

## Redescription of *Cosberella conatoa* Wray (Collembola: Hypogastruridae) and the description of *C. lamaralexanderi*

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*Abstract.*—*Cosberella conatoa* Wray, 1963, the type and only species of the genus, is redescribed from the type specimens. *Mucrella* Fjellberg, 1985 is synonymized with *Cosberella* as characters that delimit *Mucrella* (e.g., reduced and hidden maxilla lamella 4, presence of eversible antennal sac, minute to moderately developed anal horns) also apply to *C. conatoa*. The six previously described species of *Mucrella*. are transferred to *Cosberella*. *Cosberella lamaralexanderi* is newly described from Great Smoky Mountains National Park. It is differentiated from other species of *Cosberella* by its unusual body color and pattern (white to yellow-orange with a regular arrangement of dark violet spots), trilobed apical antennal bulb, and well-developed antennal sensory field.

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The All-Taxa Biodiversity Inventory (ATBI) in Great Smoky Mountains National Park (GSMNP) has as its goal the comprehensive inventory of all life in the park, from Archaea to vertebrates (see <<http://www.dlia.org>>). Many scientists and volunteers are engaged in the process of collecting and cataloging every species that occurs in GSMNP. Perhaps 100,000 species, exclusive of prokaryotes, live in GSMNP; of this 100,000, three-quarters are invertebrates (Sharkey 2001). Of the estimated 75,000 species of invertebrates, less than 10% had been recorded prior to the beginning of the ATBI in 1998. Soil arthropod taxa account for much of this unrecognized fauna.

Among soil arthropods, Collembola (common name springtails) numerically are more abundant than any other hexapod taxon. Collembola play major roles in the detritivore food web as consumers and recyclers of plant tissues and microorganisms, and as prey for a plethora of other arthropods (Hopkin 1997). No comprehensive survey of GSMNP Collembola has been published,

although a list of 55 species was published based on limited surveys, presumably along roadways (Wray et al. 1963). This compilation is today of limited value due to taxonomic changes, incorrect identifications, and imprecise collecting locations. Intensive surveys in the 1990s, and especially since the inception of the ATBI, have yielded more than 200 species, of which about a third are undescribed and many are new Park records (unpublished). One consequence of taxonomic changes and high diversity is the necessity for reevaluation of many taxa described from the southern Appalachian mountains decades ago.

From the mid-1940s until the early 1970s, David L. Wray described numerous species of Collembola, many of them from the southern Appalachian region of the United States. By today's standards, a number of these descriptions lack the necessary morphological detail to determine generic or even family placement. Through the kindness of Lewis Deitz and Robert Blinn, North Carolina State University, and Kenneth Ahlstrom and

Kathleen Kidd, North Carolina Department of Agriculture, I was able to borrow all of the Wray type material at those two institutions. The goals of this paper are to reevaluate the hypogastrurid genus *Cosberella* Wray, redescribe *C. conatoa* Wray, and describe a new species, *C. lamaralexanderi*.

*Materials and methods.*—Type specimens of *C. conatoa* were remounted due to the dark brown, degraded Hoyer's medium in which they were mounted, which obscured the specimens. The slides were placed in a humid chamber to soften the medium. Two days later, cover slips were removed and specimens were carefully removed from the slide to a dish of distilled water for further removal of old medium. Specimens were placed in 95% ethanol for a brief time, then soaked for 15–30 minutes in Andre's Fluid I to soften and partially reexpand the specimens. The specimens were remounted on the cleaned, original slides in Andre's Fluid II, cured in a 60°C oven for two days, then ringed with Glyptal. Specimens of *C. lamaralexanderi* n. sp. were cleared in Andre's Fluid I or 10% KOH and mounted on slides in Hoyer's medium, then cured in an oven and ringed with Glyptal. Several specimens were dissected to study mouthpart characteristics. Maxillary lamellae were numbered according to Fjellberg (1984), and labial setae were designated according to Fjellberg (1999). The system of Yosii (1960) was used for head and trunk chaetotaxy. Yosii's number is the number of tubercles between the p<sub>1</sub> setae of the fifth abdominal segment.

*Cosberella* Wray, 1963

*Cosberella* Wray, 1963:103.

= *Hypogastrura* (*Mucrella*) Fjellberg, 1985:12.—*Mucrella* Hopkin, 1997:204.

