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PSEUDOTREMIA CONSERVATA, A NEW CLEIDOGONID MILLIPED (DIPLOPODA: CHORDEUMATIDA), WITH A SYNOPSIS OF THE CAVERNICOLOUS MILLIPEDS OF INDIANA

by Richard L. Hoffman and Julian J. Lewis

ABSTRACT

Pseudotremia conservata is a troglobite described from Seven Springs Cave in Harrison County, Indiana. The species is most closely related to *Pseudotremia carterensis* occurring in eastern Kentucky. As a result of several recent bioinventory projects in Indiana caves, many new records of millipeds are now known and listed herein for 13 species. These include new localities for the poorly known troglomorphic species *Pseudotremia nefanda*, *P. indianae*, *Trichopetalum uncum*, and *Conotyla bollmani*. The discovery of *Pseudopolydesmus collinus* in a Jennings County cave represents the first record from Indiana and a significant range extension for this Appalachian species.

In 1996 The Nature Conservancy initiated a biological inventory of caves in the 600 square mile Blue River basin of southern Indiana. This region is one of the premier karst areas of the United States, containing hundreds of caves and springs inhabited by a unique assemblage of troglobites, many of which are endemic to the region. During the first year of this survey a new species of troglobitic milliped of the genus *Pseudotremia* was discovered and is being described herein. This opportunity is also being taken to present a synopsis of our current knowledge of cavernicolous millipeds in Indiana. The early records of numerous collectors such as Cope (1872), Packard (1873), and Blatchley (1897) in Indiana caves was summarized in Banta's (1907) classic work on the fauna of Mayfield's Cave, in Monroe County, Indiana. Many additional Indiana records are now available due to biological inventories of caves in the Blue River area (Lewis, 1993; Lewis, Pursell & Huffman, 1997), Lost River (Lewis, 1994), Crosley State Fish & Wildlife Area (Lewis, 1995), and the southeastern karst (Lewis, 1983, 1996).

In the following list literature citations are provided for collection records only at sites where newer records have not reconfirmed the presence of the milliped species. Each species is given an ecological classification (i.e., troglobite, troglophile, or trogloxene) as defined by Barr (1968). The following abbreviations have been employed: CSP-Charlestown State Park, CSFWA-Crosley State Fish & Wildlife Area, INAAP-Indiana Army Ammunition Plant, SMSP-Spring Mill State Park, TMSC-Tunnel Mill Scout Camp, and VMNH-Virginia Museum of Natural History.

ORDER CHORDEUMATIDA

FAMILY CLEIDOGONIDAE

Pseudotremia conservata, new species
Figures 1-6

Material examined: Male holotype, two male paratypes, one female paratype, three immatures (all VMNH), from Seven Springs Cave, 0.7 miles NNW of Elizabeth, 6 July 1996, Julian J. Lewis, David Black, leg.

Name: From the Latin *conservatio*, this species is named in honor of The Nature Conservancy, a non-profit organization dedicated to the preservation of significant natural areas and their communities.

