

Review of North American Species of the Genus *Onychiurus* (Collembola: Onychiuridae), With a Description of Four New Species From Caves

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ABSTRACT The history of the genus *Onychiurus* is discussed. Four new *Onychiurus* species are described from North American caves: *steinmanni* and *nathanieli* from Colorado, *relictoides* from Indiana, and *furcisetosus* from Virginia. *Onychiurus relictus* Christiansen, 1961 is redescribed. A key for all of the known North American species is provided.

KEY WORDS Collembola, *Onychiurus*, new species, cave

The genus *Onychiurus* was created by Gervais in 1841 with type species *Podura ambulans* Linnaeus. The name has had an extremely checkered history (Ellis and Bellinger 1973) but became widely used by 1900 with many species of the genus having been described under one or another synonym. The subgenus *Protaphorura* was created by Absolon in 1901 and was widely used and elevated to generic status by Stach in 1954 (Stach 1954). In 1948 and 1949, Bagnall (1948, 1949) created several new genera from the described species of these two genera and in 1954 Stach accepted most of these as valid genera, adding two more. Ironically, in his key to the world species, Stach used only *Onychiurus* sensu lato rather than any of these new generic names. Gisin (1952, 1960) accepts two *Onychiurus* sensu lato taxa as subgenera: *Protaphorura* and *Oligaphorura* but does not key them out separately. In 1996, Weiner revised the genera of old *Onychiurus* sensu lato accepting and redefining most of the genera created by Bagnall, Stach, and others and creating several new genera. The now narrowly defined genus *Onychiurus* has <40 species worldwide. It is impossible at the moment to know how many because many of the features used in the new definition of the genus are unknown in these species. The characteristics of these redefined genera can be seen in the *Onychiurus* key on the Janssens and Christiansen website at <http://www.collembola.org>.

The genus *Onychiurus*, sensu Weiner (1996) and Pomorski (1996, 1998) is represented in North America by only one clearly described species *O. relictus* (Bellinger et al. 2008). A second species, *O. wilchi* Wray 1950 almost certainly belongs in this genus, but the type specimens are in such poor condition and

Wray's description is clearly erroneous in some respects and inadequate in others such that certain placement will have to await further material study. The junior author, K. C., has several additional species with inadequate materials to merit description. This will be a fertile field for new investigators. All of the new species herein described come from caves. If we accept Pomorski's redefinition of *Onychiurus*, then most the species of the genus can be distinguished from most species of the Onychiurini by having only nine or fewer setae in the distal tibiotarsal whorl. The Nearctic species are distinguished from most of the thus narrowly defined genus members by lacking male ventral organs. We found only seven species of the genus having this feature. Of these species, one, *O. aguzouensis* Deharveng, 1978 is distinguished from all Nearctic species by having four pseudocelli at each antennal base (Deharveng 1978). A second species, *O. obsiones* Cassagnau, 1963, has pseudocelli on the venter of the thorax (Cassagnau 1963), unlike any Nearctic species. *O. decemsetosus* Yosii, 1966 is unlike any other species in having two + two pseudocelli on the first thoracic segment (Yosii 1966). It is possible that the loss of the male ventral organ is a troglomorphic feature because almost all species having this feature are either troglophile or troglobiotic.

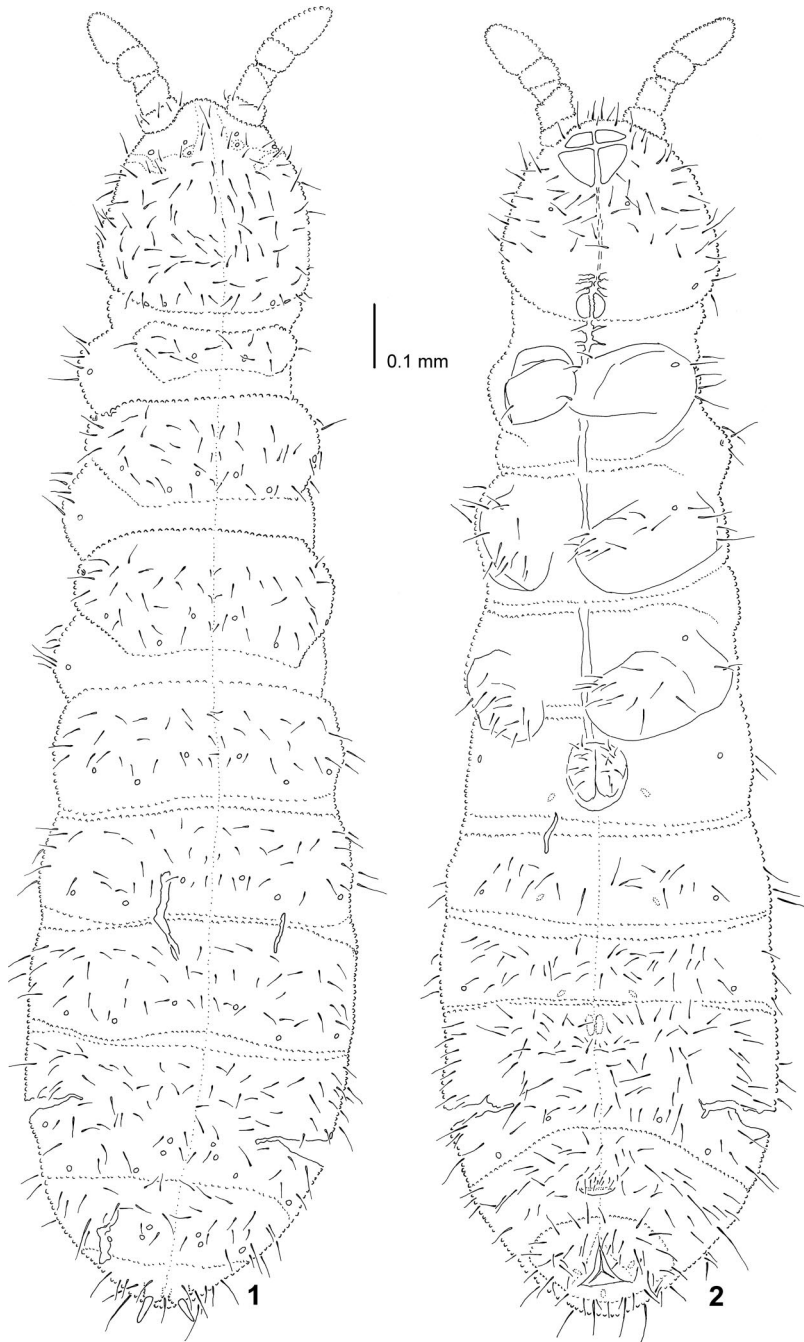
All holotypes are deposited in The Museum of Comparative Zoology (MCZ) at Cambridge, Harvard University. The chaetotaxy terminology is that used in Pomorski (1998). Drawings were made using a camera lucida.

