

MYRIAPODOLOGICA



Virginia Museum of Natural History

Vol. 6, No. 6

ISSN 0163-5395

March 1, 2000

Five new species of *Pseudotremia* from caves in the Blue River area of southern Indiana (Diplopoda: Chordeumatida: Cleidogonidae)

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ABSTRACT

A three year bioinventory of caves in southern Indiana led to the discovery of six new species of millipeds of the genus *Pseudotremia*. Of these, *P. conservata* was described by Hoffman & Lewis in 1997. Described herein are *P. purselli*, *P. blacki*, *P. burnsororum*, *P. salisae* and *P. cookorum*. This assemblage of species occurs in a narrow geographic area in which intense speciation has occurred. *Pseudotremia burnsororum* and *P. blacki* both occur in Tabler Spring Cave, which is the first report of two species of *Pseudotremia* from the same cave.

PREFACE

In the period between 1996 to 1998 I visited nearly 200 caves in southern Indiana to sample their invertebrate faunas for The Nature Conservancy (Lewis, 1998). The project area was the Blue River basin, including Harrison, Crawford, Washington and Orange counties, which comprises about half of Indiana's south central karst region as described by Powell (1960). The eastern part of this karst region is known as the Mitchell Plain (fig. 1), where sinkholes are ubiquitous, a significant part of the drainage is subterranean, and hundreds of caves are known. The limestones responsible for the presence of this karst dip gently to the west and are covered by a resistant sandstone cap near the Harrison/Crawford county line. The topography changes there to a hill country, interspersed with karst valleys, called the Crawford Upland. Caves are common in the eastern part of the Crawford Upland, but become smaller and more isolated to the west.

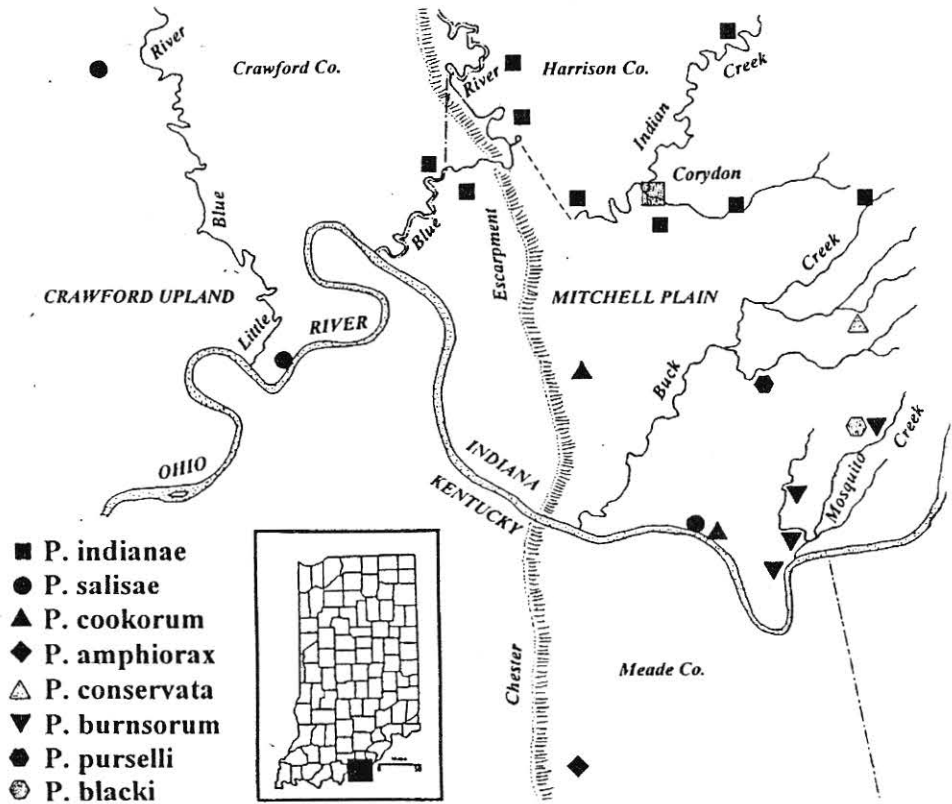


Figure 1. The distribution of millipeds of the genus *Pseudotremia* in the Crawford Upland and Mitchell Plain in southcentral Indiana and adjacent Kentucky.

The caves were sampled using pitfall traps baited with Limburger cheese spread, which attracted *Pseudotremia* effectively. Six new species were discovered, of which *P. conservata* was described by Hoffman & Lewis in 1997. Herein the other five new species are described. Added to the previously known *P. indianae* and *P. nefanda*, there are now eight species of *Pseudotremia* known from Indiana, bringing to 42 the total for the genus, with many undoubtedly remaining to be described (Shear 1972).

