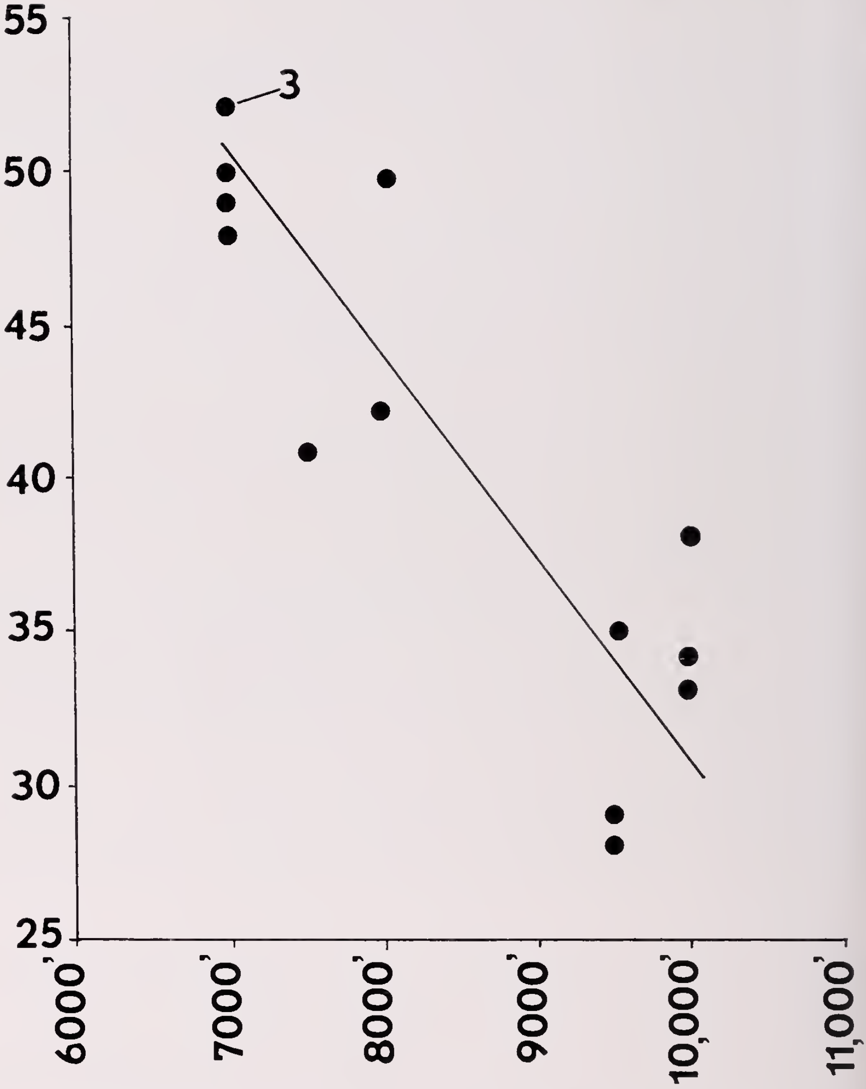

Fig. 55. Regression of antero-posterior eye diameter of males of *Kaestneriella* **mexicana**, n.sp. (y axis) on elevation in feet above sea level at which specimens were collected (x axis). Units of y axis = micrometer units at 120× (= 6.2μ). Regression line fitted by Bartlett method.

principally of a pair of elongate structures each terminating posteriorly in a process bent mesally, the process apparently much wider than in *K.* **guatemalensis**.

We have seen no examples of this species.

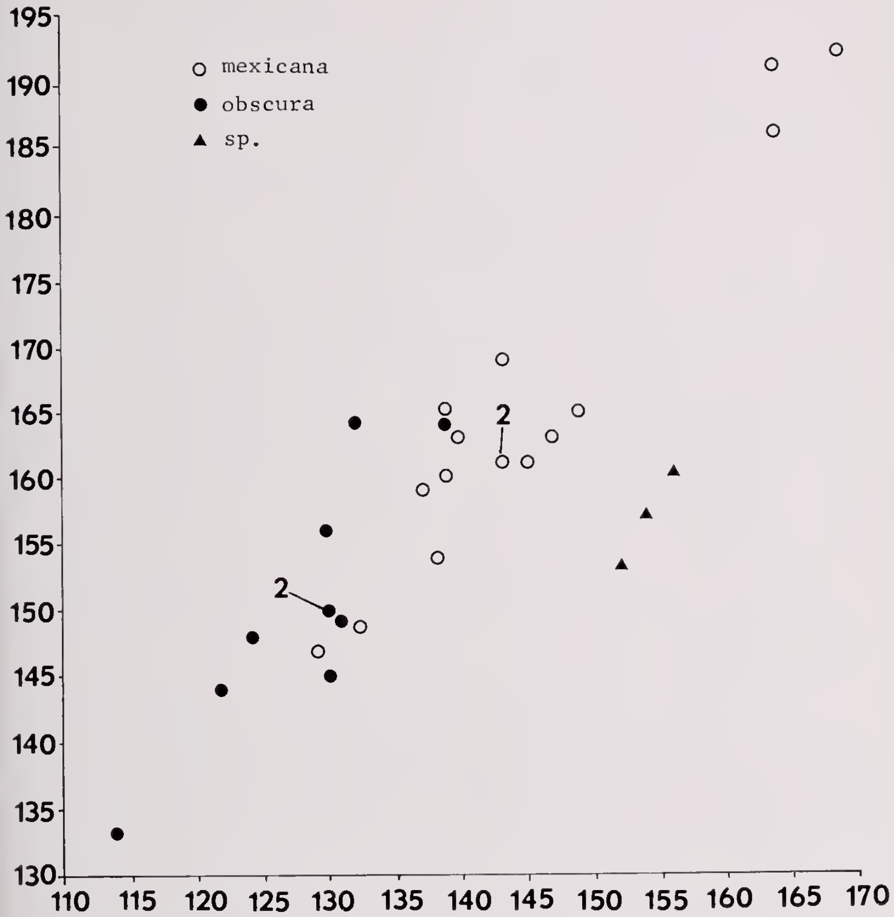

FIG. 56. Regression of Posterior tibial length (y axis, micrometer units at 120× = 6.2 μ) on forewing length (x axis, micrometer units at 42× = 17.4 μ) for females of *Kaestneriella* **mexicana**, n.sp., *K.* **obscura**, n.sp., and *K.* sp.

Kaestneriella **setosa**, n.sp. (♀)

DIAGNOSIS. Ciliation abundant and conspicuous at 70× on veins, anterior margin, and surface of pterostigma of forewing. Clypeus with usual striations, these not forming a pair of spots. Females not known to be brachypterous, the forewings measuring about 2 mm in length. Colorless area of forewing forming a more or less continuous band from base of pterostigma to tip of vein Cu_1.

FEMALE. Measurements, Table 1.

MORPHOLOGY. Rs fork in forewing about equal in length to stem. R_5 index = 1.55. Subgenital plate (Fig. 42) with small, transverse, darkly pigmented central area; median apical

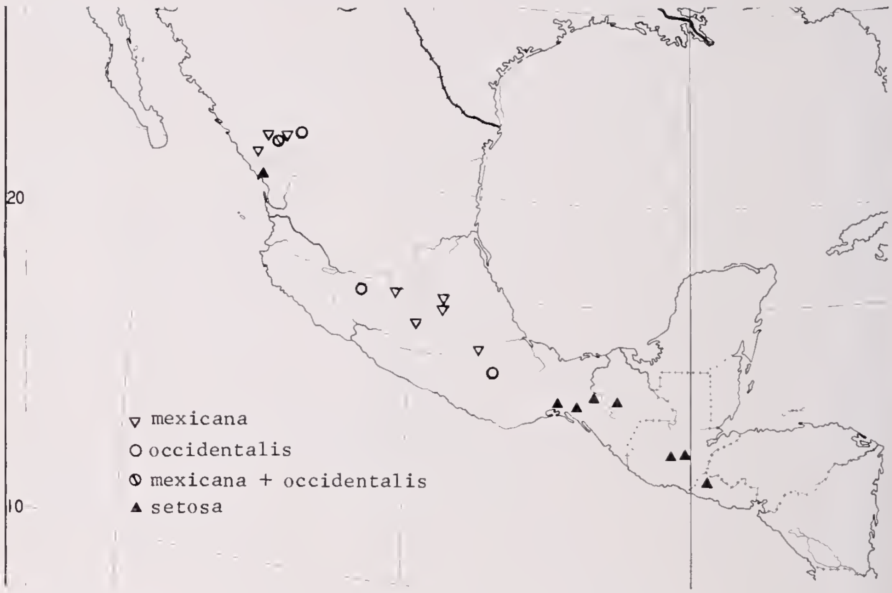

FIG. 57. Map showing distribution of *Kaestneriella* **mexicana**, n sp., *K.* **occidentalis**, n.sp., and *K.* **setosa**, n.sp.

lobe of plate somewhat tapering toward tip, beset with only a few short setae distally. Ovipositor valvulae (Fig. 41): first valvula slender, slightly upcurved at tip, the subapical region beset on medio-ventral side with numerous minute setae. Second and third valvulae typical of the genus. Sensory cushion of paraproct bearing 16 and 18 trichobothria on two sides of single specimen counted.

COLOR (in alcohol). Body essentially as described for *K.* **obscura** ♀. Forewing (Fig. 8) uniformly pale brown except for colorless area extending from base of pterostigma posteriorly to vein Cu_1, and postero-distally along that vein, with small interruptions to end of vein.

VARIATION. Some specimens are duskier than others, the differences seemingly due to a fading of the paler ones in alcohol a longer time. Color differences probably due to age are also noted within series preserved at the same time.

RANGE. Southern Mexico and Guatemala, north on the Pacific Coastal plain to Sinaloa.

TYPE LOCALITY. Ejido Libertad, 1 mile southwest of Frontera, Tabasco, Mexico, March 17 and 18, 1964, E. L. Mockford and A. Manzano, collectors, holotype ♀ and 4 ♀ paratypes. Types are in the collection of the senior author.

RECORDS (Fig. 57). El Salvador: Summit of Cerro Verde.

Guatemala: Dept. of Baja Verapaz: 1 mile north of Salama; 8 miles west of Salama.