Onychiurus relictus Christiansen, 1961 (Figs. 1–9)

Redescription. Color white. Length (without antennae) of adults: holotype–1.94 mm, reproductive male–1.25 mm, females–1.15–2.0 mm. Body shape cylindrical with anal spines. Furca reduced to small area

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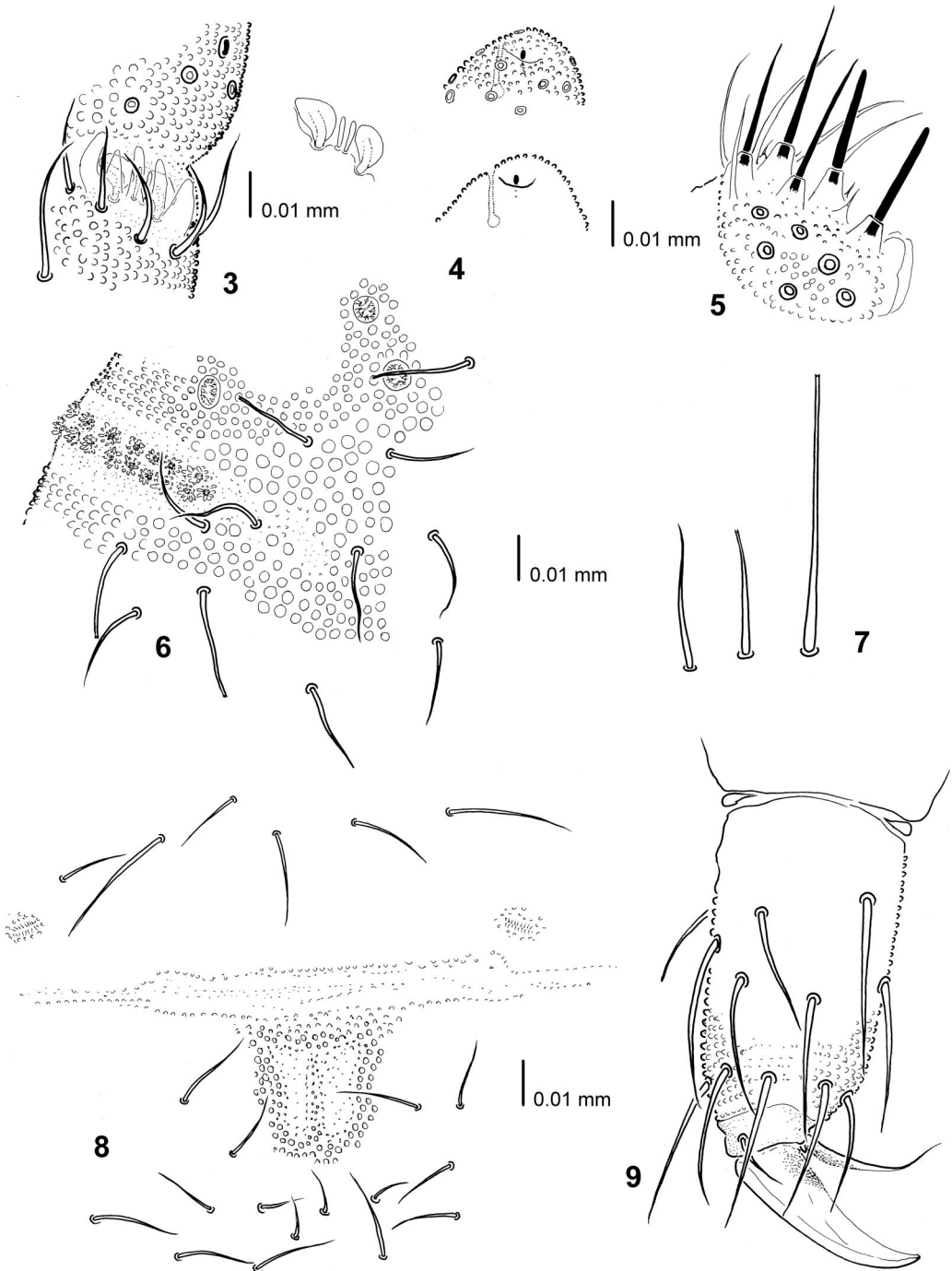
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Figs. 1-2. *Onychiurus relictus* (Christiansen, 1961): (1) habitus and dorsal chaetotaxy; (2) habitus and ventral chaetotaxy. All figures of type specimens.

of fine granulation with 2+2 setae posterior, arranged in one row. Granulation more or less uniform, distinct, somewhat coarser on terga, head capsule and around anal spines. Antennal bases marked? from head. Antennae slightly shorter than head. Antennal segment IV with a subapical organ, consists of two pits, from which the first is deep and usually ampulla like, second is shallow, with small sensillum. Microsensillum on

antennal segment IV in latero-external position, approximately one-third length from the base. Antennal segment III with microsensillum slightly below antennal III sense organ. Thoracic terga II and III with microsensilla located laterally. Antennal organ III with five guard setae, two sensory rods, two bent and smooth sensory clubs and five papillae usually irregular in shape. Postantennal organ consists of 15-16



Figs. 3-9. *Onychiurus relictus* (Christiansen, 1961): (3) antennal III sense organ with papillae and without papillae; (4) top of antennal segment IV; (5) labium, A and C thickened labial papillae; (6) postantennal organ and anterior cephalic pseudocelli; (7) macro-, meso-, and microchaetae; (8) remnant of furca; (9) tibiotarsal chaetotaxy and claw of legs III.

vesicles, covered with secondary vesicles. Pseudocellar formula: dorsal 32/133/33353, ventral 2/000/1112; subcoxae I of legs I-III with 2-2-2 pseudocelli. Formula of parapseudocelli ventrally 00/000/111003. Dorsal chaetotaxy (Fig. 1), nearly symmetrical, well dif-

ferentiated into macro-, meso-, and microsetae. Macro and mesochaetae minutely forked at the tip (Fig. 7). Body sensilla cylindrical and hidden. Abdominal tergum IV with one medial seta. Subcoxae with 5-5-5 setae. No thoracic ventral setae. Ventral

tube of males and females with 10+10 setae. Furcula vestigial. Claws without teeth. Empodial appendage without basal lamella, appendage length ≈ 0.9 –1.0 mm inner edge of claw. Tibiotarsi I–III with nine distal setae. Male ventral organ absent.

Type Material. HOLOTYPE: Reproductive female (mounted on slide) USA, IA, Jackson County, Cave 1958, leg. K. Christiansen. Deposited MCZ. PARATYPES: 4 reproductive females (mounted on two slides); same data as holotype. Other material: 1 reproductive male and 3 females: USA, WI, Crawford County, Star Valley Cave, fungus debris; May VII 1958, leg. K. Christiansen. (Deposited in collection of K.C.)

