The Great Lakes Entomologist

Volume 8
Number 4 - Winter 1975 *Number 4 - Winter 1975*

Article 1

December 1975

A New Genus, Six New Species, and Records of Protura from Michigan

Ernest C. Bernard
Michigan State University

A NEW GENUS, SIX NEW SPECIES, AND RECORDS OF PROTURA FROM MICHIGAN[1]

Ernest C. Bernard[2]

ABSTRACT

A new genus, *Proacerella* (Acerentomidae), and six new species, *Proacerella reducta, Eosentomon pruni, E. sociale, E. pomari, E. brassicae,* and *Protentomon michiganense* are described from various sites in Michigan. Records of previously described species are also listed for the species *Eosentomon vermiforme* Ewing, *E. wheeleri* Silvestri, *Proturentomon iowaense* Womersley, *Acerentulus confinis* (Berlese), *Amerentulus americanus* (Ewing), and *Yamatentomon barberi* (Ewing).

INTRODUCTION

The Protura listed have been collected from a number of counties throughout the State of Michigan. Specimens collected through 1971 were recovered by the Berlese funnel technique, while most of those collected after 1971 were recovered by the sugar flotation-centrifugation method employed for extracting soil nematodes (Caveness and Jensen, 1955 and Miller, 1957). Collectors are listed where known. Most of the illustrations were made from observations with phase-contrast microscope at magnifications of 1250. Holotypes of new species, and allotypes and some paratypes where applicable, will be deposited in the Entomology Museum, Michigan State University, East Lansing, Michigan, U.S.A.

MORPHOLOGY OF PROTURA

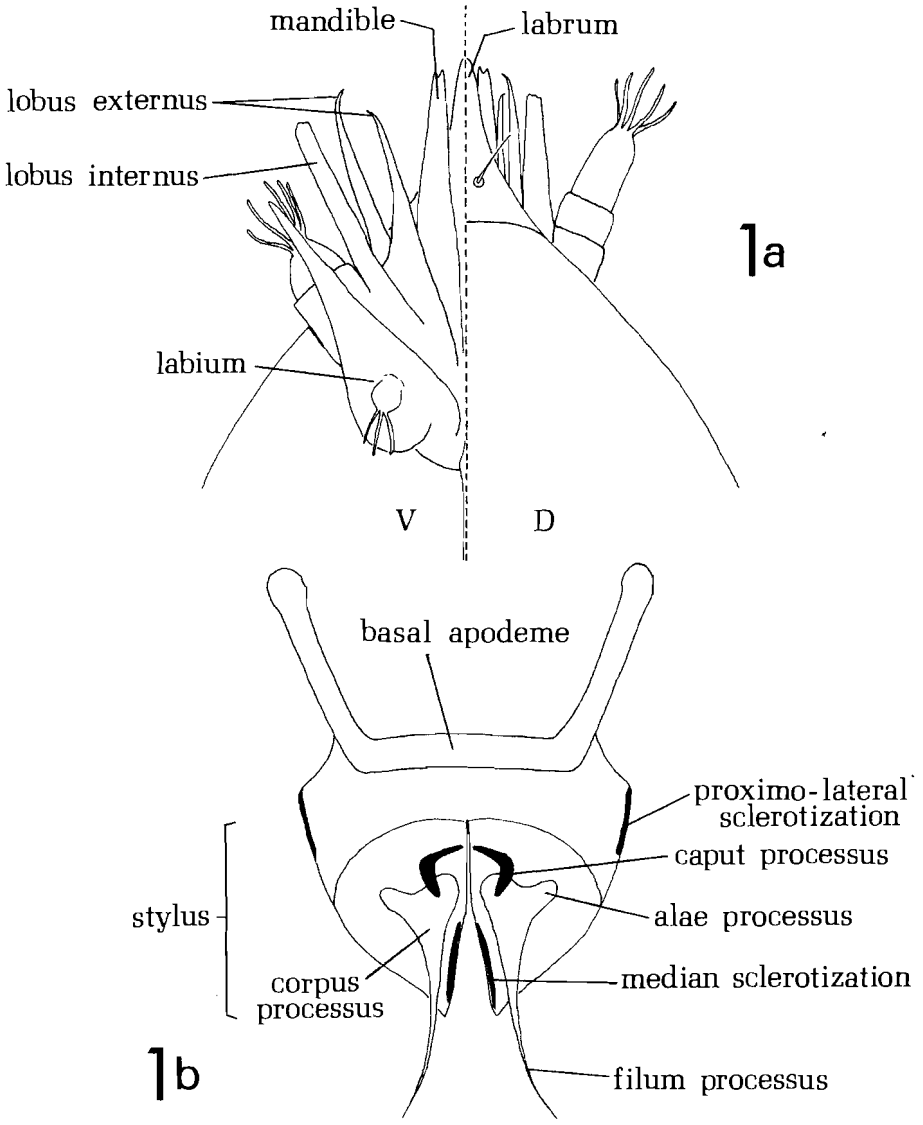
Terminology used in the description of Protura is specialized to the extent that a brief description of the salient characteristics is helpful. Tuxen's monograph (1964) should be consulted for a more complete explanation.

The more important characteristics of the head are the mouthparts, canal of the maxillary gland and pseudoculus (Fig. 1a). The immovable *labrum* projects over the mouthparts and may be elongated and/or notched at the tip. The *mandible* is styliform and possesses a variable number of teeth at the apex (Figs. 3, 50, 69). The *maxilla* is divided into four parts: the lobus externus with two shafts (= lacinia), the lobus internus (= galea), and the palpus. The lobus externus (Figs. 51, 67) is little used in Protura taxonomy. The lobus internus (Figs. 2, 51, 68) may assume different shapes and possess apical spines or blunt processes useful within the genus *Eosentomon.* The *labium* is bilobed, with a small palpus; its importance in taxonomy has not yet been thoroughly studied. Francois (1969) has studied the muscular, glandular, and nervous components of the mouthparts. The *canal of the maxillary gland* (= filamento di sostegno) assumes different shapes among the genera of Acerentomidae. It begins proximally as a large globule or set of globules, narrows and proceeds forward to a round or oval *calyx*, finally extending anteriorly as a narrow tube to the maxilla (Figs. 49, 73). The canal is invisible in cleared specimens of *Eosentomon.* The round or oval *pseudoculus* may have a posterior projection or possess lines and grooves on its surface.

The foretarsus is very important systematically. It bears a number of sensillae and other setae varying in number, arrangement, and size among the species (Figs. 10, 53, 74). The presence or absence of the empodial appendage on the middle and hind tarsi is used in the genus *Eosentomon.*

[1]This study was supported by the Michigan Agricultural Experiment Station, for which this is Journal Article 6944.

[2]Department of Entomology, Michigan State University, East Lansing, Michigan 48824. Present address: Department of Plant Pathology and Plant Genetics, University of Georgia, Athens, Georgia 30602.



Figs. 1a-b. The mouthparts and squama genitalis of Protura. Fig. 1a. Relationship of the mouthparts. Fig. 1b. Terminology of the female squama genitalis of *Eosentomon*.

The abdomen possesses a pair of ventral appendages on each of the first three segments, useful at the family and generic level. The abdominal chaetotaxy is used frequently. Most segments bear an anterior row (a-setae) and a posterior row (p-setae) on both the tergum and sternum. The chaetotaxic charts are set up so the a-setae number appears above the p-setae number, when two rows are present on a segment. A large gland with a dorsal cover exists on either side of the 8th abdominal tergite. The cover is either untoothed (*Eosentomon*) or it may be toothed to varying degrees (a "comb") in Protentomidae and Acerentomidae.

The female genital structure, the *squama genitalis,* consists of a prominent basal apodeme with two large somewhat triangular pieces, the *styli* attached to it by apparently membranous tissue. Within the genus *Eosentomon,* each stylus has a group of sclerotized structures collectively termed the *processus sternalis.* The processus sternalis is divided into a distinctively-shaped dorsal *caput processus,* a ventral *corpus processus* of variable size, usually triangular, with a distal filament, the *filum processus.* The corpus processus may expand laterally to form "wings"; these wings are the *alae processus.* Other sclerotizations may be present along the inner or outer edges of the styli (terminology from Tuxen, 1964) (Fig. 1b).

Ratios are sometimes used to further characterize species:
LR = length of head/length of labrum;
PR = length of head/length of pseudoculus;
TR = length of foretarsus/length of claw;
EU = length of empodial appendage/length of claw.

Family EOSENTOMIDAE

Genus **EOSENTOMON** Berlese, 1909

Eosentomon vermiforme Ewing

(Figs. 2-3)

Eosentomon vermiforme Ewing, 1921. Proc. Entomol. Soc. Wash. 29:193 figs. 1-2.

Two specimens collected from soil near Fife Lake, Grand Traverse County, Michigan, September, 1965: one male and one female. These individuals exhibit an outer lobus externus with minute denticles on the interior side (Fig. 2).

Eosentomon wheeleri Silvestri

(Figs. 4-5)

Eosentomon wheeleri Silvestri, 1909. Atti. Accad. Lincei 18:8.

One specimen, a female, from Kellogg Forest, Kalamazoo County, Michigan, 13 August, 1963, H. O. Schooley, coll. This individual differs from the description in Tuxen (1964) in the location and length of the accessory p-setae on tergite VI (Fig. 5).

