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PSEUDOTREMIA REYNOLDSAE, A NEW SPECIES OF TROGLOBITIC MILLIPED (DIPLOPODA: CHORDEUMATIDA: CLEIDOGONIDAE), WITH A SYNOPSIS OF THE CAVERNICOLOUS MILLIPEDS OF THE HOOSIER NATIONAL FOREST IN INDIANA

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ABSTRACT. A bioinventory of caves of the Hoosier National Forest in south-central Indiana has resulted in the collection of 12 milliped taxa, including a new species, *Pseudotremia reynoldsae*, which is described and illustrated. This species is known from only one isolated cave in the Patoka River drainage in Crawford County. *Pseudotremia reynoldsae* is structurally most similar to *P. burnsorum*, a troglobite occurring in caves of the Mosquito Creek drainage in Harrison County. Three other subterranean chordeumatidan species inhabit the Hoosier National Forest: *Pseudotremia salisae*, *Pseudotremia indianae* and *Conotyla bollmani*. Other native species found were *Euryurus leachii leachii*, *Scytonotus granulatus*, *Pseudopolydesmus* sp., *Cambala minor*, *Abacion tesselatum* and *Petaserpes* sp. Two exotic milliped species occur in the Hoosier National Forest, *Oxidus gracilis* and *Ophyiulus pilosus*.

Keywords: Cave millipeds, *Pseudotremia*, Indiana, Hoosier National Forest, Patoka River

Until 1997 only two species of cavernicolous millipeds of the genus *Pseudotremia* were known from Indiana, *Pseudotremia indianae* Hoffman (1958) from the Blue River area and *P. nefanda* Shear (1972) from Clark County. Biological sampling in over 400 Indiana caves (e.g., Lewis 1998; Lewis et al. 2002) has demonstrated a diverse subterranean milliped fauna. Hoffman and Lewis (1997) described *P. conservata* from Seven Springs Cave, Harrison County, and Lewis (2000) added five more new species of *Pseudotremia* from caves in Harrison and Crawford Counties: *P. blacki*, *P. burnsorum*, *P. cookorum*, *P. purselli* and P. salisae.

In 2000 a systematic bioinventory of the caves of the Hoosier National Forest (HNF) was begun. The HNF extends from the Ohio River north to an area east of Bloomington, Indiana. Much of the forest lies within the physiographic unit known as the Crawford Upland (Powell 1961), where cavernous limestone strata are capped with sandstone. There are presently 136 caves known to occur on HNF lands and a like number of privately-owned caves are known to exist within the proclamation boundary of the national forest.

The first species of *Pseudotremia* discovered in the HNF was found in two caves at the Hemlock Cliffs Special Area on the Little Blue River drainage (Lewis 1998) and subsequently described as *P. salisae* (Lewis 2000). Two more species of *Pseudotremia* have now been discovered within the boundary of the HNF, *P. indianae* and an undescribed species that represents the ninth member of the genus to be described from southern Indiana.

In my previous work on *Pseudotremia* (Lewis 2000) I followed the terminology concerning gonopod structures established by Shear (1972). In the light of the present understanding of gonopod anatomy, Shear (pers. commun. 2002) has suggested a new interpretation followed herein. In *Pseudotremia* the gonopods develop only from the eighth pair of legs, with the ninth pair reduced in size and playing little role in sperm transfer. Of the structures evolving from the eighth pair of legs in chordeumatidans, the telopodite is either entirely lost (as in *Pseudotremia*), or if present, is not a functional part of the gonopod (Shear 2000). The structures called the telopodite by Shear (1972) and Lewis (2000) are

actually permanently extruded, sclerotized coxal glands fused at the bases, that are now termed syncolpocoxites; and the process arising from the fused base is termed the syncolpocoxal process (Shear pers. commun. 2002). The structures referred to by Shear (1972) as colpocoxites are angiocoxites developed from the margin of the coxal gland pore and are divided into medial and lateral parts (Shear pers. commun. 2002).