Description (modified from that of *Mucrella* Fjellberg, 1985): Antenna with or without eversible sac between third and fourth segments. Six to eight sensilla on

fourth antennal segment. Sensory field on venter of fourth antennal segment composed of 30 or fewer setae. Mandible with four or five apical teeth and well-developed molar plate. Outer lobe of maxilla with two sublobal hairs. Maxilla with three teeth and six lamellae, the fourth lamella reduced, weakly denticulate or ciliate, not exceeding the apex of the fifth lamella; fourth lamella partially hidden by fifth lamella. Guard setae of labial palpus pointed; lateral process present or absent. Postantennal organ small, variable in extent of development: four small but distinct lobes, irregular, weakly defined lobes, or oval and without lobes; accessory tubercle ("boss") absent. Unguis with ventral tooth, tenent hairs pointed or clavate. Unguiculus lamellate. Pronotum usually with 2+2 setae. Ventral tube with 4+4 setae. Tenaculum with 4 + 4 teeth. Sixth abdominal segment with terminal medial seta. Dens with seven setae; latero-exterior lamella of variable shape; apex tapering, curved. Anal spines usually minute or absent.

Type species: *Cosberella conatoa* Wray, 1963.

Other species:

*C. acuminata* (Cassagnau, 1952) new combination (= *Hypogastrura* (*Mucrella*) *acuminata* Fjellberg, 1985).

*C. arborea* (Fjellberg, 1992) new combination (= *Hypogastrura* (*Mucrella*) *arborea* Fjellberg, 1992).

*C. denali* (Fjellberg, 1985) new combination (= *H. (M.) denali* Fjellberg, 1985).

*C. hibernica* (Fjellberg, 1987) new combination (= *H. (M.) hibernica* Fjellberg, 1987).

*C. navicularis* (Schött, 1893) new combination (= *H. (M.) navicularis* (Schött, 1893)).

*C. yoshiana* (Babenko, 2000) new combination (= *H. (M.) yoshiana* Babenko, 2000).

*Cosberella* was established to accommodate two specimens of Hypogastrur-

idae with an oval, double-walled post-antennal organ (PAO), untoothed unguis, tridentate tenaculum, and without anal horns. Reexamination of the type specimens revealed that except for the PAO, all of these characters were inaccurately described. The unguis is clearly toothed, the tenaculum is quadridentate, and minute anal horns are present. *Mucrella* was established as a subgenus of *Hypogastrura* Bourlet to accommodate species that have a reduced fourth lamella on the maxilla (Fjellberg 1985). This subgenus later was elevated to genus level (Hopkin 1997). In *Cosberella*, the arrangement of the maxillary lamellae is identical to that of species in *Mucrella* Fjellberg, 1985, and many other characters are similar. Therefore, *Cosberella* takes precedence, and the six species currently residing in *Mucrella* are transferred to *Cosberella*. A possibly competing and senior name for this group of species, *Proxenyllodes* Denis, 1926, also exists. This genus was erected for a taxon later hypothesized to be an ecomorph of *H. acuminata* (Christiansen and Bellinger 1980, 1998). However, *Proxenyllodes* is now considered a *nomen dubium* (Bellinger et al. 2005).

The status of *Cosberella* as a separate genus in the *Hypogastrura-Ceratophysella* complex is accepted in this paper, even though it overlaps significantly with those larger genera. It shares with *Hypogastrura* characteristics of the postantennal organ (size similar to nearest ocellus), furcula (shape of mucro and lamellae), labial palpus (longer guard setae acuminate, not spatulate as in *Ceratophysella* Börner [Fjellberg 1999]) and chaetotaxy of the second thoracic segment (seta  $p_4$  is a sensillum). However, most *Cosberella* and *Ceratophysella* have an eversible sac between the third and fourth antennal segments. Until additional characters, including appropriate molecular sequences, can be discerned among a range of species, hypogastrurids with an eversi-

ble antennal sac, reduced fourth lamella, and reduced postantennal organ with weak or confluent lobes should be assigned to *Cosberella*.

Five species (*C. acuminata*, *C. arborea*, *C. denali*, *C. hibernica*, *C. navicularis*) are united with *C. conatoa* in maxillary and PAO characteristics, and all have an eversible antennal sac. All lack or have only minute anal horns except *C. acuminata*, which has moderately developed horns (Cassagnau 1952, 1959; Fjellberg 1985). Three species are temperate or subarctic North American (Indiana, Vancouver, Alaska), one (*C. navicularis*) is Siberian (type locality: Tolstonsosovskoj, Yenisey River area), and one (*C. acuminata*) is western European (type locality: La Montagne Noire, southern France). The placement of *C. yoshiana* is problematic. This Siberian (Tuva) species possesses a maxilla with a reduced and partially hidden fourth lamella, but lacks the eversible sac between the third and fourth antennal segments. Also, *C. yoshiana* possesses the labial lateral process, which is lacking in *C. conatoa*. The unity of *Cosberella* thus is based only on the reduction of the fourth maxillary lamella, and it is possible that this character has appeared independently more than once in Hypogastruridae.