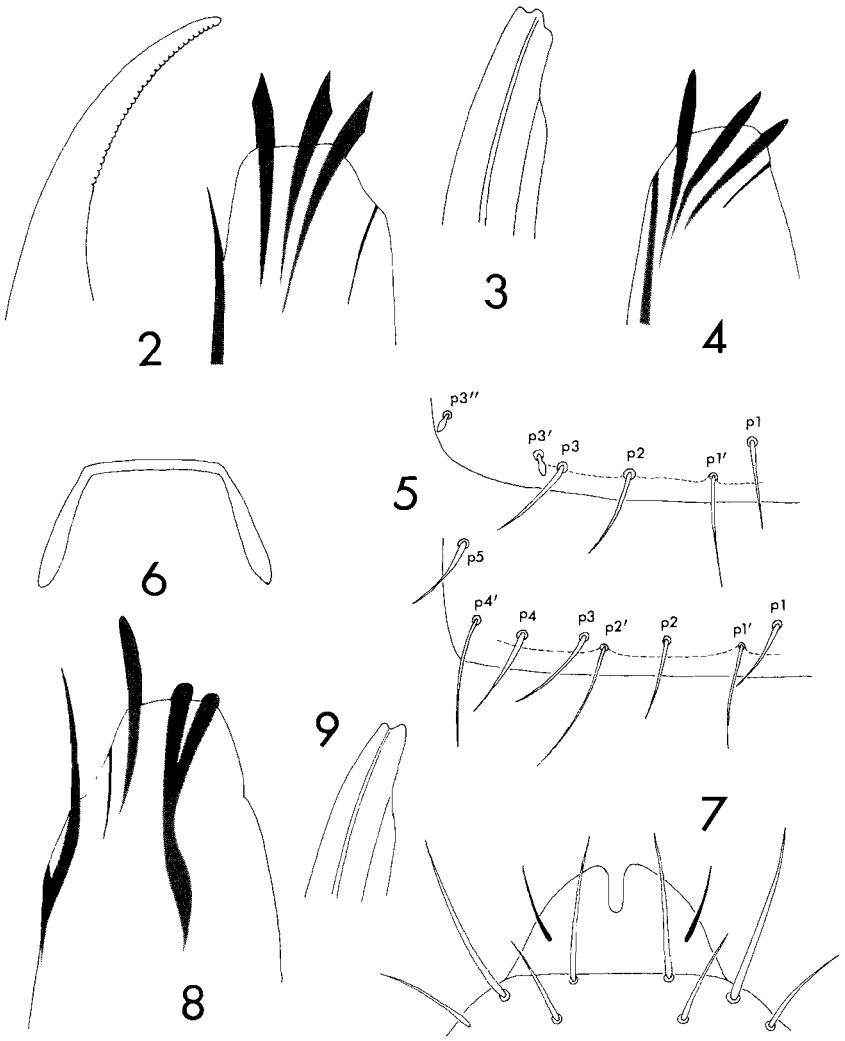
Eosentomon pruni, new species

(Figs. 6-13)

Color and Dimensions.—Body color whitish translucent with moderate yellowish sclerotizations. Length of body, 948 μm; length of head, 87 μm; length of foretarsus without claw, 64 μm.

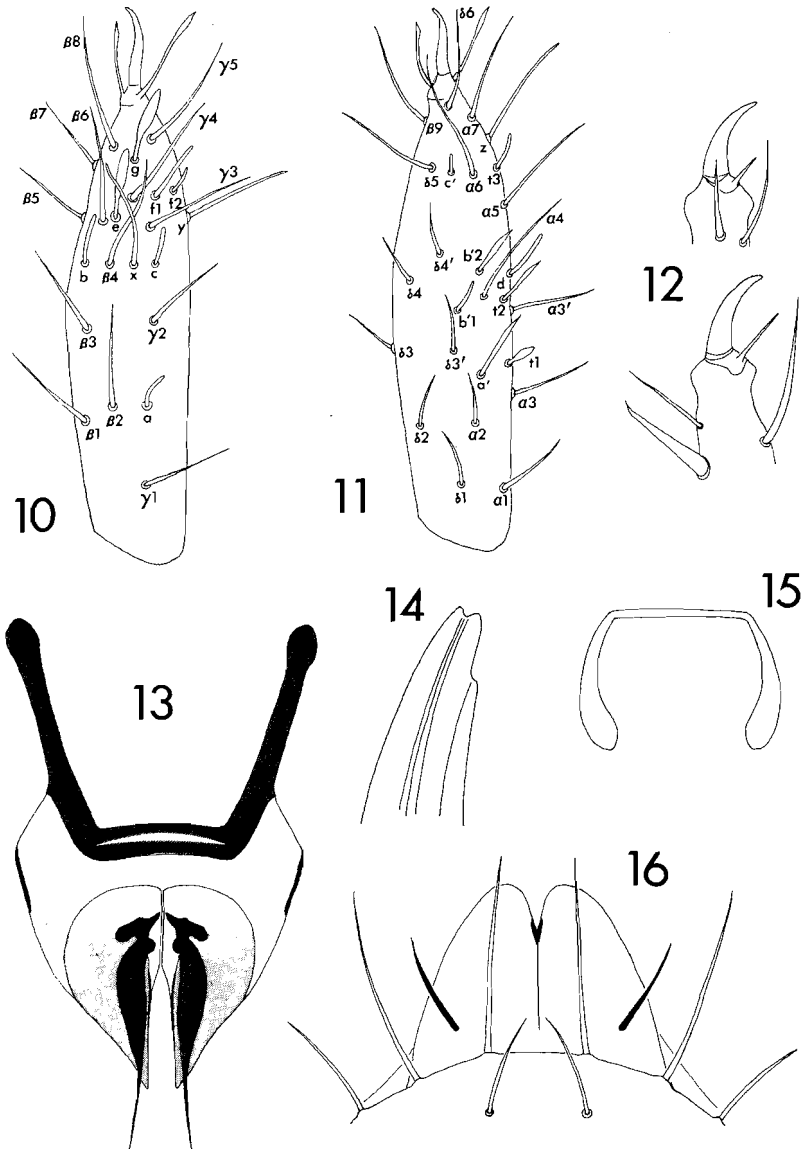
MORPHOLOGY

Head.—Pseudoculus similar to other *Eosentomon,* round and somewhat indistinct, PR = 8.6. Clypeal apodeme (Fig. 6) with slender bulbs and a slender distal transverse connection. Labrum (Fig. 7) only slightly developed, with a medium u-shaped notch; labral setae present. Mandible (Fig. 9) with two terminal, rounded, weak teeth and an inner subterminal expansion. Lobi externi as in most other *Eosentomon,* without denticles. Lobus internus (Fig. 8) moderately broad, with outer spine, median digit, and



Figs. 2-3. *Eosentomon vermiforme* Ewing. Fig. 2. Outer lobus externus (1e 1), and lobus internus. Fig. 3. Mandible. Figs. 4-5. *Eosentomon wheeleri* Silvestri. Fig. 4. Lobus internus. Fig. 5. Posterior setae of tergites I and VI, left side. Figs. 6-9. *Eosentomon pruni* n.sp. Fig. 6. Clypeal apodeme. Fig. 7. Labrum. Fig. 8. Lobus internus. Fig. 9. Mandible.

two short inner digits fused at their bases; other thickenings as shown. Maxillary palpus similar to those of other *Eosentomon,* but the inner sensilla is longer, reaching to the base of the inner subterminal seta. Lamina labii broadly and smoothly rounded distally; labial palpus of usual type.



Figs. 10-13. *Eosentomon pruni* n.sp. Fig. 10. Foretarsus, exterior view. Fig. 11. Foretarsus, interior view. Fig. 12. Claws of middle and hind legs. Fig. 13. Female squama genitalis. Figs. 14-16. *Eosentomon sociale* n.sp. Fig. 14. Mandible. Fig. 15. Clypeal apodeme. Fig. 16. Labrum.

Thorax.–Claw of foretarsus relatively short, TR = 5.8. EU = 0.85. Empodia of middle and hind legs long, EU II = 0.407, EU III = 0.652 (Fig. 12).

Abdomen.—Central lobe of praecosta entire, not indented. Female squama genitalis (Fig. 13) without stout basal apodemes and a caput processus shaped like the head of a hammer; corpus processus with fairly parallel sides; filum processus of medium length; apex styli bluntly pointed. Male squama genitalis of usual shape, basal apodemes long; acrostylus with a proximal widening.

CHAETOTAXY

Head.—Rostral setae present (Fig. 7).

Thorax.—Prothorax—2 + 2 seta dorsally, 7 + 7 seta ventrally;
mesothorax—4 + 4 anterior setae and 7 + 7 posterior setae dorsally, 4 + 4 anterior setae and 3 + 3 setae ventrally;
metathorax—4 + 4 anterior setae and 7 + 7 posterior dorsally, 5 + 5 anterior setae and 4 + 4 posterior setae ventrally.
In addition to the above setae there are 3 + 3 setae below the antero-lateral part of the tergal sclerite of the mesothorax, and 1 + 1 setae in the same area of the metathorax.

Foretarsus.—All sensillae and setae present. Sensilla a not reaching $\gamma 2$; b, b′2, d, and f1 of about the same length, f1 twice as long as f2; Sensilla c not very long, just reaching $\gamma 3$; b′1 just distal to $\delta 3'$; e and g spatulate; a′ long, reaching $\alpha 3'$, c′ present and of normal length. Sensilla t1 of usual shape, situated midway between $\alpha 3$ and $\alpha 3'$; t2 and b′2 of the same shape; t3 only slightly longer than c′; setae x, y, and z distinctly sensilliform (Figs. 10, 11).

Abdomen.—Abdominal chaetotaxy is as follows:

	I	II-III	IV-VI	VII	VIII	IX-X	XI	XII
Tergum	4 / 12[b]	10 / 16	8[a] / 16	8[a] / 16	6 / 9	8	8	6 / 3
Sternum	4 / 4	6 / 4	6 / 10	6 / 10	2 / 7	6	8	8 / 4

[a] a3 missing
[b] outer pair of sensillae on each side (p3′, p3″)

Accessory seta p1′ of terg. I-IV more than twice as long as p1; p2′ of terg. II-VI more than twice as long as p2′; in terg. VII, p1′ half the length of p1, p2′ longer than p2.

Discussion.—*Eosentomon pruni*, n.sp., falls into the *saharense*—group of Tuxen (1964), and is perhaps closest to *E. udagawai* Imadate (1961) and *E. saharense* Conde (1951). From the former it differs in the following ways: sensilla c and b′1 short, instead of long; labral setae present, PR = 8.6 instead of 10; empodium of tarsus II much longer; terg. VII with eight rather than six a-setae; alae of corpus processus absent. From *E. saharense*, it can be separated by: the presence of labral setae; f1 long instead of short; chaetotaxy of terg. VII and stern. IX-X; and the absence of alae of the corpus processus.

Collection Data.—14 October, 1973, holotype female, allotype male, and one other paratype male from soil at the base of a large American Plum (*Prunus americanus* Marsh.), at Monahan Lake, Livingston County, Michigan, E. C. Bernard, coll.

Eosentomon sociale, new species

(Figs. 14-23)

Color and Dimensions.—Body whitish with yellowish sclerites on the last several abdominal segments. Length of adult, 907 μm; length of maturus junior, 844 μm. Length of adult head, 95 μm; length of maturus head, 88 μm. Length of adult foretarsus without claw, 66 μm; length of same in maturus junior, 62 μm.

MORPHOLOGY

Head.–Pseudoculus round with three rather faint longitudinal lines; PR = 10. Clypeal apodeme (Fig. 15) with pear-shaped bulbs and a thin anterior transverse connection. Labrum (Fig. 16) one-tenth the length of the head, with a V-shaped notch anteromedially; one pair of labral setae present near the hind margin.

