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An Inventory of Endemic Leaf Litter Arthropods of Arkansas with Emphasis on Certain Insect  
Groups and Diplopoda

A thesis submitted in partial fulfillment  
of the requirements for the degree of  
Master of Science in Entomology

by

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Marietta College  
Bachelor of Science in Biology, 2012

December 2015  
University of Arkansas

This thesis is approved for recommendation to the Graduate Council.

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## Abstract

Endemic arthropods of Arkansas were sampled and their nomenclature and distributions were updated. The Arkansas endemic species list is updated to 121 species, including 16 species of millipedes. A study of the millipedes of Arkansas was undertaken, and resulted in the first checklist and key to all millipede species in the state. 68 species are known from Arkansas, including the genera *Cylindroiulus* and *Polydesmus*. The first state records for *Ophiulus pilosus*, *Cylindroiulus* sp., and *Ptyoiulus coveanus* are reported, and new county records are reported for 16 species. This represents the first key to a state's species since 1980, and the first millipede checklist for a state since 2002. A study of the circadian rhythms of leaf litter arthropods via leaf litter collection methods was undertaken as well, and resulted in the collection of over 8,000 specimens. Three time periods, 6 AM (dawn), daylight, and darkness hours were identified as important to collecting abundance and diversity, and general circadian rhythm data on selected arthropod groups, including the Myriapoda, Formicidae, Staphylinidae, Carabidae, Curculionidae, and other Coleoptera families were reported and found to agree with similar data collected from pitfall trap studies.

## **Acknowledgements**

Thanks are extended to my thesis committee for their help in the planning and execution of my projects, and for their helpful comments strengthening drafts of this thesis. I would also like to thank the Department of Entomology and its faculty, staff, and graduate students, particularly Clinton Trammel, Amber Tripodi, Joseph O'Neill, Sim Barrow, Fredericka Hamilton, Mark Janowiecki, Michael Skvarla, Danielle Fisher, and Ray Fisher. I also thank Jacqueline Guzy of the Department of Biology, and Joseph deSisto of the University of Connecticut Department of Biology, for their extraordinary help.

A special thanks goes to Dr. Rowland Shelley, for enormous assistance in learning the taxonomy of millipedes, his identification of some specimens, and the generous gift of his time. I would also like to thank Dr. Bill Shear for his identification of some specimens and lending his helpful knowledge about the Chordeumatida.

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## **I. Introduction**

This project was undertaken as part of the Dowling Lab's continuing investigations of leaf litter arthropods in the western ecoregions of Arkansas, and is composed of three parts: an update to the list of known Arkansas endemic fauna, a first synopsis of all millipede species found in Arkansas, and an examination of day-night activity cycles of selected arthropod groups (particularly Myriapoda, Coleoptera, and Formicidae). Field work for these projects took place between July 2013 and June 2015, and most field work took place in western Arkansas, based on previously identified areas of interest.

The diverse ecoregions found in the state contribute to its biodiverse assemblage of organisms (Robison & Allen 1995). The Interior Highlands region (namely the Ozark and Ouachita Mountains) has been previously identified as an area of high endemism (that is, organisms being found in only one geographic area), due to its place in geological history as glacial refugia (Robison & Allen 1995). The Interior Highlands have stood above surrounding ocean water for the past approximately 310 million years (Robison & Allen 1995), providing habitat for many organisms even while surrounding areas underwent glaciation or were covered in water. The region was also connected to the Appalachian Mountains during the Pennsylvanian era (Robison & Allen 1995), and this connection is seen in the genetic relationships of some organisms, such as millipedes and beetles.

Previous work on the endemic flora and fauna of Arkansas informed this study, the most important of which was Robison & Allen's (1995) publication, which summarized earlier work by Allen (see Allen 1988, 1990) and expanded on the biogeographical significance of endemism in the Interior Highlands. Updates by Robison et al (2008) and McAllister et al (2009) refined the list further to include changes in nomenclature and additions and deletions of species. These

updates corrected some past mistakes, but lacked up-to-date information on the Myriapoda: no centipedes were included, and nomenclature in the Diplopoda contained errors. My work corrects these problems, and adds new species to the list.

Knowledge of the millipedes of Arkansas is relatively good compared to other states in the U.S., but is scattered throughout the literature. The first attempt at listing the species in Arkansas was by Bollman (1887), in a short preliminary list. Later studies by Causey (see references) resulted in the collection and description of many species (though many were later synonymized), which gave useful distribution information. Concerted collecting and a series of papers by McAllister & Shelley beginning in the early 2000s (see references) summarized county records for a number of species, and a large number of state and county records were reported. General papers on families of millipedes, with many important ones written by Hoffman, Shear, and Shelley starting in the 1970s (see Hoffman 1962, Shear 1972, and Shelley 1984), brought millipede taxonomy into a modern age and had an ancillary effect of listing many Arkansas millipede records. However, all of this work and knowledge wasn't accessible to many non-millipede specialists.

New millipede species from Arkansas have recently been described, including *Branneria bonoculus* (Shear 2003), *Abacion wilhelminae* (Shelley et al 2003), and *Chaetaspis attenuatus* (Lewis & Slay 2013). With the pervasiveness of millipedes in many habitats throughout North America, and the variety of habitats in Arkansas, a current synopsis is needed for further investigation of millipede endemism and biogeographical relevance. Such a synopsis gives non-millipede specialists and other researchers a foundation from which to begin. The presence in Arkansas of species from many eastern North American families makes this synopsis relevant for eastern North America in general.

. During these projects, most collection of leaf litter organisms was done by sampling during daylight hours, putting litter in a litter concentrator, then transferring the concentrate to Berlese funnels. This bias towards collecting during the day led to questions of what organisms may be missed by not sampling during the night, a time at which some species are most active (Dondale et al 1972). Importantly, most previous studies on circadian rhythms of arthropods have focused on pitfall trapping methods (Siewers et al 2014), rather than leaf litter collection. To answer questions about arthropod circadian rhythms with leaf litter collection and Berlese funnel extraction, a study was performed during June 2014 at Mt. Kessler outside of Fayetteville, Arkansas. Over three periods of 24 hours, 30 leaf litter samples (per 24 hour period) were collected during six time periods, and the collected arthropods were identified to assess any activity patterns during circadian rhythm cycles.



## **II. Updates and Corrections to the Arkansas Endemic Fauna with a Focus on Myriapoda and Araneae**

### **Background**

Six distinct physiographic regions are encompassed by Arkansas's borders, which lends the state a unique biological assemblage. The Interior Highlands Region makes up much of northern and western Arkansas and contains three of the states physiographic regions: the Ozark Plateaus in the north, the Ouachita Mountains in west-central Arkansas, and the Arkansas River Valley situated in between them (Foti & Bukenhofer 1998). The West Gulf Coastal Plain occupies much of southern Arkansas, and the Mississippi River Alluvial Plain covers eastern Arkansas. Within the northeastern part of the Mississippi River Alluvial Plain, stretching from southern Missouri to Helena, Arkansas, is Crowley's Ridge. It is 1 to 10 miles (1.6 to 16 km) wide and rises 100 to 250 feet (30 to 76 m) above the flat surrounding plain (Robison & Allen 1995). While comparatively small, Crowley's Ridge warrants recognition as its own physiographic region due to its biological communities, which retain elements of organisms more common east of the Mississippi. The Mississippi River flowed west of Crowley's Ridge at a previous point in history, and its forests more closely resembles those of Tennessee (Robison & Allen 1995).

In addition to its effects on the biota of Crowley's Ridge, Arkansas's geologic history has influenced the biota of the rest of the state. The regions of the Interior Highlands are particularly useful for understanding the state's current biota. Allen (1990) identified over 200 species of plants and animals possibly restricted to the Interior Highlands, and provided preliminary discussions about the causes for the observed endemism. During the Pennsylvanian subperiod (300-310 million years ago), the Ozark Plateaus, Ouachita Mountains, and Arkansas River

Valley were uplifted, providing land above the surrounding sea that covered much of today's North American continent (Robison & Allen 1995). These areas were connected with the Appalachian Mountains by a ridge uplifted by colliding continental plates, providing a bridge for the biota of the two areas. During the early Cretaceous Period (145 to 100 million years ago), this connection was broken, isolating the Appalachian Mountains from the Interior Highlands (Robison & Allen 1995). The Interior Highlands' position as an area of land continually above-water for the past 300 million years, and its later isolation, may be key to understanding the patterns of endemism in Arkansas and the general distribution patterns of biota in North America and other parts of the world.

While other parts of the continent may have been alternatively submerged underwater or otherwise uninhabitable for some organisms, the Interior Highlands provided relatively constant environmental conditions for various organisms. These conditions could have acted as a refuge for organisms to establish their range and survive, while periodically expanding out of the region. Range expansions and contractions would be coupled with speciation events as glaciations receded and other geologic or climatic events opened or closed different paths. The formation of new species and presence of relict species in the Interior Highlands may be explained by the taxon pulse hypothesis synthesized by Erwin (1985). Evidence for this explanation is given by the distribution and relationships of organisms found in: the Interior Highlands and Asia, such as the rove beetle *Derops divalis* (Robison & Allen 1995); the Interior Highlands and western North America, such as the Dipluran genus *Occasjapyx* (Robison & Allen 1995); and the Interior Highlands and the Appalachian Mountains, such as the millipede genus *Boraria* (Shelley et al. 2011). Organisms with low vagility (such as plants or wingless

arthropods) may prove quite useful in testing the taxon pulse explanation in the future, due to their reliance on favorable environmental conditions for expanding their distributions.

Microhabitats within Arkansas's physiographic regions provide possible refuges for relict species. Though the Arkansas River Valley was uplifted around the same time as the Ozark Plateaus and Ouachita Mountains, it has since been eroded, with mountains such as Mount Magazine and Petit Jean Mountain a reminder of its past. The cooler microhabitats in this region, such as on the north face of Mt. Magazine, provide habitats for endemics ranging from Gastropoda to Coleoptera that are not found anywhere else in the state (Robison & Allen 1995).

Knowledge of the endemic species in the Interior Highlands was summarized by Allen (1990), and was accompanied with an explanation for the observed endemism due to a process other than Pleistocene glaciation, as previous workers had often cited. This work was followed by Robison & Allen (1995), which focused on the endemic species found only in Arkansas. While the somewhat arbitrary political boundaries limited what species could be included, this was the first definitive listing of Arkansas endemics, and the first state listing of endemics for any state within the boundaries of the Interior Highlands region. This synopsis included 117 Arkansas endemic taxa, with 11 species of plants and 106 animals (99 invertebrates and 7 vertebrates). The first update to the synopsis was Robison et al. (2008), which made several corrections to nomenclature, added new species to the list, updated species distributions, and deleted species from the list (due to recent synonymy or the discovery of the species outside of Arkansas). The revised number of Arkansas endemic taxa was lowered to 110, with 10 species of plants and 100 animals (92 invertebrates and 8 vertebrates). The most recent update (McAllister et al. 2009) added Fungi to the list for the first time, after two species were found to be endemic. With this update's additions and deletions, the current Arkansas endemic species list stands at

126 taxa. This number is slightly incorrect, however, due to a small mathematical error. McAllister et al. (2009) miscounted the number of endemic taxa arrived at by Robison et al. (2008), by stating "their update brought to 113 (10 species of plants and 103 species/subspecies of animals)." The actual number Robison et al. (2008) gave was 110 species. The final number McAllister et al. (2009) gave, 126 species, is also wrong. Using their starting count of 113 species, they added 19 species to the list and deleted 7, which is 125 species, not 126. Fixing this confusing state and incorporating McAllister et al. (2009)'s additions and deletions, the correct number of Arkansas endemic species is 122, made up of 10 species of plants, 2 species of fungi, and 110 animals (102 invertebrates and 8 vertebrates).

Despite the slight counting errors, the original synopsis and subsequent updates have proven to be useful resources. They brought together disparate information that would otherwise be scattered across the literature and identified the Interior Highlands as a relatively ignored area for biogeographical studies, when compared to better-sampled areas of North America such as the Appalachian Mountains or Pacific Northwest. Many of the species that were removed from the Arkansas endemics list are still endemic to the Interior Highlands region as a whole, ignoring the states' political boundaries, and are thus the information provided by previous publications is still useful for scientists interested in endemism in the Interior Highlands region.

This update to the list of Arkansas endemic taxa was undertaken to fix past mistakes with the list and add new species. It focuses on the Myriapoda and other Arthropoda. Three new endemic taxa (two spiders and one centipede) are added and four millipedes are deleted from the list, bringing the current number of Arkansas endemic species to 121: made up of 10 species of plants, 2 species of fungi, and 109 animals (101 invertebrates and 8 vertebrates). Nomenclature is updated, and a list of the current Arkansas endemic millipedes is given. Additionally, a list of

the endemic millipedes deleted by Robison et al. (2008) is given. These are species which were removed from the list, but for which no explanation was given. In the interest of preventing future confusion, this information is formally included.

## **Methods**

Sampling for this study was done throughout Arkansas, with most collections taken from western Arkansas in the Interior Highlands regions. Collection sites were chosen according to locations at which endemic species were previously found and also, based on its plant communities, how likely a site was to harbor unique species (Zachry et al 1979). Collecting was undertaken from July 2013 through April 2015, with most collection trips taking place from spring to fall. Specimens were collected from leaf litter and by hand collecting. Leaf litter was collected by use of a litter concentrator, a handheld device with two metal rings with handles, the lower one with a wire mesh, both connected by a nylon fabric sleeve. The concentrate was transferred to a gallon Ziploc<sup>®</sup> plastic bag. When collection trips spanned an entire day, the concentrated litter was put into a cooler with ice to prevent the bag from getting too hot and killing any organisms in the litter. After collection trips, the concentrated litter was transferred to Berlese funnels for extraction. Litter was left in the Berlese funnels under 40 watt light bulbs for at least 48 hours. The resulting sample was stored in 70% ethanol and the arthropods were later examined and identified under a dissecting microscope. Hand collection was done by manually overturning rocks, logs, and other debris for terrestrial arthropods. The resulting specimens were also stored in 70% ethanol and identified using a dissecting microscope. Examination of relevant literature also provided distribution records and information about endemic species.

## **Results**

### **Additions to the State Endemic Fauna**

**Class Arachnida, Order Araneae (Spiders), Family Dictynidae (Mesh Web Weavers)**

***Cicurina arkansa* Gertsch, 1992**

Gertsch (1992) first described this species from specimens collected in pine-oak woods in Bradley County on November 17, 1963. All known records are from Sumpter, Arkansas, and were collected in September and November. This species is small, ranging from 2 mm-4 mm, and males are larger than females. Can traps were the probable collecting method (Gertsch 1992).

***Cicurina secreta* Gertsch, 1992**

This species was also described by Gertsch (1992), and the female holotype is from Cove Creek Valley (15 miles south of Prairie Grove) in Washington County. The holotype collection took place in December, and other specimens were collected in August and October. This species is slightly larger than *C. arkansa*, with a length ranging from 5.0 mm-5.5 mm. Males are slightly larger and also have bigger eyes.

**Class Chilopoda (Centipedes), Order Lithobiomorpha (Stone Centipedes)**

**Family Watobiidae**

***Arkansobius lamprus* Chamberlin, 1938**

This species was first described by Chamberlin in 1938, from a collection of 16 specimens taken at an unspecified locality in Pike County on April 7, 1937. Chamberlin describes the species as generally yellow, with an orange head and antennae, and 7-8 mm long. Unfortunately, Lithobiomorpha centipede taxonomy is severely lacking due to neglect by taxonomists and badly in need of revision. Identification of this species will require a careful reading of the original description, and comparison with the female holotype at the United States

National Museum (Type Number : 102304) would be most desirable. No information on the biology or habitat in which the species was found was included by Chamberlin in his description.

The Lithobiomorpha and Geophilomorpha centipedes in general have been understudied, and there may prove to be more endemic species in Arkansas if concerted collecting is done. It's likely that undescribed centipedes from Arkansas are already sitting in museum collections, and the group is wide open for study (and in need of it).

### **New Records or Changes in Nomenclature**

#### **Class Diplopoda (Millipedes)**

##### **Order Chordeumatida, Family Cleidogonidae**

###### ***Tiganogona glebosa* (Causey, 1951)**

This species was first described from a collection of males from Mt. Kessler, Fayetteville, Washington County (Causey 1951b). Causey collected adult males in November, and also reported the species from Benton and Johnson Counties.

This species was recently (November 2, 2014) collected from Dismal Hollow, in Newton County, and another collection was made on October 12, 2012 at Petit Jean Mountain, Conway County. Both collections were from leaf litter (deciduous and mixed, respectively), and are new county records for the species. Many Chordeumatida become more active during the colder months of late fall and winter, and future cold weather collecting may turn up more records of this species (and other Chordeumatida) in Arkansas. The Conway County record represents the first collection of *T. glebosa* outside the Ozark Plateau region, extending the range of the species slightly into the Arkansas River Valley.

##### **Order Julida, Family Parajulidae**

###### ***Aliulus carrollus* Causey, 1950**

This species was first described from Blue Springs, Carroll County (Causey 1950a), and reported from Washington County as well. It was later record from Benton and Searcy Counties (Causey 1953).

Here I report a new county record, a male from Madison County caught in a pitfall trap in a forested area at Withrow Springs State Park on April 12, 2014. *Aliulus carrollus* seems to be common in the Ozark Plateau region. Another species in the genus, *A. caddoensis*, is found in the Ouachita Mountains and is endemic to the Interior Highlands, being found in Oklahoma and Arkansas (Hoffman 1999).

#### **Order Polydesmida, Family Eurymerodesmidae**

##### ***Eurymerodesmus newtonus* Chamberlin, 1942**

This species was described by Chamberlin (1942) from Newton County. Shelley (1990) synonymized the species *Eurymerodesmus bentonus* Causey 1950 with *E. newtonus* and added Benton and Washington Counties to its range.

In Robison & Allen (1995) and Robison et al. (2008), this species is spelled as both "*Eurymerodesmus newtonius*" and "*Eurymerodesmus newtonus*." To clear up confusion, the correct spelling for this species is *Eurymerodesmus newtonus*, by original designation.

#### **Order Polydesmida, Family Xystodesmidae**

##### ***Mimuloria davidcauseyi* (Causey, 1950a) syn. *Nannaria davidcauseyi* (Causey 1950b)**

Causey (1950b) placed this species in the genus *Nannaria* in her original description, based on a collection of individuals from three miles northwest of Jasper, Newton County. It was later moved to the genus *Castanaria* (Causey 1950c), back to *Mimuloria* (Causey 1955), and restored to *Nannaria* (Hoffman 1964). Most recently, Hennen & Shelley (2015) revalidated the



genus *Mimuloria* Chamberlin, 1928 and placed *M. davidcauseyi* into it, along with four other species.

This species has been collected in Newton, Johnson counties in June, August, and November (Hennen & Shelley 2015). It can be separated from other members of the genus by the slight lean of its gonopod acropodite and the prefemoral process being about 1/3 as long as the acropodite. Like other millipedes in the family Xystodesmidae, it lives in moist leaf litter.

**Class Arachnida, Order Araneae (Spiders), Family Leptonetidae**

***Ozarkia arkansa* (Gertsch, 1974) syn. *Neoleptoneta arkansa* (Gertsch, 1974)**

This species was reported by McAllister et al. (2009) as *Neoleptoneta arkansa*. The species was moved to the newly established genus *Ozarkia* in Ledford et al. (2011), which includes nine species. The genus is named after the Ozark Mountains, but *O. arkansa* is the only species that occurs in the Ozarks. The other species in the genus are found in caves in Alabama, Arizona, Georgia, and New Mexico.

*O. arkansa* has only been found in Blanchard Springs Caverns, Stone County, in September and October.

**Subphylum Hexapoda, Class Diplura, Order Dicellurata (Two-pronged Bristletails)**

**Family Japygidae (Forcepstails)**

***Occasjapyx carltoni* Allen, 1988**



**Figure 1. *Occasjapyx carltoni*, A. Detail of head B. Detail of posterior abdomen C. Body**

Allen (1988) described this species from a specimen taken under rocks along Indian Creek near Kyle's Landing, along the Buffalo National River in Newton County. I collected another individual (Figure 1) about 4 miles away from the type locality, from under a large rock beside a stream in a beech/cedar forest, along the Buffalo River Trail (N 36°01'30" W 93°21'08"). This specimen was collected on March 22, 2014 and the holotype was collected on March 7, 1988. One other collection of this species is recorded from Independence County, in muddy substrate in the twilight zone of Blevins Cave, on December 30, 2004 (McAllister & Carlton 2005). This collection may indicate that the species has a wider distribution than

previously thought, and might be found in intervening counties in the Ozark Plateaus region in the future.

### **Species Removed from the State Endemic Fauna**

#### **Class Diplopoda, Order Chordeumatida, Family Cleidogonidae**

##### ***Tiganogona moesta* (Causey, 1951)**

Robison & Allen (1995) first added *Tiganogona moesta* to the state endemics list, giving its distribution as Carroll and Washington Counties. Shear (1972) made new illustrations from a Washington County specimen after the holotype was lost in the mail, including it in his exceedingly useful monograph on the Cleidogonidae. He overlooked a short note on this species' distribution in Causey 1957, however, who reported a specimen collected from Alton, Oregon Co., Missouri collected on March 15, 1955. This record extends *T. moesta*'s range in the Interior Highlands, but removes it from the list of Arkansas endemic species.

#### **Class Diplopoda, Order Polydesmida, Family Xystodesmidae**

##### ***Boraria profuga* (Causey, 1955)**

This species was reported from an area of mixed pine and hardwoods in Montgomery County by Robison & Allen (1995). I collected more specimens in a similar habitat in nearby Garland County on May 20, 2015, constituting a new county record for the state. Robison et al. (2008) updated its taxonomy and stated that it is probably endemic to the Ouachita uplift region. The three other species in the genus are all found in the Appalachian Mountains, with some records from New England due to human-aided movement (Shelley et al. 2011).

*Boraria profuga* is noted as "legitimately rare" by Shelley et al. (2011), and 53 years passed between its first Arkansas collection and its recollection in 2009 by McAllister, despite being searched for by Causey and McAllister in the intervening years. Shelley et al. (2011)

reported this species from Monroe County, Louisiana, which is within the Ouachita River watershed. This is well outside the Interior Highlands, removing it from the endemics list.

**Class Diplopoda, Order Polydesmida, Family Xystodesmidae**

***Mimuloria castanea* (McNeill, 1887) syn. *Nannaria depalmai* (Causey, 1950)**

This species was described by Causey (1950b) as *Castanaria depalmai*, based on samples from 0.2 miles south of Lake Leatherwood, Carroll County. Hennen & Shelley (2015) synonymized this name with *M. castanea*, a species whose range includes the Ozark Plateaus of Missouri, removing it from the Arkansas endemics list.

*Mimuloria castanea* is also known from Searcy and Stone Counties, Arkansas (Hennen & Shelley 2015).

**Class Diplopoda, Order Polyzoniida, Family Polyzoniidae**

***Petaserpes bikermani* (Causey, 1951)**

Causey (1951a) described this species (as *Polyzonium bikermani*) from Devil's Den State Park in Washington County and reported records from mixed deciduous woods in Benton and Carroll Counties. Records of *P. bikermani* were reported from Missouri, Illinois, and Indiana in a revision of the family by Shelley (1998), removing it from the Interior Highlands endemics list. This was overlooked when Robison et al. (2008) updated its nomenclature. Concentrated collecting may result in this species being found in more localities within its range (Shelley 1998 lists only 4 samples). Due to its slow movement and generally flat and shiny appearance, the species is easily overlooked, being mistaken for a slug and not recognized as a millipede.

**Diplopoda Removed from State Endemic List by Robison et al. (2008)**

The table listing the updated state endemic fauna in Robison et al. (2008) made many changes to the millipedes reported as state endemics. 32 millipedes were on the original list

reported in Robison & Allen (1995). Robison et al. (2008) added 3 more species and formally removed 10 species of millipedes from the list. However, they also informally (but validly) removed 6 more species from their list and oddly made no note of it in the text. Their list included 19 species of millipedes, and here I give formal information about why those 6 species were removed.

## **Order Chordeumatida**

### **Family Cleidogonidae**

***Cleidogona laminata* Cook & Collins, 1895** syn. *Cleidogona aspera* Causey, 1951

Shear (1972) synonymized *C. aspera* with *C. laminata* in his revision and listed records for the species from Clay, Dallas, Lawrence, and Randolph Counties, in addition to Jackson Parish, Louisiana, thus removing it as an Arkansas endemic. This species may eventually be found in Missouri as well, since Clay, Lawrence, and Randolph Counties border the state. Individuals have been collected in August (Causey 1951b), March and October (Shear 1972).

***Tiganogona alia* (Causey, 1951)** syn. *Ofcookogona alia* Causey, 1951

Shear (1972) synonymized the genus *Ofcookogona* with *Tiganogona*, and reported a record from March in Lincoln County, Louisiana, which removes it from the state endemics list. In Arkansas, it is known from Washington (Shear 1972) and Union Counties (Causey 1951c), with both records taken in December. Additionally, I have collected the species in Logan and Conway Counties, both in October.

### **Family ?Conotylidae**

***Craspedosoma flavidum* Bollman, 1888**

Bollman's (1888) original description of this species is inadequate and without illustrations. After his death, the type material was lost (Chamberlin & Hoffman 1958), putting

this name in an uncomfortable limbo of uncertain generic position. However, another species described by Bollman and placed in the same genus, *C. carinatum*, is now placed in the genus *Branneria* in the family Branneriidae.

A new species of *Branneria*, *B. bonoculus*, was described in Shear 2003 based on one male taken from Nevada County. This may be the same species as *Craspedosoma flavidum*, which was collected in Okolona, Clark County, just one county away. Since the type material was lost, recollection of male *Branneria* around Okolona (no further locality information was provided) may be able to resolve the question of *C. flavidum*'s generic (and familial) status. For now, it is prudent to remove this species from the list of state endemics due to the uncertainty. If *C. flavidum* is indeed another name of *B. bonoculus*, the species should remain off the list, due to the discovery of that species in Texas (McAllister et al. 2009).

## **Order Julida, Family Parajulidae**

***Oriulus venustus* (Wood, 1864) syn. *Oriulus grayi* Causey, 1950**

Causey's *O. grayi* was found to be one of many synonyms of the widespread *O. venustus* (Shelley 2002). This species is found in at least 34 states of the United States, stretching from Massachusetts to Montana, blanketing most of the continental United States in its range.

## **Order Polydesmida**

### **Family Eurymerodesmidae**

***Eurymerodesmus angularis* syn. *Eurymerodesmus wellesleybentoni* Causey, 1952;**

***Eurymerodesmus wellesleybentonus* Chamberlin & Hoffman, 1958**

*E. wellesleybentonus*, an incorrect spelling by Chamberlin & Hoffman (1958) of Causey's (1952) *E. wellesleybentoni*, was synonymized with *Eurymerodesmus angularis* by Shelley

(1990). Robison et al. (2008) correctly removed *E. angularis* from the list, which is also known from Louisiana, Missouri, Mississippi, and Texas (McAllister et al. 2004).

***Eurymerodesmus dubius* Chamberlin, 1943** syn. *Paresmus columbus* Causey, 1950

The genus *Paresmus* was synonymized with *Eurymerodesmus* (Shelley 1990), and *P. columbus* was found to be a synonym of *E. dubius*. Robison et al. (2008) correctly removed *E. dubius* from the Arkansas list, which is also known from Oklahoma.

**Table 1. Arkansas Endemic Diplopoda**

*Abacion wilhelminae* Shelley, McAllister and Hollis

*Aliulus carrollus* Causey

*Causeyella causeyae* Shear

*Causeyella youngsteadtorum* Shear

*Cleidogona arkansana* Causey

*Eurymerodesmus compressus* Causey

*Eurymerodesmus goodi* Causey

*Eurymerodesmus newtonus* Chamberlin

*Eurymerodesmus polkensis* (Causey)

*Eurymerodesmus pulaski* (Causey)

*Mimuloria davidcauseyi* (Causey)

*Okliulus beveli* (Causey)

*Tiganogona glebosa* (Causey)

*Tiganogona ladymani* (Causey)

*Tiganogona steuartae* (Causey)

*Trigenotyla parca* (Causey)

## Discussion

Table 1 is an updated listing of the Diplopoda endemic to Arkansas, constituting 16 species from 5 families. This represents a distinct change since Robison & Allen's first list, which contained 32 species from 9 families. The removal of half the species is not terribly surprising, as the original list from Robison & Allen (1995) was based information on the Diplopoda from papers by Chamberlin and Causey. They didn't use the excellent Cleidogonidae monograph by Shear (1972), which made many important changes to the family, and the Checklist of North American Diplopoda (Hoffman 1999) was still being written at the time. The current 16 species may decrease further in the future if more scientists and amateurs alike take an interest in and collect millipedes. Many of the species, particularly in the Cleidogonidae, are only known from a few records, and other species on the list were collected near the biologically irrelevant political boundaries of Arkansas. Making the efforts to seek out these creatures will result in better data regarding the biology of these species, and will also give interested workers more clues about why they are restricted to Arkansas or the Interior Highlands. Most importantly, better distributional data will strengthen the science, rather than relying on a very small sample size to claim a species as an endemic one.

This update to the Arkansas endemic fauna fixes mistakes made in previous lists, adds three new species (two spiders and one centipede), removes four species (all millipedes), and adds new locality records and updates nomenclature. The Arkansas endemics list now stands at 121 species, made up of: 10 species of plants, 2 species of fungi, and 109 animals (101 invertebrates and 8 vertebrates).

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### **III. A Review of the Millipedes (Arthropoda: Diplopoda) of Arkansas, with Keys to the State Fauna**

#### **Background**

The first treatment of millipedes in Arkansas was by Bollman (1888), who listed 17 species found in the state. This list is now out of date, with nomenclature having changed drastically in the intervening 127 years. Further studies by Causey (1950abc, 1951abc, 1952ab, 1953, 1955, 1957) greatly enhanced knowledge of the distribution of millipedes in the state, particularly of the Parajulidae, Polydesmida, and Chordeumatida, and she described many new species, some of which are endemic to Arkansas. Causey undertook much-needed collecting in the state and provided specimens, which are still studied today, for other millipede specialists to examine. Major contributions and revisions of members of the Chordeumatida by Shear (1972, 1981, 2003ab, 2010) cleared up confusion surrounding the nomenclature and identification of some of the smallest millipedes in the state and made the group accessible to interested researchers. Shear's monograph on the Cleidogonidae (1972) is a particularly important resource for millipedes in Arkansas, as it is profusely illustrated and includes information on all families of Chordeumatida found in Arkansas. Rowland Shelley's many revisionary studies of North American millipede groups over the past four decades cleared up much confusion in nomenclature and species distribution, especially in the Polydesmida. Pertaining to Arkansas, Shelley's papers on the Polyzoniidae (Shelley 1998), Abacionidae (Shelley 1984, Shelley et al. 2003), and Parajulidae (Shelley 2000b, 2002) provided much-needed revisions at the family and genus level and provided critical diagnostic characters and keys to species. Shelley also published a large number of papers on the Polydesmida, many of which include species found in Arkansas. His work on the family Eurymerodesmidae (Shelley 1990) was the first (and remains

the only) revisionary treatment of the family, and is the best resource for information about its 25 species, 13 of which occur in Arkansas. This family contains some of the most common polydesmidan millipedes in prairie ecosystems, and ranges through the southern United States. Shelley's major papers on the subfamily Desmoninae (2000), the tribe Pachydesmini (Shelley & McAllister 2006), and the genera *Auturus* (1982), *Scytonotus* (1993), *Pleuroloma* (1980), and *Boraria* (Shelley et al 2011) all pertain to species found in Arkansas, and are stellar information resources.

Aside from taxonomic treatments of millipedes in Arkansas, a series of papers reporting distribution records for selected millipedes in the state was published, beginning in 2002, with the most recent addition being published in 2013 (McAllister & Robison 2009, 2011, McAllister & Shelley 2008, 2010; McAllister et al 2002ab, 2003, 2004, 2005, 2013;). These papers updated the distribution of species at the county level and added many new records for the state. However, these papers did not provide identification information for Arkansas's millipedes, nor did they synthesize a checklist of species recorded in Arkansas. While the papers provided many new records, most were for the western and northern portions of the state. The southern portion of the state, and the Gulf Coastal Plain in general are still areas that haven't been well-sampled for millipedes.

The only states with modern checklists of their millipede fauna are California (Shelley 2002a), Florida (Shelley 2001b), Michigan (Snider 1991), and North Carolina (Shelley 2000a). Historically, millipedes as a group have been ignored by entomologists and have not been seen as a priority for study (Shelley 1990). As a result, it has only been in the last few decades that major taxonomic confusion in the group has been cleared up. The current state of millipede nomenclature is the most stable it has ever been, and North America has an exceptionally useful

resource in the *Checklist of Millipeds of North and Middle America* (Hoffman 1999), which synthesized the species known to the continent and their distributions.

Worldwide, there are over 12,000 species of described millipedes (Brewer et al 2012), and global diversity estimates range from 15,000 species to 80,000. The true number of undescribed species is unknown (Brewer et al 2012). Regardless of how many species there actually are, millipedes represent an intriguing group for studying biogeography, evolution of bioluminescence (Marek & Moore 2015) and color (Marek & Bond 2009), and chemical ecology (Shear 2015). The low vagility of millipedes has led to endemism in various physiographic areas worldwide, and Arkansas has 16 endemic species. The Interior Highlands region of the United States contains additional endemic species.

The political boundaries of Arkansas include six distinct physiographic regions: the Ozark Plateaus (northern Arkansas), the Ouachita Mountains (west-central Arkansas), the Arkansas River Valley (west-northern Arkansas), the West Gulf Coastal Plain (southern Arkansas), the Mississippi River Alluvial Plain (eastern Arkansas), and Crowley's Ridge (eastern Arkansas) (Robison & Allen 1995). These regions contain habitats ranging from mountains to swamps to farmland and support a diverse millipede fauna, particularly in the western highlands of the Ozark and Ouachita Mountains. The Ozarks support endemic species of Chordeumatida, especially in caves of the region. The Ouachita Mountains support five endemic species of *Eurymerodesmus*, and its biotic communities share a connection to the Appalachian Mountains (Robison & Allen 1995). This is shown by the presence of *Boraria profuga*, the only species in the genus that naturally occurs outside of the Appalachians. Shelley et al (2011) identified it as a species possibly in need of protection, due to its rare occurrence.

Arkansas has yielded five new millipede species in the 21st century: the first new species of *Abacion* in 60 years (Shelley et al 2003), a second species of *Branneria* (Shear 2003a), the new genus *Causeyella* with two included species (Shear 2003b), and a new species of *Chaetaspis* from caves in northern Arkansas (Lewis & Slay 2013). The latter three species were all discovered in caves, and all are endemic to the state, displaying the importance of searching for millipedes in difficult to access and previously ignored habitats.

In addition to species solely found in Arkansas, many genera and species with wider ranges in eastern North America are found in Arkansas. The Eurymerodesmidae extend throughout the central and southern United States, and 13 of its 25 species inhabit Arkansas, five of them being endemic. The state has representatives of most common eastern North American millipede families, and within the diverse family Xystodesmidae, four tribes are found in Arkansas. Thus, knowledge of the Arkansas millipede fauna is transferrable and useful for other states.

This is the best time in the history of American Diplopodology to study millipedes. The advent and maturation of the Internet has resulted in the proliferation of well-maintained resources to learn how to identify millipedes, such as BugGuide.net (<http://bugguide.net/node/view/37>) and Rowland Shelley's website "The Myriapoda (Millipedes, Centipedes) Featuring the North American Fauna" (<http://www.nadiplochilo.com/>). Additionally, the Biodiversity Heritage Library (<http://www.biodiversitylibrary.org/>) contains a plethora of published scientific papers covering a wide range of information about millipedes, uploaded by a consortium of natural history libraries. These resources, along with papers detailing millipede collecting methods (such as Means et al 2015), provide a wide array of information and color photographs free to all. This has made the American Diplopoda accessible in ways only

imagined a few decades ago, and has the potential to lead to a veritable Renaissance of millipede research.

In pursuit of that Renaissance, the objective of this study is to provide a synopsis of the 66 millipede species reported from Arkansas (plus 2 introduced genera expected to occur in the state) and a key to each species with illustrations and color photographs. Information on the county distribution, ecology, taxonomy, and other remarks is provided for each species. New county records are reported for multiple species, and new state records are reported for *Ptyoiulus coveanus*, *Ophiulus pilosus*, and the genus *Cylindroiulus*. While this synopsis focuses solely on Arkansas, the information (and especially the key) should be useful for the surrounding states and to some extent, the entire eastern United States. It is hoped that this will enable non-millipede specialists to correctly identify species they encounter and spur on future work on the group.

## **Methods**

A review of the millipede literature was undertaken to build a list of species already known to inhabit Arkansas. This literature search was combined with an active sampling regime, which was begun in July 2013 and lasted until June 2015. Collection sites were mainly in northern, western, and central Arkansas, with a few sites sampled in southern Arkansas and also on Crowley's Ridge in eastern Arkansas. Hand collection and leaf litter collection (similar to methods described by Snyder et al 2006) were both used. During hand collection of millipedes, millipedes were searched for under leaf litter, logs, and rocks, and either collected live or put into vials of 70% ethanol for preservation. During leaf litter collection, about a square meter of leaf litter was sifted using a litter concentrator, a handheld device with two metal rings with handles, the lower one with a wire mesh, both connected by a nylon fabric sleeve, and the concentrated



litter was transferred into a gallon-sized Ziploc<sup>®</sup> plastic bag. During longer collecting trips, the litter was placed in a cooler with ice packs or bagged ice to keep the organisms inside from overheating and to chill predatory arthropods, in an attempt to keep them from eating other organisms in the sample. Much of the collected litter was taken from habitats amenable to millipede activity: shaded forest with relatively moist litter. However, habitats ranging from pine forest to dry deciduous forest to roadside habitats were also sampled.

The litter samples were transferred to Berlese funnels for extraction, and left in the funnels for 48 hours under 40 watt light bulbs. The extracted arthropods were stored in 70% ethanol in Whirl-Pak bags (Nasco, Fort Atkinson, WI) for later sorting and identification. Specimens were identified under a LeicaMZ 16 stereomicroscope and the primary literature was used to identify the millipedes to species.

Photographs of millipedes were taken *in situ* in the field using a Canon PowerShot SX150 IS; in 70% ethanol or Germ-X<sup>®</sup> hand sanitizer (63% ethanol) through the eyepiece of a LeicaMZ 16 stereomicroscope using a Samsung Galaxy SIII smartphone; some photos were focus stacked using Helicon Focus Pro 6 (Helicon Soft Ltd.). Illustrations were done with Adobe Illustrator (San Jose, California, USA).

## **Results**

Over 1,000 millipede specimens from over 300 collection events were examined over the course of this study. New state records are reported for *Ophiulus pilosus* (Washington Co.), *Cylindroiulus* (Washington Co.), and *Ptyoiulus coveanus* (Greene Co.). New county records are reported for *Polyxenus lagurus* (Conway, Garland, Logan, Montgomery, Newton, Polk, Pope, Scott, Sebastian, Stone, Washington), *Petaserpes bikermani* (Newton), *Tiganogona alia*

(Conway, Logan), *Tiganogona glebosa* (Conway, Newton), *Tiganogona moesta* (Polk), *Trichopetalum unicum* (Newton), *Abacion tessellatum* (Newton), *Abacion texense* (Howard, Newton), *Brachyiulus lusitanus* (Washington), *Aliulus carrollus* (Newton), *Oxidus gracilis* (Benton, Carroll, Ouachita, Washington), *Desmonus pudicus* (Logan, Scott), *Scytonotus granulatus* (Polk), *Pseudopolydesmus pinetorum* (Madison, Newton), *Boraria profuga* (Garland), and *Eurymerodesmus oliphantus* (Conway, Stone). A key to all of the millipedes known from Arkansas is presented, with a glossary defining some millipede-specific terms. This is followed by species accounts with identification notes, ecological notes, and other information. Included are 107 illustrations of the gonopods and photographs of the species. For those species which are unidentifiable from photographs, a representative photograph for the family or genus is provided.

### **Key to Arkansas Millipede Species:**

This key includes the 66 species of millipedes currently known to occur in Arkansas, and also includes couplets for the genera *Cylindroiulus* and *Polydesmus*, both introduced to the United States from Europe. The species from those two genera that occur in Arkansas are unknown, so their couplets stop at genus, instead of species. The key includes many widespread families of millipedes in the eastern United States, and as such, can be used to the family level for the eastern U.S. It is important to note, however, that the key does not encompass every family found in the eastern U.S., and so will be incomplete once it is used outside of Arkansas. The characters in the key are based on Arkansas's representatives of each taxon, and may not be applicable in other areas of North America where different species occur.

The key is intended to be used with adult male millipedes, as millipede species identification is based on the gonopods, which are modified 8th (sometimes 8th and 9th) leg

pairs of males (species in the order Polyxenida lack gonopods). Adult female and juvenile millipedes may be identified to family or genus level with the key, but adult males are usually necessary for positive species identification. Illustrations of somatic features and gonopods are given within the key, while photographs are included in the Species Accounts section. A glossary of terms is provided after the key for reference. Terminology, particularly of gonopods, across millipede taxa is not always the same, so the terminology used in the key follows that of the literature for the group, with deference to revisionary studies.

The list of species included in the key is given in Table 1, in the order they appear.