Mexico: Chiapas: 8 miles south of Las Cruces Junction (Hwy. 195); 6 miles west of San Cristobal de las Casas (Hwy. 190); 8 miles north of Tuxtla

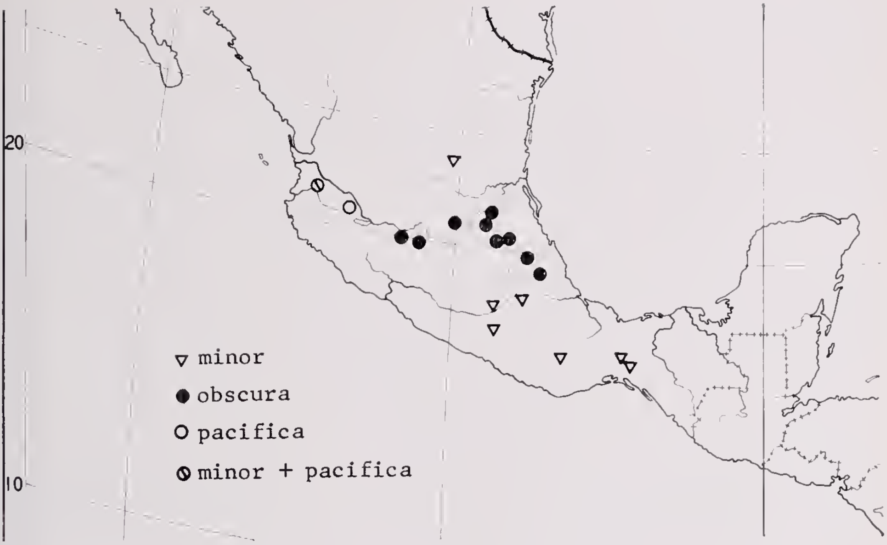

Fig. 58. Map showing distribution of *Kaestneriella* **minor**, n.sp., *K.* **obscura**, n.sp., and *K.* **pacifica**, n.sp.

Gutierrez (Hwy. 190). Oaxaca: 10 miles northwest of Tapanatepec (Hwy. 190). Sinaloa: 14 miles southeast of Villa Union (Hwy. 15).

HABITAT. This species has been taken primarily on shrubs and low trees in scrubby woodland and partially-cleared pasture areas. It was taken once on pine (*Pinus* sp.), once on tangerine (*Citrus reticulata*) and once on tamarind (*Tamarindus indica*).

DISCUSSION. A single male taken near Santiago Tuxtla, Veracruz, Mexico is of essentially the same size as females of this species, and its wing ciliation is similar. Its color is poorly developed due to tenerality, but that which can be made out of its color does not rule out the possibility of its being this species. Its measurements are included (Table 1), and figures of its genitalic structures are presented (Figs. 43, 44, and 45). Its R_5 index is 1.35.

Kaestneriella sp. (♀)[3]

Three females from southern Arizona appear to represent a distinct species. In general, they are similar to females of *K.* **obscura** and *K.* **mexicana**. The

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[3] After this paper had been accepted for publication, the senior author examined the type of *Peripsocus fumosus* Banks, described from southwestern Colorado. The type, a female, dried on a paper triangle, proved to be a *Kaestneriella*, and may be conspecific with this unidentified species. On the regression of posterior tibial length on forewing length, it falls in the space between the points formed by the unidentified species and those of *K.* **mexicana**.

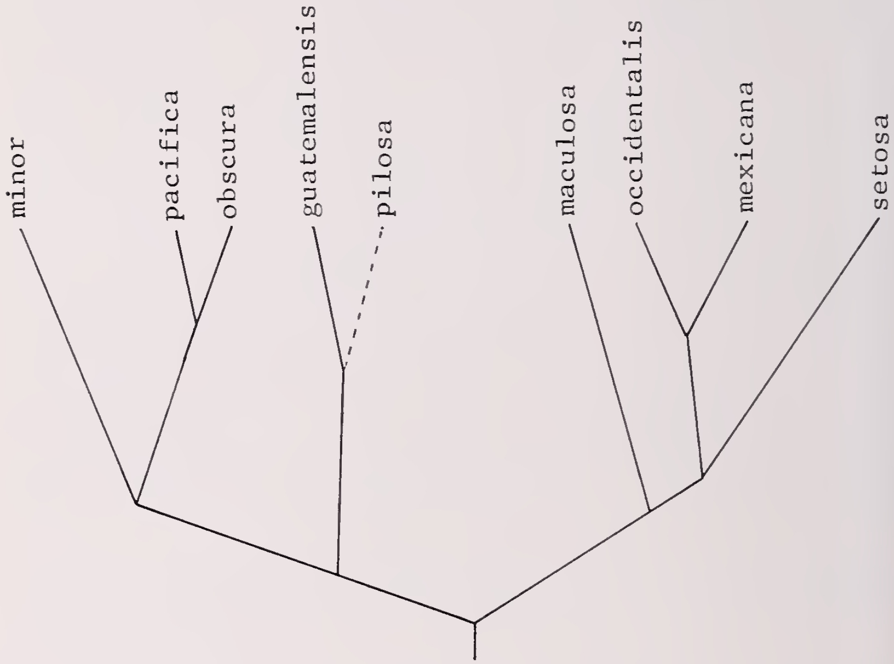

Fig. 59. Dendrogram showing the probable phylogenetic relationships of the species of *Kaestneriella*.

subgenital plate differs from those of either of these two species in that the lateral arms of its pigmented area are shorter and more rounded. On a scatter diagram of forewing lengths plotted against posterior tibial lengths (Fig. 56), these three specimens fall close together and well outside of the aggregations of points formed by *K.* **obscura** and *K.* **mexicana**. None of the other species with which they might be confused would fall near these. We decline to describe them as a new species until additional material is at hand.

RECORDS. United States: Arizona: Madera Canyon, Santa Rita Mountains (Pima County); Patagonia Mountains, 15 miles south of Patagonia (Santa Cruz County); Southwest Research Station, Portal (Cochise County).

PHYLOGENETIC RELATIONSHIPS IN *Kaestneriella*

We follow Eichler (1952) and Pearman (1960) in restricting the family Peripsocidae so as to include only the genera *Peripsocus* and *Kaestneriella*, thus treating the Ectopsocids as a distinct family. Unfortunately, the Peripsocidae is so poorly known at present that nothing can be stated about direction of evolution of any characters found within the group.

There can be no doubt that the species treated here as constituting the genus *Kaestneriella* form a monophyletic group within the Peripsocidae. A survey of the described and some undescribed forms of Peripsocidae suggests that those members of the family which do not fall within *Kaestneriella*, hence which are treated currently as *Peripsocus*, are much more diverse. Eventually, other genera will probably have to be erected within this group. A full understanding of phylogenetic relationships within this family will require much more collecting, especially in tropical upland areas.

Since the forms remaining in *Peripsocus* apparently do not constitute a natural group, it is impossible to compare *Kaestneriella* with *Peripsocus* in an attempt to determine which characters are primitive, and which specialized within these genera. We have also not been able to select a group of species within *Peripsocus* which seem to be most closely related to *Kaestneriella.*

Two ways remain open for approaching the problem of phylogeny within *Kaestneriella*. One consists in attempting to determine what is the most important morphological break within the genus and equating this with the fundamental phylogenetic dichotomy. The other consists in determination of concordances within the group for a set of all of the characters studied to date. Since the two approaches are entirely different, the two sets of data will not necessarily be perfectly correlated.

The most obvious morphological break lies in the structure of the radular sclerites, the main pair of sclerites being either three-pronged or simple. A perfect correlation exists between this break and a break in phallosome shape, so that those forms with three-pronged radular sclerites always have the phallosome tapering toward its base, while those forms with simple radular sclerites always have the sides of the phallosome straight or slightly bowed outward, but not tapering toward the base. In addition, the forms with the main pair of radular sclerites simple always have a small rounded sclerite lateral to each larger sclerite. These small, rounded sclerites are absent, as such, in the other forms. An examination of fifteen characters reveals no other morphological break of the magnitude of this one, so that we tentatively regard this break as indicating the fundamental dichotomy of our dendrogram (Fig. 59).

Concordance data based on fifteen characters (Table 2) show obvious high concordance between *K.* **mexicana** and *K.* **occidentalis**, also between *K.* **obscura** and *K.* **pacifica**, hence these species are joined in pairs on the dendrogram. In view of our postulated fundamental dichotomy, we must regard the relatively high concordance between *K.* **obscura** and *K.* **mexicana** as artificial. *K.* **setosa** is placed close to *K.* **mexicana** and **occidentalis** and *K.* **maculosa** is placed somewhat more basally on basis of our dichotomy hypothesis and the highest concordance figure for each species. On the other branch of the basal dichotomy *K.* **guatemalensis** occupies a position near the base, rather far

Table 2. Matrix of percentages of concordance for *Kaestneriella* species based on fifteen characters.*

	minor	pacifica	obscura	guatemalensis	maculosa	occidentalis	mexicana	setosa
minor	X	64.5	68.1	40.0	45.4	35.0	38.4	45.4
pacifica		X	73.3	52.1	32.2	53.3	44.5	32.2
obscura			X	51.1	24.0	66.6	69.0	47.4
guatemalensis				X	49.3	51.0	43.4	59.4
maculosa					X	44.0	48.0	60.0
occidentalis						X	75.5	67.3
mexicana							X	70.5
setosa								X

* Each number represents the number of characters shared between the pair of species indicated divided by 15 and the quotient multiplied by 100. The following characters were used:

1. Shape of phallosome: either tapering or parallel-sided.
2. R_5 index, the range (1.11 to 1.40) treated as six classes and scored from 1 to 6.
3. Forewing ciliation: present or absent.
4. Marking of vertex: dark spot bordering eye versus separated from eye.
5. Clypeal marking: two dark spots versus no dark spots.
6. Nature of radular sclerites: pair of hooks scored as 1; pair of hook-tipped sclerites with two shorter projections on each scored as 2; pair of three-pronged sclerites, the longest prong straight, scored as 3.
7. Clunial comb straight versus incurved in middle.
8. Second row of teeth in clunial comb; present or absent.
9. Dark central area of subgenital plate: single (Fig. 42) or double (Fig. 34).
10. Posterior lobe of subgenital plate: longer than wide (Fig. 32) or not longer than wide (Fig. 34).
11. Distal dark marks in forewing present (Fig. 7) or absent (Fig. 9).
12. Pale mark posterior to radio-medial junction in forewing in female: continuous to posterior wing margin (Fig. 2) or not (Fig. 9).
13. Microtrichs of first valvula: numerous (Fig. 49) or few (Fig. 47).
14. Male forewing length: three non-overlapping classes assigned scores of 1, 2, and 3.
15. Pair of rounded sclerites in radula present or absent.

When a pair of species was compared for a character assigned more than two states, they were scored as sharing the character totally if it was in the same state in both species, fractionally if one species had the character in an intermediate state (i.e., with a score of 2 where three states occurred), and as not sharing it if the character was in as different states as possible in the two species.

removed from the remaining species as suggested by its generally low concordance figures. *K.* **minor** shares a branch with the pair *K.* **obscura** and *K.* **pacifica** as suggested by its concordance figures.