Mandible (Fig. 14) with two pronounced apical teeth and a subapical tooth formed by the expansion of the mandible.

Lobi externi of maxilla similar to other *Eosentomon,* without denticles or teeth on the inner surfaces. Lobus internus (Fig. 17) fairly broad with a strong exterior spine, a moderately pointed median digit and two moderately produced interior digits, the more medial of these clubbed terminally. Maxillary palpus similar to the preceding species (*E. pruni*) (Fig. 18). Labium similar to the preceding species: apices rounded, labial palpi of the usual type (Fig. 19).

Thorax.–Claw of foretarsus very short, TR = 6.9; EU = 0.85. Empodium of middle leg about one-fourth the length of the claw; empodium of hind leg longer, about two-thirds the length of the claw (Fig. 22).

Abdomen.–Central lobe of praecosta not indented.

Squama genitalis of female (Fig. 23) distinctly seen: basal apodemes of ordinary thickness, caput processus tapering smoothly forward, gently curved; corpus processus roughly triangular, prolonged proximally into the shape of a horse head; median sclerotizations of stylus present. Alae processus weakly developed; filum processus very long. Male squama genitalis of the usual type.

CHAETOTAXY

Head.–Rostral setae present (Fig. 16).

Thorax.–Chaetotaxy of this species exactly as that of the preceding species, *E. pruni.*

Foretarsus.–Sensilla b′1 absent. Sensilla a short, not reaching $\gamma 2$; b, c, t2, d, b′2, and t3 all about the same length; sensilla c not reaching $\gamma 3$; d nearly reaching $a5$, sensillae e and g spatulate; f1 twice the length of f2; setae x, y, and z sensilliform; t1 situated closer to $a3$ than to $a3'$; sensilla a′ reaching $a3'$, sensilla c′ present, level with $a6$ (Figs. 20-21).

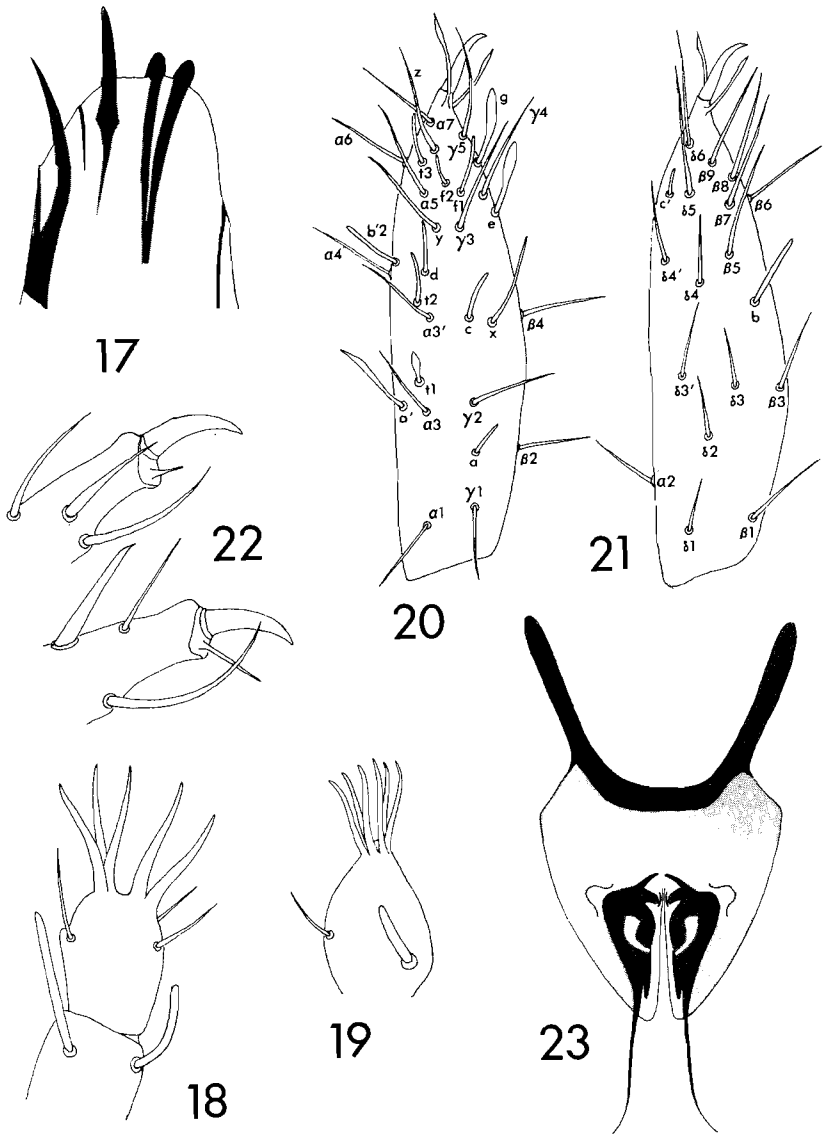
Abdomen.–Abdominal chaetotaxy is as follows:

	I	II-III	IV	V-VI	VII	VIII	IX-X	XI	XII
Tergum	$\frac{4}{12^c}$	$\frac{10}{16}$	$\frac{10}{16}$	$\frac{8^a}{16}$	$\frac{6^b}{16}$	$\frac{6}{9}$	8	8	$\frac{6}{3}$
Sternum	$\frac{4}{4}$	$\frac{6}{4}$	$\frac{6}{10}$	$\frac{6}{10}$	$\frac{6}{10}$	$\frac{2}{7}$	4	8	$\frac{8}{4}$

[a]a3 missing.
[b]a1, a3 missing.
[c]outer pair of sensillae on each side (p3′, p3″).

Accessory setae p1′ and p2′ somewhat less than twice as long as p1 and p2, except on terg. VII where p1′ is only half the length of p1 and p2′ is only a little longer than p2. One adult specimen is missing a5 on tergite III.

Discussion.–Eosentomon sociale, n.sp., lies fairly close systematically to *E. pallidum* Ewing (1921b), but differs from it in several ways: pseudoculus larger (PR = 10 rather than 15); sensilla b′1 of foretarsus absent, all sensillae of moderate length, c not reaching $\gamma 3$; seta a2 of tergite VII present, two instead of 4 a-setae present on sternite VIII, only 4, instead of 6 setae on sternites IX and X; corpus processus of female squama genitalis much smaller than in *E. pallidum. E. sociale* also has similarities with *E. udagawai* Imadate (1961), but is separated from it by the structure of the female squama genitalis, the



Figs. 17-23. *Eosentomon sociale* n.sp. Fig. 17. Lobus internus. Fig. 18. Maxillary palpus. Fig. 19. Labial palpus. Fig. 20. Foretarsus, exterior view. Fig. 21. Foretarsus, interior view. Fig. 22. Claws of middle and hind legs. Fig. 23. Female squama genitalis.

absence of b′1 in the foretarsus, and the presence of only four setae on sternites IX and X, rather than six.

In Tuxen (1964) this species keys to couplet six, but does not fit either of the alternatives. In Imadate's *Eosentomon* key (1965) it keys to *E. udagawai* in couplet 21.

Collection Data.—14 October, 1973, holotype female, two paratype females, allotype male, and two maturi juniores, from soil at the same site and locality as the preceding species at Monahan Lake, Livingston County, Michigan; and 25 July, 1972, one male from plowed bare soil, Belding sewage treatment area, Ionia County, Michigan.

Eosentomon pomari, new species

(Figs. 24-30)

Color and Dimensions.—Body whitish-translucent with weak yellow sclerotization of the abdominal segments. Various dimensions of the life stages as follows (means in μm):

	Body Length	Head Length	Foretarsus Length
LI	650 μm	85 μm	44.1 μm
LII	667	82	50.6
M.J.	785	84.5	53.6
Adult	913	88.5	59.9

MORPHOLOGY

Head.—Pseudoculus round with a single, faint, median longitudinal line; PR = 10.1 for adult females. Clypeal apodeme narrow, with very bulbous proximal ends (Fig. 24). Labrum short with a V-shaped notch anteromedially, the tip of the labrum concave; labral setae absent (Fig. 25). Mandible tridentate with two large terminal teeth and a small subterminal tooth; five striae present on surface (Fig. 27).

Lobi externi of maxilla without denticles. Lobus internus (Fig. 26) with the usual external spine, long median digit, and two internal digits, also with two small thickened lines between the exterior spine and the median digit. Labium similar to other *Eosentomon.*

Thorax.—Claw of foretarsus short, TR of adult = 6.62; EU = 0.9. Empodia of both the middle and hind legs short.

Abdomen.—Central lobe of praecosta slightly concave on anterior edge.

Squama genitalis (Fig. 30) of the female with basal apodemes short and heavy; caput processus composed of a wide proximal portion narrowing anteriorly to form a transverse bar; corpus processus small and slender; alae processus fairly large but situated near the middle of each squama lobe, filum processus of medium length. Male squama genitalis not seen.

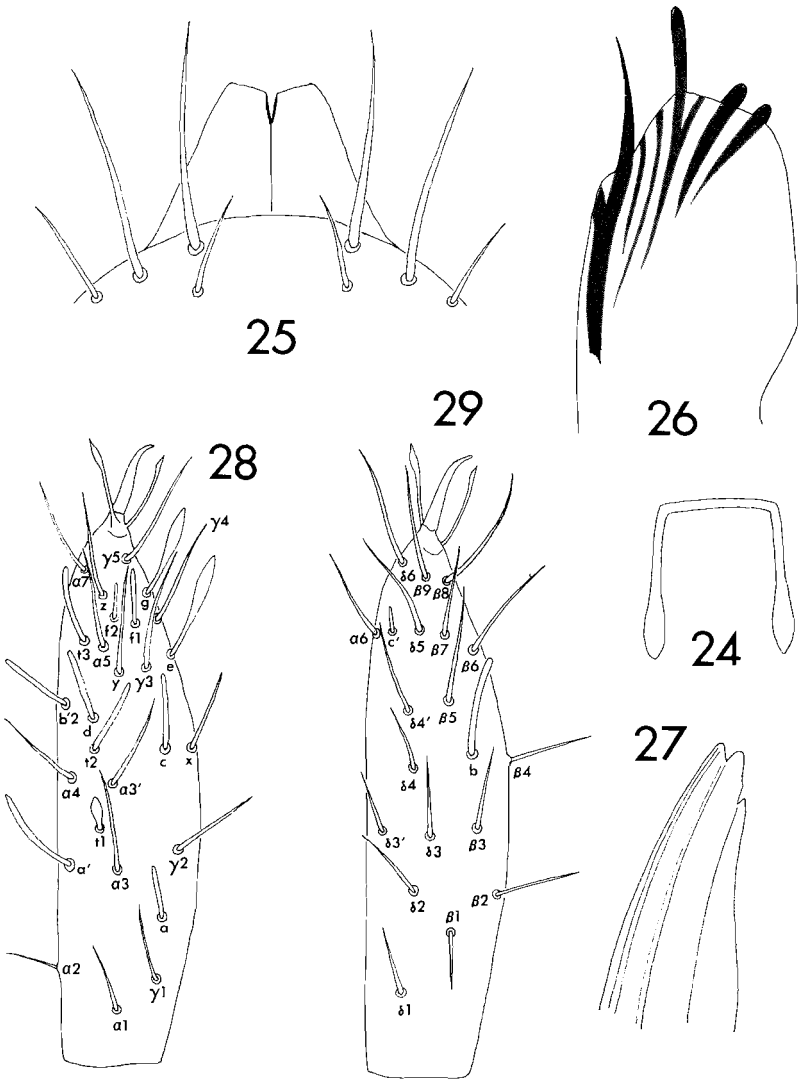
CHAETOTAXY

Head.—Rostral setae present (Fig. 25).