<b>Order</b>	<b>Family</b>	<b><i>Genus and species</i></b>
Polyxenida	Polyxenidae	<i>Polyxenus lagurus</i>
Polyzoniida	Polyzoniidae	<i>Petaserpes bikermani</i>
Platydesmida	Andrognathidae	<i>Brachycybe lecontii</i>
Chordeumatida	Branneriidae	<i>Branneria bonoculus</i>
Chordeumatida	Tingupidae	<i>Tingupa pallida</i>
Chordeumatida	Cleidogonidae	<i>Cleidogona arkansana</i>
Chordeumatida	Cleidogonidae	<i>Cleidogona laminata</i>
Chordeumatida	Cleidogonidae	<i>Tiganogona alia</i>
Chordeumatida	Cleidogonidae	<i>Tiganogona glebosa</i>
Chordeumatida	Cleidogonidae	<i>Tiganogona steuartae</i>
Chordeumatida	Cleidogonidae	<i>Tiganogona moesta</i>
Chordeumatida	Cleidogonidae	<i>Tiganogona ladymani</i>
Chordeumatida	Trichopetalidae	<i>Trichopetalum uncum</i>
Chordeumatida	Trichopetalidae	<i>Trigenotyla parca</i>
Chordeumatida	Trichopetalidae	<i>Causeyella dendropus</i>
Chordeumatida	Trichopetalidae	<i>Causeyella youngsteadtorum</i>
Chordeumatida	Trichopetalidae	<i>Causeyella causeyae</i>
Callipodida	Abacionidae	<i>Abacion tessellatum</i>
Callipodida	Abacionidae	<i>Abacion texense</i>
Spirostreptida	Cambalidae	<i>Cambala minor</i>
Spirobolida	Spirobolidae	<i>Narceus americanus</i>
Julida	Julidae	<i>Ophiulus pilosus</i>
Julida	Julidae	<i>Cylindroiulus</i>
Julida	Julidae	<i>Brachyiulus pusillus</i>
Julida	Julidae	<i>Brachyiulus lusitanus</i>

Julida	Blaniulidae	<i>Virgoiulus minutus</i>
Julida	Parajulidae	<i>Ptyoiulus coveanus</i>
Julida	Parajulidae	<i>Oriulus venustus</i>
Julida	Parajulidae	<i>Okliulus carpenteri</i>
Julida	Parajulidae	<i>Aniulus (Hakiulus) diversifrons diversifrons</i>
Julida	Parajulidae	<i>Aniulus (Hakiulus) amophor</i>
Julida	Parajulidae	<i>Ethojulus illinoensis</i>
Julida	Parajulidae	<i>Aliulus caddoensis</i>
Julida	Parajulidae	<i>Aliulus carrollus</i>
Polydesmida	Paradoxosomatidae	<i>Oxidus gracilis</i>
Polydesmida	Sphaeriodesmidae	<i>Desmonus pudicus</i>
Polydesmida	Euryuridae	<i>Euryurus leachii</i>
Polydesmida	Euryuridae	<i>Auturus evides</i>
Polydesmida	Euryuridae	<i>Auturus louisianus louisianus</i>
Polydesmida	Trichopolydesmidae	<i>Chaetaspis albus</i>
Polydesmida	Trichopolydesmidae	<i>Chaetaspis attenuatus</i>
Polydesmida	Polydesmidae	<i>Scytonotus granulatus</i>
Polydesmidae	Polydesmidae	<i>Polydesmus</i>
Polydesmida	Polydesmidae	<i>Pseudopolydesmus pinetorum</i>
Polydesmida	Polydesmidae	<i>Pseudopolydesmus minor</i>
Polydesmida	Polydesmidae	<i>Pseudopolydesmus serratus</i>
Polydesmida	Xystodesmidae	<i>Mimuloria castanea</i>
Polydesmida	Xystodesmidae	<i>Mimuloria davidcauseyi</i>
Polydesmida	Xystodesmidae	<i>Apheloria virginiensis reducta</i>
Polydesmida	Xystodesmidae	<i>Pachydesmus clarus</i>
Polydesmida	Xystodesmidae	<i>Thrinaxoria lampra</i>
Polydesmida	Xystodesmidae	<i>Pleuroloma flavipes</i>
Polydesmida	Xystodesmidae	<i>Boraria profuga</i>
Polydesmida	Eurymerodesmidae	<i>Eurymerodesmus goodi</i>
Polydesmida	Eurymerodesmidae	<i>Eurymerodesmus angularis</i>
Polydesmida	Eurymerodesmidae	<i>Eurymerodesmus varius louisianae</i>
Polydesmida	Eurymerodesmidae	<i>Eurymerodesmus compressus</i>
Polydesmida	Eurymerodesmidae	<i>Eurymerodesmus newtonus</i>
Polydesmida	Eurymerodesmidae	<i>Eurymerodesmus serratus</i>
Polydesmida	Eurymerodesmidae	<i>Eurymerodesmus pulaski</i>
Polydesmida	Eurymerodesmidae	<i>Eurymerodesmus polkensis</i>
Polydesmida	Eurymerodesmidae	<i>Eurymerodesmus hispidipes</i>
Polydesmida	Eurymerodesmidae	<i>Eurymerodesmus dubius</i>
Polydesmida	Eurymerodesmidae	<i>Eurymerodesmus mundus</i>
Polydesmida	Eurymerodesmidae	<i>Eurymerodesmus birdi birdi</i>

**Table 1. List of Millipedes Reported from Arkansas**

This key uses characters particular to the Arkansas millipede fauna and builds upon characters used in previous millipede keys, such as Hoffman (1990) and Shear (1999).

Characters for the Eurymerodesmidae are primarily adapted from Shelley (1990), which contains many more illustrations and information, and is available online from the Biodiversity Heritage Library. Further identification information for each species can be found in the sources listed in each species account.

**1a.** Body soft, with a non-calcified exoskeleton; head and tergites with rows of setae, tergites with lateral tufts of setae, and with two large posterior tufts of white setae; adults with 11 body segments and 13 pairs of legs; 2-4 millimeters long and superficially resembling larvae of dermestid beetles.....**Order Polyxenida, Family Polyxenidae, *Polyxenus lagurus*.**

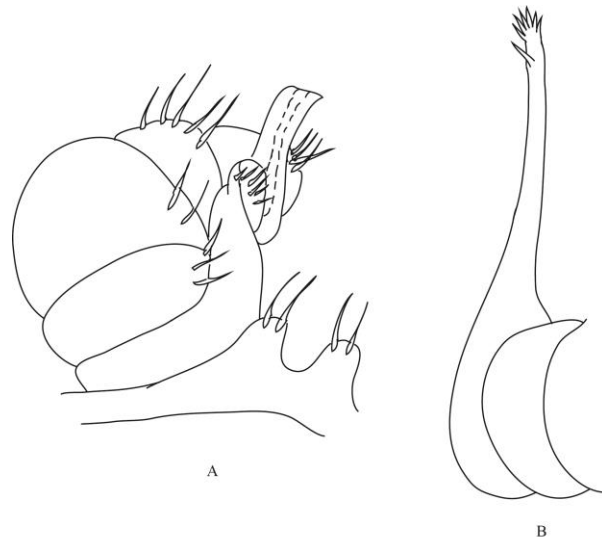
**1b.** Body hard, with a calcified exoskeleton; if setae present, simple, not arranged in tufts; adults with more than 11 body segments and at least 17 pairs of legs; longer than 3 millimeters.....**2.**

**2a.** Head much narrower than width of the body; body conceals legs when viewed from above, giving the millipedes a slug-like appearance; males with 8 pairs of legs in front of the gonopods .....**3.**

**2b.** Head almost as wide as body, at least half the width; legs apparent when viewed from above; males with 7 pairs of legs in front of the gonopods.....**4.**

**3a.** Head triangular; ocelli present; tergites without median longitudinal groove; lacking paranota, body arched; shiny, color dirty-yellow; resembling a terrestrial slug or flatworm;

8 mm-16 mm.....**Order Polyzoniida, Family Polyzoniidae, *Petaserpes bikermani*.**



**Figure 2. *Petaserpes bikermani* gonopods A. left anterior gonopod, anterior view; B. left posterior gonopod, caudal view. Redrawn from Shelley (1997).**

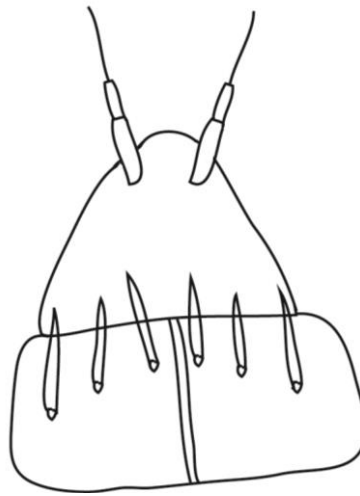
**3b.** Head spherical; ocelli absent; tergites with median longitudinal groove; body with paranota; color pinkish-orange; 15 mm-25 mm long.....

.....**Order Platydesmida, Family Andrognathidae, *Brachycybe lecontii*.**

**4a.** Body of adult with more than 20 segments; with or without ocelli; with or without paranota...  
.....**5.**

**4b.** Body of adult with 19 or 20 segments; without ocelli; with paranota.....  
.....**Order Polydesmida, 37.**

**5a.** Epiproct with a pair of spinnerets (Fig. 2); sternites loosely joined to pleurotergites; ocelli (when present) never in a linear configuration .....**6.**



**Figure 3. Spinnerets on epiproct of Chordeumatida. Redrawn from Shear (1999).**

**5b.** Epiproct without a pair of spinnerets; sternites, pleurites, and tergites joined into a cylindrical ring; ocelli sometimes in a linear configuration.....**22.**

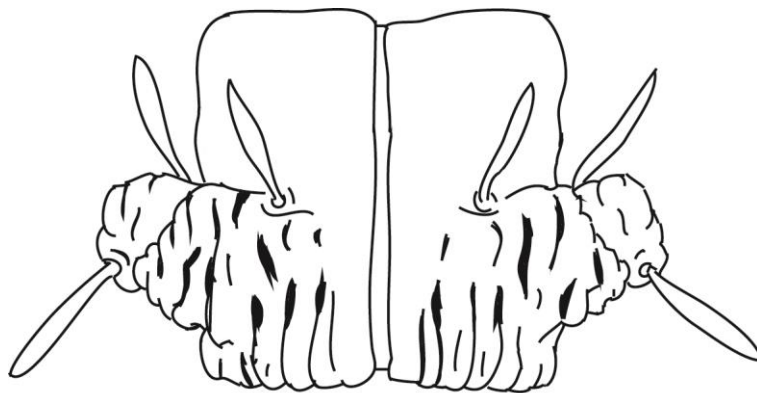
**6a.** Body with 28 or 30 segments; ocelli usually present; tergites without ozopores; with or without paranota; tergites with 6 setae; tergites lacking body crests (but Brannerioidea have rough dorsal sculpturing with small ridges); color white to light brown; body length 4 mm-20 mm.....**Order Chordeumatida, 7.**

**6b.** Body with 40-62 segments; ocelli always present; tergites with ozopores; lacking paranota; tergites with more than 6 setae, setae small and inconspicuous; tergites with conspicuous longitudinal crests; color dark brown; body length 25 mm-50 mm.....  
.....**Order Callipodida, Family Abacionidae, Genus *Abacion*, 20.**

**7a.** Metazonites with paranota present; tergites with rough surface and small longitudinal ridges;  
very small, 4 mm-6 mm long.....**Superfamily Brannerioidea, 8.**

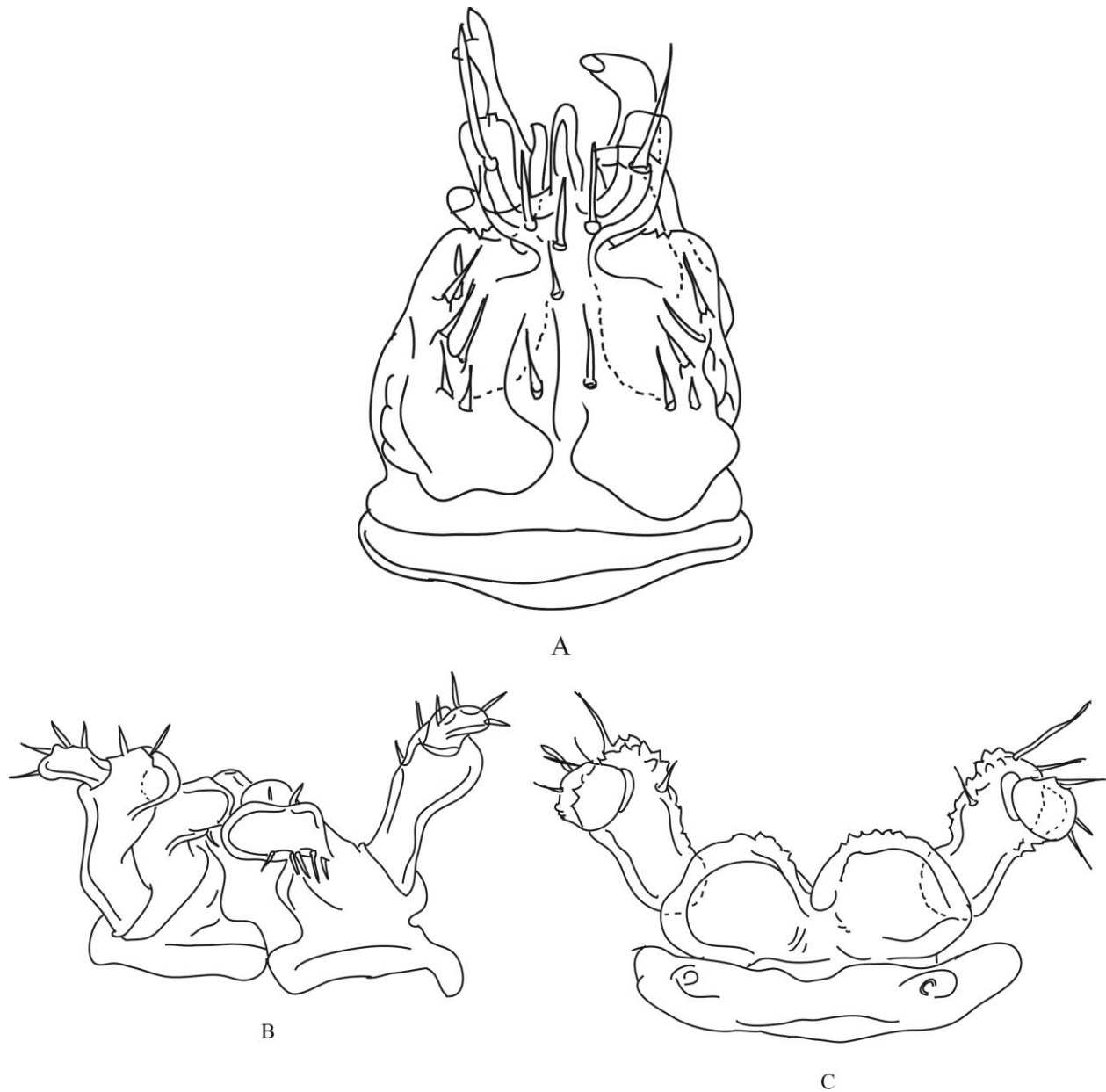
**7b.** Metazonites lacking paranota, but may have large dorsolateral knobs bearing the segmental  
setae; tergites smooth, without ridges or sculpturing; 4 mm-20 mm.....  
.....**Superfamily Cleidogonoidea, 9.**

**8a.** Body with 28 segments; brown in color; longitudinal ridges of metatergites irregular (Fig. 3)  
(but some in a well-defined row along posterior margin) and rounded, larger and fewer than in  
*Tingupa*; segmental setae thicker, ensiform; body length 4.0 mm-4.5 mm.....  
.....**Family Branneriidae, *Branneria bonoculus*.**



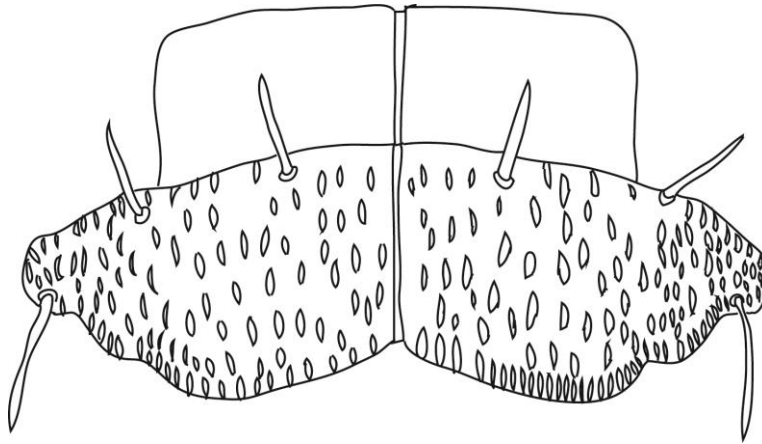
**Figure 4. Body segment of *Branneria carinata*. Redrawn from Shear (1972).**



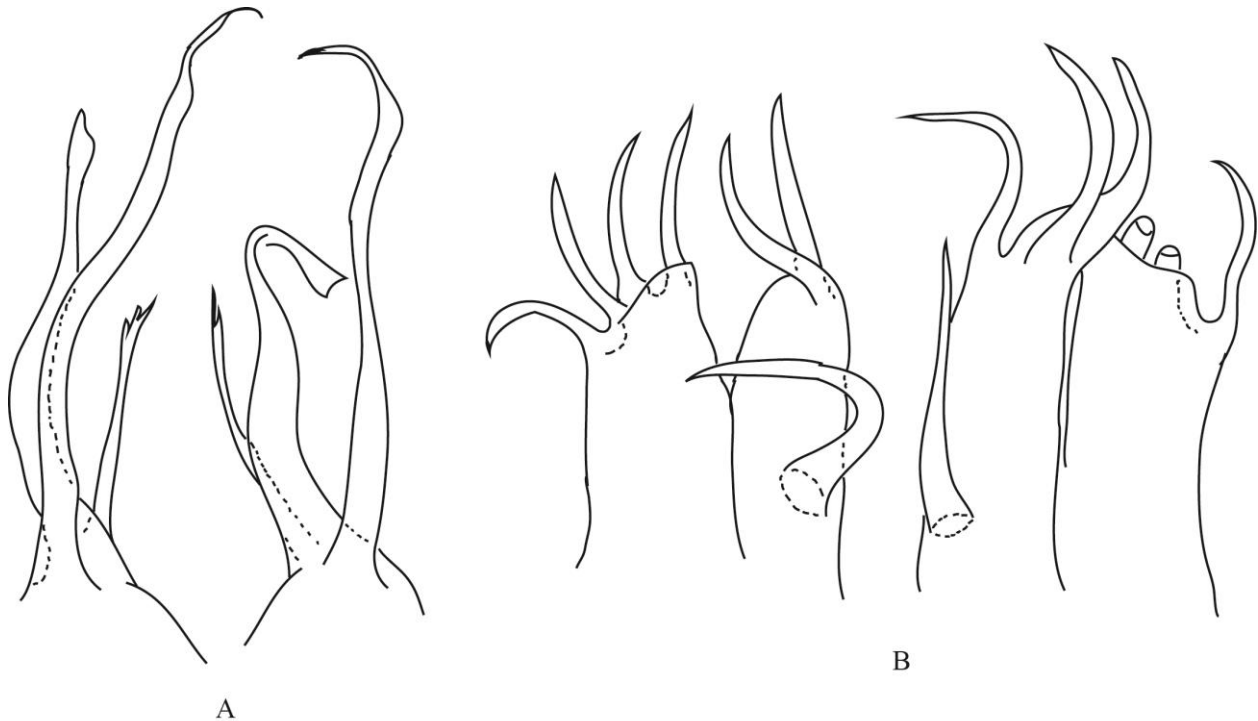


**Figure 5. Gonopods of *Branneria bonoculus*, anterior view. A. Anterior gonopods. B. Posterior gonopods. C. Tenth legpair. Redrawn from Shear (2003).**

**8b.** Body with 30 segments; unpigmented; longitudinal ridges of metatergite acute, unorganized, smaller and more than in *Branneria*; dorsal setae thinner (Fig. 5); 5 mm-6 mm.....  
 .....**Family Tingupidae, *Tingupa pallida*.**



**Figure 6. Body segment of *Tingupa utahensis*. Redrawn from Shear (1972).**



**Figure 7. Gonopods of *Tingupa pallida*. A. Anterior gonopods, posterior view. B. Coxal processes of anterior gonopods, posterior view. Redrawn from Shear (1972).**

**9a.** Body with 30 segments; segmental setae short, less than half the width of the body; ocelli always present; color light brown, usually with a pair of white spots beside the median longitudinal groove of the tergites and a white spot laterally on each side; 16 mm-20 mm

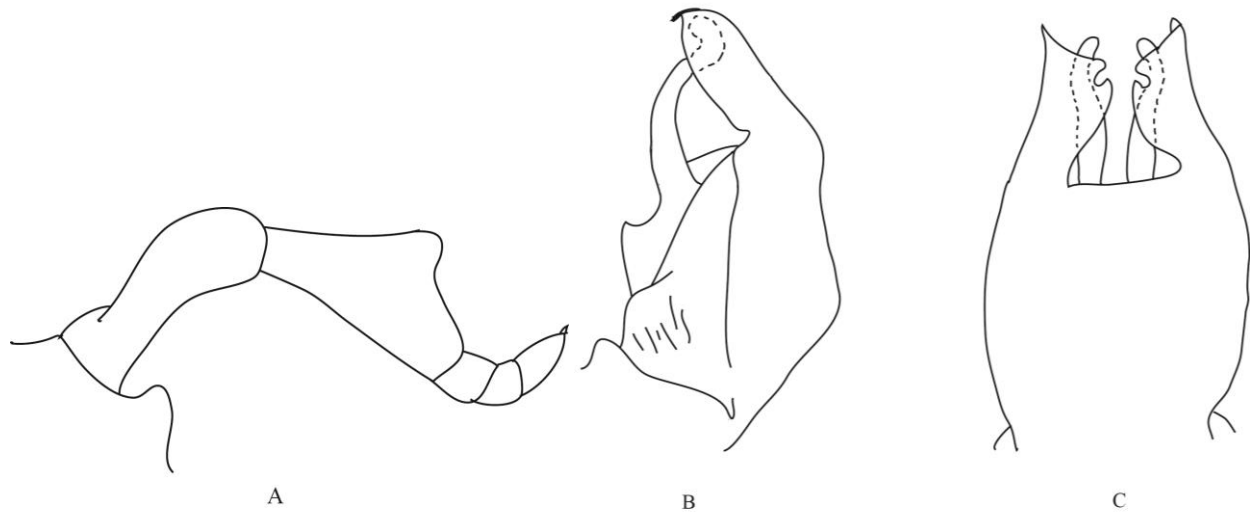
long.....**Family Cleidogonidae, 10.**

**9b.** Body with 28 or 30 segments; segmental setae long, at least half the width of the body, sometimes with a sticky droplet of liquid at base; ocelli present or absent; unpigmented or light brown; 4 mm-13 mm long.....**Family Trichopetalidae, 16.**

**10a.** Posterior gonopod coxae weakly lobed, not interlocking with anterior gonopods; telopodite of posterior gonopods 4-segmented; posterior gonopod sternum lacking a knob.....  
.....**Genus *Cleidogona*, 11.**

**10b.** Posterior gonopod coxae strongly lobed, interlocking with the anterior gonopods; telopodite of posterior gonopods 1-segmented to 3-segmented; posterior gonopod sternum with a knob.....  
.....**Genus *Tiganogona*, 12.**

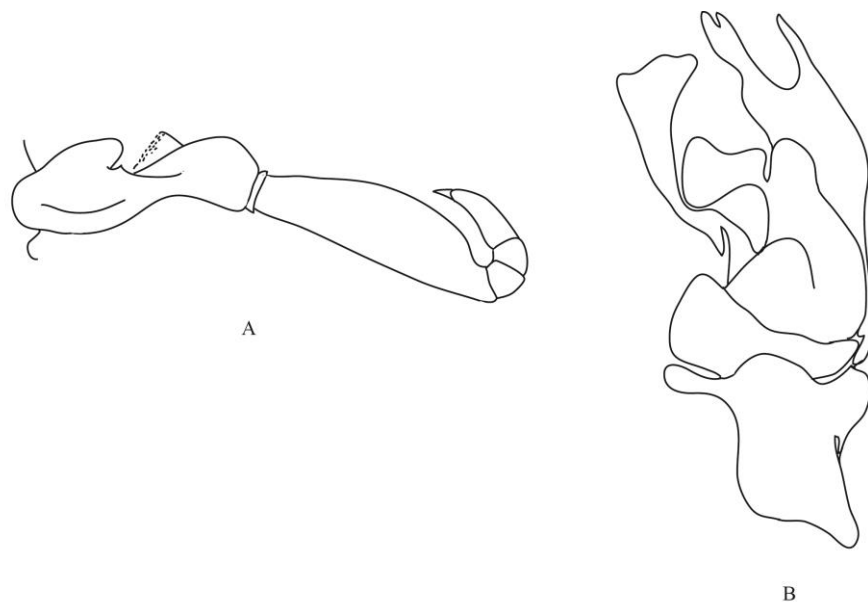
**11a.** (Fig. 7) Colpocoxite of anterior gonopod undivided and slightly curving; coxa of posterior gonopod with only a slight lobe and notch; inner margin of femur of posterior gonopod modified with a protruding notch.....***Cleidogona arkansana*.**



**Figure 8. *Cleidogona arkansana* gonopods. A. Posterior gonopod B. Left anterior gonopod, lateral view. C. Anterior gonopods, ventral view. Redrawn from Causey (1954).**

**11b.** (Fig. 8) Colpocoxite of anterior gonopod divided; coxa of posterior gonopod with a larger lobe and deep notch; inner margin of femur of posterior gonopod smooth, unmodified.....

.....*Cleidogona laminata*.

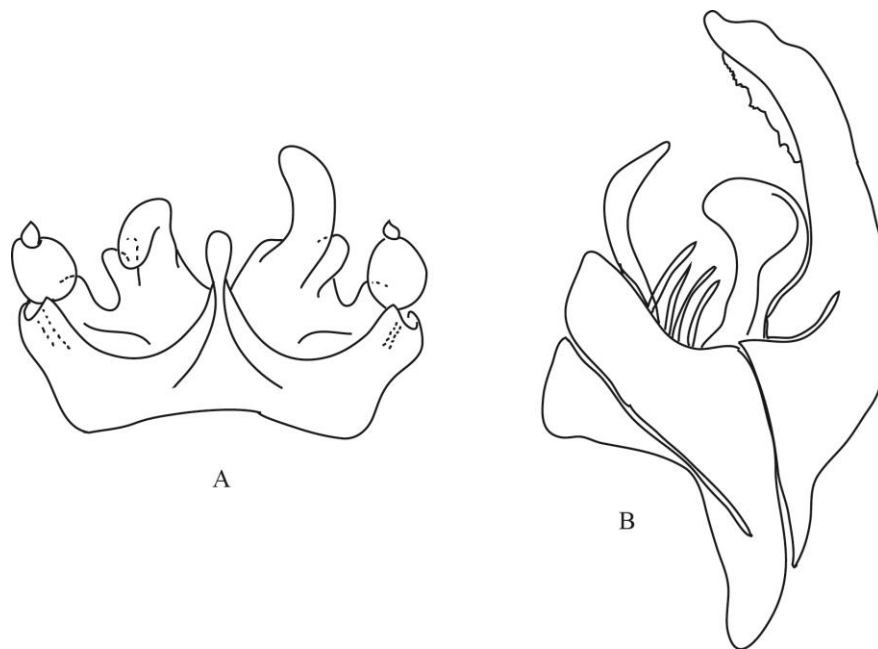


**Figure 9. Gonopods of *Cleidogona laminata*. A. Posterior gonopod. B. Left anterior gonopod, anterior view. Redrawn from Shear (1972).**

**12a.** Telopodite of posterior gonopod consisting of only 1 segment with a small claw (may not look very claw-like).....**13.**

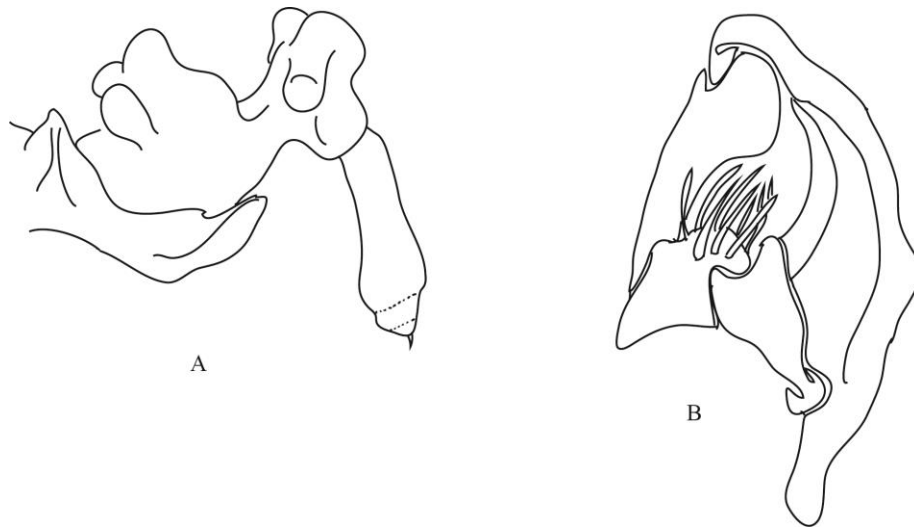
**12b.** Telopodite of posterior gonopod consisting of more than one segment.....**14.**

**13a.** Telopodite of posterior gonopod short and spherical (Fig. 9).....*Tiganogona alia*.



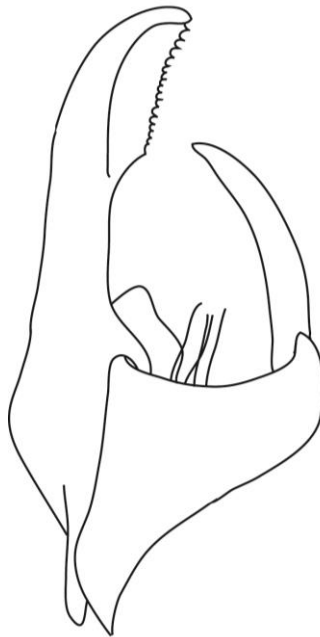
**Figure 10. Gonopods of *Tiganogona alia*. A. Posterior gonopods. B. Left anterior gonopod, lateral view. Redrawn from Shear (1972).**

**13b.** Telopodite of posterior gonopod long and thickened; telopodite with two distal sutures, making it appear to be 3 segments (Fig. 10).....*Tiganogona glebosa*.



**Figure 11. Gonopods of *Tiganogona glebosa*. A. Posterior gonopods. B. Left gonopod, lateral view. Redrawn from Shear (1972).**

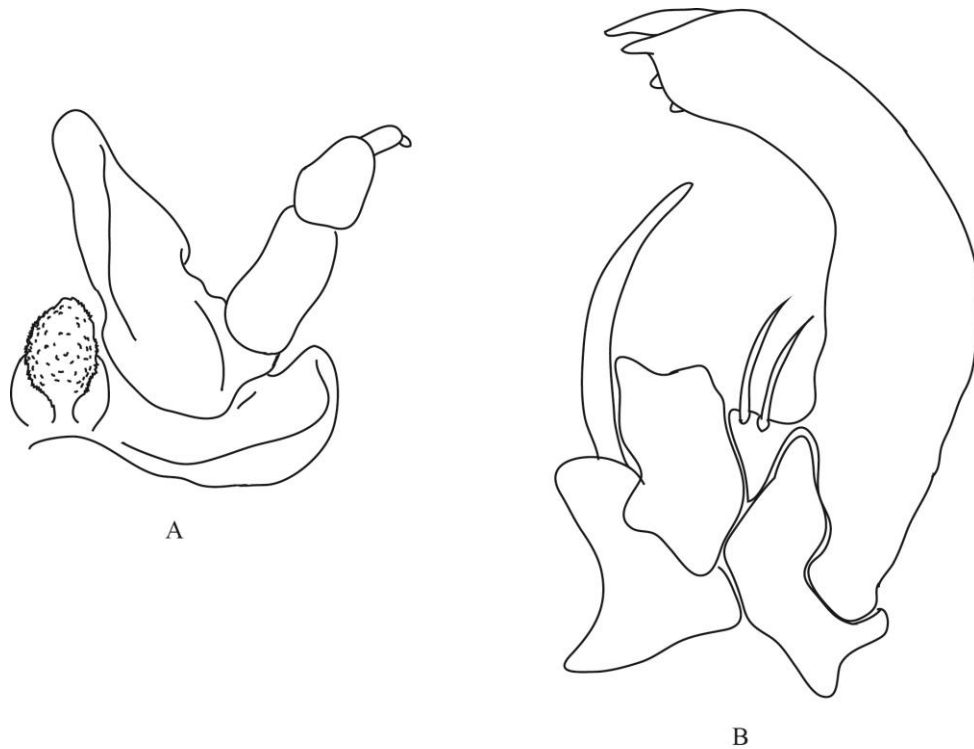
**14a.** Telopodite of posterior gonopod consisting of 2 segments.....*Tiganogona steuartae*.



**Figure 12. Lateral view of left anterior gonopod of *Tiganogona steuartae*. Redrawn from Causey (1951c).**

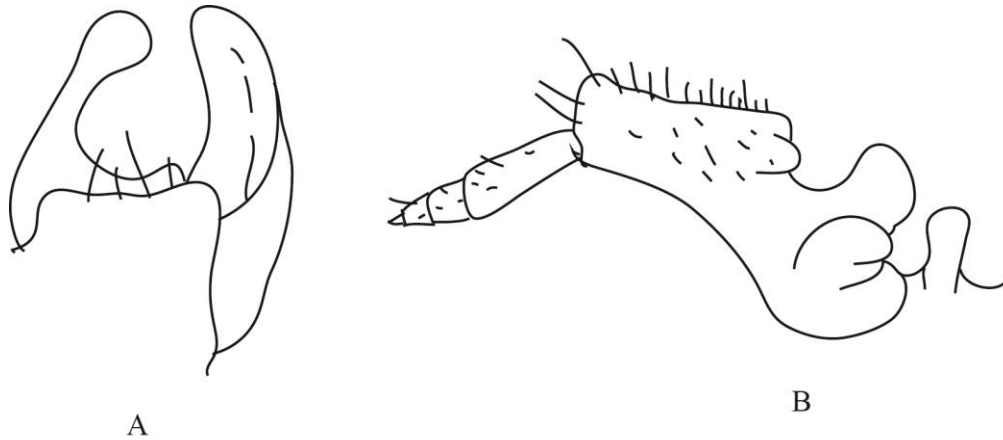
**14b.** Telopodite of posterior gonopod consisting of 3 segments.....**15.**

**15a.** Coxae of posterior gonopods with large triangular lobe projecting mesally (Fig. 12).....  
.....*Tiganogona moesta*.



**Figure 13. Gonopods of *Tiganogona moesta*. A. Posterior gonopods B. Left anterior gonopod, lateral view. Redrawn from Shear (1972).**

**15b.** Coxae of posterior gonopods with three small, complex lobes (similar to those of  
*Tiganogona glebosa*) (Fig. 13).....*Tiganogona ladymani*.



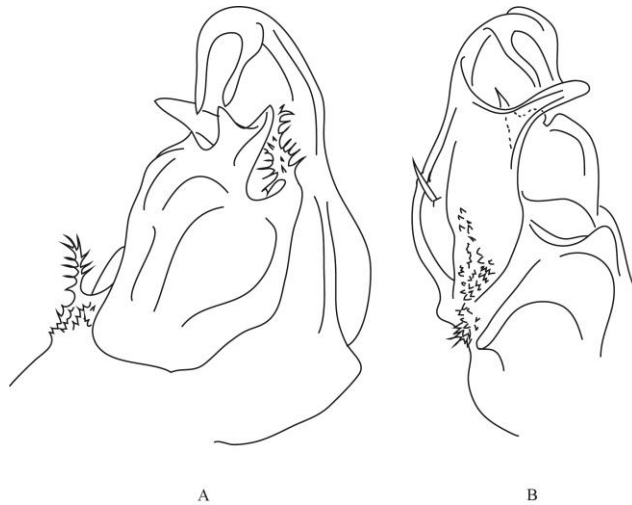
**Figure 14. Gonopods of *Tiganogona ladymani*. A. Right anterior gonopod, lateral view. B. Left posterior gonopod, cephalic view. Redrawn from Causey (1952a).**

**16a.** Body with 28 or 30 segments; length 4 mm-7 mm; ocelli present; color white or light brown; found in caves and epigean areas.....**17.**

**16b.** Body with 30 segments; length 12 mm-13 mm; ocelli absent; unpigmented, appearing white or yellow; only found in caves..... **Genus *Causeyella*, 18.**

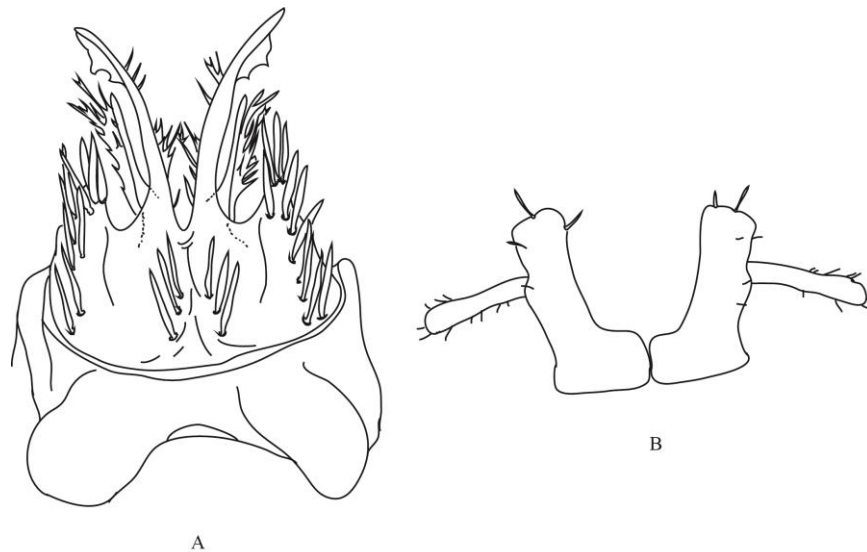
**17a.** Body with 28 segments; length 4 mm-7 mm; unpigmented or light brown; gonopod with angiocoxite strongly curved posteriorly and apically cleft, with lateral branch; anterior faces of the gonopod coxae covered with tiny trichomes (Fig. 14).....***Trichopetalum unicum*.**





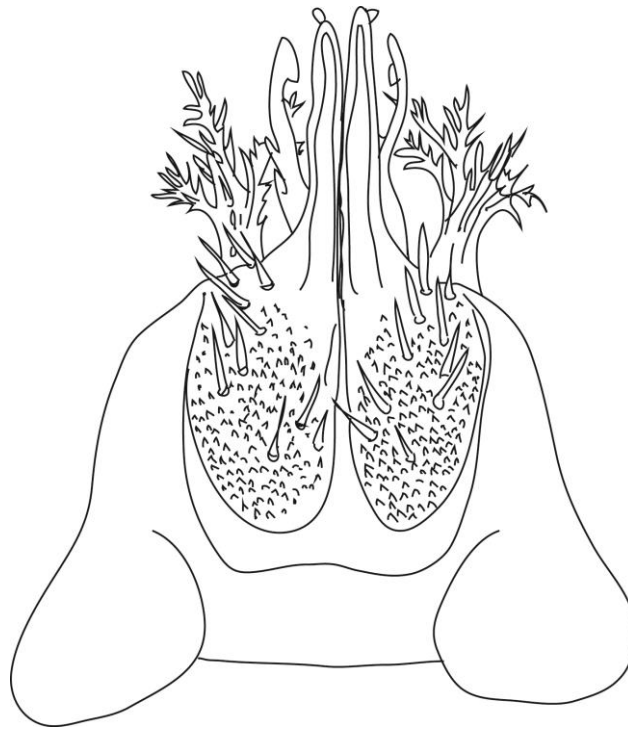
**Figure 15. Right gonopods of *Trichopetalum uncum*. A. Mesal view. B. Lateral view. Redrawn from Shear (2010).**

**17b.** Body with 30 segments; length 6 mm-7 mm; color light brown to slightly purple; gonopod with angiocoxite straight and needle-like, lacking a lateral branch; anterior faces of the gonopod coxae without tiny trichomes (Fig. 15).....*Trigenotyla parca*.



**Figure 16. Gonopods of *Trigenotyla parca*. A. Anterior gonopods, anterior view. B. Posterior gonopods, anterior view. Redrawn from Shear (2003).**

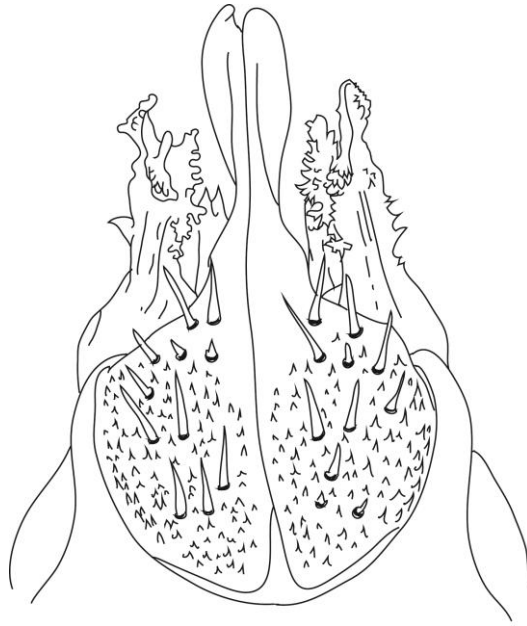
**18a.** Colpocoxite branches of anterior gonopod ending in spiky, hair-like projections; mesal coxite slightly longer than ectal coxite; about 10 setae on each gonopod coxa (Fig. 16).....  
 .....*Causeyella dendropus*.



**Figure 17. Gonopods of *Causeyella dendropus*, anterior view. Redrawn from Shear (2003).**

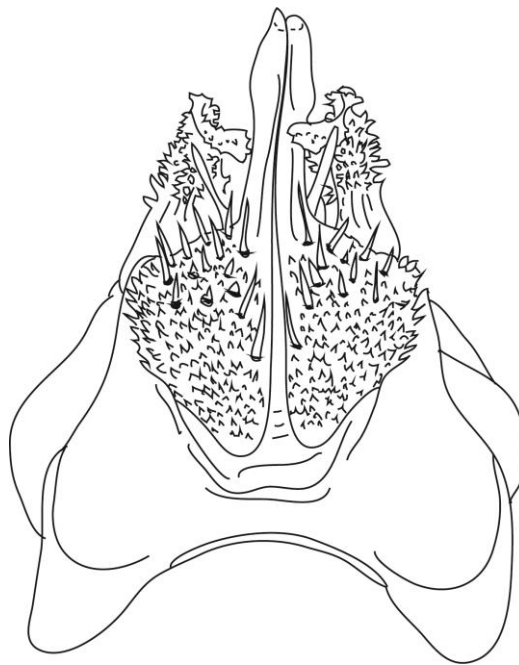
**18b.** Colpocoxite branches of anterior gonopod flattened, with bumps; mesal coxite at least twice as long as ectal coxite; about 15 setae on each gonopod coxa.....**19.**

**19a.** Mesal coxite spatulate in anterior view; ectal coxites less than half as long as mesal coxites, with subequal apical teeth (Fig. 17).....*Causeyella youngsteadtorum*.