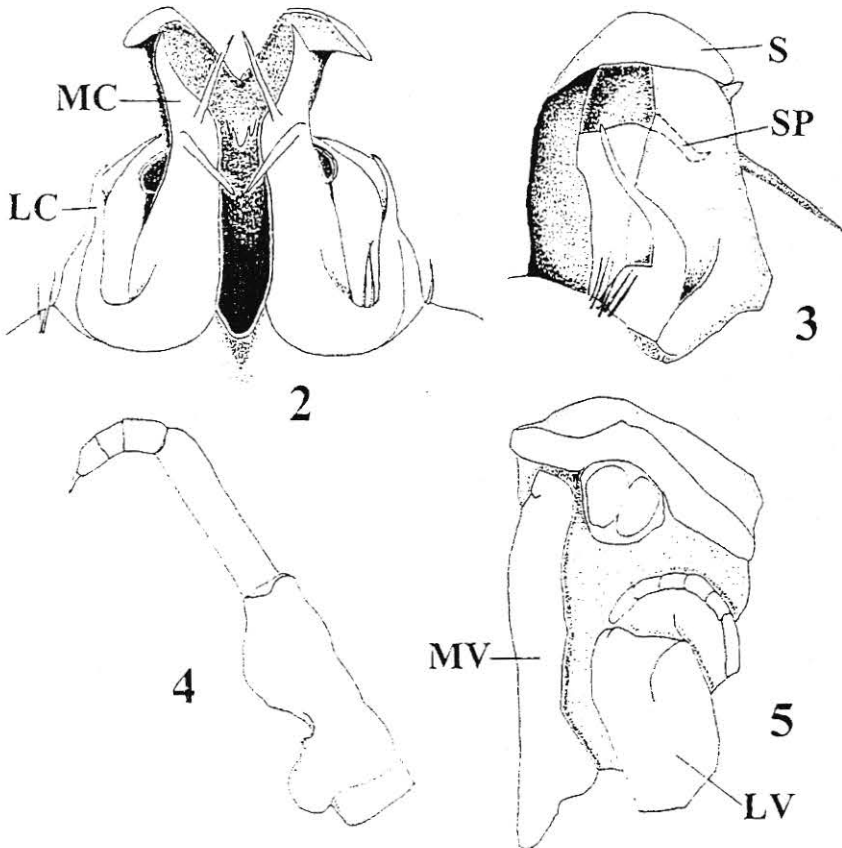
The taxonomic nomenclature as well as terms for *Pseudotremia* structures of Shear (1972), slightly modified per Hoffman & Lewis (1997), is followed here. The type specimens have been deposited in the collection of the Virginia Museum of Natural History, Martinsville.

Pseudotremia purselli, new species

Figs. 2-5

MATERIAL EXAMINED: INDIANA: Harrison Co., South Fork Cave, five miles NNE Laconia, 2 Aug 1997, J. Lewis, A. Pursell, holotype ♂, 2 paratype ♂♂, 1 paratype ♀, 16 ♀♀/juv.

DIAGNOSIS: Unpigmented, reduced eyes; anterior gonopods with syntelopodites medially fused, process arising below the medial cleft; median colpocoxite with two elongate spines. *Pseudotremia purselli* is related to *P. blacki* (described herein) in the adjacent Mosquito Creek drainage and *P. stupefactor* in eastern Kentucky. These species have medially fused syntelopodites that cover all (*P. stupefactor*) or part (*P. purselli*, *P. blacki*) of the anterior colpocoxites, and syntelopodite processes arising



Figures 2-5. *Pseudotremia purselli*, holotype male (figs. 2-4) and paratype female (fig. 5) from South Fork Cave, Harrison Co., Indiana. 2, gonopods, anterior; 3, same, lateral; 4, posterior gonopod (leg 9); 5, cyphopod, ventral. Abbreviations: S, syntelopodite; SP, syntelopodite process; LC, lateral colpocoxite; MC, median colpocoxite; LV, lateral valve; MV, median valve.

from directly below the medial cleft in the syntelopodite (class I telopodite process of Shear, 1972). The digitiform part of the syntelopodite in *P. purselli* is more elongate than in *P. blacki*. *P. purselli* is further distinguished by the long subapical spine directed anteriorly on the median colpocoxite, which is absent in *P. blacki*.

DESCRIPTION OF MALE: Longest about 21mm, white with vestigial dorsal purple pigmentation; antenna segment 3 (A3) about 1.0-1.1 mm; 14-15 ocelli, irregular in size, placed in 5 irregular rows in a compressed subtriangular pigmented ocellarium. Segmental shoulders mildly produced, reduced to level of lateral striae about segment 18-19; lateral striae 9-10. Each mid-body segment dorsum with about 10 tubercles to each side, medial 1/3 relatively free of tubercles. Anterior gonopods, syntelopodites medially fused, curved anteriorly to cover colpocoxites; syntelopodite process arising directly below cleft, extending perpendicularly as an elongate finger-like knob (in lateral view) between the median colpocoxites. Median and lateral colpocoxites divided by a deep U-shaped cleft; median colpocoxite erect, somewhat sigmoid, about equidistant with subapical spine, a second longer spine directed anteriorly; lateral colpocoxite simple, torsion apparent, distally curved medially. Posterior gonopod (leg 9) with 3 discrete distal segments, claw present.