Thorax.—Chaetotaxy of this species exactly as in the preceding two species.

Foretarsus.—Sensilla b′1 absent in all stages. Sensilla a somewhat indistinct but almost reaching γ2; Sensilla b and d long, c shorter; sensillae e and g spatulate; f1 slightly enlarged, almost reaching γ5; sensilla f2 about one-half the length of f1. Sensilla t1 equidistant between α3 and α3′; t2 and t3 similar in size and shape, a′ long, bypassing α4; b′2 similar to t2 and t3, c′ short and level with α6 and δ5 (Figs. 28, 29).

Abdomen.—Abdominal chaetotaxy and variation as in Table 1. Accessory seta p1′ of Abd I-VI equal to p1 in LI, but progressively longer in succeeding stages (almost twice as long as p1 in the adult). Seta p2′ absent in LI, shorter than p3 in LII, slightly longer in the maturus junior, one and one-half times the length of p3 in the adult; on terg. VII, p1′ short; p1′ centered between p1 and p2; p2′, when present, close to p3.



Figs. 24-29. *Esoentomon pomari* n.sp. Fig. 24. Clypeal apodeme. Fig. 25. Labrum. Fig. 26. Lobus internus. Fig. 27. Mandible. Fig. 28. Foretarsus, exterior view. Fig. 29. Foretarsus, interior view.

Discussion.—*Eosentomon pomari,* n.sp., keys in Tuxen's monograph (1964), with difficulty, to *E. westraliense* Womersley (1932) but possesses the following characteristics: pseudoculus small (PR = 10.1) instead of large (PR = 6); c′ short and level with *a*6, not close to b′2; six setae on sternites IX and X, rather than four, and squama genitalis very distinctly different. In Imadate's Asian key (1965), *E. pomari,* n.sp., keys to *E. tokiokai*

Table 1. Abdominal chaetotaxy of *Eosentomon pomari* n.sp.

		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
LARVA I	tergite	8	?	10	2/10	2/10	2/10	2/10	6/7	–	–	–	6/3
	sternite	4/2	2/4	2/4	2/6	2/6	2/6	2/6	2/3	–	–	–	8/3[a]
LARVA II	tergite	12	2/12	4[b]/12	4/14	4/16	4/16	4/16	6/9	–	8	–	6/3
	sternite	4/4	4/4	4/4[b]	4/8	4/8	4/8[b]	4/8	7	–	4	–	8/4
MATURUS JUNIOR	tergite	4/12	10/14	10/14	10[b]/16[b]	10/16[b]	10/16	6/16[c]	6/9	8	8	8	6/3
	sternite	4/4	6/4	6[b]/4	6/10[b]	6/10	6[b]/10	6[b]/10	7	6[b]	4	4	8/4
ADULT	tergite	4/12	10/14[e]	10[b]/14[e]	10[b]/16[b]	10/16[b]	10[b]/16	6[d,f]/16[d]	6/9	8	8	8	6/3
	sternite	4/4	6[b]/4	6/4	6/10	6/10	6/10	6/10	7	6	6	8[b]	8/4

Holotype with fifteen p-setae on tergite IV (asymmetric).

[a]asymmetric.
[b]one seta missing from these rows in one or more specimens.
[c]an extra seta present in this row in one specimen.
[d]three setae missing from this row in one specimen.
[e]p4 ′missing.
[f]a1, a3 missing.

Imadate (1964), but differs from it by the absence of sensilla b′1, the setal patterns of tergites V-VII, six rather than four setae on sternites IX and X, and also in body length, length of head and foretarsus, and in the various ratios. Of the American species described by Copeland (1964), *E. pomari,* n.sp., perhaps falls closest to *E. dureyi,* but the following differences exist: in *E. pomari,* n.sp., b′1 absent, sensilla s without a large terminal club; tergites V, VI, VII with 10, 10, 6 a-setae instead of 8, 8, 4, respectively; squama genitalis with distinct processus sternalis.

Collection Data.—16 August, 1973, holotype female, two paratype females, six maturi juniores, five LIIs, and one LI, from orchard soil, on the Joseph Smiltzer farm near Frankfort, Benzie County, Michigan.

Eosentomon brassicae, new species

(Figs. 31-40)

Color and Dimensions.—Body whitish, with some yellowish sclerotization, more prominent on the abdomen. Length of body, 918 μm; length of head, 85 μm; length of foretarsus without claw, 62 μm.

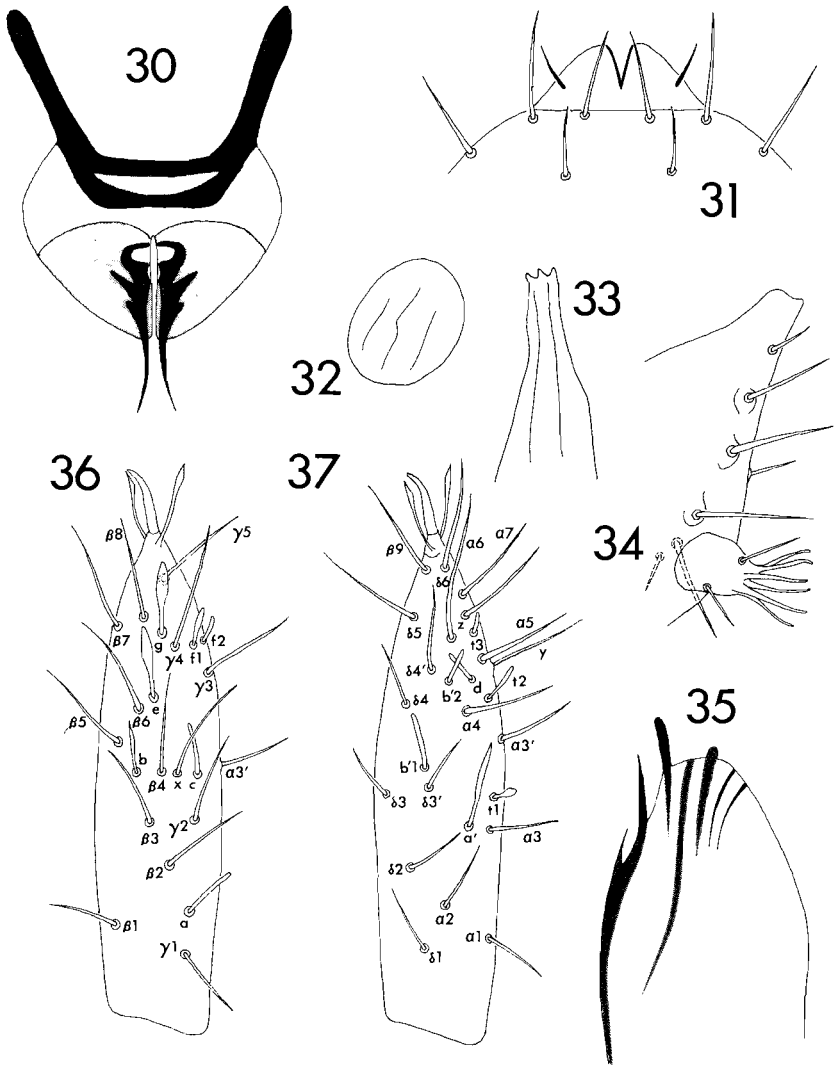


Fig. 30. *Eosentomon pomari* n.sp. Female squama genitalis. Figs. 31-37. *Eosentomon brassicae* n.sp. Fig. 31. Labrum. Fig. 32. Pseudoculus. Fig. 33. Mandible. Fig. 34. Left prelabium, ventral side. Fig. 35. Lobus internus. Fig. 36. Foretarsus, ventral view. Fig. 37. Foretarsus, dorsal view.

MORPHOLOGY

Head.—Pseudoculus (Fig. 32) round, with three longitudinal lines, and very large, PR = 5.6. Clypeal apodeme not visible. Labrum (Fig. 31) small with large V-shaped incision; labral setae present. Mandible with three terminal teeth (Fig. 33). Lobi externi

of the usual type; inner edges smooth, without denticles. Lobus internus (Fig. 35) broad, with an accessory outer proximal spine, the usual outer subterminal spine, and relatively slender median digit, first inner digit reduced, not projecting apically, second inner digit of normal shape, protruding beyond edge of lobus lamella; two slender sclerotizations present interior to the second inner digit. Maxillary palpus similar to other species of *Eosentomon,* inner sensilla not reaching the base of the subterminal setae. Lamina labii (Fig. 34) irregularly concave at tip; labial palp with six terminal appendages.

Thorax.—Claw of foretarsus fairly short, TR = 6.4; EU = 1.0. Empodium of middle leg very short, empodium of hind leg long, EU III = 0.64 (Fig. 38).

Abdomen.—Central lobe of praecosta entire, neither indented nor lobed. Female squama genitalis (Fig. 40) seen in an expanded position: caput processus combined with corpus processus to form a distinct S-shape. Alae weak and small; median sclerotizations present; filum processus very long, much longer than the rest of the corpus processus.

CHAETOTAXY

Head.—Rostral setae of usual type of arrangement (Fig. 31).