*Cosberella conatoa* Wray, 1963

Figs. 1A–H, 2A–E

*Cosberella conatoa* Wray, 1963:103, Figs. 1I–K.—Christiansen & Bellinger, 1981:1246, *incertae sedis*.—Christiansen & Bellinger, 1998:1430, *incertae sedis*.

*Description*.—"Body color bluish white except for black eye patches" (Wray 1963). Surface sculpture coarsely granulate; Yosii's number = 10. Length 769  $\mu\text{m}$  (holotype), 779  $\mu\text{m}$  (paratype).

Head with 8+8 ocelli, posterior ocelli slightly smaller than anterior ocelli (Fig. 1D, G). Postantennal organ oval or very weakly lobed (Fig. 1D–G); acces-

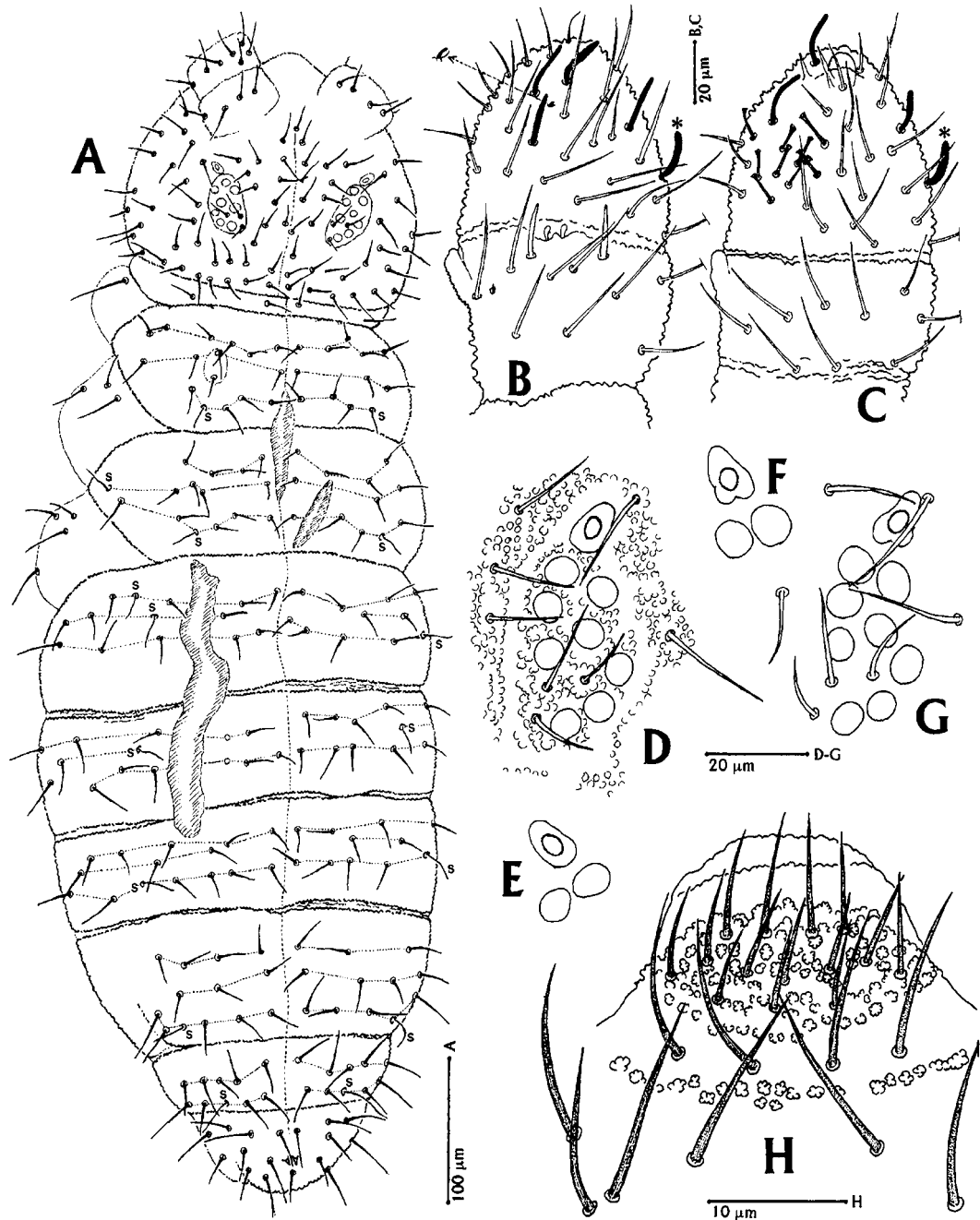


Fig. 1. *Cosberella conatoa*. A, dorsal chaetotaxy, holotype. B, antennal segments 3 and 4, dorsal view, holotype. C, antennal segments, ventral view, holotype. D, right eyepatch and postantennal organ, holotype. E, left postantennal organ and anterior ocelli, holotype. F, left postantennal organ and anterior ocelli, paratype. G, right eyepatch and postantennal organ, paratype. H, labrum, holotype. Hatched areas indicate tears in specimen; s = sensilliform seta; asterisks indicate identical antennal sensillum.