DESCRIPTION OF FEMALE: Longest about 20 mm, non-sexual morphology similar to male. Cyphopods unpigmented, lateral valve suboval, median valve elongate, distal end of receptacle visible in ventral view.

NAME: It is a pleasure to name this species in honor of F. Allen Pursell, manager of the Blue River Project for The Nature Conservancy. In addition to conceiving the idea for the Blue River cave bioinventory, Mr. Pursell sampled many sites including South Fork Cave and its *P. purselli* population. The suggested vernacular name for the species is Pursell's cave milliped.

HABITAT & RANGE: This species is known only from the type-locality on the South Fork of Buck Creek in Harrison Co., Indiana. The cave lies on the eastern side of the Mitchell Plain. South Fork Cave consists of a small stream passage connected by two entrances. *P. purselli* was found on riparian mudbanks.

Pseudotremia blacki, new species

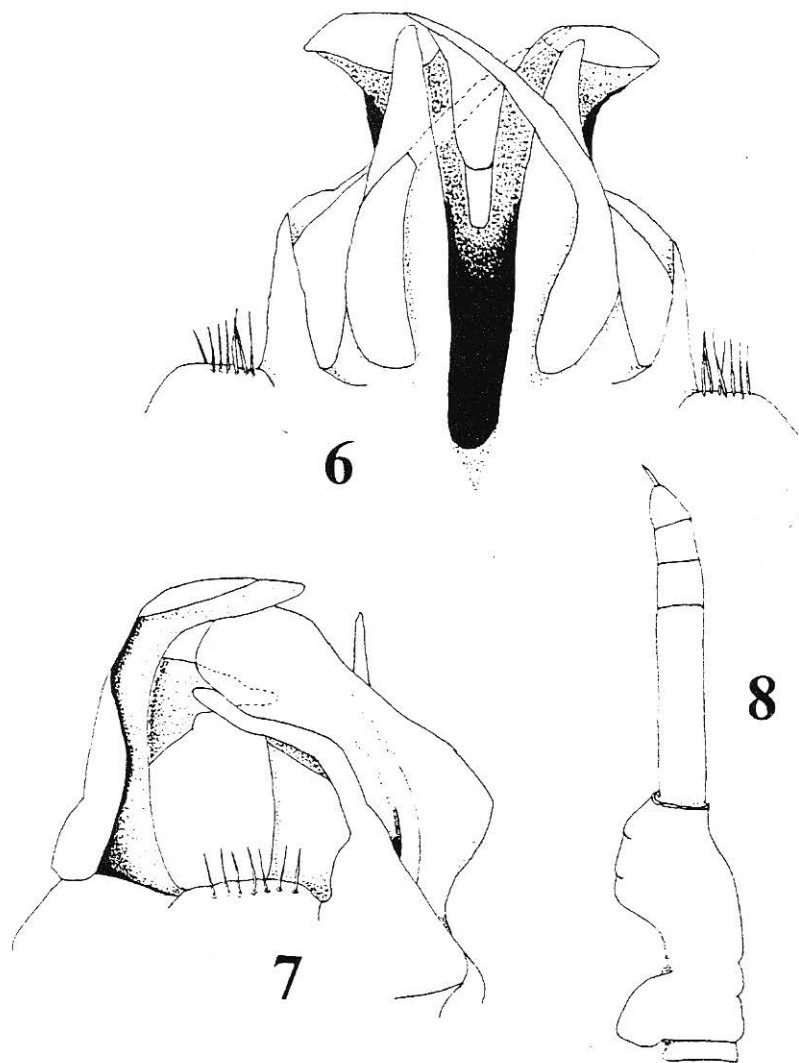
Figs. 6-8

MATERIAL EXAMINED: INDIANA: Harrison Co., Tabler Spring Cave, 4 miles SSE Elizabeth, 30 May 1998, J. Lewis, A. Pursell, holotype ♂.

DIAGNOSIS: Unpigmented, reduced eyes; anterior gonopods with fused syntelopodites with a process that originates directly beneath the syntelopodite cleft, and a prominent subapical spine that arcs medially across the median colpocoxite.

DESCRIPTION OF MALE: About 18mm, white with vestigial dorsal purple pigmentation on head and first segments; A3 about 1.0 mm; 10-11 ocelli, irregular

in size, placed in 5 rows (3-3-2-2-1) in a flattened subtriangular pigmented ocellarium. Segmental shoulders small but distinctly produced, reduced to level of lateral striae about segment 18; lateral striae 7-8. Each mid-body segment dorsum with about 8-10 moderately large tubercles to each side, medial 1/3 relatively free of tubercles. Anterior gonopods, syntelopodites medially fused, curved anteriorly to cover colpocoxites; syntelopodite process arising midlength directly beneath cleft, extending perpendicularly as a short knob. Median and lateral colpocoxites divided



Figures 6-8. *Pseudotremia blacki*, holotype male from Tabler Spring Cave, Harrison Co., Indiana. 6, gonopods, anterior; 7, same, lateral; 8, posterior gonopod (leg 9).

by a deep U-shaped cleft; median colpocoxite with prominent subapical spine directed anteriorly in a shallow arc to the tip of the colpocoxite of the other side; lateral colpocoxite simple, torsion apparent, distally curved medially. Posterior gonopod with 3 unfused distal segments, claw present.