Thorax.—Setal arrangement as in the previously described species, *E. pruni.*

Foretarsus.—Sensilla c′ absent. Sensilla a almost reaching $\gamma 2$; b′1 fairly long, almost reaching the base of $\delta 4$; a′ long, almost reaching $\alpha 3'$, t3 very short, barely reaching seta z; sensillae e and g spatulate; f1 slightly enlarged distally, about one and one half times the length of f2, other sensillae short and nondescript. Sensilla t1 closer to $\alpha 3$ than $\alpha 3'$ (Figs. 36-37).

Abdomen.—Abdominal chaetotaxy as follows:

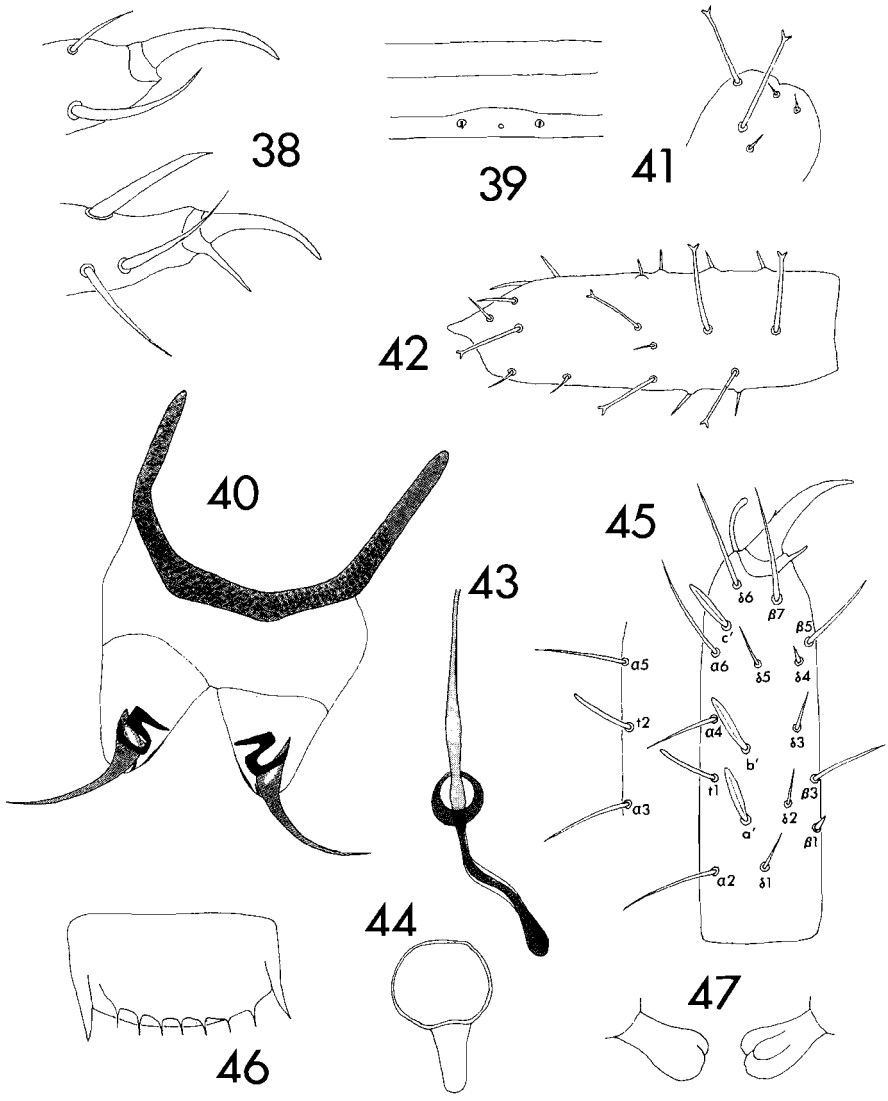
	I	II-III	IV-VI	VII	VIII	IX-X	XI	XII
Tergum	$\frac{4}{12^d}$	$\frac{10^a}{16}$	$\frac{10}{16}$	$\frac{6^b}{16}$	$\frac{6}{9}$	8	6^c	$\frac{6}{3}$
Sternum	$\frac{4}{4}$	$\frac{6}{4}$	$\frac{6}{10}$	$\frac{6}{10}$	$\frac{2}{7}$	6	8	$\frac{8}{4}$

[a]holotype with an extra seta below a4 on right side.
[b]a1, a3 missing.
[c]median pair of setae as microchaetae (Fig. 39).
[d]outer pair of sensillae on each side (p3′,p3″).

Chaetotaxy of LII similar to the LII of the preceding species (*E. pomari*) except that tergites II and III each possess one more pair of p-setae. Accessory seta p1′ of tergites I-VI twice as long as p1, in tergite VII less than half the length of p1; p2′ in tergites II-VII twice the length of p2; p1′ equidistant from p1 and p2, p2′ close to p3.

Discussion.—*Eosentomon brassicae,* n.sp., keys to couplet six in Tuxen (1964), but fits neither of the choices. In both Tuxen's work and Imadate's key (1965), this new species appears to fall closest to *E. udagawai* Imadate (1961). From that species, *E. brassicae* can be differentiated by the presence of labral setae, the absence of sensilla c′, the shape of t3, and the shorter filum processus. Both species possess the very small microchaetae of tergite XI. The most prominent difference is the ratio PR; in *E. brassicae,* PR = 5.6 while in *E. udagawai,* PR = 10.

Collection Data.—27 July, 1973, holotype female, allotype male, one maturus junior in molt, and one larva II, from soil taken from a cabbage field (*Brassica oleracea* L.), Livingston County, Michigan.



Figs. 38-40. *Eosentomon brassicae* n.sp. Fig. 38. Claws of middle and hind legs. Fig. 39. Dorsal microchaetae of tergite XI. Fig. 40. Female squama genitalis. Figs. 41, 42. *Eosentomon* sp. (prelarva). Fig. 41. Oral papilla. Fig. 42. Foretarsus. Figs. 43-47. *Proturentomon iowaense* Womersley. Fig. 43. Canal of maxillary gland (filamento di sostegno). Fig. 44. Pseudoculus. Fig. 45. Foretarsus (edge of exterior side, and entire interior side). Fig. 46. Lid of abdominal gland (comb VIII). Fig. 47. Acrostyli of female squama genitalis.

NOTES ON OTHER MEMBERS OF THE GENUS *EOSENTOMON*

Among the species taken from Monahan Lake (*E. pruni, E. sociale*) was a single prelarva (Figs. 41, 42), most remarkable for the presence of apically bifurcate setae. Since

it was found with the two previously mentioned species, it cannot be assigned to either one.

Counties in which specimens of *Eosentomon* were taken in too few numbers to describe or in larval stages only were: Antrim, Ionia, Tuscola and Wayne.

Family PROTENTOMIDAE

Genus **PROTURENTOMON** Silvestri, 1909

Proturentomon iowaense Womersley

(Figs. 43-47)

Proturentomon iowaense Womersley 1938. Bull. Brooklyn Entomol. Soc. 33:221, pl XII, figs. a-c.

Individuals of this species were collected with the following species (*Protentomon michiganense* n.sp.), from shrubby field, East Lansing, Ingham County, Michigan, 3 December, 1973: eight females, five maturi juniores, two larvae II, and two larvae I. These specimens differ from the type material on the following points: foretarsus (Fig. 45) with t1 and t2 slender, and setae β1 and δ4 very short; lid of abdominal gland (Fig. 46) with fewer teeth (less than nine), often irregularly distributed; acrostyli of female squama genitalis (Fig. 47) with tips divided at apex; other foretarsal and setal characteristics as in the type material.

Genus **PROTENTOMON** Ewing, 1921b

Protentomon michiganense, new species

(Figs. 48-65)

Color and Dimensions.—Body color whitish-translucent in life with some yellow-orange sclerotization of the last four or five abdominal segments; body white in alcohol. Length of body, 715 μm; length of foretarsus without claw, 45 μm. Long slender proturans, the forelegs scarcely extending past the mouthparts.

MORPHOLOGY OF FEMALE

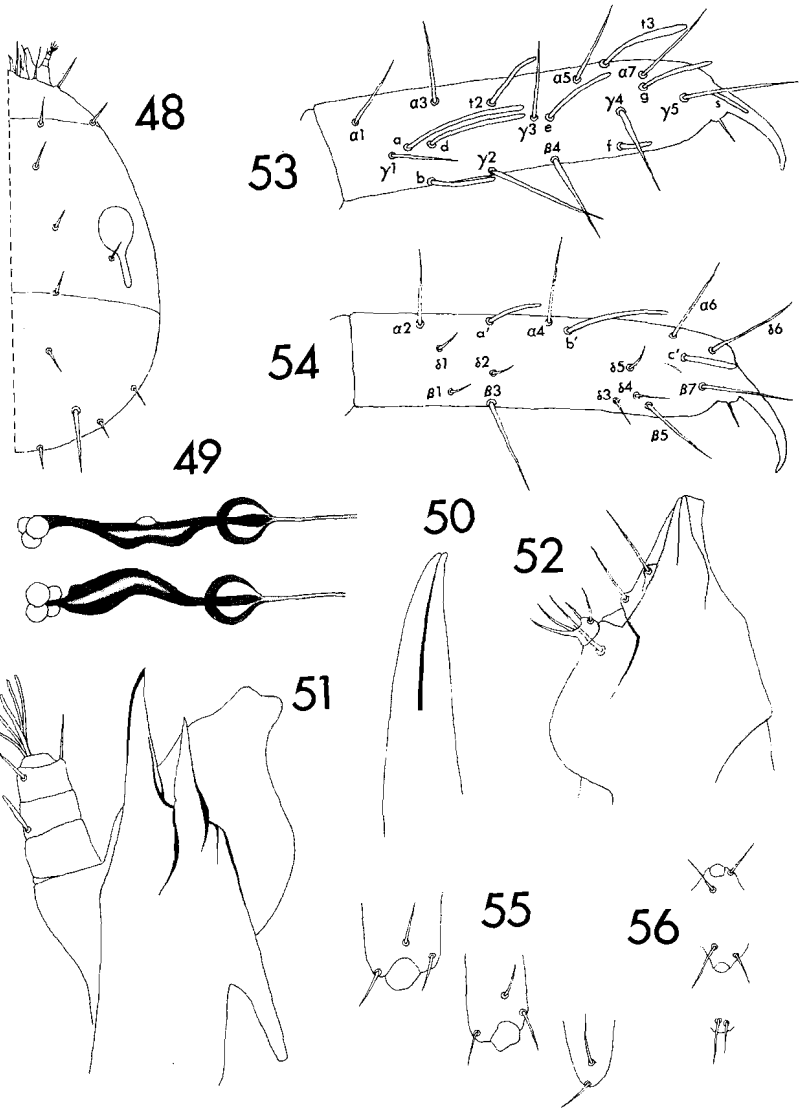
Head.—Pseudoculus similar to those of other *Protentomon*, broadly oval with a long lever, PR = 8.5 (Fig. 48). Canal of maxillary gland (filamento di sostegno) quite variable in appearance (Fig. 49); with two, three or four visible globules proximally, and with or without a turbercle proximal to these globules; calyx very broadly oval, almost round.

