

NEW SPECIES, CLARIFICATIONS, AND CHANGES IN  
STATUS WITHIN *EOSENTOMON* BERLESE  
(HEXAPODA: PROTURA: EOSENTOMIDAE)  
FROM THE UNITED STATES

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*Abstract.*—Nine new species of *Eosentomon* Berlese are described from the United States: seven from South Carolina (*E. crypticum*, *E. hargrovei*, *E. nudilabratum*, *E. renateae*, *E. richardi*, *E. savannahense*, *E. xenomystax*); one from Arkansas (*E. osageorum*); and one from Michigan (*E. snideri*). *Eosentomon brassicae* Bernard is synonymized with *E. pusillum* Ewing, which is redescribed from the holotype. *Eosentomon pusillum ewingi* Bonet is redescribed and raised to specific rank as *E. ewingi* Bonet.

The genus *Eosentomon* Berlese (Eosentomidae), the largest genus among the Protura, now contains more than 180 species. Recently, Dr. R. J. Snider, Michigan State University, sent to me several thousand specimens of Protura collected from the U.S. Department of Energy's Savannah River Site (SRS) in South Carolina. In this collection were 13 *Eosentomon* species, of which seven are undescribed. In addition, specimens in collections from Arkansas and Michigan were determined to represent other undescribed species of *Eosentomon*. Also, type specimens of *E. pusillum* Ewing and *E. pusillum ewingi* Bonet were redescribed as a step in the evaluation of the South Carolina material.

#### Materials and Methods

Protura were extracted from soil and litter in Tullgren funnels and preserved in 95% ethanol. Specimens were cleared, expanded, and mounted in a polyvinyl alcohol-lactophenol medium. Slides were dried overnight in an oven at 60°C. Most drawings were made with the use of a drawing tube on an interference-contrast microscope. Female genital structures were interpreted with brightfield and interference-contrast optics,

and relative sclerotization of the parts was estimated with a phase-contrast microscope. Head and labral lengths were generally measured in dorsal view. For most species, only females were used for descriptions because of difficulties in identifying males and juveniles. All holotypes and some paratypes are deposited in the National Museum of Natural History (NMNH). Remaining paratypes, except as designated, are in the Apterygote Section of the University of Tennessee Entomology Museum (UTEM). Unless otherwise noted, all specimens were collected by W. W. Hargrove.

#### Terminology

Terms and designations, except as noted below, are used as given in Tuxen (1964). Szeptycki (1984) has been followed for designations of anterior additional head seta (*aa*), posterior additional head seta (*pa*), anterior sensillum (*as*), posterior sensillum (*ps*), median subposterior seta (*sp*), and median posterior seta (*p*). In this paper, the other paired, median head setae are designated for convention as follows, from anterior to *sp*: *rs* (median rostral seta) and *cs* (clypeal seta) (Copeland 1964), *m1*, *m2*, *m3*, *m4*, and *m5*; *rs*, *cs*, *m2*, *m3*, *m5*, *sp*, and *p* are considered

the innermost setae of transverse rows of setae (Fig. 8). Identification of these rows greatly facilitates the location of *aa* and *as*. Seta *m4* is present in all the species described in this paper, but is absent in *E. vermiforme* Ewing.

The form of the galea is similar among *Eosentomon* spp., with an external spine and three apical projections (Fig. 3). The shape of the projections, here termed digits (outer, median, inner), varies among species and is a very useful supplementary taxonomic character.

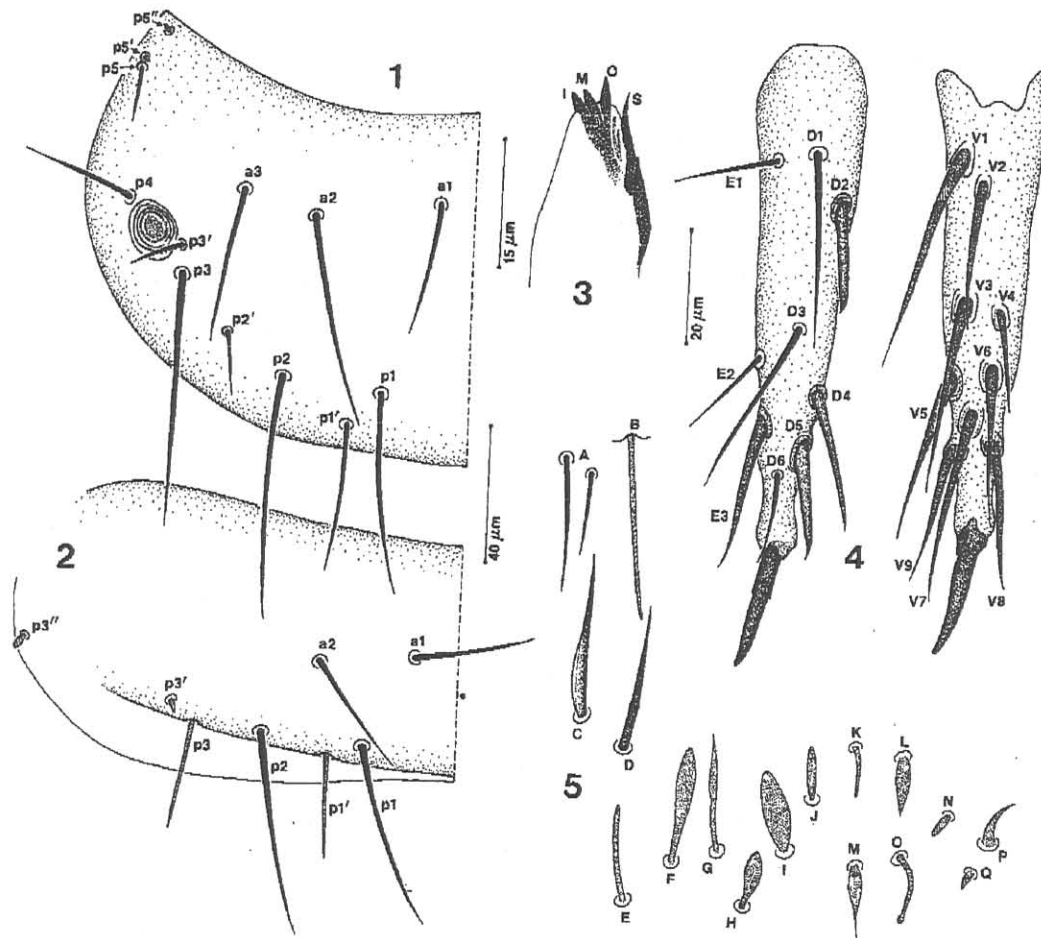
The mesonotum and metanotum each have certain characters not hitherto used in eosentomid systematics. On each segment, seta *p3'* may be setiform, lanceolate, claviform, or ovate. Mesonotal seta *p2'* is almost always setiform but occasionally mimics a modified *p3'*. On the metanotum, *p5* is associated with two minute microchaetae near the anterolateral margin (Fig. 1), which for convention may be designated *p5'* and *p5''*. The bases of seta *p5* and *p5'* are usually contiguous, although occasionally there is discernible space between them, useful as a supplementary character. Imadate (1989) observed and sketched the location of these microchaetae in *Eosentomon woroae* Imadate.

Bernard (1975a) noted that, in addition to the 5+5 posterior setae usually reported on abdominal tergite I, there was an additional microchaeta (*p3''*) near each posterior corner (Fig. 2). The socket of *p3''* is much less distinct than that of *p3'*, making it more difficult to detect. All *Eosentomon* spp. I have examined possess *p3''*, but Imadate (1989) recently reported that *E. woroae* Imadate does not possess it. The tergite I setal formula introduced by Copeland (1964) is used in this paper. A formula of 3:1:2 means three normal setae, one delicate seta, and two microchaetae.

The microchaetae, sensilla, and setae of eosentomids display a wide variety of

shapes. Terms that define these shapes are given (Fig. 5); some of these terms have been in use for many years. A "delicate" seta (Tuxen 1964) is one found in the posterior rows of the terga, less sclerotized than the normal setae and without a pronounced socket. Inflated and indented setae are unusual forms of the median rostral setae; inflated setae are swollen in the basal half, while indented setae suddenly narrow in the middle third. Copeland (1964) has referred to the inflated type as "alate." Sensilla are those specialized sensory setae found on the forelegs. Microchaetae are the small sensory setae found on the head, terga, middle legs, and hind legs. Among the more specialized forms, "aristate" refers to a lanceolate microchaeta with a terminal filament; "capitulate" (small-headed) applies to minutely capitate microchaetae on tergum VIII, and "gemmate" (bud-like) refers to the minute microchaetae of the metanotum and sometimes tergum VIII.

The metatarsus possesses, at least in North American species, a constant number and arrangement of setae, some of which are variable in thickness and length. A numbering system for the metatarsal setae is proposed and illustrated in Fig. 4. Six dorsal setae (D1-6) are arranged in an irregular zigzag row; the most variable of these is D2, referred to as the basal seta (*bs*) by Szeptycki (1984). Since BS is already used for a foretarsal ratio, it is desirable to use a different term for this metatarsal seta. D2 varies from a thin seta to a thick spine. D5 is always a distinct spine but its thickness varies. D4 is variably spiniform, while D1, D3, and D6 are setiform. On the exterior surface, E1 and E2 are setiform, while E3 is spiniform. All nine ventral setae (V1-V9) are rather heavy spines, whose length may vary among species; V4 is the shortest of the ventral setae. The interior side is considered to be free of setae. In this paper, usually only the view that best shows D2 is illustrated.



Figs. 1-5. *Eosentomon vermiforme*: 1, metanotum, left side; 2, abdominal tergum I, left side; 3, galea (S: exterior spine; O: outer digit; M: median digit; I: inner digit); 4, metatarsus, dorsal and ventral views (D: dorsal setae; E: exterior setae; V: ventral setae). *Eosentomon* spp.: 5, Setal types (A-D, setae: A, normal; B, delicate; C, inflated; D, indented. E-J, sensilla: E, linear; F, rounded spatulate; G, pointed spatulate; H, claviform; I, oval; J, oblong. K-Q, microchaetae: K, linear; L, lanceolate; M, aristate; N, oblong; O, capitulate; P, falcate; Q, gemmate).

*Eosentomon crypticum*, new species

Figs. 6-17; Table 1

*Color and dimensions.*—Body weakly sclerotized, yellow-amber posteriorly. Length 795  $\mu\text{m}$ ; length of head 99  $\mu\text{m}$ ; length of foretarsus without claw 64  $\mu\text{m}$ . LR = 12.3; PR = 7.0; TR unknown (foretarsal claw broken).

*Morphology.*—Pseudoculus oval with a

few longitudinal striae (Fig. 8). Clypeal apodeme small but robust, with thick anterior bar and a central keel-like appendage extended posteriorly (Fig. 10). Labral margins coarsely scalloped anteriorly, apices rounded to a very narrow U-shaped notch; labral setae present, extended well past labrum apex (Fig. 10). Rostral setae greatly inflated. Mandible slender with two apical teeth; galea with cylindrical, apically rounded outer

digit and slender-conoid middle and inner digits, the middle digit shorter than the inner; outer lobe of lacinia slender, slightly curved at apex, not serrate; inner lacinial lobe slender and curved anteriorly, not hooked (Fig. 9).

Empodia of middle and hind tarsi short.

Central lobe of praecosta sinuate (Fig. 15). Female squama genitalis (Fig. 17) with very thin caput processus bent sharply toward inner stylus margins; corpus processus extending as a narrow lobe anteriorly past the caput, and without prominent alae; median sclerotizations present, rod-like; proximolateral sclerotizations very heavy and well-developed. Filum processes short, stylus apex bluntly pointed.

*Chaetotaxy*.—Cephalic seta *aa* absent, *pa* present, anterior sensillum present (Fig. 8). Setae *sp* and *p* about equal in length.

On mesonotum and metanotum (Figs. 12, 13), lengths of *p1* and *p1'* equal, *p2'* two-thirds the length of *p2*, *p3* setiform and shorter than *p2'*; on mesonotum, *p5* very short, its base contiguous with that of *p5'*.

On foretarsus (Figs. 6, 7), all sensilla present; *b*, *a'*, *b'2*, and *t* narrowly spatulate; *b'1* very large and ovate, nearly level with *b'2*; *e* and *g* rounded-spatulate and large; *f1* linear, long; *d* broken near base; *t3* robust; sensilla *a*, *c*, *f2*, and *c'* short and slender. Sensillum *t1* closer to  $\alpha3$  than to  $\alpha3'$ ; BS = 0.81. Metatarsal seta D2 of moderate thickness (Fig. 11).

Abdominal setal composition given in Table 1. Tergite I formula 3:1:2, *p1'* longer than *p1*. On tergites II–VI, *p1'* and *p2'* twice the length of *p1* and *p2*; *p4'* delicate and shorter than *p4* (Fig. 14) but becoming progressively longer and stronger on tergites V–VII. On tergite VII, *p1'* short and weakly capitulate, *p2'* longer than *p2*. On tergite VIII, *pc*, *p1'* and *p1''* aristate, the filament short; *p2'* clearly capitulate (Fig. 16).