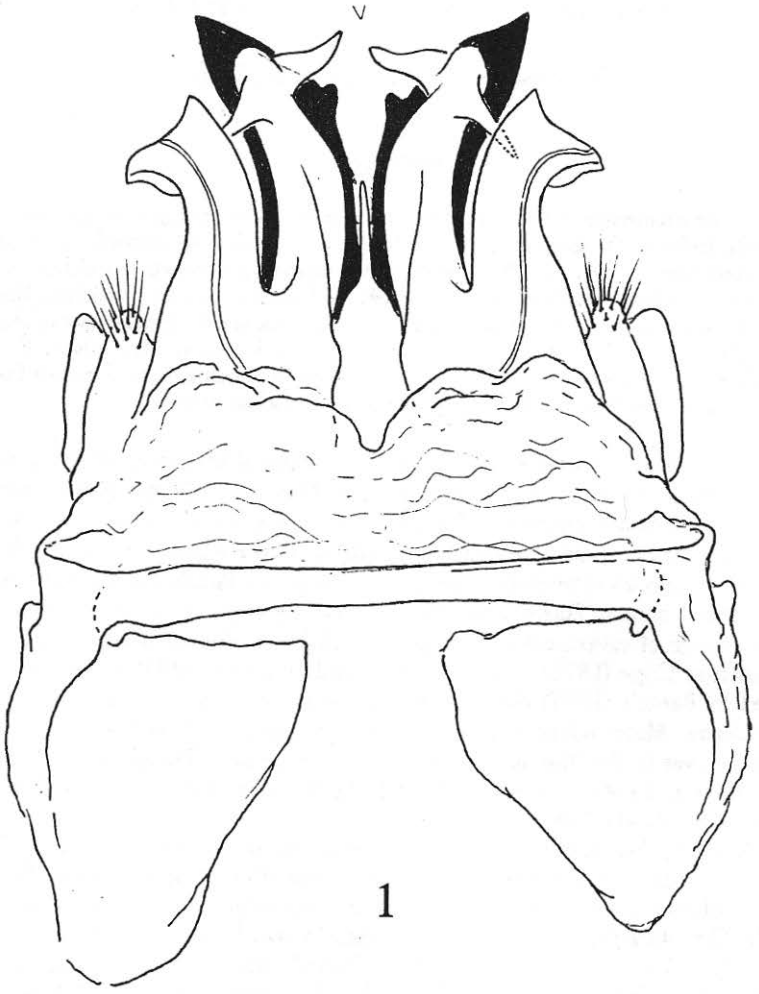
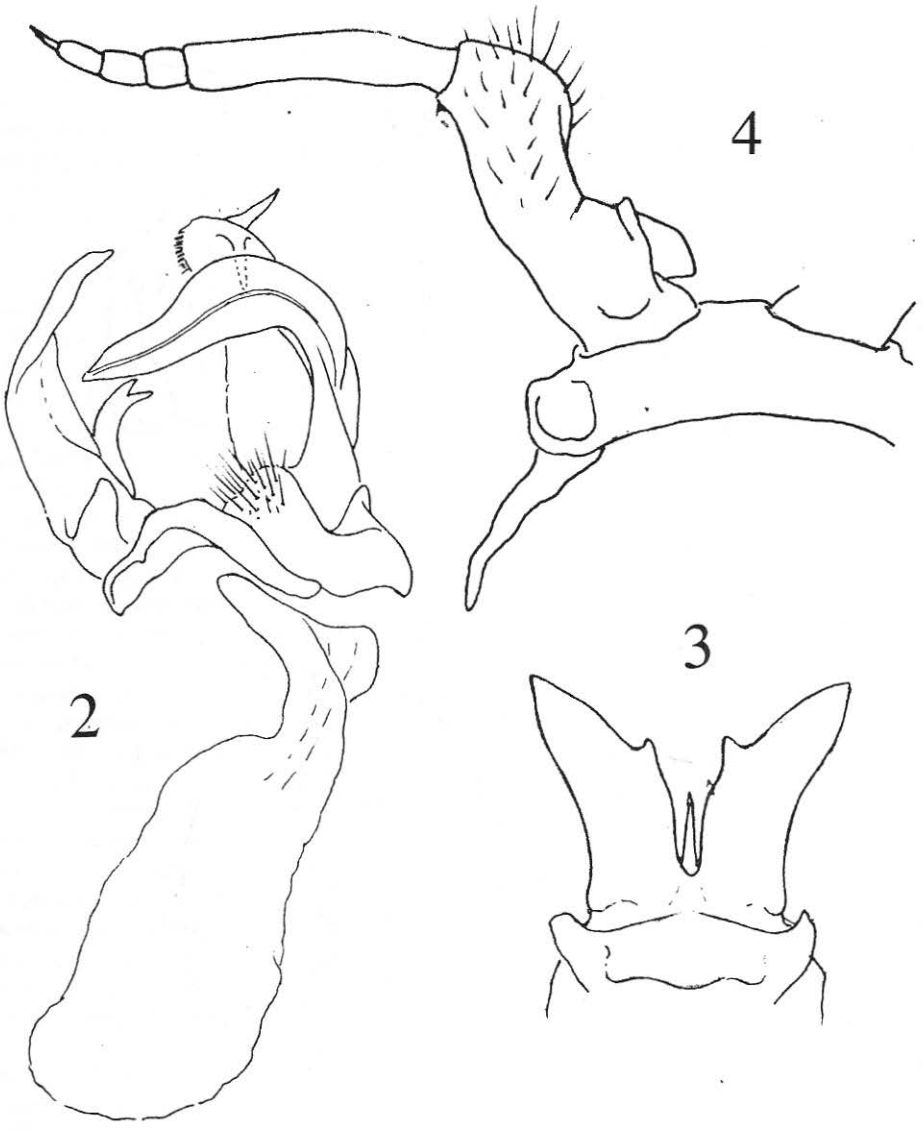