METHODS

Between 2000–2002 a total of 104 caves was sampled within the Hoosier National Forest. The primary means of sampling the milliped fauna was pitfall traps using four ounce (approximately 160 ml) jars filled with 70% isopropyl alcohol and baited with Kraft™ limburger process cheese spread. To a lesser extent specimens were collected by hand or obtained through Berlese extraction of organic litter. Appendages were placed on temporary glycerin slide mounts and drawn using a Leica compound microscope with an optical drawing tube.

In the interest of cave conservation specific localities are not provided. Those in need of specific localities can apply for the information from the Indiana Cave Survey (www.caves.org/conservancy/ICS).

The spelling of the word milliped (rather than millipede) as explained by Hoffman (2000) is the usage preferred by North American specialists in the group dating back to its apparent origin with Cook in 1911 and is followed herein.

MILLIPEDS OF THE HOOSIER NATIONAL FOREST

Twelve taxa discovered to date in caves of the HNF are listed with the sampling sites recorded by county of occurrence. Many of the caves in which collecting has been conducted occur on national forest wilderness or special areas that have been designated as such for the protection of the ecosystems. In the following list the taxa are arranged by county, with caves sampled within designated forest service areas listed in the appropriate area.

ORDER CHORDEUMATIDA

Family Cleidogonidae

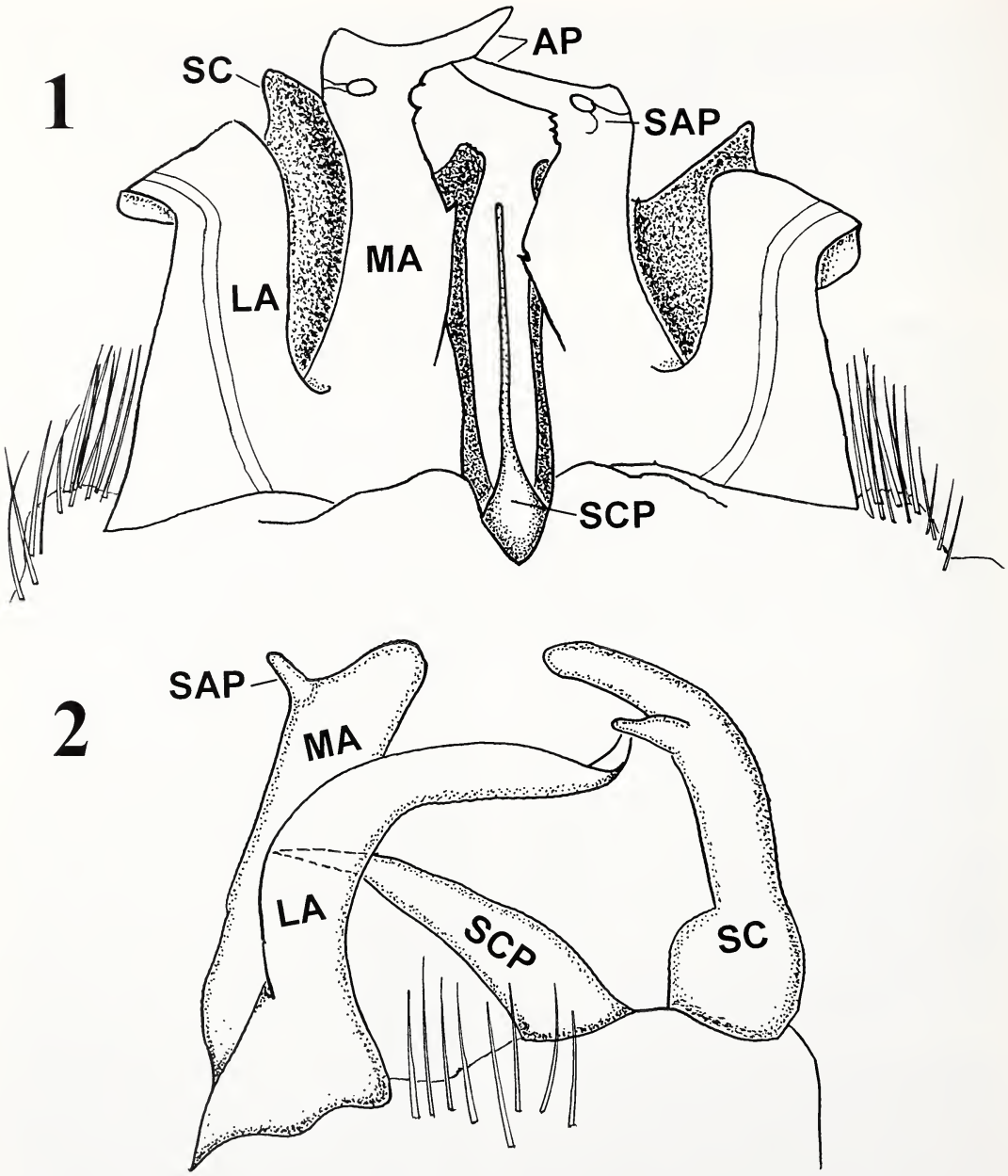
Pseudotremia reynoldsae new species

(Figs. 1–5)

Material examined.—*Crawford County:* Megenity Peccary Cave, south room, holotype ♂, 3 juveniles, 28 July 2001 (J. Lewis, Salisa T. Rafail); same locality, paratype ♂, 5 juveniles, 8 September 2001 (J. Lewis, Ron Burns). All material has been deposited in the Virginia Museum of Natural History, Martinsville, Virginia.