**Figure 18. Gonopods of *Causeyella youngsteadtorum*, anterior view. Redrawn from Shear (2003).**

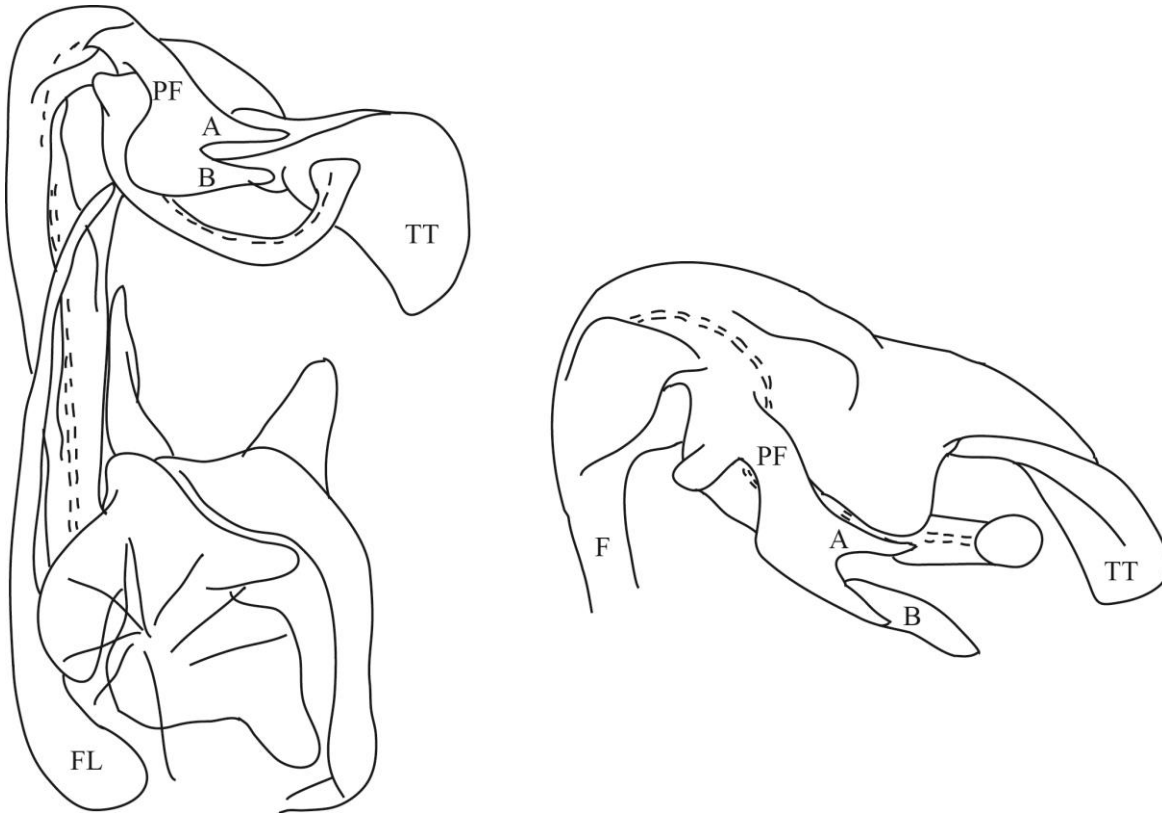
**19b.** Mesal coxite not very spatulate in anterior view; ectal coxites half as long as mesal coxites (Fig. 18).....*Causeyella causeyae*.



**Figure 19. Gonopods of *Causeyella causeyae*, anterior view. Redrawn from Shear (2003).**

20a. Apex of tibiotarsus strongly curved medially.....21.

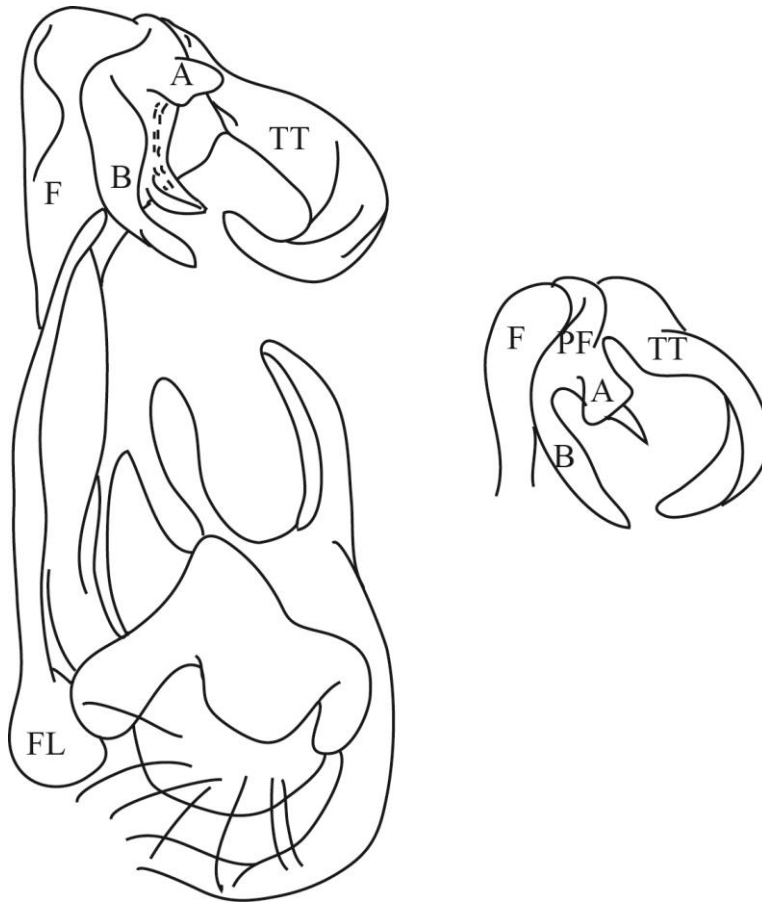
20b. Apex of tibiotarsus only weakly curved medially (Fig. 19).....*Abacion tessellatum*.



**Figure 20. Gonopod of *Abacion tessellatum*. FL=flagellum, PF=postfemur, F=femur, A=proximal branch of postfemur, B=distal branch of postfemur, TT=tibiotarsus. Redrawn from Shelley (1984).**

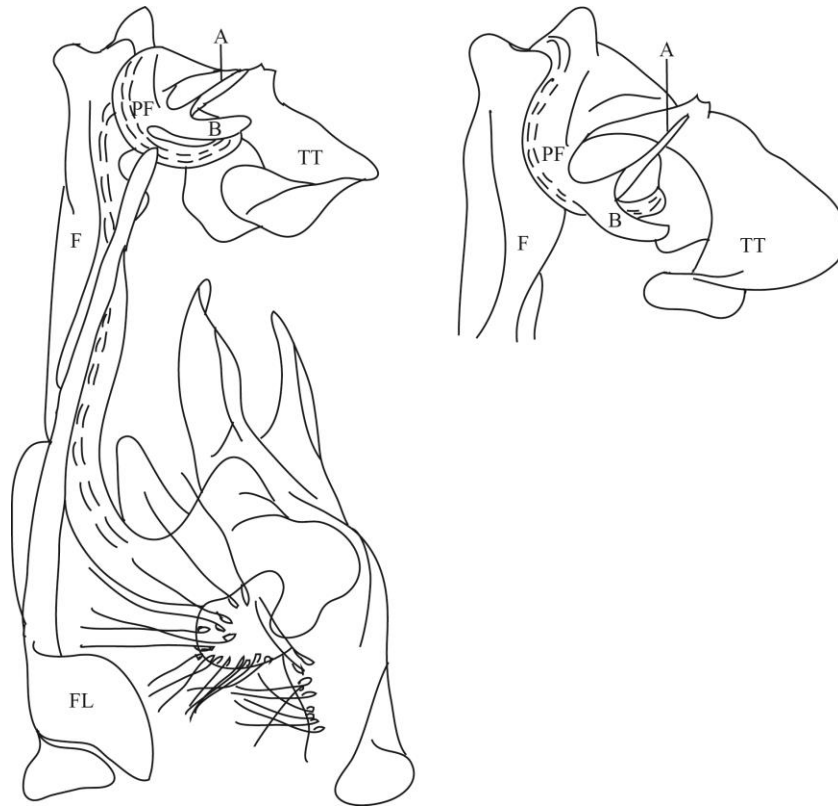
21a. Tibiotarsus tapering to a point; proximal branch of postfemur apically blunt (Fig. 20).....

.....*Abacion texense*.



**Figure 21. Gonopod of *Abacion texense*. FL=flagellum, PF=postfemur, F=femur, A=proximal branch of postfemur, B=distal branch of postfemur, TT=tibiotarsus. Redrawn from Shelley (1984).**

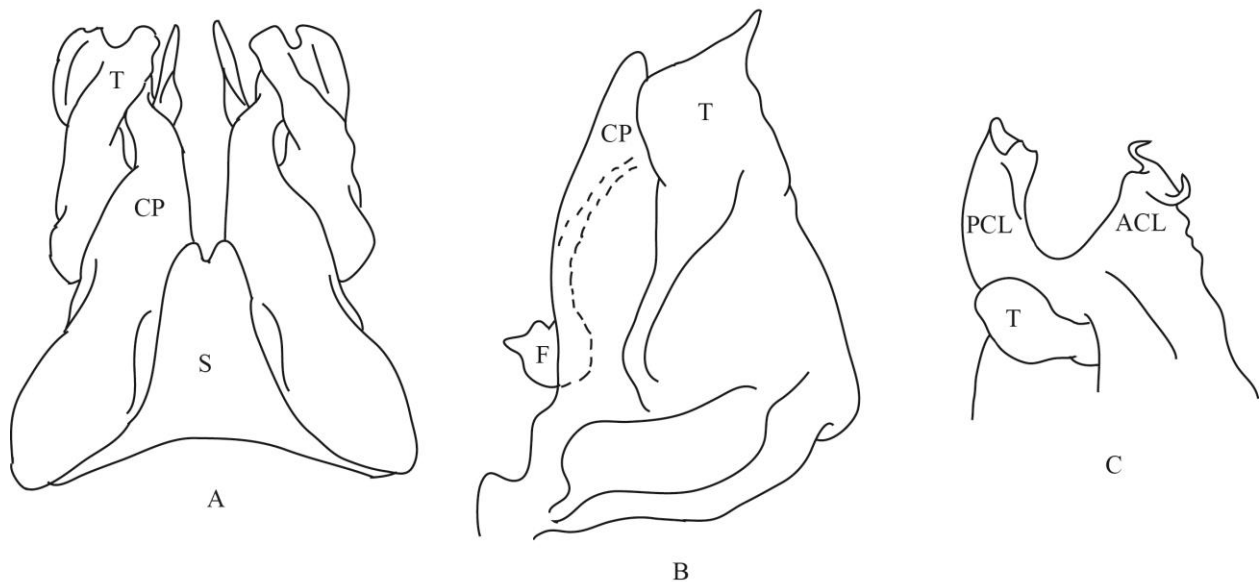
**21b.** Tibiotarsus not tapering to a point; proximal branch of postfemur directed anteriad, tapering to a point (Fig. 21).....*Abacion wilhelminae*.



**Figure 22. Gonopod of *Abacion wilhelminae*. FL=flagellum, PF=postfemur, F=femur, A=proximal branch of postfemur, B=distal branch of postfemur, TT=tibiotarsus. Redrawn from Shelley et al (2003).**

**22a.** Body with longitudinal crests encircling the segments, most prominent dorsally; color light pink with pale brown head; fifth segment with two pairs of legs.....

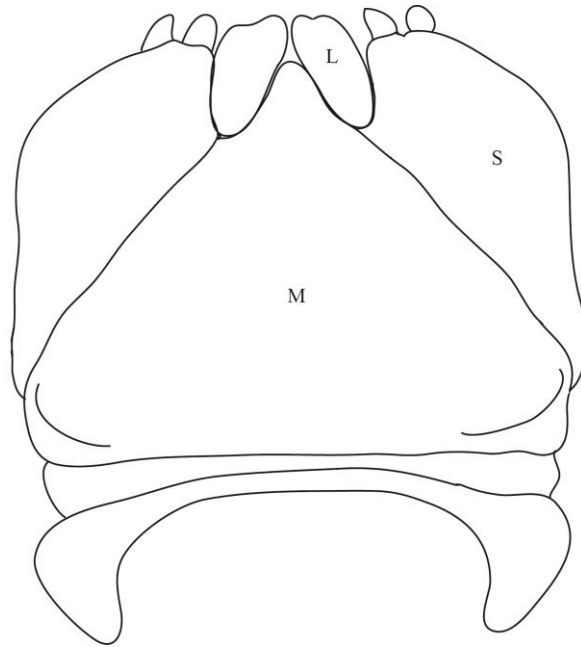
.....**Order Spirostreptida, Family Cambalidae, *Cambala minor*.**



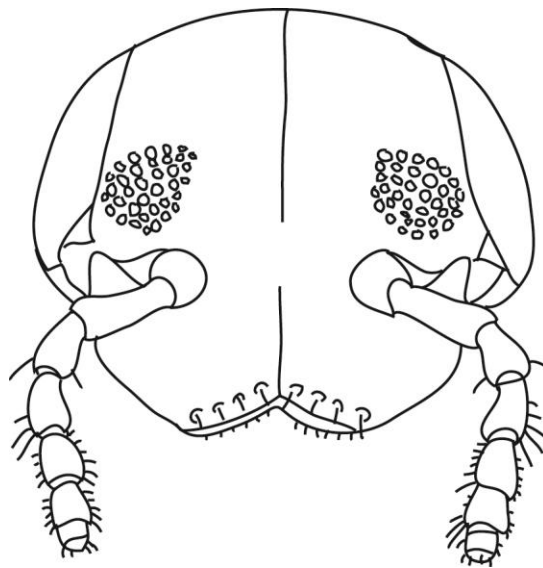
**Figure 23. Gonopods of *Cambala minor*. A. Anterior gonopods, cephalic view. B. Left anterior gonopod, lateral view. C. Left posterior gonopod, lateral view. T=telopodite, CP=coxal plate, S=sternum, F=flagellum, PCL=posterior coxal lobe, ACL=anterior coxal lobe. Redrawn from Shelley (1979).**

**22b.** Body without longitudinal crests; color varies; fifth segment with one or two pairs of legs.....**23.**

**23a.** Body segments dark blue-black anteriorly with an orange-red line posteriorly; reaching lengths up to 120 mm; sidepieces of gnathochilarium separated by the mentum (Fig. 23); median suture on head extending up from labrum (Fig. 24) .....  
.....**Order Spirobolida, Family Spirobolidae, *Narceus americanus/annularis* complex.**

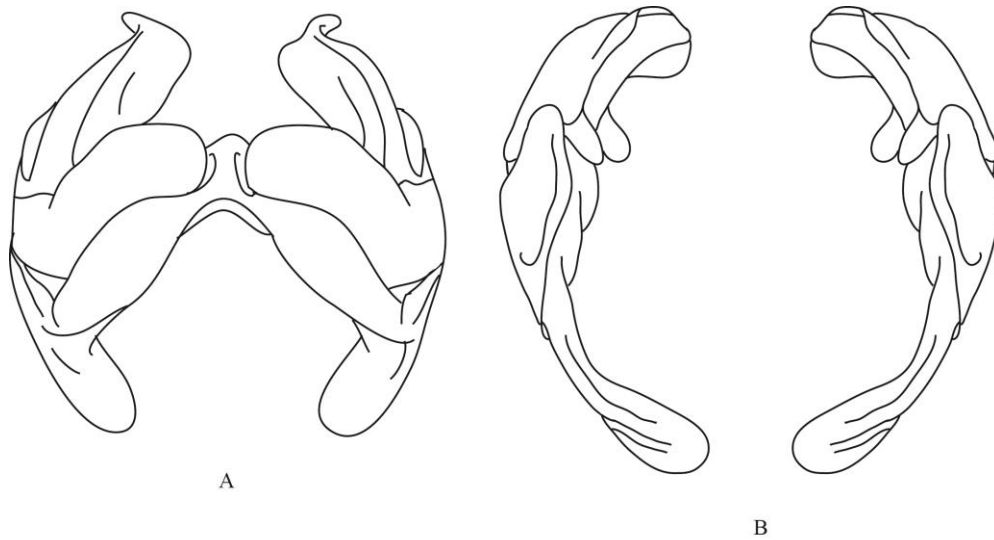


**Figure 24. Spirobolidae gnathochilarium. L=lingual lamella, S=stipe, M=mentum.  
Redrawn from Hoffman (1990).**



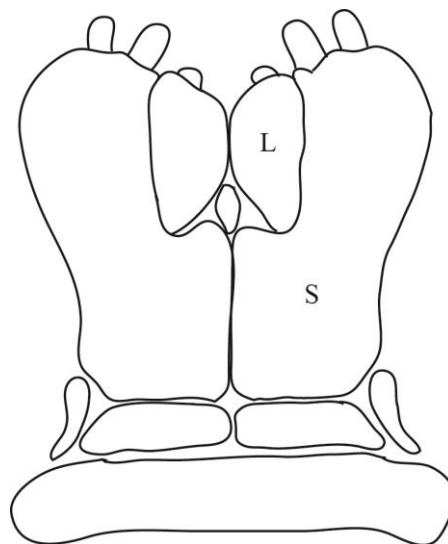
**Figure 25. Head of *Narceus*. Redrawn from Snodgrass (1952).**





**Figure 26. Gonopods of *Narceus americanus-annularis* complex, cephalic view. A. Anterior gonopods. B. Posterior gonopods. Redrawn from Shelley (1978).**

**23b.** Body color varies, but never as in 23a; body length 10 mm-50 mm; sidepieces of gnathochilarium not separated by the mentum (Fig. 26); median suture on head not extending up from labrum.....**Order Julida, 24.**



**Figure 27. Gnathochilarium of Julidae. L=lingual lamella, S=stipe. Redrawn from Hoffman (1990).**

**24a.** Body with longitudinal striations encircling each segment; usually with a caudal projection of the epiproct, but may not be obvious; ocelli present; male first legpair hook-like.....

.....**Family Julidae, 25.**

**24b.** Body with longitudinal striations, but only up to about the level of the ozopores, appearing more as wrinkles; with or without caudal projection of the epiproct; ocelli present or absent; male first legpair huge and modified, or dissimilar to following legs.....**28.**

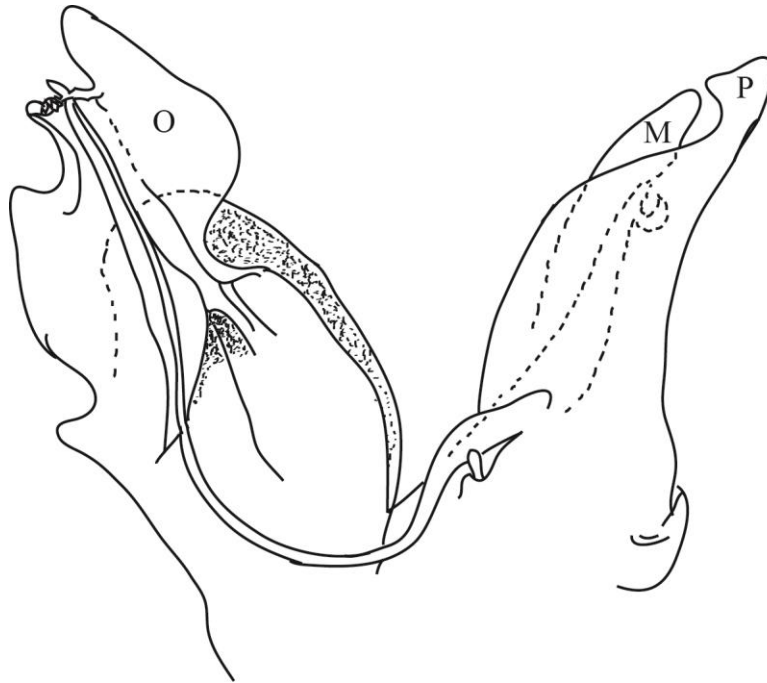
**25a.** Body length 13 mm-30 mm; color mottled brown-black; caudal projection of epiproct obvious and pointed.....***Ophiulus pilosus*.**



**Figure 28. Gonopods of *Ophiulus pilosus*. P=promerite, M=mesomerite, V=velum, O=opisthomerite, PH=phylacum. Redrawn from Blower (1985).**

**25b.** Body length 7 mm-40mm; caudal projection of epiproct (if present) small, non-obvious.....**26.**

**26a.** Body length 20 mm-40mm; color black with brown caudal metazonal stripes; usually without caudal projection of epiproct; usually without setae fringing the metazonites; epiproct and paraprocts with only a few setae; gonopod mesomerite associated with promerite (Fig. 28)....  
.....**Genus *Cylindroiulus*.**

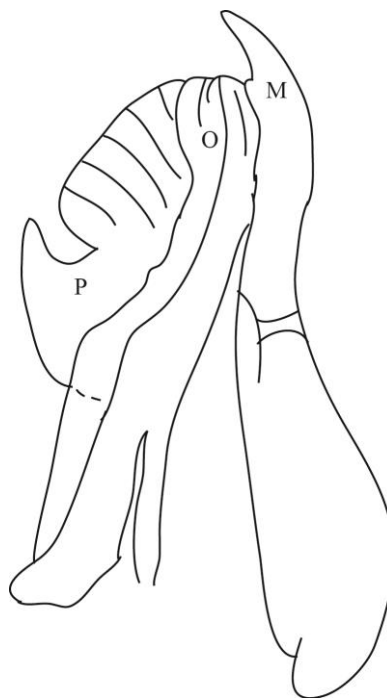


**Figure 29. Gonopods of *Cylindroiulus caeruleocinctus*. P=promerite, M=mesomerite, O=opisthomerite. Redrawn from Blower (1985).**

**26b.** Body length 7 mm-13 mm; color tan brown, with two darker brown longitudinal stripes dorsolaterally; caudal projection of epiproct small, non-obvious; with setae fringing the

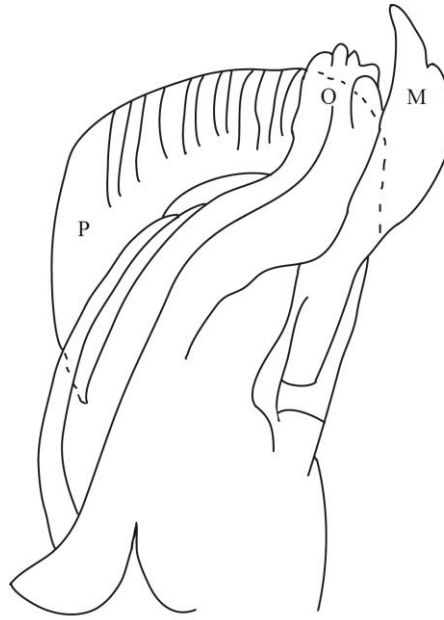
metazonites; epiproct and paraprocts with moderate number of setae; gonopod mesomerite associated with opisthomerite.....**Genus *Brachyiulus*, 27.**

**27a.** (Fig. 29) Phylacum of opisthomerite with 7-8 wrinkled ridges and a distal hook-like notch; opisthomerite itself divided at the tip into two sections with pointed teeth.....  
.....***Brachyiulus pusillus*.**



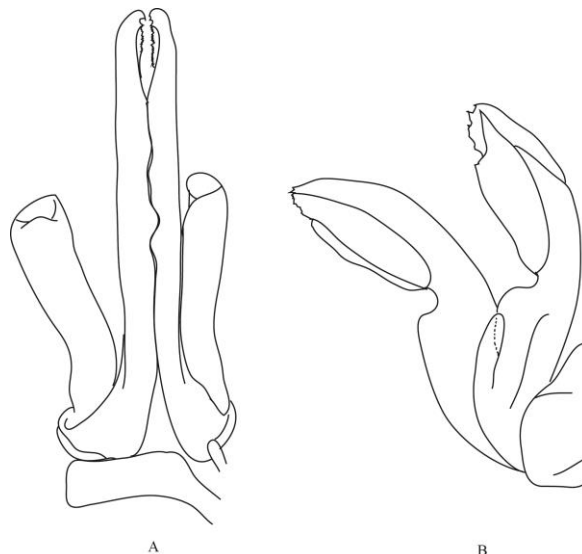
**Figure 30. Gonopods of *Brachyiulus pusillus*. P=promerite, M=mesomerite, O=opisthomerite. Redrawn from Verhoeff (1898).**

**27b.** (Fig. 30) Phylacum of opisthomerite entire, with numerous wrinkled ridges, but ridges not as strong; opisthomerite not divided into two sections, but more serrated...***Brachyiulus lusitanus*.**



**Figure 31. Gonopods of *Brachyiulus lusinatus*. P=promerite, M=mesomerite, O=opisthomerite. Redrawn from Blower (1985).**

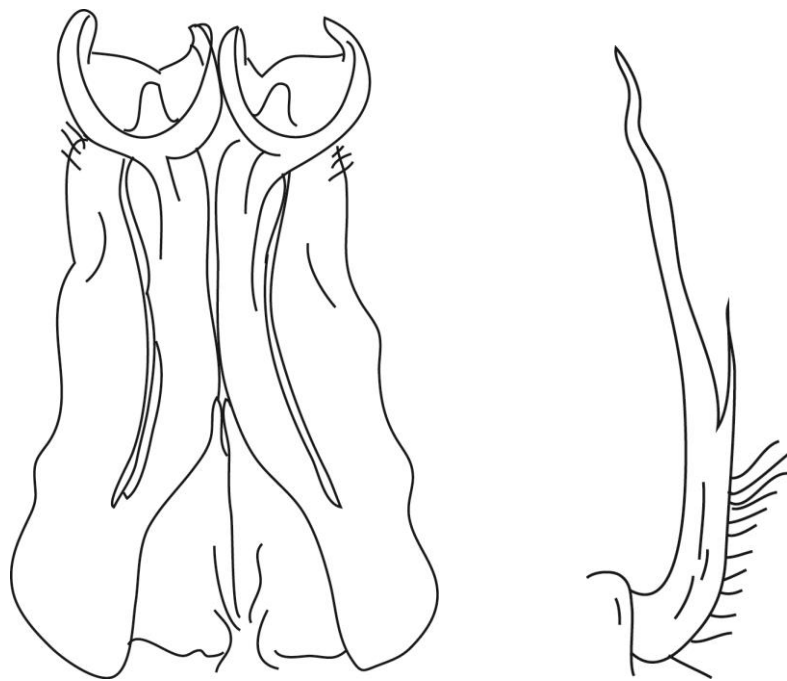
**28a.** Ocelli in a single line, sometimes with two or three additional ocelli in a second line; body length less than 10 mm, width about 1 mm; male first leg pair short and thick, dissimilar to other legs.....**Family Blaniulidae, *Virgoiulus minutus*.**



**Figure 32. Gonopods of *Virgoiulus minutus*. A. Anterior gonopods, anterior view. B. Posterior gonopods, lateral view. Redrawn from Enghoff & Shelley (1979).**

**28b.** Ocelli always present in a triangular arrangement; body length longer than 10 mm, wider than 1 mm; male first legpair very large and distinct.....**Family Parajulidae, 29.**

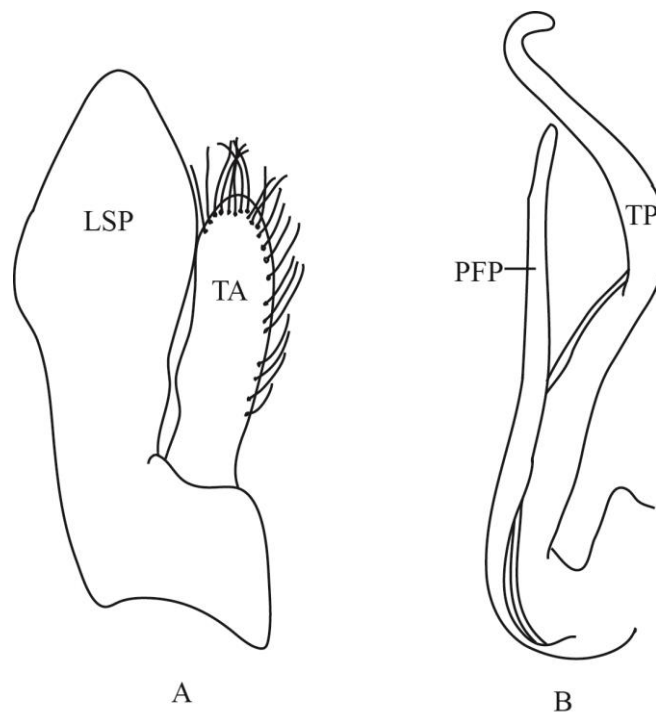
**29a.** Posterior body segments hairy, paraprocts, hypoproct, and epiproct especially with many setae; color deep purple-brown; male anterior gonopods with lateral syncoxal process as long as the telopodite and apically cleft into a cup-like calyx (Fig. 32).....*Ptyoiulus coveanus*.



**Figure 33. *Ptyoiulus coveanus*: (left) anterior gonopods, caudal view; (right) right posterior gonopod, lateral view. Redrawn from Filka & Shelley (1980) and Chamberlin (1943).**

**29b.** Posterior body segments without setae, epiproct with only a few setae; color light tan-orange; male anterior gonopods with lateral syncoxal process short or long, but never apically cleft into a cup-like calyx.....**30.**

**30a.** (Fig. 33) Anterior gonopods without anterior syncoxal lobes, telopodite and lateral syncoxal process same general shape, but lateral syncoxal process larger and expanded medially on both sides; posterior gonopods with thin prefemoral process and telopodite, telopodite curving and only slightly tapering.....*Oriulus venustus*.



**Figure 34. *Oriulus venustus*. A. Left anterior gonopod, lateral view. B. Left posterior gonopod, lateral view. LSP=lateral syncoxal process, TA=anterior gonopod telopodite, PFP=prefemoral process, TP=posterior gonopod telopodite. Redrawn from Shelley (2002b).**

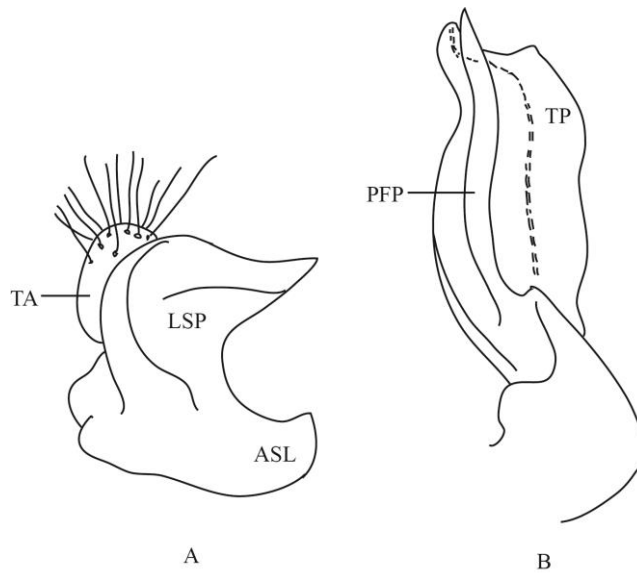
**30b.** Anterior gonopods with anterior syncoxal lobes, telopodite and lateral syncoxal process not as in 30a., various shapes and sizes; posterior gonopods usually with thin prefemoral process, but sometimes modified, telopodite variously modified with or without spurs and curves.....**31.**

**31a.** Anterior gonopods with small, short telopodite and lateral syncoxal process, lateral syncoxal process with an anterior medial extension; anterior syncoxal lobe covering most of the gonopodal cavity anteriorly; posterior gonopod telopodite and prefemoral process not sigmoid in shape; male first legs longer and thinner than in other genera of Parajulidae.....  
.....**Genus *Okliulus*, 32.**

**31b.** Anterior gonopods with telopodite and lateral syncoxal process large, lateral syncoxal process without anterior medial extension; anterior syncoxal lobe varies, not as in *Okliulus*; posterior gonopod telopodite and prefemoral process curved or sigmoid in shape; male first legs enlarged, but slightly shorter and thicker than in *Okliulus*.....**33.**

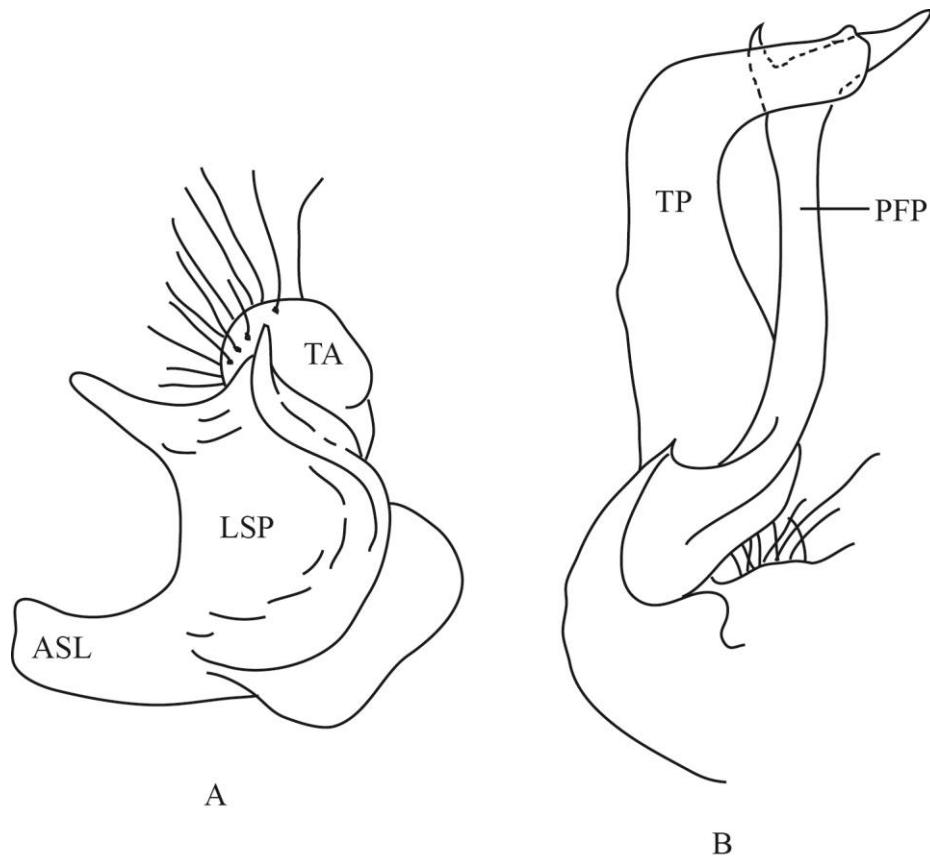
**32a.** (Fig. 34) Posterior gonopods of male with simple prefemoral process, telopodite broad and flat.....***Okliulus beveli*.**





**Figure 35. *Okliulus beveli*. A. Right anterior gonopod, caudal view. B. Right posterior gonopod, lateral view. LSP=lateral syncoxal process, TA=anterior gonopod telopodite, ASL=anterior syncoxal lobe, PFP=prefemoral process, TP=posterior gonopod telopodite. Redrawn from Causey (1953).**

**32b.** (Fig. 35) Posterior gonopods of the male with bifid prefemoral process, telopodite thinner, distally curving at almost a right angle.....*Okliulus carpenteri*.

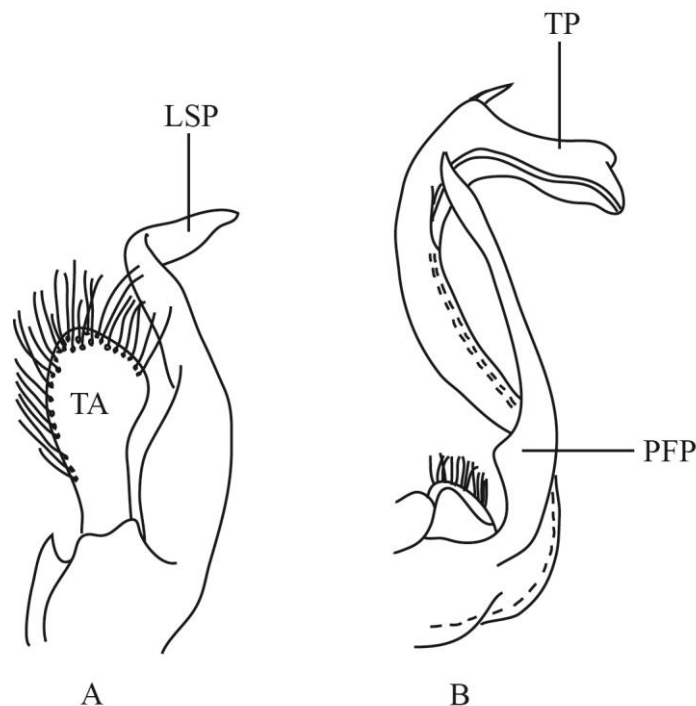


**Figure 36. *Okliulus carpenteri*. A. Left anterior gonopod, caudal view. B. Left posterior gonopod, ectal view. LSP=lateral syncoxal process, TA=anterior gonopod telopodite, ASL=anterior syncoxal lobe, PFP=prefemoral process, TP=posterior gonopod telopodite. Redrawn from Causey (1950a).**

**33a.** Distal part of the telopodite of the posterior gonopods curving at a right angle, or only slightly curved; telopodite with a large distal spur.....**Genus *Aniulus* (*Hakiulus*), 34.**

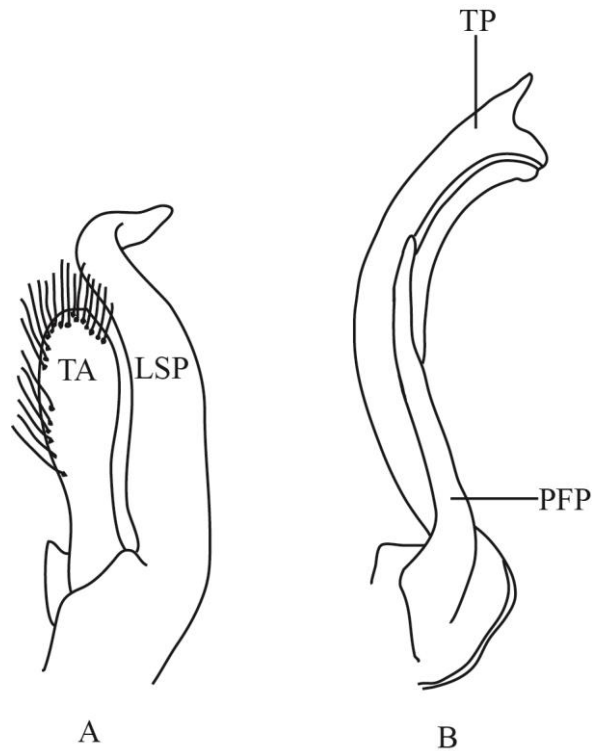
**33b.** Distal part of the telopodite of the posterior gonopods with an apical curve or curving towards the base of the telopodite, but not with as sharp a curve as described in 33a.; lacking a large distal spur on the telopodite, but may have a small subapical spur; telopodite sigmoid in shape.....**35.**

**34a.** (Fig. 36) Distal zone of the telopodite of the posterior gonopods curving at a right angle, with a large distal spur arising near the base of the curve; telopodite with the general shape of a "swan-neck"; prefemoral process slightly expanded apically.....  
 .....*Aniulus (Hakiulus) diversifrons diversifrons*.



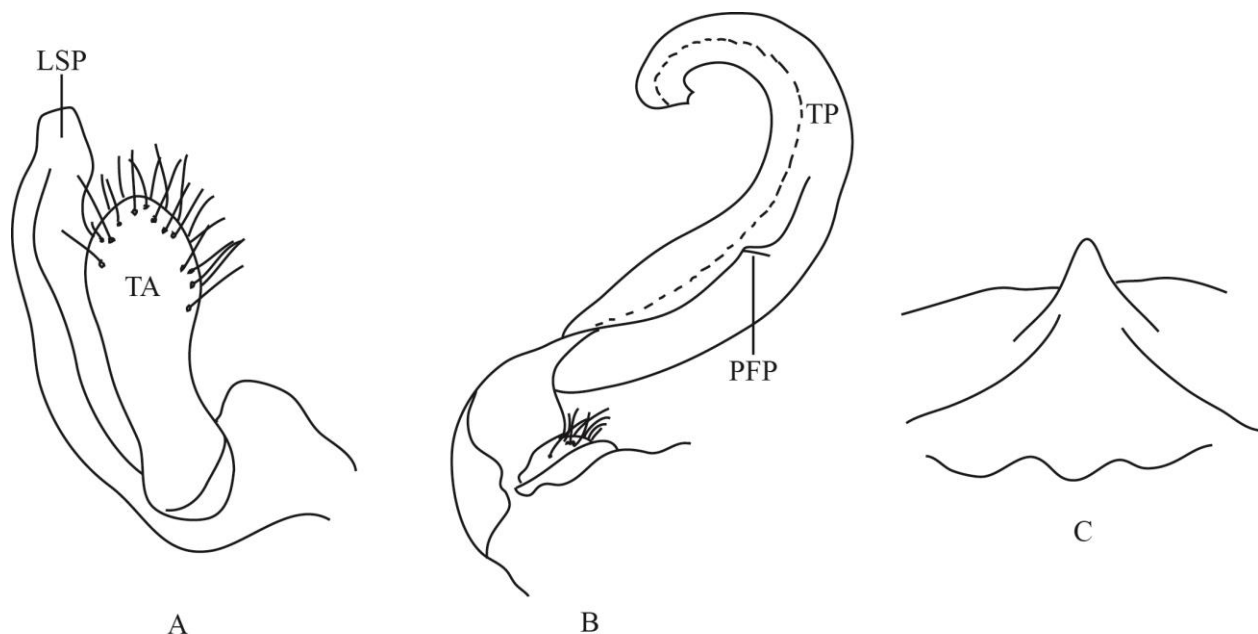
**Figure 37.** *Aniulus (Hakiulus) diversifrons diversifrons*. A. Left anterior gonopod, lateral view. B. Left posterior gonopod, lateral view. LSP=lateral syncoxal process, TA=anterior gonopod telopodite, PFP=prefemoral process, TP=posterior gonopod telopodite. Redrawn from Shelley (2000b).

**34b.** (Fig. 37) Distal zone of the telopodite of the posterior gonopods continuing the general curve of the telopodite; distal zone with a triangular spur subterminally; telopodite without a "swan-neck" shape; prefemoral process not expanded apically.....*Aniulus (Hakiulus) amophor*.



**Figure 38. *Aniulus (Hakiulus) amophor*. A. Left anterior gonopod, lateral view. B. Left posterior gonopod, lateral view. LSP=lateral syncoxal process, TA=anterior gonopod telopodite, PFP=prefemoral process, TP=posterior gonopod telopodite. Redrawn from Shelley (2000b).**

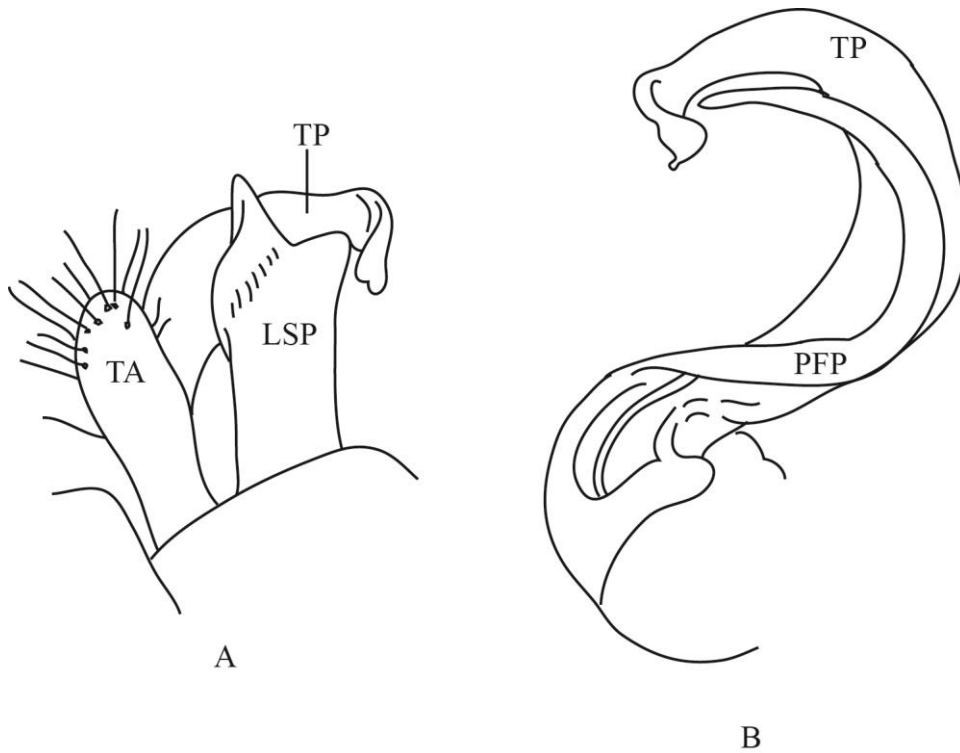
**35a.** (Fig. 38) Anterior gonopods with lateral syncoxal process leaf-like and flattened, slightly concave; telopodite of posterior gonopods without a subapical distal spur; male with sternite of 8th segment produced anteriorly into a pointed process.....*Ethojulus illinoensis*.