sory tubercle ("boss" of authors) absent. Labrum with 5+5+4 setae, anterior margin crenulate; rostrum with four anterior setae (Fig. 1H). Maxillary palpus with two sublobal hairs (Fig. 2B). All maxillary lamellae with denticulate or ciliate fringes (Fig. 2A); lamella 4 reduced, not extending past lamella 5. Labial palpus (Fig. 2C) with six proximal setae; lateral process absent; guard setae  $a_1$ ,  $b_1$ ,  $b_2$ , and  $h_2$  of similar length and longer than  $d_2$ ,  $e_2$ , and  $h_1$ ; guard setae  $b_3$ ,  $b_4$ ,  $d_3$ , and  $d_4$  hooked apically, pointed; guard setae  $e_1$  and  $e_3$ - $e_6$  pointed but not hooked.

Antennae (Fig. 1B, C) with eversible sac between third and fourth segments. First segment with seven setae, second segment with about eleven setae (segment partially obscured). Sense organ of third antennal segment with two clavate inner sensilla and two pointed outer sensilla (Fig. 1C). Fourth segment with simple subapical lobe, two pointed, non-articulated papillae, and eight well-differentiated sensilla; dorsal sensory peg curved; ventral sensory field (ventral file) with less than 10 or fewer setae.

Tibiotarsus of foreleg and middle leg with 11 a-setae and 8 b+m-setae; hind tibiotarsus with 11 a-setae and 7 b+m-setae; tenent hair pointed (Fig. 2D). Unguis with distinct inner tooth and pair of weak basal teeth; unguiculus lamellate, two-thirds length of unguis (Fig. 2D). Ventral tube with 4+4 setae. Tenaculum with 4+4 teeth; dens with seven smooth setae, tubercular field confined to setal area; length of mucro about  $0.4\times$  that of dens, with rounded external lamella and curved, tapering apex (Fig. 2E); ventral dental sac not seen.

*Chaetotaxy*.—All notal setae smooth, short, slightly longer posteriorly; setal arrangements often asymmetrical (Fig. 1A). Pronotum with 2+2 setae. On mesonotum, lateral sensilliform setae of m-row ( $m_6$ ) not seen; posterior sensilliform setae in  $p_4$  position;  $m_3$  and  $m_4$  longitudinally aligned on left side in both specimens.

On metanotum, sensilliform setae in  $m_6$  and  $p_4$  positions. Microsensilla not seen. On abdominal segment I (Abd. I) sensilliform seta locations variable, occurring in  $a_5$ ,  $m_4$ , or  $p_5$  positions, or absent; sensilliform setae on Abd. II in  $m_4$  (holotype) or  $p_5$  (paratype) positions; on Abd. III,  $p_5$ ; on Abd. IV,  $p_4$ ; on Abd. V,  $p_3$ . Sensilliform setal lengths similar to those of neighboring setae. Postero-median seta on Abd. VI.

*Types and type locality*.—Holotype ("type") and paratype ("cotype"), Cocke County, Tennessee, Great Smoky Mountains National Park, 27 October 1959, leaf litter, elevation 1900 feet (580 m), T. P. Copeland, collector (Wray 1963).

*Diagnosis*.—*Cosberella conatoa* is very similar to *C. hibernica* from Indiana. Both species have few setae in the Ant. IV ventral sensory field, unlobed subapical bulb on Ant. IV, short body setae, short sensilliform setae, and minute anal horns. The PAOs of the two species are similar in reduction of the lobes to a nearly or fully confluent state. However, *C. conatoa* has eight prominent sensilla on Ant. IV, whereas *C. hibernica* has only six. On the pronotum, *C. conatoa* has 2+2 setae, while *C. hibernica* is illustrated as having 3+3 setae but apparently described as having 2+2 or 3+3 setae.