FEMALE: Unknown.

NOTE: The prominent spine present on the median colpocoxite had broken on one side. It is illustrated in figure 6 as it was estimated to look judging from the unbroken side. The syntelopodite process of *P. blacki* and *P. purselli* is of the form named by Shear (1972 page 167) class I that arises from directly below the cleft of the syntelopodite. The digitiform syntelopodite process of *P. blacki* and *P. purselli* does not conform to any of the five known types designated by Shear.

NAME: This species is named in honor of David L. Black, president of the Indiana Cave Survey. Mr. Black played an important part in the bioinventory by suggesting dozens of sites for potential sampling. He accompanied me to numerous caves, as well as collecting leaf litter samples from the floors of numerous deep shafts for Berlese extraction of the arthropod community of this unique habitat. The suggested vernacular name is Black's cave milliped.

HABITAT & RANGE: This species is known only from the type-locality near the headwaters of Mosquito Creek, on the eastern edge of the Mitchell Plain. The habitat in Tabler Spring Cave consists of riparian gravel bars and mudbanks. The unique unpigmented male specimen was picked from among the more numerous specimens of the darkly pigmented *P. burnsororum* taken in the same cave. This is the first report of two species of *Pseudotremia* from the same cave. From the structure of the gonopods it appears that the two species are not closely related.

Pseudotremia burnsororum, new species

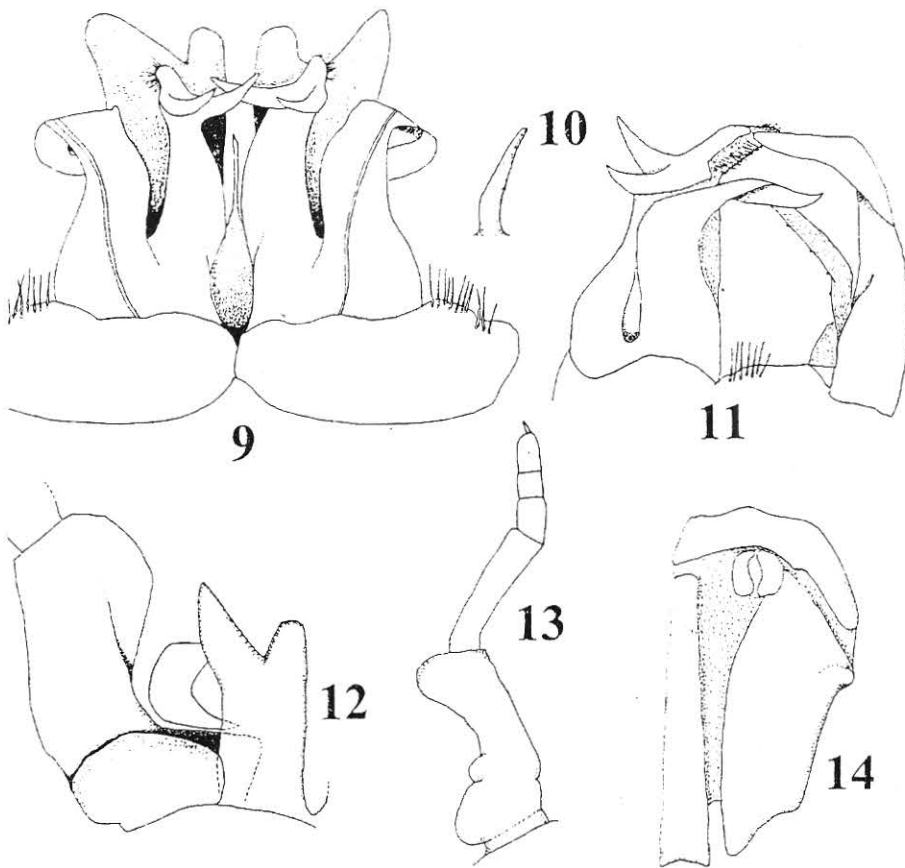
Figs. 9-14

MATERIAL EXAMINED: INDIANA: Harrison Co., Wallier Cave, 4 miles SE Laconia, 26 Apr 1997, J. Lewis, S. Rafail, holotype ♂, 1 paratype ♂, 1 paratype ♀, 6 ♀♀/juv; Tabler Spring Cave, 4 miles SSE Elizabeth, 30 May 1998, J. Lewis, A. Pursell, 4♂♂, 16♀♀/juv; Earl Williams Cave, 3.1 miles SE Laconia, 29 May 1999, J. Lewis, S. Rafail, R. Burns, E. Burns, 2♀♀/juv; same locality, 5 June 1999, J. Lewis, R. Burns, 2 paratype ♂♂, 21 ♀♀/juv; Klintstiver Spring Cave, 3.0 miles E. Laconia, 29 May 1999, J. Lewis, S. Rafail, R. Burns, E. Burns, 3♀♀/juv; same locality, 5 June 1999, J. Lewis, R. Burns, 6♀♀/juv.