The only striking incongruity in the above pattern of phylogeny lies in the decidedly similar head markings of *K.* **maculosa** and *K.* **minor**. In both species, the clypeus is marked by a conspicuous pair of spots. In *K.* **maculosa** the dark mark ordinarily bordering the compound eye is separated by a space from the eye, and in *K.* **minor** the dark mark which probably corresponds to the one bordering the compound eye is further separated from the eye and larger. In view of the general low concordance between these two species, their similar head markings must have arisen independently.

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BUTTERFLY SPECIMENS WANTED

W. V. Krivda (P.O. Box 864, The Pas, Manitoba, Canada) wishes to obtain for his research specimens of *Limenitis* or *Basilarchia* from the contact zone of *L. arthemis* and *L. a. astyanax*. He especially hopes for the "hybrids" between the two. The condition of the specimens is not important.

In exchange he can offer northern Canadian butterflies, or population samples of species in his locality.

Two New Species of *Hydrozetes*, Extant and Fossil (Acari: Cryptostigmata, Hydrozetidae)[1]

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Abstract: One species, *Hydrozetes* **laccosis**, is described from plankton net collections from City Park Lake, Fort Collins, Colo. and is compared with European and New World forms. It has 16 pairs of notogastral setae in contrast to 17 pairs in *H. dimorphus* Hammer, 1962, 15 pairs in *H. parisiensis* Grandjean, 1948, and 11 pairs in *H. mollicoma* Hammer, 1958, *H. lemnae* (Coggi) 1898 and *H. petrunkevitchi* Newell 1945. The extant new species is shorter in length than most other species, except *lemnae*. The fossil species, *H.* **oryktosis**, is described from three cotype specimens extracted from peaty sediments of a mastodon site (*Mammut americanus*) in Lapeer Co., the Thumb region of Michigan; estimated age 10,750 ± 400 years B.P. by C-14 dating. The fossil differs from extant species in the eight pairs of genital setae and two pairs of widely spaced aggenital hairs.

The genus *Hydrozetes* originated with Berlese in his writing of 1902 wherein he redescribed *Notaspis lacustris* Michael, 1882. Chinaglia (1917) is credited with the revision of the genus which Berlese evidently completed for Chinaglia posthumously. In this writing, *H. platensis*, *H. confervae*, and *H. terrestris* are described.

In 1945, Newell reviewed the genus *Hydrozetes* mainly for species in North America and described collections of *H. lacustris* (Michael) from ponds in Connecticut. He also described a new species, *H. petrunkevitchi*, taken from various water plants at Miami, Florida. It is in this paper also that Newell describes the activity of levitation in Hydrozetes, a rather unique phenomenon for oribatids.

Grandjean (1948) wrote a paper on the occurrence of *Hydrozetes* in occidental Europe and described two new species, *H. parisiensis* and *H. incisus*. He also made comparisons of some of the morphological features by which species might be differentiated, as well as descriptions of the nymphs, other immature stages and their characteristics.

Hammer (1958) in her paper on the oribatids of Argentina and Bolivia describes *Hydrozetes mollicoma*. Later (1962) she describes *Hydrozetes dimorphus* from Patagonia. In another article (1966) she also cites collections of *H. lemnae* (de Coggi) from several locations in New Zealand.

From plankton net samples taken in City Park Lake in Fort Collins, in the fall of 1967, I obtained a number of specimens of *Hydrozetes*. This is the first

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[1] Research supported in part by NIH-NAIAD-TG-TO1-AI00094-09,-10.

species of this particular genus that I have found in the vicinity, as my oribatid collections have been confined primarily to terrestrial habitats. Earlier in the same year, Dr. Ronald O. Kapp, at Alma College, Michigan, had sent me three specimens of an undescribed fossil species of *Hydrozetes* unearthed from peat beds in the Thumb region of Michigan.

Comparing these species with the various species delineated in the literature, I determined that both the fossil form from the peat diggings in Michigan and the species taken from City Park Lake in Fort Collins are new. They comprise the subject of this article and their descriptions follow.

Hydrozetes **laccosis**, n. sp.

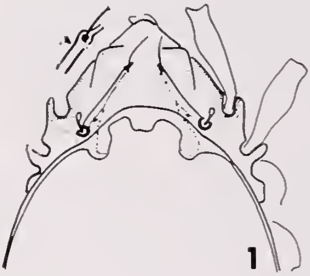
(Figs. 1–5)

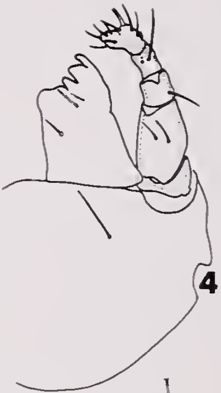
Diagnosis: The principal difference between *Hydrozetes* **laccosis**, n. sp., and other New World forms is that the new species exhibits 16 pairs of notogastral setae (including both C_1 and C_2) compared to 17 pairs in *H. dimorphus* Hammer, 1962, 11 pairs in *H. mollicoma* Hammer, 1958, *H. lemnae* (Coggi) 1898, and *H. petrunkevitchi* Newell, 1945, and 15 pairs of notogastral setae in *H. parisiensis* Grandjean, 1948. The new species seems to be intermediate in length between the smallest representatives of the genus, *Hydrozetes lemnae* (Coggi) 1898 (375 μ–470 μ) and others. It overlaps in measurements with *H. petrunkevitchi* (409–436 μ × 270–284 μ) and *H. confervae* (450 μ–560 μ), the next larger species. *H. parisiensis* Grandjean, 1948, ranges from 450 μ–510 μ in length; *H. mollicoma* Hammer, 1958, is 490 μ in length; while *H. dimorphus* Hammer, 1962, shows a differentiation in size between males and females and is the largest species recorded. The males range from 680 μ to 700 μ in length; females from 590 μ to 640 μ in length. The length of *H. incisus* Grandjean, 1948, extends from 515 μ to 600 μ.

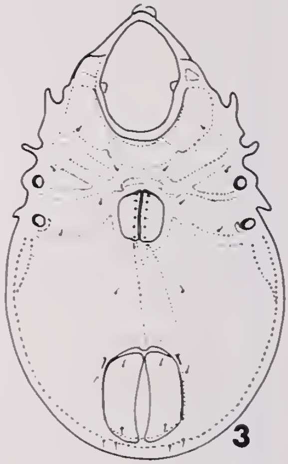
The trivial name for the new species comes from the Greek, *lakkos*, implying pond or reservoir, the type of habitat from which the specimens were taken.

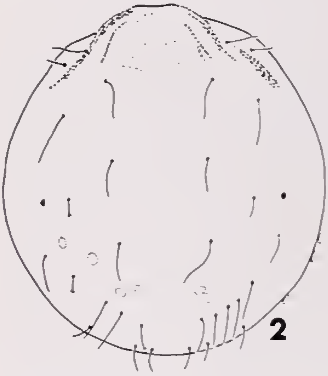
Description: Color reddish-brown; prodorsum broadly triangular, rostrum rounded, rostral hairs fine, decurved, inserted in small tubercles slightly less than their lengths from anterior tip; anterior and posterior tutoria forming an inverted "L-shaped" bar mid-way between rostrum and tips of lamellae; lamellae like tapered bars converging behind tutoria, about as wide as width of head of sensillus, tapering anteriorly, without cusps; lamellar hairs twice as long as rostral hairs, fine, decurved inserted in alveolae that are comma-shaped (Fig. 1A); translamella absent; interlamellar hairs shorter than width of lamellae, inserted slightly more than their lengths anterior to pseudostigmata, directed mediad; pseudostigmata at posterior base of lamellae, rounded with slightly erected rims; sensillus slightly curved, capitate with nearly globular head, head shorter than pedicel; pedotecta I and II as in Fig. 1.

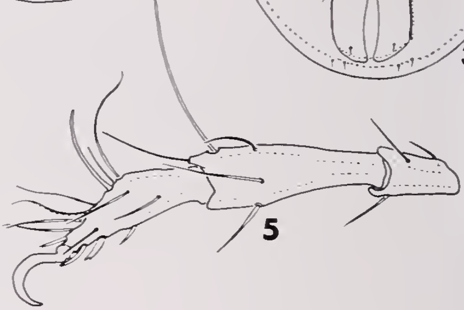
Notogaster nearly rounded, dorsosejugal suture arched anteriorly, projection of notogastral margin forming a slight hood anterior to circular ocular area (Fig. 2), anterior notogastral apodematal structures from dissected female as in Fig. 1; anterior margin and shoulders of notogaster with slight tubercles, notogastral hairs as in Fig. 2 (surface of

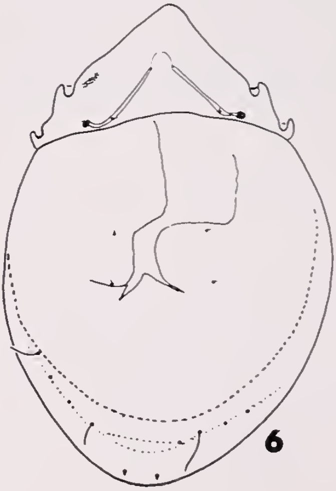












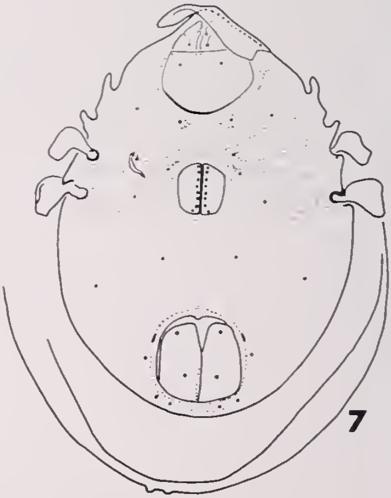


Fig. 1. Predorsum and dorsosejugal apodemes of *Hydrozetes* **laccosis** from dissected female; A. enlarged view of insertion of lamellar hair and distal lamellar projection.

Fig. 2. Notogastral plate of *H.* **laccosis** from dorsal aspect showing hairs and slight hood anterior to ocular spot; diatoms adhering to surface; from dissected female.

Fig. 3. Venter of *H.* **laccosis**, legs omitted, from dissected female.

many specimens with discoid diatoms attached to integument); hairs C_1 and C_2 both present; seta h_4 is missing on the left side in the type specimen.

Camerostome oval in outline; articulating condyles, mentum and submentum as in Fig. 3; palp, mentum and rutellum as in Fig. 4. Ventral setae and apodemata as seen in Fig. 3; genital opening cover with six setae (Fig. 3); anal opening at least twice as large as genital opening, each anal cover with two setae, a:1 in anterior fourth of cover, a:2 in posterior fourth, inserted midway between the margins of cover; fissure *iad* curved, at anterolateral corner of anal opening; adanal setae as in Fig. 3, ada:3 near anterolateral corner of opening, ada:2 and ada:1 posterior to opening, closer to lateral margin.