Mandible styliform as in other Protura, but unlike other described *Protentomon* by the possession of two small but distinct terminal teeth, the subapical longitudinal groove of the mandible extending distally to the teeth (Fig. 50).

Maxilla (Fig. 51) with lobus internus widest at the base of the maxillary palpus, narrowing anteriorly to a truncated, slightly concave tip. Maxillary palpus four-segmented, with a blunt sensory seta located sub-dorsally to sub-ventrally on the second segment, two pointed setae on the third segment, and five long sensory setae arising from the apex of the fourth segment; the entire palpus is retractile into the outer part of the lobus internus. The lobi externi similar in shape to each other; the outer lobe (le 1) somewhat longer than the inner lobe (le 2) and curved slightly inward; le 2 curved very slightly outward; le 2 with an indentation at the level of its meeting with le 1. Fulcrum and cardo of the usual shape as described by Tuxen (1964).

Labium bilobed, each lobe somewhat triangular in shape (Fig. 52), widest at its base and strongly narrowing anteriorly to a two-toothed process with a thin, sclerotized flap on either side. Palpus apparently one-segmented, with four setae; each lobe of labium with three setae along the exterior edge.

Thorax.—Forelegs short, reaching only slightly past the head. Claw of foretarsus fairly long, TR = 3.3. Empodial appendage longer than in other species of Protentomon, EU = .29.



Figs. 48-56. *Protentomon michiganense* n.sp. Fig. 48. Dorsal view of head, right side. Fig. 49. Two views of canal of maxillary gland (filamento di sostegno). Fig. 50. Mandible, left side. Fig. 51. Head of left maxilla. Fig. 52. Right lobe of labium, ventral view. Fig. 53. Foretarsus, exterior view. Fig. 54. Foretarsus, interior view. Fig. 55. Abdominal appendages of adult. Fig. 56. Abdominal appendages of prelarva.

Abdomen.—Abdominal appendages of adult with 3,3,2 setae (Fig. 55), the apical seta of the third appendage about two-thirds the length of the subapical seta. Lid of the eighth tergite with a smooth or sparsely and irregularly toothed posterior edge (Fig. 57). Tergites X and XI with numerous pectines arranged as in Fig. 58. Toothed pleural and ventral pectines absent. Female squama genitalis is difficult to see clearly, but rather similar to *Protentomon perpusillum* (Berlese) (see Tuxen, 1964); slender basal apodeme, irregularly-shaped perigynium, but with a curving stylus and relatively large, peg-like acrostylus (Fig. 59).

MORPHOLOGY OF PRELARVA

One prelarva near ecdysis was found in the material collected. The body was distorted during mounting, and therefore the description may contain a few errors; however, the following observations were noted.

Head.—Head of prelarva evidently with more setae than the adult. Pseudoculus small, with only a short lever; PR = 10.5 (Fig. 60). Spines present on dorsum of head in two rows, four in the anterior row and two in the posterior row. Two palpi present, each with three setae (Fig. 61).

Thorax.—Forelegs very short and thick; claw and empodial appendage present, TR = 4.5; EU = 0.25. This foreleg is considerably different from that of *Proturentomon discretum* Conde (1961) in that the large dorsal triangular spur of *P. discretum* is absent in this prelarva of *Protentomon,* as in the accessory sensilla "s". In addition, the number and arrangement of setae are different. In *Protentomon* (Figs. 63-64), the setae are shorter, fewer, and all spiniform (no sensillae).

Abdomen.—Abdominal appendages present but reduced, with 2,2,2 setae; terminal vesicles present on the first two pair (Fig. 56). Abdominal segments II thru VIII with posteriorly projecting dorsal spines, these most numerous on segments II, III, IV, V and VIII (Fig. 65).

MORPHOLOGY OF OTHER IMMATURE STAGES

The larva I, larva II, and maturus junior are quite similar to the adult except in certain dimensions, with only the following features somewhat different: lid of tergite VIII more oval and relatively smaller than in the adult; toothed tergal pectines present only in the maturus junior, but the larva II with similar, untoothed plates on the ninth abdominal segment (actually Abd. X in the adult).

CHAETOTAXY OF ADULT

Head.—Setae of the head relatively sparse, dorsal setae confined to two longitudinal rows between the pseudoculi. Posteriorly, 4 + 4 setae present, p2 considerable longer than the others. One seta present near the inner edge of the pseudocular lever (Fig. 48).

Thorax.—Prothorax with 2 + 2 setae along the posterior dorsal edge and with ten setae ventrally. Mesothorax dorsally with an anterior row of 5 + 5 setae and a posterior row of 3 + 3 seta, p1′ a microchaeta; 5 + 5 setae ventrally. Metathorax dorsally with 4 + 4 anterior setae and 3 + 3 posterior setae, p1′ a microchaeta; 6 + 6 setae ventrally.

Foretarsus.—Sensillae t1 and c absent. Sensilla a long and nearly reaching $\gamma 3$; sensilla b only about half as long as a'; sensilla d long, its base very close and just anterior to a', also nearly reaching $\gamma 3$. Sensilla t2 midway between $a3$ and $\gamma 3$; t3 long and weakly clavate, placed near $a5$. Sensilla e just anterior to $\gamma 3$ and reaching to the base of t3; sensilla f short, about half the length of e and below the base of $\gamma 4$. Sensilla g just below $a7$, about the same length as e. Accessory sensilla s long, almost half the length of the claw (Fig. 53).

On the interior side, sensillae a′, b′, and c′ present; a′ midway between $a2$ and $a4$; b′ twice as long as a′ and arising just anterior to $a4$; sensilla c′ only as long as a′ and relatively stout (Fig. 54).

Abdomen.—The chaetotaxy of the abdomen is summarized in Table 2. With regard to variation, three of the fourteen females examined showed an abnormal absence of an a2 seta from the first abdominal sternite.

CHAETOTAXY OF PRELARVA

Head.—Setae of prelarva more numerous than those of the adult (Fig. 60).

Foretarsus.—Sensillae absent; remaining setae mostly short (Figs. 63-64).

Thorax.—Ventral setae absent. Dorsally, prothorax with 3 + 3 setae, mesothorax with 4 + 4 setae, and metathorax with 3 + 3 setae (Fig. 62).

Abdomen.—See Fig. 62 and Table 2 for the abdominal chaetotaxy of the prelarva.

CHAETOTAXY OF OTHER IMMATURE STAGES

The chaetotaxy of these stages is similar to that of the adult with the exceptions noted in Table 2 and the following:

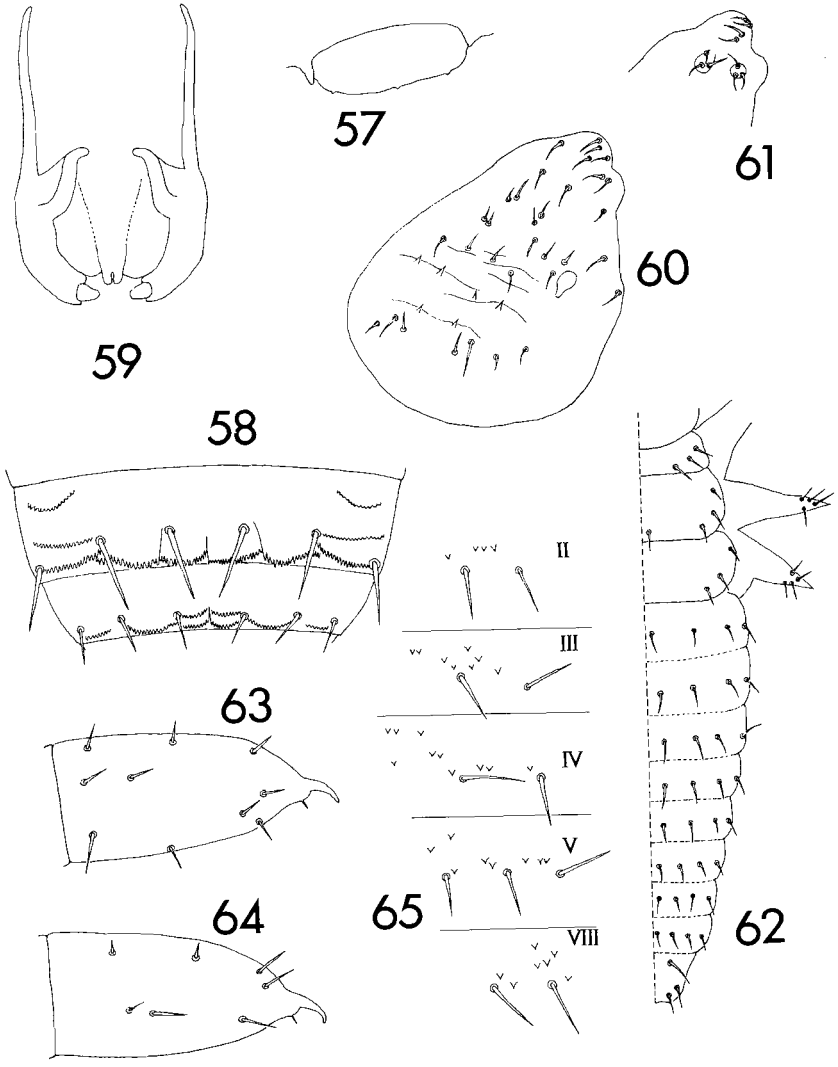
Foretarsus.—Some sensillae absent in the immature stages: larva I and II, t1, t2, c, c′; maturus junior, t1, t2, and c.

Discussion.—*Protentomon michiganense*, n.sp., falls closest to *P. fallax* Conde (1948), from which it can be separated by the following chaetotaxic characteristics: tergite of Abd. 1 with 5 + 5 setae, rather than 6 + 6; sternite of Abd. I with four setae in the anterior row, rather than three; and twelve setae in the posterior row of tergite VIII, rather than

Table 2. Abdominal chaetotaxy of *Protentomon michiganense* n.sp.