DIAGNOSIS: Moderately pigmented and eyed; anterior gonopods with syntelopodite mitten-shaped with large distomedial knob, process simple, slender; medial colpocoxite with the two subapical processes being directed sharply medially. This species is most closely related to *P. conservata* (Hoffman & Lewis 1997) in the

adjacent Buck Creek drainage, which is separated from *P. burnsororum* in having one of the subapical processes on the median colpocoxite being directed distinctly laterad.

DESCRIPTION OF MALE: Longest about 25 mm, darkly pigmented bluish-gray; dorsal surface of mid-body segments with medial 1/3 smooth, darkly pigmented bilaterally to the usual light median stripe, lateral 1/3s with lighter stippled ovate area with about 20 small tubercles on each side. A3 1.1-1.4 mm, 18-20 ocelli in a tight subtriangular cluster, ocelli regular in shape, increasing in size from anterior to posterior; segmental shoulders mildly produced, reduced to level of lateral striae about segment 20; lateral striae about 12-13. Anterior gonopods, syntelopodites separated by deep cleft, mitten shaped with prominent median knob; syntelopodite process of the saber type. Median colpocoxites with two subapical processes, one



Figures 9-14. *Pseudotremia burnsororum*, holotype male (figs. 9-13) and paratype female (fig. 14) from Wallier Cave, Harrison Co., Indiana. 9, gonopod, anterior; 10, distal end of syntelopodite process, lateral; 11, gonopods, lateral; 12, interlocked posterior gonopod, lateral colpocoxite, and syntelopodite process, posterior; 13, posterior gonopod (leg 9); 14,

originating laterally but directed mediad, the other a superior subapical process also directed mediad and crossing above the cleft between the colpocoxites; apical process forming a blunt knob from anterior aspect, tapering to a point from ventral aspect, many very fine setae present along posterior margin. Lateral colpocoxite separated from median by relatively deep cleft; broad, entire, simply curving.

DESCRIPTION OF FEMALE: Longest to about 30 mm, ocelli 20-22, lateral striae 11-12, otherwise non-sexual characters about as per male. Cyphopods with typical elongate median valve, suboval lateral valve.

NAME: This species is named in honor of Ronnie Burns, president of the Harrison Crawford Grotto (HCG) of the National Speleological Society, and his wife Elizabeth Burns, also an HCG member, who assisted in sampling many caves during the Blue River Project. The suggested vernacular name of this species is the Burns' cave milliped.

HABITAT & RANGE: *P. burnsororum* is known from caves near Mosquito Creek, on the eastern edge of the Mitchell Plain in southern Harrison Co. Despite repeated sampling a male was not found in Klinstiver Spring Cave. In my opinion this population is too small to deplete further by efforts to obtain a male, so the species is here identified as *P. burnsororum* (rather than *P. conservata* per Hoffman & Lewis 1997) based on the similarity of the cyphopods and its presence in the Mosquito Creek drainage. *P. burnsororum* was found on riparian mudbanks, under stones or on racoon dung, frequently with the troglophile *Cambala minor*.