*Collection data*.—Holotype female collected from wet sand and liverworts along Road 5, SRS, Barnwell County, South Carolina, 9 Sep 1983; deposited in NMNH.

*Derivation of name*.—The latinized Greek word *crypticum* means "hidden," and refers both to the small size of the holotype and my failure to find it initially in the thousands of SRS proturans.

*Diagnosis*.—*Eosentomon crypticum* is distinguished from all other *Eosentomon* spp. by the large, anteriorly displaced foretarsal sensillum *b'1*. The structure of the corpus processus is reminiscent of the "transitorium" species group (Tuxen 1964), but the very thin caput processus is distinctive.

*Eosentomon ewingi* Bonet,  
new status

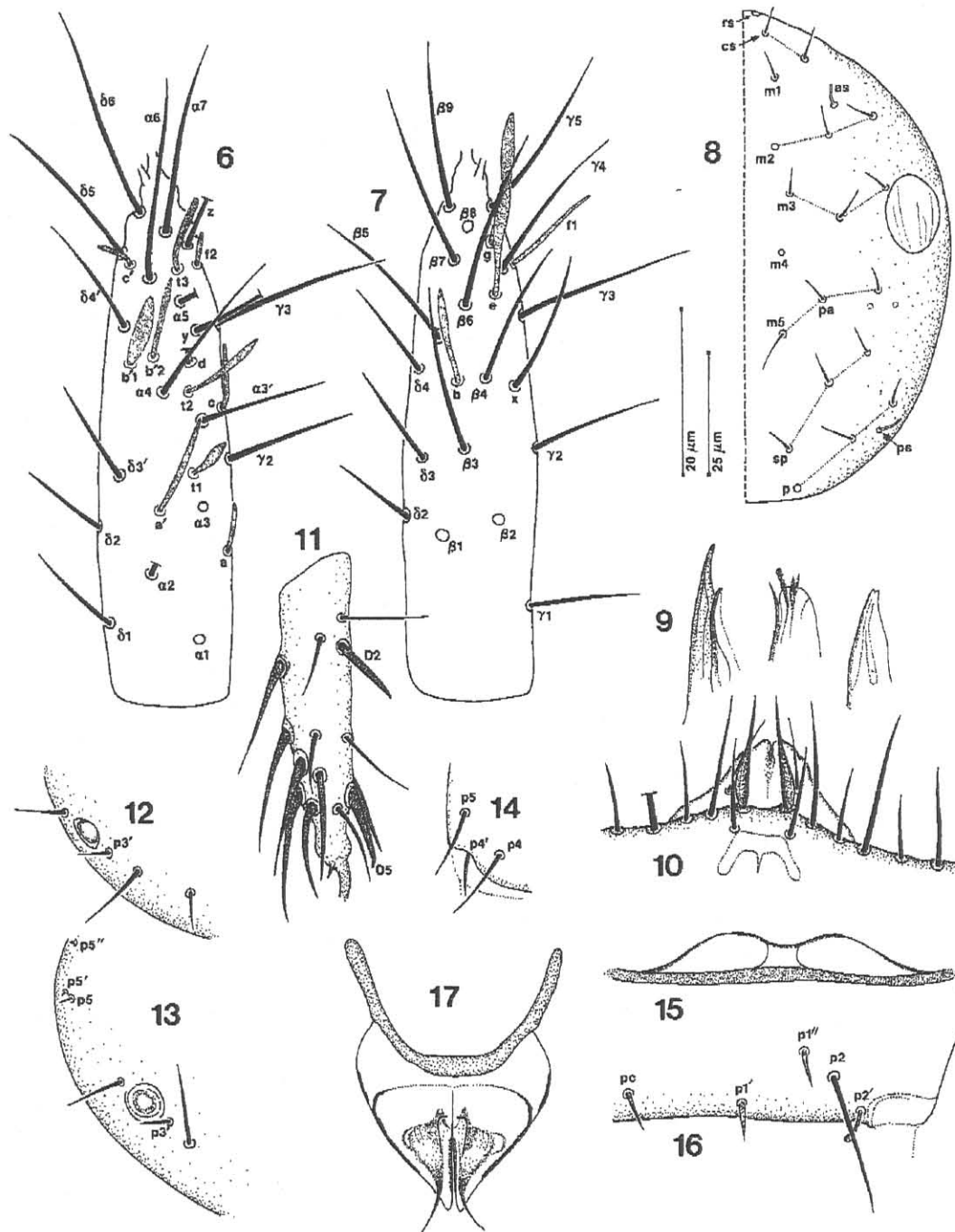
Figs. 18–29; Table 2

*Eosentomon pusillum* f. *ewingi* Bonet 1950:  
113; Tuxen 1964:112, fig. 131.

Ewing (1940), in his description of *E. pusillum*, included three specimens from North Carolina in the type series. Bonet (1950) considered these specimens a distinct form of *E. pusillum* because they lacked anterior setae on sternite VIII, and designated them as forma *ewingi*. Tuxen (1964:112) noted the very shrivelled state of the specimens and considered that "It seems advisable . . . to omit this form from the catalogue." This action, apparently a recommendation to declare *E. pusillum* f. *ewingi* a forma *inquirenda*, has no validity since specimens and a published, albeit very inadequate, description exist.

With the collection of many undescribed species from South Carolina, it became necessary to reassess *E. pusillum* f. *ewingi*. A male proturan collected from Great Smoky Mountains National Park is nearly identical to Ewing's specimens and is used to complete the following description, which is based on the specimen designated as lectotype (Type #65881, USNM) by Tuxen. Characters determined from the male are described in parentheses, following the designation GRSM.

*Color and dimensions*.—Body small and



Figs. 6-17. *Eosentomon crypticum*: 6, Foretarsus, dorsal view; 7, Foretarsus, ventral view; 8, Right side of head, dorsal view; 9, Lacinia, galea, mandible; 10, Labrum and rostral region; 11, Metatarsus, exterior view; 12, Mesonotal margin; 13, Metanotal margin; 14, Posterior corner of tergum IV; 15, Praecosta of tergum VI; 16, Posterior margin of tergum VIII; 17, Squama genitalis. (20  $\mu\text{m}$  scale applies to Figs. 6-7, 9-11, 15-17, 25  $\mu\text{m}$  scale to all others.)



Table 1.—Abdominal chaetotaxy of *Eosentomon crypticum*, n. sp.

	I	II-III	IV	V-VI	VII	VIII	IX-X	XI	XII
Dorsal	$\frac{4}{12}$	$\frac{10}{16}$	$\frac{10}{16}$	$\frac{8^1}{16}$	$\frac{6^2}{16}$	$\frac{6}{9}$	8	8	9
Ventral	$\frac{4}{4}$	$\frac{6}{4}$	$\frac{6}{10}$	$\frac{6}{10}$	$\frac{6}{10}$	$\frac{0}{7}$	6	8	12

<sup>1</sup> Seta *a3* absent.<sup>2</sup> Setae *a1*, *a3* absent.

slender, weakly sclerotized, light amber. Length 603  $\mu\text{m}$  (GRSM: 868  $\mu\text{m}$ ); head length about 70  $\mu\text{m}$  (GRSM: 82  $\mu\text{m}$ ); PR approximately 3.6 (GRSM: 4.5); (GRSM: foretarsus length 65  $\mu\text{m}$ ). LR: (GRSM 9.9); TR: (GRSM 4.4).

**Morphology.**—Pseudoculus extremely large, appearing round or broadly oval with at least three prominent longitudinal striae (Figs. 20, 21). Labrum, mouthparts, and clypeal apodeme all unobservable on lectotype. (GRSM: Labrum rounded-truncate anteriorly, the lobes angled inward to a small V-shaped notch, labral setae present [Fig. 22]. Median rostral setae inflated. Mandible tridentate with small subapical and two apical teeth; on galea, outer digit the longest, inner digit the shortest [Fig. 23]; lacinia not clearly observable. Clypeal apodeme stout, side arms short and heavy.)

Empodium of middle leg almost a third the length of the unguis, EU<sub>II</sub> = 0.29 (GRSM: 0.31); empodium of hind leg long, EU = 0.69 (GRSM: 0.70) (Fig. 24).

Central lobe of praecosta slightly incised (Fig. 27). Styli of female squama genitalis presenting slightly different appearances (Fig. 29): caput processus semicircular; thickened rods in corpus processus united to form a Y-shape, the Y spread to the exterior edge on the left stylus but in the usual position on the right stylus. Median sclerotizations linear; proximo-lateral sclerotizations distinct. Filum processus very long and slender; stylus apices narrowly rounded.

**Chaetotaxy.**—Cephalic seta *aa* not ob-

served on lectotype, *pa* present (Fig. 20); (GRSM: *aa* and *pa* present, anterior sensillum present [Fig. 21]). Seta *sp* 1.6 $\times$  the length of seta *p* (GRSM: 1.5).

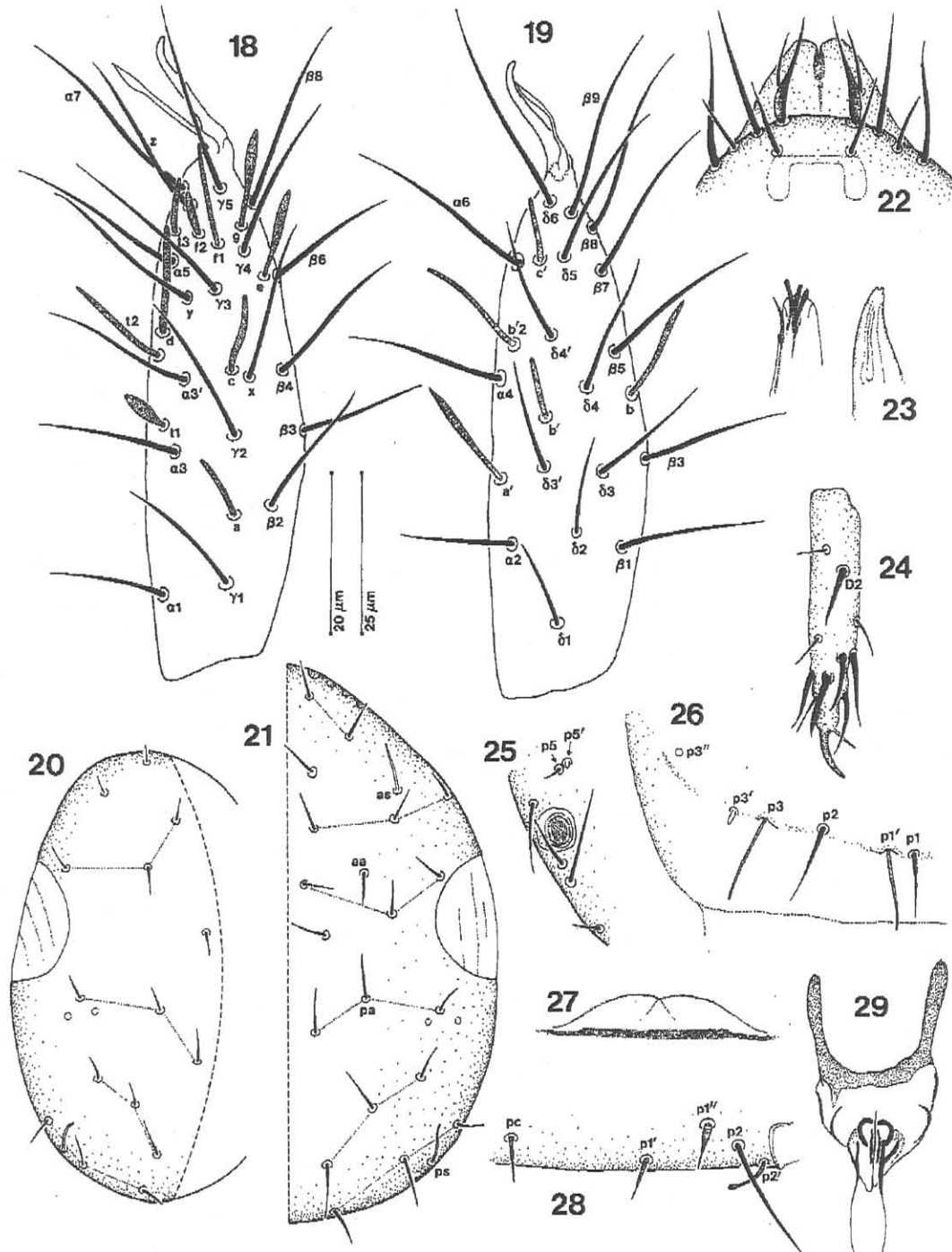
Mesonotal seta *p2'* and *p3'* short; on metanotum, seta *p3'* longer than *p2'*, *p5* very short and contiguous with *p5'* (Fig. 25).

Foretarsi absent on lectotype. (GRSM: foretarsus [Figs. 18, 19] broad, all sensilla present. Sensilla *a'* and *b* narrowly spatulate; *b'2*, *f1*, and *t2* long and slender; *f2* ovate; sensillum *t1* closer to *a3* than to *a3'*, BS = 0.94.) Metatarsal seta D2 a spine of moderate thickness; D5 relatively slender (Fig. 24).