Onychiurus furcisetosus sp. nov.
(Figs. 10–19)

Description. Color white. Length (excluding antennae) of adults: holotype–2.15 mm, reproductive males–2.08–2.15 mm, reproductive females–2.2–2.3 mm. Furca reduced to small concavity, granulation smaller and sparser than on remainder of body, with two + two setae arranged in one row. Granulation more or less uniform, distinct, somewhat coarser on terga, head capsule, and around anal spines. Antennal bases clearly marked from head. Antennae slightly shorter than head. Antennal segment IV with a sub-apical organ, consists of two pits, from which the first is deep and usually ampulla-like, second is shallow, with small sensillum. Microsensillum on antennal segment IV in latero-external position, approximately one-third length from the base. Antennal segment III with microsensillum slightly below antennal III sense organ. Thoracic terga II and III with microsensilla located laterally. Antennal organ III with five guard setae, two sensory rods, two bent and smooth sensory clubs and five papillae of regular shape (Fig. 15). Postantennal organ consists of 16–17 vesicles, covered with secondary vesicles. Pseudocellar formula: dorsal 32/133/33353, ventral 2/000/11212; subcoxae I of I–III legs each with two pseudocelli. Formula of parapseudocelli ventrally 00/000/111003. Dorsal chaetotaxy (Fig. 10), nearly symmetrical, differentiated into macro-, meso-, and microchaetae. Macro- and mesochaetae are strongly forked at the tip (Fig. 19) Body sensilla cylindrical, poorly differentiated. Abdominal tergum IV with p_6 setae. Subcoxae each with five setae. No thoracic ventral setae. Ventral tube males and females with 8(9)+8(9) setae. Furcula vestigial. Claws without teeth. Empodial appendage without basal lamella, appendage length ≈ 1.0 –1.1 inner edge of claw. Tibiotarsi I–III with nine distal setae. Male ventral organ absent.

Type Material. HOLOTYPE: reproductive male (mounted on slide) USA, VA, Loudon County, Rust Cave #1, old wood and scat, four-IX-2000, leg. David Hubbard. PARATYPES: one reproductive male, two females, two juveniles (mounted on three slides); the same data as holotype (deposited in The Museum of Comparative Zoology at Cambridge, Harvard Univer-

sity, paratypes will be deposited in the collection of K. C.).

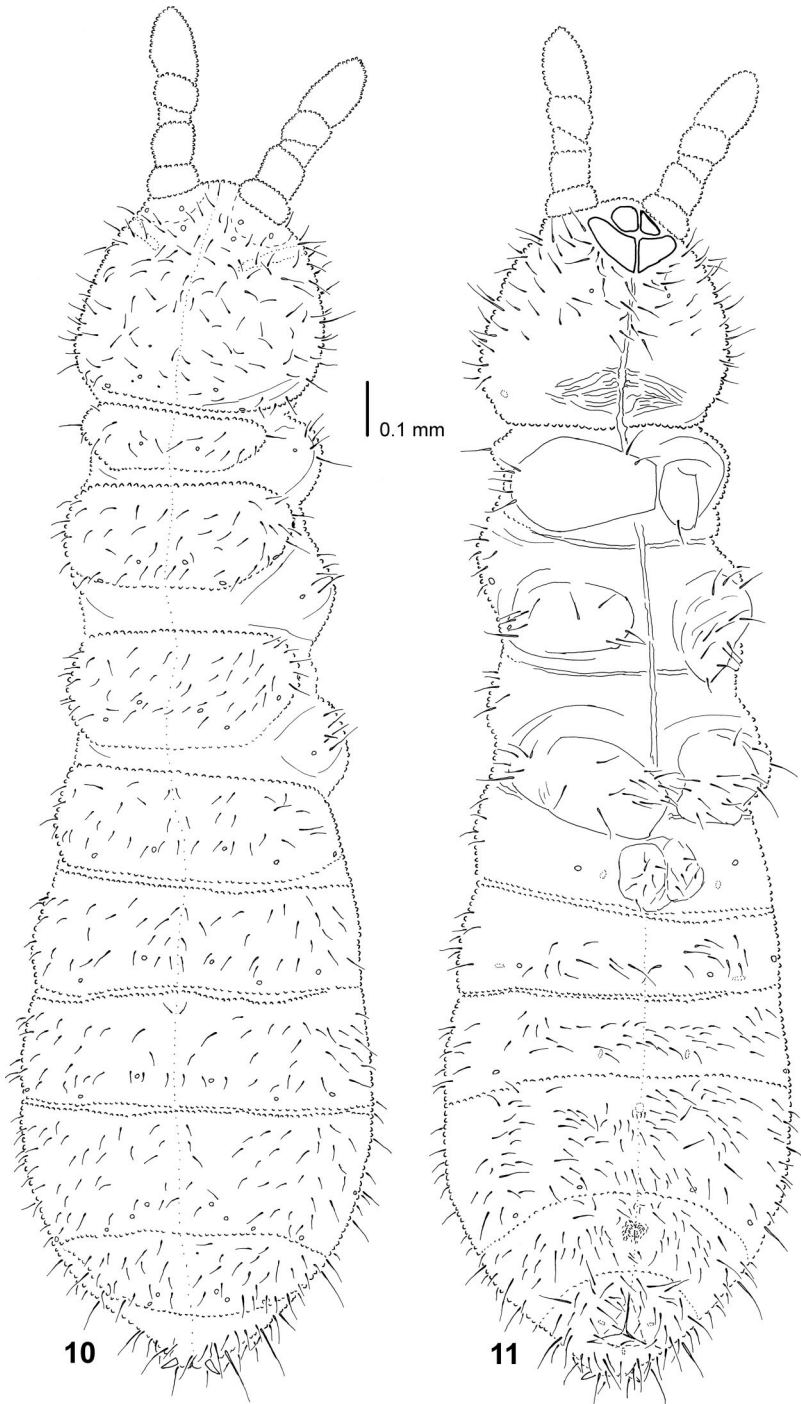
Etymology. The species name is derived from two Latin words “furca” and “setae”, that mark characteristic feature showing very distinctly forked macro- and mesochaetae on the dorsum and sides of body.

Remarks. The furcate macrochaetae distinguish this species from all congeners.

Onychiurus nathanieli sp. nov.
(Figs. 20–27)

Description. Color white. Length (excluding antennae) of adults: holotype–1.16 mm, reproductive males–1.12–1.16 mm, females–1.34–1.96 mm. Body shape cylindrical with anal spines present. Furca reduced to small area of fine granulation with two + two setae posterior, arranged in one row. Granulation of body more or less uniform, distinct, somewhat coarser on terga, head capsule and around anal spines. Antennal bases marked from head. Antennae slightly shorter than head. Antennal segment IV with a sub-apical organ, consisting of two pits, of which the first is deep and usually ampulla-like, second is shallow, with small sensillum. Microsensillum on antennal segment IV in latero-external position, approximately one-half length from the base. Antennal segment III with microsensillum slightly below antennal III sense organ. Thoracic terga II and III with microsensilla located laterally. Antennal organ III with five guard setae, two sensory rods, two bent and smooth sensory clubs and five papillae of irregular shape (Fig. 22). Postantennal organ consists of 15 vesicles, covered with secondary vesicles. Pseudocellar formula: dorsal 32/033/33354(3), ventral 2/000/1112; subcoxae of legs I–III each with two pseudocelli. Formula of parapseudocelli ventrally 10/000/101003. Dorsal chaetotaxy (Fig. 20), nearly symmetrical, well differentiated into macro- and microchaetae. Body sensilla cylindrical; those on ventral side hidden; on dorsal side arranged in formula: 2/011/111121, poorly differentiated, except for abdominal terga V, where they are clearly visible. Abdominal terga V with one medial seta. Subcoxae with 4–5–5 setae. No thoracic ventral setae. Ventral tube of both males and females with six + six setae. Furcula vestigial. Claws without teeth. Empodial appendage with basal lamella, appendage length ≈ 0.65 length of inner edge of claw, or somewhat longer. Tibiotarsi I–III with nine distal setae. Male ventral organ absent.