Pseudotremia salisae, new species

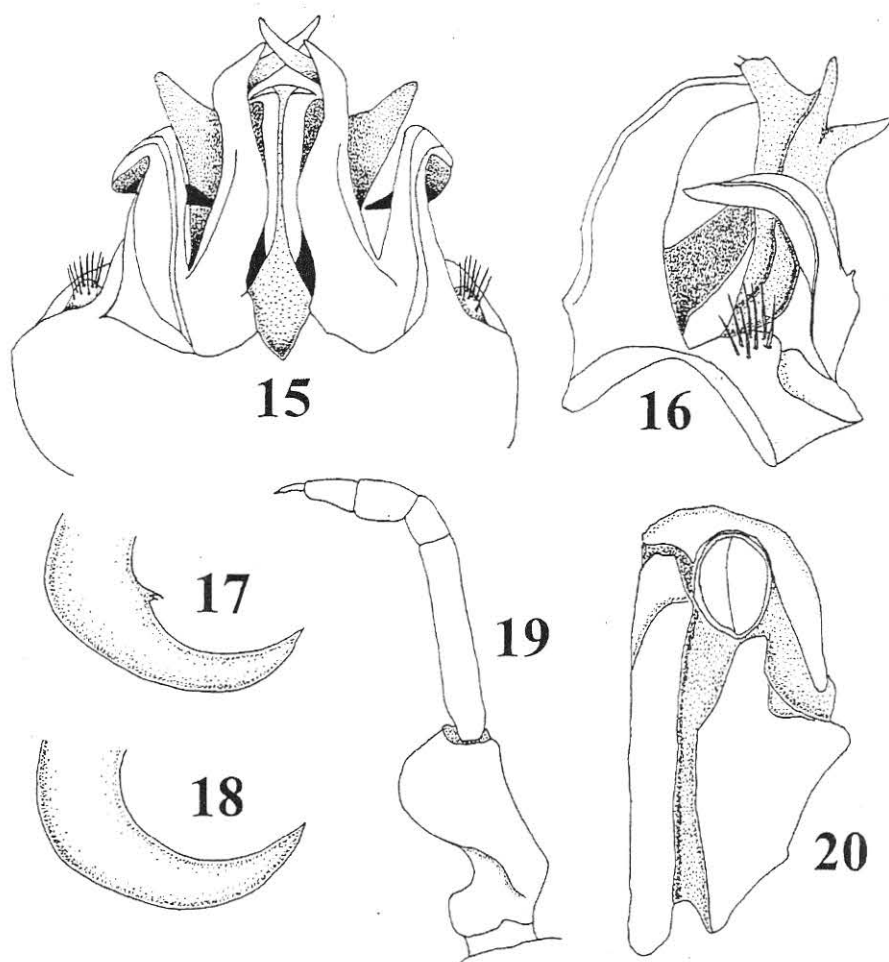
Figs. 15-20

MATERIAL EXAMINED: INDIANA: Crawford Co., Heron Cave, 1 mile E Alton, 4 Feb 1998, J. Lewis, S. Rafail, holotype ♂, 10 ♀♀ juv; same locality, 11 Jul 1998, J. Lewis, R. Burns, 6 juv; same locality, 18 Jul 1998, J. Lewis, R. Burns, E. Burns, 3 paratype ♂♂, 26 ♀♀/juv; Mesmore Spring Cave, Hoosier National Forest, 5 Jul 1997, J. Lewis, S. Rafail, 1♂, 5 juv; Indian Cave, Hoosier National Forest, 12 Sep 1997, J. Lewis, S. Rafail, 1♂ fragment, 4 juv; Harrison Co., Lower Pipe Cave, 2 miles S Laconia, 25 Mar 1999, J. Lewis, S. Rafail, 1♂.

DIAGNOSIS: Almost white to moderately pigmented and eyed; anterior gonopods with syntelopodite process divided distally to form a structure of the appearance of a grappling hook (grapple type of Shear 1972); median colpocoxite distinctly bifid distally, the distal colpocoxite processes criss-crossed in appearance. *P. salisae* and *P. indianae* both have a syntelopodite process of the grapple type. *P. salisae* is separated by the larger size, pigmented appearance, larger number of ocelli, and the distally bifid, criss-crossed processes on the median lobe of the colpocoxite. *P. salisae* resembles *P. burnsororum* in that both possess an undivided linguiform lateral

colpocoxite and median colpocoxite with criss-crossed apical spines. The syntelopodite process of *P. burnsororum* is short and simple, not of the grapple type.

DESCRIPTION OF MALE: Mature specimens about 22-30 mm; pigmented blue-gray; A3 about 1.2-1.4mm; 16-20 ocelli placed in 5-6 irregular rows within a pigmented triangular ocellarium. Moderate segmental shoulders present, reduced to level of lateral striae by segment 18; dorsum heavily tuberculate, about 80 small tubercles on mid-body segments, arranged somewhat suggestive of lateral lines continuing dorsally in the manner of the lateral striae and shoulders; lateral striae 12-13. Anterior gonopods, syntelopodite large, of the mitten-shape typical of the genus,



Figures 15-20. *Pseudotremia salisae*, holotype male (figs. 15-17) and paratype female (fig. 20) from Heron Cave, Crawford Co., Indiana, and male (fig. 18) from Indian Cave, Crawford Co., Indiana. 15, gonopods, anterior; 16, same, lateral; 17, lateral colpocoxite, anterior; 18, same; 19, posterior gonopod (leg 9); 20, cyphopod, ventral.

curved to or somewhat over median colpocoxite, with nearly entire medial cleft; syntelopodite process large, curving in an arc between the colpocoxites of each side, divided apically, divisions recurved, forming a grapple-like structure. Median and lateral colpocoxites divided by a deep U-shaped cleft; median colpocoxite with apical and subapical spines directed mediad, interlocking; lateral colpocoxite linguiform, with one or two small teeth along mesial margin. Posterior gonopod with 3 unfused distal segments, claw present.

DESCRIPTION OF FEMALE: longest about 30mm, non-sexual morphology similar to male, 20-24 ocelli. Cyphopods pigmented, densely setose, lateral valve subtriangular, medial valve elongate; distal end of the receptacle formed along the anterior vertical edge of the cyphopod visible in ventral view, long setae present along this distal margin.