**Figure 39. *Ethojulus illinoensis*. A. Left anterior gonopod, ectal view. B. Left posterior gonopod, ectal view. C. Sternite of male 8th segment. LSP=lateral syncoxal process, TA=anterior gonopod telopodite, PFP=prefemoral process, TP=posterior gonopod telopodite. Redrawn from Causey (1950a).**

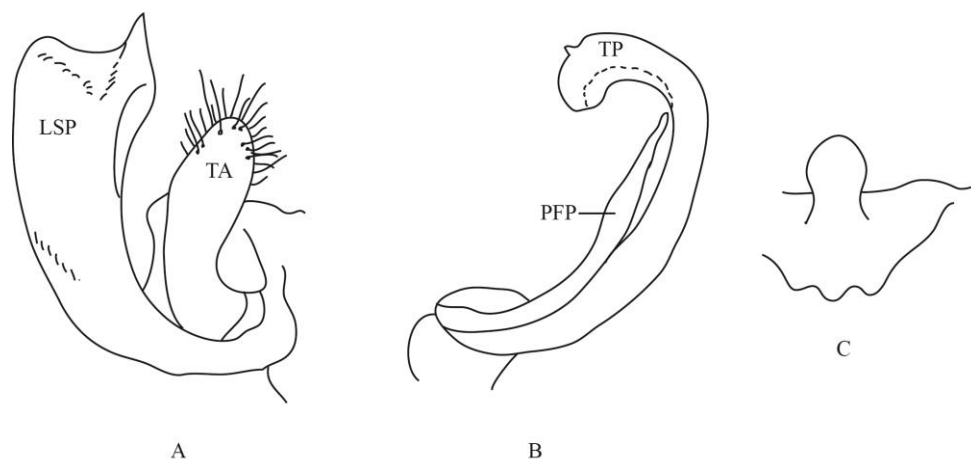
**35b.** Anterior gonopods with lateral syncoxal process plate-like, apically cleft medially;  
telopodite of posterior gonopods with a subapical distal spur; male with sternite of 8th segment  
produced anteriorly into a blunt process.....**Genus *Aliulus*, 36.**

**36a.** (Fig. 39) Lateral syncoxal process of anterior gonopods with pointed anterior division large,  
sharply bent ventrally; prefemoral process of posterior gonopods reaching the end of the apical  
bend of the telopodite.....***Aliulus caddoensis*.**



**Figure 40. *Aliulus caddoensis*. A. Right anterior gonopod, ectal view. B. Left posterior gonopod, ectal view. LSP=lateral syncoxal process, TA=anterior gonopod telopodite, PFP=prefemoral process, TP=posterior gonopod telopodite. Redrawn from Causey (1950a).**

**36b.** (Fig. 40) Lateral syncoxal process of anterior gonopods with pointed anterior division small and horizontal; prefemoral process of posterior gonopods not reaching the end of the apical bend of the telopodite.....*Aliulus carrollus*.



**Figure 41. *Aliulus carrollus*. A. Left anterior gonopod, ectal view. B. Left posterior gonopod, ectal view. C. Sternite of male 8th segment. LSP=lateral syncoxal process, TA=anterior gonopod telopodite, PFP=prefemoral process, TP=posterior gonopod telopodite. Redrawn from Causey (1950a).**

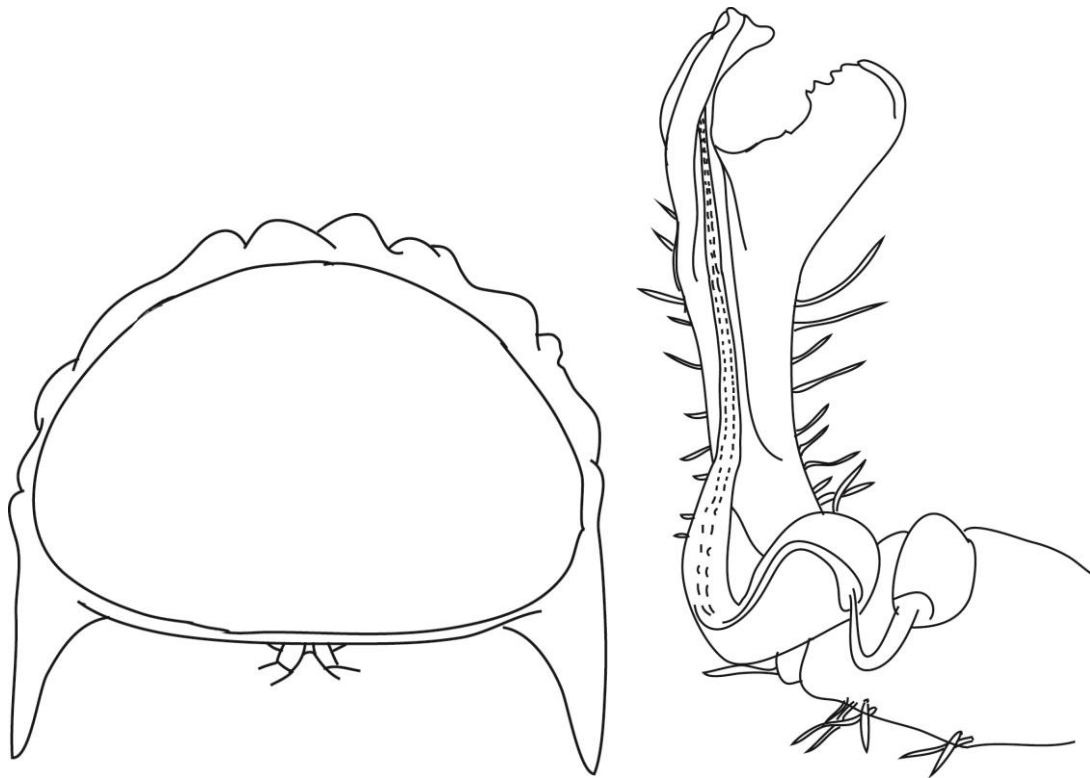
**37a.** Body tergites with transverse groove; mid-body paranota slightly blunt and rounded; gonopodal socket constricted between gonopods; tergites dark brown to black with light yellow paranota.....**Family Paradoxosomatidae, *Oxidus gracilis*.**



**Figure 42. Gonopod of *Oxidus gracilis*, lateral view. Redrawn from Mikhaljova (2009).**

**37b.** Body tergites without transverse groove; mid-body paranota not usually blunt and rounded; gonopodal socket not constricted between gonopods; tergites various colors.....**38.**

**38a.**Body segments distinctly arched, with paranota directed ventrally (Fig. 42); paranota of segments 2-4 enlarged, epiproct enlarged, capable of rolling up into a sphere; body cream colored, but usually with a dirt and debris coating, giving it a brown color; metatergites of segments 5-19 with raised bumps.....**Family Sphaeriodesmidae, *Desmonus pudicus*.**

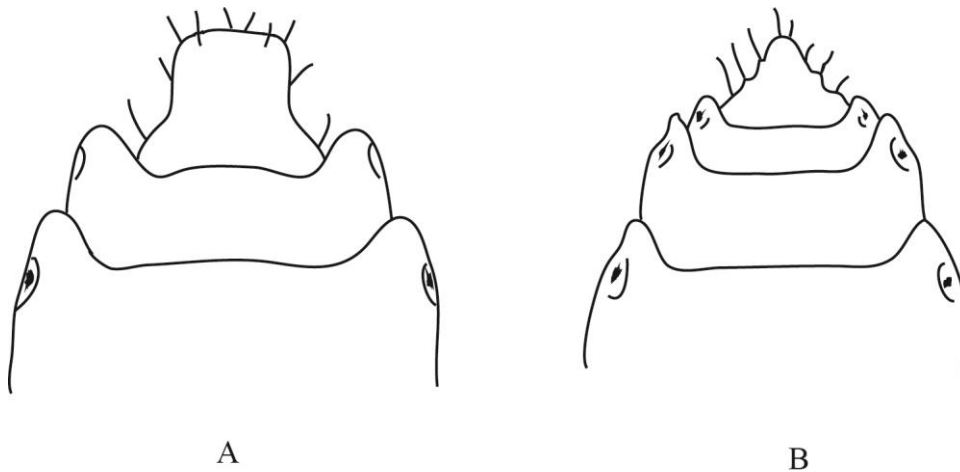


**Figure 43. *Desmonus pudicus*, body segment and gonopod. Redrawn from Shelley (2000d).**



**38b.** Body segments not arched, paranota at most slightly directed ventrally, those of segments 2-4 and epiproct not enlarged, only capable of rolling up into a loose spiral with legs exposed; color varies; metatergites without bumps.....**39.**

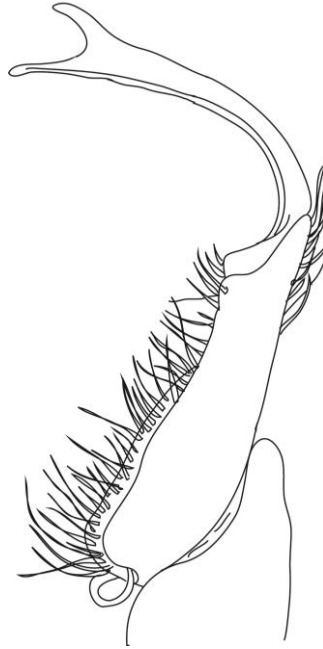
**39a.** Epiproct square and broad (Fig. 43A).....**Family Euryuridae, 40.**



**Figure 44. Caudal end of millipede body. A. With squared epiproct (Euryuridae) B. With triangular epiproct. Redrawn from Hoffman (1990).**

**39b.** Epiproct triangular or rounded (Fig. 43B).....**42.**

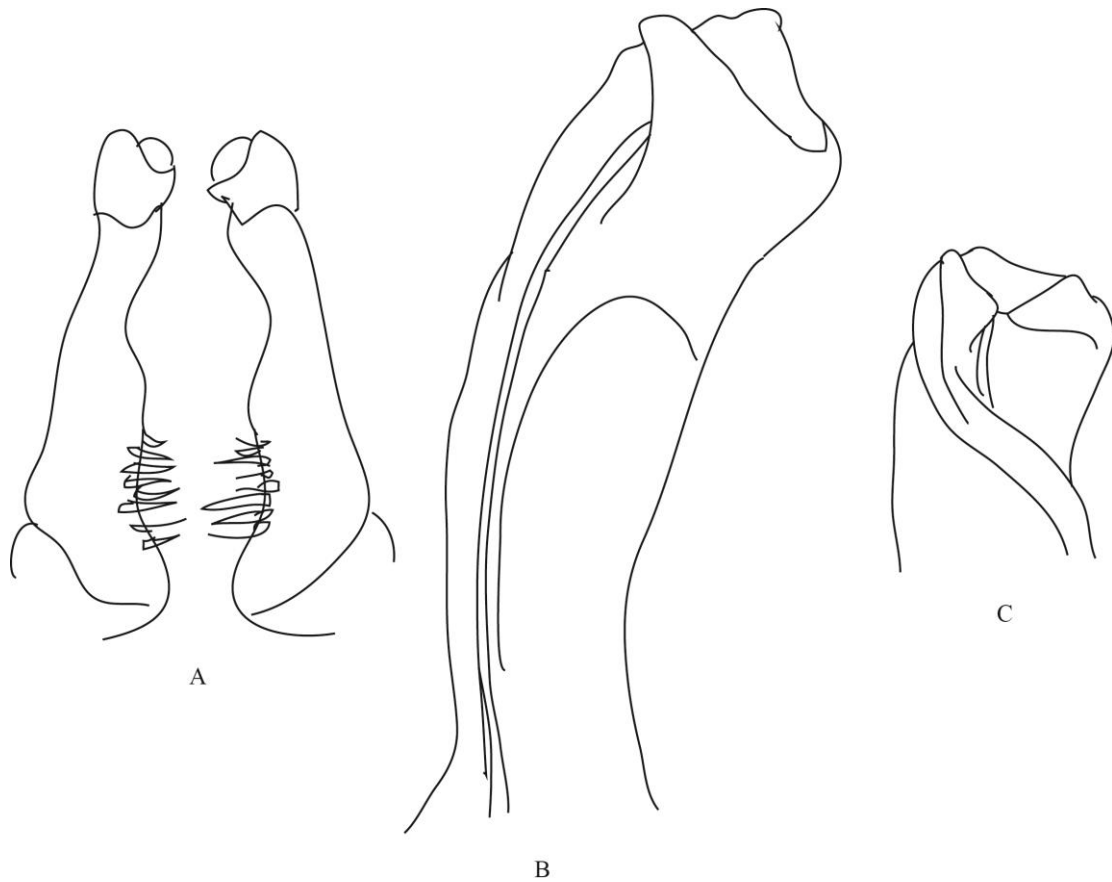
**40a.** Gonopods with telopodite narrowing distally and ending in a forked projection, which curves mesally (Fig. 44); only known from Crowley's Ridge.....***Euryurus leachii*.**



**Figure 45. *Euryurus leachii*, left gonopod, subventral view. Redrawn from Shelley et al (2012).**

**40b.** Gonopods with telopodite not noticeably narrowing distally, ending with the prefemur smoothly joining the acropodite distally, the acropodite appearing smooth and somewhat glassy, slightly transparent and orange.....**Genus *Auturus*, 41.**

**41a.** (Fig. 45) Gonopods with calyx opening directed anteriad *in situ*; all of tibiotarsus visible in medial view; occurs north of the Arkansas River and in the Ozark Plateau.....***Auturus evides*.**

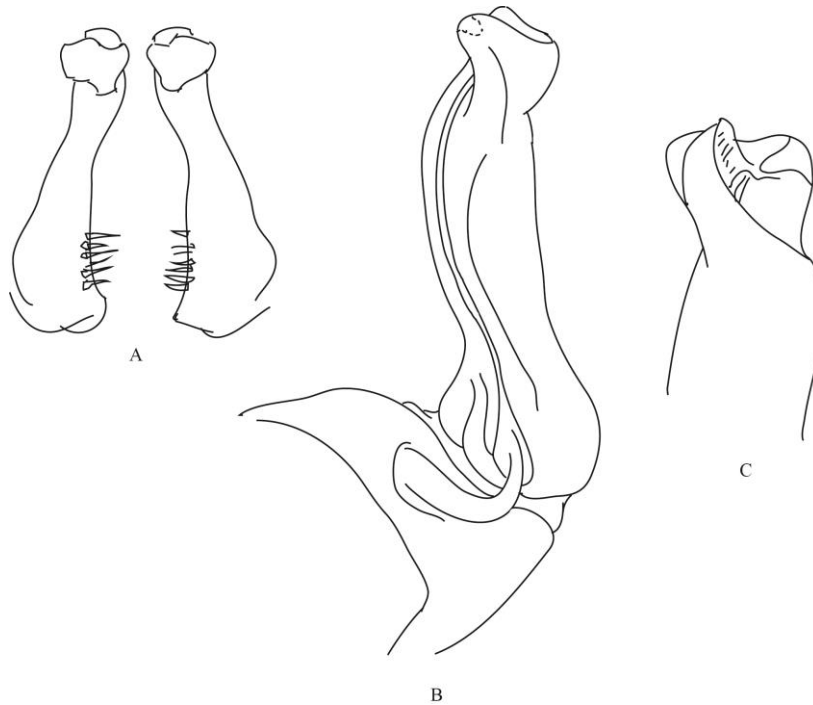


**Figure 46. *Auturus evides*. A. Gonopods, ventral view. B. Left gonopod telopodite, medial view. C. Left gonopod acropodite, subdorsal view. Redrawn from Shelley (1982).**

**41b.** (Fig. 46) Gonopods with calyx opening directed sublaterad *in situ*; apex of tibiotarsus

obscured in medial view; occurs south of the Arkansas River and in the Ouachita

Mountains.....*Auturus louisianus louisianus*.



**Figure 47. *Auturus louisianus louisianus*. A. Gonopods, ventral view. B. Left gonopod, medial view. C. Acropodite, lateral view. Redrawn from Shelley (1982).**

**42a.** Metatergites with transverse rows of polygonal areas, sometimes with tubercles; collum flat, either narrower than head or as wide as head; body with 19 or 20 segments; without pigment or pink to red in color; length 5 mm-32 mm.....**43.**

**42b.** Metatergites smooth, never with tubercles; collum wider than head and extended ventrolaterad behind the mandibles; body with 20 segments; base color of metazonites dark brown or black, usually with orange or yellow caudal stripe, paranota usually orange, red, pink, or yellow; length 14 mm-75 mm.....**49.**

**43a.** Body with 20 segments; unpigmented; sides of metazonites with ridge above base of legs

(Fig. 47); length 5 mm-8 mm.....**Trichopolydesmidae, Genus *Chaetaspis*, 44.**



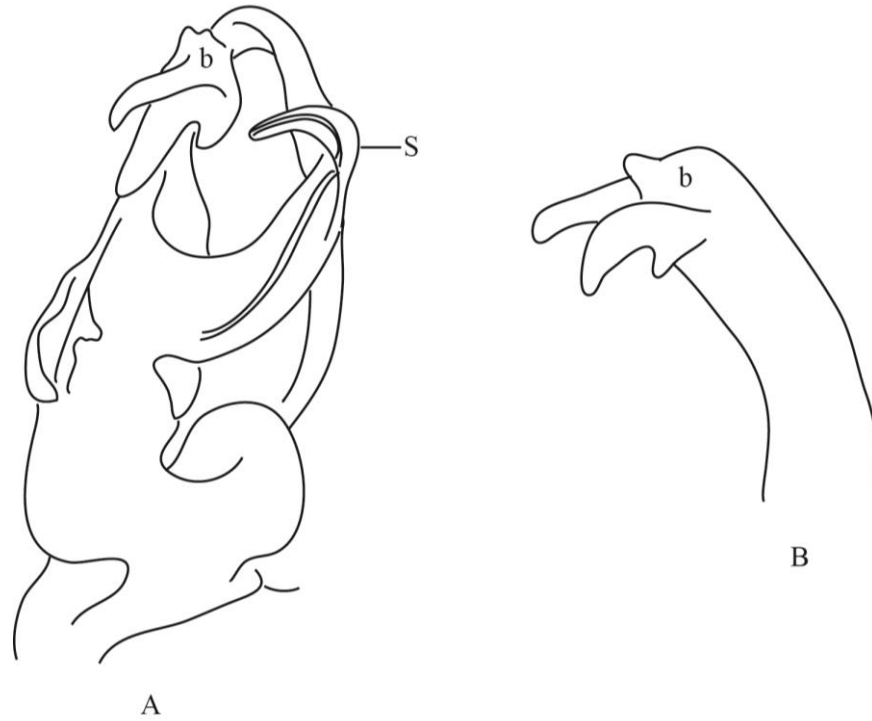
**Figure 48. Lateral view of metazonite of Trichopolydesmidae, showing ridge above legs. Redrawn from Hoffman (1990).**

**43b.** Body with 19 or 20 segments; length 7 mm-32 mm; color pink to red; sides of metazonites

without ridge above base of legs.....**Polydesmidae, 45.**

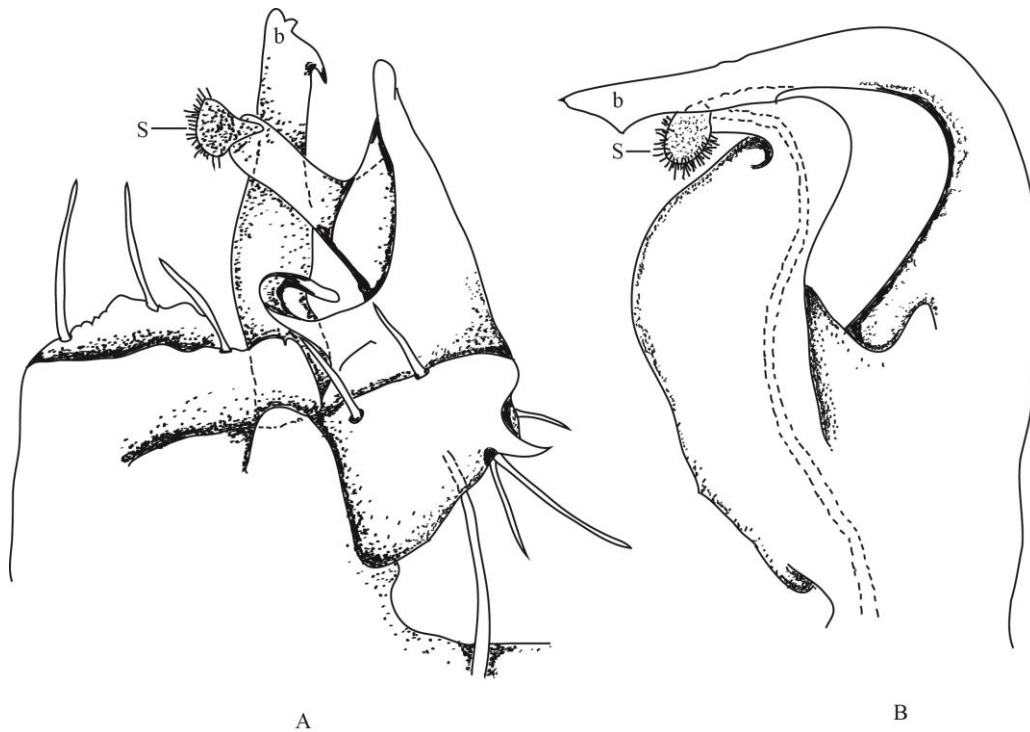
**44a.** (Fig. 48) Gonopod solenomere without terminal disc of setae; process B ending in three

lobes: one small, the other two longer, one of which is bifurcated.....***Chaetaspis albus*.**



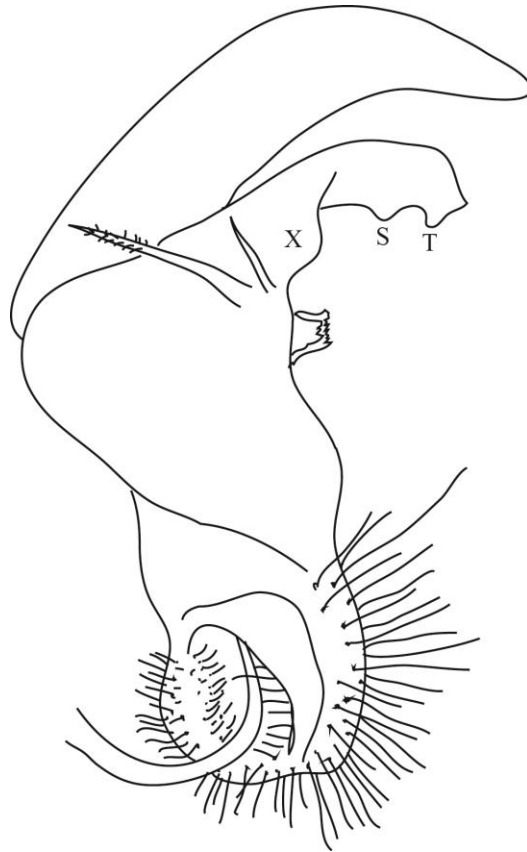
**Figure 49. *Chaetaspis albus*. A. Gonopod. B. Gonopod posterior process, lateral view. S=solenomere, b=process b of posterior process. Redrawn from Lewis (2002).**

**44b.** (Fig. 49) Gonopod solenomere ending in a terminal disc of setae; process B tapering to a single point.....*Chaetaspis attenuatus*.



**Figure 50. *Chaetaspis attenuatus*. A. Gonopod, posterior view. B. Gonopod, lateral view. S=solenomere, b=process b of posterior process. Redrawn from Lewis & Slay (2013).**

**45a.** Body with 19 segments; length 7 mm-20 mm; collum narrower than head; paranota dentate; tergites with four rows of tubercles bearing setae, giving it a fuzzy appearance; tibiae of legs 13-20 of males with distal lobes.....*Scytonotus granulatus*.



**Figure 51.** *Scytonotus granulatus* left gonopod, medial view. X=process x, S=process s, T=process t. Redrawn from Hoffman (1962).

**45b.** Body with 19 or 20 segments; length 10 mm-32 mm; collum as wide as head; paranota only slightly dentate; tergites with a polished appearance, lacking tubercles bearing setae; tibiae of legs 13-20 of males without such lobes.....**46.**

**46a.** Body with 19 or 20 segments; length 10 mm-25 mm, generally smaller than *Pseudopolydesmus*; polygonal areas of tergites more pronounced; gonopod telopodite consisting of two branches (Fig. 51); color brown to pink.....**Genus *Polydesmus*.**

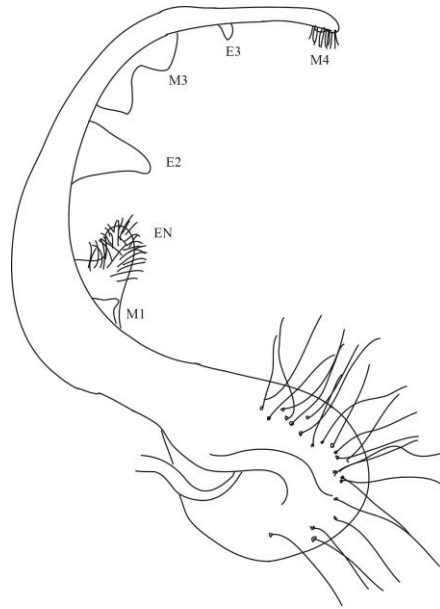




**Figure 52. *Polydesmus inconstans* right gonopod, lateral view. Redrawn from Blower (1985).**

**46b.** Body with 20 segments; length 10 mm-32 mm; polygonal areas of tergites smoother; color pink to deep red; gonopod telopodite a single undivided branch....**Genus *Pseudopolydesmus*, 47.**

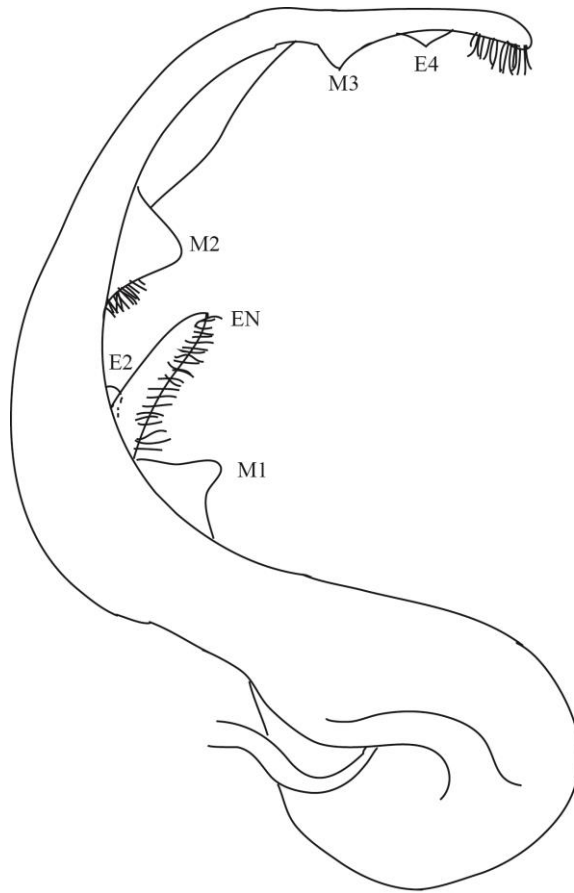
**47a.** Epiproct downturned; gonopod with processes M1, M3, M4, and E2 and E3 (Fig. 52); hypoproct normal; length 11 mm-27 mm.....***Pseudopolydesmus pinetorum*.**



**Figure 53.** *Pseudopolydesmus pinetorum* right gonopod, mesal view. M=mesal processes, E=ectal processes, EN=endomerite.

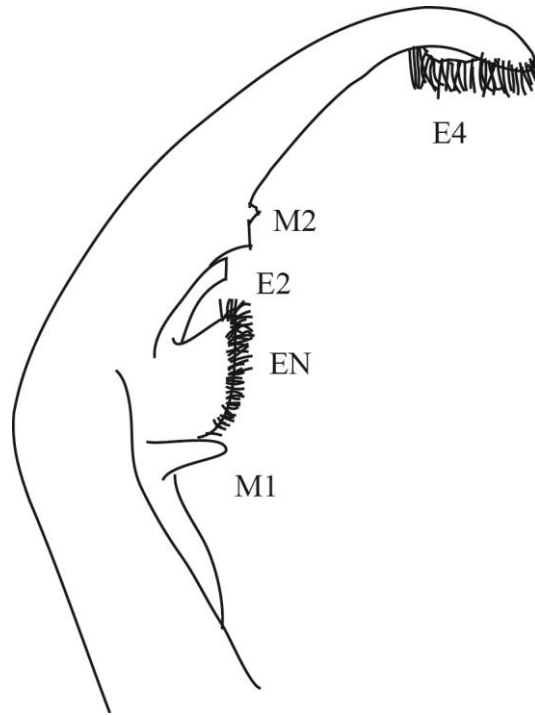
**47b.** Epiproct straight; gonopod including processes M2 and E4, lacking process E3; hypoproct normal, bilobed, or trilobed; length 9 mm-32 mm.....**48.**

**48a.** Gonopod with processes M1, M2, M3 and E2, E4 (Fig. 53); hypoproct normal; individuals usually small, 9 mm-14 mm.....*Pseudopolydesmus minor*.



**Figure 54.** *Pseudopolydesmus minor* right gonopod, mesal view. M=mesal processes, E=ectal processes, EN=endomerite. Redrawn from Loomis (1959).

**48b.** Gonopod with processes M1, M2 and E2, E4 (Fig. 54); hypoproct bilobed or sometimes trilobed; individuals usually large, 13 mm-32 mm.....*Pseudopolydesmus serratus*.



**Figure 55.** *Pseudopolydesmus serratus* left gonopod acropodite, mesal view. Redrawn from Shelley & Snyder (2012).

**49a.** Prefemur of leg with distal spine; gonopodal aperture unmodified, lacking long setae; base color of tergites black or dark brown with pinkish, red, or yellow paranota, sometimes with a caudal metaternal stripe; usually found in moist areas; large species, 20 mm-75 mm long.....  
 .....**Family Xystodesmidae, 50.**

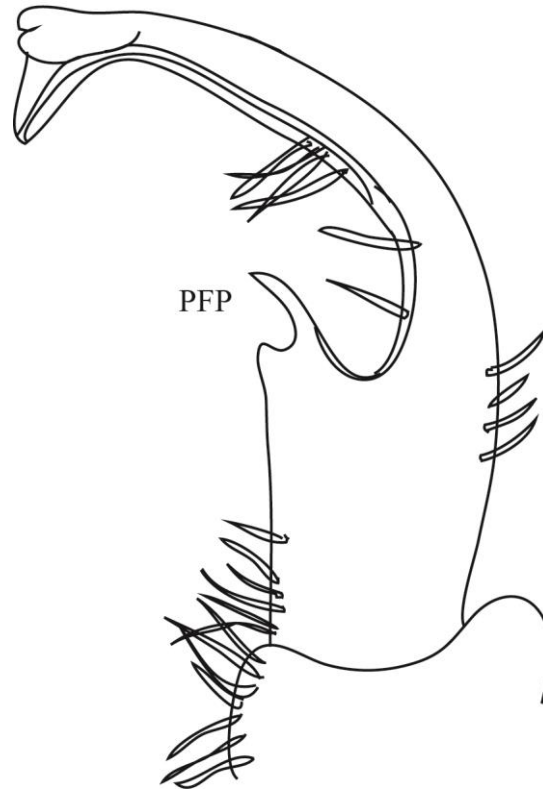
**49b.** Prefemur of leg without distal spine; gonopodal aperture sometimes with lobes or other modifications, with long setae; base color of tergites dark brown with red-orange paranota and various patterns of stripes and spots; found in moist or drier areas; moderately-sized species, 14 mm-37 mm long.....**Family Eurymerodesmidae, Genus *Eurymerodesmus*, 56.**

**50a.** Midbody sterna with spines projecting caudally between the legs; male pregonopodal tarsal claws broad and spatulate, twisted or not, midbody and posterior claws curved; metatergites chestnut brown with pink-orange paranota; small-bodied, 20 mm-25 mm long.....

.....**Tribe Nannariini, Genus *Mimuloria*, 51.**

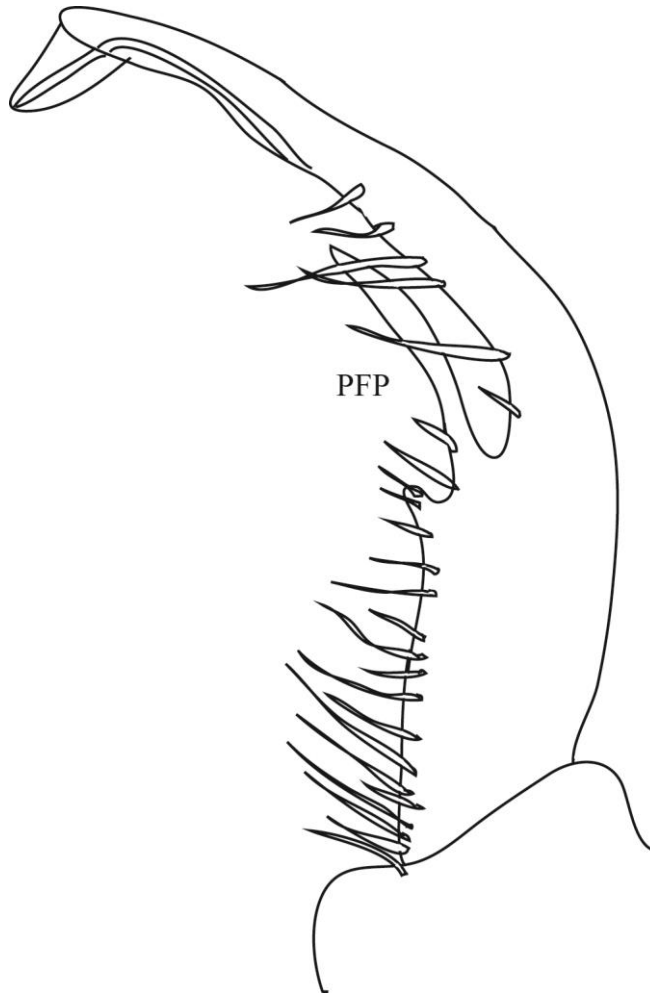
**50b.** Midbody sterna modified or not, but never with spines; male pregonopodal tarsal claws not spatulate; color varies; larger, 25 mm-75 mm long.....**52.**

**51a.** Gonopod acropodite curving strongly mediad; inner projection from prefemoral process short, tapering to a point, extending for 1/8 length of acropodite (Fig. 55)....***Mimuloria castanea*.**



**Figure 56.** *Mimuloria castanea* left gonopod, ventral view. PFP=prefemoral process.  
Redrawn from Hennen & Shelley (2015).

**51b.** Gonopod acropodite leaning mediad; inner projection from prefemoral process long, blade-like, 1/3 as long as the acropodite (Fig. 56).....*Mimuloria davidcauseyi*.



**Figure 57. *Mimuloria davidcauseyi* left gonopod, ventral view. PFP=prefemoral process.  
Redrawn from Hennen & Shelley (2015).**

**52a.** Midbody sterna unmodified; gonopods in a circular, curved sickle shape (Figs. 57,58);

metatergites black with yellow paranota; 50 mm-60 mm long.....

.....**Tribe Apheloriini, *Apheloria virginiensis reducta*.**



**Figure 58.** *Apheloria virginiensis reducta* gonopods *in situ*.



**Figure 59.** *Apheloria virginiensis reducta* left gonopod, submesal view.

**52b.** Midbody sterna unmodified or with lobes or elevations; gonopods straight or slightly curving, with various processes in addition to the telopodite; color variable; 30 mm-75 mm long

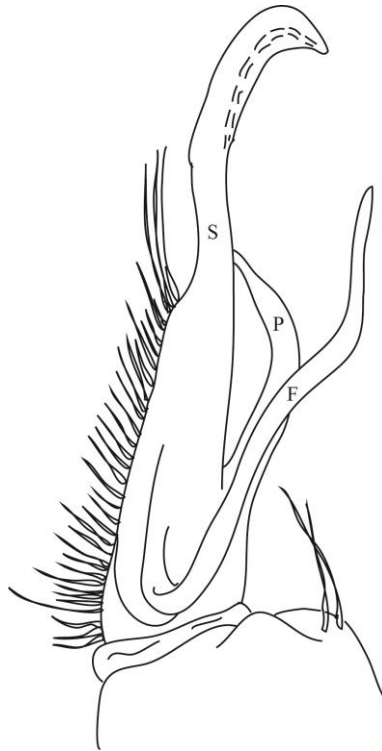
.....**53.**



**53a.** Metatergites chocolate brown with pale yellow or slightly pink paranota; metasternum elevated sharply; large species, 30 mm-75 mm long.....**Tribe Pachydesmini, 54.**

**53b.** Metatergites black with red or yellow paranota, sometimes with a caudal stripe on the metazonite; metasternum lobed or unmodified; small species, 25 mm-30 mm long.....  
.....**Tribe Rhysodesmini, 55.**

**54a.** (Fig. 59) Solenomere and femoral process arising from prefemur, directed distad; femoral process narrow and tapering to a point distally, shorter than solenomere; body length 50 mm-70 mm.....***Pachydesmus clarus.***



**Figure 60. *Pachydesmus clarus* left gonopod, lateral view. S=solenomere, P=prefemoral process, F=femoral process. Redrawn from Shelley & McAllister (2006).**

**54b.** (Fig. 60) Solenomere and tibial process arising from acropodite, directed or curving caudad; acropodite deeply cleft apically; body length 30 mm-50 mm.....*Thrinaxoria lampra*.



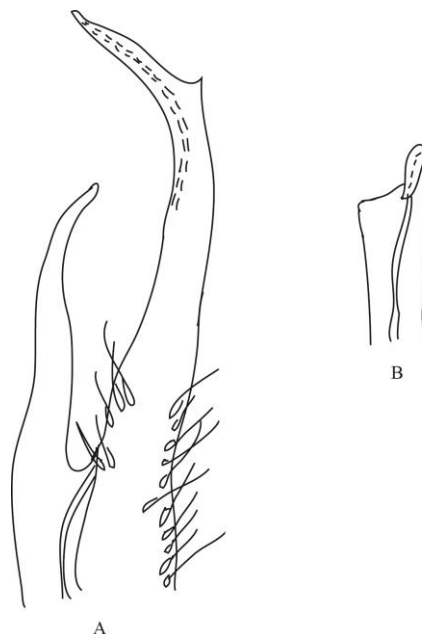
**Figure 61.** *Thrinaxoria lampra* left gonopod, lateral view. S=solenomere, P=prefemoral process, T=tibial process, A=acropodite, C=coxa. Redrawn from Shelley & McAllister (2006).

**55a.** Sterna bilobed, broadly rounded, with setae; metatergites brown-black with yellow-orange paranota, sometimes connected by caudal metatergal stripe.....*Pleuroloma flavipes*.



**Figure 62. *Pleuroloma flavipes* left gonopod, medial view (without setae). Redrawn from Shelley (1980).**

**55b.** Sterna unmodified, without setae; metatergites black with caudal half of paranota red.....  
 .....*Boraria profuga*.

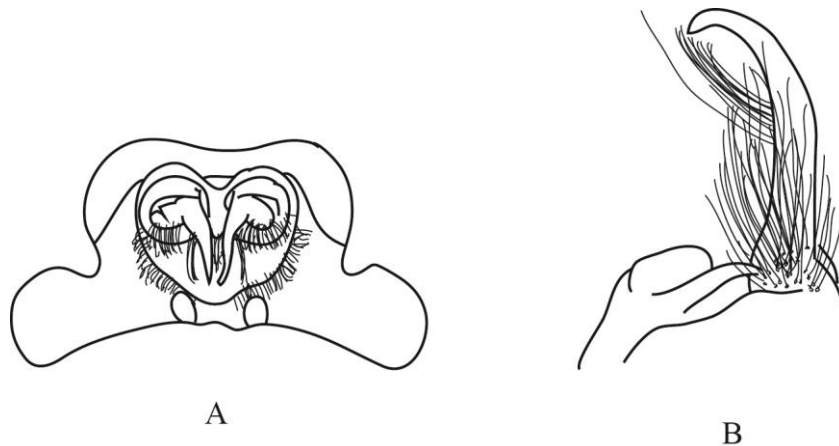


**Figure 63. *Boraria profuga* A. left gonopod telopodite, anteromedial view B. acropodite apex, medial view. Redrawn from Shelley et al (2011).**

**56a.** Gonopod acropodite long, making up at least half the length of the telopodite.....**57.**

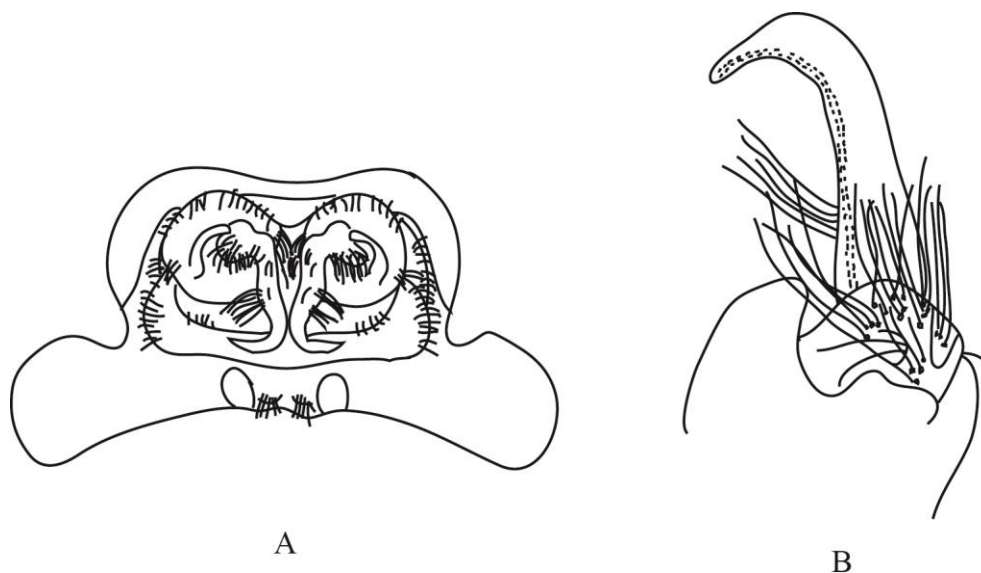
**56b.** Gonopod acropodite quite short, making up much less than half the length of the telopodite.  
.....**58.**

**57a.** (Fig. 63) Sides of aperture entire, peaking at or near the caudolateral corners; corners of cyphopod valves rounded but not extending into projections; metatergites olive, without caudal metatergal stripes, paranota reddish-orange; Polk & Montgomery Counties.....  
.....*Eurymerodesmus goodi*.