Diagnosis.—Moderately pigmented and eyed; anterior gonopods with syncolpocoxite mitten-shaped with prominent distolateral knob, process simple, entire, of saber type of Shear (1972); median angiocoxite with irregularly dentate medial margin, apical knob and process and reduced subapical process, lateral angiocoxite broad, entire. This species is most similar to *P. conservata* and *P. burnsorum* that occur in caves in southern Harrison County, and *P. nefanda* in caves in Clark County. *Pseudotremia reynoldsae* is immediately separable from this assemblage by the short subapical process on the median angiocoxite. *Pseudotremia reynoldsae* can furthermore be separated from all known *Pseudotremia* in Indiana by the presence of the dentate mesial margin of the median angiocoxite.

Description.—*Male:* Longest approximately 26 mm in length (coiled), maximum width 2.2 mm (7th segment); body overall medium brown with purplish suffusion, each metatergum with a prominent subovate reticulated spot bilaterally and scattered tubercles, adults notably more pigmented than subadults and juveniles, which appear more uniformly light beige. Head and antenna darker purple, sternum and legs light beige with purplish tinge. Eyes with 18–19 unpigmented ocelli within subtriangular, pigmented ocellaria. Antennae about 4.2 mm long, slender, 3rd segment longest, about 1.2 mm. Segmental paranota small to moderate in size, largest anteriorly, becoming indistinguishable from lateral striae in posterior segments. Lateral striae 11–13. Gonopods with syncolpocoxites separated by U-shaped cleft; process simple, tapering to a point, of the saber type of Shear (1972). Median angiocoxite, mesial margin irregularly dentate; apical round knob, two processes, the larger a blade-shaped apical structure crisscrossing in the cleft between the angiocoxites, the other a smaller subapical structure originating from the lateral side and extending anteriomesiad, not extending beyond mesial margin of angiocoxite. Lateral angiocoxite separated from median by a relatively deep, U-shaped cleft, broad, entire, simply curving.