*Discussion*.—Severe compression of the *C. conatoa* specimens rendered difficult the exact interpretation of some morphological structures, especially the maxilla, and the extent of lamellar denticulation and ciliation illustrated in Fig. 2A should be considered approximate. The severity of the original mounting apparently also caused tears in the body that may have resulted in distortions of the chaetotaxy and missing setae. The two type specimens are juveniles, as they lack well-developed genital apertures; however, the paratype may be an immature female. Additional collections are needed in order to more fully describe the important maxilla characteristics and

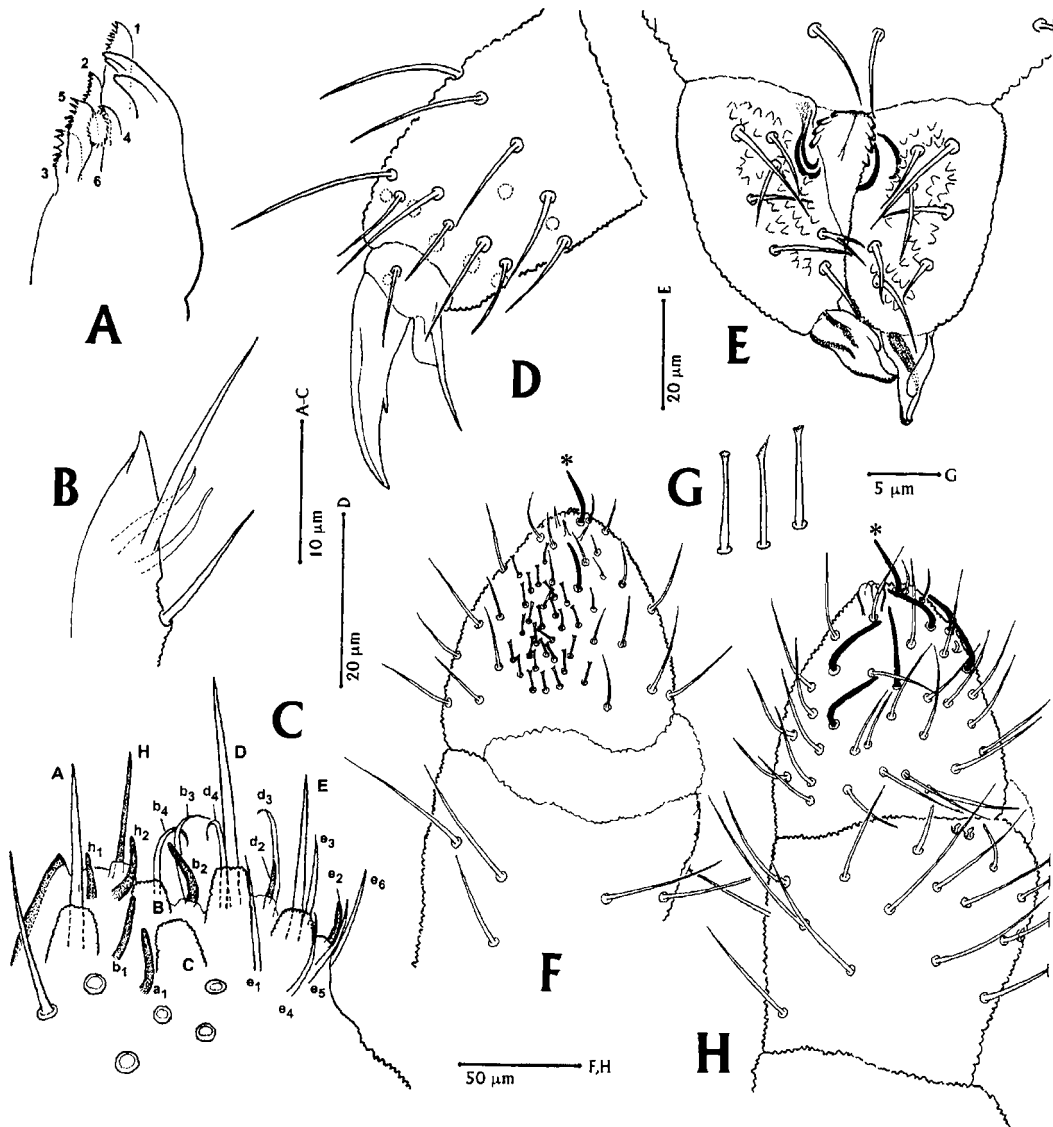


Fig. 2A-E. *Cosberella conatoa*. A, maxilla. B, maxillary palpus. C, labial palpus. D, hind tibiotarsus and foot. E, tenaculum, dentes, and mucrones. F-H. *C. lamaralexanderi* n. sp. F, antennal segments 3 and 4, ventral view. G, setae of antennal sensory field. H, antennal segments 3 and 4, dorsal view.

to better differentiate *C. conatoa* from *C. hibernica*.