**Figure 64. *Eurymerodesmus goodi* A. gonopods *in situ*, ventral view B. left gonopod, lateral view. Redrawn from Shelley (1990).**

**57b.** (Fig. 64) Sides of aperture slightly to moderately elevated, divided and with caudolateral pouches; projections of cyphopod valves relatively narrow, finger-like; metatergites mottled dark olive-brown, with or without caudal stripes; Izard County south to Union County.....  
.....*Eurymerodesmus angularis*.



**Figure 65. *Eurymerodesmus angularis* A. gonopods *in situ*, ventral view B. left gonopod, lateral view. Redrawn from Shelley (1990).**

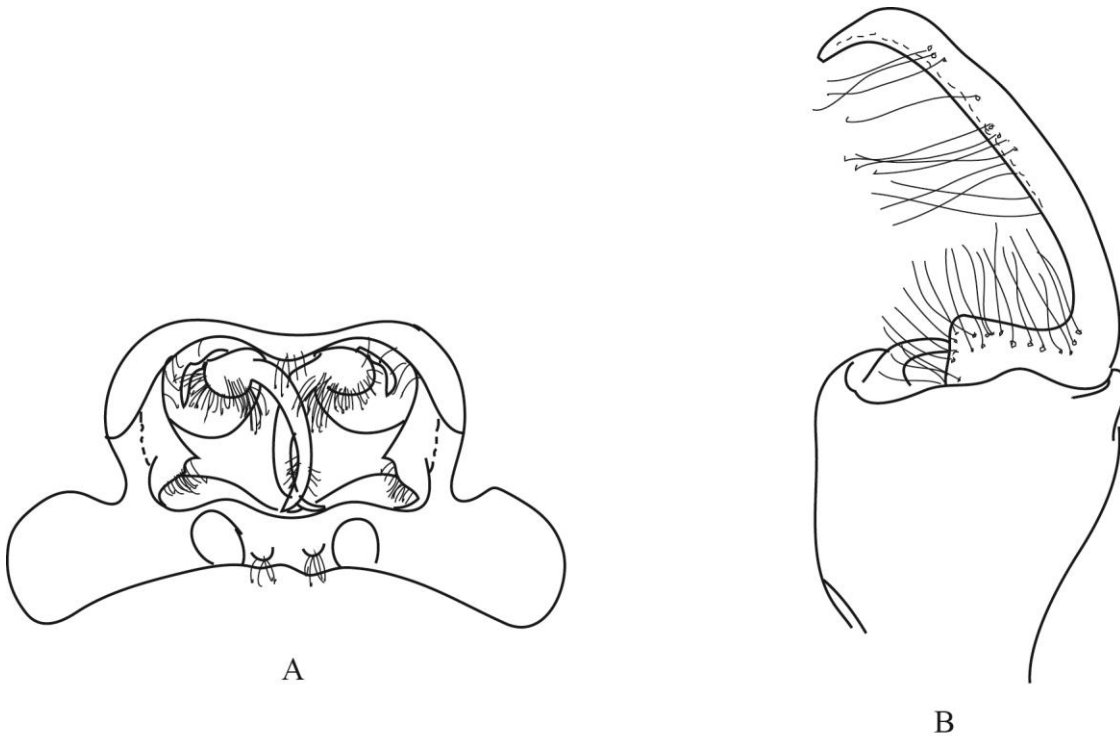
**58a.** Caudolateral sides of gonopod aperture divided into inner and outer margins, with variably open to closed caudolateral pouches.....**59.**

**58b.** Sides of gonopod aperture entire, without such pouches.....**66.**

**59a.** Acropodite smoothly continuous with prefemur, boundary between acropodite and prefemur difficult to see; prefemur at most only slightly expanded on outer margin.....**60.**

**59b.** Acropodite noticeably separated from prefemur, variably subterminal to terminal, strongly separated from prefemur, sometimes may be on inner margin of prefemur and not immediately obvious; prefemur with strong distal lobe on outer margin.....**63.**

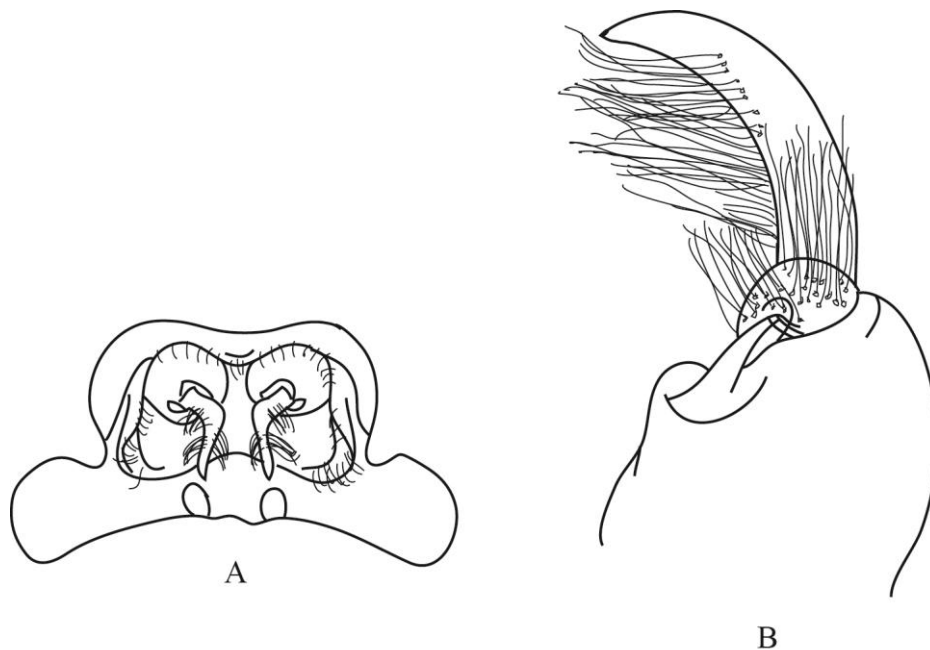
**60a.** (Fig. 65) Prefemur with sparse to light number of setae, with light distomedial tuft of setae and at most, scattered and sporadic hairs along telopodite, hairs arranged irregularly, with variable, sometimes large, gaps between patches; Columbia, Union Cos.....  
 .....*Eurymerodesmus varius louisianae*.



**Figure 66.** *Eurymerodesmus varius louisianae* A. gonopods *in situ*, ventral view B. left gonopod, lateral view. Redrawn from Shelley (1990).

**60b.** Prefemur with more setae, moderately to densely hairy, with variable distomedial tuft of setae and essentially continuous hairs along stem, hairs without sizeable gaps, arranged regularly or irregularly.....**61.**

**61a.** (Fig. 66) Acropodite long, more than 1/4 of telopodite length, broad for most of length, compressed laterally; prefemur without distal swelling; distal corners of cyphopod valves extended into closely appressed projections, projection of outer valve very long and narrow, finger-like, overhanging proceeding body segment; paranota orange, metaterga dark, mottled olive, without caudal stripes. Collum with anterior orange stripe along anterior margin; body longer than 32 mm; Union Co.....*Eurymerodesmus compressus*.



**Figure 67. *Eurymerodesmus compressus* A. gonopods *in situ*, ventral view B. left gonopod, lateral view. Redrawn from Shelley (1990).**

**61b.** Acropodite short, less than 1/4 of telopodite length, relatively narrow, with sides usually tapering rapidly, not compressed; prefemur usually with slight distal swelling; corners of cyphopod valves lacking finger-like projections; metatergites with caudal orange-red stripes; size small to moderate (20 mm-30 mm long).....**62.**

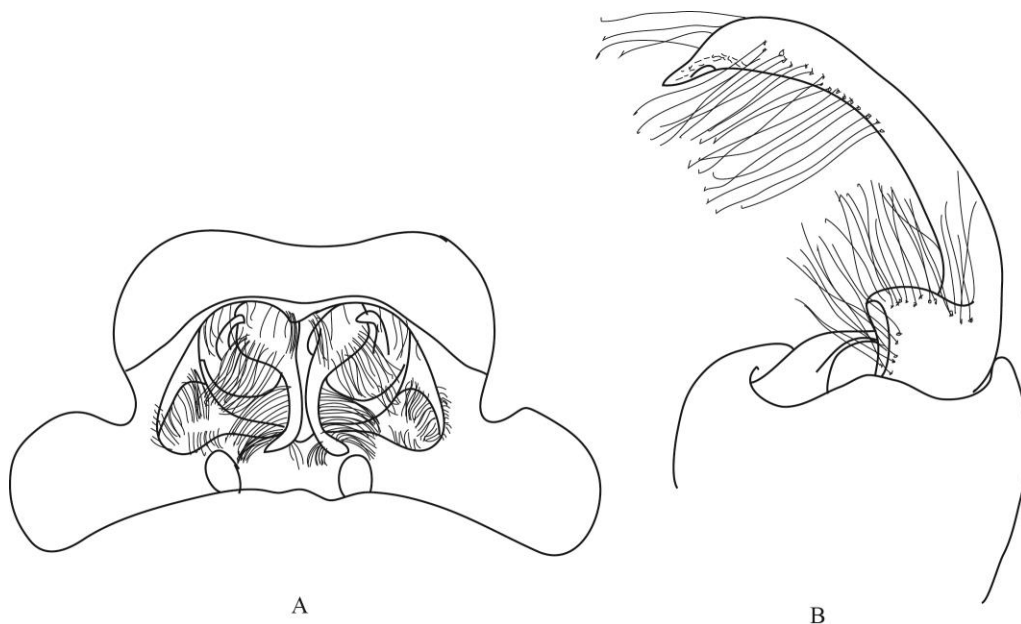


**62a.** (Fig. 67) Acropodite hook-like, curving downward or dorsolaterad; caudolateral pouch partly closed, covered by lean of outer lateral margin; projection of mandibular stipes small; Washington, Benton, and Newton Cos.....*Eurymerodesmus newtonus*.



**Figure 68. *Eurymerodesmus newtonus* A. gonopods *in situ*, ventral view B. left gonopod, lateral view. Redrawn from Shelley (1990).**

**62b.** (Fig. 68) Acropodite curving distal to midlength; caudolateral pouch large, broadly open, outer lateral margin flaring strongly caudolaterad, revealing entire inner margin in ventral view; projection of mandibular stipes long; north-central Arkansas.....*Eurymerodesmus oliphantus*.

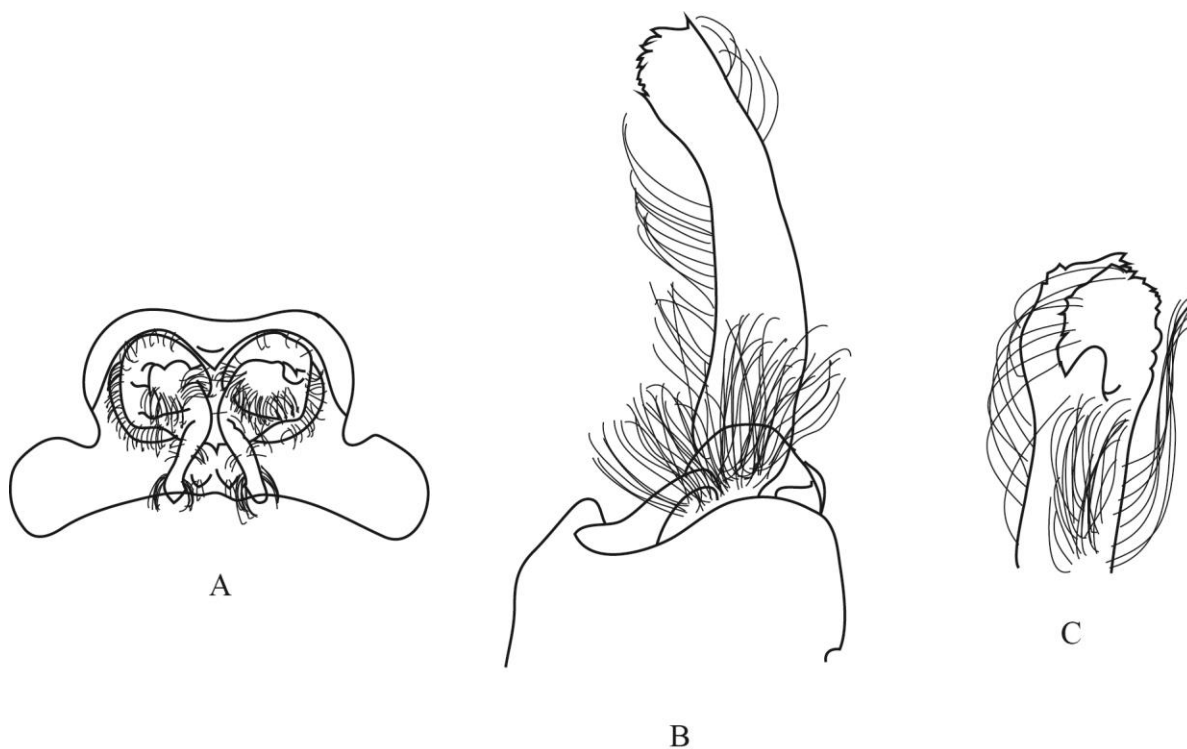


**Figure 69. *Eurymerodesmus oliphantus* A. gonopods *in situ*, ventral view B. left gonopod, lateral view. Redrawn from Shelley (1990).**

**63a.** Acropodite arising subterminally from prefemur, on inner margin, sometimes difficult to see; prefemur variable distally but forming the end of telopodite.....**64.**

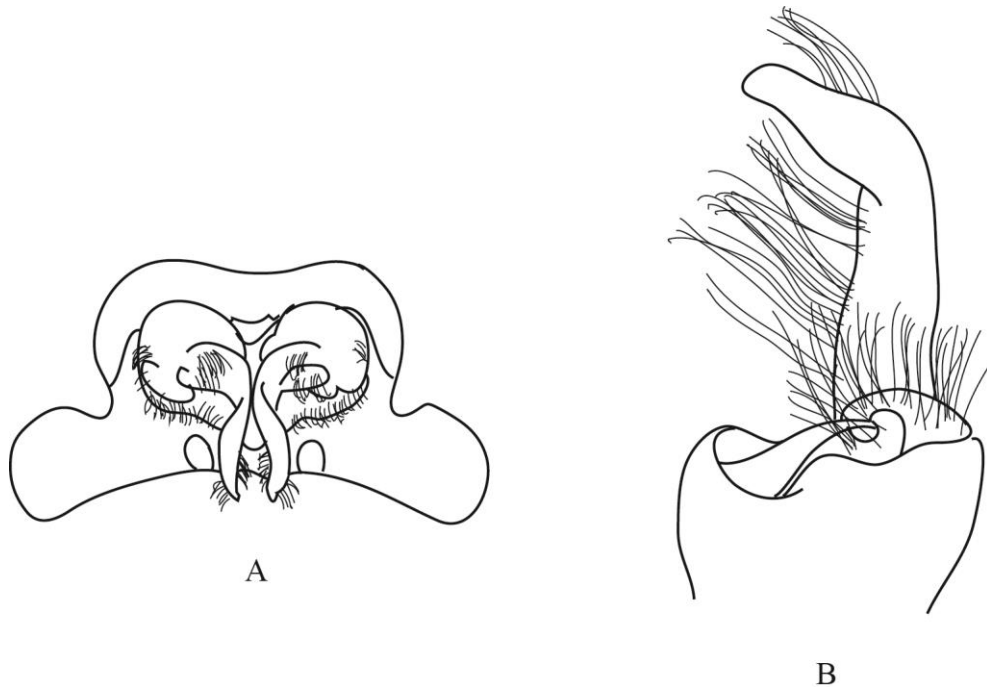
**63b.** Acropodite arising terminally, either from inner prefemoral margin or separated by strong distal lobe on outer surface of prefemur.....**65.**

**64a.** (Fig. 69) Terminal part of prefemur broadly expanded, margin irregularly serrate to jagged; gonopod aperture with lobes on caudal margin.....*Eurymerodesmus serratus*.



**Figure 70. *Eurymerodesmus serratus* A. gonopods *in situ*, ventral view B. left gonopod, lateral view. C. left gonopod telopodite, dorsal view. Redrawn from Shelley (1990).**

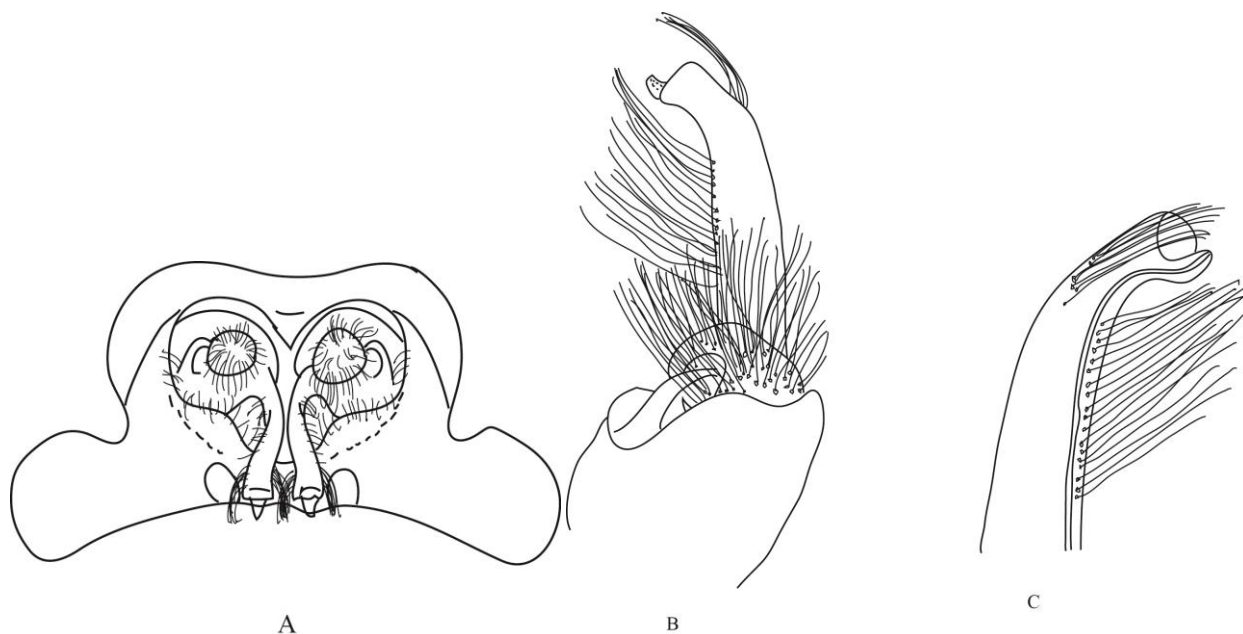
**64b.** (Fig. 70) Terminal part of prefemur variably elongate but not expanded or wide, tapering to blunt or slightly pointed tip, margins smooth; distal part of prefemur straight or apically hook-like; gonopod aperture without lobes.....*Eurymerodesmus pulaski*.



**Figure 71. *Eurymerodesmus pulaski* A. gonopods *in situ*, ventral view B. left gonopod, lateral view. Redrawn from Shelley (1990).**

**65a.** (Fig. 65) Acropodite broadly terminal but distinct from prefemur; prefemur with outer margin expanding distally into rounded lobe; sides of aperture divided, with pouches; body size small to moderate (19 mm-23 mm); paranota red-orange, metatergites with caudal red-orange stripes; southern AR.....*Eurymerodesmus varius louisianae*.

**65b.** (Fig. 71) Acropodite narrowly terminal, slightly stubby, and clearly visible, arising from inner margin of prefemur; prefemur with sides relatively parallel throughout, but slightly curving distally; terminal margin of prefemur without hairs; sides of aperture entire, without pouches; body size large (32 mm); paranota red-orange, metatergites with red-orange medial triangles; Polk Co.....*Eurymerodesmus polkensis*.



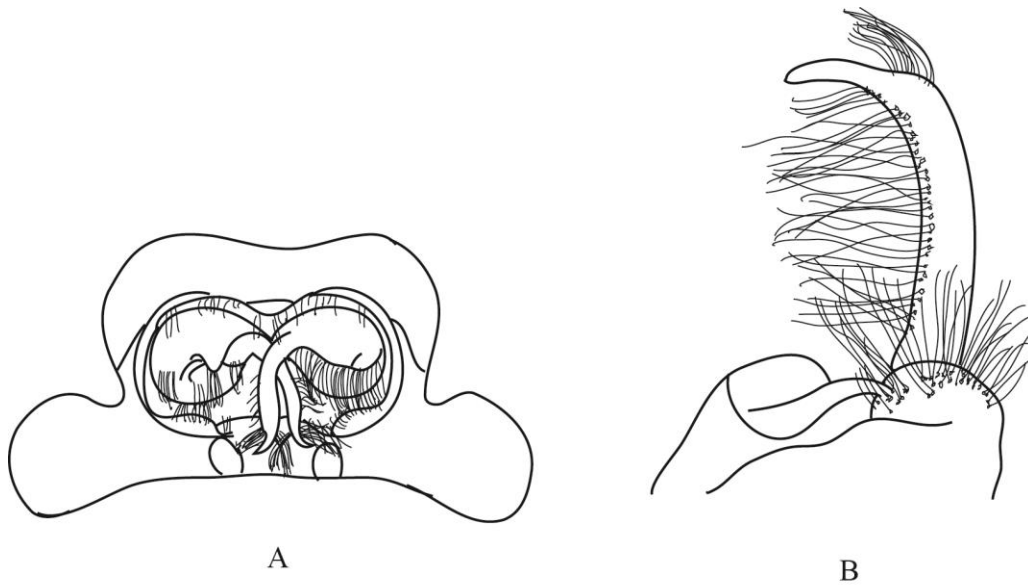
**Figure 72.** *Eurymerodesmus polkensis* A. gonopods *in situ*, ventral view B. left gonopod, lateral view. C. left gonopod telopodite, medial view. Redrawn from Shelley (1990).

**66a.** Gonopod aperture without distinct lobes.....**67.**

**66b.** Gonopod aperture with densely hirsute, variable lobes on caudal margin or at caudolateral corners.....**68.**

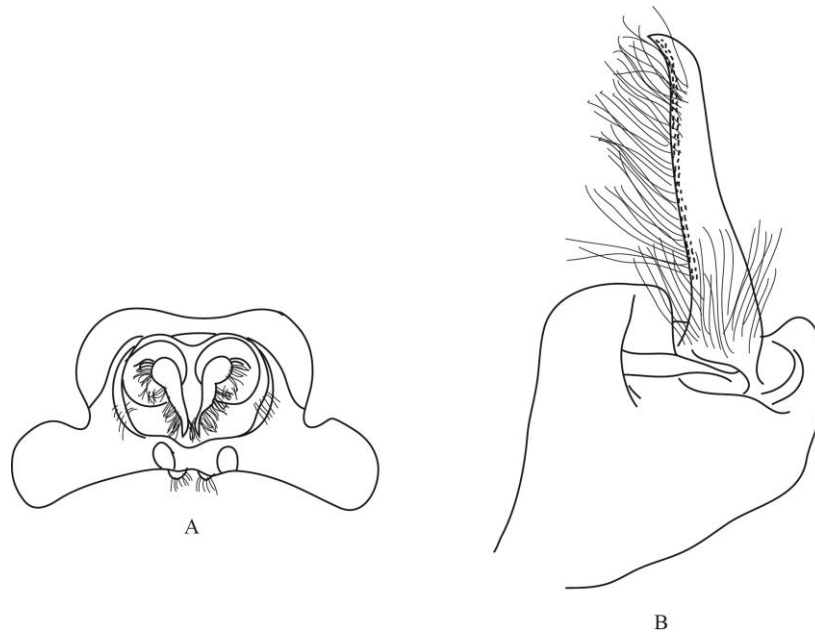
**67a.** (Fig. 72) Tip of gonopod acropodite curving dorsolaterad; projection of mandibular stipes pointed; body size small to moderate (19 mm-23 mm); Ashley Co.....

.....*Eurymerodesmus hispidipes*.



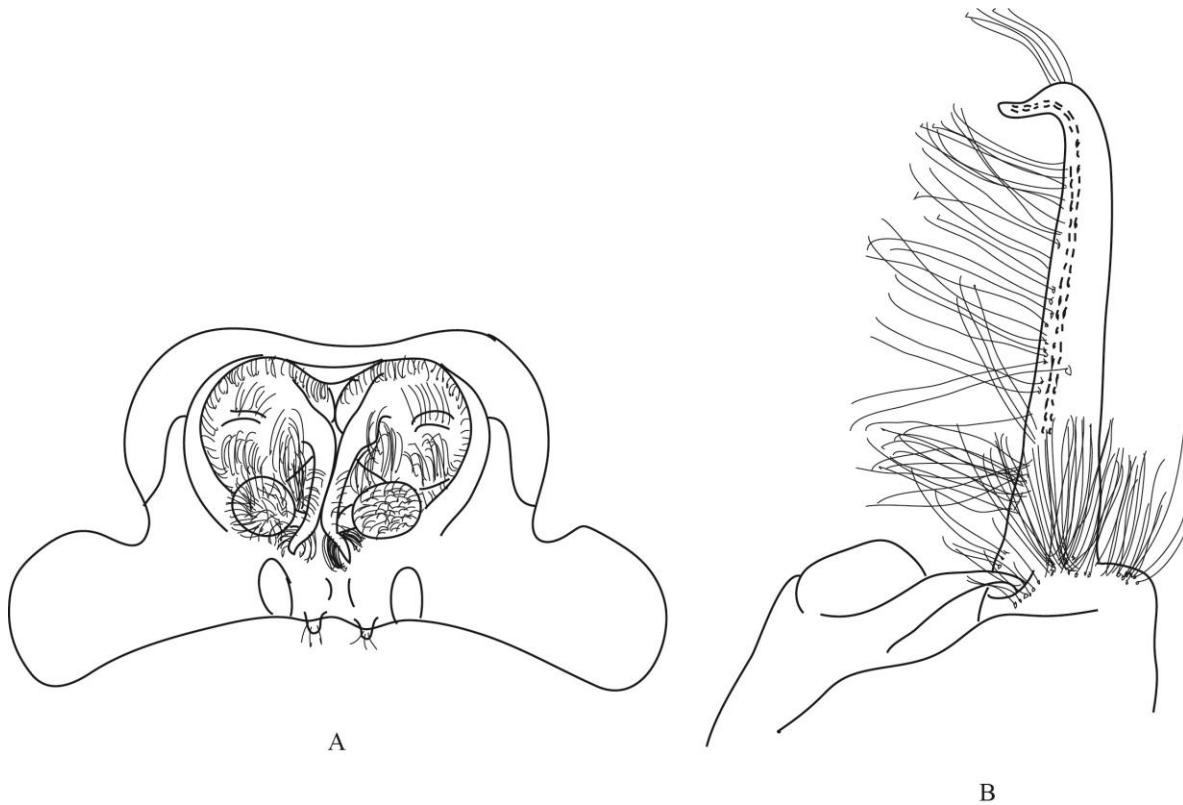
**Figure 73. *Eurymerodesmus hispidipes* A. gonopods *in situ*, ventral view B. left gonopod, lateral view. Redrawn from Shelley (1990).**

**67b.** (Fig. 73) Tip of gonopod acropodite with only a slight curve; projection of mandibular stipes rounded; body size large (32 mm); west-central and southern AR.....  
 .....*Eurymerodesmus dubius*.



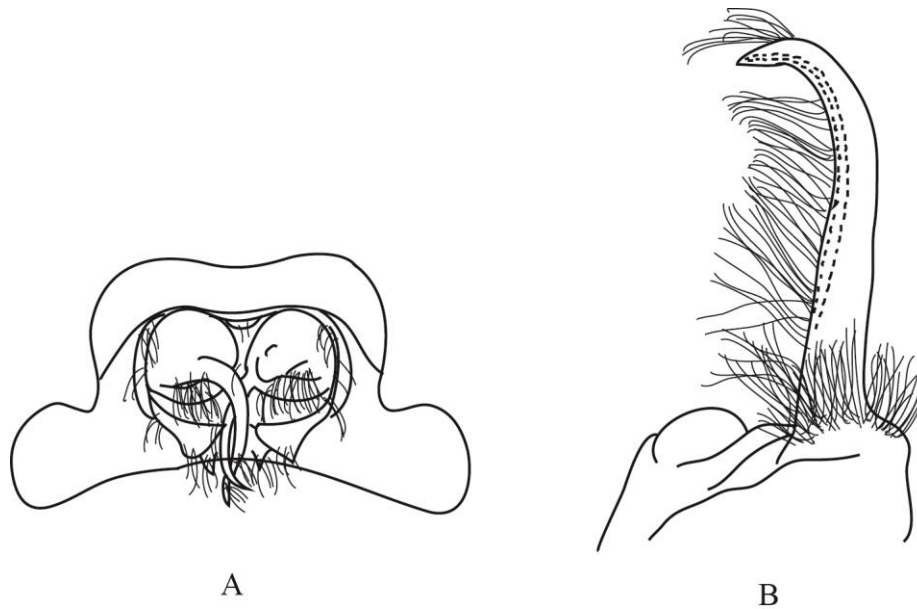
**Figure 74. *Eurymerodesmus dubius* A. gonopods *in situ*, ventral view B. left gonopod, lateral view. Redrawn from Shelley (1990).**

**68a.** (Fig. 74) Aperture lobes clavate, very large, clearly located on caudal margin, distinctly removed from caudolateral corner; paranota red, metatergites brown with red stripes along caudal margin.....*Eurymerodesmus mundus*.



**Figure 75. *Eurymerodesmus mundus* A. gonopods *in situ*, ventral view B. left gonopod, lateral view. Redrawn from Shelley (1990).**

**68b.** Aperture lobes short to long, variably triangular, never clavate, variably higher than marginal elevation, located at caudolateral corner or on caudal margin at varying distances; paranota orange, metatergites dark with orange stripes, usually wider mediad, giving a trimaculate appearance.....*Eurymerodesmus birdi birdi*.



**Figure 76. *Eurymerodesmus birdi birdi* A. gonopods *in situ*, ventral view B. left gonopod, lateral view. Redrawn from Shelley (1990).**

#### **Glossary of Terms:**

(G) indicates a term referring to parts of the gonopods

**acropodite:** (G) the part of the telopodite distal to the boundary of the prefemur (this boundary is sometimes indistinct)

**brachit:** (G) the anterior lobe of the opisthomerite in the tribe Cylindroiulini of the family Julidae.

**calyx:** (G) cuplike structure made by the acropodite

**colpocoxite:** (G) in Chordeumatida, the part of the gonopod that is thought to be a sclerotized coxal gland

**distal zone:** (G) part of the acropodite distal to the solenomere [has been referred to as tibiotarsus, endomerite, and exomerite]



**ensiform:** sword-like in shape

**epigean:** active above the soil surface

**epiproct:** the dorso-median projection on the final body ring, appears as a short "tail"

**flagellum:** (G) a whip-like structure arising from the mesial side of the base of the promerite in Julidae.

**gnathochilarium:** the ventral plate under the millipede head, made of the fused 2nd maxillae

**gonopods:** modified 8th or 9th legs of males used for sperm transfer

**hypoproct:** the sclerite located below the anus.

**lateral syncoxal process:** (G) in Parajulidae, part of the anterior gonopods.

**mentum:** a median sclerite of the gnathochilarium

**mesal:** towards the midline of the body

**mesomerite:** (G) in Julidae, the anterior part of the posterior gonopods (modified 9th legpair).

**metazonite:** the posterior part of the diplosegment, into which the prozonite of the following diplosegment is inserted.

**opisthomerite:** (G) in Julidae, the posterior part of the posterior gonopods (modified 9th legpair).

**ozopore:** the external opening of the millipede's chemical defense gland

**paranota:** a dorso-lateral extension of the metazonite, often into a flange-like or wing-like structure; most often seen in Polydesmida and Chordeumatida

**paraproct:** the sclerite on the sides of the anus at the posterior end of the millipede

**phylacum:** (G) in Julidae, a leaf-like lobe on the outer posterior side of the solenomerite.

**pleurite:** the sclerotized lateral part of the millipede body segments

**prefemoral process:** (G) a process of the basal part of the gonopod, precise usage varies between millipede groups

**promerite:** (G) in Julidae, the anterior gonopod (modified 8th legpair).

**prozonite:** the anterior part of the diplosegment, which inserts into the metazonite of the preceding diplosegment

**sigmoid:** resembling the Greek letter sigma: ζ.

**solenomere:** (G) a tubular projection with the prostatic groove opening apically

**spinnerets:** conical tubercles on the posterior end of the body from which millipedes secrete silk-like fibers

**sternite:** the sclerotized ventral body plate, from which the legs and spiracles arise

**telopodite:** all structures distal to the coxa

**tergite:** the dorsal body plate

**tibiotarus:** (G) tapering finger-like projection at tip of acropodite that meets with the lateral wall of acropodite to form the calyx.

## Species Accounts:

### Order Polyxenida, Family Polyxenidae:



**Figure 76. *Polyxenus lagurus***

***Polyxenus lagurus* (Linnaeus, 1758)**

**Sources:** Bollman 1887, Eisner et al. 1996, Enghoff 1976, Hoffman 1999, Hopkin & Read 1992, Kane 1981, Williams & Hefner 1928, Wright & Westh 2006

**Description:** 2 mm-4 mm in length, <1 mm in width. *Polyxenus lagurus* is quite different from other millipedes in Arkansas, it's soft-bodied and has numerous setae. It also has tufts of setae laterally and two large tufts at the posterior end of the body. Adults are a light tan color, but juveniles and preserved specimens are usually white.

**County Distribution:** Pulaski, Sevier, Pike. **New Records:** Conway, Garland, Logan, Montgomery, Newton, Polk, Pope, Scott, Sebastian, Stone, Washington.

**Habitat:** *P. lagurus* was collected from various leaf litter habitats via Berlese funnel extraction and was found in both deciduous (beech, elm, oak, hickory) and pine litter. It has previously been reported from under rocks, under tree bark and in tree crevices (Williams & Hefner 1928),

and from old rock walls. This species seems to tolerate dry conditions better than most other millipedes in the state.

**Remarks:** Due to its small size, *Polyxenus lagurus* isn't commonly seen, despite its large distribution throughout Arkansas, particularly in the west. While there are no records of the species from the Gulf Coastal Plain, future collecting may find it there. It can be found most easily by leaf litter collection, but checking under tree bark and stones may also reveal specimens, though this method is more time consuming. It has been collected from April through December. *P. lagurus* is reported to feed on lichen and algae (Wright & Westh 2006). The abundance of setae gives millipedes in this order the common name of bristly or pincushion millipedes, and the posterior setal tufts serve a useful function. The posterior setal tufts are modified into hooked bristles, and these are used in defense against ants. The bristles hook onto the setae of ants and serve as adequate defense (Eisner et al. 1996). Unlike most other millipedes in Arkansas, *P. lagurus* lacks chemical defenses; instead it relies on its bristles for defense.

Mating in *P. lagurus* differs markedly from all other Arkansas millipedes. Males do not possess gonopods to transfer sperm to the female. Instead, they deposit sperm onto signal threads on the ground. Adult females find the threads and are led to the sperm, which they take up into their body to fertilize eggs (Hopkin & Read 1992). However, females of this species have been found to be thelytokous (Enghoff 1976), a type of parthenogenesis in which females hatch from unfertilized eggs, and it may be that this is how the species reproduces in Arkansas.

The taxonomy of this species is currently unresolved. Four species of *Polyxenus* are reported from North America (Hoffman 1999), and the main eastern species reported in the literature is *Polyxenus fasciculatus* (Say, 1821). However, in an unpublished dissertation, Kane (1981) found evidence that *P. fasciculatus* may be *P. lagurus*, a species originally described

from Europe. Kane sent some samples of *Polyxenus* from Michigan and Ohio to Henrik Enghoff, who wrote that they were "unquestionable *P. lagurus*" (Enghoff 1976). *P. lagurus* has been reported from New England as well, but since Kane never published his dissertation, no official change to the taxonomy of North American *Polyxenus* has occurred. Based on the preceding information, however, I include Arkansas's *Polyxenus* records as *Polyxenus lagurus*.

**Order Polyzoniida, Family Polyzoniidae:**



**Figure 77. *Petaserpes bikermani***

***Petaserpes bikermani* (Causey, 1951)**

**Sources:** Causey 1951a, Hoffman 1999, Robison & Allen 1995, Shelley 1998

**Description:** 8 mm-16 mm in length, 2 mm in width. *Petaserpes bikermani* superficially appears somewhat slug-like, due to its smooth and shiny appearance. Its legs are concealed under the body, and its head is triangular with two rows of black ocelli. Its color is a dirty-yellow to muted orange, and is lighter laterally.

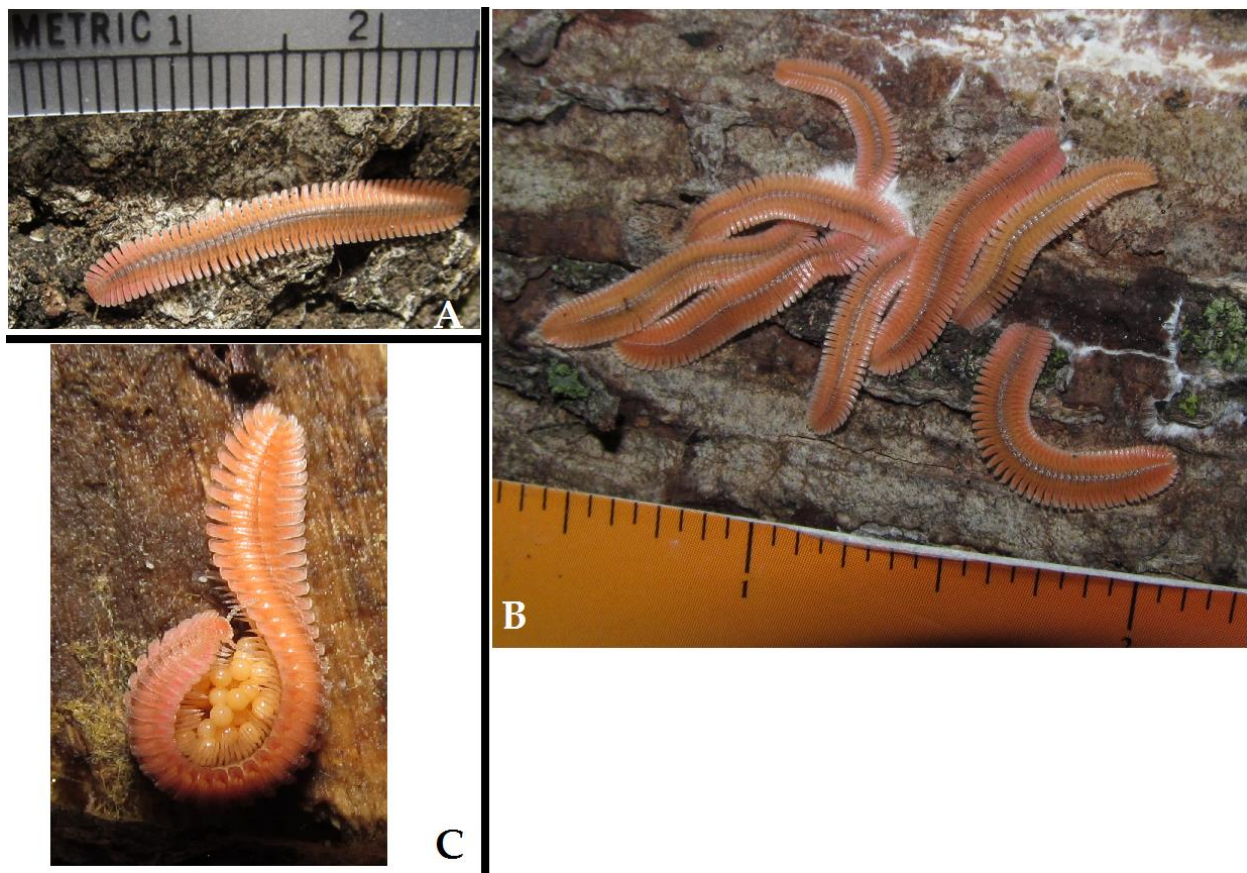
**County Distribution:** Washington, Benton, Carroll. **New Record:** Newton.

**Habitat:** *P. bikermani* has been collected most often from moist leaf litter, but can also be found near moist rocks.

**Remarks:** *P. bikermani* is a slow-moving millipede, which contributes to its slug-like appearance. Indeed, the genus name means "broad creeper" (Shelley 1998). Millipedes in this family are known for the camphor-like smell of their chemical defenses, and *P. bikermani* is no exception. Shelley (1998) even reported that during his field work he was able to smell the millipedes in this genus before seeing them. However, Causey (1951) reported that this species doesn't smell as strongly as the related species *P. rosalbus*.

Causey reported the species from "mixed deciduous woods" in the listed counties, and the type locality is Devil's Den State Park in Washington County. The type individuals were collected in September, and Causey wrote that she collected the species "throughout the year." Fall is probably the best time to collect this species, but Shelley (1998) recorded collections from July and August in Illinois and Indiana. *Petaserpes bikermani* was formerly listed as endemic to Arkansas (Robison & Allen 1995), but has since been found in the southern parts of Missouri, Illinois, and Indiana as well (Shelley 1998). It likely occurs in more counties in Arkansas's Ozark Plateaus.

Order Platydesmida, Family Andrognathidae:



**Figure 78. *Brachygybe lecontii*.** A. Adult, ruler in centimeters. B. Aggregation showing rosette shape, ruler in inches. C. Adult male brooding eggs.

*Brachygybe lecontii* Wood, 1864

**Sources:** Bollman 1888, Gardner 1975, Shelley et al. 2005, McAllister et al. 2003, McAllister & Robison 2013

**Description:** 15 mm-25 mm in length, 3 mm-4 mm in width. *Brachygybe lecontii* is usually pink in color, sometimes with hints of orange or darker shades approaching red. It has paranota, which conceal the legs. Its head is spherical and lacks ocelli.