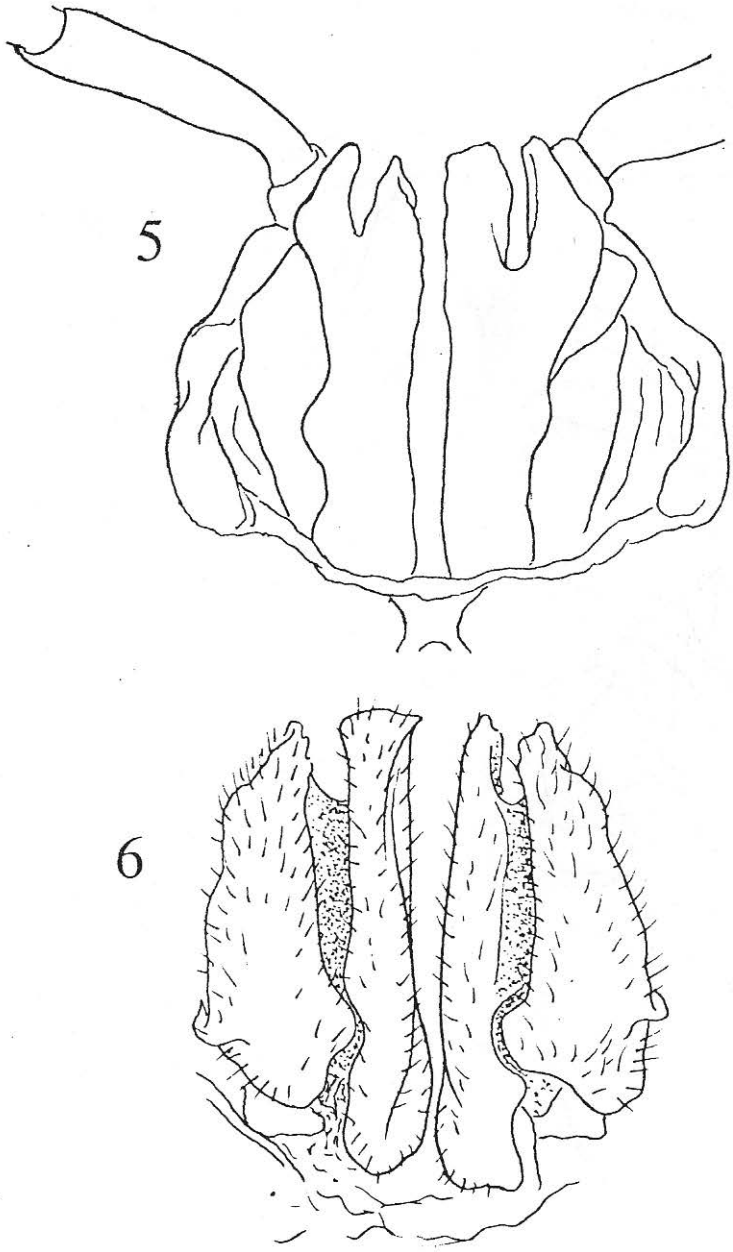
Fig. 1. *Pseudotremia conservata*, gonopods of holotype, anterior aspect.

Diagnosis: A member of the genus as defined by Shear (1972) most similar to *P. carterensis* (Packard), to which it is identified by Shear's key to species (1972: 168-170) of *Pseudotremia*. From *carterensis*, *conservata* differs in (1) the short, apically bifid syntelopodite process, (2) the presence of a lateral subapical process on the median colpocoxite, (3) a much larger median subapical process, (4) absence of marginal projections on the syntelopodite, and (5) much smaller basolateral projection on the lateral valves of the cyphopods.



Figs. 2-4. *Pseudotremia conservata*. 2, gonopods of holotype, cleared in trypsin, lateral aspect. 3, syntelopodite, posterior aspect. 4, 9th leg and sternum.

Holotype: Curved and broken, length approximately 22 mm; maximum width (segment 7), 2.5 mm; body overall medium brown with bluish infusion, perhaps purplish in life, each metatergum with a large reniform reticulated light spot on each side; tergal tubercles



Figs. 5-6. *Pseudotremia conservata* 5, cypopods of paratype female, posterior aspect. 6, the same, ventral (distal) aspect.

somewhat darker; head and antennae dark brown, face and mandibles reticulated with lighter; anterior segments with two round whitish spots on lower sides; legs very pale beige, indistinctly marmorated.

Twenty ocelli in a pigmented triangular cluster. Antennae long and slender, ca. 3.7 mm, 3rd and 5th antennomeres similar in size and shape, 4th much shorter, but subequal to combined lengths of 1+2 or 6+7. Anterior terga nearly smooth, those posterior to 7th becoming increasingly ornamented with low tubercles in three to five very irregular transverse series; sides of segments with 12-15 longitudinal striations. Segmental paranota moderate in size for the genus, largest anteriorly as usual.