Legs monodactylous (Fig. 5).

MEASUREMENTS: The type specimen (a female) measured 444 $\mu \times 282$ μ. The other measurable specimens showed a range of 438 μ–486 $\mu \times 276$ μ–312 μ for females, average 470 $\mu \times 300$ μ; the males ranged 480 μ–486 $\mu \times 300$ μ–318 μ, average 484 $\mu \times 309$ μ.

COLLECTION DATA: Ten female and 5 male specimens were taken in a plankton net sample at City Park Lake, Fort Collins, Colorado, 30 October, 1967, by T. A. Woolley. The drawings were made from a dissected female.

Hydrozetes **oryktosis**, n. sp.

(Figs. 6–7)

DIAGNOSIS: Inasmuch as the three specimens of this species are fossil forms from a peat bog in Michigan and the specimens are broken, all characteristics that normally would be compared in a diagnosis were not observable. The principal difference, however, between the new species and extant forms of this genus are the 8 pairs of genital setae and the two pairs of widely spaced aggenital setae present in the fossils. The breakage of the notogaster in each fossil specimen is such that detailed comparisons of the dorsal notogastral hairs is not possible. The trivial name comes from the Greek *oryktos*, implying that these fossils were "dug up." The description that follows is a combination of features exhibited by the three cotypes collected from the peat.

DESCRIPTION: Color yellowish-brown, integument finely stippled in all specimens; prodorsum broadly triangular, rostrum rounded (Fig. 6), rostral hairs not visible; tutoria indiscernible in specimens because of breakage; lamellae narrow, converging ridges, connecting to pseudostigmata, extended medially and anteriorly from pseudostigmata; lamellar hairs fine, decurved, at least three times as long as interlamellar hairs, inserted in distal tips of lamellae; interlamellar hairs very fine and short, shorter than width of lamellae, inserted in medial edge of lamella near pseudostigmata; pseudostigmata rounded, connected

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FIG. 4. Palp, rutellum and part of mentum of dissected female of *H.* **laccosis**.

FIG. 5. Genu, tibia, tarsus I of *H.* **laccosis**.

FIG. 6. Dorsum of fossil *Hydrozetes* **oryktosis**, broken notogaster. Drawing of cotype specimen (A) female.

FIG. 7. Venter of fossil *H.* **oryktosis**, drawing of cotype specimen (B), notogastral plate displaced posteriorly and showing two projections.

to base of lamellae by a short, slightly curved ridge; pedicel of sensillus broken, head of sensillus absent.

Notogaster rounded; notogastral hairs and/or alveolae as indicated in Fig. 6.

Camerostome broadly triangular; mentum and rutella with hairs, ventral setae and apodemata as seen in Fig. 7; genital opening nearly square, each genital cover with 8 setae along medial margin; g:8 displaced more laterally than other setae; insertions of two pairs of widely spaced aggenital setae apparent in venter posterolaterad of opening (Fig. 7); anal opening at least twice as large as genital opening, each anal cover with two setae, a:1 in middle of anterior part of cover, a:2 posteriorly placed in cover and nearer medial margin; fissure *iad* near anterolateral margin of anal opening, margin formed as sclerotized ring with preanal piece coalesced; adanal setae *ada*:3 at level of middle of anal cover each side of anal opening, *ada*:2 at posterolateral corner of cover, *ada*:1 posterior to anal cover (Fig. 7).

The legs of each of the three cotypes are broken and missing leaving only the femora showing in some instances. Since all of the other characteristics indicate the genus *Hydrozetes* it is assumed that the legs in this instance were also monodactylous, though this must remain a supposition, when compared with extant forms.

Measurements: Each of the cotype specimens is somewhat flattened which may distort the accuracy of the measurements, but the lengths and widths for each specimen are as follows: A. 420 μ × 306 μ (female), B. 408 μ × 300 μ (male?) and C. 408 μ × 288 μ (female).

Collection data: Three specimens, two females and one male (?), were taken in peat, SW corner S 21, T 10 N, R 11 E, Lapeer Co., Michigan, by R. O. Kapp. The three cotype specimens will be deposited in the U. S. National Museum.

DISCUSSION

The three fossil mites were recovered from peaty sediments by Dr. Ronald O. Kapp while screening for plant macrofossils. He mounted the specimens in glycerin jelly and sent them to Dr. Robert Beer at the University of Kansas for identification. They were referred to me by Dr. Beer.

To quote from Dr. Kapp's letter to Dr. Beer: "The excavation of the site is under the direction of Dr. Warren Wittry, Director of the Cranbrook Institute of Science, Bloomfield Hills, Michigan. The site is especially significant because there seems to be conclusive evidence that the mastodon was 'butchered' or at least 'salvaged' by the Paleo-Indians on the scene. All except 3 or 4 bones has been recovered."

At the site the mites were recovered "in peat near base of about 13 inches of peat and buried approximately 25 inches below the present surface of the soil slightly older or about contemporaneous with fossil mastodon specimen (*Mammut americanus*)." In another letter Dr. Kapp adds, "The material was extracted from calcareous silty clay beneath peat and about 12–14 inches below the 10 inch zone of agricultural tillage."

"It is clear that the age of the mites is 10,750 ± 400 years BP. . ." based on C-14 dates of this and stratigraphically higher levels (M-780 and M-1781, University of Michigan C-14 Lab).

Not too much recent ecological information is available on species of *Hydrozetes*. Following is a brief summary of what is available.

In addition to the taxonomy of North American species of *Hydrozetes*, Newell (1945) describes them as usually living on completely submerged fresh-water plants, but some occasionally are found on plants at the surface. One or more are terrestrial, living among wet leaves. It is in this same article that Newell describes the ability of *Hydrozetes* to form a bubble of gas in the mid-gut and decrease their density sufficiently to rise in a column of water. He also found that these mites respond to different intensities of light during this levitation process.

Grandjean's article (1948) does not describe any ecological data concerning *Hydrozetes*; it is mainly concerned with taxonomic features of the mites he collected in the environs of Paris.

Hammer (1962) discusses the collection of *Hydrozetes dimorphus* on the beach of Lago Moreno in 2 cm high moss and associated with *Scirpus*, *Ranunculus*, besides a little *Salicornia* on wet black soil. She mentions that several specimens were taken in nearly similar bio-types with almost homogeneous vegetation of *Salicornia* and others richer in *Ranunculus* and *Scirpus*; in all about 40 specimens of *Hydrozetes dimorphus* were found. In 1966 she reported on the collecting sites of several specimens of *Hydrozetes lemnae* (de Coggi): "One specimen in wet moss on a stone in a brook, another in moss on the edge of a swamp, another specimen in *Selaginella*, numerous examples in wet moss on a stone on the edge of a pond and a few individuals in wet moss, *Lemna*, water cress on the edge of a spring"; near Queenstown, New Zealand, she found a few individuals in soaked moss on the bank of Lake Hayes.

Not much is added to the ecological data on *Hydrozetes* by this present article other than a new species from a new location in North America. The "accidental" recovery of these mites in plankton samples, however, may alert collectors as to how to obtain them and may stimulate specialists in the oribatids to be more on the lookout for *Hydrozetes* in their collecting.

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ERRATA

In the article by C. F. dos Passos, "*Lethe eurydice* (Johansson) and *L. fumosus* (Leussler) Sibling Species (Lepidoptera: Satyridae)," which appeared in the June, 1969 issue of the **Journal** (**77:** 117–122) *fumosus* should read *fumosa* throughout the paper. Also, on p. 120 Sarky County should read Sarpy County.

and

In the article by P. P. Shubeck, "Ecological Studies of Carrion Beetles in Hutcheson Memorial Forest," which appeared in the September, 1969 issue of the **Journal** (**77:** 138–151) in the last line of the Abstract the word *most* should read *least*.

The Effects of Temperature and Humidity on Longevity of Insecticide Resistant and Susceptible *Musca domestica* Linnaeus[1]

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Abstract: The effects of three humidities and three temperatures were tested on the longevity of both sexes of two strains of *Musca domestica* L. House flies survive longest at the combination of the lowest temperature (15°C) and the highest humidity tested (97%). Their longevity is least at the highest temperature (35°C) and lowest humidity (7%) combination, and the intermediate temperature-humidity combinations are intermediate in effect on longevity with the effect of temperature in all cases greater than the effect of humidity. There is no difference in longevity between the insecticide resistant and susceptible strains tested. The factor of desiccation appears to be the primary mechanism involved in determining longevity with temperature determining the rate.

It is believed that temperature and relative humidity are of great importance in determining the times and places of insect distribution. Furthermore the relationship of some fly-borne diseases to climatic conditions has been known for some time, but in the field it is difficult to isolate the factors of temperature and humidity from interactions with such factors as sunlight, predators, food supply, etc. which also probably serve to limit distribution. For this reason it was desirable to test the effects of these factors under controlled laboratory conditions where the effects of temperature and humidity could be isolated and their relative importance assessed in determining the longevity of house flies.

It was decided to compare males with females and to compare an insecticide susceptible strain with an insecticide resistant strain of house flies (*Musca domestica* L.) for response to different temperature and humidity combinations in an effort to determine if any differences between sexes or strains might exist and further to give some insight into the possible mechanisms involved in determining longevity at different temperature and humidity combinations. These

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[1] Paper of the Journal Series, New Jersey Agricultural Experiment Station. This investigation was supported in part through a grant to the senior author from the Thurlow C. Nelson Undergraduate Research Fund.

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Acknowledgment: Assistance with experimental design and analysis of data received from Mr. Daniel Chilko is much appreciated.

tests were designed to approximate the range of temperature and humidity variations to which house flies are commonly exposed in nature.

MATERIALS AND METHODS

Musca domestica of the Rutgers A-strain and the World Health Organization IN-strain were reared separately at an approximately constant temperature of 26°C. The flies were reared on CSMA artificial fly larval medium (Ralston Purina Co.) by the standard method as outlined in the Soap and Chemicals Specialties Blue Book (1967) and were fed reconstituted dry skim milk after emergence as adults. The flies were anesthetized with carbon dioxide, separated as to sex, and weighed prior to insertion into the humidity chambers.

The humidity chambers were clear plastic cylindrical containers with a tight-fitting plastic top and measured 15.2 cm inside diameter by 6.5 cm in height. Each chamber contained 100 ml of a saturated salt solution with an aluminum screen elevated 3 cm above the bottom of the dish separating the flies from the solution. The salts, NaOH, K_2CO_3, and K_2SO_4, were dissolved in distilled water until the solutions reached saturation, and then an excess of salt was added. According to Winston and Bates (1960) these solutions give constant humidities over a long period of time with relative humidities of 7% for NaOH, 43% for K_2CO_3, and 97.5% for K_2SO_4 at 25°C. The humidity levels at 15°C and 35°C varied approximately 1.5% from the values at 25°C. Each humidity chamber had a small plastic dish with approximately 2 gm of powdered dry milk for food.