**County Distribution:** Baxter, Benton, Carroll, Cleburne, Conway, Crawford, Garland, Hot Spring, Independence, Izard, Johnson, Lawrence, Logan, Madison, Marion, Montgomery, Newton, Pike, Polk, Pope, Pulaski, Saline, Scott, Searcy, Sevier, Sharp, Stone, Washington, White

**Habitat:** Under decaying logs in forests.

**Remarks:** *Brachycybe lecontii* is a gregarious species, often found in large groups under logs. It can sometimes be found in leaf litter, usually near areas with dead logs. The logs are normally hardwoods, such as beech, oak, or hickory, but I have also found two specimens beneath dead pine logs in a recently-burned forest in Montgomery County. The association of this species with dead logs is due to its food preferences; the species feeds on fungi that grow in the decaying wood (Gardner 1975).

Gardner (1975) reported that the males exhibit egg brooding behavior (Figure 78C), in which they hold onto the eggs with the legs of their anterior body segments, and use the posterior legs to hold onto the substrate. The life history of *Brachycybe* species remains to be studied (Gardner 1975), but I have observed males brooding eggs in late May in Washington County, and have also seen aggregations of about 25 individuals (both adults and juveniles) at the same time. An interesting behavior of the aggregations of this species is that they tend to form "star clusters" (Gardner 1975), or rosette formations (Figure 78B), with their heads at the center and posterior lengths of the body radiating outward. In my observations, fungi have been at the center of these rosettes, but the exact purpose, whether for feeding, predator defense, or something else, has not been established. The activity period for this species ranges from May to December.



Within Arkansas, *B. lecontii* can be found in the Ozark Plateaus, Arkansas River Valley, Ouachita Mountains, and the western portion of the West Gulf Coastal Plain. *Brachycybe lecontii* and other species in the genus are generally found in upland, hilly areas, but the Coastal Plains may be inadequately collected (Shelley et al. 2005), and could hold new records. This species occurs throughout the eastern US, from Oklahoma and Texas east to Virginia and south to Florida. Shelley et al. (2005) identified five allopatric populations, stating that the species range is fragmented and shrinking, partly due to deforestation.

## **Order Chordeumatida**

### **Families present in the state: Branneriidae, Tingupidae, Cleidogonidae, Trichopetalidae**

The Chordeumatida is one of the most diverse orders of Diplopoda worldwide, and in Arkansas it is represented by 4 families and 14 species. They are generally small millipedes, ranging from 4 mm-25 mm in length, and are white to light brown in color. Adults have 28 or 30 body segments, and most have ocelli, but three cave-adapted species lack ocelli. The Chordeumatida, along with the Polyxenida, lack ozopores and repugnatorial glands (Shear 2015), and so are not chemically defended like other millipedes in the state. The epiproct of these millipedes possesses a pair of spinnerets, which are used to spin a silk-like substance, and the millipedes cocoon themselves within the strands to form a molting chamber (Blower 1985). These spinnerets are also used by females of some species to make a sac for depositing eggs (Shear 2008).

These millipedes are usually smooth-bodied and cylindrical (the families Cleidogonidae and Trichopetalidae), but two species, *Branneria bonoculus* (Branneriidae) and *Tingupa pallida* (Tingupidae), have small ridges on their metatergites and possess paranota. Some species in the

Cleidogonidae and Trichopetalidae have swollen dorsolateral knobs that bear the segmental setae, which may be confused for true paranota at first glance. All Chordeumatida have six tergal setae on each segment, and these setae are sometimes modified: they are ensiform (blade-like) in *B. bonoculus* (Shear 2003a), and in the Trichopetalidae, they are very long, nearly the width of the body.

The Chordeumatida are generally found during the activity periods of most millipedes: during the spring and the fall, with lowered activity during the summer (Shear 1972). Based on my own collecting, adults were found more often in the fall, with juveniles being prevalent during the spring. Winter has been identified as a promising season in which to search for Chordeumatida, especially for the Trichopetalidae (Shear 2003b) and *B. bonoculus* (Shear 2003a). New species have recently been found, even in well-collected areas, by searching for millipedes in the winter (Shear 2003b), and collecting during this season may turn up more species or extended distribution records for the Chordeumatida.

**Family Branneriidae:**



**Figure 79. *Branneria carinata* from Highlands, North Carolina. A. Full body of adult B. Adult, curled up. (This is not the species found in Arkansas, but is representative for the features of the genus.)**

***Branneria bonoculus* Shear, 2003**

**Sources:** McAllister et al. 2009, Shear 1972, Shear 2003a

**Description:** 4.0 mm in length, 0.4 mm in width. *B. bonoculus* is a small, brown millipede with 28 body segments and 11 well-formed ocelli on each side of the head. It has paranota and ensiform segmental setae, and its metatergites are rough with longitudinal ridges.

**County Distribution:** Nevada.

**Habitat:** The only habitat information known for *B. bonoculus* is leaf litter from a deciduous and pine forest in Marion County, Texas (McAllister et al. 2009). The single other species in the family, *B. carinata*, has been collected from Berlese samples of logs and leaf litter (Shear 1972).

**Remarks:** Little is known about the biology of *B. bonoculus*, which was only described in 2003. The collector and precise locality is unknown, being somewhere in Nevada County and collected on 25 February, 1977 (Shear 2003a). It wasn't until 2009 that two more specimens were reported in the literature, a male and a female, collected in Marion County, Texas, on 8 March, 2003 (McAllister et al. 2009). This was the first record of the species from outside Arkansas, and was 145 km from Nevada County (McAllister et al. 2009). More winter collection in Arkansas's southwestern counties should turn up more specimens, and the species may also eventually be found to occur in nearby northern counties of Louisiana as well.

Bollman (1888) lists two species of *Craspedosoma* (= *Branneria*) in Arkansas, *C. flavidum* and *C. carinatum*. *C. flavidum* was reported from Okolona, Clark County, but is currently listed as a name of uncertain status (Chamberlin & Hoffman 1958), and *C. carinatum* was written off as an "undescribed form." Collecting near Okolona for *C. flavidum* and Fourche Bottoms, south of Little Rock, may help clear up these names and determine if they are indeed species of *Branneria*.

**Family Tingupidae:**



**Figure 80.** *Tingupa pallida*, photo by Mike Slay, used with permission.

***Tingupa pallida* Loomis, 1939**

**Sources:** Loomis 1939, Shear 1981, Shear & Hubbard 1998

**Description:** 5 mm-6 mm in length, width not recorded in the literature. *Tingupa pallida* has 30 segments and is unpigmented. It has paranota, and the metatergites have many small, sharp longitudinal ridges which are irregularly distributed. Its segmental setae are slightly clavate.

**County Distribution:** Randolph, Sharp.

**Habitat:** Caves.

**Remarks:** A troglobite, *T. pallida* has been reported from caves in Arkansas, in addition to Missouri and Illinois, where it may be the most common cave millipede (Shear 1981). This is the only species in the genus found in the eastern United States; nine other species are found in the west (Shear & Hubbard 1998).

### Family Cleidogonidae:



**Figure 81.** *Tiganogona alia*, adult male.

### Genera present in the state: *Cleidogona* and *Tiganogona*

The Cleidogonidae is a large family, and two genera with seven species occur in Arkansas. This family lacks the paranota found in the Branneriidae and Tingupidae, but some species may have swollen knobs on the metatergal shoulders that look similar to paranota. These swollen areas bear the segmental setae. In the Cleidogonidae, these setae are unmodified and short. Adults have 30 body segments, and all species have ocelli. These millipedes are generally brown dorsally and white ventrally, and have two white spots dorsally and laterally, which may give the impression of white stripes along the body. They are smooth and cylindrical and can reach lengths up to about 25 mm, quite large for Chordeumatidans. They range throughout eastern North America.

Cleidogonids can be found in leaf litter (often in between layers of leaves, rather than under leaf pack) and under rotten wood. Like most other millipedes, they will usually curl up into a loose spiral, but are more prone to fleeing and can move quickly.

The two genera in Arkansas are indistinguishable without adult males. Their color doesn't vary much and should not be relied upon for identification. Since full body photographs are not instructive for identification, they are omitted for this family (except for Figure 81, above).

Examining the coxae of the posterior gonopods of the males is the simplest way to differentiate the genera: the gonopod coxae of *Tiganogona* have large lobes that interlock with the anterior gonopods, while *Cleidogona* have only weakly lobed coxae that do not interlock with the anterior gonopods. Shear (1972) adeptly revised the genera, but the species *C. arkansana*, *T. ladymani*, and *T. steuartae* were not included in the revision due to the type material not being available, or lost in the mail. These species may prove to be synonyms of other species, but until adult male specimens are collected from the type localities and compared with current species concepts, their status remains valid. Illustrations and identification information for these species are based on their original descriptions, listed under their respective species accounts.

### ***Cleidogona arkansana* Causey, 1954**

**Sources:** Causey 1954, Shear 1972

**Description:** 15 mm long. With characters of the genus. Prefemur of posterior gonopod medially expanded, gonopods as in Figure 7. Causey (1954) likens the gonopods of this species to *Cleidogona fustis*.

**County Distribution:** Dallas

**Habitat:** Usual leaf litter habitats of the family.

**Remarks:** Shear (1972) was unable to include this species in his revision, but based on the original description, notes that it may be a synonym of *C. unita* Causey. As the current taxonomy stands, however, *C. arkansana* is an Arkansas endemic. If it turns out to be a synonym of *C. unita*, it will lose endemic status.

***Cleidogona laminata* Cook & Collins, 1895**

**Sources:** Shear 1972, Causey 1951b

**Description:** 20 mm long, 2.1 mm wide. With characters of the genus. Prefemur of posterior gonopod not expanded, coxa moderately lobed. Gonopods as in Fig. 8.

**County Distribution:** Clay, Dallas, Lawrence, Randolph

**Habitat:** Usual leaf litter habitats of the family, has been collected in March, August, and October.

**Remarks:** The species *C. aspera* Causey, 1951 was synonymized with *C. laminata* (Shear 1972). It has also been collected from Louisiana.

***Tiganogona alia* (Causey, 1951)**

**Sources:** Shear 1972, Causey 1951c



**Description:** 12 mm long, with characters of the genus. Gonopods as in Fig. 9., posterior gonopod telopodite single-segmented, short and spherical.

**County Distribution:** Union, Washington. **New Records:** Conway, Logan

**Habitat:** Usual leaf litter habitats of the family.

**Remarks:** This species has only been collected in the fall and winter in deciduous and mixed pine-hardwood forests. It has also been reported from Louisiana.

***Tiganogona glebosa* (Causey, 1951)**

**Sources:** Causey 1951b, Shear 1972

**Description:** 14 mm-16 mm long, with characters of the genus. Gonopods as in Fig. 10, posterior gonopod telopodite single-segmented, long and thickened.

**County Distribution:** Benton, Johnson, Washington **New Records:** Conway, Newton

**Habitat:** Usual leaf litter habitats of the family.

**Remarks:** This species has been collected in fall and winter from deciduous (oak, beech, umbrella magnolia) and mixed-deciduous habitats (oak, pine). *Tiganogona glebosa* is endemic to Arkansas.

***Tiganogona steuartae* (Causey, 1951)**

**Sources:** Causey 1951c, Shear 1972

**Description:** 13 mm long, 1.3 mm wide, with characters of the genus. Anterior gonopod as in Figure 11. According to the original description, the posterior gonopod telopodite consists of two segments.

**County Distribution:** Sebastian

**Habitat:** Usual leaf litter habitats of the family.

**Remarks:** This species was not included in Shear's revision, as the type specimen was lost in the mail during transit. Collection of topotypic material from near Greenwood, Sebastian County is needed to validate or synonymize the species. As it stands, *T. steuartae* is an Arkansas endemic species.

***Tiganogona moesta* (Causey, 1951)**

**Sources:** Causey 1951b, Causey 1957, Shear 1972

**Description:** 12 mm-15 mm long, with characters of the genus. Gonopods as in Figure 12, posterior gonopod telopodite consisting of three segments, coxae with large triangular lobe mesally.

**County Distribution:** Carroll, Washington **New Record**: Polk

**Habitat:** Moist deciduous or mixed leaf litter.

**Remarks:** This species has been collected in the fall from beech, hickory, and mixed beech-pine litter in moist habitats. It has also been reported from Missouri.

***Tiganogona ladymani* (Causey, 1952)**

**Sources:** Causey 1952a, Shear 1972

**Description:** Width 1.5 mm, with characters of the genus. Gonopods as in Figure 13, posterior gonopod telopodite consisting of 3 segments, coxae with small, complex lobes, lobes simpler than in *T. glebosa*.

**County Distribution:** Clay

**Habitat:** Usual leaf litter habitats of the family.

**Remarks:** This species could not be located at its repository and was not included in Shear's revision. It appears very similar to *T. glebosa*, and collection of new material at the type locality is needed. As it stands, *T. ladymani* is an Arkansas endemic.

**Family Trichopetalidae**

**Genera present in the state:** *Trichopetalum*, *Trigenotyla*, *Causeyella*

The Trichopetalidae ranges across eastern North America (Shear 2003b, 2010), and in Arkansas, five species in three genera are found. The species in this family range from small (4 mm) to medium-sized (13 mm), and are unpigmented to light brown in color. They can be identified by their long segmental setae, which are half the width of the body or longer, giving these millipedes a hairy appearance. They have 28 or 30 body segments, and ocelli can be present or absent. Many can be found in epigeal habitats as well as caves, while some (*Causeyella*) are only found in caves.

Like other Chordeumatida, the Trichopetalidae lack chemical defenses. However, globs of sticky secretions have been observed at the bases of their long hairs (Youngsteadt 2008), which may serve both a defensive and a cleaning purpose. The secretions are carried up the hair shafts, removing debris from the body.

Three of the five Trichopetalid species in Arkansas are endemic to the state, and all can be found in caves (the two endemic *Causeyella* species are limited to caves only).

***Trichopetalum unicum* Cook & Collins, 1895**



**Figure 82. *Trichopetalum unicum*, showing dorsal (top) and lateral (bottom) views.**

**Sources:** Shear 1972, Shear 2010, Causey 1951c

**Description:** 4 mm-7 mm long, body with 28 segments, ocelli present, unpigmented to light brown in color. Gonopods as in Figure 14; with angiocoxite strongly curved posteriorly and cleft apically, with a lateral branch. Gonopod coxae anterior faces covered with trichomes.

**County Distribution:** Logan, Sharp, Washington **New Record:** Newton

**Habitat:** Moist deciduous leaf litter in coves and ravines, also found in caves.

**Remarks:** *T. unicum* is found in caves more common than other *Trichopetalum* species, but may also be found in epigeal habitats during the cooler seasons of the year (Shear 2010). This species is wide-ranging throughout the eastern US, found from Oklahoma to South Carolina and north to Indiana. It replaces *T. lunatum* in the south, but is probably sympatric with it in some northern localities (Shear 2010).

***Trigenotyla parca* Causey, 1951**



**Figure 83. *Trigenotyla parca*, adult male (top), juvenile (bottom)**

**Sources:** Causey 1951b, Shear 1972, 2003b

**Description:** Body with 30 segments, length 6 mm-7 mm, width 1 mm, color light brown to slightly purple. Gonopods as in Figure 15; angiocoxite of gonopod straight and needle-like, without lateral branch, gonopod coxae anterior faces lacking trichomes. Segmental setae set on swollen shoulders.

**County Distribution:** Carroll, Madison, Newton, Washington.

**Habitat:** Caves and moist leaf litter in cooler seasons of the year.

**Remarks:** Most collections of this species have come from caves (Shear 2003b), with epigeal records sparse. The species has also been collected from beech and umbrella magnolia leaf litter

(see appendix A) and from a dead stump covered in oak leaves. Shear (2003b) predicted this species would be found generally throughout northern Arkansas as well as in Oklahoma and Missouri. For now, all records are from Arkansas, making *T. parca* an Arkansas endemic.

### Genus *Causeyella*



**Figure 84.** *Causeyella* sp., adult male. Photo by Mike Slay, used with permission.

Three species of *Causeyella* are known from Arkansas, *C. dendropus*, *C. youngsteadtorum*, and *C. causeyae*. The latter two are endemic, while *C. dendropus* is also known from Missouri. All three species are troglobitic. They lack eyes and are unpigmented to light yellow in color. They are the largest species of Trichopetalidae, ranging from 12 mm-13 mm long, and have 30 body segments.

Each species is separated based on gonopod characters, the body characteristics (Figure 84) are not enough to separate species. Thus, an adult male is needed to positively identify *Causeyella* to species. All species are found in the White River drainage (Shear 2003b). Basic

biological and behavioral information from a laboratory study was reported by Youngsteadt (2008), so far the only notes on the biology of *Causeyella*.

***Causeyella dendropus* (Loomis, 1939)**

**Sources:** Shear 2003b

**Description:** With characters of the genus. Gonopods as in Figure 16; colpocoxite branches of anterior gonopod ending in spiky, hair-like projections; mesal coxite slightly longer than ectal coxite; about 10 setae on each gonopod coxa.

**County Distribution:** Newton

**Habitat:** Caves

**Remarks:** Most records are from north of the White River. Also known from Missouri.

***Causeyella youngsteadtorum* Shear, 2003**

**Sources:** Shear 2003b

**Description:** With characters of the genus. Gonopods as in Figure 17, ectal coxites less than half as long as mesal coxites.

**County Distribution:** Boone, Newton, Searcy

**Habitat:** Caves



**Remarks:** *Causeyella youngsteadtorum* has been found between the White River and the Buffalo River (Shear 2003b). This species is only known from Arkansas.

***Causeyella causeyae* Shear, 2003**

**Sources:** Shear 2003b

**Description:** With characters of the genus. Gonopods as in Figure 18, ectal coxites half as long as mesal coxites, mesal coxite not very spatulate when seen from anterior view.

**County Distribution:** Independence, Izard, Stone

**Habitat:** Caves

**Remarks:** This species is only known from Arkansas.

**Order Callipodida, Family Abacionidae:**

**Genus *Abacion***



**Figure 85. *Abacion* sp., dorsal view (head at top right).**

There are three species of the genus *Abacion* found in Arkansas: *Abacion tessellatum*, *A. texense*, and *A. wilhelminae*. These are the only representatives of the order Callipodida in the state, and can be recognized by their dark brown color with dorsolateral tan stripes running down their bodies, and the conspicuous crests circling the tergites. Species of *Abacion* have 40-62 body segments and range from 25 mm-50 mm in length, always have ocelli, and have ozopores on their tergites. Species of *Abacion* have some of the worst-smelling chemical defenses of all Arkansas millipedes, the main component of their secretions has been found to be *p*-cresol (Shear 2015).

The Abacionidae are widespread and common through the eastern United States, occurring in leaf litter in both dry and moist areas and under rocks, and have been collected from pitfall traps and Malaise traps, and can be found in urban areas. They are active throughout most

of the year. They are very quick for millipedes, and their brown coloration camouflages them in the leaf litter.

Adult males are needed to identify *Abacion* to species, based on the gonopods. Somatic features can, however, be used to identify individuals to the genus level. The three species in Arkansas are sympatric in a few counties, but Polk is the only Arkansas county where all three species occur together.

***Abacion tessellatum* Rafinesque, 1820**

**Sources:** Shelley 1984, McAllister & Robison 2011, McAllister et al 2013

**Description:** With the characters of the genus. Gonopods as in Figure 19; apex of tibiotarsus only weakly curved medially.

**County Distribution:** Benton, Cleburne, Cross, Jefferson, Polk, Pulaski, Stone, White, Union

**New Record:** Newton

**Habitat:** Leaf litter, under rocks and logs.

**Remarks:** *A. tessellatum* occupies a wide range, from Wisconsin to Florida and much of the eastern U.S. in between.

***Abacion texense* (Loomis, 1937)**

**Sources:** Causey 1953, McAllister & Shelley 2010, McAllister et al 2002, 2003, 2013, Youngsteadt & McAllister 2014

**Description:** With the characters of the genus. Gonopods as in Figure 20; proximal branch of postfemur apically blunt.

**County Distribution:** Baxter, Boone, Carroll, Clay, Clark, Conway, Dallas, Drew, Franklin, Garland, Hempstead, Hot Spring, Jefferson, Johnson, Lawrence, Logan, Madison, Marion, Miller, Montgomery, Nevada, Newton, Pike, Polk, Pope, Saline, Scott, Searcy, Washington **New**

**Records:** Howard, Sebastian

**Habitat:** Leaf litter, under rocks and logs.

**Remarks:** This species is common in the central and southern U. S. Youngsteadt & McAllister (2014) includes a photo of the silken molting cocoon this species and other *Abacion* use, a rarely-observed behavior.

***Abacion wilhelminae* Shelley, McAllister, and Hollis 2003**

**Sources:** Shelley et al 2003

**Description:** With the characters of the genus. Gonopods as in Figure 21, smaller than in other *Abacion*; proximal branch of postfemur directed anteriad, tapering to a point.

**County Distribution:** Polk

**Habitat:** Usual habitat for the genus.

**Remarks:** *A. wilhelminae* is so far only known from Rich Mountain in Polk County. It is only reported from Arkansas so far, but may be found in nearby Oklahoma in the future.

**Order Spirostreptida, Family Cambalidae:**



**Figure 86. *Cambala minor*, dorsal view.**

***Cambala minor* Bollman, 1888**

**Sources:** Shelley 1979, Hoffman 1999, McAllister et al 2002, 2003, Thomas et al 2011

**Description:** *Cambala minor* is the only representative of the Spirostreptida known to occur in Arkansas. It's a moderately-sized millipede, about 22 mm long and 1.5 mm wide. The body segments have longitudinal crests (similar to those of *Abacion*), but the crests at the dorsolateral "shoulders" are more rounded. Its body color is a light pink, with a pale brown head. Its eyes are arranged in a linear configuration. Gonopods as in Figure 22.

**County Distribution:** Benton, Clay, Columbia, Garland, Howard, Independence, Lawrence, Little River, Nevada, Ouachita, Polk, Pulaski, Randolph, Stone, Union, Washington

**Habitat:** *C. minor* is troglophilic, and can be found in cave habitats or above ground. It has been collected in wet and dry habitats, such as pine forests and oak-hickory forests (Shelley 1979), and in leaf litter, wet gravel, and even animal dung.

**Remarks:** *C. minor* occurs in the central and eastern U. S. While it is the only *Cambala* reported for Arkansas, the related species *C. ochra* has been found in Texas, Louisiana, and Mississippi, and may be found in Arkansas in the future.

**Order Spirobolida, Family Spirobolidae:**



**Figure 87. *Narceus americanus/annularis* complex, adult male.**

***Narceus americanus/annularis* complex (Palisot de Beauvois, 1817)**

**Sources:** Shelley et al 2006, McAllister & Robison 2011

**Description:** The largest millipede in Arkansas, *N. americanus/annularis* complex reaches lengths up to 120 mm. Its color is gray-black with orange stripes (with variations in both stripe and base color), and its legs and antennae are red. The sidepieces of the gnathochilarium are separated by the mentum (Figure 23), and the median suture on its head extends up from the labium (Figure 24). Gonopods as in Figure 25.

**County Distribution:** (Statewide.) Arkansas, Benton, Calhoun, Conway, Columbia, Craighead, Cross, Desha, Drew, Faulkner, Garland, Greene, Hempstead, Hot Spring, Independence, Izard, Jackson, Jefferson, Lafayette, Lawrence, Lincoln, Little River, Logan, Marion, Montgomery, Miller, Nevada, Ouachita, Pike, Polk, Pope, Pulaski, Saline, Scott, Sevier, Stone, Union, Washington, Yell

**Habitat:** In leaf litter, in dead deciduous logs, moist to dry habitats.

**Remarks:** Shelley et al (2006) recommends the use of "*Narceus americanus/annularis* complex" to refer to species in the genus, which are currently in need of a molecular-based study to sort out the systematics of the group. This species is very large and quite common throughout eastern North America. Its rather large balls of feces will sometimes alert a collector to its presence before the millipede itself is seen, and females coat their eggs in their fecal pellets.

When alarmed, this species will coil into a spiral, and if disturbed, will release a large volume of its chemical defenses. These are harmless to humans, but will stain skin a bright yellow before fading to a deep purple-brown within hours. The stain is visible for a few days after the initial encounter. Individuals of this species can live for over 2 years.

## **Order Julida**

**Families present in the state: Julidae, Blaniulidae, Parajulidae**

The Julida are a diverse group worldwide, and are sometimes known by the common name "snake millipedes," due to their long, thin bodies (long being a relative term for these millipedes). Julida range from darkly colored millipedes (Julidae) to light orange or deep purple



(Parajulidae) to white or light brown (Blaniulidae). They are generally between 10 mm and 50 mm in length.

The family Julidae is not native to North America, and all representatives are introduced from Europe. At least 10 species have been introduced to North America (Hoffman 1999). In Arkansas, only a few species of Julidae have been reported, but there are likely more that have been unknowingly introduced. Julids are quite hardy, and are some of the most common millipedes in urban areas.

The Blaniulidae contains one species native to North America, though other species native to Europe have been introduced to other areas of the United States. Arkansas's only reported Blaniulid is *Virgoiulus minutus*, but it is likely that some European Blaniulidae have been introduced to the state, but not discovered yet.

The Parajulidae is a large and diverse family native to North America that is sorely in need of revision. Dr. Nell Causey (herself having done much millipede work in Arkansas) was working on a revision of the family, but never published it (Hoffman 1999). Only a few revisionary papers on the family have been published, and this group presents many excellent opportunities for study.

### **Family Julidae:**

**Genera present in the state: *Ophiulus*, *Cylindroiulus*, *Brachyiulus***

The introduced Julidae are common in urban and disturbed habitats, and in the case of the former, surviving in areas that would otherwise be too harsh of an environment for most



millipedes. Individuals can often be found in yards or parks in urban areas, hidden within stumps or under leaves or wood. This family ranges in size from 7 mm (*Brachyiulus*) to 40 mm (*Cylindroiulus*), and its species sport dark coloration for the most part. The two species of *Brachyiulus* have light brown longitudinal stripes, making them stand out more than the other Julids.

Locality records for Arkansas are scarce, but this is certainly due to a lack of collecting, rather than the absence of Julidae in most of the state. Searching for these millipedes in cities and towns, as well as disturbed natural habitat, will establish the true distribution of Julidae in the state.

The Julidae can be distinguished from the similar families Blaniulidae and Parajulidae by the body features of both males and females, and conveniently enough, can be identified to genus whether the specimen is a male or female. Julidae have longitudinal striations encircling each trunk segment, and these striations are deeply impressed and obvious. They always have ocelli, and have a caudal projection of the epiproct (usually more pronounced than in the Parajulidae, but *Cylindroiulus* and to a lesser extent, *Brachyiulus*, have weak projections of the epiproct). Males have their first pair of legs modified into hook-like structures.

***Ophiulus pilosus* (Newport, 1843)**



**Figure 88. *Ophiulus pilosus***

**Sources:** Blower 1985, Hoffman 1999

**Description:** 13 mm-30 mm long, mottled brown-purple-black in color, caudal projection of the epiproct obvious, pointed. Setae fringing the body, posterior end of the body particularly hairy. Gonopods as in Fig. 27.

**County Distribution:** *New State Record*: Washington

**Habitat:** Urban areas and disturbed natural habitat, in leaf litter, under rocks and logs.

**Remarks:** This species can be found in much of eastern North America, and has been found as far west as California (Shelley 2002a). Its introduction onto the continent appears to have been very successful, and its true distribution here is still unknown. *O. pilosus* certainly occurs in more counties in Arkansas than presently known, and future collecting will result in many county records.

**Genus *Cylindroiulus***



**Figure 89. *Cylindroiulus* sp., with debris.**

**Sources:** Blower 1985, Hoffman 1999

**Description:** 20 mm-40 mm long, color black with brown caudal metazonal stripes; caudal projection of epiproct small, non-obvious; without setae fringing the body, epiproct and paraprocts with only a few setae. Gonopods as in Fig. 28, gonopod mesomerite associated with promerite.

**County Distribution:** New State Record: Washington

**Habitat:** Urban areas and disturbed natural habitat, in leaf litter, under rocks and logs.

**Remarks:** A juvenile specimen of *Cylindroiulus* was found on the campus of the University of Arkansas in Fayetteville on February 13, 2015, representing the first record of this genus in the state. It was unidentifiable to the species level, but an example gonopod of *C. caeruleocinctus* is given in Fig. 28 to show the general form of the gonopods for this genus. Hoffman (1999) lists six species in the genus that have been introduced to North America, and gonopod illustrations and other identification information for the genus can be found in Blower (1985).

### **Genus *Brachyiulus***



**Figure 90. *Brachyiulus* sp.**

Two species of *Brachyiulus* occur in Arkansas and can only be identified to species based on the gonopods, so adult males are necessary for positive identification. Both species are 7 mm-13 mm long, tan brown with two darker brown longitudinal stripes dorsolaterally, with the caudal projection of epiproct small, and with setae fringing the body and the epiproct and paraprocts moderately hairy. The gonopod mesomerite is associated with the opisthomerite.

*Brachyiulus* is the smallest genus of Julidae in Arkansas, and is a widespread in North America. So far, only *B. pusillus* and *B. lusitanus* are known to be introduced to North America, and Arkansas is the only state with confirmed records of both species (McAllister et al 2003). Like other Julidae, *Brachyiulus* is found in urban areas, and the genus seems to be more likely to be found in stumps and woody debris than other introduced Julids.

***Brachyiulus pusillus* (Leach, 1815)**

**Sources:** Blower 1985, Hoffman 1999, McAllister et al 2003, Verhoeff 1898

**Description:** With the usual characters of the genus. Gonopods as in Fig. 29.

**County Distribution:** Pulaski

**Habitat:** In normal habitats of the genus.

**Remarks:** Literature records and museum specimens labeled as this species may in fact be *B. lusitanus*, as *B. pusillus* was long thought to be the only introduced species in North America (Hoffman 1999). Thus, the actual distribution of this species may be overstated.

***Brachyiulus lusitanus* Verhoeff, 1898**

**Sources:** Blower 1985, Hoffman 1999, McAllister et al 2003, Verhoeff 1898

**Description:** With the usual characters of the genus. Gonopods as in Fig. 30.

**County Distribution:** Pulaski, Sevier **New County Record:** Washington

**Habitat:** In normal habitats of the genus.

**Remarks:** A male individual of *B. lusitanus* was collected crawling on the side of a concrete building along Dickson Street in Fayetteville on April 14, 2015, a new county record. This record makes Washington County the most well-collected county for introduced Julids, as 3 of the 4(?) species are represented.

### Family Blaniulidae



**Figure 91.** *Virgoiulus minutus*, many individuals.

### *Virgoiulus minutus* (Brandt, 1841)

**Sources:** Bollman 1888, Enghoff & Shelley 1979, McAllister et al 2002, 2003, 2005, McAllister & Robison 2011

**Description:** Color a light amber, striations on body segments weak, only reaching to level of ozopores, ocelli arranged into a single line, length less than 10 mm long and about 1 mm wide, male first leg pair short and thick, dissimilar to other legs, with extremely short, microscopic setae fringing body segments. Gonopods as in Fig. 31.

**County Distribution:** Baxter, Bradley, Calhoun, Clark, Craighead, Drew, Hempstead, Lafayette, Lincoln, Logan, Miller, Nevada, Ouachita, Poinsett, Polk, Pope, Pulaski, Scott, Searcy, Sevier, Washington

**Habitat:** Under bark and logs in pine forests, sometimes found in deciduous forests, also in urbanized areas.

**Remarks:** *V. minutus* is the only species in the family Blaniulidae so far reported from Arkansas, but this is likely to change in the future as more collecting is done. Introduced Blaniulids are common in agricultural systems, where they feed on roots and fruits of crops. *V. minutus* is the only known Blaniulid that is native to North America, but was thought to be native to Europe until recently (Enghoff & Shelley 1979, McAllister et al 2005).

Like other species in the family, *V. minutus* is quite small and very thin. It can be identified based on body characteristics, which is fortunate: only two adult males have ever been found and reported in the literature (Enghoff & Shelley 1979). This species is parthenogenetic (McAllister et al 2005), and ranges throughout the eastern United States.



**Family Parajulidae**



**Figure 92. A millipede in the family Parajulidae (Tribe Aniulini) on a human finger.**



**Figure 93. *Aliulus* sp. male, with greatly enlarged first leg pair typical of the family.**

**Genera present in the state: *Ptyoiulus*, *Oriulus*, *Okliulus*, *Aniulus* (*Hakiulus*), *Ethojulus*, *Aliulus***



The Parajulidae is a large and diverse family, and is the dominant component of the North American millipede fauna (Hoffman 1992). Unfortunately, it is poorly understood, despite the amount of material held in collections and its ubiquity in habitats throughout the continent. There are currently about 28 genera recognized (Hoffman 1999) and 125 nominal species (Hoffman 1992), but the true number of species is unknown, due to the taxonomic confusion in the group and the number of undescribed species awaiting discovery. Much of the confusion is due to Chamberlin's lackluster descriptions of new taxa (Hoffman 1992), coupled with the lack of recent published papers on the group. Nell Causey, a millipede specialist who did much of her work in Arkansas, gathered data and specimens while other workers refrained from publishing on the group, but her synthesis and revisions of the group were never produced before her death in 1979 (Hoffman 1992). Causey did, however, establish the current tribal names of the Parajulidae, based on gonopod and somatic characters (Causey 1974).

Cutting through the disorder of the group, Hoffman (1992) published the modern standard for a revision of the family, building upon a quality paper by Mauriès (1972) that provided excellent illustrations and explanations of Parajulid structures. Later papers by Shelley (2000bc, 2001a, 2002b, 2007ab, 2008), Shelley & Medrano (2006), and McAllister et al (2009) have built the foundations for a modern study of the group, and it is as good of a time as it has ever been for interested students to tackle the group and make meaningful (and exceedingly useful) contributions. Much work remains to be done on the taxonomy, ecology, and basic biology of the Parajulidae. With specimens easily collectable across the continent, ample opportunities for scientific advances await.

The Parajulidae inhabit a wide swath of North America, stretching from southern Alaska down to Guatemala, and one species is known from Asia (Causey 1974). They are the largest

Julida in the eastern United States, and can be identified by the weak longitudinal striations on their body segments that reach the level of the ozopores, an epiproct with a small caudal projection (though in some other tribes outside Arkansas the epiproct is strongly decurved), and the presence of ocelli in a triangular pattern. They can reach lengths of about 50 mm, separating them from the smaller Blaniulidae, and the first leg pair of males are greatly enlarged, which helps them hold onto the female during mating (Fig. 93).

Nine species of Parajulid are known from Arkansas, and this number is sure to change in the future as the group is revised and more collecting is done. Bollman (1888) lists the species *Parajulus caesius* in his preliminary checklist of the state's species, but this species is of uncertain status (Hoffman 1999) and its true identity is unknown, so it is not included in this study. There are two tribes in the state: Aniulini (8 species) and Ptyoiulini (1 species). The Aniulini are all similar in color, being a light orange to tan with various darker spots along the body (Fig. 92). Due to this, photos are not given of each species. The Ptyoiulini are generally a deep purple and differ in a few somatic characters.

The Parajulidae in Arkansas can survive in many different habitats, ranging from dry and mesic forests to meadow or prairie-type habitats, and can be found in leaf litter and under logs, and sometimes even climbing or descending trees at night. Their tolerance for a wide variety of habitats makes them ubiquitous throughout the state. When first uncovered, Parajulids will curl up for a short time before wandering away. If grabbed or otherwise disturbed, they may run away or exude their defensive chemicals, which can stain skin. If picked up, they will rotate the anterior end of their bodies alarmingly quickly in a snake-like manner, though their only defense against humans is slightly scraping the skin, which feels like a small pinch. Despite this, the

defensive behavior can be a bit frightening, if for no other reason than because such agility isn't normally associated with millipedes.

Since so much work still remains to be done with the Arkansas Parajulidae, the associated couplets of the key and accompanying illustrations should be read with a critical mindset. In most cases, gonopod illustrations have been reproduced from their original description, and the genera *Ptyoiulus*, *Okliulus*, *Ethojulus*, and *Aliulus* remain to be adequately revised, and may prove to be synonyms of other genera. It is fully expected that nomenclature in this group will change in the future--a good indication by then that our knowledge of the Parajulidae has expanded. For now, this section serves as a useful summary of the current knowledge of the Arkansas Parajulidae.

**Subfamily Ptyoiulinae, Tribe Ptyoiulini:**



**Figure 94. *Ptyoiulus coveanus*, adult male.**

***Ptyoiulus coveanus* Chamberlin, 1943**

**Sources:** Causey 1952, 1974, Chamberlin 1943, Hoffman 1999, Filka & Shelley 1980

**Description:** Dark purple in color, with mottled darker and lighter spots along the body. Length about 32 mm and width 2 mm. Body moderately setaceous, becoming quite hairy at the caudal end of the body and on the epiproct and paraprocts. Caudal projection of epiproct small.

Gonopods as in Fig. 32.

**County Distribution:** *New State Record*: Greene

**Habitat:** Oak litter, mixed pine-deciduous litter, around logs.

**Remarks:** The genus *Ptyoiulus* is known from various states in the eastern U. S. (Alabama, Georgia, Illinois, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee), but its true distribution is unknown, due to the confusing taxonomic history of the genus, similar to other Parajulidae. The gonopods of the specimens collected on March 29, 2014 from Crowley's Ridge agree with the illustrations given by Chamberlin (1943) and Filka & Shelley (1980) (reported by them as *P. ectenes*), in which the lateral syncoxal process of the anterior gonopods forms a calyx distally. *P. ectenes* Bollman was removed from the genus and is not a valid species of *Ptyoiulus* (Hoffman 1999). This record of *P. coveanus* extends the range of the species dramatically, as the closest locality in the literature is Gallatin Co., IL, about 260 km away (Causey 1952).

The unique geographic history of Crowley's Ridge most likely restricts *P. coveanus* to areas along the ridge, a similar pattern to *Euryurus leachii*. Crowley's Ridge used to be on the eastern side of the Mississippi River, but the river's flow changed, putting the ridge west of the river, which formed a barrier to biotic exchange (Robison & Allen 1995). This barrier trapped some species on Crowley's Ridge, which is surrounded by the Gulf Coastal Plain.

The hairiness of this Parajulid allows all individuals except very young juveniles to be identified to genus based on body characters, easily separating it from all other Parajulids in the state. Additionally, the gonopods of the male are dramatically different from the Aniuline species.

### **Subfamily Parajulinae, Tribe Aniulini**

The eight other Parajulid species in Arkansas are representatives of the tribe Aniulini, which are only sparsely hairy at the caudal end of the body, usually a light tan or orange color, have anterior gonopods that are more curving and do not have a calyx, and have slightly stronger caudal projections of the epiproct, separating them from *Ptyoiulus*. They can be found throughout the state, and the gonopods of some taxa are quite similar and difficult to separate, possibly hinting at synonymies awaiting revision.

#### ***Oriulus venustus* (Wood, 1864)**

**Sources:** Causey 1950, McAllister et al 2003, 2013, Shelley 2002b

**Description:** With the characters of the tribe. 19 mm-30 mm long (Causey 1950, Shelley 2002b), 1.5 mm-2.5 mm wide, 48-54 segments. Gonopods as in Fig. 33.

**County Distribution:** Baxter, Benton, Calhoun, Clay, Craighead, Drew, Monroe, Prairie, Pulaski, Union, Washington

**Habitat:** Usual habitats for the family, wide range: leaf litter to under rocks, sometimes found inside buildings.

**Remarks:** *O. venustus* is the most widely distributed Parajulid in North America, found in 3/4 of the continental U.S. and Canada (Shelley 2002b). Causey (1950) records this species as *O. grayi*, but this name was later synonymized (Shelley 2002b).

### **Genus *Okliulus***

The genus *Okliulus* contains two species in Arkansas: *O. beveli* and *O. carpenteri*. It still awaits revision.

#### ***Okliulus beveli* Causey, 1953**

**Sources:** Causey 1953

**Description:** With the characters of the tribe. 42 mm long, 3.1 mm wide, 56 body segments.

Male first leg pair thicker than those of *O. carpenteri*. Gonopods as in Fig. 34.

**County Distribution:** Union

**Habitat:** Usual habitats for the family.

**Remarks:** This species is only known from Arkansas.

#### ***Okliulus carpenteri* Causey, 1950**

**Sources:** Causey 1950a, 1953, Hoffman 1999, McAllister et al 2013

**Description:** With the characters of the tribe. Gonopods as in Fig. 35.

**County Distribution:** Drew, Sebastian

**Habitat:** Typical habitats for the family.

**Remarks:** This species was originally described from Latimer Co., Oklahoma, and has been found in central and southeastern Arkansas. It has been collected in October and November.

***Genus Aniulus (Hakiulus)***

*Hakiulus* was formerly thought to be its own genus, but was revised to subgeneric status by Shelley in his revision (Shelley 2000b). Thus, *Aniulus (Hakiulus)* is one of the few groups of Parajulidae that has been adequately revised and can be confidently identified. Two species occur in Arkansas, *A. (H.) diversifrons diversifrons* and *A. (H.) amophor*. They can be recognized by the presence of a distal spur on the posterior gonopod telopodite and by the syncoxal lobes on the anterior gonopods. Millipedes in the subgenus have 50-55 body segments as adults and a light longitudinal stripe with a narrow dark line along the body. There are eight described species, ranging from the central U. S. to Michigan and Ohio. Texas is the center of diversity for this subgenus.

McAllister et al (2002) reports a possible unknown species of *Aniulus (Hakiulus)* from Miller County, collected during February. They report it as having a strongly pointed epiproct unlike other species in the subgenus, but more specimens need to be collected in order to formally describe the species.

***Aniulus (Hakiulus) diversifrons diversifrons (Wood, 1865)***

**Sources:** McAllister et al 2002a, Shelley 2000b

**Description:** With characters of the subgenus. Gonopods as in Fig. 36. Posterior gonopod telopodite described as having the shape of a "swan-neck" (Shelley 2000b).

**County Distribution:** Izard, Johnson, Little River, Sebastian, Washington

**Habitat:** In habitats typical of the tribe.

**Remarks:** A very widespread species, *A. (H.) d. diversifrons* can be found from Texas to Ohio.

***Aniulus (Hakiulus) amophor* (Chamberlin, 1940)**

**Sources:** McAllister & Robison 2009, Shelley 2000b

**Description:** With characters of the subgenus. Gonopods as in Fig. 37.

**County Distribution:** Union

**Habitat:** Under leaves and logs, in oak logs (Shelley 2000b), urban areas (McAllister & Robison 2009)

**Remarks:** This species has only been collected in Arkansas once, caught in a pitfall trap in an urban yard. More collecting in southern Arkansas may turn up additional specimens and county records. The closest known collected individual was from Jasper, Texas, 365 km away (McAllister & Robison 2009), a sizeable gap.

***Ethojulus illinoensis* (Causey, 1950)**

**Sources:** Causey 1950a, 1952b, Hoffman 1999



**Description:** With characters of the tribe. Gonopods as in Fig. 38.

**County Distribution:** Jefferson, Yell; northwest Arkansas (Hoffman 1999)

**Habitat:** "From wet debris" near a spring (Causey 1950a); in typical habitats of the tribe.

**Remarks:** Hoffman (1999) reported this species from northwest Arkansas, but did not list any specific localities. This species was first described from Illinois.