Gonopods similar to those of *carterensis*, but distinct as stated in the diagnosis, compare our figures 1-4 with figures 141-143 in Shear's monograph. The relatively small, short, evenly curved and apically bifid syntelopodite process contrasts strongly with the much longer, sigmoidally curved, apically acuminate process of *carterensis*. Posterior gonopods (9th legs) similar to those of *carterensis*, the distal podomeres slightly more slender.

Female paratype: Broken, approximately 23 mm long, body diameter ca. 3.7 mm over much of length; structure similar to that of male except (1) 5th antennomere shorter than 3rd and somewhat more clavate, (2) paranota less developed, (3) tergal ornamentation more prominent, with the rows of tubercles more regular. Cyphopods (Figs. 5, 6) similar to those of *carterensis*, but with the basolateral projection of the outer valves much less prominent.

Range: Pseudotremia conservata is presently known from Seven Springs Cave, which comprises the headwater of the South Fork of Buck Creek; and Klinstiver Spring Cave, on Mosquito Creek about 3.0 miles east of Laconia (8.1 miles SSW of the type-locality). Klinstiver Spring Cave was visited on 4 December 1996 by JJL and Allen Pursell and pitfall traps baited with limburger cheese were placed at that time. The cave was revisited on 14 December 1996 by JJL to retrieve the traps. A series comprised of one mature female and four juveniles was taken feeding on the decaying bait around the traps, tentatively identified as *Pseudotremia conservata* (pending collection of a mature male). The species is known only from Harrison County along the eastern edge of the Mitchell Plain.

Habitat: Seven Springs Cave is a short cave (no more than 100 feet of passage) consisting of a water crawlway passage that leads to a small room. The enterable cave is a short section of a probably much longer passage that has been truncated by ceiling breakdown. The type-series of *Pseudotremia conservata* was taken in a pitfall trap baited with limburger cheese that was placed by JJL in a mudbank near the back of the cave on 15 June 1996. The mudbanks were littered with a few decomposing raccoon scats, inhabited by spiders (*Phanetta subterranea*), collembolans (*Pseudosinella fonsa, Tomocerus bidentatus, T. flavescens, Sminthurinus malmgreni*), crickets (*Ceuthophilus*), staphylinid beetles, and flies (*Spelobia tenebrarum, Megaselia cavernicola*, psychodids). Klinstiver Spring Cave consists of about 200 feet of low stream passage connecting sinking stream and spring entrances.

Remarks: Among known members of the genus, *Pseudotremia conservata* and *P. carterensis* are clearly adelphotaxa which have nonetheless become specifically differentiated. Comparison of the various gonopod processes with those of congeneric species suggests that *conservata* may be the more derived of the two although character polarities are extremely difficult to establish. The status of these two millipeds becomes complicated by the occurrence in southern Indiana of a population of *P. nefanda* that shows substantial resemblances in gonopod structure to *P. carterensis*, as noted in the following account. Assignment of *Pseudotremia conservata* to one of the species groups designated by Shear (1972) is deferred until the relationships between the species (many remaining undescribed) of this rather large genus can be better understood.

Pseudotremia indianae Hoffman

Crawford County: Batwing Cave, Hoton Canyon Cave, Marengo Cave, Robinson's Ladder Cave, Route 66 Cave, Sharpe Creek Cave, Sibert's Well Cave, Wildcat Cave, Wyandotte Cave (type-locality), Wyman's Cave; Harrison County: Baker Hollow Cave, Bevin Cave (Shear, 1972), Binkley's Cave, Black Medusa Cave, Bradford Cave (Shear, 1972), Bryant's Cave, Carter Byrne's Cave, Devil's Graveyard Cave, Dragon Mouth Cave #1, Feller Cave, King's Cave, Langdon's Cave, Limekiln Hollow Cave, Mauck's Cave, Ott's Endless Agony Cave, Potato Run Cave, Stygian River Cave, Swinney Cave, Zollman's Cave; Orange County: Saltpeter Cave; Washington County: Fredericksburg Cave, Howard's Cave

This species was initially identified erroneously as *Pseudotremia cavernarum* from Wyandotte Cave (Cook and Collins, 1895). The name *Pseudotremia indianae* was validated by Hoffman (1958) in a clarification of the status of *Pseudotremia cavernarum*. *Pseudotremia indianae* was redescribed by Shear (1972) from specimens taken from King's Cave and recorded from five additional localities.