Abdominal setal composition given in Table 2. Tergite I formula 2:2:2, *p3* delicate (Fig. 26). (GRSM: on tergites II–VI, *p1'* and *p2'* longer than *p1* and *p2*; *p4* delicate and slightly longer than *p1* on tergite II, delicate and equal to *p4* on tergites III–VII. On tergite VII, *p1'* short and capitulate, *p2* and *p2'* of equal lengths; on tergite VIII [Fig. 28], *p1'* and *p1''* aristate, *p2'* capitulate).

**Material examined.**—Lectotype female (USNM Type #65881) collected in peach orchard soil by W. F. Turner, Moore County, North Carolina, 8 May 1937; one male collected by E. Bernard from Great Smoky Mountains National Park, North Carolina, Swain County, southern face of Mine Ridge, elev. 817 m, in mixed hemlock-oak forest, deposited in UTEM.

**Diagnosis.**—*Eosentomon ewingi* is distinguished from most *Eosentomon* spp. by the enormous pseudoculus, long metatarsal empodium, and semicircular caput processus.



Figs. 18-29. *Eosentomon ewingi*: 18, Foretarsus, exterior view (GRSM); 19, Interior view (GRSM); 20, Left side of head (lectotype); 21, Right side of head (GRSM); 22, Labrum and rostral region (GRSM); 23, Galea and mandible (GRSM); 24, Metatarsus (lectotype); 25, Metanotal margin (lectotype); 26, Posterior setae of tergum I (lectotype); 27, Clypeal apodeme (lectotype); 28, Posterior margin of tergum VIII (GRSM); 29, Squama genitalis (lectotype). (25  $\mu$ m scale refers to Figs. 20-21, 20  $\mu$ m scale to all others.)

Table 2.—Abdominal chaetotaxy of *Eosentomon ewingi* Bonet.

	I	II-III	IV-VI	VII	VIII	IX-X	XI	XII
Dorsal	$\frac{4^1}{(12)}$	$\frac{10}{16}$	$\frac{10}{16}$	$\frac{6^2}{16}$	$\frac{6}{9}$	8	8	(9)
Ventral	$\frac{(4)}{(4)}$	$\frac{(6)}{(4)}$	$\frac{6}{10}$	$\frac{6}{10}$	$\frac{0}{7}$	6	8	(12)

<sup>1</sup> Setal formulas in parentheses determined from male collected in Great Smoky Mountains National Park.

<sup>2</sup> Setae *a1*, *a3* absent.

It shares these characters with *E. brevicorpusculum* Yin (1965, 1982), but lacks anterior setae on sternite VIII (two setae in *E. brevicorpusculum*) and has a much longer foretarsal sensillum fl. *Eosentomon ewingi* does not bear any special relationship to *E. pusillum*; on the basis of the squama genitalis, *E. ewingi* is related to *E. yosemitense* Ewing, while *E. pusillum* is allied to *E. udagawai*.

*Eosentomon hargrovei*,  
new species  
Figs. 30-40; Table 3

*Color and Dimensions.*—Body moderately sclerotized, yellowish. Length of fully expanded female 1097  $\mu$ m. Length of foretarsus without claw 64  $\mu$ m. Length of head without labrum 98  $\mu$ m. LR = 14.2; PR = 10.6; TR = 5.1.

*Morphology.*—Pseudoculus broadly oval, with obscure linear and circular depressions in the posterior half (Fig. 34). Clypeal apodeme not visible. Labrum in lateral view short, with labral setae extending past anterior edge of labrum (Fig. 32). Central pair of rostral setae inflated basally. Mandible (Fig. 32) with two apical and one subapical teeth. Galea of maxilla with slender outer spine; median apical lobe slightly clavate and rounded, two inner apical lobes adjacent, fused on galeal blade; outer lobe of lacinia short, almost straight, broadly rounded apically, without inner teeth, inner lobe thin and slightly curved, not hooked at apex (Fig. 33).

Empodium of foretarsus almost as long as claw, EU = 0.96. Empodia of middle and hind legs very short, less than one-fifth the length of the claws.

Central lobe of praecosta incised (Fig. 38). Squama genitalis of female (Fig. 40) short and broad, basal apodeme thick and heavy. Median sclerotization of each stylus weakly developed; caput processus strong, curving and tapering to a narrowly rounded point; corpus processus weakly sclerotized, extending as a lobe to the inner edge of the stylus and with distinct ala; lateral sclerotizations of perigynium and stylus present; filum short, less than half the length of the stylus; apex of stylus rounded.

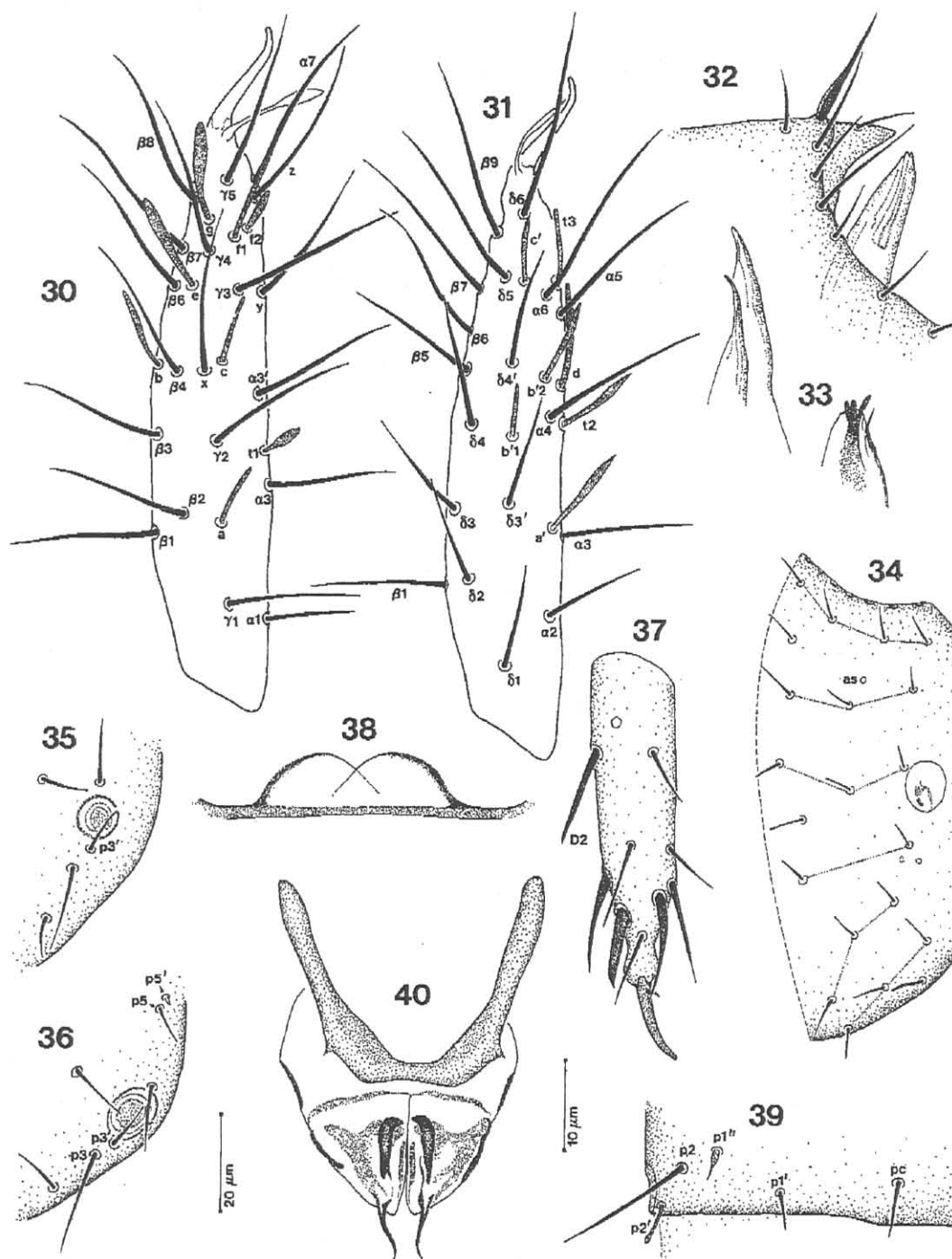
*Chaetotaxy.*—Cephalic setae *aa* and *pa* absent, anterior sensillum present (Fig. 34). Seta *sp* about 1.4  $\times$  the length of seta *p*.

On mesonotum and metanotum, seta *p1'* about equal in length to *p1*; *p2'* much shorter than *p2*; seta *p3'* normal, length equal to spiracle width (Figs. 35, 36). On metanotum, seta *p5* as long as *p3'*, its base close to but not contiguous to *p5'* (Fig. 36).

On foretarsus (Figs. 30, 31), sensilla *b'1* and *c'* present; sensillum *a* short and slender, *b* reaching the base of  $\beta 6$ , *c* reaching  $\gamma 3$ ; *d* reaching  $\alpha 6$ ; *f1* slender, *f2* shorter and broader than *f1*. Sensilla *a'*, *b'2*, and *t2* narrowly spatulate, *e* and *g* broadly spatulate. Sensillum *t1* closer to  $\alpha 3$  than to  $\alpha 3'$ , BS = 0.81; *t3* long and slender. Metatarsal seta D2 a long, slender spine (Fig. 37).

Abdominal setal composition given in Table 3. Tergum I setal formula 3:1:2. Seta *p'1* longer than *p1* on terga I-VI, very short





Figs. 30-40. *Eosentomon hargrovei*: 30, Foretarsus, exterior view; 31, Foretarsus, interior view; 32, Labral region and mandible; 33, Lacinia and galea; 34, Right side of head, dorsal view; 35, Mesonotal margin; 36, Metanotal margin; 37, Metatarsus; 38, Praecosta of tergum VI; 39, Posterior margin of tergum VIII; 40, Squama genitalis. (20  $\mu\text{m}$  scale applies to Figs. 34-36, 10  $\mu\text{m}$  scale to all others.)

Table 3.—Abdominal chaetotaxy of *Eosentomon hargrovei*, n. sp.

	I	II-III	IV-VI	VII	VIII	IX-X	XI	XII
Dorsal	$\frac{4}{12}$	$\frac{10}{16}$	$\frac{8^1}{16}$	$\frac{7^{1,2}}{16}$	$\frac{6}{9}$	8	8	9
Ventral	$\frac{4}{4}$	$\frac{6}{4}$	$\frac{6}{10}$	$\frac{6}{10}$	$\frac{2}{7}$	4	8	12

<sup>1</sup> Seta *a3* absent.

<sup>2</sup> Setae *a4* absent on right side of holotype.

and weakly claviform on tergum VII. Seta *p'2* longer than *p2* on terga II–VI, equal to *p2* on tergum VII. Accessory seta *p'4* similar in appearance to but slightly shorter than *p4*. On tergum VIII, *p1''* aristate (Fig. 39).

*Collection data.*—Holotype female extracted from deciduous litter along Road F past Road 4, SRS, Aiken County, South Carolina, 18 May 1984, deposited in NMNH.

*Derivation of name.*—This species is named with gratitude after Mr. William W. Hargrove, who collected most of the proturan material described in this paper.

*Diagnosis.*—*Eosentomon hargrovei* can be separated from other members of the genus by the very strong caput processus and well developed corpus process with prominent lateral alae. The squama genitalis is reminiscent of that in some "wheeleri" group species (Copeland 1964, Tuxen 1964), but otherwise *E. hargrovei* bears no resemblance to them.

*Eosentomon nudilabratum*,  
new species  
Figs. 41–53; Table 4

*Color and dimensions.*—Body moderately sclerotized, yellowish. Mean length of partially expanded adults 792  $\mu\text{m}$  (699–892,  $n = 4$ ). Length of foretarsus without claw 64  $\mu\text{m}$  (61–67,  $n = 4$ ). Length of head without labrum 96  $\mu\text{m}$  (91–100,  $n = 4$ ). LR = 0.17 (0.15–0.20,  $n = 4$ ), PR = 8.8 (7.5–9.7,  $n = 6$ ); TR = 6.1 (5.6–7.1,  $n = 7$ ).