		I	II-III	IV-VI	VII	VIII	IX	X	XI	XII
PRELARVA	tergite	8	8	8	8	8	–	–	–	6
	sternite	0	0	2	2	2	–	–	–	6
LARVA I	tergite	10	10	10	12	12	–	–	–	9
	sternite	$\frac{2}{2}$	2	4	2	2	–	–	–	8
LARVA II	tergite	10	12	12	16	12	–	8	–	9
	sternite	$\frac{3}{2}$	3	6	6	4	–	4	–	8
MATURUS JUNIOR	tergite	10	12	12	16	$\frac{6}{12}$	12	8	6	9
	sternite	$\frac{4}{2}$	$\frac{2}{3}$	$\frac{2}{6}$	6	4	4	4	0	8
ADULT	tergite	10[a]	12[b]	12[b]	16[c]	$\frac{6}{12}$[d]	12	8	8	9
	sternite	$\frac{4}{2}$	$\frac{2}{3}$	$\frac{2}{6}$	6	4	4	4	4	8

[a] p1′a microchaeta, p4′absent.
[b] p4′a microchaeta, p1′absent, p5 present.
[c] p1′, p3′, p4′present, p4′a microchaeta.
[d] p4′absent.



Figs. 57-65. *Protentomon michiganense* n.sp. Fig. 57. Lid of tergite VIII, left side. Fig. 58. Tergal pectines of the tenth and eleventh segments. Fig. 59. Female squama genitalis. Fig. 60. Head of prelarva, dorsal view. Fig. 61. Anterior-ventral view of prelarva head. Fig. 62. Dorsal chaetotaxy of prelarva, right side. Fig. 63. Foretarsus of prelarva, exterior view. Fig. 64. Foretarsus of prelarva, interior view. Fig. 65. Tergal spines of prelarva abdomen, right side, segments II-V and VIII.

fourteen. From the other described American species, *P. transitans* Ewing (1921b), it is most easily separated by the absence of sensilla c, presence of 3,3,2 setae on the abdominal appendages instead of 4,4,2, and 2, not 4, setae in the anterior row of abdominal sternites II-VI.

This is the only species of *Protentomon* yet described that has less than 14 setae in the posterior row of tergite VIII (accessory seta p4′ missing).

Collection Data.—1 October, 1972, four females, one maturus junior, and two larvae I, from soil-litter samples in the Michigan State University Horticulture Gardens, East Lansing, Ingham County, Michigan, E.E. Leuck, collector.

12 October, 1972, holotype female, eight paratype females, one maturus junior, one larva I, and one prelarva, from soil and litter beneath a boxwood hedge (*Buxus sempervirens* L.); and one female, one maturus junior, two larvae II and four larvae I, from grass-soil cores collected under crabapple trees, (*Malus purpurea* Rehd.) same locality as above, E. E. Leuck and E. C. Bernard, collectors..

Family ACERENTOMIDAE

Genus **ACERENTULUS** Berlese, 1908

Acerentulus confinis (Berlese)

Acerentomon confine Berlese 1908. Redia 5:16, figs. 3-5.

Specimens referrable to this species have been recovered from soil and litter at the following sites: three specimens (one male, one preimago male, and one maturus junior), Kellogg Forest, Kalamazoo County, Michigan, 13 August, 1963; three specimens (two females and one maturus junior), Gwinn, Marquette County, Michigan, 28 July, 1969; and one female, Ray Thomas farm, Bellaire, Antrim County, Michigan, October, 1973.

Genus **AMERENTULUS** Tuxen, 1963

Amerentulus americanus (Ewing)

Acerentomon americanum Ewing 1921. Proc. Entomol. Soc. Wash. 29:197, fig. 6.

This large and distinctive species has so far been found at two sites in Michigan: ten specimens (four males, four females, one male preimago, and one maturus junior), Fife Lake, Grand Traverse County, Michigan, September, 1965; one female, E. Lansing, Ingham County, Michigan, 1 October, 1972, E. E. Leuck and E. C. Bernard, collectors.

Genus **YAMATENTOMON** Imadate, 1964

Yamatentomon barberi (Ewing)

Acerentulus barberi Ewing 1921. Entmol. News 32:240.

Nine specimens (seven females, one preimago male, and one larva I), Fife Lake, Grand Traverse County, Michigan, September, 1965.

Genus **PROACERELLA**, new genus

Moderately small acerentomids with the following characteristics: mouthparts large, mandible stout, maxilla relatively thick, lobus internus wide, not pointed, labial palpus reduced to three setae and one sensilla; pseudoculus heart-shaped with a median longitudinal line; distal end of canal of maxillary gland bulbous, faint expansions present proximal to the calyx. Labrum very short, truncate; clypeal apodeme apparently present and visible. Sensilla t1 claviform, t2 setiform; sensilla g nearly level with t3, about the same length; sensilla b′ absent. Abdominal legs II and III each with two setae, the apical seta more than half the length of the subapical. Comb VIII with about twelve teeth; striate band well developed; petite pectines with about three teeth. Female squama

genitalis with stylus extending as a sharp point past the apex of the acrostylus. Tergite of Abd. XII with only seven setae. Genotype: *Proacerella reducta* n.sp. (see below)

The generic description may become altered to some degree if other species are discovered; however, the characters of this new genus indicate that it straddles aspects of *Acerentulus, Acerella,* and the Protentomids. It bears resemblances to *Acerentulus* in the female squama genitalis, to *Acerella* in the expansions of the maxillary gland and the presence of two long setae on abdominal legs II and III, and to Protentomidae by the shape and size of the foretarsal sensillae.

Proacerella, n.gen., also shows affinities with *Maderentulus* Tuxen, 1963 in the shape of the canal of the maxillary gland, and the female squama genitalis, but differs in the possession of short and stout mouthparts, instead of long and slender ones, the length of foretarsal sensillae (short instead of long) and the presence of two setae on abdominal appendages II-III, instead of three. The larva II of each species (see Tuxen, 1964) are very similar. In form and general structure of the mouthparts, *Proacerella,* n.gen., resembles *Gracilentulus* Tuxen, 1963 but differs from it by having two long setae on abdominal appendages II-III, instead of one long and one short, in the length of foretarsal sensillae, and in certain aspects of the squama genitalis.

Proacerella reducta, new species

(Figs. 66-82)

Color and Dimensions.—Relatively small acerentomid proturans, slightly yellowish to whitish; postembryonic life stages with the following average dimensions (foretarsus measurement without claw):

	Body Length	Head Length	Foretarsus Length
LI	454 μm	60 μm	32 μm
LII	600	60	38
M.J.	633	70	41
Adult	723	73	44

MORPHOLOGY

Head.—Pseudoculus (Fig. 71) somewhat heart-shaped, with a strong median longitudinal line, PR = 9.0. Clypeal apodeme (Fig. 66) apparently present and visible, consisting of two straight rods with extensions anteriorly and laterally; labrum (Fig. 66) fairly short, LR = 7.8, somewhat trapezoidal in shape and concave apically with a small projection medially; labral setae may be present, depending on an interpretation of the proximal limit of the labrum.

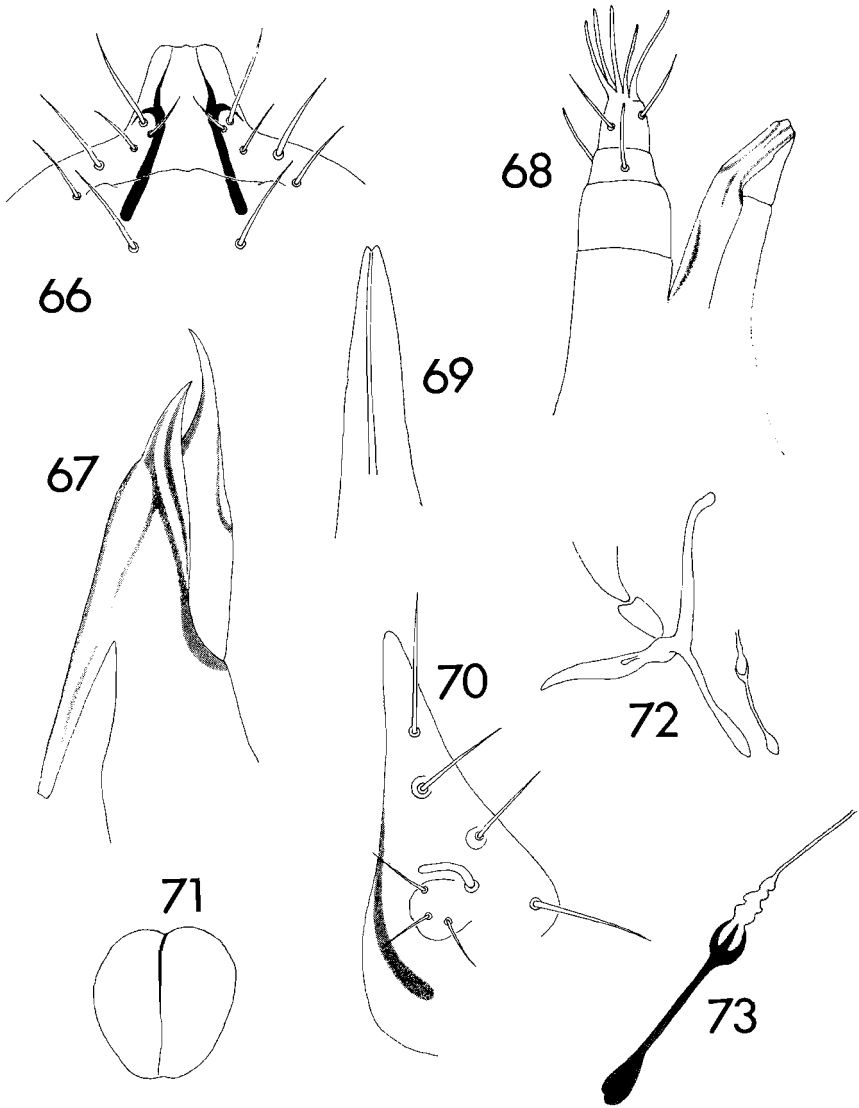
Mandible (Fig. 69) moderately slender, terminating in two weak and rounded teeth; two striae present, extending only along the distal fifth of the mandible.

Maxillary components stout. Lobi externi (Fig. 67) relatively short, curved toward each other. Lobus internus (Fig. 68) very stout, with three rounded terminal lobes and an inner, weakly sclerotized lamella; maxillary palpus with two slender sensillae proximally, two setae subterminally, and a terminal tuft of five sensillae. Canal of maxillary gland (filamento di sostegno) (Figs. 72-73) nearly as long as the proximal branch of the fulcrum; apical dilation oval, sometimes appearing bipartite, calyx oval, duct with indistinct expansions near the calyx.