Pseudotremia indianae is a troglobite endemic to caves of the Blue River, Indian Creek, and part of Buck Creek. Within the range of this species it is common in riparian cave habitats (e.g., Wildcat or Zollman's caves), sometimes coming by the hundreds to pitfall traps. Smaller populations of *P. indianae* are also found in streamless, upper level cave habitats (e.g., Saltpeter, Howards, or Sharpe Creek caves).

Pseudotremia nefanda Shear

Clark County: Ballistics Lab Cave (INAAP), CC Dryer Cave (INAAP), Indian Cave (type-locality), Jenny Lind Run Cave (INAAP), Oak Hill Cave (TMSC), 221-1 Pack House Cave (INAAP), Peyton Beechwood Cave, Peyton Spring Cave, Poacher's Cave (INAAP), RDX Cave (CSP), Sunset Village Cave, Thomas Crews Cave, Watson Spring Cave

Pseudotremia nefanda is a troglobite known only from the glaciated karst of southeastern Indiana, in caves within the margin of the Illinoian glacier. The species was described by Shear (1972) from Indian Cave, in Charlestown, Clark County. Indian Cave lies near Pleasant Run, a tributary of Silver Creek. Lewis (1983) added three more cave localities: Peyton Beechwood, Watson Spring (Pleasant Run drainage), and Sunset Village (Bull Creek drainage) caves. In an inventory of the cavernicoles of Clark County (Lewis, 1996a) other cave localities were added in the drainages of Fourteen Mile Creek and Jenny Lind Run.

A series (2 males, 2 females) from C. C. Dryer Cave, on the Indiana Army Ammunition Plant (Fourteen Mile Creek drainage), differed from the nominotypical population in the shape of the syntelopodite process. The males in the collection agree very closely with Shear's (1972) description and illustrations of the species. Differences noted were the: (1) presence of distinct lateral subapical processes on the median colpocoxite, (2) absence of marginal projections on the syntelopodite elements, and (3) slightly longer and more evenly curved syntelopodite process. All of these are matters of degree, not of kind. However, the general gonopodal configuration of these millipeds suggest a previously unremarked relationship with *Pseudotremia carterensis*. The situation is further confused by the fact that C.C. Dryer Cave lies on the grounds of the Indiana Army Ammunition Plant. There is evidence that the community of C.C. Dryer Cave was subjected to the effects of many different harmful chemicals, and two caves (Ballistics Lab, Jenny Lind Run) inhabited by populations of *Pseudotremia nefanda* were filled with nitric acid during World War II (Lewis, 1996b, 1996c). The populations were presumably destroyed during the inundation of the caves, then repopulated from upper level populations unaffected by the acid. Thus, morphological differences in the INAAP populations could be attributable to their occurrence on a different drainage basin (i.e., geographic isolation), the effects of the many chemicals, or both.

Pseudotremia spp.

Crawford County: Heron Cave; Harrison County: Little Mouth Cave

These sites represent populations for which only females have been collected. Little Mouth Cave is on the bluff of the Ohio River between the presently known ranges of *Pseudotremia indianae* and *P. conservata*. Heron Cave lies on the Ohio River bluff southwest of known populations of *Pseudotremia indianae*.

Cleidogona sp.

Harrison County: Limekiln Hollow Pit, Swinney's Cave

These collections represent immatures of forest dwelling species taken from leaf litter at the base of the entrance pits. It is not unusual for mesic forest litter habitat to extend from the surface uninterrupted into the twilight or even dark zones of Indiana caves. This provides ideal habitat for trogloxenic millipeds.

FAMILY CONOTYLIDAE

Conotyla bollmani (McNeill)

Crawford County: near Wyandotte Cave (Bollman, 1889); Jennings County: Jug Cave (CSFWA); Lawrence County: Phitt's Cave (Bollman, 1889), Donnehue's Cave (Bollman, 1889), Shiloh Cave (Causey, 1959), Sullivan Cave (Causey, 1959), Twin Cave (Banta, 1907); Monroe County: Coon's Cave (Bollman, 1889), Mayfield's Cave (type-locality), Neeld's Cave (Bollman, 1889), Truett's Cave (Bollman, 1889); Orange County: Black Cave, Elrod Cave, Lost River Cave #1, Mount Horeb Cave, Peacher Cave North, Peacher Cave South, Silent Brook Cave, Simmon's Cave, Tolliver Swallowhole, Wesley Chapel Gulf Cave, William Cleveland Cave; Owen County: Boone Cave (Shear, 1971), Porter's Cave (Blatchley, 1897); Washington County: Bat Cave.