Twenty house flies were inserted into the chambers through a small hole in the top by means of a glass tube open at both ends. The anesthetized flies were placed in the tube, counted, and then dropped into the humidity chambers which were kept in incubators. The three incubators used were maintained at 15°, 25°, and 35°C with the light constant at approximately 70 footcandles. Twelve humidity chambers were placed in each incubator with four at each of the three humidities. Of the four chambers at the same humidity, two were used for males and two for females. Thus, there were three incubators with four chambers at each of the three humidities in each incubator with 20 flies in each chamber resulting in a total of 720 flies for each test.

Tests were run over weekends, beginning on Friday at 9:00 A.M. and generally ending on the following Tuesday evening when all the flies had died. The flies were observed and the number dead was recorded every four hours with the exception of the 5:00 A.M. reading. Only one strain was tested at a time and a total of six tests were run in pairs alternately between strains on successive weekends with three tests of each strain. After each pair of tests the humidity chambers were rotated among the incubators. Because of the limited shelf size in the incubators, it was necessary to place one group of four chambers on a lower shelf where they were exposed to somewhat reduced light, but this

TABLE 1. Comparison of LT_{50} values for the 2 strains of flies (average of 3 tests).

	LT_{50} values expressed in hours					
	A (7% humidity)		C (43% humidity)		E (97% humidity)	
	males	females	males	females	males	females
A-strain						
15°C	39	43	49	53	57	58
25°C	17	18	23	22	23	20
35°C	7.6	7.2	9.6	9.2	10.0	9.6
IN-strain						
15°C	31	54	42	59	53	70
25°C	14	21	20	27	23	26
35°C	6.0	7.6	6.6	9.2	9.6	10.4

was compensated for by rotating the containers after each pair of tests so that each of the three humidities was placed on the lower shelf for one pair of tests. To compensate for any temperature gradient in the incubators the chambers were randomly distributed on the shelves.

RESULTS AND DISCUSSION

The data were graphed for each temperature-humidity combination separately for each strain, (Figs. 1 and 2) but combining the sexes, the replicates, and the three tests so that each curve represents 240 flies. For direct comparisons of the series of curves, LT_{50} determinations were made for each temperature-humidity combination. The LT_{50} is the time of exposure when 50% of the flies were dead and was determined (Table 1) from similar graphs where data for the sexes were plotted separately.

The LT_{50} values in Table 1 were statistically analyzed as a $3 \times 3 \times 2 \times 2$ factorial experiment to determine the significance of the differences between temperatures and humidities and to determine if there was any difference between the IN and A strains. The difference between both humidities and temperatures was highly significant at the 95% level of significance and the interaction between temperature and humidity effects was significant as well. The fact that the humidity effect is not the same at different temperatures can be seen on the graphs as the generally increased separation of the lines with decreasing temperatures, resulting from the increased longevity of flies at lower temperatures.

The effects of temperature on longevity were greater than the humidity effects and clearly indicated an increased longevity with decreased temperature. The differences between strains were determined not significant as the two strains responded similarly to all treatments. It was found that the higher hu-

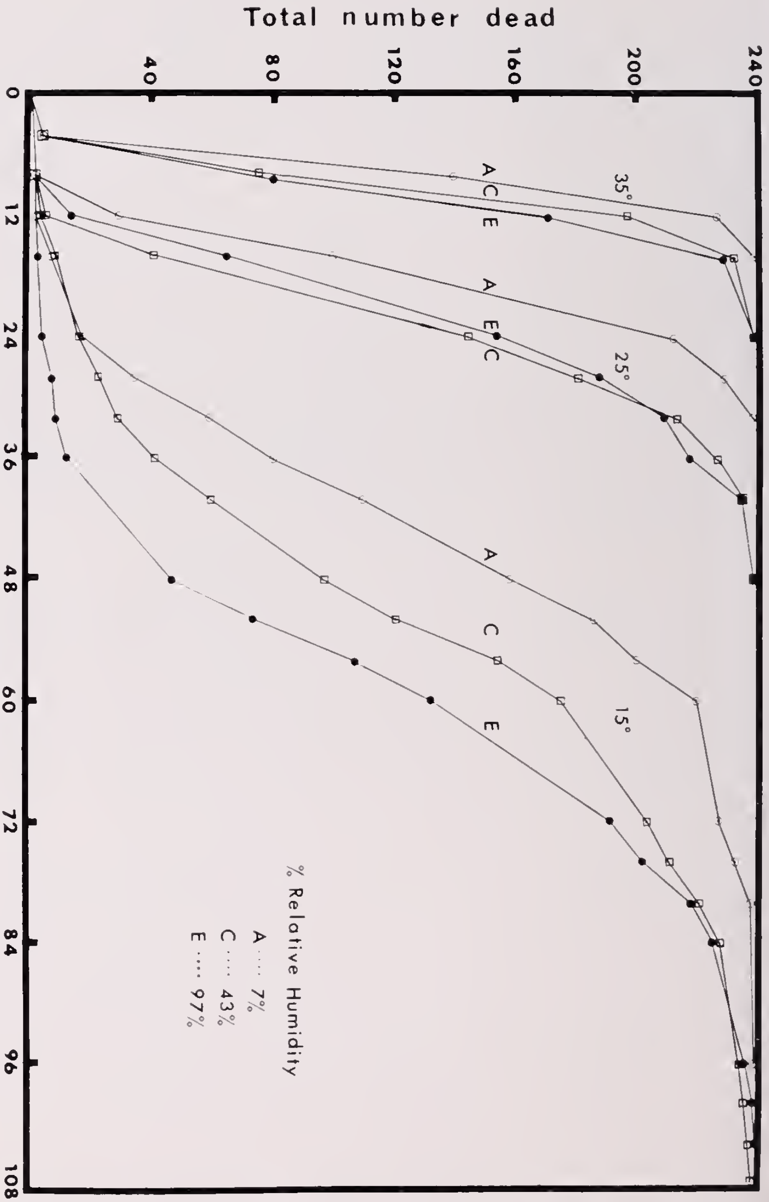

Fig. 1. Rutgers A-strain flies showing the effects of the 3 temperatures and the 3 humidities on longevity.

Table 2. Weight and longevity values for sexes and strains (average of 3 tests).

	A-strain	IN-strain
Avg. wt. males	43.6 mg	39.7 mg
Avg. LT_{50} males	26.1 hr	22.8 hr
Avg. wt. females	47.8 mg	58.9 mg
Avg. LT_{50} females	26.7 hr	31.6 hr

midities resulted in progressively greater longevity at the three temperatures tested with the exception of a slight reversal of the intermediate and high humidity effects at 25°C for the A strain.

The survival differences between the sexes were found to vary greatly from test to test, but these differences could be directly correlated with the weight differences between the groups of flies. In cases where the sexes weighed about the same, they survived about the same. There was a greater weight difference between the sexes in the IN-strain than in the A-strain. This resulted in large survival differences between the sexes in the IN-strain, but small differences in the A-strain (Table 2).

Behavioral differences at the different temperatures were observed shortly after the flies were inserted into the humidity chambers. The flies exposed at 15°C moved very little, if at all, but the flies at 35°C were in constant motion, both crawling and flying, and the flies at 25°C were intermediate in activity. This behavioral pattern was apparent in all six tests for the duration of each test. It was suspected that the flies died from lack of water and that as a result of this water-loss they would decrease in weight during the test. To determine if this water-loss was the same at the three humidities, 20 flies were weighed and exposed to each of the three humidities without food for 10 hours and then anesthetised and weighed again. Those flies exposed at 97%, 43% and 7% humidity lost an average of 3.09 mg, 3.67 mg, and 4.62 mg per fly, respectively. These results indicate that there is a greater desiccation of the flies at lower humidities and serve, in part, to explain the differences in longevity at different humidity levels.

The flies were observed to be feeding on the dry powdered milk at frequent intervals during the tests and a surprising number of flies died in the milk dishes. At the high, intermediate and low humidity there was an average of 1.9, 3.1, and 5.1 flies, respectively found dead in the milk dish. By calculating the area of the milk dish and comparing it to the area of the humidity chamber, it was determined that by random chance an average of 1.4 flies should have died in each dish. The fact that in all cases more flies died in the powdered milk than would be expected by chance alone probably results from the fact that the flies were feeding on the powdered milk, but it was suspected that

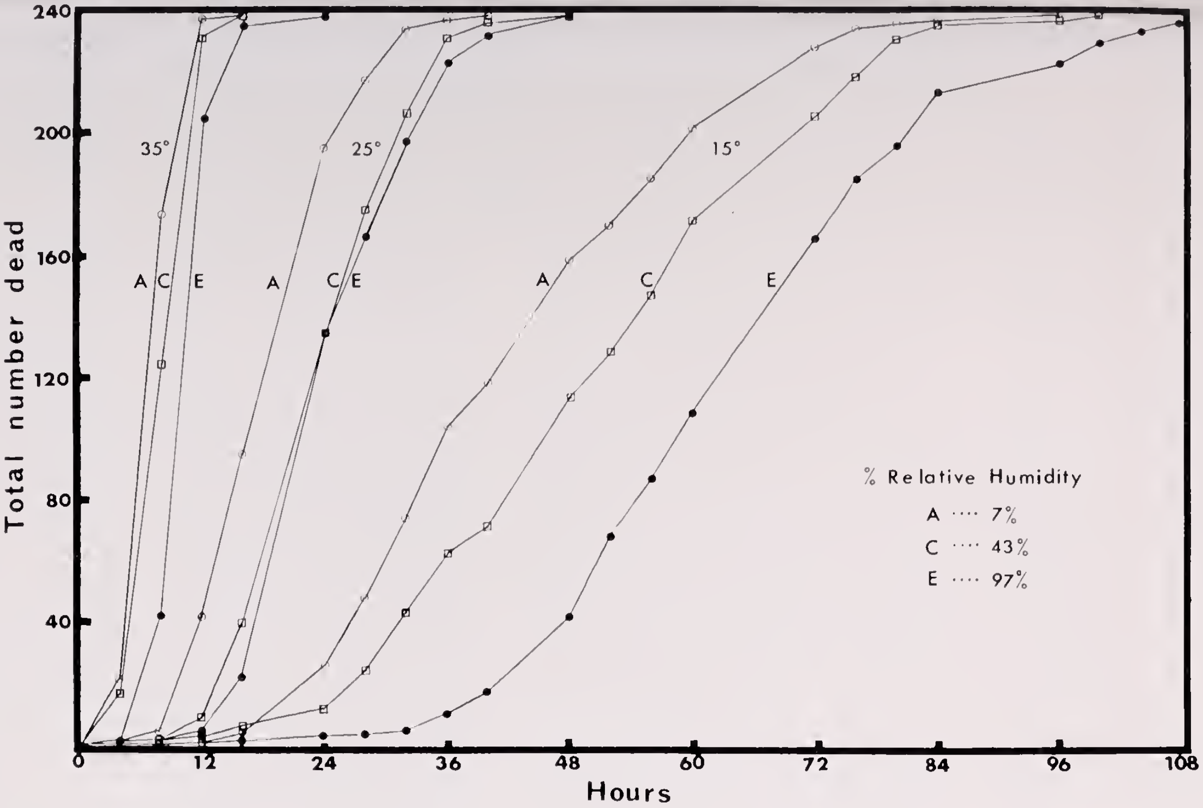

FIG. 2. World Health Organization IN-strain flies showing the effects of the 3 temperatures and the 3 humidities on longevity.