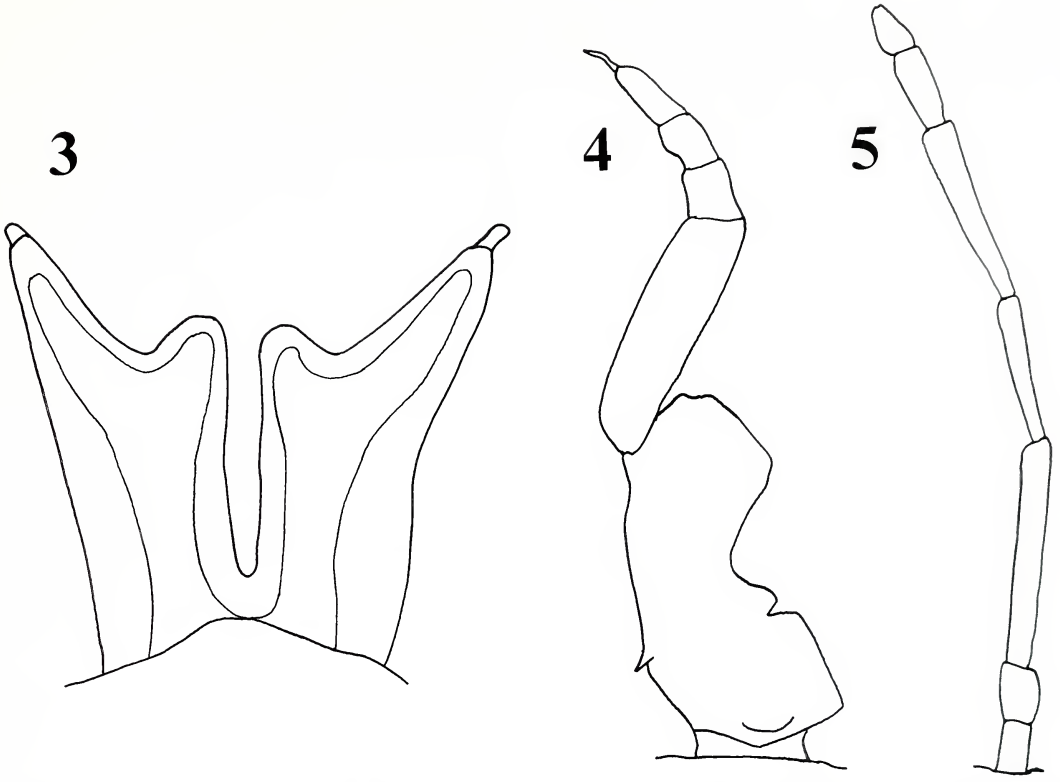
Figures 1–2.—***Pseudotremia reynoldsae*** new species, Megenity Peccary Cave, Crawford County, Indiana, holotype male. 1. Anterior gonopods, anterior aspect; 2. Anterior gonopods, lateral aspect. *Abbreviations:* SC = syncolpocoxite; SCP = syncolpocoxite process; LA = lateral branch of angiocoxite; MA = median branch of angiocoxite; AP = apical process; SAP = subapical process.

Leg 9 with basal spinous process on mesial margin, broadly rounded apophysis absent; distal 3 segments well formed and apparently fully functional, claw present.

Female: Adult unknown.

Etymology.—This species is named in honor of Kelle Reynolds, Forest Wildlife Biologist and Karst Coordinator for the Hoosier National Forest, U.S. Forest Service. The suggested vernacular name is the Reynold's cave milliped.

Habitat and range.—*Pseudotremia rey-*



Figures 3–5.—***Pseudotremia reynoldsae*** new species, Megenity Peccary Cave, Crawford County, Indiana, holotype male. 3. Syncolpocoxite, anterior aspect; 4. Leg 9; 5. Antenna.

noldsae is known only from Megenity Peccary Cave, which lies in the Patoka River drainage in south-central Indiana. This cave consists of 126 m of mapped passages formed in limestone and enlarged by collapse of the overlying sandstone. The cave is maze-like, comprised of a series of joint controlled passages that were apparently originally streamless; but it has been excavated for paleontological material (Richards 1994), and one area now contains flowing water. *Pseudotremia reynoldsae* specimens were taken on and around cheese-baited pitfall traps in the parts of the cave farthest from the entrance.

Pseudotremia salisae Lewis

HNF localities.—*Crawford County:* Enlow's Back Door Cave, Perfect Circle Cave, Salt Shake Rock Cave. Hemlock Cliffs Special Area: Sentinel Rock Cave, Pavey Cave.

Habitat and range.—Lewis (2000) listed the species from Heron and Mesmore Spring Caves in the HNF Hemlock Cliffs Special Area, in Crawford County, and Pipe Cave in Harrison County. This species is notably guanophilic and was found associated with raccoon droppings at every collection site.

Pseudotremia indianae Hoffman

HNF localities.—*Orange County:* Duggin's Spring Cave, Little Africa Pleasure Palace Cave, Springs Spring Cave, Wells Cave.