This species was described as *Trichopetalum bollmani* by McNeill (1887) from Mayfield's Cave, Monroe County. Bollman (1889) described *Scotherpes wyandotte* from "near Wyandotte Cave", in Crawford County. Shear (1971) redescribed the species and synonymized Bollman's species with *Conotyla bollmani*. Shear reported that although it was primarily known from unpigmented troglomorphic populations in caves, a few pigmented surface populations were known. Cave populations of *Conotyla bollmani* appear to be absent within the Blue River area inhabited by the troglobites *Pseudotremia conservata* and *P. indianae* in Crawford and Harrison, as well as parts of Orange and Washington counties. Almost 100 caves have been inventoried in this area and *Conotyla bollmani* has yet to be found in any of them (Lewis, Pursell & Huffman, 1997). Banta (1907) reported this species to be abundant in caves north of the East Fork of White River. Lewis (1994) also found *Conotyla bollmani* to be a common member of terrestrial cave communities in the Lost River karst of Orange County. The Jennings County record from Jug Cave is a presumptive identification of a female *Conotyla*, as no other species of the genus are presently known from Indiana.

FAMILY TRICHOPETALIDAE

Trichopetalum uncum Cook and Collins

Jennings County: Biehle Cave (CSFWA), Dryden Cave (CSFWA), Wool's Whim Cave (CSFWA); Monroe County: Bloomington (Cook & Collins, 1895), Salamander Cave

This species was described from an unspecified site in Bloomington by Cook & Collins

(1895). The collection used as the type series was reportedly in the company of a vial from Coon's Cave, near Bloomington, and we strongly suspect that this is the actual site of the collection. A juvenile milliped collected from Salamander Cave (on the same ridge as Coon's Cave) also appears to be this species. *Trichopetalum uncum* is troglomorphic in appearance, being unpigmented with ocelli either vestigial or absent (Shear, 1972). The ecological classification of this milliped is unclear (i.e., troglobite vs. troglomorphic troglophile), as all of the collections over its rather wide range are from caves with the exception of one from Mammoth Cave Hollow (Mammoth Cave National Park, Kentucky). It is unknown if this collection is from a cave or surface collection. Chamberlin & Hoffman (1958) gave the distribution of *Trichopetalum uncum* as Indiana and Illinois, south to Arkansas. Causey (1967) gave localities in Missouri, Oklahoma, and Kentucky. Shear (1972) redescribed the species from a cave in Missouri.

ORDER SPIROSTREPTIDA

FAMILY CAMBALIDAE

Cambala minor Bollman

Clark County: Igloo 5042D Cave (INAAP), Indian Cave, Oak Hill Cave (TMSC), Peyton Spring Cave, RDX Cave (CSP), Thomas Crews Cave; Harrison County: Big Mouth Cave, Howard's Cave, King's Cave (Shelley, 1979), Not So Grand Caves I & II; Jennings County: Dryden Sinks Cave (CSFWA), Dug Cave (CSFWA), Wool's Whim Cave (CSFWA); Washington County: Howard's Cave

This species was reported by Shelley (1979) from about 60 localities from Virginia east to Oklahoma, including six localities in the Indiana counties of Crawford, Harrison, Jefferson and Monroe (Bloomington, type-locality). It is a frequent troglophile with about half the known populations occurring in caves. In Indiana *Cambala minor* is frequently taken from raccoon dung, where it may occur by the dozens.

Cambala annulata (Say)

Crawford County: Little Wyandotte Cave (Packard, 1888); Monroe County: Mayfield's Cave (Banta, 1907)

Although this species was not collected during the present survey, its presence in the area is established by a large series deposited in the collections of the VMNH that were taken in upland oak woods 1.5 m. N. of Solon, Clark County, 28 April 1956 by Leslie Hubricht. The records by Packard (1888) and Banta (1907) of *C. annulata* must be held in abeyance, however, since the identification was made at a time when only one species of this genus was recognized.

ORDER JULIDA

FAMILY JULIDAE

Ophyiulus pilosus (Newport)

Clark County: CC Dryer Cave (INAAP); Harrison County: Fence Line Swallowhole, PP Pot; Jennings County: E.Y Green Cave (CSFWA), Jug Cave (CSFWA), Meek Cave; Orange County: William Cleveland Cave.

This milliped is a trogloxene that is occasionally abundant in caves. It occurs through northern Europe and eastern North America, where it is usually found inhabiting gardens and

urban areas.