*Morphology.*—Pseudoculus broadly oval,

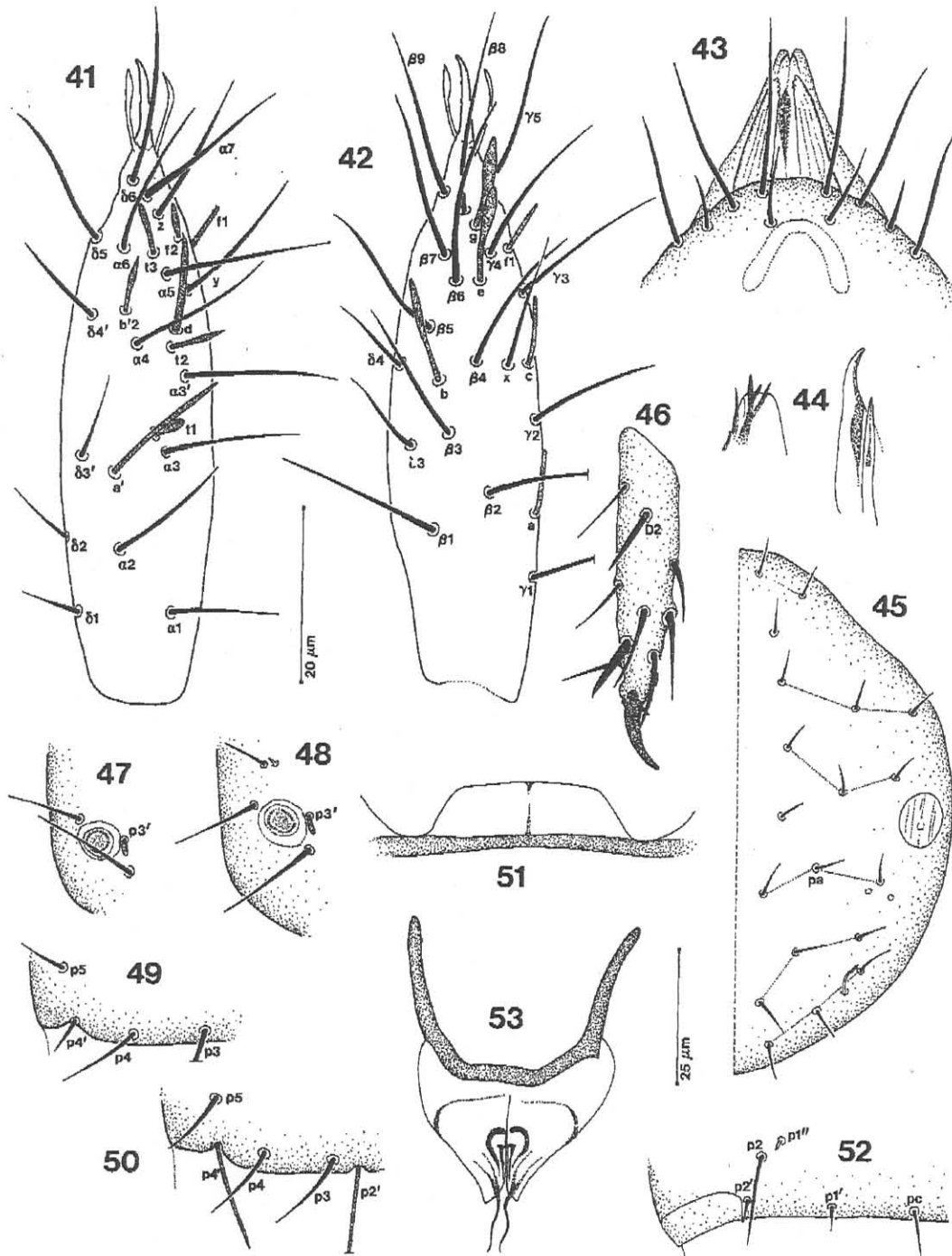
with a small circular, central depression and several longitudinal striae (Fig. 45). Clypeal apodeme (Fig. 43) stout, the side arms heavy and slightly enlarged posteriorly. Labrum prominent, tapering anteriorly to small, rounded apices and a V-shaped notch; labral setae absent (Fig. 43). Median pair of rostral setae not inflated or otherwise modified. Mandible (Fig. 43) with three to five minute teeth along the inner edge. Galea of maxilla with outer spine, tapering outer digit and minute median and inner digits, all three digits appearing bluntly pointed; outer lobe of lacinia smoothly curved, not serrate; inner lobe tapering and straight (Fig. 44).

Empodium of foretarsus slightly longer than the claw, EU = 1.08 (0.95–1.15,  $n = 7$ ). Empodia of middle and hind legs very short, less than one-fifth the length of the claws.

Central lobe of praecosta trapezoidal, not incised (Fig. 51). Squama genitalis of female (Fig. 53) small, each stylus tapering to a point; median sclerotization strong, capitate proximally; caput processus thin and smoothly curved, shaped like a question mark; corpus processus weakly developed, bifurcate; filum short, about half the length of the stylus.

*Chaetotaxy.*—Cephalic seta *aa* absent, *pa* present; anterior sensillum absent (Fig. 45). Seta *sp* 1–1.3  $\times$  the length of seta *p*.

Seta *p1'* on mesonotum and metanotum slightly shorter than *p1''*; seta *p3'* short and clavate; on metanotum, seta *p5* nearly as long as *p2'*, its base close to that of *p5'* (Figs. 47, 48).



Figs. 41-53. *Eosentomon nudilabratum*: 41, Foretarsus, dorsal view; 42, Foretarsus, ventral view; 43, Labrum and rostral region; 44, Galea and lacinia; 45, Right side of head, dorsal view; 46, Metatarsus, subdorsal view; 47, Mesonotal margin; 48, Metanotal margin; 49, Posterior margin of tergum III; 50, Posterior margin of tergum IV; 51, Praecosta of tergum VI; 52, Posterior margin of tergum VIII; 53, Squama genitalis. (25  $\mu\text{m}$  scale applies to Figs. 45, 47-50, 20  $\mu\text{m}$  scale to all others.)

Table 4.—Abdominal chaetotaxy of *Eosentomon nudilabratum*, n. sp.

	I	II-III	IV-VII	VIII	IX-X	XI	XII
Dorsal	$\frac{4}{12}$	$\frac{8^1}{16}$	$\frac{8^1}{16}$	$\frac{6}{9}$	8	8	9
Ventral	$\frac{4}{4}$	$\frac{6}{4}$	$\frac{6}{10}$	$\frac{0}{7}$	6	8	12

<sup>1</sup> Seta  $\alpha 3$  absent.

On foretarsus (Figs. 41, 42), sensilla  $b'1$  and  $c'$  absent; sensillum  $a$  not reaching  $\gamma 2$ ,  $b$  long and nearly reaching  $\beta 7$ ,  $c$  reaching  $\gamma 3$ ,  $d$  extending to  $f 2$ ;  $f 1$  short and linear,  $f 2$  oblong;  $e$  and  $g$  spatulate. Sensilla  $t 2$  and  $b' 2$  narrowly spatulate;  $t 3$  reaching the base of  $\alpha 7$ ;  $a'$  long and slender. Sensillum  $t 1$  close to  $\alpha 3$ , BS = 0.94 (0.87–1.00,  $n = 7$ ).

Abdominal setal composition given in Table 4. Tergum I setal formula 3:1:2;  $p 1'$  almost twice the length of  $p 1$ . On tergites II–VI,  $p 1'$  and  $p 2'$  longer than  $p 1$  and  $p 2$ ;  $p 4'$  tergites II–III setiform, short (Fig. 49), but on tergites IV–VII,  $p 4'$  longer than  $p 4$  and delicate (Fig. 50). Seta  $p 1'$  short and slightly capitulate on tergum VII. On tergite VIII,  $p 1''$  minute, oblong (Fig. 52);  $p 2'$  pointed, not clubbed.

*Collection data.*—Holotype female and two paratype females extracted from wet oak and Spanish moss litter, SRS near Dunbarton, Barnwell County, South Carolina, 13 Apr 1984; one paratype female, same locality, 18 May 1984. Holotype and one paratype in NMNH, two paratypes in UTEM.

*Derivation of name.*—The specific epithet is a compound Latin word meaning “provided with a naked lip,” referring to the lack of labral setae.

*Diagnosis.*—*Eosentomon nudilabratum* is distinguished from all other *Eosentomon* spp. by the lack of labral setae, mandibles with three to five inner teeth, foretarsal sensillum  $t 1$  very close to  $\alpha 3$ , and claviform seta  $p 3'$  on the mesonotum and metanotum. The squama genitalis is somewhat similar to that of *E. pomari* Bernard, which also

lacks labral setae, but possesses median sclerotizations of the styli (absent in *E. pomari*). In addition, *E. nudilabratum* lacks foretarsal sensillum  $c'$  ( $c'$  present in *E. pomari*) and has eight anterior setae on abdominal terga II–VI (ten in *E. pomari*).

*Eosentomon osageorum*,  
new species

Figs. 54–66; Table 5

*Color and dimensions.*—Body well sclerotized, amber brown. Mean length of fully expanded individuals 1332  $\mu\text{m}$  (1217–1446,  $n = 6$ ). Length of foretarsus without claw 103  $\mu\text{m}$  (101–106,  $n = 9$ ). Length of head without labrum 124  $\mu\text{m}$  (122–127,  $n = 6$ ). LR = 11.2 (8.9–13.5,  $n = 6$ ); PR = 10.0 (9.1–12.0,  $n = 9$ ); TR = 6.4 (5.9–6.6,  $n = 9$ ).

*Morphology.*—Pseudoculus oval, with several weak longitudinal striae in the anterior half (Fig. 48). Clypeal apodeme indistinct. Labrum with truncated apices sloping inward to a U-shaped notch, inner corners with fine, curved striae (Fig. 56); labral setae present and reaching just past labral apices. Median rostral setae slightly inflated basally. Mandible tridentate, with two apical and one subapical teeth (Fig. 56). Digits of galea well-developed and rounded apically, the median and inner digits of equal length; outer lobe of lacinia smoothly curved and tapering, distinctly serrate on the inner edge; margin of inner lobe bent at tip to form finger-like process supporting a thin inner lamina (Fig. 57).

Foretarsal empodium shorter than the

claw, EU = 0.87 (0.79–0.84,  $n = 7$ ). Empodia of both middle and hind legs long, EU of middle leg 0.59 (0.52–0.67,  $n = 10$ ), EU of hind leg 0.66 (0.61–0.74,  $n = 11$ ) (Figs. 59–61). Central lobe of praecosta weakly incised on tergites IV–V, very weak and linear on tergites VI–VII (Figs. 64, 65).

Styli of female squama genitalis (Fig. 63) elongate, median sclerotizations present and with small median spurs. Caput processus thin, smoothly curved, and reaching stylus edge, not heavily sclerotized; outer and inner edges of corpus process heavily sclerotized, the outer edge thickened and clavate proximally. Filum processus long and slender; tips of styli bluntly pointed.

*Chaetotaxy.*—Cephalic setae *aa* and *pa* present, anterior sensillum present (Fig. 58); seta *sp* 1.2–1.3 × the length of seta *p*.

Seta *p1'* on meso- and metanotum slightly shorter than *p1*; *p3'* normal, longer than the width of the spiracles; on metanotum, *p5* remote from *p5'* (Fig. 62).

On foretarsus (Figs. 54, 55), *c'* present, *b'1* absent. Most sensilla long and slender; *c*, *d*, *f1*, and *b'2* all about of equal length; *a'* nearly reaching *d*; sensillum *e* long and slender, not spatulate; *g* weakly spatulate. Sensillum *t1* much closer to  $\alpha 3$  than to  $\alpha 3'$ , BS = 1.09 (1.02–1.12,  $n = 9$ ). Metatarsal seta D2 a very stout spine, nearly as large as D5 (Fig. 61).

Abdominal setal composition given in Table 5. Tergum I setal formula 3:1:2; *p1'* 1.5 × the length of *p1*. Accessory setae *p1'* and *p2'* longer than *p1* and *p2* on terga II–VI, *p4'* short and delicate but becoming stronger on each succeeding segment. On tergum VII, *p1'* much shorter than *p1*, rounded but not capitulate at its apex. On tergum VIII, *p1'* and *p1''* aristate, *p2'* slender, very slightly capitulate apically (Fig. 66).

*Collection data.*—Holotype female and three male, three female, and two matus junior paratypes collected from swampy soil near Pine Bluff, Jefferson County, Arkansas, 8 Jul 1988, N. Elkassabany and M. A. Muegge, coll. Holotype and four paratypes

deposited in NMNH, four paratypes in UTEM.

*Derivation of name.*—The specific epithet is derived from the name of a Native American tribe, the Osage, who inhabited parts of what is now Arkansas.

*Diagnosis.*—*Eosentomon osageorum*, in its possession of long mesotarsal and metatarsal empodia, differs from all *Eosentomon* spp. except *E. saharensis* Conde and *E. adakense* Bernard, but differs radically from both in the structure of the corpus process, which appears similar to that of the Japanese *E. asahi* Imadate. The combination of linear foretarsal sensillum *e* and spatulate *g* appears to be unique within the *Eosentomidae*; *Madagascarentomon* Nosek has both sensilla long and setiform.

*Eosentomon pusillum* Ewing  
Figs. 67–75; Table 6

*Eosentomon pusillum* Ewing, 1940:527, fig. 13.—Bonet, 1950:111.—Bonet and Tuxen, 1960:281, figs. 37–42.—Tuxen, 1964:110–112, figs. 128–130.—Tuxen, 1976:436, fig. 19.

*Eosentomon brassicae* Bernard, 1975b:167–169, figs. 31–40. New synonymy.

This species, known originally from a single specimen collected in Florida, has been examined several times and until 1976 was considered to have a short hind empodium (Bonet & Tuxen 1960, Tuxen 1964). Tuxen (1976) studied the holotype once again and found it possessed foretarsal sensillum *b'1* and a long metatarsal empodium. However, many characters are still not described, necessitating yet another restudy of the holotype. After this reexamination, it is obvious that *E. brassicae* Bernard from Michigan is a junior synonym of *E. pusillum*; references to *E. brassicae* below are in parentheses and designated MS (Michigan specimens).