Wray labeled the two specimens as "type" and "cotype," and in his 1963 paper (p. 101) indicated that "Types and cotypes of this [*Clingmantha copelandi*] and the following described forms are in the author's collection." As the illustration of the *C. conatoa* PAO in Wray's

paper (Fig. 1J, p. 102) fits the specimen he labeled "type," I consider it the specimen on which the description was based, and therefore the *de facto* holotype. Wray himself never explicitly designated holotypes. He usually used the term "type" if a species was based on a single specimen, and "type series" or "cotypes" if there were multiple specimens of a new species.

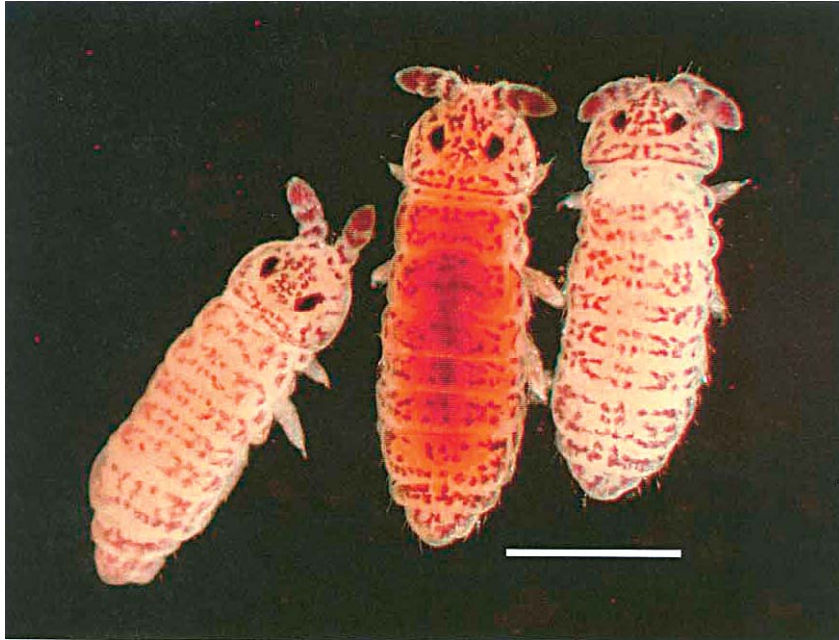


Fig. 3. *Cosberella lamaralexanderi*, paratypes in ethanol, dorsal view. Scale = 500  $\mu$ m.

***Cosberella lamaralexanderi*, new species**  
Figs. 2F–H, 3, 4

*Description of adults.*—Ground color white to orange yellow with symmetrical patterns of violet spots, antennae violet, legs and furcula pale (Fig. 3). Cuticle coarsely granulate; Yosii's number = 9 (Fig. 4G). Length of adult specimens expanded and mounted on slides 1.5–2.0 mm (N = 5), length of specimens in ethanol 1.0–1.5 mm (N = 6).

Head with 8+8 ocelli of about equal diameters. Postantennal organ (Fig. 4D) slightly larger than nearest ocelli, with four weak lobes, anterior lobes larger than posterior lobes, frequently partially confluent; accessory tubercle absent. Labrum with 5+5+4 setae. On maxilla head (Fig. 4B), ventral edge of maxillary lamella 1 with prominent apical denticles, minute medial denticles or cilia, long proximal denticles; dorsal edge with prominent ciliate and denticulate head, smooth medial area, and minutely denticulate proximal area. Lamella 2 ovate,

ciliate, with three distinct central denticles; lamella 3 ciliate; lamella 4 reduced, ciliate; lamella 5 densely ciliate or denticulate; lamella 6 with clawlike apical denticles. Labial palpus (Fig. 4C) with six proximal setae; lateral process absent; guard seta  $h_2$  long, thin, twice the length of  $h_1$ ;  $b_1$  longer than  $a_1$  and  $b_2$ ;  $d_2$  and  $e_2$  short and slender;  $b_3$ ,  $b_4$ ,  $d_3$ ,  $d_4$ ,  $e_1$ , and  $e_3$ – $e_6$  pointed, frequently weakly hooked,  $e_1$  longest.

Antennae (Fig. 2F, H) with eversible sac between third and fourth segments. First segment with seven pointed setae, second segment with 13 pointed setae. Sense organ of third segment with asymmetrically clubbed inner sensilla and tapering outer sensilla. Fourth segment with trilobed subapical bulb, two pointed, non-articulated papillae, and seven sensilla; sensory peg curved, rod-like; ventral sensory field with 25–30 straight or curved setae (ventral file setae), slightly inflated basally, with expanded brush-like tips (Fig. 2G).