VARIATION: Mature males collected in the Mesmore Cliffs area were somewhat shorter at 24-26mm and less pigmented than the Heron Cave population. The mesial margin of the lateral colpocoxite lacked the small tooth found midlength in Heron Cave specimens.

NAME: This species is named in honor of Salisa Taylor Rafail, a member of the Harrison Crawford Grotto of the N.S.S., who as my primary assistant in the 1998-99 field seasons sampled dozens of sites, including all caves where *P. salisae* was found. The vernacular name suggested for the species is Salisa's cave millipede.

HABITAT & RANGE: This species occurs across the southern Crawford Upland in Crawford County into the southwestern Mitchell Plain in Harrison County. Heron and Pipe caves lie in the bluffs of the Ohio River on either side of (but not within) the Blue River basin. Indian and Mesmore Spring caves (probably parts of the same cave system) occur in the Mesmore Cliffs area of the Hoosier National Forest, in the Little Blue River drainage. In Heron and Pipe caves the millipeds were taken in non-riparian, relatively dry habitats on clay substrate. In Pipe Cave the millipeds were found in racoon dung with abundant *Cambala minor*. Indian Cave is formed in sandstone and the millipeds were found in leaf litter on the sand substrate of the wet weather drain in the rear of the cave. In Mesmore Spring Cave *P. salisae* was taken on moist riparian mudbanks. A juvenile *Pseudotremia* from Little Indian Cave (adjacent to Indian Cave), is almost certainly also *P. salisae*.

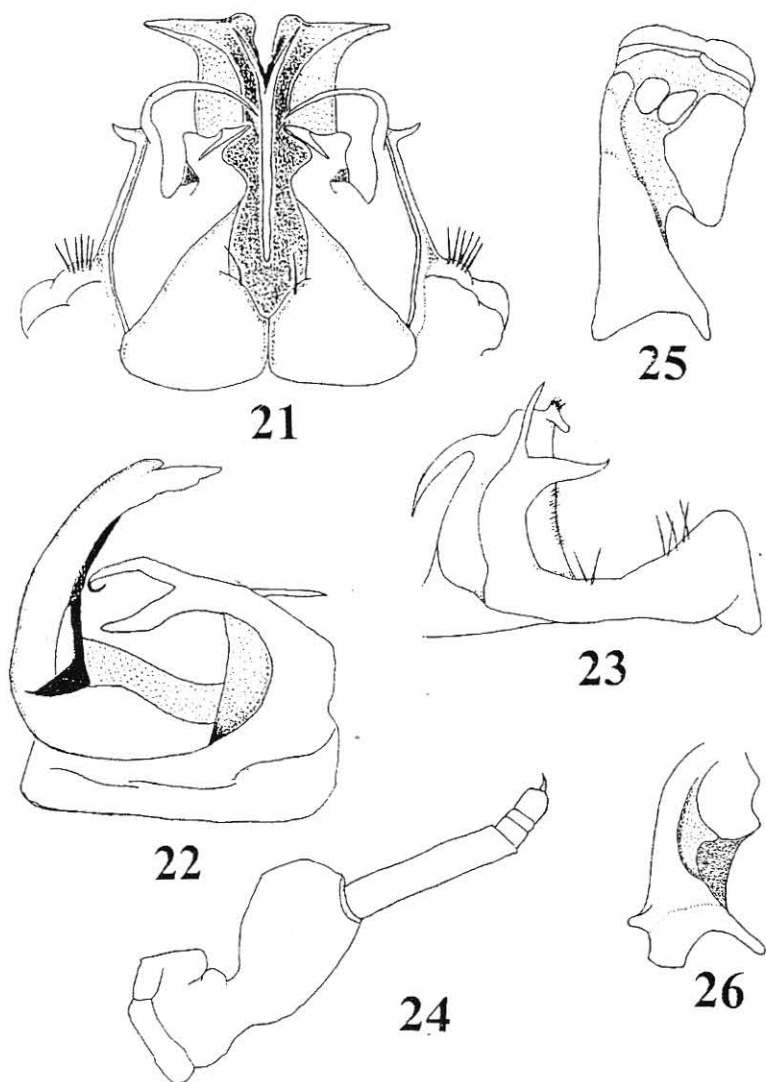
Pseudotremia cookorum, new species

Figs. 21-26

Pseudotremia conservata Kinch, 1998 (photograph)

MATERIAL EXAMINED: INDIANA: Harrison Co., Little Mouth Cave, 2 miles S Laconia at Tobacco Landing, 27 Dec 1997, J. Lewis, N. Lewis, holotype ♂, 1

depauperate ♂, 10 juv; Weber's Swallow Hole, 2 miles W. Central, 10 Jan 1998, J. Lewis, A. Pursell, 6♂♂, 13♀♀/juv; Drowned Mouse Hole, 2 miles W. Central, 10 Jan 1998, J. Lewis, A. Pursell, 11♀♀/juv; Squire Boone Caverns (=Boone's Mill Cave), 3 miles SE Central, 26 June 1999, J. Lewis, S. Rafail, 1 ♂, 4♀♀/juv.