ORDER POLYDESMIDA

FAMILY PARADOXOSOMATIDAE

Oxidus gracilis (Koch)

Clark County: Indian Cave, Twin Cave; Crawford County: Hidden Spring Cave; Jennings County: Crosley Canyon Cave (CSFWA), Mucscatatuck Caverns, Vernon Mill Tunnel

This is an introduced Asiatic species that is common in greenhouses and gardens.

FAMILY PLATYRHACIDAE

Euryurus leachii (Gray)

Harrison County: Bevin Cave, Coon Cave, King's Cave (Hoffman, 1978), Swinney's Cave; Jenning's County: Cemetery Cave (CSFWA); Monroe County: Matlock's Cave, Mayfield's Cave (as *E. erythropygus*, Banta, 1907); Orange County: William Cleveland Cave

This milliped is a forest litter dweller that occurs as an occasional threshhold trogloxene.

FAMILY POLYDESMIDAE

Polydesmus inconstans Latzel

Harrison County: Limekiln Hollow Pit

This milliped was found in the leaf litter at the bottom of the shallow entrance pit. *P. inconstans* is native to western Europe, but is now widespread in the central U.S. as a naturalized synanthropic species.

Pseudopolydesmus collinus Hoffman

Jennings County: Crosley Canyon Cave (CSWA)

Several of these millipeds were found in near total darkness in a pile of firewood carried in by previous visitors for recreational use in the cave. This is the first record of *Pseudopolydesmus collinus* in Indiana, which is about 140 miles beyond the previous western-most locality for this Appalachian species in Carter County, Kentucky (Hoffman, 1974). Future collecting may establish a continuity of populations, or suggest disjunction as a post-glacial relict in Indiana.

Pseudopolydesmus serratus (Say)

Harrison County: Limekiln Hollow Pit; Jennings County; Cemetery Cave (CSWA), Dug Cave (CSWA); Monroe County: Mayfield's Cave (Banta, 1907); Washington County: Howard's Pit II

This species is a forest litter dweller and occurs in caves as a threshhold trogloxene.

Scytonotus granulatus (Say)

Clark County: Twin Cave; Crawford County: Little Wyandotte Cave (Blatchley, 1897); Harrison County: Limekiln Hollow Pit; Jennings County: Wool's Whim Cave (CSFWA); Lawrence County: Shiloh Cave (Banta, 1907), Twin Cave (SMSP) (Banta, 1907); Monroe County: Mayfield's Cave (type-locality, Bollman, 1887); Orange County: Lost River Cave #1

This milliped was described as *Scytonotus cavernarum* by Bollman (1887) from Mayfield's Cave, Monroe County, Indiana. This species was synonymized with *Scytonotus granulatus* by Hoffman (1962). It appears to be primarily a trogloxene and is usually found in small numbers in the entrance zone of caves.

FAMILY XYSTODESMIDAE

Apheloria corrugata butleriana (Bollman)

Harrison County: Swinney's Cave

One male was taken from leaf litter at the base of the entrance pit that is probably referable to this subspecies, which was described from localities in LaFayette and Brookville, Indiana (Bollman, 1888).

Zoogeographic and Evolutionary Considerations

The discovery of *Pseudotremia conservata* requires modification of the evolutionary scenario proposed by Lewis (1983) for the subterranean fauna of southern Indiana. The epigean ancestors of Indiana's present terrestrial troglobitic fauna probably entered the area prior to the Pleistocene, when the Ohio River was a minor stream with headwaters west of the Knobstone Escarpment. Dispersal into the area would have been facilitated by following the valley of the Salt River, which prior to glaciation flowed north along the east side of the escarpment to join with the ancient Teays River. In this manner the ancestral *Conotyla*, *Trichopetalum*, and *Pseudotremia* could have entered Indiana. At the time of the Illinoian Glaciation southcentral Indiana remained an unglaciated refugium. The southeastern Indiana karst (i.e., the Scottsburg Lowland and Muscatatuck Regional Slope) was entirely covered by ice during the maximum extent of the glacier, with the edge of the ice in Clark County. With the climatic drying and warming of the Sangamon Interglacial the millipeds found cool, moist habitats in the caves of the Mitchell Plain and Crawford Upland in the southcentral unglaciated region. The Ohio River became a major stream carrying glacial runoff, and isolated *Pseudotremia* populations in Indiana from those to the south in Kentucky. This resulted in *Pseudotremia indianae* and *P. conservata* in the Blue River area of Indiana, *P. amphiorax* in adjacent Meade County, Kentucky, and *P. carterensis* in eastern Kentucky. The entrenchment of the Ohio River during this time may have created stream gradients sufficient to excavate caves covered by the glaciation near the Ohio River in Clark County, thus providing habitat for *Pseudotremia* to escape the conditions prevalent on the surface. This would account for the narrow range of *Pseudotremia nefanda* today in Clark County caves.