*Color and dimensions.*—Body lightly sclerotized, amber. Length 570  $\mu\text{m}$  (MS: 918). Length of head without labrum 87  $\mu\text{m}$





Table 5.—Abdominal chaetotaxy of *Eosentomon osageorum*, n. sp.

	I	II-III	IV-VI	VII	VIII	IX-X	XI	XII
Dorsal	$\frac{4}{12}$	$\frac{10}{16}$	$\frac{10}{16}$	$\frac{8^1}{16}$	$\frac{6}{9}$	8	8	9
Ventral	$\frac{4}{4}$	$\frac{6}{4}$	$\frac{6}{10}$	$\frac{6}{10}$	$\frac{0}{7}$	4	4	12

<sup>1</sup> Seta  $\alpha 3$  absent.

(MS:85). Length of foretarsus without claw 55  $\mu\text{m}$  (MS:62). LR = 17.6; PR = 6.1 (MS:5.6). TR = 5.6 (MS:6.4).

**Morphology.**—Pseudoculus very large but obscure in holotype, (MS: broadly oval, three longitudinal striae). Clypeal apodeme stout, side arms hooked inward (Fig. 70). Labrum short, apices broadly rounded, medially with a deep V-shaped notch; labral setae present, extending past labral tip (Fig. 70). Rostral setae not inflated. Mandible with two apical teeth and a minute subapical denticle; galea with slender outer digit, rudimentary middle digit, and short, slender inner digit; outer lobe of lacinia short, stout, and slightly curved, inner lobe curved inward at apex but not hooked (Fig. 71).

Empodium of foretarsus about equal to claw, EU = 1.0 (Tuxen [1964]: 0.9, MS 1.0). Empodium of middle leg less than one-fourth the length of its unguis, EU = 0.22; empodium of hind leg nearly two-thirds the length of its unguis, EU = 0.63 (MS:0.64) (Fig. 72).

Central lobe of praecosta very weakly incised (Fig. 73). Female squama genitalis (Fig. 75) distorted, the basal apodeme lying in the horizontal plane but the remainder turned sharply upward. Proximo-lateral sclerotizations present; caput processus shaped somewhat like a duck's head, the apex slightly recurved anteriorly; caput and ala processus appearing to be combined into an S-shape. Median sclerotizations present but thin; filum processus of medium length; stylus apex narrowly rounded.

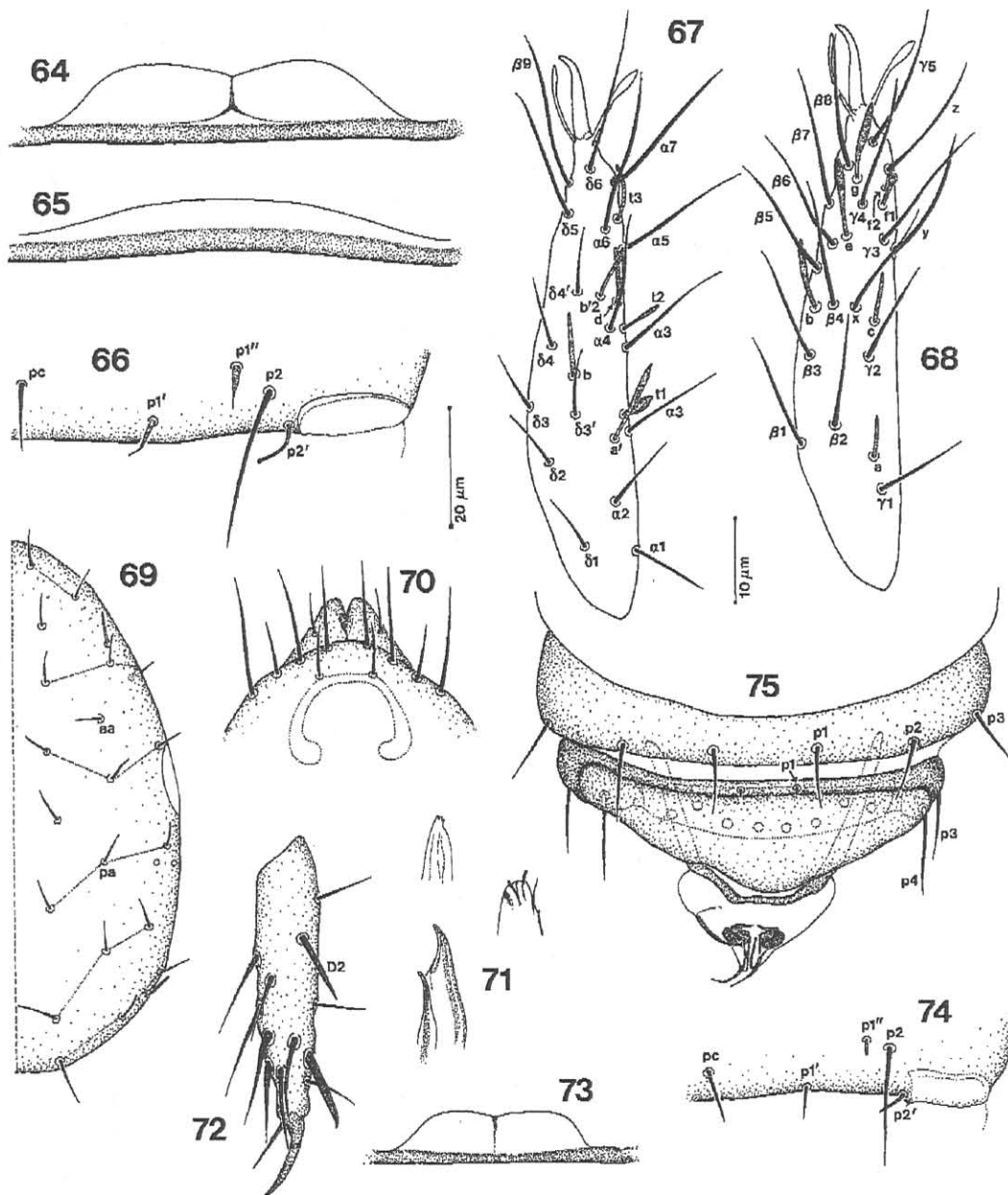
**Chaetotaxy.**—Cephalic setae *aa* and *pa*

present, anterior sensillum present (Fig. 69). Seta *sp* about equal to seta *p*. Setae *p1* and *p1'* of equal length on mesonotum and metanotum; seta *p3'* the same length as the spiracle width; on metanotum, bases of *p5* and *p5'* contiguous.

On foretarsus (Figs. 67, 68) sensillum *c'* absent; *b*, *a'*, and *t2* narrowly spatulate; *e* and *g* rounded spatulate, *f1* spatulate but turned upward and foreshortened; sensillum *b1'* present; *f2* not clearly visible but appearing oblong; *t1* very close to  $\alpha 3$ , BS = 0.75; *t3* thin, curving, reaching the level of  $\delta 6$ . Metatarsal seta D2 a slender spine, slightly thicker than D4 (Fig. 72).

Abdominal setal composition given in Table 6. Setal formula of tergum I 3:1:2; *p1'* longer than *p1*. On terga II–VI, *p1'* and *p2'* longer than *p1* and *p2*; *p4'* delicate and shorter than *p4*. Seta *p1''* on tergite VIII oblong, minute, *p1'* setiform but very short; *p2'* not capitulate (Fig. 74). Tergum XI with only six setae (*p2* absent), the middle pair minute (Fig. 75).

**Diagnosis.**—*Eosentomon pusillum* is similar to the "kumei" group of Tuxen (1964) and Imadate (1974), and to *E. udagawai* Imadate in the S-shaped form of the caput processus + ala processus. It differs from all but *E. udagawai* in the presence of a long metatarsal empodium. *Eosentomon pusillum* differs from *E. udagawai* in the presence of labral setae and lack of foretarsal sensillum *c'* (in *E. udagawai*, labral setae absent, sensillum *c'* present). In Bernard (1985), *E. pusillum* will key to *brassicae*, a species here synonymized with *E. pusillum*.



Figs. 64–75. *Eosentomon osageorum*: 64, Praecosta, tergum V; 65, Praecosta, tergum VI; 66, Posterior margin of tergum VIII. *Eosentomon pusillum*, holotype: 67, Foretarsus, interior view; 68, Foretarsus, exterior view; 69, Right side of head, dorsal view; 70, Labrum and rostral region; 71, Mandible, galea, and lacinia; 72, Metatarsus; 73, Praecosta of tergum VI; 74, Posterior margin of tergum VIII; 75, Posterior abdominal segments with extruded squama genitalis (dotted circles: setal bases of sternite XI; setae of abdominal segment XII not shown). (20  $\mu\text{m}$  scale refers to Figs. 66, 69; 10  $\mu\text{m}$  scale to all others.)

Table 6.—Abdominal chaetotaxy of *Eosentomon pusillum* Ewing.

	I	II-III	IV-VI	VII	VIII	IX-X	XI	XII
Dorsal	$\frac{4}{12}$	$\frac{10}{16}$	$\frac{10}{16}$	$\frac{6^1}{16}$	$\frac{6}{9}$	8	6 <sup>2</sup>	9
Ventral	$\frac{4}{4}$	$\frac{6}{4}$	$\frac{6}{10}$	$\frac{6}{10}$	$\frac{2}{7}$	6	8	12

<sup>1</sup> Setae *a1*, *a3* absent.<sup>2</sup> Seta *p2* absent.

*Eosentomon renateae*,  
new species  
Figs 76–86; Table 7

*Color and dimensions.*—Body moderately sclerotized, yellowish. Mean length of females with various degrees of expansion 884  $\mu\text{m}$  (675–1024,  $n = 3$ ). Length of head without labrum 106  $\mu\text{m}$  (97–110,  $n = 3$ ). Length of foretarsus without claw 67  $\mu\text{m}$  (66–68,  $n = 5$ ). LR = 12.2 (10.7–14.0,  $n = 3$ ); PR = 10.2 (9.6–10.7,  $n = 2$ ); TR = 5.1 (4.8–5.9,  $n = 5$ ).

*Morphology.*—Pseudoculus round, with several very obscure circular depressions in the center (Fig. 80). Clypeal apodeme moderately developed, side arms slightly clavate (Fig. 78). Labrum with rounded apices and deep U-shaped notch; labral setae present, extending past anterior margin (Fig. 78). Central pair of rostral setae indented, apical three-fifths of each seta much narrower than the basal part. Mandible with two apical and one subapical teeth; digits of galea rounded, the outer digit curving outward and longer than the other two digits; outer lobe of lacinia curved and tapering distally and not serrate, inner lobe hooked at apex (Fig. 79).

Empodium of foretarsus shorter than unguis, EU = 0.91 (0.86–0.96,  $n = 5$ ). Empodia of middle and hind legs less than one-sixth the lengths of their unguis.

Central lobe of praecosta incised (Fig. 84). Female squama genitalis (Fig. 86) with short, wide styli; weak proximo-lateral sclerotizations present; caput processus thin and shaped like a boomerang, angled toward inner stylus margin; corpus processus extend-

ing nearly to inner stylus margin; median sclerotizations very well-developed; filum processus almost as long as stylus; stylus apices tapering to finely rounded tips.

*Chaetotaxy.*—Cephalic setae *aa* and *pa* present, anterior sensillum also present (Fig. 80). Seta *sp* 1.5  $\times$  the length of seta *p*.

On mesonotum, *p2'* and *p3'* lanceolate (Fig. 82), *p1* and *p1'* of equal length; metanotal chaetotaxy similar except *p2'* setiform; bases of *p5* and *p5'* contiguous (Fig. 83).