Figures 21-26. *Pseudotremia cookorum*, holotype male (figs. 21-22, 24) and female (fig. 20) from Little Mouth Cave, Harrison Co., Indiana; female (figs. 25-26) from Weber's Swallow Hole, Harrison Co., Indiana; 21, gonopods, anterior; 22, same, lateral; 23, same, syntelopodite removed; 24, posterior gonopod (leg 9); 25, cyphopod, ventral view; 26, same, rotated to view from a more posterior aspect.

DIAGNOSIS: Unpigmented, with reduced eyes; anterior gonopods with syntelopodite process forked distally; median colpocoxite sigmoid, with sharply recurved apical spine. *P. cookorum* is related to *P. indianae* and *P. amphiorax*, from which *P. cookorum* can be readily separated by the syntelopodite process of the split saber type, which is of the grapple type in *indianae*, and a short saber in *amphiorax*.

DESCRIPTION: Male about 19 mm, appears unpigmented, light grayish-purple dorsal pigmentation when magnified, white glossy areas between segments; A3 between 0.9-1.2 mm; 15-16 clear ocelli, placed in 5-6 irregular rows in a compressed subtriangular pigmented ocellarium. Segmental shoulders mildly produced, reduced to level of lateral striae about segment 18-20; lateral striae 7-8. Mid-body segments dorsally with about a dozen moderately large tubercles on lateral thirds, central third with smaller tubercles. Anterior gonopods, syntelopodites not of the mitten shape typical of the genus, curving anteriorly, divided by distinct cleft, distinct medial shelf present; telopodite process of the divided saber type (per Shear 1972). Median colpocoxites with apical spine sharply recurved, directed at 45 degree angle laterally. Lateral colpocoxite branching from median somewhat more than $\frac{1}{2}$ the length of the median colpocoxite, separated by a relatively shallow cleft. Lateral colpocoxite divided, median branch curving sharply behind median colpocoxite, lateral branch extending posteriorly. Posterior gonopod with 3 segments, 2 distal segments appear fused, claw present.

DESCRIPTION OF FEMALE: longest about 23 mm, non-sexual structure similar to male, about 17 ocelli in 7 rows placed in a compressed, pigmented ocellarium. Cyphopods setose, lateral valve subtriangular, about $\frac{1}{2}$ the length of the medial valve; medial valve elongate, subtriangular, with distinctively shaped processes projecting from posterior margin.

NAME: This species is named in honor of William and Gayle Cook, the owners of Little Mouth Cave, for their support of The Nature Conservancy's Blue River Project. The vernacular name suggested for this species is Cooks' cave millipede.

HABITAT & RANGE: The localities from which *Pseudotremia cookorum* is known lie in the southwestern Mitchell Plain in Harrison County, in or near the lower Buck Creek drainage. Little Mouth Cave has no stream and much of the cave is covered by flowstone. Weber's Swallow and Drowned Mouse holes are, as the names imply, sinkhole drains. Although normally streamless, these caves take significant quantities of water after storms. These caves are within 300 feet of one another, probably draining into the same cave system. Squire Boone Caverns is perhaps the largest cave in the general vicinity and has a perennial stream, where *P. cookorum* was taken from riparian mudbanks.

Pseudotremia indianae Hoffman

MATERIAL EXAMINED: INDIANA: Harrison Co., Zollman Cave, 2 miles S. Lanesville, 1 June 1999, J. Lewis, V. Lewis, 2♀♀/juv; same locality, 5 June 1999, J. Lewis, R. Burns, 7♂♂, 13♀♀/juv.

HABITAT & RANGE: This is the only record of *P. indianae* outside of the Blue River drainage (including its tributary Indian Creek). Zollman Cave lies in the northern part of Buck Creek at about the same latitude and 5 miles to the east of Shear's (1972) King's Cave locality for *P. indianae* (fig. 1).

NAME: The vernacular name suggested for this species is the Blue River cave milliped.

ACKNOWLEDGMENTS

The description of these new species of *Pseudotremia* was funded by the Indiana Department of Natural Resources, Division of Nature Preserves, Natural Heritage Program. I thank Mr. Cloyce Hedge for facilitating this funding and for many other kindnesses through the course of the Blue River cave bioinventory. I am grateful to my son, Victor M. Lewis, for accompanying me to several caves and assisting in placing pitfalls and other sampling during the 1999 field work. My brother, Norman M. Lewis, Jr., assisted in collecting at Little Mouth Cave. I thank Claudia Wiley, manager of Squire Boone Caverns, for allowing me to repeatedly enter the cave for sampling. Dr. Richard Hoffman, Dr. William Shear, Dr. Rowland Shelley and Mr. F. Allen Pursell read the manuscript and made suggestions for its improvement. In particular I would like to thank Dr. Hoffman for his friendly encouragement of my straying from the systematics of the Isopoda into that of the Chordeumatida.

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