the differences between humidities might result from an ability of the flies to detect the small amount of moisture present in the powdered milk when they were suffering from desiccation. To test this hypothesis 12 dishes of powdered milk were weighed and placed in 12 humidity chambers with four at each of the three humidities. After 24 hours exposure these dishes were weighed again. At the lowest humidity the powdered milk lost an average of 0.7 mg per dish. At the intermediate humidity the powdered milk gained an average of 3.6 mg per dish, and at the highest humidity gained an average of 22.9 mg per dish during the 24 hour period. The results of this test indicate that at the lowest humidity the powdered milk had more moisture than the atmosphere and at the other two humidities there was more moisture in the air than in the milk. The flies were evidently able to detect these moisture differences and this resulted in the substantially different numbers of flies which died in the milk dishes at different humidities.

The results of these experiments differ somewhat from what was expected on the basis of the experiments of a similar nature found in the literature. Prevalent in the literature, Headlee (1917), Beattie (1928), is an idea that high humidity inhibits evaporative cooling and thus proves rapidly lethal at high temperatures (usually over 100°F). The results of this experiment indicate that the flies survive best at the high humidities at all temperatures though extreme temperatures were not studied. The desiccation of the flies seemed to be the primary mechanism involved in the death of the flies in this experiment. Even at high humidities the flies lost 6% weight in 10 hours. If inhibition of evaporative cooling played an important role in determining longevity, those exposed at the intermediate humidity and high temperature would be expected to survive better than those exposed to the high humidity and high temperature. This clearly is not the case.

It was expected that possibly the A-strain, as a side effect of selection for insecticide resistance might have developed a greater tolerance to a desiccation environment either as a result of a thickened cuticle or increased weight. Such clearly was not the case as the A-strain (resistant) averaged 45.7 mg and the IN-strain (susceptible) averaged 49.3 mg per fly and the difference in survival between the strains was extremely small and not statistically significant.

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Xanthopygus cognatus Sharp (Coleoptera: Staphylinidae), an Enemy of the Coconut Weevil, *Rhynchophorus palmarum* L. (Coleoptera: Curculionidae) in El Salvador

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Abstract: *Rhynchophorus palmarum* attacks coconut trees, papaya trees and is a vector of red ring disease of palms. *Xanthopygus cognatus,* whose eggs are laid in coconut and papaya stems, is an egg and larval predator of *R. palmarum.* Both larvae and adults of *X. cognatus* will feed on the eggs of the coconut weevil, and the adults of the staphylinid will eat the larval weevils. Although *X. cognatus* shows a feeding preference for the coconut weevil, it is not completely host specific and will eat other prey when the weevil is unavailable. The staphylinid is amenable to mass rearing in insectaries. To aid in its identification, a brief description of *X. cognatus* is provided.

The coconut weevil, *Rhynchophorus palmarum* L., is an important pest in tropical America. Its larvae excavate tunnels in the stems and crowns of standing coconut trees, whose tissues may be destroyed in a matter of weeks when the infestations are high. The crowns collapse and fall over, and the activity of the weevils and their larvae is more evident at this time. Standing papaya trees may also be attacked, but those which are cut down or have fallen, furnish the best breeding sites for the weevil (Quezada, 1968). The role of *R. palmarum* as a vector of the red ring disease of palms has been demonstrated (Hagley, 1963). The possibility of using biological control agents against this pest has not seriously been explored. Quezada (1968) reported a staphylinid, *Xanthopygus cognatus* Sharp, as an egg-larval predator of *R. palmarum.* This predator has been found wherever infestations of the weevil occur in fallen coconut or papaya trees. The purpose of this paper is to summarize the studies made on the biology of *X. cognatus* in El Salvador. To facilitate the identification of the species discussed in this paper, the third author, who identified the specimens, has provided a brief description of the species and illustrations of the aedeagus.

Acknowledgments: The authors wish to thank Arelí Díaz and Carlos Cornejo for their help in the laboratory and field work. Thanks also go to Mr. Napoleón Quezada and Mr. Evodio Quezada, who made one of their plantations available and helped in the field work.

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BIOLOGY OF *Xanthopygus cognatus*

Most observations were made in the laboratory, where temperatures ranged from 23° to 28°C and relative humidity from 65% to 90%. Field observations were also made, especially during the rainy season (May to September), during which the temperature ranged from 25° to 32°C and relative humidity from 65% to 93%.

Adults and pupae of the staphylinids were collected in the field by inspecting fallen papaya or coconut trees in which activity of *R. palmarum* was evident, and brought to the laboratory, where the adults were offered abundant eggs and first instar larvae of the weevil and then allowed to breed. Pupae of the predators were confined in three-dram vials plugged with cotton, and kept at about 70% relative humidity to await emergence of adults. Mating pairs, or single mated females, were confined in petri dishes with decomposing papaya stem material containing eggs and small larvae of the prey. A good stock of all stages of the staphylinids could be secured when cultures of *R. palmarum* (Quezada, 1968) were infested with *X. cognatus*.

Life cycle (Fig. 1): *The egg*—The egg is whitish, ovoid, with its chorion marked by an equatorial line and fine longitudinal striations. It measures up to 4 mm. long and from 2.5 to 3.0 mm. at its maximum width. The eggs were deposited by the females in the darkest and most protected areas of the containers in the laboratory. In the field they were found under the cortex of the papaya stems, or among the fiber bundles of the coconut stems, and always when such plants were fallen, decaying, and attacked by *R. palmarum*. The incubation period ranged from 48 to 72 hours, and 81 per cent of the eggs hatched in the laboratory.

Larvae: There are four larval instars which last two, three, and four days, respectively. The larvae are very active and will readily devour the eggs of *R. palmarum*, which they grasp with their sharp, sickle-shaped mandibles, chew and suck their contents. The first instar larva measures up to 8 mm. in length and the last instar up to 20 mm. In the laboratory, an average of 47 eggs of *R. palmarum* was required by the larvae to attain complete development. About 72 hours before pupation, the mature larva neither moves nor eats. Then the skin is shed and the pupa formed in a small space among the decomposing material. In the field, pupae were found enclosed in a thin layer of soil. Molting of larvae and pupation were observed to occur during the night or early morning, a fact that was reported by Mank (1923) for other staphylinid species.

Pupa: When newly formed, it is creamy white, but in about six hours it is completely sclerotized and darkened, gradually changing from yellowish to dark brown. It rests on its dorsal side, and its head is bent ventrally. In both the laboratory and the field, the pupal stage lasted between seven and ten days.

Fig. 1. Life stages of *Xanthopygus cognatus*. The egg and the first instar larva are shown at left. Toward the right, respectively, mature larva, pupa and adult.

The life cycle of the predator is completed in about 20 days. In the laboratory, a 91% adult emergence from pupae was observed, and emergence also occurred during the night.

Adult: When newly emerged, the adult is pale, but gradually attains its black color with its characteristic bright orange-colored band at the tip of the abdomen. It displays great activity and appetite. When disturbed, it raises the tip of its abdomen in an evidently warning posture. Mating occurs about 24 hours after emergence, and there is some courtship behavior before copulation takes place. The male approaches the female face to face, with the tip of its abdomen raised. Its antennae touch those of the female. Then he goes around and touches the tip of the female's abdomen with his antennae, after which he bends his abdomen and, without actually mounting the female, copulation is secured. The female remains still, and copulation may continue for 28 minutes (Fig. 2). A male is capable of mating with more than one female, and copulation occurs at any time during the day or night. A preovipositional period of 48 hours was recorded, after which the female will begin to lay her eggs. From seven to 18 eggs may be laid by a female during the 16 days of her life span, provided that food is always available. Males seem to live only a slightly shorter period than females.

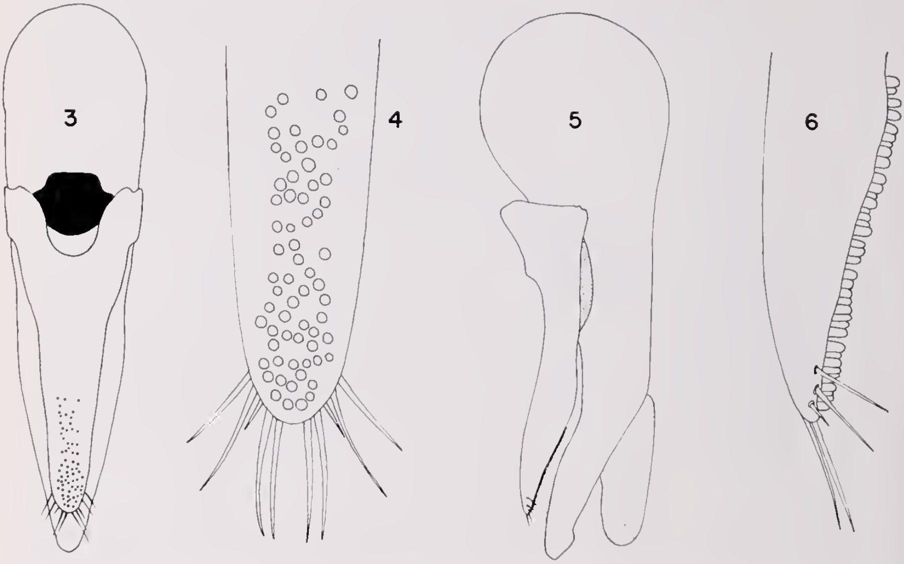
Fig. 2. Mating of *Xanthopygus cognatus*. While the female remains quiet, the male bends its abdomen to secure copulation.