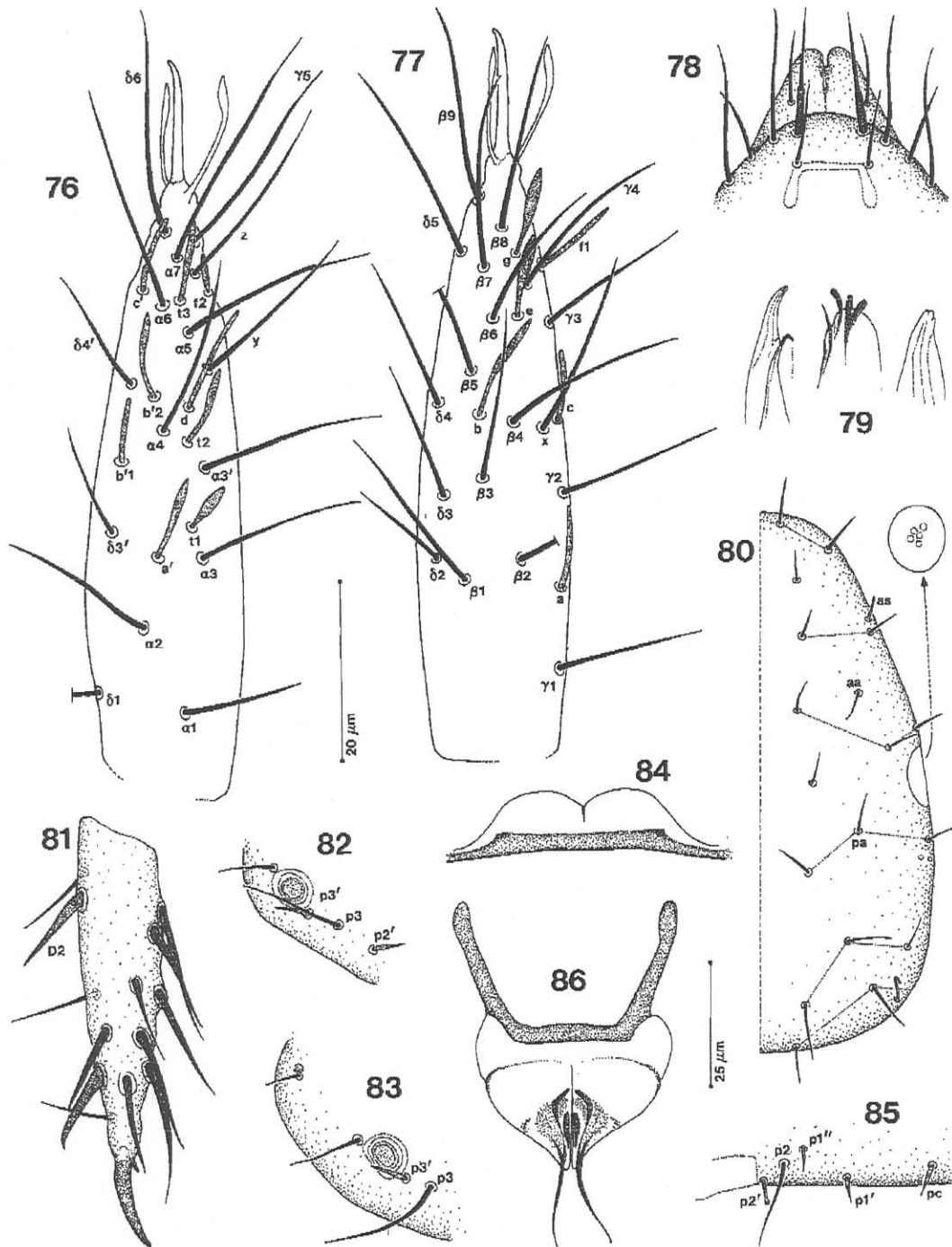
All sensilla present on foretarsus (Figs. 76, 77), sensilla *b*, *e*, *g*, *t2*, *a'*, and *b'2* spatulate; *a*, *c*, *d*, *f1*, *b'1*, *c'*, and *t3* linear, but *t3* slightly broader than the others; *f2* oblong. Sensillum *t1* closer to  $\alpha3$  than to  $\alpha3'$ , BS = 0.84 Metatarsal seta D2 spiniform, stouter than D4 (Fig. 81).

Abdominal setal composition given in Table 7. Tergum I setal formula 3:1:2, *p1'* longer than *p1*. On terga II–VI, *p1'* and *p2'* longer than *p1* and *p2*, *p4'* about half the length of *p4* and less robust.

On tergum VII, *p1'* short and capitulate, *p4'* nearly the length of *p4* and equally robust. On tergum VIII, *pc*, *p1'*, and *p1''* all aristate, *p2'* clearly capitulate (Fig. 85).

*Collection data.*—Holotype female and one paratype female extracted from decaying wood, Upper Three Runs Creek and Road F, SRS, Aiken County, South Carolina, 17 Aug 1983; one paratype female from mixed pine-deciduous litter, SRS, Barnwell County, Road F near the guard rail, 4 Jan 1984. Holotype and one paratype in NMNH; one paratype in UTEM.

*Derivation of name.*—It is a pleasure to



Figs. 76-86. *Eosentomon renatae*: 76, Foretarsus, dorsal view; 77, Foretarsus, ventral view; 78, Labrum and rostral region; 79, Lacinia, galea, and mandible; 80, right side of head, dorsal view, and pseudoculus; 81, Metatarsus; 82, Posterior margin of mesonotum; 83, Posterior margin of metanotum; 84, Praecosta of tergum VI; 85, Posterior margin of tergum VIII; 86, Squama genitalis. (25  $\mu\text{m}$  scale refers to Figs. 80, 82, 83, 85; 20  $\mu\text{m}$  scale refers to all others.)



Table 7.—Abdominal chaetotaxy of *Eosentomon renatae*, n. sp.

	I	II-III	IV	V-VI	VII	VIII	IX-X	XI	XII
Dorsal	$\frac{4}{12}$	$\frac{10}{16}$	$\frac{10}{16}$	$\frac{8^1}{16}$	$\frac{4^2}{16}$	$\frac{6}{9}$	8	8	9
Ventral	$\frac{4}{4}$	$\frac{6}{4}$	$\frac{6}{10}$	$\frac{6}{10}$	$\frac{6}{10}$	$\frac{0}{7}$	6	8	12

<sup>1</sup> Seta *a3* absent.<sup>2</sup> Setae *a1*, *a2*, *a3* absent.

name this species for Dr. Renate M. Snider, Michigan State University, who has made significant contributions to our knowledge of soil arthropod ecology.

**Diagnosis.**—*Eosentomon renatae* is similar to *E. richardi* (this paper) in most chaetotaxic and foretarsal characteristics, but differs primarily in the squama genitalis. In *E. renatae*, the caput processus is boomerang-shaped and the median sclerotizations are strong and prominent, whereas in *E. richardi* the caput processus is shaped like the head of a duck and bent sharply, and the median sclerotizations are thin and rod-like. Also, *E. renatae* has indented median rostral setae, while those of *E. richardi* are thin and not modified. The squama genitalis of *E. renatae* is similar to that of *E. asakawaense* Imadate, but lacks the distinct accessory sclerotization described for that species, and possesses prominent median sclerotizations (very thin in *E. asakawaense*).

*Eosentomon richardi*,  
new species  
Figs. 87-95; Table 8

**Color and dimensions.**—Body moderately sclerotized, yellow-orange. Mean length 782  $\mu\text{m}$  (699-892,  $n = 9$ ). Length of foretarsus 71  $\mu\text{m}$  (69-74,  $n = 13$ ). Length of head without labrum 103  $\mu\text{m}$  (93-115,  $n = 9$ ). LR = 10.7 (9.0-11.3,  $n = 9$ ); PR = 11.0 (9.1-13.3,  $n = 110$ ); tr = 4.5 (4.1-5.3,  $n = 13$ ).

**Morphology.**—Pseudoculus round, with

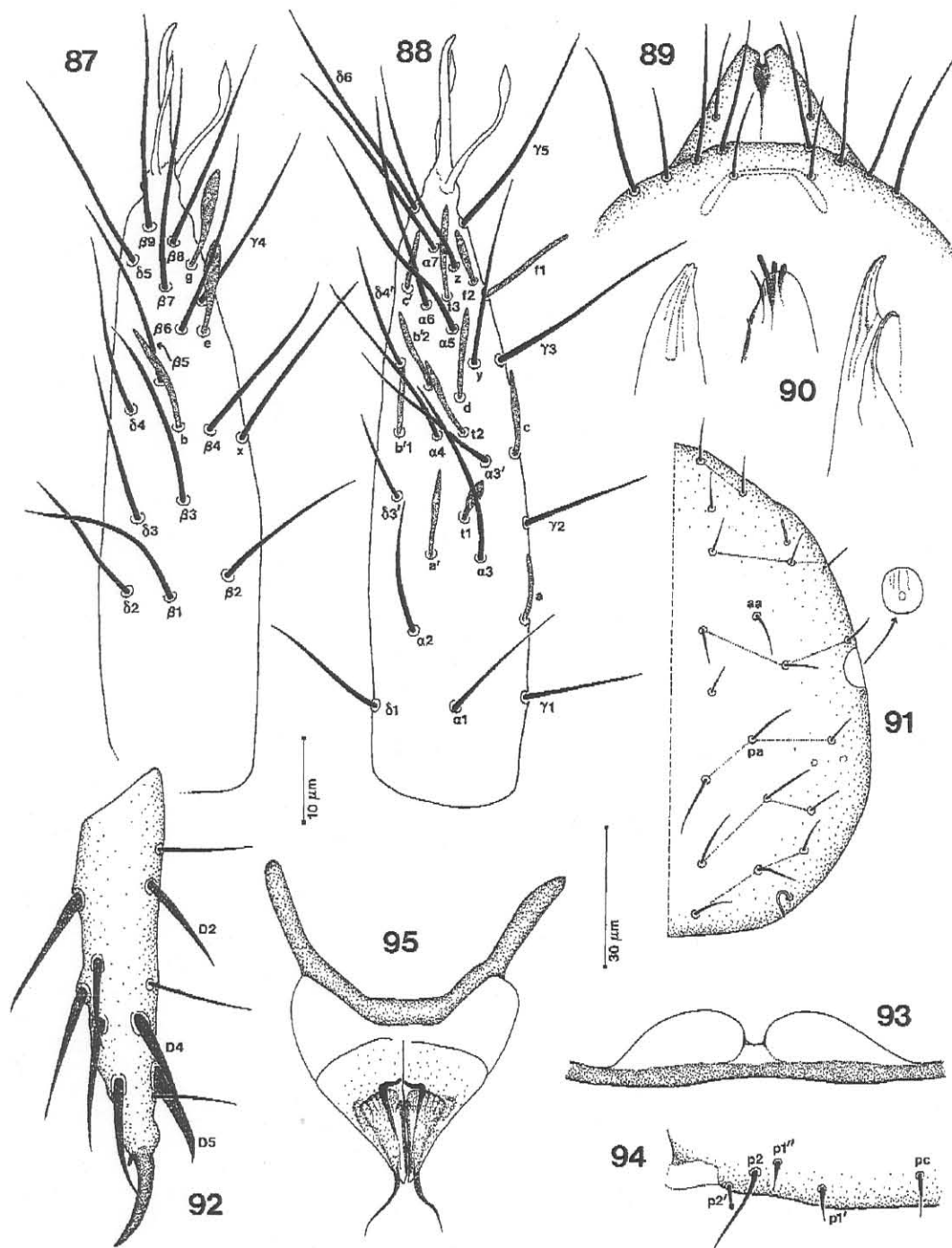
an oval median depression and a few faint, longitudinal striae in the anterior half (Fig. 91). Clypeal apodeme thin, side arms divergent. Labrum with truncate apices angled inward and terminating medially as a U-shaped notch; labral setae present, extending past tip of labrum (Fig. 89). Central pair of rostral setae not inflated. Mandible with three apical teeth, the middle teeth slightly larger than the others; digits of galea cylindrical and rounded apically, the outer digit about twice the length of the other two; outer lacinial lobe tapering, slightly curved, and without serrations; inner lacinial lobe sharply bent at apex (Fig. 90).

Empodium of foretarsus about the same length as the unguis, EU = 0.97 (0.89-1.07,  $n = 10$ ). Empodia of middle and hind legs less than one-fifth the lengths of their unguis.

Central lobe of praecosta deeply sinuate (Fig. 93). Female squama genitalis (Fig. 95) with caput processus in the shape of a duck's head; corpus processus weakly developed, appearing striate in the proximal part, with outlines of the alae processus distinct; median sclerotizations rod-like, filum processus of medium length; stylus apices bluntly pointed.

**Chaetotaxy.**—Cephalic setae *aa* and *pa* present, anterior sensillum present; seta *sp* 1.2-1.5  $\times$  the length of seta *p* (Fig. 91).

Seta *p1'* on mesonotum much longer than, and on metanotum slightly longer than, *p1*; *p3'* setiform, slightly longer than spiracle width; sockets of *p5* and *p5'* on metanotum contiguous.



Figs. 87-95. *Eosentomon richardi*: 87, Foretarsus, ventral view; 88, Foretarsus, dorsal view; 89, labrum and rostral region; 90, Mandible, galea, lacinia; 91, Right side of head and pseudoculus; 92, Metatarsus; 93, Praecosta of tergum VI; 94, Posterior margin of tergum VIII; 95, Squama genitalis. (30  $\mu$ m scale applies to Figs. 91, 94; 10  $\mu$ m scale to all others.)

Table 8.—Abdominal chaetotaxy of *Eosentomon richardi*, n. sp.

	I	II-III	IV-VI	VII	VIII	IX-X	XI	XII
Dorsal	$\frac{4}{12}$	$\frac{10}{16}$	$\frac{8^1}{16}$	$\frac{4^2}{16}$	$\frac{6}{9}$	8	8	9
Ventral	$\frac{4}{4}$	$\frac{6}{4}$	$\frac{6}{10}$	$\frac{6}{10}$	$\frac{0}{7}$	6	8	12

<sup>1</sup> Seta *a3* absent.<sup>2</sup> Setae *a1*, *a2*, *a3* absent.

All sensilla present on foretarsus (Fig. 97, 88); *b*, *c*, *a'*, *b'2*, *t2* and *t3* very weakly spatulate, *e* and *g* broadly spatulate; *f2* oblong, unusually large; all other sensilla except *t1* linear; sensilla *d*, *a'*, *b'2*, *t2*, and *t3* all about equal in length. Sensillum *t1* closer to  $\alpha3$  than to  $\alpha3'$ , BS = 0.83 (0.76–0.91,  $n = 13$ ). Metatarsal seta D2 a slender spine, weaker than D4 (Fig. 92).