Type Material. Holotype: Reproductive male (mounted on slide) USA, CO, Garfield County, 11,100 m elevation, 107° 18' 39" 40' In dark zone. Collected ≈ 100 m from entrance on organic matter near moist areas; 3-IX-2006, leg. D. Steinmann. PARATYPES: 1 molting male and 3 reproductive females (mounted on three slides); the same data as holotype. (Holotype is deposited in the Museum of Comparative Zoology; paratypes are in the collection of K. C.).

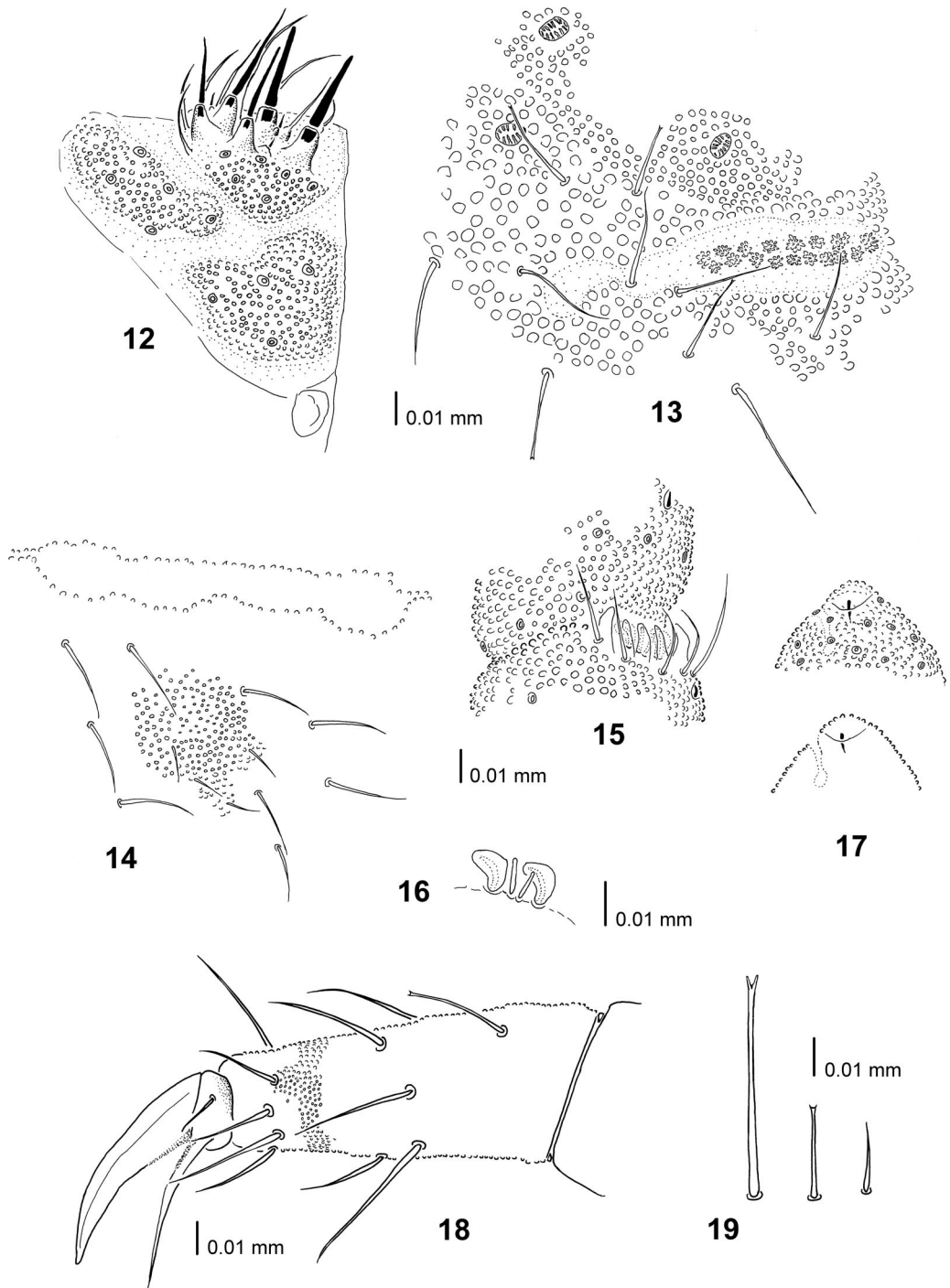


Figs. 10–11. *Onychiurus furcisetosus* sp. n.: (10) habitus and dorsal chaetotaxy; (11) habitus and ventral chaetotaxy.

Etymology. The species is dedicated to the son of David Steinmann, Nathaniel, who together with his father explores the North American caves.

Remarks. This species resembles *Onychiurus bhattii* Yosii, 1963 from Pakistan but differs in the less

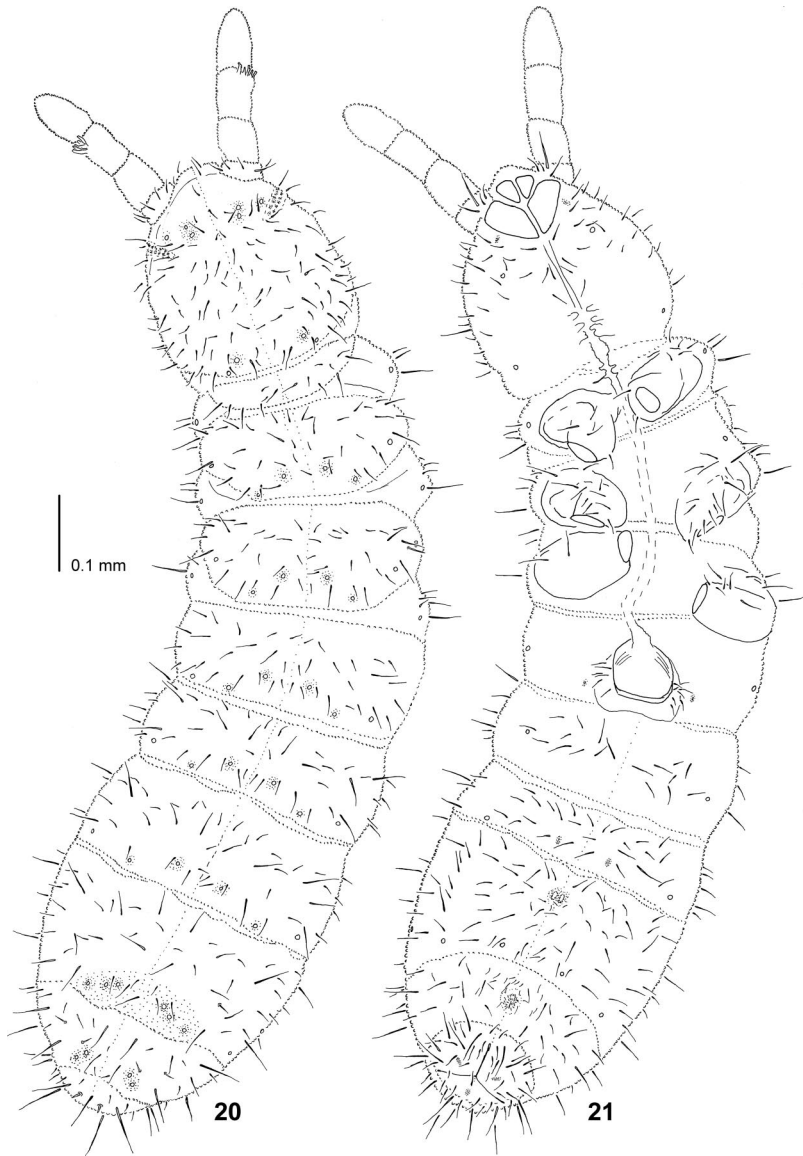
oligochaetotic chaetotaxy and the presence of two fifth abdominal ventral pseudocelli and strikingly in having a basally lamellate unguiculus (Yosii 1966). This feature also serves to distinguish the species from all its Nearctic congeners as well as the North African