Habitat and range.—This milliped is the most highly cave-adapted of any of the Indiana species of *Pseudotremia* and is primarily an inhabitant of riparian habitat where it occurs on mudbanks adjacent to cave streams. It has previously been recorded from numerous caves along the Blue River drainage in Crawford, Harrison, Washington and Orange Counties (Shear 1972; Hoffman & Lewis 1997) and is known to have crossed the drainage divide eastward into the Buck Creek drainage (Lewis 2000). Duggin's Spring Cave lies in an area of the Blue River drainage that extends into the eastern edge of the HNF. The Springs Spring Cave collection is the first record of *P. indianae* extending past the western drainage

divide of Blue River, crossing into the Patoka River drainage. At Little Africa Pleasure Palace, *P. indianae* occurs in the headwaters of the East Fork of White River drainage on the same ridge as Bond Cave (inhabited by *Conotyla bollmani*).

Family Conotylidae
Conotyla bollmani (McNeill)

HNF localities.—*Lawrence County:* King/Bug Ear Cave, Carpenter Cave; Tincher Karst Special Area: Brick Pit, Burton Hollow Cave, Crystal Falls Cave, Fuzzy Hole, Gory Hole, Henshaw Bend Cave, Horse Bone Hole, HNF Swallowhole, JJ's Cave, Smith's Folly Cave, Tincher Hollow Cave, TRAC Cave, William's Cave. *Martin County:* Bluff House Cave, Redberry Cave; Gypsy Bill Allen Special Area: Gypsy Bill Allen Cave. *Monroe County:* Charles C. Deam Wilderness: Dead Possum Pit, Frog Pond Pot, Frog Pond Ridge Pit, Patton Cave. *Orange County:* Apple Cave, Beaver Attack Cave, Bond Cave, Dillon Cave, Eckleberger Cave; Paoli Experimental Forest: Garlow Spring Cave; Wesley Chapel Gulf Special Area: Elrod Cave, Wesley Chapel Gulf Cave; Springs Valley Recreation Area: Campground Cave, Not Our Area Cave, Tucker Dam Quarry Cave, Tucker Lake Spring Cave.

Habitat and range.—This milliped occurs in riparian habitats as well as streamless cave habitats like pit floors, particularly on rotting wood. It occurs in caves in the East Fork of White River drainage, from south-central Orange County through Lawrence into Monroe and Owen Counties (Hoffman & Lewis 1997). A record of a juvenile *Conotyla* from a cave on the Crosley State Fish & Wildlife Area in Jennings County is suggestive of this species, but remains unconfirmed. Shear (1972) cited a surface collection of this species, but provided no specific records, perhaps an allusion to the "near Wyandotte Cave" collection of *Scotherpes* (sic) *wyandotte* (= *Conotyla bollmani*). I have sampled over 190 caves in that area (Hoffman & Lewis 1997; Lewis 2000), and *C. bollmani* was never found, so it seems unlikely that this species occurs in the Blue River drainage.

ORDER SPIROSTREPTIDA
Family Cambalidae
Cambala minor Bollman

HNF localities.—*Crawford County:* Heron Cave, Megenity Peccary Cave. *Lawrence County:* Tincher Karst Special Area: Smith's Folly Cave.

Habitat and range.—This species is troglophilic and frequently found on raccoon droppings. In Indiana it has been recorded from caves in Clark, Crawford, Harrison, Lawrence, Orange and Washington Counties (Shelley 1979; Lewis 1996, 1998; Lewis et al. 2002), as well as surface records from Monroe, Posey and Putnam Counties (Bollman 1888). The range includes the south-central United States, from Oklahoma east into western Virginia.

ORDER POLYDESMIDA
Family Euryuridae
Euryurus leachii leachii (Gray)

HNF localities.—*Crawford County:* Megenity Peccary Cave; Hemlock Cliffs Special Area: Arrowhead Arch. *Lawrence County:* Tincher Karst Special Area: Smith's Folly Cave. *Martin County:* Dave's Dig Cave.

Habitat and range.—This species is a trogloxene and has been reported in Indiana from caves in Crawford, Harrison, Jennings, Lawrence, Martin and Orange Counties (Hoffman 1978; Lewis, 1995, 1998; Lewis et al. 2002). Bollman (1888) reported this species from surface habitats (as the synonym *E. erythropygus* per Hoffman 1999) in the additional counties of Benton, Clark, Hamilton, Howard, Putnam, Tippecanoe, Vigo and Washington. This species is found in the central United States in Illinois, Indiana, Kentucky and Ohio (Hoffman 1978, 1999).