Abdominal setal composition given in Table 8. Tergum I formula 3:1:2, *p1'* longer than *p1*. On terga II–VI, *p1'* and *p2'* longer than *p1* and *p2*; *p4'* shorter than *p4* but robust. On tergum VII, *p1'* short and weakly capitulate, *p2'* shorter than *p2*. On tergum VIII, *pc*, *p1'*, and *p1''* aristate and rather slender, *p2'* capitulate (Fig. 94).

**Collection data.**—Holotype female, two male paratypes, and two female paratypes collected from deciduous litter near the Road F guard rail SRS, Aiken County, South Carolina, 26 Mar 1984; one male and two female paratypes from soil under a log in deciduous forest along Road F, SRS, Barnwell County, South Carolina, 18 Jul 1983; one female paratype, decaying wood from Upper Three Runs Creek at Road F, SRS, Aiken County, South Carolina, 17 Aug 1983. Holotype and three paratypes deposited in NMNH, five paratypes in UTEM.

**Derivation of name.**—This species is named for Dr. Richard J. Snider, Michigan State University, who generously allowed me to examine the many proturans collected from the SRS.

**Diagnosis.**—*Eosentomon richardi* is one of the few known North American repre-

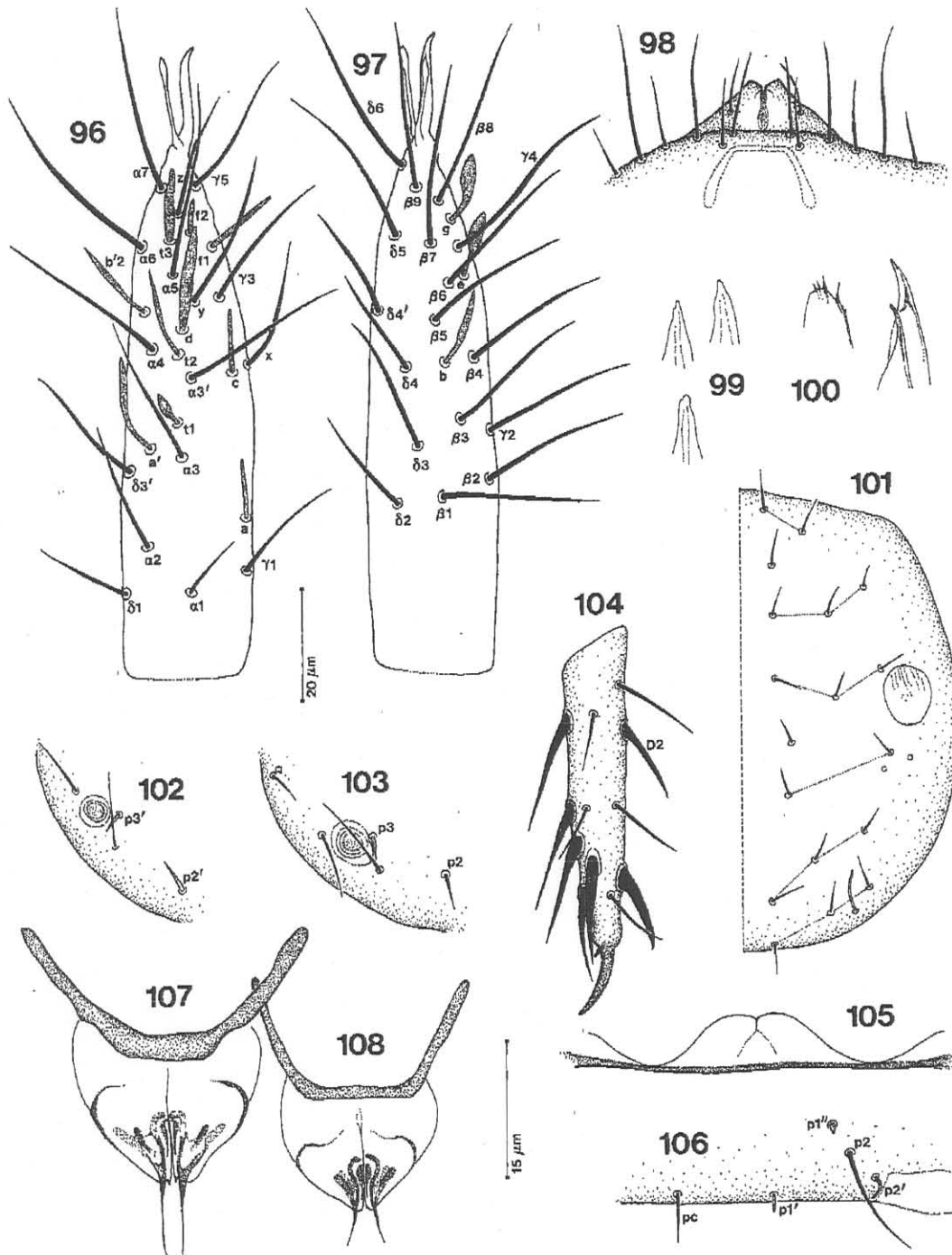
sentatives of the mostly European “*transitorium*” group (Tuxen, 1964), species of which are distinguished by the sharply bent and recurved caput processus, resembling a duck’s head. The presence of the two cephalic setae, *aa* and *pa*, places it among the subset named “*delicatum*” group by Szeptycki (1985) where it will key to *E. zodion* Szeptycki. It differs from this and the other “*delicatum*” group species, and from the North American species *E. vermontense* Nosek and *E. bernardi* Nosek (Nosek & Kevan 1984), in the presence of foretarsal sensillum *b'1*, the presence of eight, rather than ten, anterior setae on abdominal tergum IV, and the presence of six, not four, setae on sternites IX–X.

*Eosentomon savannahense*,  
new species

Figs. 96–108; Table 9

**Color and dimensions.**—Body moderately sclerotized, yellowish. Mean length of females with various degrees of expansion 759  $\mu\text{m}$  (603–1036,  $n = 9$ ). Length of head without labrum 82  $\mu\text{m}$  (70–95,  $n = 9$ ). Length of foretarsus without claw 57  $\mu\text{m}$  (48–63,  $n = 17$ ). LR = 15.3 (11.8–18.5,  $n = 9$ ); PR = 6.1 (5.6–6.5,  $n = 6$ ); TR = 5.8 (5.3–6.4,  $n = 16$ ).

**Morphology.**—Pseudoculus broadly oval, with several faint longitudinal striae in the anterior half and a small, circular central depression (Fig. 101). Clypeal apodeme with thin connecting bar and bulbous side arms (Fig. 98). Labrum small, much wider than



Figs. 96–108. *Eosentomon savannahense*: 96, Foretarsus, dorsal view; 97, Foretarsus, ventral view; 98, Labrum and rostral region; 99, Mandibles; 100, Galca and lacinia; 101, Right side of head, dorsal view; 102, Posterior margin of mesonotum; 103, Posterior margin of metanotum; 104, Metatarsus; 105, Praecosta of tergum VI; 106, Posterior margin of tergum VIII; 107, Variation in squama genitalis. (20 μm scale applies to Figs. 101–103, 15 μm scale to all others.)

Table 9.—Abdominal chaetotaxy of *Eosentomon savannahense*, n. sp.

	I	II-III	IV-VII	VIII	IX-X	XI	XII
Dorsal	$\frac{4}{12}$	$\frac{8^1}{16}$	$\frac{8^1}{16}$	$\frac{6}{9}$	8	8	9
Ventral	$\frac{4}{4}$	$\frac{6}{4}$	$\frac{6}{10}$	$\frac{2}{7}$	4	8	12

<sup>1</sup> Seta *a3* absent.

long, apices truncated to form a shallow V (Fig. 98); labral setae present. Central pair of rostral setae not inflated. Mandible (Fig. 99) slender, rounded terminally or with an obscure, rounded subapical protuberance. Digits of galea spine-like, the outer digit the longest; outer lacinial lobe slightly curved, not serrate, inner lacinial lobe slender and curved but not bent near apex (Fig. 100).

Empodium of foretarsus usually shorter than the unguis, EU = 0.90 (0.85–1.0, *n* = 14). Empodia of middle and hind tarsi less than one-sixth the lengths of their unguis.

Central lobe of praecosta slightly incised (Fig. 105). Female squama genitalis (Figs. 107, 108) with well developed, clubbed or hooked median sclerotizations and weakly sclerotized, semi-circular caput processus; corpus processus reduced except for well-developed alae processus; filum of variable length; stylus apices broadly rounded with a weak to well-developed subterminal spur. Basal apodeme rather thin; proximo-lateral sclerotizations clearly present.

*Chaetotaxy*.—Cephalic setae *aa* and *pa* and anterior sensillum all absent (Fig. 101). Seta *sp* 1.1–1.4 × the length of seta *p*; posterior sensillum longer than the posterior setae.

On mesonotum and metanotum, setae *p1* and *p1'* of equal lengths; *p3'* lanceolate and as long as width of spiracle (Fig. 102). On mesonotum, *p2'* similar in shape to *p3'*; on metanotum *p2'* setiform; *p5* about equal to *p2'* and contiguous with *p5'* (Fig. 103).

On foretarsus (Figs. 96, 97), sensilla *b'1* and *c'* absent; *b*, *a'*, *b'2* and *t2* all pointed-spatulate; lengths of *b'2* and *t2* variable; sen-

sillum *d* long and broad, reaching or bypassing the base of *f2*; *t3* broad, half the length of *d*; *f1* linear. Sensillum *t1* closer to *α3* than to *α3'*, BS = 0.91 (0.83–0.96, *n* = 17). Metatarsal seta D2 a slender spine, much thinner than D5 (Fig. 104).

Abdominal setal composition given in Table 9. Tergum I setal formula 3:1:2; seta *p1'* twice the length of *p1*. On terga II–VI, *p1'* and *p2'* longer than their primary setae; *p4'* delicate and longer than *p4* on terga II–V, robust and shorter than *p4* on terga VI and VII. On tergum VII, *p1'* two-thirds the length of *p1* and capitate, *p2'* longer than *p2*. On tergum VIII, seta *p1'* oblong, *p1''* gemmate, *p2'* short, not noticeably capitate (Fig. 106).

*Collection data*.—Holotype female and two paratype females collected from oak litter, Road F near Dunbarton, SRS, Barnwell County, South Carolina, 18 May 1984; one paratype female, rotted wood and deciduous litter, same general locality, junction of Road 6 and Road C, 10 Mar 1982; one paratype female, soil cores near Road C, SRS, Barnwell County, 26 Sep 1983; one paratype female, soil cores in live oak stand, near Road F—Road B junction, SRS, Barnwell County, 10 Oct 1983; two paratype females, deciduous litter near Road 6 and guard rail, SRS, Barnwell County, 4 Jan 1984; one paratype female, pitfall trap in deciduous swamp near Road 4 and guard rail, SRS, Aiken County, 2 Mar 1984; one paratype female, wet oak and Spanish moss litter near Dunbarton, SRS, Barnwell County, 13 Apr 1984; one paratype female, oak litter in U.S. Forest Service pine plantation, SRS,



Aiken County, 15 May 1984; one paratype female, deciduous litter near Road F guard rail, SRS, Aiken County, 23 Jul 1984. Holotype and four paratypes deposited in NMNH, the remaining paratypes in UTEM.

*Derivation of name.*—This species is named after the Savannah River, which flows near the type locality.

*Diagnosis.*—*Eosentomon savannahense* is very similar to *E. ewingi*, *E. pseudoyosemitense* Copeland and White, and *E. yosemitense* Ewing in the form of the squama genitalis. The following key will serve to separate the four species:

1. Sternum VII with two anterior setae; terga II–VII each with eight anterior setae ..... 2
- Sternum VIII without anterior setae; tergum VII with four or six anterior setae ..... 3
2. Foretarsal sensillum *b'1* present; sterna IX–X each with six setae; median rostral setae indented .....  
..... *E. pseudoyosemitense*
- Foretarsal sensillum *b'1* absent; sterna IX–X each with four setae; median rostral setae thin .....  
..... *E. savannahense*
3. Empodium of metatarsus short; tergum VII with four anterior setae ..  
..... *E. yosemitense*
- Empodium of metatarsus long; tergum VII with six anterior setae ..  
..... *E. ewingi*

*Eosentomon snideri*, new species  
Figs. 109–118; Table 10

*Eosentomon australicum* Womersley of Bernard, 1975b:187, figs. 1–5.

The specimens of this new species from southern Michigan were identified originally as *E. australicum* Womersley 1939 by Bernard (1975b). After reexamination of the specimens with the aid of interference contrast microscopy, and especially with a reinterpretation of the female genitalia, it is

clear they represent a species allied to east Asian taxa such as *E. udagawai* Imadate.

*Color and dimensions.*—Body moderately sclerotized, amber-yellow. Mean length of adults 1183  $\mu\text{m}$  (940–1362,  $n = 6$ ). Length of head without labrum 134  $\mu\text{m}$  (121–148,  $n = 6$ ). Length of foretarsus without claw 88  $\mu\text{m}$  (83–90,  $n = 11$ ). LR = 11.0 (10.1–12.1,  $n = 6$ ); PR = 11.9 (10.2–12.1,  $n = 12$ ); TR = 4.8 (4.2–5.2,  $n = 11$ ).