Feeding habits: The adults of *X. cognatus* are active searchers, and although they are usually seen walking, they are good fliers, too. When they encounter an egg of *R. palmarum* they grab it with their mandibles and devour it in about one minute. If the egg is found in an area where there is too much light, it is taken to a protected dark spot and quickly devoured there. Observations in the laboratory showed the staphylinids were very cautious when coming into the light where weevil eggs were offered to them. When they got one between their mandibles, they quickly ran to a hiding place and ate the egg there. As many as eight eggs a day were consumed per beetle, with no more than 32 eggs consumed during the adult life. Weevil eggs deposited 1 cm. or less into the pulp of pineapple or papaya stem were extracted by adult *X. cognatus*. First instar *R. palmarum* larvae were eaten by the predators with the same readiness as eggs. Second instar larvae also often were attacked, mutilated with the mandibles, and fed upon.

Alternate prey: When a regular supply of *R. palmarum* eggs was available, *X. cognatus* adults or larvae did not show interest in other prey. However, when starved for three days, both adults and larvae readily ate *Drosophila* sp. larvae and also attacked *Anastrepha* sp. larvae.

CONTROL OF *R. palmarum* BY *X. cognatus*

X. cognatus has been observed to occur in fallen coconut and papaya trees infested with the weevil which may indicate that this predator has good searching capacity. Even though the presence of histerids and staphylinids as well as *X. cognatus* is always found, *X. cognatus* seems to predominate. The destruction of eggs and young larvae of the weevil, mentioned above, may mean that *X. cognatus* is probably responsible for an initial reduction of the pest popula-



FIGS. 3–6. Aedeagus of *Xanthopygus cognatus* Sharp. 3. Ventral view. 4. Enlarged ventral view of apex of parameres to show distribution of pegs. 5. Lateral view. 6. Enlarged lateral view of apex of parameres to show pegs.

tion. Although the predator is not completely specific, and may feed on prey besides eggs and young larvae of the coconut weevil, its potentialities as a good biological control agent may depend on its ability to utilize other prey during periods of *R. palmarum* scarcity. As DeBach (1964) points out: ". . . if the host population is periodically depressed by other factors, a specific natural enemy will suffer most, whereas a more general feeder will maintain itself on other hosts during adverse periods." The short life cycle of the predator would also have some advantages in the building up of its populations and would make it amenable for insectary mass rearing. It is thought that the present action of *X. cognatus*, and probably that of other predators of the coconut weevil, may be enhanced if enough knowledge about their biology and ecology is accumulated. A mass production program could be set up, and periodic releases of adults and/or larvae made at the appropriate time when the populations and activity of *R. palmarum* require them. This, in addition to sanitary cultural practices in papaya and coconut plantations such as removal and disposal of fallen trees, would probably diminish the damage presently done by the coconut weevil in El Salvador.

DESCRIPTION OF *Xanthopygus cognatus* Sharp

Length approximately 12.0 to 15.0 mm.

Body black dorsally and dark brownish-black ventrally; abdomen with base of sixth and all of seventh, eighth and ninth segments bright reddish orange.

Dorsum of head with coarse punctation, punctation increasingly dense basally and laterally; median region impunctate.

Pronotum with irregular row of setigerous punctures laterad of midlongitudinal, impunctate strip; punctation increasingly dense laterally; punctures distinct and coarse.

Seventh sternite of abdomen of male unmodified; with three pairs of large, black setae in transverse row across base. Eighth sternum of male with shallow median emargination of posterior margin; emargination rounded. Seventh and eighth abdominal segments of female unmodified.

Aedeagus trilobed; with parameres fused; parameres with numerous, short, black, heavily sclerotized rounded pegs on dorsal surfaces; parameres with five pairs of setae on lateral sides near apex. (Figs. 3–6).

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Proceedings of the New York Entomological Society

(Meetings held in Room 129 of the American Museum of Natural History unless otherwise indicated.)

Meeting of October 1, 1968

President David Miller presided; 24 members and 15 guests were present. Dr. Miller announced that the consolidation of the New York and Brooklyn Entomological Societies had been consumated under the title THE NEW YORK ENTOMOLOGICAL SOCIETY INCORPORATING THE BROOKLYN ENTOMOLOGICAL SOCIETY, INC. Miss Alice Gray described the Junior Society's recent trip to the Archbold Biological Station in Lake Placid, Florida. Mr. Philip Tates of New York City was proposed for active membership. Dr. Charles P. Alexander of Amherst, Mass. and Mr. Rowland R. McElvare of Southern Pines, N.C. were proposed and elected to Honorary Membership. (See: **J. N. Y. Entomol. Soc., 77:** 129.) Dr. Elsie Klots reported on plans for the 75th Anniversary Dinner of the Society which will be held at the American Museum of Natural History on October 29, 1969.

PROGRAM. **On Hands and Knees Through Africa** by Dr. James Slater of the University of Connecticut.

HOWARD R. TOPOFF, *Sec.*

Meeting of October 15, 1968

Vice-president Dr. Lee Herman presided; 16 members and 9 guests were present. Mr. Philip Tates of New York City was elected to active membership.

PROGRAM. **The Causes of Certain Insect and Plant Diseases** by Dr. Karl Maramorosch of the Boyce-Thompson Institute, Yonkers, N.Y.

HOWARD R. TOPOFF, *Sec.*

November 5, 1968—Election Day—No Meeting.

Meeting of November 19, 1968

Doctor David Miller presided; 10 members and 4 guests were present. Dr. Elsie Klots noted that the Danish Entomological Society had recently celebrated its 100th Anniversary. Dr. Klots also reported that congratulatory telegrams from Dr. Jerome Rozen and Mr. Raymond Bush were received too late to be read at the Society's 75th Anniversary Dinner. Mr. Joseph Concello, Jr. of the Peabody Museum of Natural History and Mr. Gerald Benham of the Dept. of Entomology at the University of Rhode Island were proposed for active membership. Mr. Louis Kudon of Narraganset, R.I. was proposed for student membership.

PROGRAM. **Spider Beetles in Ant Nests** by Dr. John Lawrence of Harvard University.

HOWARD R. TOPOFF, *Sec.*

Meeting of December 3, 1968

President David Miller presided; 17 members and 8 guests were present. Secretary Topoff read letters from Dr. Charles Alexander and Mr. Rowland McElvare expressing their appreciation of election to Honorary Membership in the Society. Mr. Joseph Concello, Jr. of the Peabody Museum of Natural History and Mr. Gerald Benham of the Dept. of Entomology at the Univ. of R. I. were elected to active membership. Mr. Louis Kudon of Narraganset, R.I. was elected to student membership. Mr. Dominick Pirone informed the Society that the Tri-State Highway Commission was planning an expressway running from Peekskill to New Haven which would have a major interchange in the southern part of Westchester County's Ward Pound Ridge Reservation. Upon motion made by Mr. Teale and duly seconded the membership agreed that the Society express to the Tri-State Highway Commission its opposition to such use of public park and forest preserve. Copies of the letter are to be sent to the Connecticut Entomological Society, the American Entomological Society, and the Dept. of Limnology of the Philadelphia Academy of Natural Sciences.

PROGRAM. **Morphological Trends in Several Populations of Grasshoppers** by Dr. Nick Jago of the Academy of Natural Sciences in Philadelphia. (An abstract follows.)

Howard R. Topoff, *Sec.*

MORPHOLOGICAL TRENDS IN SEVERAL POPULATIONS OF GRASSHOPPERS

(and their bearing on an understanding of possible speciation mechanisms in the groups concerned)

1. The grasshoppers reviewed belong to the Palaearctic-Ethiopian sub-family Calliptaminae. Their general habitat preferences, and some points of anatomical and behavioural interest were noted.

2. The species distribution and intraspecific population variation in *Calliptamus* are strongly suggestive of speciation resulting from isolation of populations in the last glacial/interglacial phase in Europe, Asia, and North Africa (20,000 to 30,000 years). The genus is split into two groups with different tolerance to aridity and pluvial conditions. The theory of stasipatric speciation (White and later Key) was discussed in relation to explanation for existence of different geographical colour forms in the genus.

In Africa speciation may well have resulted from parallel hypo/hyperthermal phases on that continent producing similar isolating effects, with the alternate growth and disappearance of semidesert and desert corridors, or forest barriers.

3. In Africa south of the Sahara the effect of daylength mechanisms, closely tied to timing of the rains in Panequatorical Africa, seems in the past and at present to be an additional mechanism producing temporal and geographical isolation of breeding populations. Such processes may perhaps still be seen operating in *Acorypha* at infraspecific level.

4. It is assumed that recent glacial/interglacial and hypothermal/hyperthermal correlations suggest by Coetzee for East Africa are true. The climate of East Africa was discussed briefly to show how the present regime allows the coexistence of hypothermally and hyperthermally adapted sections of the genus *Acorypha.*

5. It was suggested that species may have evolved along similar lines in other groups in tropical Africa, e.g. Mormyridae-fishes with curious species pairs. Considering the great effect of seasonal variation on river flow it is not unlikely that marine and freshwater life may have been similarly affected. Daylength mechanisms could still operate to trigger maturation and other subtle ecological adaptations induce isolation and species divergence.

N. Jago

Meeting of December 17, 1968

Doctor David Miller presided; 16 members and 6 guests were present. Mr. Joseph Routh of Armonk, N.Y. was proposed for active membership. Mr. Stanley Mallcom of the Dept.

of Biology of the City University and Mr. Ginter Ekis of the Dept. of Entomology at Rutgers were proposed for student membership.

PROGRAM. **Two Naturalists in South America.** Mr. and Mrs. Bernard Heineman described their recent travels up and down South America and illustrated their talk with color slides.

Howard R. Topoff, *Sec.*

Meeting of January 7, 1969—The Annual Meeting

President David Miller presided; 13 members and 5 guests were present. Mrs. Patricia Vaurie, Asst. Treasurer, read a preliminary report of the Treasurer. Dr. Forbes, Editor of the **Journal** pointed out that while the regular quarterly dates of publication had not been met, volume **76** for 1968 will contain over 300 pages which is 70 pages more than the average of the three previous volumes. Mr. Robert Buckbee reported briefly on arrangements being made to resume publication of **Entomologica Americana** under the editorship of Dr. James Slater. The Nominating Committee, consisting of Dr. Jerome Rozen, Miss Anna Flaherty, and Mr. Robert Buckbee presented the following slate of officers for the year 1969:

President—David Miller
Vice-president—Lee Herman
Treasurer—Winifred Trakimas
Assistant Treasurer—Patricia Vaurie
Secretary—Howard R. Topoff
Assistant Secretary—Michael Boshes
Trustees (for two year terms): Elsie Klots
Bernard Heineman
Publication Committee:
Lucy Clausen, John Schmitt, and Asher Treat

There were no further nominations and upon motion made and duly seconded the Secretary was instructed to cast one ballot for the unanimous election of the above mentioned candidates.