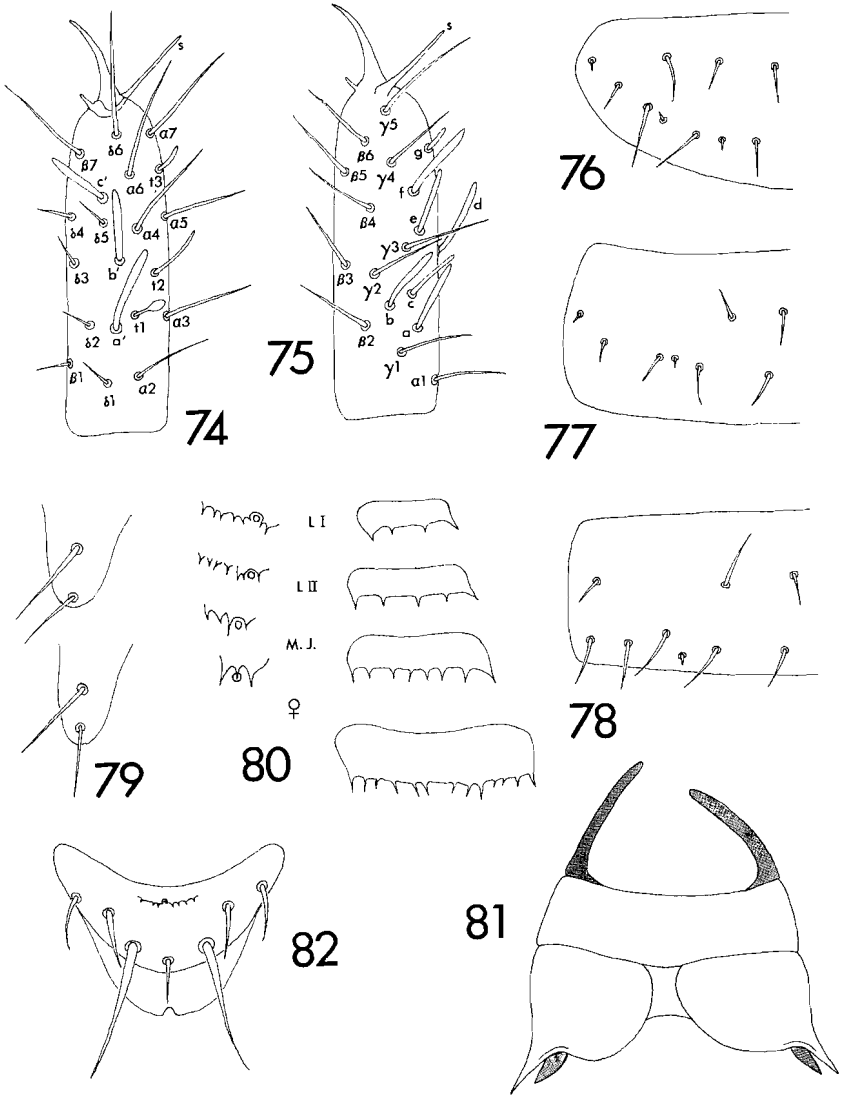
Labium (Fig. 70) bilobed, each lobe roughly triangular, outer edge of lamina labii with four setae; labial palpus strongly reduced, with only three setae and basal sensilla.

Thorax.—Claw of foretarsus untoothed, of moderate length, TR = 3.81; empodium short, EU = 0.2. Claws of middle and hind legs similar to those of *Acerentulus.*

Abdomen.—Appendages of the second and third segments (Fig. 79) with two setae, the apical about three-fourths the length of the subapical. Striate band of segment eight well



Figs. 66-73. *Proacerella reducta* n.g. and n.sp. Fig. 66. Labrum and clypeal apodeme. Fig. 67. Lobi externi of maxilla, right side. Fig. 68. Lobus internus and maxillary palpus, left side. Fig. 69. Mandible. Fig. 70. Left prelabium and labial palpus, ventral view. Fig. 71. Pseudoculus. Fig. 72. Fulcrum and canal of maxillary gland. Fig. 73. Canal of maxillary gland (filamento di sostegno).



Figs. 74-82. *Proacerella reducta* n.g. and n.sp. Fig. 74. Foretarsus, interior view. Fig. 75. Foretarsus, exterior view. Fig. 76. Metanotum, left side. Fig. 77. Abdominal tergite I, left side. Fig. 78. Abdominal tergite V, left side. Fig. 79. Appendages of Abd II and Abd III. Fig. 80. "Petite pectine" (left) and lid of Abd VIII (right) of the postembryonic stages (both from left side of terg. VIII.) Fig. 81. Female squama genitalis. Fig. 82. Tergite XII.

developed, comb of tergite VIII with 12 or 13 short teeth. The addition of teeth continues from LI to adult (Fig. 80). "Petite pectine" with about three teeth in the adult, but with more teeth in younger instars (Fig. 80); other scattered teeth present on tergite VIII. Tergite XII with an antero-median row of very small teeth, centered on the dorsal abdominal pore (Fig. 82).

Female squama genitalis (Fig. 81) with short basal apodemes, pointed styli, and pointed acrostylus, each stylus bypassing its acrostylus. No males seen.

CHAETOTAXY

Head.—Rostral setae present (Fig. 66).

Thorax.—Prothorax—2 + 2 setae dorsally, 7 + 7 ventrally;
mesothorax—5 + 5 anterior and 6 + 6 posterior setae dorsally, eleven setae ventrally;
metathorax (Fig. 76)—3 + 3 anterior and 7 + 7 posterior setae dorsally, thirteen setae ventrally.

Foretarsus.—All setae and sensillae present. Sensilla t1 clavate with a slender stalk and oval apical knob; t2 of medium length, very slender and almost setiform; t3 short, similar in size and shape to sensilla g. Sensilla a′ long and broad, almost reaching *a*4; b′ and c′ similar in shape, almost as long as a′. Sensillae on exterior side shorter than in other Acerentomidae; c nearly level with b, g level with t3; sensilla s about 80% the length of the claw (Figs. 74-75). Larva I without sensillae b′ and c′, larva II without b′.

Abdomen.—Abdominal chaetotaxy as in Table 3. *Proacerella reducta* n.sp. is exceptional among described Acerentomidae in its possession of only seven setae on tergite XII (Fig. 82).

Discussion.—This new species exhibits, as mentioned before, structural affinities with both the more generalized forms (Protentomidae, Eosentomidae) and the more differentiated

Table 3. Abdominal chaetotaxy of *Proacerella reducta* n.g. and n.sp.

		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
LARVA I	tergite	8	10	10	10	10	10	10[a]	12	–	–	–	7
	sternite	2	3	3	5	5	5	5	2	–	–	–	8
LARVA II	tergite	10	12	12	12	12	12	14	2/14	–	8	–	7
	sternite	3/2	1/3	1/3	1/6	1/6	1/6	1/6	4	–	4	–	8[a]
MATURUS JUNIOR	tergite	4/10	6/12	6/12	6/12	6/12	6/12	8/14	6/15	8	8	4	7
	sternite	3/2	3/3	3/3	3/7	3/6[b]	3/8	3/8	4	4	4	0	6[b]
ADULT	tergite	4/12	6/12	6/12	6/12	6/12	6/12	8/14	6/15	12	10	4	7
	sternite	3/2	3/4	3/5	3/8	3/8	3/8	3/8	4	4	4	4	6

Holotype with only five setae in the a-row of tergite VIII.

[a]one seta missing from these rows in one or more specimens.
[b]an extra seta in these rows in one or more specimens.

Acerentomidae. The blunt lobus internus with sclerotized lines and the short, heavy maxilla head point to more primitive characteristics, while the reduced labial palpus and reduced abdominal appendages point to forms more specialized.

Collection Data.—16 August, 1973, holotype female, fourteen paratype females, seven maturi juniores, four larvae II, and three larvae I, from orchard soil on the Joseph Smiltzer Farm, near Frankfort, Benzie County, Michigan.

ACKNOWLEDGMENTS

I would like to thank Drs. R. L. Fischer, F. W. Stehr, and S. K. Wellso for review of the manuscript. I am grateful to Dr. B. Conde for lending me a lectotype (female, locality 127, Madeira) of the species *Maderentulus maderensis* (Conde), so that the species might be compared with specimens of the new genus *Proacerella*.

LITERATURE CITED

Berlese, A. 1908. Nuovi Acerentomidi. Redia 5:16-19.

————. 1909. Monografia dei Myrientomata. Redia 6:1-182.

Caveness, F. E. and H. J. Jensen. 1955. Modification of the centrifugal-flotation technique for the isolation and concentration of nematodes and their eggs from soil and plant tissue. Proc. Helminth. Soc. Wash. 2:87-89.

Conde, B. 1948. Protoures d'Algerie. Rev. Fr. D'Entomol. 14:194-202.

————. 1951. Protoures du Maroc. Bull. Soc. Sci. Nat. Maroc. 30:165-173.

————. 1961. Nouvelles recoltes de Protoures au Maroc. Bull. Mus. Hist. Nat. (2) 33:495-499.

Copeland, T. P. 1964. New Species of Protura from Tennessee. J. Tenn. Acad. Sci. 39:17-29.

Francois, J. 1969. Anatomie et morphologie cephalique des Protoures. Mem. Mus. Nat. Hist. Nat. Nouv. Ser. A, Zool. 59:1-144.

Imadate, G. 1961. Two new Proturan species of the genus *Eosentomon* Berlese from Japan. Kontyu 29:132-141.

————. 1964. Taxonomic arrangement of Japanese Protura (I). Bull. Nat. Sci. Mus. Tokyo 7:37-81.

————. 1965. Proturans-fauna of southeast Asia. Nature and Life in SE Asia 4:195-302.

————. 1966. Taxonomic arrangement of Japanese Protura (IV). The proturan chaetotaxy and its meaning to phylogeny. Bull. Nat. Sci. Mus. Tokyo. 9:277-315.

Miller, P. M. 1957. A method for the quick separation of nemotodes from soil samples. Pl. Dis. Reptr. 41:194.

Tuxen, S. L. 1963. Art-und Gattungsmerkmale bei den Proturen. Ent. Medd. Kopenhagen 32:84-98.

————. 1964. The Protura. A Revision of the Species of the World. Hermann, Paris, 360 p.

Womersley, H. 1932. A preliminary account of the Protura of Australia. Proc. Linn. Soc. N.S. Wales 57:69-76.