*Morphology.*—Pseudoculus broadly oval with two small, contiguous, oval median depressions (Fig. 113). Labrum robust, apices rounded-truncate, with several fine, longitudinal lines distally; median notch a rounded U-shape; labral setae present, extending past labral apex (Fig. 111). Clypeal apodeme with large, clavate side arms. Rostral setae inflated. Mandible with two apical and one minute inner teeth; digits of galea cylindrical and apically rounded, the median and inner digits about two-thirds the length of the outer digit; outer lobe of lacinia tapering and curved inward slightly, not serrate on the inner margin; inner lacinial lobe hooked at apex (Fig. 112).

Empodium of foretarsus slightly shorter than the unguis, EU = 0.92 (0.85–1.03,  $n = 11$ ). Empodia of middle and hind legs less than one-fifth the lengths of their unguis.

Central lobe of praecosta sinuate (Fig. 116). Processus sternalis of female squama genitalis (Fig. 118) formed into an S-shape by the caput processus and an ala processus, the caput processus shaped like a duck's head; median sclerotization very broad but weakly sclerotized; filum processus nearly as long as stylus; stylus pointed apically.

*Chaetotaxy.*—Cephalic seta *aa* and *pa* present, anterior sensillum present (Fig. 113). Seta *sp* 1.3–1.5  $\times$  the length of seta *p*.

On mesonotum and metanotum, *p3'* setiform, slightly longer than spiracle width; *p1'* longer than *p1*; on metanotum, *p5* nearly as long as *p3'*, bases of *p5* and *p5'* nearly contiguous (Fig. 114).

On foretarsus (Figs. 109–110), sensillum *b'1* absent; sensilla *b*, *f1*, and *a'* slender and

spatulate, *e* and *g* rounded-spatulate; *f2* clearly claviform; except for *t1*, all other sensilla linear. Sensillum *d* nearly reaching *f2*; *t3* and *c'* of equal length; *a* reaching  $\gamma 2$ . Sensillum *t1* closer to  $\alpha 3'$  than to  $\alpha 3$ , BS = 1.00 (0.93–1.05, *n* = 11). Metatarsal seta D2 a robust spine; most of the ventral spiniform setae very long and slender (Fig. 115).

Abdominal setal composition given in Table 10. Tergum I formula 3:1:2, *p1'* longer than *p1*. On terga II–VI, *p1'* and *p2'* longer than *p1* and *p2*; *p4'* a normal seta, two-thirds of the length of *p4*. On tergum VII, *p1'* capitate, very short, less than one-fifth the length of *p2'*. Setae *p1''* and *p2'* on tergum VIII aristate, base of *pc* far from margin (Fig. 117).

*Collection data.*—Holotype female and two paratype females extracted from moss near Monahan Lake, Livingston County, Michigan, 19 May 1974, E. Bernard, coll.; three paratype females, pine forest soil, Kellogg Forest, Kalamazoo County, Michigan, 23 Jun 1963. Holotype and one paratype deposited in NMNH, three paratypes in UTEM, and one paratype in the Michigan State University Entomology Museum.

*Derivation of name.*—This species is named with pleasure for Dr. Richard J. Snider, world authority on the Collembola and my first mentor for studies on apterygote insects.

*Diagnosis.*—*Eosentomon snideri* is similar to *E. kumei* Imadate and *Yosii* from Japan and *E. udagawai* Imadate from Japan and China (Imadate 1974) but differs in tergal chaetotaxy, length of metatarsal empodium, and details of the squama genitalis. *Eosentomon snideri* has a short metatarsal empodium (long in *E. udagawai*), ten *a*-setae on terga IV–V, four *a*-setae on tergum VII, no *a*-setae on sternite VIII, and four setae on sternites IX–X (in *E. kumei*, eight *a*-setae on terga IV–V; in *E. udagawai*, six *a*-setae on terga IV–V, two *a*-setae on sternite VIII, and six setae on sternites IX–X). The squama genitalis of *E. snideri* has a compact "S" formed from the caput pro-

cessus and ala processus well anterior to the stylus apex, as in *E. udagawai* ("S" large in *E. kumei* and close to stylus apex), possesses median sclerotizations (absent in *E. kumei*), and has sublateral alae (absent in *E. kumei* and *E. udagawai*).

*Eosentomon xenomystax*,  
new species

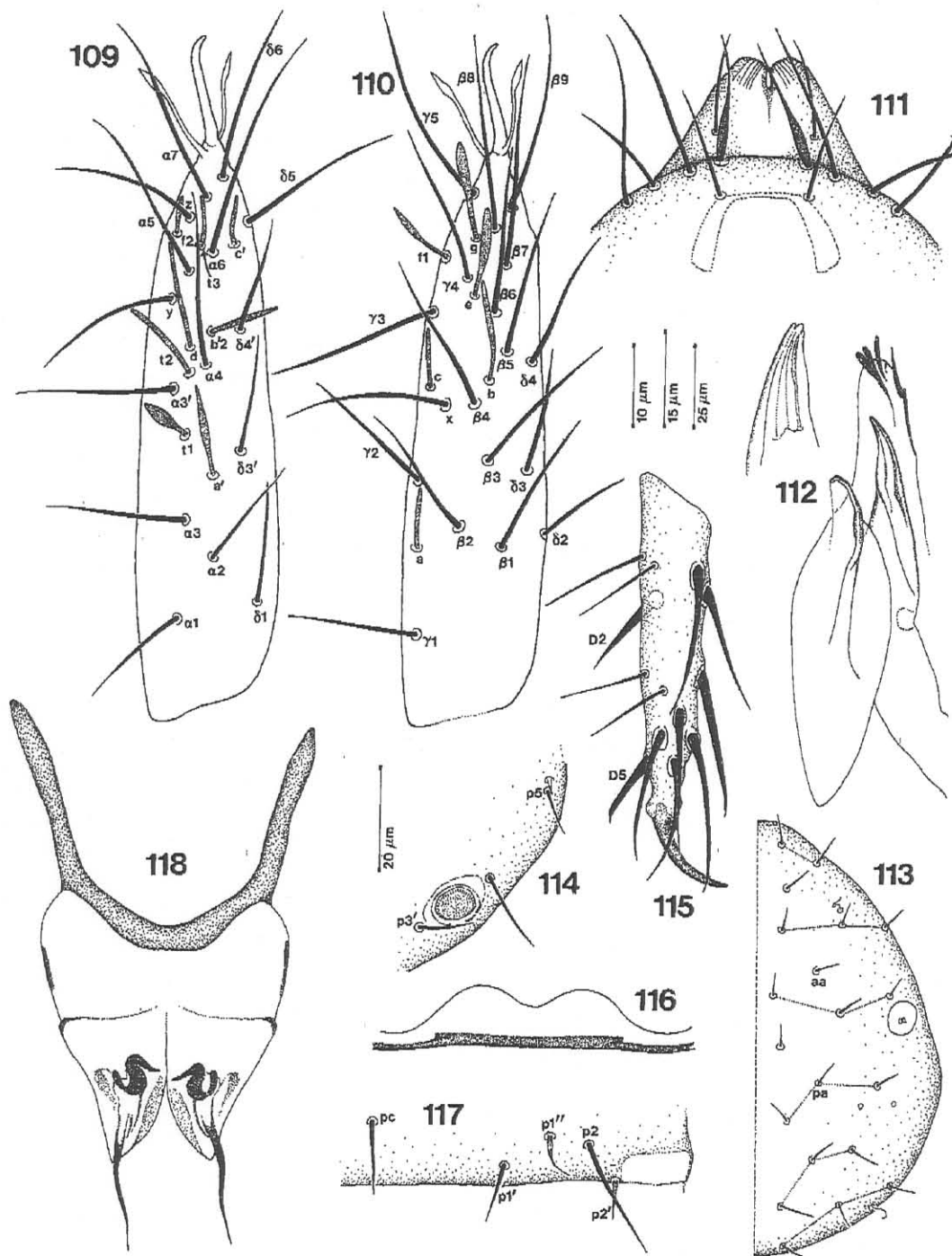
Figs. 119–129; Table 11

*Color and dimensions.*—Body lightly sclerotized except posteriorly, yellowish amber. Mean length of expanded adults 759  $\mu\text{m}$  (627–831, *n* = 4). Length of foretarsus without claw 51  $\mu\text{m}$  (49–54, *n* = 6). Length of head without labrum 81  $\mu\text{m}$  (75–87, *n* = 4). LR = 8.9 (7.2–10.3, *n* = 4); PR = 7.4 (6.8–8.0, *n* = 8); TR = 5.7 (5.4–6.3, *n* = 6).

*Morphology.*—Pseudoculus nearly round, with median line, a few obscure lines anteriorly, and two small circular depressions near its center (Fig. 123). Clypeal apodeme thin, side arms slightly swollen. Labrum of a peculiar shape, the sides concave in the distal half and tapering to small, truncated apices and a minute U-shaped cleft; labral setae present but minute, much shorter than the labrum (Fig. 121). Central pair of rostral setae not inflated. Mandible small and bidentate, with an apical tooth and an inner retrorse tooth; galea of maxilla with the usual outer spine and thin, delicate digits, the outer digit the longest; all three digits fused on the galeal blade; each lacinial lobe curved and evenly tapering, serrations not observed on the outer lobe (Fig. 122).

Empodium of foretarsus generally slightly shorter than the unguis, EU = 0.9 (0.8–1.0, *n* = 7). Empodia of middle and hind legs less than one-sixth the lengths of their unguis.

Central lobe of praecosta trapezoidal, not incised (Fig. 126). Female squama genitalis (Fig. 129) with well-developed sclerotizations of the perigynium and stylus; caput process thin but distinct, smoothly curved to the inner stylus edge; corpus processus



Figs. 109-118. *Eosentomon snideri*: 109, Foretarsus, dorsal view; 110, Foretarsus, ventral view; 111, Labrum and rostral region; 112, Mandible and head of maxilla; 113, Right side of head, dorsal view; 114, Posterior margin of metanotum; 115, Metatarsus; 116, Praecosta of tergum VI; 117, Posterior margin of tergum VIII; 118, Squama genitalis. (10  $\mu\text{m}$  scale applies to Figs. 111, 112, 118; 15  $\mu\text{m}$  scale applies to Figs. 109, 110, 115-117; 20  $\mu\text{m}$  scale applies to Fig. 114; 25  $\mu\text{m}$  scale applies to Fig. 113.)

Table 11.—Abdominal chaetotaxy of *Eosentomon xenomystax*, n. sp.

	I	II-III	IV-VII	VIII	IX-X	XI	XII
Dorsal	$\frac{4}{12}$	$\frac{8^1}{16}$	$\frac{8^1}{16}$	$\frac{6}{9}$	8	8	9
Ventral	$\frac{4}{4}$	$\frac{6}{4}$	$\frac{6}{10}$	$\frac{2}{7}$	4	8	12

<sup>1</sup> Seta *a*<sub>3</sub> absent.

*turneri* Bonet, *E. vermiforme* Ewing, *E. wheeleri* Silvestri, and *Styletoentomon rostratum* (Ewing). This total of 13 species from the SRS represents a more diverse fauna than hitherto observed in North America, and is a richer assemblage of species for the size of the area than reported either in Europe or Japan, two well-studied regions. Imadate (1974) reported 13 species from all of Japan, and Nakamura (1983a, 1983b) has since described two more. Nosek (1973) listed 14 species from all of Europe; since then 26 additional species have been described, mostly by Szeptycki (e.g., 1986); the majority of these are very similar forms separated by small setal and sensilla differences. The greater perceived diversity in the SRS may be due partly to very intensive collecting and the discrimination of isolated specimens of very small species (e.g., *E. crypticum*, *E. renateae*, *E. xenomystax*), which relates to the method of extraction. Proturans usually are extracted with Tullgren-type funnels, which favor the collection of larger, more heavily sclerotized species (> 1 mm length). All of the new species from the SRS described in this paper have lengths usually much less than one mm, whereas all of the previously described SRS species, except *E. pseudoyosemitense*, are longer than one mm. Small proturan species tend to inhabit soil, rather than leaf litter and fermentation layers. Since there is no reason to assume that small species are rarer than large species, it is likely that the choice of extraction method is critical in the quantitative study of Protura.

The species described in this paper help clarify geographical relationships among various *Eosentomon* species groups, which Tuxen (1964) differentiated on the basis of the squama genitalis. The primarily European "transitorium" group is represented in North America by three species: *E. bernardi* (Quebec), *E. vermontense* (Vermont), and *E. richardi* (South Carolina). The east Asian "kumei" group is represented in North America by *E. pusillum* (Michigan, Florida) and *E. snideri* (Michigan). Conversely, the "wheeleri" group is almost exclusively North American, with two species in western Europe and one in Japan. The "maya" group, which includes *E. ewingi* (North Carolina), *E. pseudoyosemitense* (North Carolina, South Carolina, Tennessee), *E. savannahense* (South Carolina), and *E. yosemitense* (California), appears restricted to North America, except for *E. brevicorpusculum* in China.

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