Figs. 12–19. *Onychiurus furcisetosus* sp. n.: (12) labium; (13) postantennal organ and anterior cephalic pseudocelli; (14) remnant of furca; (15) antennal III sense organ with papillae; (16) antennal III sense organ without papillae; (17) top of antennal segment IV; (18) tibiotarsal chaetotaxy and claw of legs III; (19) macro-, meso-, and microchaetae.

O. obsiones. *O. nathanieli* sp. nov. also resembles the Spanish *O. borensis* Beruete et al. (1994) in several of features but differs in number of pseudocelli with the latter having 6+6 pseudocelli on abdominal segments

IV and V, whereas the former has 4+5 and 4+4 or 3+3, respectively (Beruete et al. 1994). *O. nathanieli* is also similar to Yosii's *O. decemsetosus* but differs in lacking pseudocelli on the first thoracic segment.

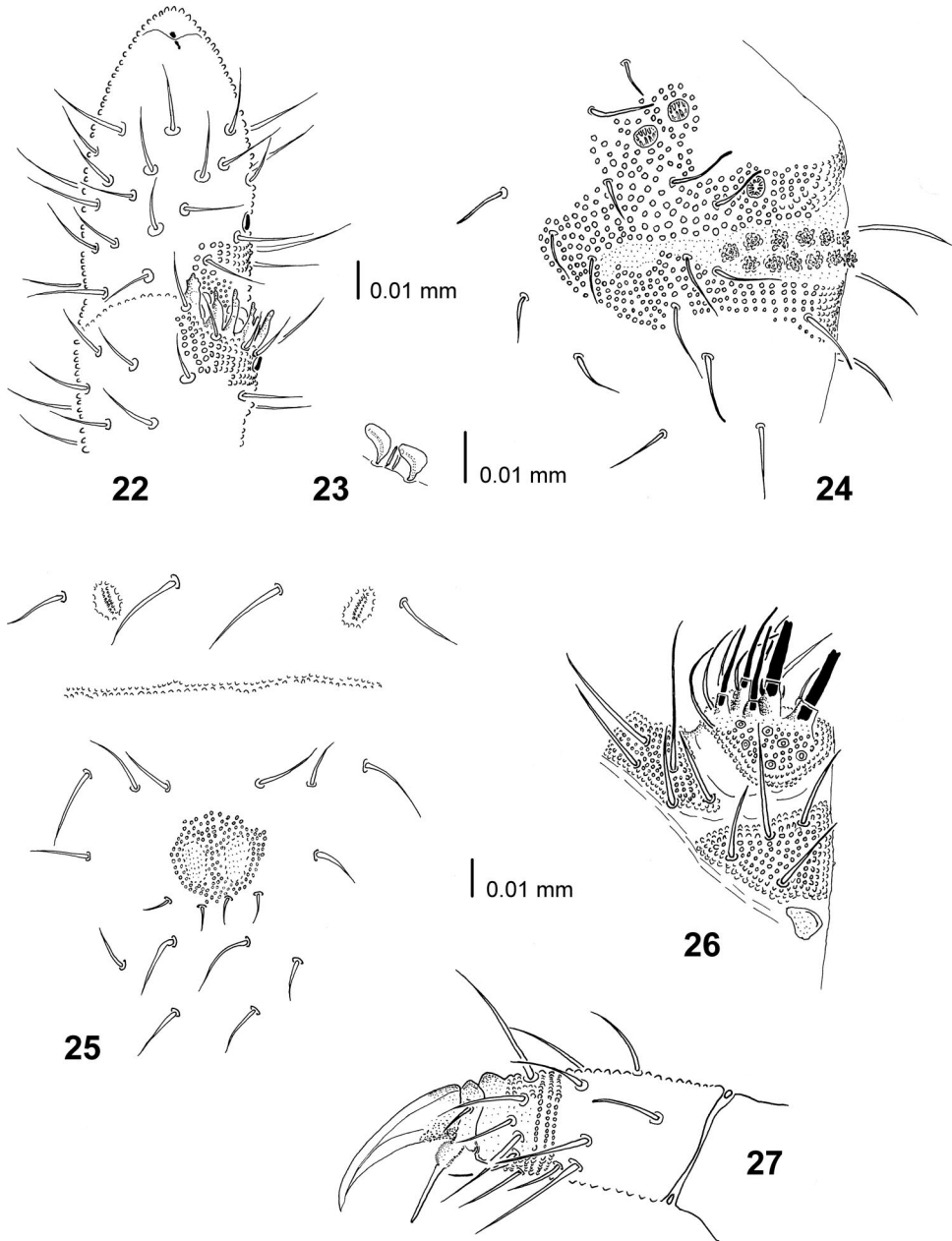


Figs. 20–21. *Onychiurus nathanieli* sp. n.: (20) habitus and dorsal chaetotaxy; (21) habitus and ventral chaetotaxy.

Onychiurus reluctoides sp. nov.
(Figs. 28–34)

Description. Color white. Length (excluding antennae) of adults: holotype–1.0 mm, reproductive males–1.0–1.6 mm, females–1.25–1.5 mm. Body shape cylindrical with anal spines present. Furca reduced to small area of fine granulation with 2+2 setae posterior, arranged in one row. Granulation more or less uniform, distinct, somewhat coarser on terga, head capsule and around anal spines. Antennal bases clearly marked ? from head. Antennae slightly shorter than head. Antennal segment IV with a subapical organ, consisting of two pits, from which the first is deep and usually ampulla-like, second is shallow, with small sensilla. Microsensillum on antennal segment IV in latero-

external position, approximately one-half its length from the base. Thoracic terga II and III with microsensilla located laterally. Antennal segment III with microsensillum slightly below antennal III sense organ. Antennal organ III with five guard setae, two sensory rods, two bent and smooth sensory clubs and five papillae, from which second from external side is forked on the top (Fig. 30). Postantennal organ consists of 14–15 vesicles, covered with secondary vesicles. Pseudocellar formula: dorsal 32/133/33354, ventral 2/000/1212; subcoxae of legs I–III each with two pseudocelli. Formula of parapseudocelli ventrally 1/000/101003. Dorsal chaetotaxy (Fig. 28), usually symmetrical, well differentiated into macro- and microchaetae. Body sensilla cylindrical and poorly dif-