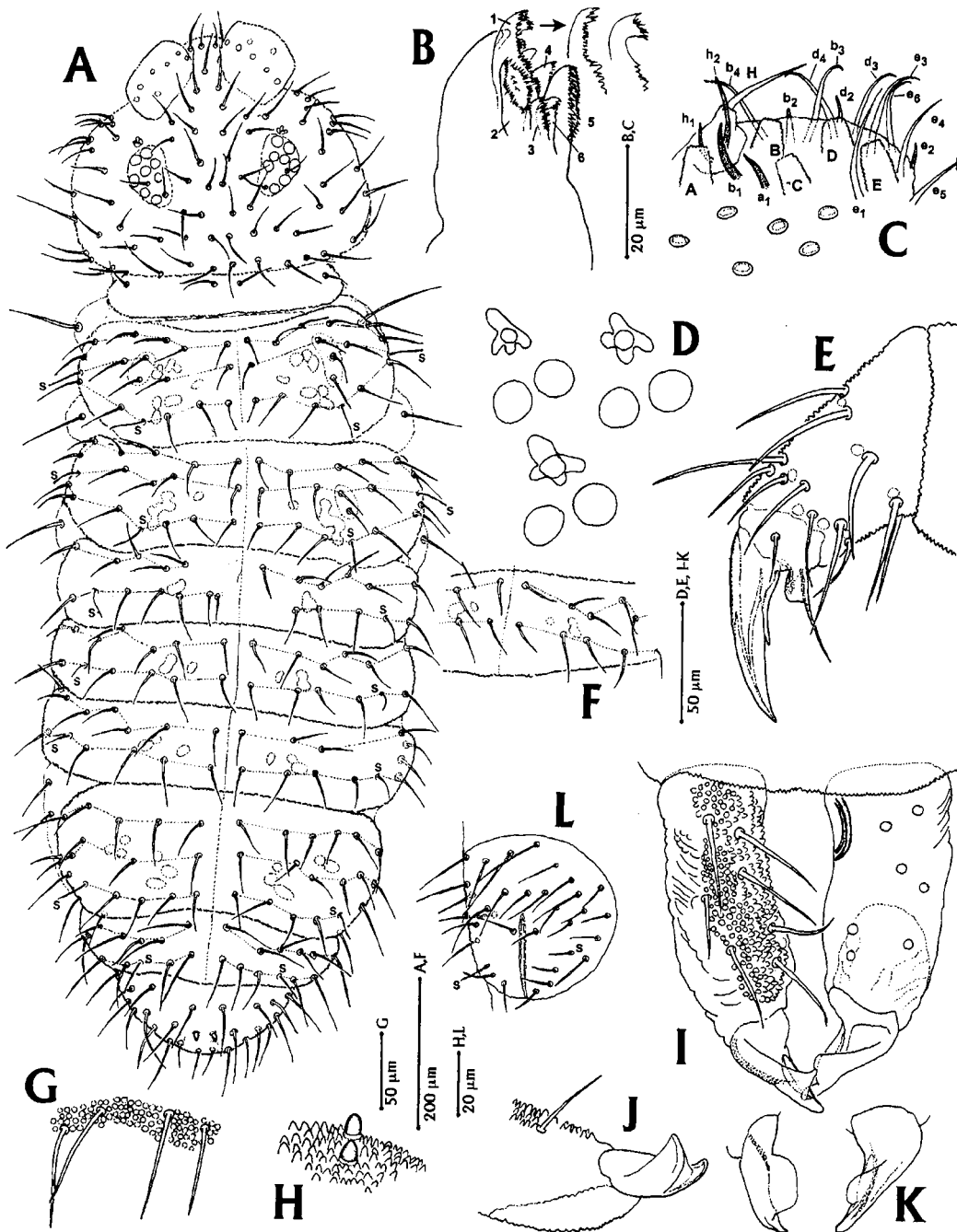


Fig. 4. *Cosberella lamaralexanderi*. A, dorsal chaetotaxy, holotype. B, maxilla, paratype. C, labial palpus, paratype. D, postantennal organs and anterior ocelli, paratypes. E, tibiotarsus and foot complex of anterior leg, paratype. F, chaetotaxy of dorsum of first abdominal segment, paratype. G, posteromedial region of fifth abdominal segment, holotype. H, anal horns, paratype. I, dentes and mucrones, dorsal view, paratype. J, dens apex and mucro, extero-lateral view, paratype. K, mucrones, paratype. L, male genital plate, paratype. Asterisks indicate identical antennal sensillum; s = sensilliform seta.