McAllister et al (2013) report an undescribed species in this genus from Columbia and Union Counties. This genus has not undergone any revision.

### **Genus *Aliulus***

Based on my own collecting, *Aliulus* seems to be one of the most common Parajulid genera in Arkansas. There are two species in the state, *A. caddoensis* and *A. carrollus*. The third species in the genus, *A. rugosus*, ranges from Illinois to Pennsylvania. This genus awaits revision.

### ***Aliulus caddoensis* Causey, 1950**

**Sources:** Causey 1950a, 1953, Hoffman 1999, Robison et al 2008; McAllister & Robison 2011, McAllister et al 2003

**Description:** With characters of the tribe. Adults with about 58 segments, 42 mm long, 2.2 mm wide. Gonopods as in Fig. 39.

**County Distribution:** Dallas, Howard, Pike, Polk, Sebastian, Sevier, Scott

**Habitat:** Typical habitat of the tribe. I have collected this species from oak-hickory forest.

**Remarks:** This species has usually been collected during the fall. It is also known from Oklahoma. Based on the collection localities, this species range is within the Ouachita Mountains and surrounding prairie ecosystems (McAllister et al 2003). However, the gonopods are very similar to those of *A. carrollus*, and the two species may be synonymous (McAllister & Robison 2011).

***Aliulus carrollus* Causey, 1950**

**Sources:** Causey 1950a, 1953

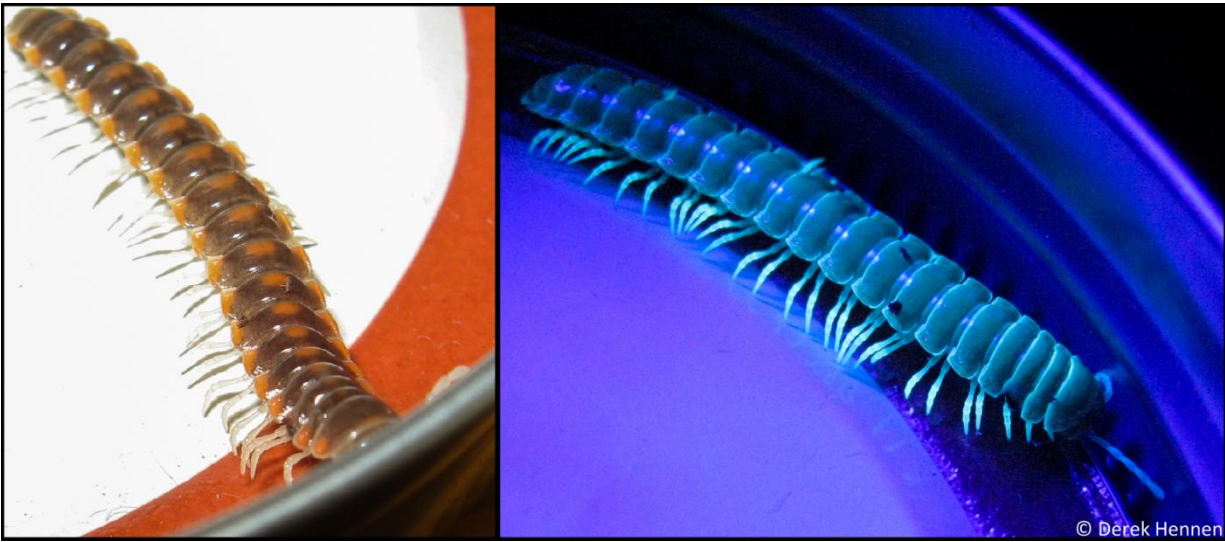
**Description:** With characters of the tribe. Adult with 60 body segments, 48 mm long, 2.4 mm wide. Gonopods as in Fig. 40.

**County Distribution:** Benton, Carroll, Searcy, Washington **New County Record:** Newton

**Habitat:** Typical habitat of the tribe.

**Remarks:** This species is only known from Arkansas. As noted in the species account of *Aliulus caddoensis*, the two species may be synonyms.

## Order Polydesmida



**Figure 95. *Auturus evides*: under visible light (left), under ultraviolet light (right).**

**Families present in the state: Paradoxosomatidae, Sphaeriodesmidae, Euryuridae, Trichopolydesmidae, Polydesmidae, Xystodesmidae, Eurymerodesmidae**

Worldwide, the Polydesmida (commonly known as flat-backed millipedes) is the largest order of millipedes, and its diversity in Arkansas reflects this. In Arkansas, 31 of the 68 millipede species are in this order, and they represent all families found in eastern North America except one (Pyrgodesmidae). The Polydesmida can be found in many different habitats, including urban yards, caves, mesic deciduous forests, and dry pine forests. All Polydesmida are blind and lack ocelli. Adults have either 19 or 20 segments, and males have their 8th pair of legs modified into gonopods. All possess paranota, lateral or dorso-lateral extensions of the metazonite, that assist the millipedes' movement by wedging themselves through dirt or decaying wood. The paranota also possess the openings of the ozopores, from which the Polydesmida exude their chemical defenses. Many species excrete hydrogen cyanide (Shear 2015) and sport

bright warning coloration to advertise their potent chemical defenses. The amount of cyanide they give off is not dangerous to humans, but it is enough to ward off other would-be predators. Some species also secrete benzaldehyde, which make them smell something like maraschino cherries or almonds.

The Polydesmida is the most charismatic order of millipedes in Arkansas, and certainly has the most aesthetically pleasing colors. The Xystodesmidae in particular are quite beautiful, and large enough to be appreciated with the unaided eye. Interestingly enough, the Euryuridae, Eurymerodesmidae, and to a lesser extent, the Xystodesmidae, all contain species that fluoresce under ultraviolet light. The entire body of Euryurid and Eurymerodesmid millipedes glow a brilliant blue-green color, and the ventral half and legs of Xystodesmids (and in some tribes, the entire body) glow as well. With the aid of a portable UV flashlight, collecting fluorescent Polydesmida at night becomes quite simple, and will usually turn up more individuals than would be collected during daylight hours.

**Family Paradoxosomatidae**



**Figure 96. *Oxidus gracilis***

***Oxidus gracilis* (C. L. Koch, 1847)**

**Sources:** Hoffman 1999, McAllister et al 2002a, 2003, Thomas et al 2011

**Description:** Tergites of body with a transverse groove, mid-body paranota slightly blunt and rounded, body light to dark brown with pale yellow paranota. Gonopods as in Fig. 41, gonopodal socket constricted between the gonopods. About 20 mm long, 2 mm wide.

**County Distribution:** Columbia, Independence, Lafayette, Miller, Stone **New County Records:**  
Benton, Carroll, Ouachita, Washington

**Habitat:** Urban areas, edges of disturbed forests, caves

**Remarks:** *O. gracilis* is an introduced species from Asia, commonly known as the greenhouse millipede. It occurs throughout the United States, and is sometimes an unwelcome guest in homes. When one is found, there are often more around, and they're usually mating. Though

records for this species in Arkansas are scarce, it can be assumed to be established throughout most of the state. This is Arkansas's only Paradoxosomatid, but other species in the family have been introduced to California and states along the Gulf Coast.

#### **Family Sphaeriodesmidae**



**Figure 97. *Desmonus pudicus*, female (top) and male (bottom)**

***Desmonus pudicus* (Bollman, 1888)**

**Sources:** Bollman 1888, McAllister et al 2003, Shelley 2000d

**Description:** Body segments distinctly arched, paranota oriented almost vertical, those of segments 2-4 enlarged, epiproct enlarged, body cream-colored, but usually covered in dirt and debris, metatergites of segments 5-19 with raised bumps. About 7 mm long and 2 mm wide.

Gonopods as in Fig. 42.

**County Distribution:** Benton, Carroll, Clark, Columbia, Conway, Hempstead, Johnson, Newton, Pike, Polk, Pulaski, Sebastian, Sevier, Washington **New County Records:** Logan, Scott

**Habitat:** Mesic forests, in leaf litter (beech, hickory, oak, umbrella magnolia), in tree holes, and under logs.

**Remarks:** *Desmonus pudicus* is one of the northernmost representatives of the Sphaeriodesmidae, a family with most of its diversity in the tropics. True to the family name, *D. pudicus* can roll up, forming a flat disk rather than a loose sphere like the rest of the state's millipedes. It is able to protect itself by covering its head and legs with its modified anterior and posterior segments. *Desmonus* have been referred to as pill millipedes, but this name is more often used for millipedes in the order Glomerida.

This species is quite small, only about 7 mm long (males are slightly smaller than females), and appears even smaller when curled up, making it difficult to find. Its coating of dirt and other debris functions as excellent camouflage, helping it blend into the leaf litter habitats it lives in. Thus, it is most easily collected by processing leaf litter through a Berlese funnel. *Desmonus pudicus* also occurs in Missouri, Oklahoma, Louisiana, and Texas, and a related species, *D. earlei*, lives in the Appalachians.



## Family Euryuridae

Genera present in the state: *Euryurus*, *Auturus*



**Figure 98.** *Auturus louisianus louisianus*

The Euryuridae is one of the prettiest millipede families in Arkansas: its species have a dark brown dorsum with a trimaculate pattern of three orange-red spots: one on each paranotum and one middorsal spot. Their legs and antennae are a pale off-white color. Three species are known in the state, *Euryurus leachii*, *Auturus evides*, and *Auturus louisianus louisianus*, and each one has the same color pattern. They are 31 mm-34 mm in length and 3.5 mm-5 mm wide, and are distinguished from each other based on the male gonopods. Additionally, *Auturus* females can be separated from *Euryurus* based on the distal excavation of the valve of the cyphopods (*Euryurus* lacks this excavation) (Hoffman 1978).

There are two genera in the Euryuridae: *Auturus* Chamberlin, 1942 (4 species) and *Euryurus* Koch, 1847 (8 species), along with a monotypic genus of uncertain validity (Shelley et



al 2012), *Illiniurus. Auturus* is generally found from the north-central United States towards the southeastern portion of the country, and *Euryurus* occupies the northeast and southwest to the Mississippi River. Members of the Euryuridae are easily distinguished from other families based on their shared color pattern and their squared-off epiproct (Fig. 43a), instead of the triangle-shaped epiproct of the other families in Arkansas. Euryurids are almost always found either under the bark of dead, moist hardwood logs or nearby. They are almost never found in association with pine logs (though similar-looking Eurymerodesmids sometimes are), and are some of the few millipedes that one can set off to find and be successful, due to their strong habitat association.

Euryurid chemical defenses involve hydrogen cyanide and benzaldehyde, and smell reminiscent of maraschino cherries or almonds. As seen in Fig. 95, Euryurids fluoresce under ultraviolet light, making them easy to find and collect at night.

***Euryurus leachii* (Gray, 1832)**

**Sources:** Shelley et al 2012, Hoffman 1978, 1999

**Description:** With the characters of the family. Gonopods as in Fig. 44, telopodite ending in a forked projection.

**County Distribution:** Cross, Lee, Phillips, Poinsett

**Habitat:** Moist and decaying hardwood logs. It has also been found in a few caves in Indiana and Ohio.

**Remarks:** In Arkansas, *Euryurus leachii* is only found along Crowley's Ridge (*Auturus evides* also occurs there). It's the only site west of the Mississippi River where *E. leachii* is found, possibly as a remnant from before the Mississippi River took its present course (Shelley et al 2012). The individuals in Arkansas are intermediate between the two subspecies (Shelley et al 2012). *E. leachii* is commonly found in the central and eastern United States (Hoffman 1999).

### **Genus *Auturus***

*Auturus* is the more common Euryurid genus in the state, occurring widely throughout Arkansas. It can be separated from *Euryurus* based on the male gonopods: in *Auturus*, the acropodite of the gonopod ends in a cup-like structure (referred to by Shelley 1982 as the calyx) instead of the fork of *Euryurus*. *Auturus evides* is found north of the Arkansas River, and *A. louisianus louisianus* is found south of the Arkansas River.

Most species of *Auturus* are found generally west of the Mississippi River, from Minnesota south through Mississippi, but a disjunct species (*A. erythropygos*) occupies an area from North Carolina to Florida (Hoffman 1978). This distributional pattern is somewhat similar to that of the Xystodesmid genus *Boraria*, which has three Appalachian species and one (*B. profuga*) in the Interior Highlands of Arkansas.

### ***Auturus evides* (Bollman, 1887)**

**Sources:** McAllister et al 2013, Shelley 1982

**Description:** With the characters of the family. Gonopods as in Fig. 45, calyx opening directed anteriad.

**County Distribution:** Arkansas, Benton, Cleburne, Craighead, Crawford, Cross, Franklin, Fulton, Independence, Izard, Jefferson, Johnson, Lawrence, Madison, Marion, Newton, Poinsett, Pulaski, Searcy, Stone, Washington, White

**Habitat:** In typical habitats of the genus: moist hardwood logs (oak, beech, etc.).

**Remarks:** This species is found mostly in northern Arkansas, and all records are from north of the Arkansas River. Its distribution extends north to Minnesota. *Auturus evides* is often found in caves and is the only cave-associated species in the genus.

***Auturus louisianus louisianus* (Chamberlin, 1918)**

**Sources:** McAllister et al 2013, McAllister & Robison 2011, Shelley 1982

**Description:** With the characters of the family. Gonopods as in Fig. 46, with calyx opening directed sublaterad.

**County Distribution:** Clark, Columbia, Conway, Drew, Garland, Hot Springs, Logan, Montgomery, Nevada, Pike, Polk, Scott, Sevier

**Habitat:** In typical habitat of the genus.

**Remarks:** This species is found in central and southern Arkansas, and all records are from south of the Arkansas River. *Auturus louisianus louisianus* extends its range south to Louisiana and Mississippi.

**Family Trichopolydesmidae (formerly Macrosternodesmidae)**



**Figure 99. *Chaetaspis attenuatus*. Photo by David Thomas, used with permission.**

**Genus *Chaetaspis***

The Macrosternodesmidae was recently classified as a synonym of the Trichopolydesmidae (Golovatch 2013), along with another family in eastern North America, the Nearctodesmidae. Useful discussion about the family's gonopod anatomy and terminology can be found in Shelley 1994 and Shear & Shelley 2007. This family includes small Polydesmidan millipedes, which in the case of Arkansas's species, are small and colorless (Fig. 77). *Chaetaspis* is the only genus found in Arkansas, with two species: *C. albus* and *C. attenuatus*. The former is found in soil and leaf litter habitats, while the latter is found in caves (Lewis & Slay 2013).

*Chaetaspis* can be recognized by having 20 body segments, with transverse rows of polygonal areas on the metatergites, and having a ridge above the bases of the legs on the metazonite (Fig. 47). Its two species are a maximum of about 8 mm long. They are known from Independence, Izard, and Pulaski Counties, and unidentifiable individuals have been found in

Marion and Stone Counties (Lewis & Slay 2013). Another species, *C. aleyorum* is known from nearby Taney County, Missouri, and may eventually be found in Arkansas.

***Chaetaspis albus* Bollman, 1887**

**Sources:** Bollman 1888, Hoffman 1999, Lewis 2002, Lewis & Slay 2013

**Description:** With characters of the genus. Gonopods as in Fig. 48.

**County Distribution:** Pulaski

**Habitat:** A deep soil species found often in karst terrain, collected from leaf litter in deciduous forests. Not reported from caves, though has been found near springs and rockhouses (Lewis 2002).

**Remarks:** Only Bollman's record from Little Rock is known for the distribution of the species in Arkansas (Bollman 1888). It is also known from Alabama, Indiana, Kentucky, Mississippi, Missouri, Tennessee, and Virginia.

***Chaetaspis attenuatus* Lewis & Slay, 2013**

**Sources:** Lewis & Slay 2013

**Description:** With characters of the genus. 5.3 mm-6.5 mm long, 0.45 mm-0.55 mm wide, unpigmented, white in appearance. Gonopods as in Fig. 49.

**County Distribution:** Independence, Izard

**Habitat:** Dark zones of caves, under rocks, leaf litter, woody debris.

**Remarks:** *Chaetaspis attenuatus* is currently known only from limestone caves in northeastern Arkansas.

## **Family Polydesmidae**

**Genera present in the state:** *Scytonotus*, *Polydesmus*, *Pseudopolydesmus*

The Polydesmidae is a common family in Arkansas and throughout North America. Its member species have 19 or 20 body segments, range in length from 7 mm-32 mm, and are pink to red in color. *Pseudopolydesmus* and *Scytonotus* are native to North America, but *Polydesmus* is an introduced genus from Europe.

Polydesmids are general in their habitat preferences and more tolerant of low quality habitats, being found in both dry and moist habitats, in leaf litter and under woody debris, and in more urbanized areas.

***Scytonotus granulatus* (Say, 1821)**



**Figure 100. *Scytonotus granulatus***

**Sources:** Hoffman 1962, Shelley 1993, Shelley et al 2005

**Description:** Body with 19 segments, 7 mm-20 mm long, tergites with tubercles bearing setae, giving it a fuzzy appearance. Gonopods as in Fig. 50.

**County Distribution:** Craighead, Independence, Logan **New County Record:** Polk

**Habitat:** Moist leaf litter, under logs.

**Remarks:** *Scytonotus granulatus* is common in the eastern United States, and with more collecting can be expected to be found in additional counties in central and northern Arkansas. This species is the state's smallest Polydesmid, and can easily be identified by its velvety appearance, due to small tubercles bearing setae on its tergites.

### **Genus *Polydesmus***

**Sources:** Blower 1985, Hoffman 1999

**Description:** This genus can have 19 or 20 segments (depending on the species), and is usually smaller than *Pseudopolydesmus*, from 10 mm-25 mm long. The polygonal areas on the tergites are more distinct and pronounced than in *Pseudopolydesmus*. Gonopods similar to Fig. 51.

**County Distribution:** Not yet reported in Arkansas.

**Habitat:** Urbanized and disturbed habitats

**Remarks:** This genus has not yet been reported from Arkansas, but it surely occurs in urban areas and surrounding disturbed habitats. Hoffman (1999) lists five species of *Polydesmus* introduced to North America, in the key the gonopod of *P. inconstans* is given as an example for the genus. Notes on biology and identification of species can be found in Blower (1985).

**Genus *Pseudopolydesmus***



**Figure 101. *Pseudopolydesmus* sp., scale in millimeters.**

*Pseudopolydesmus* is a genus of moderately large, pink millipedes, which are the most common Polydesmids in the state. Its members have the widest tolerance for habitats in the state and are found in both moist and dry habitats, usually in numbers. Three species are known from Arkansas: *P. pinetorum*, *P. minor*, and *P. serratus*. They are distinguished from *Polydesmus* by their smoother tergites with less distinct polygonal areas, adults have 20 body segments, and their gonopods are simpler, thin, and finger-like with triangular processes. The arrangement and presence of certain processes distinguish the species from each other. The genus has a confused taxonomic history, and though a revision was done (Withrow 1988), it is an unpublished Ph. D. thesis. Thus, it is not official and a new (published) revision is needed.



***Pseudopolydesmus pinetorum* (Bollman, 1888)**

**Sources:** Causey 1952c, Hoffman 1999, McAllister et al 2002, 2003, 2013, Shelley & Snyder 2012

**Description:** Epiproct curved slightly downward, 11 mm-27 mm long. Gonopods as in Fig. 52, with processes M1, M3, M4, E2, and E3, gonopod coxae without prominent lateral lobes.

**County Distribution:** Arkansas, Baxter, Benton, Clark, Clay, Columbia, Craighead, Dallas, Drew, Faulkner, Franklin, Fulton, Garland, Greene, Hempstead, Hot Spring, Independence, Izard, Johnson, Lafayette, Lee, Lincoln, Little River, Miller, Montgomery, Nevada, Ouachita, Polk, Pope, Pulaski, Searcy, Sevier, Sharp, Washington, White, Yell. **New County Records:** Madison, Newton.

**Habitat:** Usual habitat for the genus.

**Remarks:** This is the most common species of *Pseudopolydesmus* in Arkansas. It can be as large as 27 mm, but is usually around 19 mm long (Causey 1952c). Its range includes the south-central United States.

***Pseudopolydesmus minor* (Bollman, 1887)**

**Sources:** Hoffman 1999, Loomis 1953, McAllister et al 2002, 2013

**Description:** Usually small, 9 mm-14 mm. Gonopods as in Fig. 53, with processes M1, M2, M3, and E2 and E4. Hypoproct normal.

**County Distribution:** Lafayette, Lee, Pulaski

**Habitat:** Usual habitat for the genus.

**Remarks:** *Pseudopolydesmus minor* is the smallest species of *Pseudopolydesmus* in Arkansas, and less commonly found than *P. pinetorum*. It is also reported from Tennessee and Illinois.

***Pseudopolydesmus serratus* (Say, 1821)**

**Sources:** Hoffman 1999, McAllister et al 2003, 2013, Shelley & Snyder 2012

**Description:** Usually larger, 13 mm-32 mm long. Hypoproct bilobed or trilobed. Gonopods as in Fig. 54, with processes M1, M2, E2, and E4.

**County Distribution:** Craighead, Jefferson, Nevada, Phillips, Poinsett, Pulaski

**Habitat:** Usual habitat for the genus.

**Remarks:** This species occurs widely throughout the eastern U. S., and is only found sporadically west of the Mississippi River. It is the largest species of *Pseudopolydesmus*.

**Family Xystodesmidae**

**Genera present in the state:** *Mimuloria*, *Apheloria*, *Pachydesmus*, *Thrinaxoria*, *Pleuroloma*, *Boraria*

The Xystodesmidae is one of the largest and most well-studied millipede families in North America. Many revisions of its genera have been published since the 1980s, clearing up much confusion that has historically been associated with the group. Despite this, much work remains to be done, both taxonomically and ecologically.

Xystodesmids are usually large-bodied millipedes, ranging from 20 mm-75 mm long. Their leg prefemora have distal spines, their gonopodal apertures are unmodified, and the base color of their tergites is usually black with paranota red, yellow, or pink. They sometimes have metatergal stripes, have potent chemical defenses of hydrogen cyanide, which are advertised via their aposematic warning coloration. Individuals are usually found in moist areas under leaf litter. They are most often found in deciduous forests, but sometimes occur in mixed forests as well. Collecting methods targeting this family of millipedes can be found in Means et al (2015).

The Xystodesmidae has its center of diversity in the Appalachian Mountains, and another diverse assemblage of its species can be found in California. The Californian genus *Motyxia* contains all of North America's bioluminescent millipede species, which luminesce as an aposematic warning to predators (Marek & Moore 2015). Many other species in the Xystodesmidae fluoresce under ultraviolet light, but this phenomenon has not been well-studied (Korsós et al 2011).

**Tribe Nannariini, Genus *Mimuloria***



**Figure 102. *Mimuloria castanea***

The Tribe Nannariini currently contains three genera: *Mimuloria*, *Nannaria*, and *Oenomaea*. *Mimuloria* was recently revalidated as a genus with 5 species (Hennen & Shelley 2015), *Nannaria* has 22 named species, with more undescribed species in museum collections awaiting descriptions, and *Oenomaea* has 1 species. The tribe can be found from Arkansas east to New York and south to Georgia. The Nannariini is the least well-known tribe of eastern Xystodesmidae.

In Arkansas, two species are known: *Mimuloria castanea* and *M. davidcauseyi*, both from northern Arkansas. They can be separated from other Xystodesmids by having midbody sterna with caudally projecting spines, broad and spatulate male pregonopodal tarsal claws, which are usually twisted. They are chestnut brown with pinkish orange paranota, and are relatively small, from 20 mm-25 mm. *Mimuloria* are found in moist leaf litter habitats, especially around streams. They usually are not very numerous when found.

***Mimuloria castanea* (McNeill, 1887)**

**Sources:** Causey 1950c, 1952c, Hennen & Shelley 2015, Hoffman 1999

**Description:** With characters of the genus. Gonopods as in Fig. 55, acropodite strongly curving mediad, projection of prefemoral process short.

**County Distribution:** Carroll, Searcy, Stone

**Habitat:** In typical habitat of the genus, oak-hickory forests.

**Remarks:** This species was described as *Castanaria depalmai* (Causey 1950c) and thought to be endemic to Arkansas, but recently was synonymized with *Mimuloria castanea*, a species also

found in Missouri, Tennessee, and Indiana. The possible new species of *Nannaria* listed by McAllister et al (2013) from Searcy County was found to be this species.

***Mimuloria davidcauseyi* (Causey, 1950)**

**Sources:** Causey 1950b, Hennen & Shelley 2015, Hoffman 1999

**Description:** With characters of the genus. Gonopods as in Fig. 56, projection from prefemoral process long and bladelike, about 1/3 the length of the acropodite.

**County Distribution:** Johnson, Newton

**Habitat:** In typical habitat of the genus.

**Remarks:** *Mimuloria davidcauseyi* is only known from two counties in Arkansas and is endemic to the state.

**Tribe Apheloriini**



**Figure 103.** *Apheloria virginiensis reducta*, scale in inches.

***Apheloria virginiensis reducta* Chamberlin, 1939**

**Sources:** Causey 1952c, Hoffman 1999, McAllister et al 2003, 2013

**Description:** Midbody sterna unmodified, metatergites black with yellow paranota, 50 mm-60 mm long. Gonopods as in Figs. 57, 58, in a circular, sickle shape.

**County Distribution:** Baxter, Benton, Boone, Carroll, Cleburne, Conway, Craighead, Crawford, Cross, Franklin, Greene, Independence, Izard, Johnson, Lawrence, Lee, Logan, Madison, Marion, Newton, Polk, Pope, Saline, Scott, Searcy, Sharp, Stone, Van Buren, Washington

**Habitat:** Moist forest leaf litter, under logs.

**Remarks:** The only member of the Apheloriini in the state, a tribe which reaches its peak diversity in the Appalachian Mountains. Records are concentrated in the central and northern parts of the state, and *A. v. reducta* is also known from Missouri and Oklahoma. *Apheloria virginiensis* is divided into five ill-defined subspecies, and *A. v. reducta* is one of two western subspecies, the other being the enigmatic *A. v. iowa* (Shelley & McAllister 2007). The species itself ranges throughout eastern North America. This is the most commonly seen Xystodesmid in Arkansas, and is known as the "cherry millipede," due to the smell of its chemical defenses.

**Tribe Pachydesmini**

The Pachydesmini is a tribe occurring in the southeastern United States, from southwest North Carolina to northern Florida and west to Texas. It has two species in Arkansas:

*Pachydesmus clarus* and *Thrinaxoria lampra*, and they are known from the southwestern portion of the state.

Species in this tribe have their metasterna sharply elevated and without spines or lobes, and lack the bold aposematic coloration of related Xystodesmid tribes, their coloration being tan or brown with light yellow or pinkish paranota (Shelley & McAllister 2006). They are large Xystodesmids, being 30 mm-75 mm long. Habitat reports for this tribe are similar to habitats of other large Polydesmida, but seem to be found in pine forests and mixed forests than other millipedes.

***Pachydesmus clarus* (Chamberlin, 1918)**



**Figure 104. *Pachydesmus clarus***

**Sources:** Hoffman 1999, Shelley & McAllister 2006

**Description:** Typical coloration for the tribe (see Fig. 104), large, 50 mm-70 mm long.

Gonopods as in Fig. 59.

**County Distribution:** Columbia

**Habitat:** Typical habitat for the tribe, particularly under logs and pieces of bark.

**Remarks:** A male *Pachydesmus clarus* has yet to be collected from Arkansas, but females are known from Logoly State Park in Columbia County. While species identification of females is provisional and male individuals are needed for confirmation, the large size of this species helps to separate it from *Thrinaxoria lampra*. This is the largest Polydesmidan in the state, and with more collecting, may be found in other counties in southern Arkansas. This entire body of this species fluoresces under UV light, and based on its large size, should be relatively easy to find by searching for it at night. *P. clarus* is also found in Texas and Louisiana.

***Thrinaxoria lampra* (Chamberlin, 1918)**

**Sources:** Hoffman 1999, Shelley & McAllister 2006

**Description:** With typical characters of the tribe. 30 mm-50 mm long, gonopods as in Fig. 60.

**County Distribution:** Miller

**Habitat:** In typical habitat of the tribe.

**Remarks:** *Thrinaxoria lampra* is only known from near Genoa, Miller County, signifying a need for more collecting for Pachydesmini in southern Arkansas. It is smaller than *P. clarus*, and is also known from Tennessee, Alabama, Louisiana, Texas, and Mississippi.

**Tribe Rhysodesmini**

This tribe was proposed for millipedes that have their gonopod coxae attached to a sternite that appears slender and distinct, and which join the gonopod prefemora at a right angle (Hoffman 1960). Many species in this tribe have metatergites that appear slightly wrinkled



(shown well in *Pleurolooma*), but the tribe is not as distinct in its diagnosis as other Xystodesmid tribes.

Two species in this tribe are found in Arkansas, *Pleurolooma flavipes* and *Boraria profuga*. They are slightly bigger than the Nannariini, from 25 mm-30 mm long, and their metatergites are black with red or yellow paranota. In the case of *P. flavipes*, a yellow caudal stripe is present on the metazonite. They can be found in moist leaf litter habitats, both deciduous litter and deciduous-pine litter. The tribe itself is widespread in eastern North America, mostly thanks to the very large range of *P. flavipes*.

***Pleurolooma flavipes* Rafinesque, 1820**



**Figure 105. *Pleurolooma flavipes***

**Sources:** Hoffman 1965, Shelley 1980

**Description:** Coloration black with yellow paranota and a yellow-orange caudal metatergal stripe. 30 mm long, gonopods as in Fig. 61.

**County Distribution:** Carroll, Clark, Clay, Craighead, Desha, Greene, Hot Springs, Jefferson, Johnson, Lee, Phillips

**Habitat:** Wide range, from moderately moist leaf litter to under logs and in areas with sandy soil.

**Remarks:** *Pleurolooma flavipes* is one of the most widespread millipedes in eastern North America, and not uncommon in Arkansas. It is adaptable to a variety of habitats, and many individuals are sometimes known to aggregate and migrate together (Shelley 1980), contributing to the species' large range. Both males and females of this species can be identified by the hairy lobes on their sterna.

***Boraria profuga* (Causey, 1955)**



**Figure 106. *Boraria profuga*, male (left) and female (right).**

**Sources:** Causey 1955, Hoffman 1965, 1999, Shelley et al 2011

**Description:** Coloration black with red orange paranota. 25 mm-30 mm long, gonopods as in Fig. 62.

**County Distribution:** Montgomery **New County Record:** Garland

**Habitat:** Moist deciduous-pine leaf litter near streams.

**Remarks:** *Boraria profuga* is uncommonly collected in Arkansas, and was previously only known from Montgomery County. I collected a new county record on May 20, 2014 from Garland County in moist mixed litter (oak/elm/hickory/pine), and mixed deciduous-pine litter seems to be the habitat they are most commonly found in. This species is also known from one county in Louisiana (Shelley et al 2011) and was previously considered an Arkansas endemic. Its rarity may indicate it as a species in need of conservation protection (Shelley et al 2001). This is the only non-Appalachian species of *Boraria*, exhibiting the former connection between the Ouachitas and the Appalachians (Robison & Allen 1995). In this species, the sterna are unmodified (separating it from *Pleurolooma flavipes*), and females are larger than males.

**Family Eurymerodesmidae, Genus *Eurymerodesmus***



**Figure 107. *Eurymerodesmus birdi birdi***

The Eurymerodesmidae is a monogeneric family with 25 species, 13 of which are known from Arkansas, with five of them being endemic. Information on the Eurymerodesmidae was limited mostly to species descriptions until Shelley's excellent revision of the family (Shelley 1990), which synonymized the genera *Kewanius* and *Paresmus* with *Eurymerodesmus*. In his revision, Shelley lists and describes in much detail the characters he used to define species in the family, and identifies characters which may be useful for the taxonomy of the group in the future. He split the family into 4 lineages (Hispidipes, Kewanius, Birdi, Melacis) and 7 species groups (Hispidipes, Impurus, Dubius, Varius, Simplex, Birdi, Melacis). The Arkansas species fall into the following groups and lineages: Hispidipes lineage, Hispidipes group: *E. hispidipes*; Kewanius lineage, Impurus group: *E. angularis*, *E. compressus*, *E. goodi*, Dubius group: *E. dubius*, Varius group: *E. varius*, *E. newtonus*, *E. oliphantus*, Simplex group: *E. pulaski*, *E. polkensis*, *E. serratus*; Birdi lineage, Birdi group: *E. birdi*, *E. mundus*.

Only the Arkansas species are treated in the following species accounts, but the full ranges of the Eurymerodesmidae aren't well known, and species new to the state may eventually be found. Additionally, Shelley (1990) noted in his revision that the family may be revised into as few as five species, or split into even more species than there are currently. For more comprehensive information, particularly covering variation within the species, the Shelley 1990 revision should be consulted. It has a veritable goldmine of information on the family, and will prove a fruitful starting point for any future taxonomic work in the family.

The Eurymerodesmidae are easily distinguished from other Polydesmida. They lack the distal spine on the prefemora of their legs that Xystodesmidae have, the male gonopodal apertures have lobes or other modifications and long setae around the aperture rim, and males have projections of their mandibular stipes. Males also have dorsal lobes on the prefemora of their legs. The sterna of both sexes are hairy, they have bifid epicranial sutures on their heads, and their paranotal corners are rounded. Eurymerodesmids range from small (14 mm) to large (37 mm), and their dorsum is dark brown with orange to red caudal stripes, or sometimes spots. Their coloration is somewhat similar to that of the family Euryuridae, but the two families are easily separated based upon the triangular epiproct of the Eurymerodesmidae.

Eurymerodesmids are tolerant of dry conditions, which has allowed them to spread into the central plains and conditions that exclude most other large-bodied Polydesmidans. They can also be found in moist areas and forests (deciduous or pine), in leaf litter but particularly under logs. Species in this family light up brightly under UV light, making night collecting an easy way to find these millipedes. The distribution of this family extends from Nebraska south to Texas and east to the Carolinas.

***Eurymerodesmus goodi* Causey, 1952**

**Sources:** Robison et al 2008, Shelley 1990

**Description:** Body size large (above 32 mm), sides of aperture entire, without pouches, aperture lacking lobes, anterior margin of gonopod aperture with a long, distinct midline indentation extending into aperture opening. Paranota reddish-orange, dorsum olive, lacking metaternal stripes. Gonopods as in Fig. 63. Females with long, finger-like distal corners of cyphopod valves rounded.

**County Distribution:** Montgomery, Polk

**Habitat:** Typical habitat for the genus.

**Remarks:** *Eurymerodesmus goodi* is an Arkansas endemic species.

***Eurymerodesmus angularis* Causey, 1951**

**Sources:** McAllister et al 2013, Shelley 1990

**Description:** Body size large (above 32 mm), sides of aperture divided, with pouches, paranota orange; metaterga dark brown, with or without orange caudal stripes, collum with orange stripe along anterior margin. Gonopods as in Fig. 64. Females with long, finger-like distal corners of cyphopod valves that project out.

**County Distribution:** Arkansas, Columbia, Drew, Izard, Jefferson, Ouachita, Phillips, Prairie, Union

**Habitat:** Typical habitat for the genus.

**Remarks:** *Eurymerodesmus angularis* is a variable species and is also known from Louisiana, Mississippi, and Missouri.

***Eurymerodesmus varius louisianae* (Chamberlin, 1942)**

**Sources:** Shelley 1990

**Description:** Body size small to moderate (19 mm-23 mm), sides of aperture divided, with pouches, anterior margin of gonopods with a slight indentation. Paranota red-orange with caudal metatergal stripes. Gonopods as in Fig. 65. (But see illustrations in Shelley 1990 for variation.)

**County Distribution:** Columbia

**Habitat:** Typical habitat for the genus.

**Remarks:** As the species epithet implies, *E. varius louisianae* is a variable species, and as such it shows up in two places in the key. Shelley (1990) gives more illustrations showing the full variation seen in the species. This species was also cited to occur in Union County, but the specimen was lost and is unconfirmed there (Shelley 1990). This species can also be found in Louisiana.

***Eurymerodesmus compressus* Causey, 1952**

**Sources:** Robison et al 2008, Shelley 1990

**Description:** Body size large (above 32 mm), sides of aperture divided, with pouches, paranota orange; metaterga dark brown, without orange caudal stripes. Gonopods as in Fig. 66.

**County Distribution:** Union

**Habitat:** Typical habitat for the genus.

**Remarks:** This species is endemic to Arkansas.

***Eurymerodesmus newtonus* Chamberlin, 1942**

**Sources:** McAllister & Robison 2011, McAllister et al 2013, Robison et al 2008, Shelley 1990

**Description:** Body size moderate (25 mm-30 mm), sides of aperture divided, with pouches, paranota orange with orange caudal stripes. Gonopods as in Fig. 67.

**County Distribution:** Benton, Carroll, Johnson, Marion, Newton, Searcy, Washington

**Habitat:** Typical habitat for the genus.

**Remarks:** This species is endemic to northwest Arkansas.

***Eurymerodesmus oliphantus* Chamberlin, 1942**

**Sources:** McAllister & Robison 2011, Shelley 1990

**Description:** Body size small to moderate (19 mm-23 mm), sides of aperture divided, with pouches. Paranota red with red caudal metaternal stripes. Gonopods as in Fig. 68.

**County Distribution:** Fulton, Independence, Izard, Jackson, White **New County Records:**  
Conway, Stone

**Habitat:** Typical habitat for the genus.



**Remarks:** *Eurymerodesmus oliphantus* has the largest and most open pouches on its aperture, making the species easy to identify. It also occurs in Illinois and Missouri.

***Eurymerodesmus serratus* Shelley, 1990**

**Sources:** McAllister et al 2003, Shelley 1990

**Description:** Body size moderately large (30 mm-32 mm), sides of aperture entire, without pouches, aperture with lobes, anterior margin of aperture with a long and distinct midline projection, paranota orange with caudal stripe. Gonopods as in Fig. 69, distal part of telopodite jagged.

**County Distribution:** Faulkner, Pulaski

**Habitat:** Typical habitat for the genus.

**Remarks:** This species is known from Arkansas and Florida.

***Eurymerodesmus pulaski* (Causey, 1950)**

**Sources:** Robison et al 2008, Shelley 1990

**Description:** Body size moderately large (30 mm-32 mm), sides of aperture entire, without pouches, aperture without lobes, anterior margin of aperture with a long and distinct midline projection, paranota orange with slightly a expanding orange caudal stripe. Gonopods as in Fig. 70.

**County Distribution:** Pulaski, Saline

**Habitat:** Typical habitat for the genus.

**Remarks:** This species is an Arkansas endemic.

***Eurymerodesmus polkensis* (Causey, 1952)**

**Sources:** McAllister et al 2003, Robison et al 2008, Shelley 1990

**Description:** Body size large (above 32 mm), sides of aperture entire, without pouches, aperture with lobes, anterior margin of aperture with a long and distinct midline projection. Paranota red-orange, with medial triangles instead of caudal stripes. Gonopods as in Fig. 71.

**County Distribution:** Montgomery, Polk, Scott, Yell

**Habitat:** Typical habitat for the genus.

**Remarks:** This species is an Arkansas endemic.

***Eurymerodesmus hispidipes* (Wood, 1864)**

**Sources:** Shelley 1990

**Description:** Body size small to moderate (19 mm-23 mm), sides of aperture entire, without pouches, aperture without lobes. Gonopods as in Fig. 72.

**County Distribution:** Ashley

**Habitat:** Typical habitat for the genus.

**Remarks:** This species is also known from Illinois.

***Eurymerodesmus dubius* Chamberlin, 1943**

**Sources:** McAllister et al 2002, 2013, Shelley 1990

**Description:** Body size large (above 32 mm), sides of aperture entire, without pouches, aperture without lobes, anterior margin of aperture with a slight indentation. Gonopods as in Fig. 73.

**County Distribution:** Bradley, Clark, Columbia, Dallas, Garland, Hempstead, Hot Springs, Montgomery, Nevada, Ouachita, Pike, Saline

**Habitat:** Typical habitat for the genus.

**Remarks:** This species was mistakenly omitted from the key in Shelley (1990).

*Eurymerodesmus dubius* is also reported from Louisiana.

***Eurymerodesmus mundus* Chamberlin, 1931**

**Sources:** McAllister et al 2002, Shelley 1990

**Description:** Body size moderate (25 mm-30 mm), sides of aperture entire, without pouches, aperture with lobes, paranota red with red metaternal caudal stripes. Gonopods as in Fig. 74.

**County Distribution:** Lafayette, Miller, Polk, Sevier, Scott

**Habitat:** Typical habitat for the genus.

**Remarks:** This species is also known from Nebraska, Kansas, Oklahoma, and Texas.

***Eurymerodesmus birdi birdi* Chamberlin, 1931**

**Sources:** McAllister et al 2002, 2003, 2013, Shelley 1990

**Description:** Body size moderate (25 mm-30 mm), sides of aperture entire, without pouches, aperture with lobes, anterior margin of aperture with a slight indentation. Paranota orange with orange metatergal caudal stripes that widen medially. Gonopods as in Fig. 75.

**County Distribution:** Benton, Carroll, Johnson, Lafayette, Logan, Madison, Polk, Pope, Washington, Yell

**Habitat:** Typical habitat for the genus.

**Remarks:** A widespread and variable species, it is also known from Kansas, Missouri, Oklahoma, Mississippi, Louisiana, and Texas.

**Discussion**

This study provides the first key to eastern North American millipede families since Hoffman (1990) and Shear (1999, unpublished), and is the first species key for a state since Filka & Shelley (1980)'s key to North Carolina's millipedes. Arkansas becomes the fifth state with a complete millipede checklist, the first since California's was published in 2002 (Shelley 2002a). Importantly, Arkansas's location in the south-central United States makes its key and information applicable to other states in the region, and in the eastern United States as a whole, since a large diversity of families and genera are found in the state.

Shelley (2007c) referred to research on the Diplopoda since the 1990s as the "ultra-modern" period of Diplopod taxonomy, citing synthesizing works creating a stable taxonomic

framework for research and new molecular methods as evidence. It is an exciting and much less confusing time to work on millipedes due to all the work that has contributed to this ultra-modern period, but would-be millipede students in the United States still lack basic identification resources for the group. The published millipede checklists and catalogs, while useful for those with a base knowledge of the Diplopoda, do not provide identification information that would help interested novices. The best way to attract new attention to millipedes and related Myriapods is through the creation of regional keys and checklists with identification information that will make the group accessible to non-specialists. It is hoped that this study will encourage future work on millipedes, particularly by ecologists, as much important information on habitat needs and basic life history is still unknown for many species of millipedes. Through publications of regional identification materials, a group as charismatic and biogeographically interesting as the Diplopoda will surely attract much attention and yield fascinating research results.