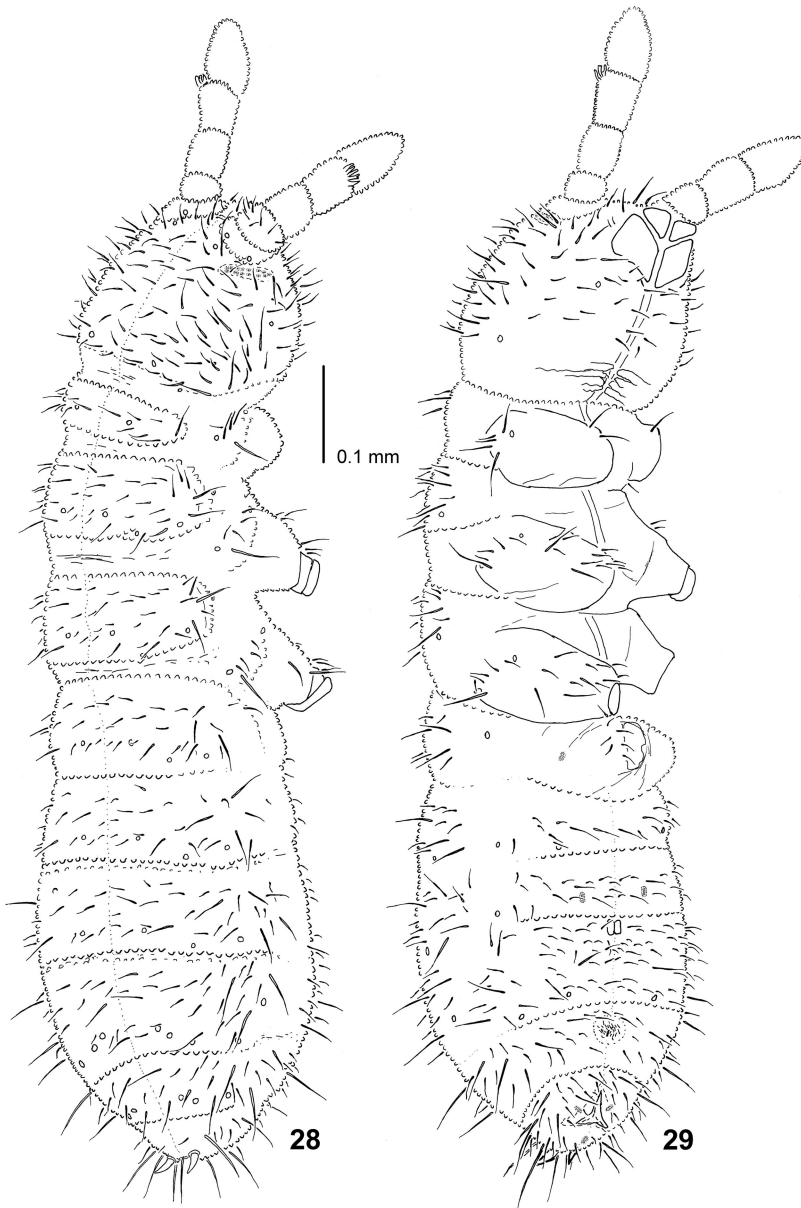


Figs. 22–27. *Onychiurus nathanieli* sp. n.: (22) antennal III sense organ with papillae; (23) antennal III sense organ without papillae; (24) postantennal organ and anterior cephalic pseudocelli; (25) remnant of furca; (26) labium; (27) tibiotarsal chaetotaxy and claw of legs III.

ferentiated from normal setae. Abdominal tergum IV with p_0 seta. Subcoxae each with five setae. No thoracic ventral setae. Tubus ventralis without setae at base. Ventral tube of males and females with nine + nine setae. Setae in front of anal spines relatively long, usually reaching anal spines. No setae between legs. Ventral abdominal chaetotaxy (Fig. 29). Furcula vestigial. Male ventral organ absent. Claws always without teeth. Empodial appendage without basal lamella, appendage length about 1.1 times length of

inner edge of the claw. Tibiotarsi with distal whorl of nine setae.

Type Material. HOLOTYPE: Reproductive male (mounted on slide), USA, IN, Lawrence County, J.J.'s sister cave, ≈ 1 mi. SW Bryantsville, 29 by 2000, leg. Jerry Lewis. PARATYPES: Reproductive male, 2 females, 1 juvenile (mounted on three slides); same data as holotype (Holotype is deposited in the n Museum of Comparative Zoology, paratypes in the collection of K. C.).



Figs. 28–29. *Onychiurus reluctoides* sp. n.: (28) habitus and dorsal chaetotaxy; (29) habitus and ventral chaetotaxy.

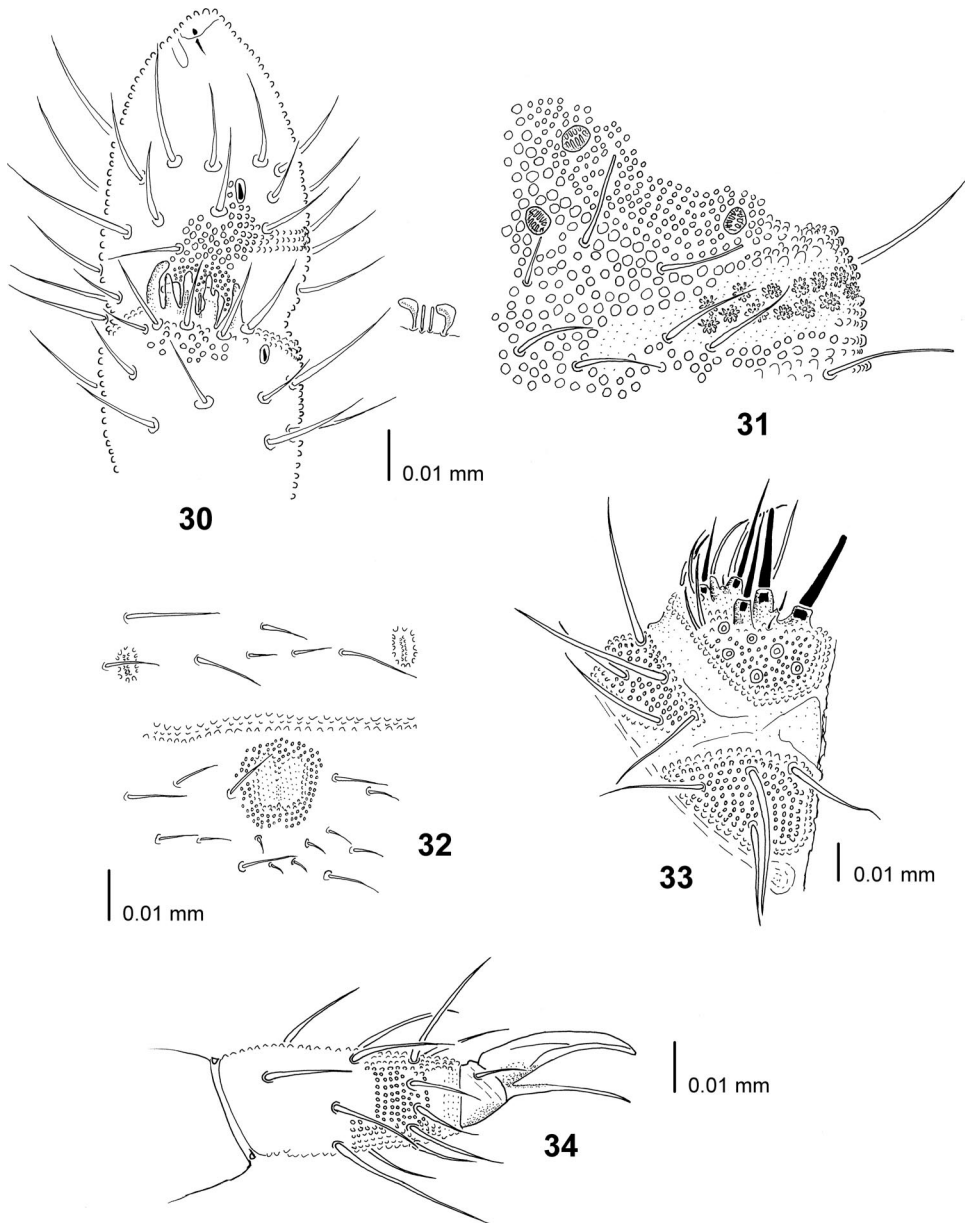
Etymology. The species name is derived from the previously described similar species *O. reluctus*.