Family Paradoxosomatidae
Oxidus gracilis (Koch)

HNF localities.—*Crawford County:* Carnes Mill Special Area: Carnes Mill Spring Cave. *Lawrence County:* Carpenter Cave; Tincher Karst Special Area: Henshaw Bend Cave, South Gardner Mine.

Habitat and range.—This milliped is an exotic of uncertain origin, although indications are that it probably came from Japan. It now occurs in a nearly world wide distribution in temperate climates and at higher elevations in the tropics. In North America it occurs in "astronomical numbers" in many parts of the southeastern U.S. (Hoffman 1999). In Indiana it has been reported from caves in Clark, Crawford, Harrison, Jennings, Lawrence, Orange and Washington Counties (Lewis

1995, 1996, 1998, 2002). Sampling of rotting logs in the Deam Wilderness Area, Monroe County, revealed that *Oxidus* outnumbered the native *Scytonotus* by a ratio of perhaps 50:1. *Oxidus* was not noted as present in Indiana at the time of Bollman (1888).

Family Polydesmidae

Scytonotus granulatus Say

HNF localities.—*Monroe County:* Charles C. Deam Wilderness: Patton Cave. *Orange County:* Paoli Experimental Forest: Garlow Spring Cave; Wesley Chapel Gulf Special Area: Wesley Chapel Gulf Cave.

Habitat and range.—This species is a trogloxene that usually occurs in leaf litter in caves. In Indiana it has been reported from caves in Crawford, Harrison, Jennings, Monroe, Orange and Washington Counties (Lewis 1995, 1998). The range of *S. granulatus* extends through the southeastern U.S. (Shelley 1993). Bollman (1888) characterized the species as abundant.

Pseudopolydesmus sp.

HNF localities.—*Martin County:* Dave's Dig Cave. *Orange County: Paoli Experimental Forest: Q1B3 Cave.*

Habitat and range.—Hoffman (1999) reported 12 species in this genus occurring across eastern North America. The localities cited represent collections of single juveniles taken in the entrance zone of the caves in deep leaf litter.

ORDER POLYZONIIDA

Family Polyzoniidae

Petaserpes sp.

HNF localities.—*Monroe County:* Charles C. Deam Wilderness: unnamed pit on Frog Pond Ridge. *Orange County:* Grease Gravy Special Area: Grease Gravy Cave; Springs Valley Recreation Area: Not Our Area Cave.

Habitat and range.—Shelley (1997) reported three species of *Petaserpes* from Indiana, including *P. bikermani* from Donaldson Cave and *P.* sp. from Sullivan Cave, both in Lawrence County. The HNF collections are comprised of juveniles that can not be identified to species.

ORDER CALLIPODIDA

Family Caspiopetalidae

Abacion tesselatum Rafinesque

HNF localities.—*Crawford County:* Enlow's Back Door Cave. *Orange County:* Grease Gravy Special Area: under rocks at spring associated with Grease Gravy Cave.

Habitat and range.—This species occurs from the Gulf Coastal Plain through the east-central U.S., where it is a common inhabitant of both native and urban environments (Shelley 1984).

ORDER JULIDA

Family Julidae

Ophyiulus pilosus (Newport)

HNF localities.—*Lawrence County:* King/Bug Ear Cave; Tincher Karst Special Area: Brick Pit, Fuzzy Hole, Garden Hose Pit, HNF Swallowhole, Pail Cave, Tincher Swallowhole Cave, Tincher Hollow Cave, Williams Cave. *Orange County:* Allen Cave; Paoli Experimental Forest: Garlow Spring Cave.

Habitat and range.—This species is an exotic probably native to Italy that is now widespread in the northeastern U.S. (Hoffman 1999). It frequents caves and is ubiquitous in leaf litter and detritus in caves of the Tincher Karst Special Area. It is also known from caves in Clark and Harrison Counties (Lewis 1996, 1998).

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