Tibiotarsus of foreleg and middle leg with 11 a-setae and 8 b+m setae; hind tibiotarsus with 7 b+m setae; tenent hair pointed (Fig. 4E). Unguis with strong inner tooth, basal teeth absent; unguiculus lamellate, two-thirds length of unguis. Tenaculum with 4+4 teeth. Dens with seven acuminate setae; tubercular field confined largely to width of setal area (Fig. 4I); length of mucro 0.4× that of dens, external lamella of variable shape: triangular, trapezoidal, or rounded (Fig. 4I–K); apex of mucro tapering, slightly curved. Ventral dental sac nearly half the length of dens (Fig. 4J). Anal horns minute, rounded or bluntly pointed, on rudimentary bases (Fig. 4H).

*Chaetotaxy*.—All setae smooth and of moderate length (Fig. 4A); setal arrangements often asymmetrical; sensilliform setae shorter than neighboring setae. Pronotum with 2+2 setae. On mesonotum and metanotum, sensilliform setae in positions  $m_6$  and  $p_4$ ;  $m_6$  sensilliform seta occasionally doubled on one side;  $m_3$  and  $m_4$  aligned longitudinally, occasionally joined by  $m_2$ . Mesonotal and metanotal lateral microsensilla gemmate or rod-like, inserted near lateral sensilliform seta  $m_6$ ; bases of microsensillum and  $m_6$  separated by 1–4 times the length of microsensillum. On Abd. I, posterior setae frequently asymmetrical or doubled, sensilliform setae typically in  $p_5$  position (Fig. 4F); on Abd. II–IV, sensilliform setae in  $p_5$  position. On Abd. V,  $p_1$  and  $p_2$  setae of similar lengths (Fig. 4G); sensilliform setae in  $p_3$  or  $p_4$  positions. Male genital plate with about 16+16 acuminate setae, 1+1 sensilliform setae (Fig. 4L); female genital region with about 18 short, slender setae anterior to aperture.

*Juveniles*.—Similar to adults in morphology, proportions, cuticular characteristics, setal arrangements, and setal lengths. Color white with violet spots. Apical antennal bulb weakly trilobed; eight sensilla on Ant. IV; ventral sensory field of Ant. IV with 10 setae. Postanten-

nal organ with three or four weak lobes.

*Types and localities*.—Holotype, eight paratypes mounted on slides, and three paratypes in ethanol, Tennessee, Sevier County, Great Smoky Mountains National Park, Goshen Prong, cove hardwood forest, elevation 895 m, pitfall traps, 31 January–14 February 2001, C. Parker, I. Stocks, and M. Petersen, collectors; one paratype in ethanol, same locality and collectors, 11 December 2000–15 January 2001. One paratype in ethanol, North Carolina, Jackson County, Yellow Face tract adjacent to Waterrock Knob, spruce-fir forest, elev. 1918 m, pitfall trap, 6–20 June 2002, J. Robertson, collector. Four paratypes (juveniles), North Carolina, Haywood County, Blue Ridge Parkway, across road from Devil's Courthouse parking lot, elev. 1664 m, Tullgren funnel extract of leaf litter in spruce forest, 20 July 2005, E. Bernard, collector.

*Disposition of types*.—Holotype, three paratypes on slides, and two paratypes in ethanol deposited in the National Museum of Natural History, Washington, D.C.; two paratypes in alcohol deposited in the Great Smoky Mountains National Park Museum, Gatlinburg, Tennessee; remaining paratypes deposited in The University of Tennessee Entomology Museum, Knoxville, Tennessee.

*Etymology*.—This species is named in honor of Senator Lamar Alexander, friend of Great Smoky Mountains National Park and sponsor of legislation to provide Congressional funding for the All-Taxa Biodiversity Inventory.

*Diagnosis*.—*Cosberella lamaralexanderi* differs from most described *Cosberella* spp. in having a trilobed apical antennal bulb and numerous (up to 30) setae in the antennal ventral sensory field. *Cosberella acuminata* has up to 30 of these setae as well (Fjellberg 1987), but possesses long anal horns (minute in *C. lamaralexanderi*). *Cosberella denali* has a simple to

weakly trilobed antennal bulb, but has fewer ventral file setae (10–15) than *C. lamaralexanderi*. The color and pattern of *C. lamaralexanderi* is quite distinct from that of other *Cosberella* spp. except *C. conatoa*, which was described as bluish white. Juvenile *C. lamaralexanderi* are white with violet spots and have distinctly lobed postantennal organs and relatively long setae. *Cosberella conatoa* has unlobed or very weakly lobed postantennal organs and short body setae.

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