Remarks. This species is very similar to *O. reluctus* but can be distinguished both on the pseudocellar formula and the absence of truncate macrochaetae on the abdomen.

***Onychiurus steinmanni* sp. nov.**
(Figs. 35–43)

Description. Color white. Length (excluding antennae) of adults: holotype–2.1 mm, reproductive males–1.6–2.5 mm, females–1.5–2.6 mm. Body shape

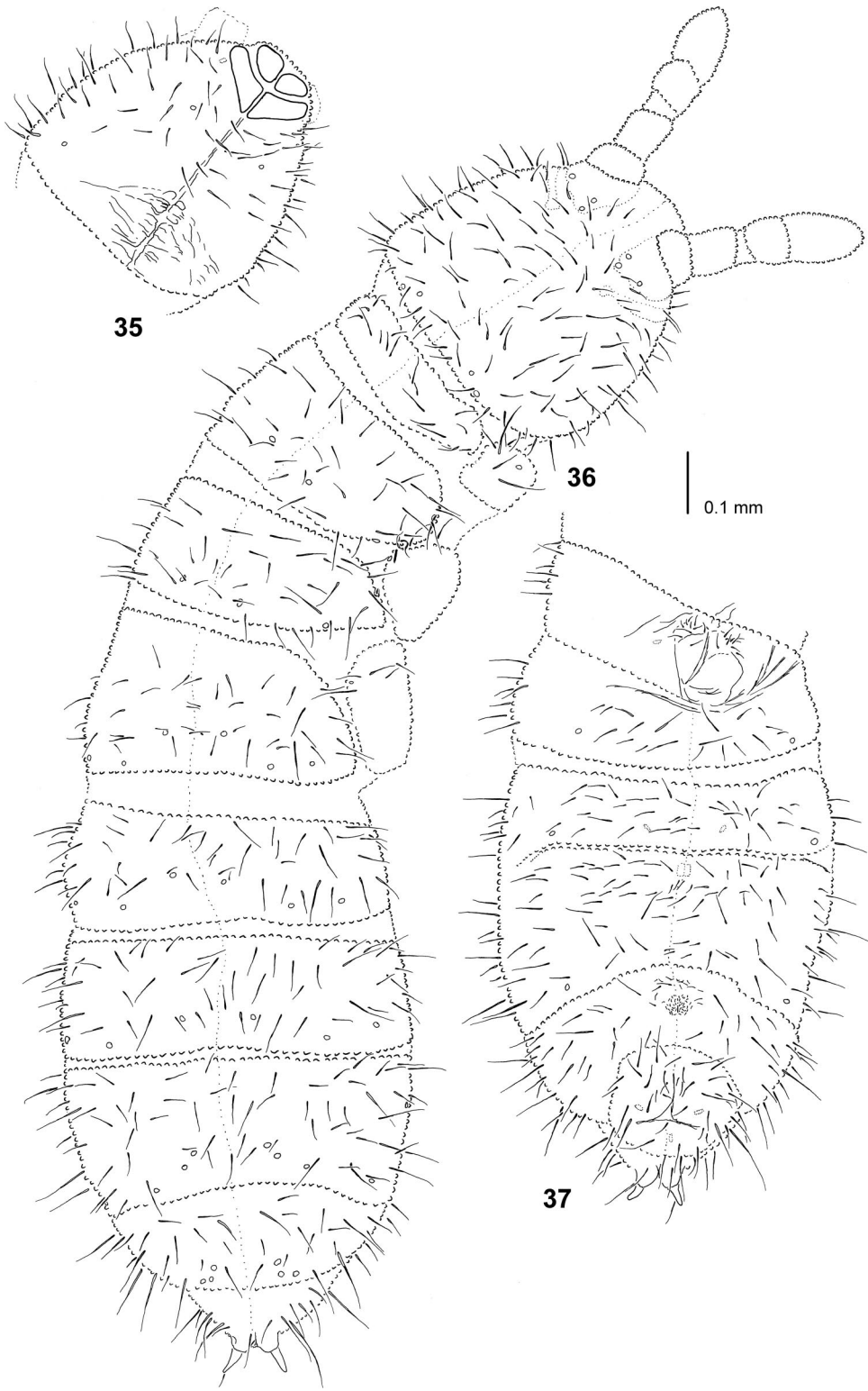
cylindrical with anal spines present. Furca reduced to small concavity of fine granulation with 2+2 setae arranged in one row. Granulation more or less uniform, distinct, somewhat coarser on terga, head capsule and around anal spines. Antennal bases marked from head. Antennae slightly shorter than head. Antennal segment IV with a subapical organ, consists of two pits, from which the first is deep and usually ampullaceous, but less than at other species, second is shallow, with small sensillum. Microsensillum on antennal segment IV in latero-external position, approximately one-half its length from the base. Antennal segment III with microsensillum