Mr. Joseph Routh of Armonk, N.Y. was elected to active membership.

Mr. Stanley Mallcom of the Dept. of Biology of the City University and Mr. Ginter Ekis of the Dept. of Entomology at Rutgers were elected to student membership.

PROGRAM. **Wildlife, Past, Present and Future in the New Jersey Pine Barrens.** Mr. Ginter Ekis, substituting for Dr. Howard Topoff who was ill, showed color slides of amphibians, reptiles, birds, mammals, and insects to illustrate his studies in this area. Many of the animals are nocturnal and Mr. Ekis explained his technique in photographing these subjects.

James Forbes, *Sec., pro tem.*

Meeting of January 21, 1969

Doctor Miller presided; 23 members and 7 guests were present. The Annual report of the Treasurer, submitted by Mr. N. Shoumatoff was accepted and incorporated into the records of the Society. Dr. Daniel Sullivan of Fordham Univ. was proposed for active membership. Mr. William Krinsky of Yale University School of Medicine was proposed for student membership. Mr. Heineman proposed Dr. Alexander B. Klots and Dr. Asher Treat for

Honorary Membership. Dr. Miller reported that the Society had reached an agreement with the Steckert-Hafner Service Agency to handle back issues of its publications. (See: **J. N. Y. Entomol. Soc., 77:** 39.) Dr. Elsie Klots called the Society's attention to an article by Dr. Ethel Tobach in the January issue of **Natural History** about the late Dr. T. C. Schneirla, a member of the Society. (See: **J. N. Y. Entomol. Soc., 76:** 175.)

PROGRAM. **In Search of the Black Bees of Morocco and the White Bees of South Africa.** Dr. Jerome Rozen discussed the special relationship of two kinds of burrowing bees to their surroundings and illustrated his talk with many colored slides.

Howard R. Topoff, *Sec.*

Meeting of February 4, 1969

President Miller presided; 18 members and 6 guests were present. Dr. Daniel Sullivan of Fordham University was elected to active membership, and Mr. William Krinsky of the Yale University School of Medicine was elected to student membership. Dr. Alexander Klots and Dr. Asher Treat were elected to Honorary Membership. In recognition of these two new honorary members, Dr. Topoff cited the services that both men had rendered to the Society over a period of many years, to the City University, and to the biological sciences. (See: **J. N. Y. Entomol. Soc., 77:** 130.) Mr. Christopher Stephens of New York City, Mr. David Franklin of Elmsford, N.Y., and Mr. Robert Bechtel of the Nevada Dept. of Agriculture were nominated for active membership. Miss Diane Witwer of Kent State University was proposed for student membership.

PROGRAM. **To Fly, To Creep, To Burrow—How Beetles Get To and Flourish Everywhere.** Mr. Tom Hlavac of Harvard University discussed relationships between the habitat and movement of beetles and the functional morphology of their thoraces.

Howard R. Topoff, *Sec.*

Meeting of February 18, 1969

President Miller presided; 12 members and 12 guests were present. Mr. Christopher Stevens of New York City, Mr. David Franklin of Elmsford, N.Y., and Mr. Robert Bechtel of the Nevada Department of Agriculture were elected to active membership. Miss Diane Witwer of Kent State University was elected to student membership. Mr. Frederick Miller of Seaford, N.Y. was proposed for active membership.

PROGRAM. **How We Study Communication in Ants** by Dr. Howard Topoff. (The abstract follows.)

HOW WE STUDY COMMUNICATION IN ANTS

Populations of army ants are characterized by group predation and cyclic behavior consisting of alternating nomadic and statory phases. In the nearctic army ant, *Neivamyrmex nigrescens,* raiding and migrations take place on chemical trails laid down from the hindguts of the workers .

Laboratory tests have shown that individual ant workers are sensitive enough to be able to follow the trail of only one ant running across a piece of filter paper. Although males of *N. nigrescens* are three to four times as large as adult workers, they also can follow the trail of one worker. Immature (callow) workers were tested on these same trails. Callows removed from intact colonies in the field were equally as sensitive to trail chemicals as adult workers. However, callows reared in the laboratory from pupae isolated from their colonies, were significantly less sensitive. The development of trail-following behavior in army ants may be influenced by a form of olfactory conditioning in the immature stages.

Howard R. Topoff

Meeting of March 4, 1969

Doctor David Miller presided; 12 members and 4 guests were present. The Auditing Committee, consisting of Miss Anna Flaherty and Mr. Bernard Heineman reported that they had examined the books and found the Annual Report of the Treasurer to be correct. They commended the Treasurer, Mr. Shoumatoff, on the excellent condition of the financial records. Mr. Frederick Miller of Seaford, N.Y. was elected to active membership. Mr. Richard Schaffer, a visitor, exhibited insects collected by him in Vietnam.

PROGRAM. **The Digestive System and Genitalia of Some Beetles** by Dr. A. P. Gupta of the Department of Entomology at Rutgers the State University. He also showed color slides made in the summer of 1968 when he attended the International Entomological Congress held in Moscow.

Winifred Trakimas, *Sec., pro tem.*

Meeting of March 18, 1969

President David Miller presided; 14 members and 6 guests were present. Dr. A. P. Gupta of the Department of Entomology at Rutgers and Dr. Paul Shubeck of Montclair State College were proposed for active membership. Miss Jeural Singleton of Grand Forks, North Dakota, was proposed for student membership.

PROGRAM. **Song of the Katydids** by Dr. Michael Emsley of the Academy of Natural Sciences in Philadelphia. (An abstract follows.)

Howard R. Topoff, *Sec.*

SONG OF THE KATYDIDS

For many years laymen and scientists have known that different species of katydids sing different songs. The almost exclusive dependence upon sound for sexual selection has been responsible for a conservative morphology which has made the taxonomy of Tettigoniidae very difficult. Perhaps it was because of traditional mounting techniques and care for the conservation of the specimen that the sound producing organ that lies beneath the base of the left tegmen had not been thoroughly examined before. Now that these organs have been studied it is apparent that the number and linear spacing of the teeth on the stridulatory file is a prime specific character, and can be presented graphically for publication. The talk was illustrated with colored transparencies of whole insects and their stridulatory organs, together with tape recordings of their songs.

Michael Emsley

Meeting of April 1, 1969

President Miller presided; 16 members and 3 guests were present. Dr. A. P. Gupta of the Department of Entomology at Rutgers University and Dr. Paul Shubeck of Montclair State College were elected to active membership. Miss Jeural Singleton of Grank Forks, North Dakota, was elected to student membership.

PROGRAM. **Bird Plumage as an Insect Attractant** by Mr. John Morony, a member of the Department of Ornithology of the American Museum of Natural History, discussed relationships between bird plumage colors and their feeding habits.

Howard R. Topoff, *Sec.*

Meeting of April 15, 1969

Vice-president Lee Herman presided; 9 members and 12 guests were present. Dr. T. D. Sargent of the Department of Zoology at the University of Massachusetts was nominated for active membership. Mr. Howard Harris of the Department of Entomology at Clemson University and Mr. Joseph Hengst of Valley Stream, Kentucky were nominated for student membership.

PROGRAM. **Cave Entrance Communities.** Dr. Richard Graham discussed ecological relationships between animals living in zones of varying distance from cave entrances.

Howard R. Topoff, *Sec.*

Meeting of May 6, 1969

President Miller presided; 11 members and 2 guests were present. In the absence of the Secretary Dr. Winifred Trakimas served as secretary *pro tempore.*

Dr. T. D. Sargent of the Department of Zoology at the University of Massachusetts was elected to active membership. Mr. Howard Harris of the Department of Entomology at Clemson University and Mr. Joseph Hengst of Valley Stream, Kentucky were elected to student membership.

PROGRAM. **Certain Diseases Transmitted by Mosquitoes.** Dr. Dominic Do-Van-Quy of Fairleigh Dickinson University discussed the biology, ecology, and genetics of two disease-producing mosquitoes in South Vietnam.

Winifred Trakimas, *Sec., pro tem.*

Meeting of May 20, 1969

President Miller presided; 19 members and 5 guests were present. Dr. Dominic Do-Van-Quy was nominated for active membership. Since this meeting will be the last for the spring session, with the next meeting not scheduled until October, the membership unanimously agreed to suspend the By-laws and elect Dr. Do-Van-Quy immediately.

President Miller explained that the N. Y. Entomological Society had a Trust Fund administered by the First National Bank of New York. The capital value has declined from $4,000.00 in 1964 to approximately $3,300.00 currently. The Executive Committee at a meeting held this afternoon at 5:15 P.M. agreed to convert to cash and deposit the cash in a savings account. Since, under an agreement signed in 1917, ¾ of the membership of the Society must agree to any transfer of these funds, Dr. Miller further explained that a letter will be received by every member asking that the enclosed form be signed and returned to the Society so that the Society will be authorized to liquidate this trust fund.

PROGRAM. **Are Taxonomists Antievolutionists?** Mr. Conor Duggan of Fordham University was the speaker. (An abstract follows.)

Howard Topoff, *Sec.*

ARE TAXONOMISTS ANTIEVOLUTIONISTS?

This study examines the role of various conceptual frameworks in the theory and practice of Systematics. A conceptual framework refers to the context in and through which man views the world. The framework specifies the investigator's presupposition (presuppositions which are not usually questioned) and such presuppositions determine the kinds of questions asked and the types of problems to be dealt with in the investigation. Scientific progress then may be looked upon as the synthesis and replacement of successive scientific conceptual frameworks.

The history of systematics serves to illustrate the all-persuasive influence of a framework upon the investigator. For instance, the Greeks, with their static picture of the world, viewed organisms as fixed kinds or types. Deviation from this fixed type was an imperfect manifestation of what was real and consequently change to them was an illusion. This type of thinking played an important role among 18th and 19th century biologists. Those who accepted it (e.g. Linnaeus, Cuvier, Agassiz, etc.) had to deny the reality of evolution; while those who accepted evolution (e.g. Darwin, Lamarck) refused to acknowledge the reality of taxonomic categories.

This confrontation of frameworks (systematics emphasizing static essences and evolution stressing process and change) was resolved when organisms were viewed in terms of dynamic interbreeding populations rather than as individual types. This conceptual revision in populational dynamics is the basis upon which both the synthetic theory of evolution and the systematics of today depend.

C. Duggan

INDEX TO SCIENTIFIC NAMES OF ANIMALS AND PLANTS

VOLUME LXXVII

Generic names begin with capital letters. New genera, species, subspecies and varieties are printed in italics. The index does not include Siphonaptera from Northern New York pp. 193–198 and the Arthropod Fauna of Bovine Dung in Central New York and Sources on Its Natural History pp. 210–215.

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