Alternately, during the Wisconsin Glaciation opportunities for dispersal were again favorable and *Pseudotremia* that remained in the southcentral Indiana karst would have again been able to disperse to the east to establish populations in Clark County. *Conotyla bollmani* and *Trichopetalum uncum* remained incompletely adapted to caves, with at least some surface populations remaining in suitable surface habitats (e.g., sinkholes).

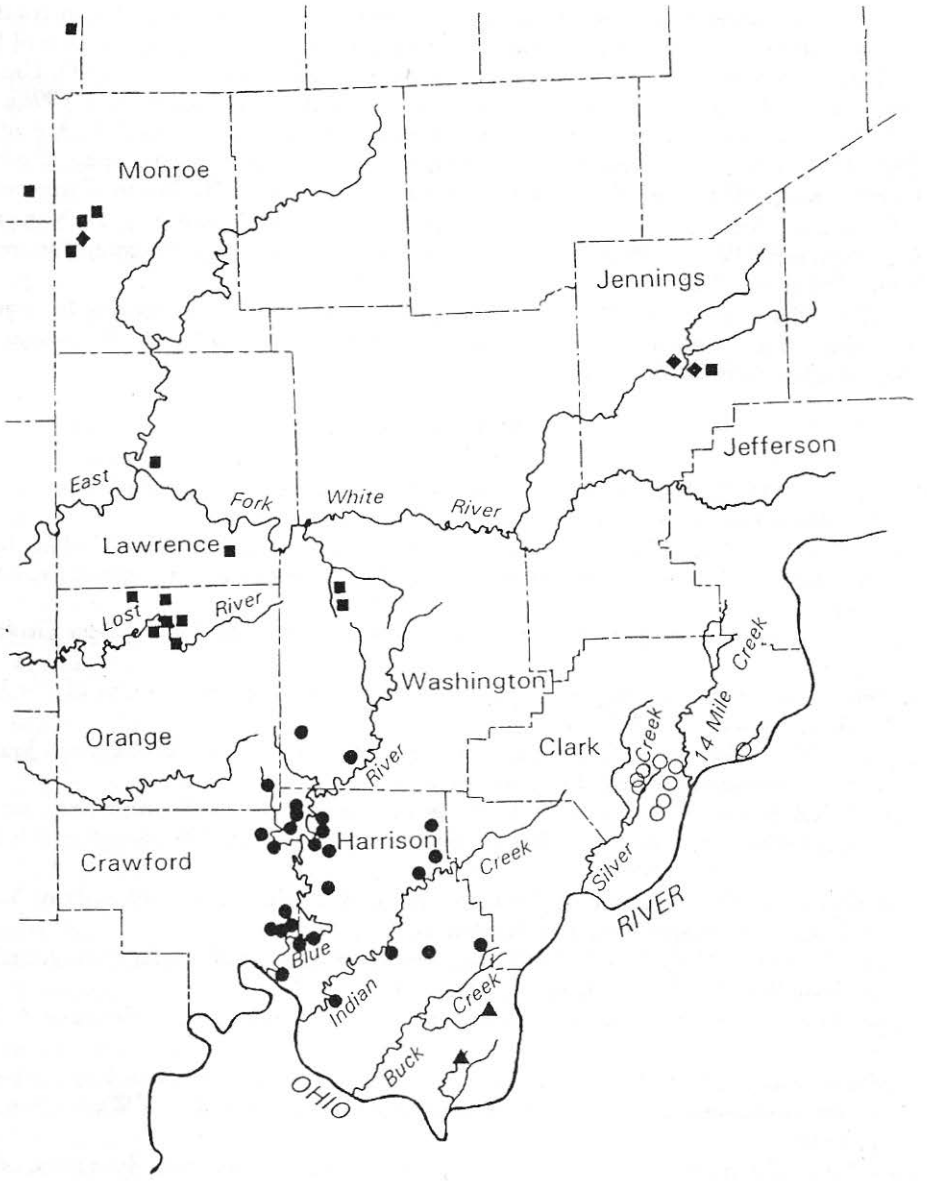


Fig. 7. The distribution of troglomorphic millipeds in southern Indiana, correlated with selected surface streams: triangles, *Pseudotremia conservata*; filled circles, *Pseudotremia indianae*; open circles, *Pseudotremia nefanda*; squares, *Conotyla bollmani*; diamonds, *Trichopetalum uncum*.

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