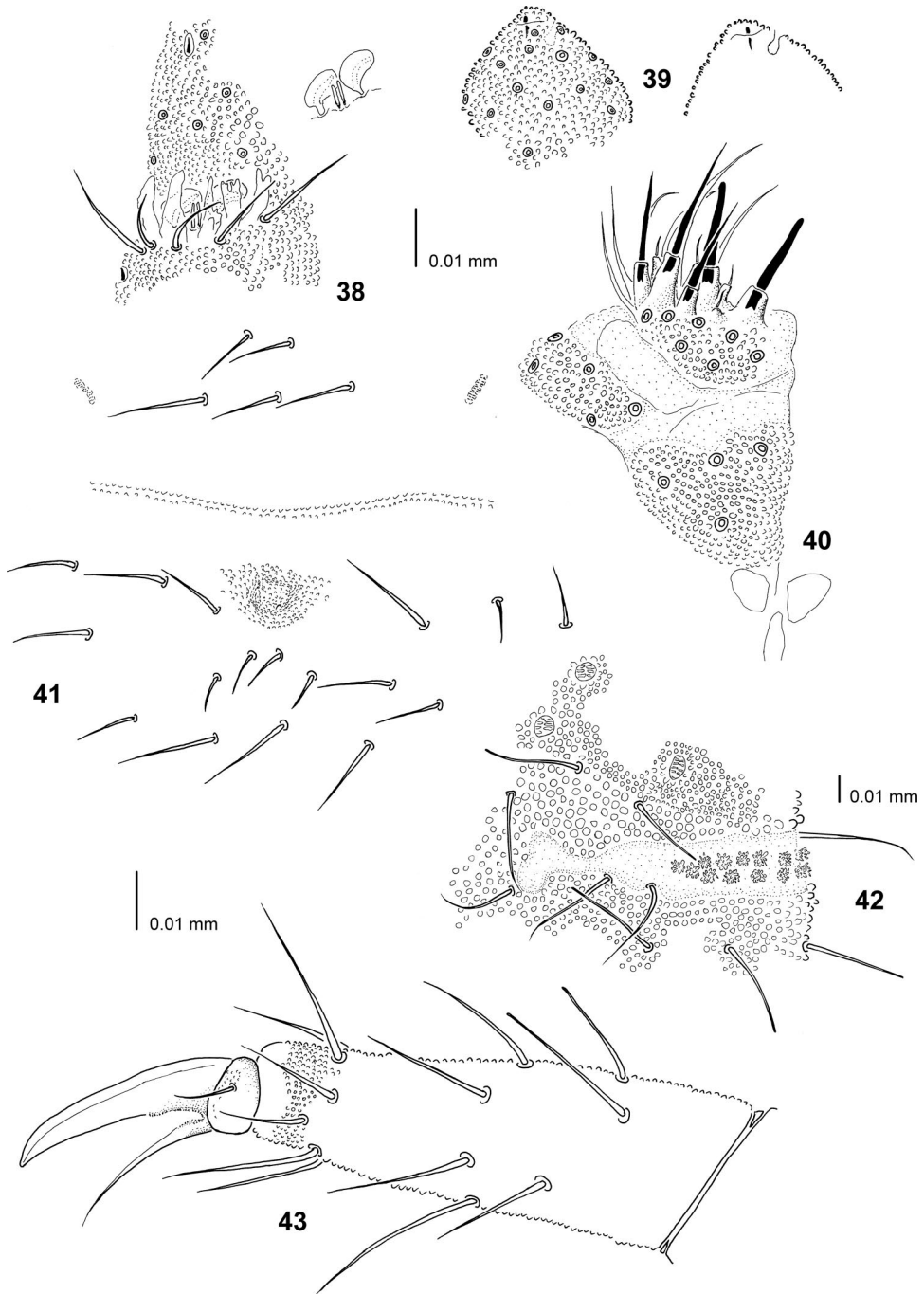
Figs. 30-34. *Onychiurus relictoides* sp. n.: (30) antennal III sense organ with papillae and without papillae; (31) postantennal organ and anterior cephalic pseudocelli; (32) remnant of furca; (33) labium; (34) tibiotarsal chaetotaxy and claw of legs III.

slightly below antennal III sense organ. Thoracic terga II and III with microsensilla located laterally. Antennal organ III with five guard setae, two sensory rods, two bent and smooth sensory clubs and five papillae of irregular shape (Fig. 38). Postantennal organ consists of 16-17 vesicles, covered with secondary vesicles. Pseudocellar formula: dorsal 32/022/33353, lateral pseudocelli on abdominal tergum V absent, ventral 2/000/1112; subcoxae of legs each with one pseudocellus and one parapseudocellus. Formula of parapseudocelli ventrally 1/000/101003.

Dorsal chaetotaxy (Fig. 36), nearly symmetrical, well differentiated into macro- and microchaetae. Body sensilla cylindrical, poorly differentiated. Abdominal tergum IV with p_0 setae. Subcoxae each with five setae. No thoracic ventral setae. Ventral tube of males and females with 9(10)+9(10) setae. Claws without teeth. Empodial appendage without basal lamella, appendage as long as inner edge of claw. Tibiotarsi I-III with nine distal setae. Male ventral organ absent.



Figs. 35–37. *Onychiurus steinmanni* sp. n.: (35) ventral side of head; (36) habitus and dorsal chaetotaxy; (37) ventral side of abdomen.



Figs. 38–43. *Onychiurus steinmanni* sp. n.: (38) antennal III sense organ with papillae and without papillae; (39) top of antennal segment IV; (40) labium; (41) remnant of furca; (42) postantennal organ and anterior cephalic pseudocelli; (43) tibiotarsal chaetotaxy and claw of legs III.

Type Material. HOLOTYPE: Reproductive male (mounted on slide) USA, CO, Garfield County, 2,580 ft elevation, Hubbards Cave, in dark zone on moist rock and bat scat; 15-IX-2001, leg. D. Steinmann. PARATYPES: 1 reproductive male and 4 females (mounted on four slides); the same data as

holotype. (Holotype is deposited in the Museum of Comparative Zoology; paratypes in the collection of K. C.).

Other Material. Five males and 4 females (mounted on two slides); USA, CO, Garfield County, Hubbards Cave, cave depths; 16-IX-1999, leg. Steinmann.

Etymology. The species is dedicated to David Steinmann who collected specimens of this species from North American caves.

Remarks. This species is distinguished from all others described herein by the absence of pseudocelli on the first thoracic segment. The species named *O. wilchi* may be a synonym but is so poorly known that this is impossible to ascertain. In addition, the collection sites are so different (an alpine cave and an Illinois garden) that it seems highly improbable that they are the same species.

Key to North American Species of *Onychiurus*

- 1. Empodial appendage with basal lamella
 *O. nathanieli* sp. nov.
 - Empodial appendage without basal lamella
 2
- 2. Thoracic tergum I with 1+1 pseudocelli 3
 - Thoracic tergum I without pseudocelli
 *O. steinmanni* sp. nov.*
- 3. Abdominal sternum II with 2+2 pseudocelli
 4
 - Abdominal sternum II with 1 + 1 pseudocelli.
 *O. relictus* Christiansen, 1961
- 4. Abdominal tergum V with 3+3 pseudocelli
 *O. furcisetosus* sp. nov.
 - Abdominal tergum V with 4+4 pseudocelli
 *O. relictoides* sp. nov.

* *O. wilchi* will key out here, but the collection sites make it improbable that they are the same species.

Acknowledgments

Stephanie Peterson was of great aid in preparation of this manuscript. Publication was made possible by a grant from Grinnell College. A disastrous accident to R.J.P. that placed him in a coma has made the global distribution of this genus problematic. As a result, we can be relatively certain of the species belonging to the genus from very few regions. Many of the features he used to redefine the genus are not given in many descriptions.

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