Within Arkansas, much research remains to be done. Collection in the Coastal Plains of southern and eastern Arkansas is needed to fill in gaps in our knowledge of species distributions, particularly within the Branneriidae, Cleidogonidae, and Xystodesmidae (Pachydesmini), and Eurymerodesmidae. New collecting around Little Rock and Okolona will clarify if what Bollman (1888) recorded as *Craspedosoma* is actually *Branneria*, and collecting at the type localities of Cleidogonidae not included in Shear's (1972) revision will improve our understanding of *Cleidogona* and *Tiganogona*. Studies of Arkansas's cave millipedes have yielded many interesting results, along with new species, and more research will reveal a fuller picture of millipedes' ecological roles in caves. More investigations of Crowley's Ridge may turn up more species common east of the Mississippi River but nowhere else in the state, offering intriguing

biogeographical results. The effects of Diplopoda in agricultural ecosystems is another understudied area, some introduced Julidae and Blaniulidae have been reported as pests on young crops in other areas of the U.S., but few particulars are known.

The largest gap in knowledge of Arkansas's millipedes is the Parajulidae, and the group is in great need of dedicated workers. Basic taxonomic and ecological information is needed, and has become less intimidating thanks to the work by Shelley. The Eurymerodesmidae is another common family in Arkansas that would benefit from more study now that a revision has been completed.

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## **IV. Circadian Rhythms of Leaf Litter Arthropods in a Temperate Deciduous Forest**

### **Background**

During a 24 hour day most organisms follow a circadian rhythm, wherein their behavior changes and is often influenced by both light and darkness. Ground-dwelling arthropods follow these patterns, which have been studied in forest leaf litter habitats as well as in crop ecosystems. However, sampling regimes for these arthropods do not always take these rhythms into account, which may introduce bias into studies. Bias should be mitigated in order to obtain representative and reproducible results by examining inherent biases in sampling methods (see Spence & Niemelä 1994 and Siewers et al 2014) and taking these into account while designing experiments.

Ground beetles (Carabidae) are large components of arthropod leaf litter fauna in forests and are predaceous (Allen & Thompson 1977); they are also well-represented in sampling studies in the literature (Siewers et al 2014, Spence & Niemelä 1994). Individual species of Carabidae have specific behavioral preferences for their activity periods, ranging from different parts of the night to the day, contributing to niche differentiation among species (Kamenova et al 2015). Differences in circadian rhythms have also been shown among various other predatory arthropod families (Petersen & Woltz 2015), with implications for crop systems.

The trend is also seen in other groups, such as the Myriapoda, Formicidae, and other Coleoptera families. The Diplopoda are most active during the night and at crepuscular hours (Banerjee 1967, Hopkin & Read 1992). The Chilopoda are active equally over the day's time periods according to Dondale et al (1972), but may show differences at more specific taxonomic levels. Tuf et al (2006) showed that Chilopoda are slightly more active during the dark time periods, but the difference between light and dark period activity is less pronounced than in the



Diplopoda. Activity patterns in the Formicidae are measured based on the foragers, while the rest of the ant colony stays within the nest. Their activity is affected by behavioral and ecological factors (Raimundo et al 2009), particularly temperature (Bernstein 1979). Thus, ant circadian rhythms can differ within subfamily (Raimundo et al 2009) and may depend on co-occurring species. Staphylinidae have been reported to be active during the day and the night (Dondale et al 1972). Hunter et al (1991) reported dung-associated Staphylinidae in eastern Texas as being strictly diurnal, suggesting that the circadian rhythms of individual species may differ. Hemiptera have been reported to be mostly diurnal (Dondale et al 1972).

The varying circadian rhythms of arthropods mean that if samples of arthropods are biased towards a particular time period, species that are present in a habitat may be missed by a collector sampling at the wrong time. This may result in erroneous perceptions of species absence, rarity, or similarly biased results (Petersen & Woltz 2015).

Most studies examining circadian rhythms of arthropods have used time sorted pitfall traps as a sampling method, due to their portability, ease of use, and low cost (Siewers et al 2014). Data on the presence, activity, and density of arthropods can be taken from pitfall collections (Spence & Niemi 1994). However, criticisms of pitfall traps focus on the influences of the trap's surrounding habitat, materials from which they are made, size and arrangement, and other factors (Spence & Niemi 1994). Pitfall traps may also repel some arthropods, leading to biased perceptions of activity or abundance (Gerlach et al 2009). For example, pitfall traps may not catch larger species of beetles or litter-dwelling species, which are underrepresented in pitfall catches (Siewers et al 2014). Another way of sampling leaf litter arthropods is by collecting the leaf litter itself and extracting the arthropods in Berlese/Tullgren funnels. This method has been used less often than pitfall traps, but has been compared to pitfall results for Carabidae by

Spence & Nieml  (1994). Advantages of direct leaf litter collection include knowing the exact time of collection, inclusion of small litter-dwelling species, and similar convenience as pitfall traps but with less preparation and cleanup (such as digging holes or returning to collect a trap). There are also disadvantages of direct leaf litter collection, such as missing swift species that may avoid the collector's samples, the sample being influenced strongly by local weather conditions and the act of collection itself, possible exclusion of larger species if a litter sifter is used during collection, and differences in the extraction process. Thus, litter sampling may capture species missed by pitfall traps. Questions remain about litter sampling, however, such as how its abundance and diversity results compare with pitfall trap studies. Additionally, how results vary among a range of taxonomic groups is unknown, with Carabidae being the best-studied.

With the previous information in mind, this study was undertaken to examine activity periods for selected groups of forest leaf litter arthropods. The objective was to determine whether arthropod abundance and diversity varied as a function of circadian rhythm for selected groups, particularly the Myriapoda, Formicidae, and some families of Coleoptera. These results would then be compared to reported data from pitfall trap studies.

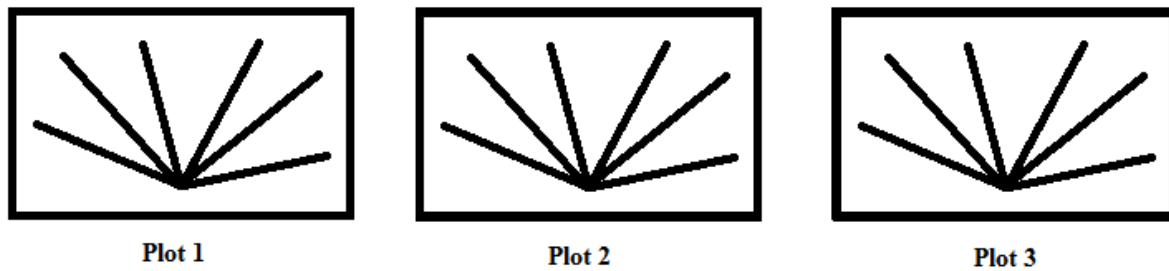
## **Methods**

This study was conducted in a forest on the south side of Mt. Kessler, roughly 4 kilometers southwest of Fayetteville, Arkansas (N 36 01'28" W 94 13'03") in the Ozark Plateau region of the state. The study area is about 540 meters in elevation, in a forest mainly oak (*Quercus* spp.)-maple (*Acer* spp.)-hickory (*Carya* spp.) in composition, with hackberry (*Celtis occidentalis*), and black walnut (*Juglans nigra*) trees also common. Small rocks and boulders

were scattered throughout each sampling plot, and each plot had a moderately deep (3-8 centimeters) deciduous litter layer, with dead logs and other woody debris scattered throughout.

Sampling at the site was done in late Spring 2014 over three non-consecutive 24 hour periods during a span of 11 days: June 1, 7, and 11. This was done to mitigate differences in litter composition due to precipitation and temperature differences on each sampling day. These differences were negligible, making habitat conditions similar on each sampling day. Light rainfall occurred on each day before sampling, making the collected leaf litter samples moist by time of collection.

Three plots were established (Figure 1), each 120 meters wide by 100 meters long, and containing six transects. The plots were at least 30 meters away from each other. A starting point was marked by going 30 meters into the plot halfway up the edge of the plot. From that starting point, leaf litter was collected from five sampling locations, each spaced 15 meters apart. The transects were laid out as an array from the starting point, at 15°, 45°, 75°, 105°, 135°, and 165°, for an even spread throughout the plot. Each transect was sampled at one of six time periods: 6 AM, 11 AM, 4 PM, 8:30 PM, 11 PM, or 3 AM. These time periods included two crepuscular periods coinciding with dusk and dawn (6 AM and 8:30 PM), two daytime periods (11 AM and 4 PM), and two nighttime periods (11 PM and 3 AM). At each sampling location along a transect, a 1 square meter quadrat was dropped randomly and the leaf litter within the template area was collected with a litter concentrator, a handheld device with two metal rings with handles, the lower one with a wire mesh, both connected by a nylon fabric sleeve. Three grabs of leaf litter were collected at each sample point, and the sifted litter was stored in a 1 gallon Ziploc® bag for later lab transport. In total, 90 leaf litter samples were taken from each plot, and across all plots, 15 samples were taken for each time period (5 from each plot).



**Figure 1. Schematic of sampling protocol, showing plots with transects. Not to scale.**

It took from 50 - 80 minutes to collect all leaf litter samples during each time period. The collected samples were immediately transported to the lab and placed in Berlese funnels for extraction under 40 watt light bulbs. The samples were left in the Berlese funnels for 48 hours. The extracted arthropods were stored in 70% ethanol in Whirl-Pak bags (Nasco, Fort Atkinson, WI) for later sorting and identification. Specimens were identified under a LeicaMZ 16 dissecting microscope. Myriapods were identified using Shear (1999) and Shelley (1989). Coleoptera were identified using Arnett & Thomas (2000) and Arnett et al (2002). Formicidae were identified using Fisher & Cover (2007).

Additionally, five sets of two pitfall traps were haphazardly placed in each plot. Each pitfall trap was a 32 ounce plastic cup 14 centimeters tall with a diameter of 11.5 centimeters, with a lid. The traps were connected by a metal drift fence to direct passing arthropods into them. One of the pitfall traps in each set was open (lid removed) during daylight hours, while the other was open during night hours.

Groupings of taxa and time periods were identified and analyzed with two-way cluster analysis in PCORD, v5 (McCune & Mefford 1999). The data were standardized by total number per time period and a square root transformation was done to downweigh very abundant taxa. The Bray-Curtis Index was used as the distance measure, and the group average method was

used for linking groups. To test whether time periods were significantly different from each other, the SIMPROF routine in PRIMER, v6 was used (Clarke & Gorley 2006). Pitfall trap data were not analyzed, due to having caught few taxa in the traps.

## **Results**

From 90 leaf litter samples, 8,017 leaf litter arthropod specimens were collected, including 227 Diplopoda, 1183 Chilopoda, 23 Japygidae, 4086 Formicidae, 66 Pentatomidae, 599 Staphylinidae, 72 Carabidae, 117 Scarabaeidae, 408 Curculionidae, 213 Nitidulidae, 254 Ptiliidae, 76 Chrysomelidae, and 51 Leiodidae specimens. These groups were selected for further analysis due to having large enough numbers for statistical analysis. From these groups, 40 taxa were chosen for analysis, ranging from class and family level for examination of broader trends, to species level for specific temporal trends. Pitfall catches did not capture enough of the focal taxa for further analysis.

The numbers of individual arthropods extracted from each leaf litter sample ranged from 22 to 334, with an average of 83 arthropods. The average number of arthropods (rounded to nearest whole number) collected at 6 AM was 60, at 11 AM was 88, at 4 PM was 94, at 8:30 PM was 71, and at 11 PM was 85, and at 3 AM was 98. An ANOVA single factor analysis of total numbers of arthropods collected by time period found no significant differences ( $p < 0.531$ ) among the time periods. Species richness for each sample ranged from 9 to 36, with an average of 19 species per sample. The average species richness for samples collected at 6 AM was 17.07, at 11 AM was 19.93, at 4 PM was 19.87, at 8:30 was 18.67, at 11 PM was 17.8, and at 3 AM was 21.07. An ANOVA single factor analysis of species richness by time period found no significant differences ( $p < 0.353$ ) among the time periods. Numbers of each taxa collected during each time period are given in Table 1.

**Table 1. Total numbers of taxa collected during each time period**

	6:00 AM	11:00 AM	4:00 PM	8:30 PM	11:00 PM	3:00 AM
<b>Diplopoda</b>	28	40	32	28	44	55
<i>Brachycybe lecontii</i>	1	2	0	0	0	5
<i>Desmonus pudicus</i>	13	14	10	10	15	16
<i>Apheloria virginiensis reducta</i>	0	0	0	0	2	0
<i>Eurymerodesmus</i> sp.	0	0	1	0	0	0
<i>Abacion texense</i>	5	3	2	2	4	5
<i>Polyxenus lagurus</i>	4	1	3	5	3	14
Cleidogonidae	4	16	15	9	19	14
<b>Chilopoda</b>	134	157	192	194	243	263
<i>Arenophilus bipuncticeps</i>	0	1	4	4	0	3
<i>Geophilus mordax</i>	37	47	62	60	69	77
<i>Strigamia branneri</i>	20	21	24	34	31	44
Lithobiidae	25	32	55	35	46	51
<i>Sonibius politus</i>	0	0	2	0	0	0
<i>Taiyubius</i> cf. <i>dux</i>	1	1	0	2	4	0
<i>Nampabius</i> sp.	0	5	11	2	0	0
<i>Lithobius celer</i>	0	4	1	1	1	0
<i>Cryptops leucopodus</i>	49	55	43	60	76	84
<i>Scolopocryptops sexspinosus</i>	2	1	3	1	2	3
<i>Scolopocryptops rubiginosus</i>	1	0	0	0	0	0
<i>Theatops spinicaudus</i>	0	0	1	0	0	0
<b>Japygidae</b>	1	5	6	5	5	1

<b>Formicidae</b>	409	821	832	501	697	826
<i>Crematogaster</i> sp.	34	182	62	60	50	123
<i>Ponera pennsylvanica</i>	21	15	16	18	25	15
<i>Amblyopone</i> sp.	3	3	1	4	4	5
<i>Myrmecina americana</i>	23	45	28	27	16	88
<i>Tapinoma sessile</i>	1	0	0	1	0	1
<i>Aphaenogaster</i> sp.	126	119	204	114	98	101
<i>Temnothorax curvispinosus</i>	7	19	57	26	13	46
<i>Solenopsis</i> sp.	54	435	455	244	479	436
<i>Strumigenys</i> sp.	5	1	0	1	9	8
<i>Brachymyrmex depilis</i>	0	1	0	0	0	0
<i>Nylandria faisonensis</i>	0	0	6	2	0	2
<i>Camponotus</i> sp. 1	0	1	0	0	0	0
<i>Camponotus chromaiodes</i>	0	1	2	0	0	0
<i>Camponotus americanus</i>	0	0	0	0	1	0
<i>Camponotus snellingi</i>	0	0	0	1	0	0
<i>Formica subsericea</i>	0	1	0	0	0	0
<i>Proceratium</i> sp.	0	1	1	2	1	1
<i>Stenamma</i> sp.	0	1	0	0	0	0
<i>Prenolepis imparis</i>	0	0	0	1	0	0
<b>Pentatomidae</b>						
<i>Meneclis insertus</i>	22	8	17	5	6	8
<b>Aradidae</b>						
<i>Mezira</i> sp.	0	1	8	3	1	2
<b>Cydnidae sp.</b>	0	1	1	7	3	0
<b>Staphylinidae</b>	80	81	103	114	96	125
<i>Trimiomelba dubia</i>	3	0	1	1	0	1

<i>Conoplectus susae</i>	3	1	4	4	4	0
<i>Pselaphinae</i> sp. 3	1	0	0	0	0	0
<i>Baeocera</i> sp. 1	0	6	0	1	4	5
<i>Baeocera</i> sp. 2	0	0	1	0	0	0
<i>Baeocera</i> sp. 3	0	1	0	0	0	0
<i>Chevrolatia</i> sp.	0	0	0	0	1	0
<i>Euconnus (Naphochus)</i> sp. 1	3	4	3	4	3	3
<i>Euconnus (Naphochus)</i> sp. 2	0	1	0	0	0	0
<i>Euconnus (Napoconnus)</i> sp. 3	0	0	0	1	0	0
<i>Euthiconus</i> sp.	0	0	1	1	0	0
<i>Bryoporus rufescens</i>	3	7	2	6	4	6
<i>Tachyporus</i> sp.	0	1	0	0	1	1
<i>Tachinus fimbriatus</i>	1	0	0	0	0	0
<i>Lordithon</i> sp.	0	0	3	0	0	0
<i>Mycetoporus</i> sp.	0	0	2	0	0	3
<i>Sepedophilus</i> sp. 1	0	0	0	1	0	0
<i>Sepedophilus</i> sp. 2	3	2	1	1	3	0
<i>Pycnoglypta</i> sp.	0	1	0	0	1	0
<i>Osorius</i> sp.	0	0	0	1	0	0
<i>Erichsonius</i> sp. 1	5	1	0	5	0	0
<i>Erichsonius</i> sp. 2	0	3	5	1	0	1
<i>Bisnius</i> sp.	0	0	2	0	0	0
<i>Lathrobium</i> sp. 1	8	5	4	4	2	7
<i>Lathrobium</i> sp. 2	1	2	3	5	2	1
<i>Echiaster</i> sp.	3	9	11	4	7	10



<i>Orus</i> sp.	7	1	1	3	1	3
<i>Astenus americanus</i>	0	1	0	0	0	0
<i>Aleochara</i> sp.	0	2	0	0	0	0
<i>Phanerota</i> sp.	2	0	0	0	0	0
<i>Drusilla</i> sp.	1	1	1	0	1	0
Aleocharinae sp. 1	0	1	1	0	0	0
Aleocharinae sp. 2	0	1	1	0	1	0
Aleocharinae sp. 3	1	1	1	1	1	4
Aleocharinae sp. 4	0	0	0	0	0	1
Aleocharinae sp. 5	2	0	7	0	1	0
Aleocharinae sp. 6	0	0	0	1	0	0
Aleocharinae sp. 7	0	0	1	0	0	0
Aleocharinae sp. 8	0	0	0	0	0	1
Aleocharinae sp. 9	13	16	13	18	10	11
<b>Carabidae</b>	7	12	24	10	12	7
<i>Bembidion (Furcacampa) affine</i>	1	0	0	0	0	0
<i>Apenes sinuata</i>	1	0	1	1	0	0
<i>Dicaelus elongatus</i>	0	0	1	0	0	0
<i>Trichotichnus autumnalis</i>	3	9	19	3	6	0
<i>Trichotichnus fulgens</i>	1	1	0	1	0	2
<i>Notiobia sayi</i>	0	0	1	0	0	0
<i>Cyclotrachelus incisus</i>	0	0	1	0	0	0
<i>Agonum punctiforme</i>	0	0	0	0	0	1
<i>Agonum pallipes</i>	0	1	0	0	0	0
<b>Scarabaeidae</b>	20	32	28	13	12	12
<i>Aphotaenius carolinus</i>	3	4	7	4	6	4
<i>Ataenius</i> sp.	1	1	0	1	1	0

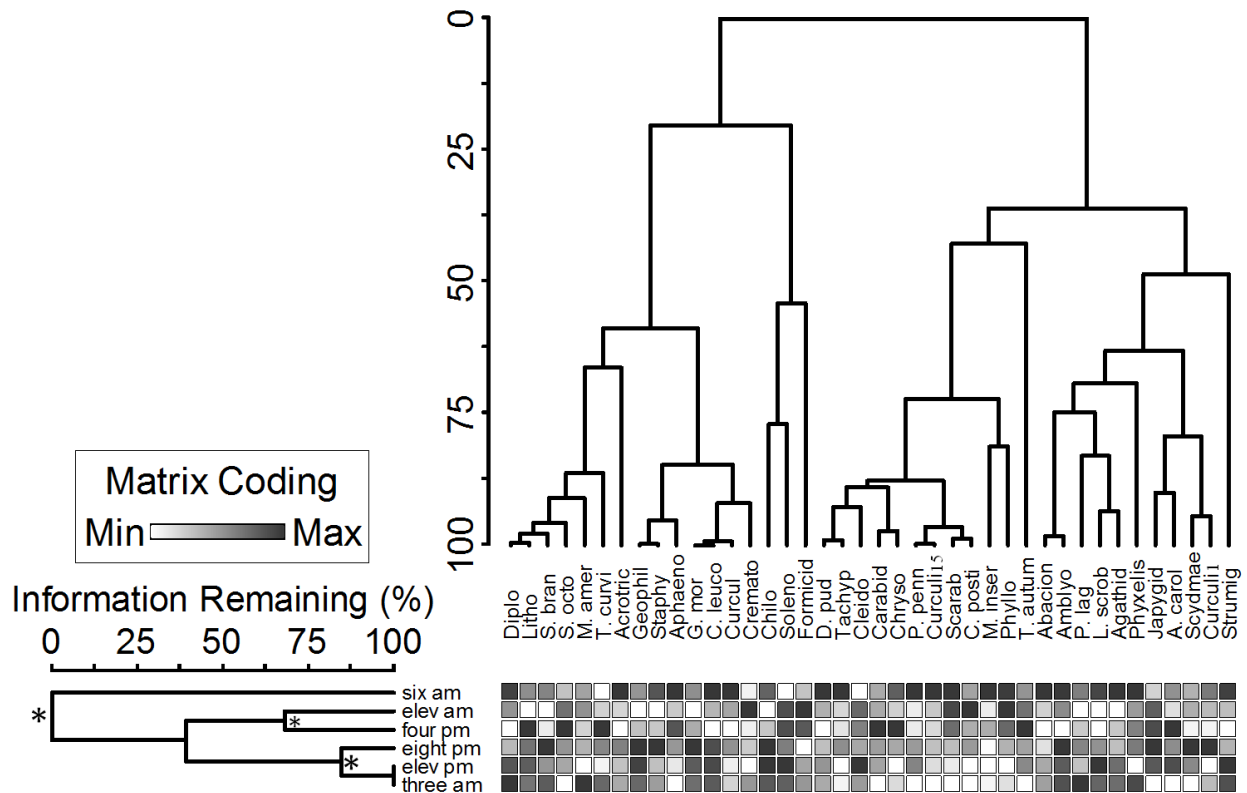
<i>Aphodius</i> sp.	0	0	0	1	0	0
<i>Ateuchus histeroides</i>	0	0	1	1	1	0
<i>Canthon viridis</i>	1	1	2	1	1	3
<i>Serica</i> sp.	1	1	0	0	2	2
<i>Phyllophaga</i> sp.	14	25	17	5	1	3
<b>Curculionidae</b>	64	80	62	65	60	77
<i>Lymantes scrobicollis</i>	6	1	1	4	11	9
<i>Stenomimus pallidus</i>	0	0	0	0	0	0
<i>Phyxelis</i> sp.	7	3	5	4	0	11
<i>Piazorhinus pictus</i>	0	1	0	0	0	1
<i>Hypera</i> sp.	2	1	1	0	0	0
<i>Cophes fallax</i>	0	0	2	2	4	2
<i>Conotrachelus posticatus</i>	11	28	19	15	12	14
<i>Conotrachelus</i> sp. 1	0	0	0	0	0	1
<i>Conotrachelus</i> sp. 2	0	0	1	0	1	0
Curculionidae sp. 1	7	9	7	12	6	10
Curculionidae sp. 2	0	0	0	0	1	0
Curculionidae sp. 3	0	1	0	0	0	1
Curculionidae sp. 4	0	0	3	1	0	0
Curculionidae sp. 5	0	0	0	0	0	1
Curculionidae sp. 6	1	0	0	0	2	1
Curculionidae sp. 7	0	0	0	0	1	0
Curculionidae sp. 8	2	4	2	4	3	2
Curculionidae sp. 9	0	0	0	2	0	1
Curculionidae sp. 10	0	0	1	0	0	0
Curculionidae sp. 11	0	0	0	0	1	0
Curculionidae sp. 12	0	1	0	0	0	1

Curculionidae sp. 13	0	2	1	0	1	5
Curculionidae sp. 14	0	0	0	3	1	0
Curculionidae sp. 15	23	20	19	16	17	16
<b>Histeridae</b>	2	1	1	1	0	0
<b>Nitidulidae</b>	18	45	58	29	38	25
<i>Epuraea rufa</i>	1	1	1	0	5	2
<i>Stelidota octomaculata</i>	17	43	57	28	32	23
<b>Ptiliidae</b>	83	23	12	60	28	48
<i>Acrotrichis</i> sp.	78	20	7	52	27	46
<i>Micridium lineatum</i>	0	1	1	2	0	0
<i>Nossidium</i> sp.	0	0	0	1	0	1
<i>Ptiliolum</i> sp.	0	2	2	2	0	0
<i>Pteryx</i> sp.	0	0	0	1	0	0
<b>Chrysomelidae</b>	13	9	30	10	5	9
<i>Capraita circumdata</i>	1	1	1	0	1	1
<i>Tymnes metasternalis</i>	0	1	0	0	0	0
<i>Tymnes tricolor</i>	1	0	0	0	0	0
<i>Phyllotreta bipustulata</i>	1	0	8	5	2	1
<i>Xanthonia striata</i>	4	1	4	2	0	4
<i>Xanthonia</i> sp.	5	5	3	0	0	1
<i>Paria</i> sp.	0	1	9	1	0	0
<i>Capraita sexmaculata</i>	0	0	2	0	0	1
<i>Glyptina spuria</i>	0	0	1	0	0	0
<i>Derocrepis erythropus</i>	1	0	0	0	0	0
<i>Babia quadriguttata</i>	0	0	1	0	0	0
<i>Margaridisa atriventris</i>	0	0	1	0	0	0
<i>Phaedon desotonis</i>	0	0	0	1	0	0

<b>Endomychidae</b>						
<i>Endomychus biguttatus</i>	0	0	1	1	1	0
<b>Erotylidae</b>	1	0	0	2	2	0
<i>Tritoma sanguinipennis</i>	1	0	0	0	0	0
<i>Tritoma biguttata</i>	0	0	0	0	1	0
<i>Tritoma</i> sp. 1	0	0	0	1	1	0
<i>Tritoma</i> sp. 2	0	0	0	1	0	0
<b>Leiodidae</b>						
<i>Agathidium</i> sp.	10	2	5	4	11	13
Leiodidae sp.	0	2	2	2	0	0
<b>Buprestidae</b>						
<i>Agrilus</i> sp.	1	0	0	0	0	0
Buprestidae sp.	1	0	0	0	0	0
<b>Mordellidae sp.</b>	1	1	0	0	0	0
<b>Latridiidae sp.</b>	3	1	0	4	3	4
<b>Phengodidae sp.</b>	1	0	0	0	0	0
<b>Cerambycidae</b>						
Cerambycidae sp. 1	0	0	1	0	0	0
Cerambycidae sp. 2	0	0	0	1	0	0
Cerambycidae sp. 3	0	0	0	0	0	1
<b>Scraptiidae sp.</b>	0	0	0	1	0	0

Cluster analysis of the data showed the abundance of arthropod taxa was significantly different at three time periods (Fig. 2): 6 AM, the dawn time period (at 86.67% similarity, SIMPROF,  $\pi = 0.64$ ,  $p < 0.05$ ), and the daylight periods of 11 AM and 4 PM and the dusk and nighttime periods of 8:30 PM, 11 PM, and 3 AM (at 88.48% similarity, SIMPROF,  $\pi = 0.69$ ,  $p < 0.05$ ). Each time within the day and night periods was not found to be significantly different

from the others within their time group. Within Figure 2, greater abundance is indicated by darker shaded squares.



**Figure 2. Two-way cluster analysis of abundance of taxa by time period. Horizontal dendrogram is of taxa (coded by first few letters of their rank names); vertical dendrogram is of time periods. The darkness of the shading is proportional to the abundance. Significantly different time periods are marked with an asterisk. Codes: *Diplo* = Diplopoda; *Litho* = Lithobiomorpha; *S. bran* = *Strigamia branneri*; *S. octo* = *Stelidota octomaculata*; *M. amer* = *Myrmecina americana*; *T. curvi* = *Temnothorax curvispinosus*; *Acrotric* = *Acrotrichis* sp.; *Geophil* = Geophilomorpha; *Staphy* = Staphylinidae; *Aphaeno* = *Aphaenogaster* sp.; *G. mor* = *Geophilus mordax*; *C. leuco* = *Cryptops leucopodus*; *Curcul* = Curculionidae; *Cremato* = *Crematogaster* sp.; *Chilo* = Chilopoda; *Soleno* = *Solenopsis* sp.; *Formicid* = Formicidae; *D. pud* = *Desmonus pudicus*; *Tachyp* = Tachyporinae; *Cleido* = Cleidogonidae; *Carabid* = Carabidae; *Chryso* = Chrysomelidae; *P. penn* = *Ponera pennsylvanica*; *Curculi15* = Curculionidae sp. 15; *Scarab* = Scarabaeidae; *C. posti* = *Conotrachelus posticus*; *M. inser* = *Menecles insertus*; *Phyllo* = Phyllophaga; *T. autum* = *Trichotichnus autumnalis*; *Abacion* = *Abacion* sp.; *Amblyo* = *Amblyopone* sp.; *P. lag* = *Polyxenus lagurus*; *L. scrob* = *Lymantes scrobicollis*; *Agathid* = *Agathidium* sp.; *Phyxelis* = *Phyxelis* sp.; *Japygid* = Japygidae; *A. carol* = *Aphotaenius carolinus*; *Scydmae* = Scydmaeninae; *Curculi1* = Curculionidae sp. 1; *Strumig* = *Strumigenys* sp.**

## **Myriapoda**

Broadly, the most Diplopoda were collected from 11 PM through 6 AM, with the 3 AM time period yielding the highest abundance. *Desmonus pudicus*, (Polydesmida: Sphaeriodesmidae) reached its peak abundance in the samples at 6 AM, as did *Abacion* sp. (Callipodida: Abacionidae). *Polyxenus lagurus* was most often collected at 3 AM, and the species of Cleidogonidae was found most at 11 PM.

The Chilopoda's peak collection time was 8:30 PM and 11 PM--similar to the Diplopoda, this group was most often found during the night hours. The Geophilomorpha reflected this, and two species in that order, *Geophilus mordax* and *Strigamia branneria* were collected most frequently at 8:30 PM. Species in the Lithobiomorpha were most often collected during the day, (4 PM), but were present during the nighttime periods as well. *Cryptops leucopodus* (Scolopendromorpha: Cryptopidae) was common throughout the night, with its peak at 6 AM.

## **Diplura**

Individuals in the family Japygidae were found during the day, and reached their peak at dusk, 8:30 PM.

## **Formicidae**

The ants were the most numerous group in the samples, representing slightly over 50% of all collected arthropods. Their peak at the family level was at 11 AM, as was the peak abundance of *Crematogaster* sp. Both *Ponera pennsylvanica* and *Aphaenogaster* sp. were most abundant at 6 AM. The peak of *Amblyopone* sp. was 8:30 PM, *Myrmecina americana* was 3 AM, *Temnothorax curvispinosus* was 4 PM, *Solenopsis* sp. was at 11 PM, and *Strumigenys* sp. had peaks at 11 PM and 6 AM.

## **Pentatomidae**

The Pentatomidae was represented by *Menecles insertus*, which had its peak abundance at 6 AM.

## **Coleoptera**

The Staphylinidae were collected most often at 8:30 PM, with another peak at 6 AM. Within the Staphylinidae, the Scydmaeninae had a distinct collecting peak at 8:30 PM, and the Tachyporinae were most abundant at 6 AM.

Peak abundance of the Carabidae was seen at 4 PM. *Trichotichnus autumnalis* followed this, and had higher abundance during the dawn and daylight hours. The Scarabaeidae and *Phyllophaga* sp. were most abundant at 6 AM, followed by 11 AM, while *Aphotaenius carolinus* was most abundant at 4 PM.

The Curculionidae was most abundant at 6 AM, as were its species *Phyxelis* sp. and Curculionidae sp. 15. *Lymanthes scrobicollis* was most abundant at 11 PM, with a lower abundance at 6 AM. *Conotrachelus posticatus* was most abundant at 11 AM. The Curculionidae sp. 1 was somewhat different, being most abundant at 8:30 PM.

In the Nitidulidae, the species *Stelidota octomaculata* was most abundant at 4 PM. Individuals in the family Chrysomelidae were also most abundant at 4 PM. *Acrotrichis* sp., in the family Ptiliidae, was most abundant at 6 AM. *Agathidium* sp., in the family Leiodidae, was also most abundant at 6 AM.

## **Discussion**

One of the most important distinctions the statistical tests revealed was the presence of three distinct periods of leaf litter arthropod abundance: the 6 AM dawn period, the daylight hours, and the darkness or night hours. The six sampling periods chosen can be consolidated into these three time categories without missing a significant number of taxa from sampling.

Designing a robust sampling program that collects during the three time periods can reduce bias in sampling programs, a weakness identified by Petersen & Woltz (2015). In this study then, 6 AM can be grouped on its own, 11 AM and 4 PM can together be considered the daylight hours, and 8:30 PM, 11 PM, and 3 AM can be considered the nighttime hours.

The data collected for the selected taxa broadly agree with the results of previous studies that used pitfall traps. The Myriapoda follow the trend of being most abundant at night, with the Chilopoda being less strictly nocturnal as the Diplopoda (Dondale et al 1972, Tuf et al 2006). At the species level for the Diplopoda, these results were similar, but each species was most abundant at a different time period. *Desmonus pudicus* is somewhat of an outlier, having its peak abundance at 6 AM. This result, and other seemingly different results like it in other sampled groups, may be caused by particular behavioral elements of each taxa.

Leaf litter collection gives abundance data, but care must be taken whether to interpret results as showing true activity of the organisms, or as simply showing presence-absence. Leaf litter collection samples less active litter-dwelling species that may be missed by pitfall traps (Siewers et al 2014), and thus may be including individuals that are resting or otherwise located under debris in the leaf litter (rocks, logs, twigs, moss, leaf pack). If this collection method is sampling taxa which are taking refuge under such debris or in its interstitial spaces, the abundance data would be showing presence of individuals at a particular time, instead of measuring solely activity. The question of measuring activity or presence is also relevant to pitfall traps, as trap covers may similarly attract taxa that would otherwise seek refuge under stones or wood (Siewers et al 2014). It is unclear, however, how much this affects abundance data from litter samples, another disadvantage of using this sampling method. Until more



research is done to resolve this, it is prudent to be cautious about interpreting abundance data as an accurate reflection of activity, and is considered here as certainly reflecting species presence.

Within the Chilopoda, taxa were found most abundantly during nighttime, similar to the Diplopoda. As reported by Tuf et al (2006), however, centipedes are less strict in their circadian rhythms than millipedes, and may also often be found during the day. The Lithobiomorpha exhibited this, as they were most abundant at 4 PM. The Lithobiomorpha are commonly referred to as the stone centipedes, and are found in leaf litter and under logs and wood in addition to under stones. This behavior probably shields them from the dangers of being out during day hours (though these habitat preferences are by no means restricted solely to the Lithobiomorpha: the other native centipede orders Geophilomorpha and Scolopendromorpha are somewhat more common in the soil and within logs), and these common habitat preferences of centipedes, along with their swiftness, may contribute to their being more common than millipedes during daylight hours.

The Diplurans in the samples, represented by the family Japygidae, were not as abundant as most other groups, but showed their greatest abundance at 8:30 PM. They are not usually included in circadian rhythm studies, but are reported here for future comparison with other studies.

The Formicidae are very well-represented in ecological studies, and their abundance in terrestrial habitats make them a convenient group to research, as well as an excellent comparison between studies. At the course family level, ants were most abundant at 11 AM, but this varied at the genus and species level. This may be a function of behavioral modifications due to competitive factors within the ant community (Raimundo et al 2009), resulting in a partitioning of the foraging activity by each species. Indeed, peak abundance for the various species of ants

covered each time period, rather than a general trend applying to all ants. It is important to note that the data for the ants may suffer particularly highly in the activity vs. presence question of leaf litter collection. Many foraging ant workers were collected, but often parts or entire nests were also captured, due to simply being located within the square meter of area sampled. In the case of the ants, this factor surely means that leaf litter collection of ants indicates presence, rather than foraging activity. This interpretation depends somewhat on behavior of the ant species. *Temnothorax curvispinosus*, for example, is a small-bodied ant species that makes its nests in cavities and under soil debris (Fisher & Cover 2007), and was often collected nesting in acorns and other such material. These collections grabbed most of the colony, and as such, are not a reflection of foraging activity.

The Pentatomid stink bug *Menecles insertus* was collected most often by far at 6 AM, which compares favorably with the diurnal patterns for most Hemiptera (Dondale et al 1972). However, *M. insertus* is identified as an arboreal nocturnal species in McPherson (1982), making this result seem incongruous. It may be that this species takes refuge in the leaf litter around dawn, and that its abundance in this study captured this activity, instead of merely presence, as it is not well-represented during nighttime, when it would be in the trees. Thus, collection times coinciding with the dawn hours may reveal basic biological trends of arthropods that have mostly been overlooked due to a focus on day or night collecting.

Within the Coleoptera, the peak activity of the Staphylinidae at 8:30 PM and 6 AM shows a slightly more nocturnal abundance for the family, as opposed to the somewhat higher diurnal activity previously reported (Chatzimanolis et al 2004, Dondale et al 1972). This abundance pattern is less pronounced within the subfamilies Scydmaeninae and Tachyporinae, though still present. The difference may be due to the habitat (Dondale et al 1972 was performed

in a meadow ecosystem, and Chatzimanolis et al 2004 was on a tropical island with a flight intercept trap) and particularly species composition of the site, as well as the collection method. Hunter et al (1991) reported very few nocturnal Staphylinidae in their study, but their methods focused on dung-attracted beetles, behavior not exploited in this study.

Abundance of Carabidae was highest during the day, a pattern also shown by the species *Trichotichnus autumnalis*. Species of Carabidae have been reported to be both diurnal and nocturnal, with precise patterns differing based on species (Kamenova et al 2015). Dondale et al (1972) reported slightly higher diurnal abundance, which agrees with the results of this study. The general predaceous behavior of Carabidae (along with omnivorous habits as well) means that the temporal abundance of Carabidae in a habitat will depend on the species community itself, depending on both intra- and inter-specific competition and niche partitioning (Kamenova et al 2015).

Members of the Scarabaeidae were found most often during daylight hours, with the genus *Phyllophaga* most abundant at 6 AM (and also abundant at 11 AM) and the species *Aphotaenius carolinus* most abundant at 4 PM. These two taxa are herbivorous, and *Phyllophaga* is arboreal, meaning that these results may indicate collection from refuges in the litter.

Individuals in the family Curculionidae were most abundant at 6 AM, a pattern reflected in *Phyxelis* sp. and Curculionidae sp. 15, while *Lymantes scrobicollis* had its peak abundance at 11 PM (along with a distinct abundance at the 6 AM time period), and *Conotrachelus posticatus* had its highest abundance at 11 AM. As in other families, individual species do break the general trend, as shown by Curculionidae sp. 1, which was most abundant at 8:30 PM. It and *Lymantes scrobicollis* share a similar abundance level during the night hours. Weevils are generally herbivorous, and many may be expected to be arboreal. The 6 AM abundance pattern may be a

reflection of weevil activity moving downward into the leaf litter for refuge during the day, as mentioned for the Scarabaeidae. However, more work is needed to confirm such behavior.

The Nitidulidae, represented by the species *Stelidota octomaculata*, had its peak abundance at 4 PM. These beetles are saprophagous, and are encountered frequently in the leaf litter. Due to their feeding habits, collections of Nitidulidae may accurately reflect activity data. The general trend for Chrysomelidae was also for peak abundance at 4 PM, but this is a composite of the various species, which have species-specific circadian rhythms.

The 6 AM dawn time period was the peak abundance for the Ptiliidae, represented by *Acrotrichis* sp., as well as the Leiodidae, shown in the genus *Agathidium*. Both these taxa are small-bodied beetles, with the Ptiliidae having some of the smallest beetles in North America, and are common in leaf litter samples. They are saprophagous and not commonly included in temporal activity studies.

At the coarse family level, leaf litter collections are likely to sample a representative distribution of taxa, akin to pitfall catches. Abundance of taxa varied during the 24 hour periods, but the selected 40 taxa were able to be collected at each of the six time periods without missing any. However, at finer levels, species may be missed if all three consolidated time periods are not sampled, particularly if a species is rare in a habitat or cryptic in its behavior.

Broadly speaking, results from leaf litter collections agree with patterns of circadian rhythms observed in pitfall trap studies, and in some cases may be better sampling programs than pitfall traps, such as if small-bodied or less active litter-dwelling species are the taxa of interest (Siewers et al 2014). Due to basic differences between pitfall traps and leaf litter collection, abundance may not be able to be compared adequately. However, activity periods of species may be compared, with each method able to capture different taxa and give a broader view of

circadian rhythms in arthropod communities. Pitfall data was not available from this study, due to the small amount of arthropod taxa captured by the traps (being mostly Collembola, Aranae, and Opiliones). Each pitfall was only open for the daylight and night hours, about 12 hours each (a shorter time period than in other experiments), and this was probably not enough time to adequately capture active taxa. Leaf litter collection is not always superior to pitfall trap studies, of course. Weaknesses identified earlier in this study, such as fewer captures of large-bodied taxa, habitat factors (such as depth of the litter layer), and less familiarity with the method as compared to pitfalls, will influence researchers' decisions. Future studies to further explore differences between litter collection and pitfall catches will aid in these decisions. Spence & Nieml  (1994) identified litter samples as better for comparing species abundance across separate habitats, and as more effective for density estimates of adult Carabidae. However, differences in the exact collection and extraction from leaf litter (such as Berlese extraction versus washing, see Spence & Nieml  1994) are not as well-investigated as minute differences of pitfall traps, such as material the traps are made of and use of covers or drift fences (Siewers et al 2014).

While the question of measuring activity or presence through abundance data from leaf litter collection remains unanswered, this study has shown that there are significant differences between arthropod abundance at three different time periods: 6 AM, daylight hours, and nighttime hours. In order to get a true measure of species richness at a site, collections should be made at each of these time periods. Leaf litter sampling programs should aim to cover each of these periods for robust abundance measures and to ensure the capture of rare or cryptic taxa. Data about the circadian rhythms of leaf litter arthropods is similar whether it was collected with leaf litter or pitfall trap methods, and fine scale data at the species level varies according to

species and may not reflect the broader accepted circadian rhythms at the courser family level.

Leaf litter collection has advantages over pitfall trap collection, and more studies examining the differences between the two methods should be done in the future to gain a clearer understanding what taxa may or may not be overlooked by each method.

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#### **IV. Conclusions**

These studies of leaf litter arthropods of Arkansas correct past mistakes and offer new insights into the state's fauna. Previously published lists of the Arkansas endemic fauna contained many errors with regards to the Diplopoda, overestimating the number of endemic species in the state. The original list from Robison & Allen (1995) listed 32 endemic millipedes, but that number now stands at 16. This discrepancy is due to the scattered nature of millipede records in the literature, combined with a lack of general collecting that would suss out true species ranges. However, it is important to note that while the Arkansas endemic list has declined, most of the species are still endemic to the Interior Highlands. Thus, the actual rate of endemism for Diplopoda remains relatively stable in this region, which is consistent with the identification of the Interior Highlands as a unique area of endemism. This result is to be expected, since the political boundaries of Arkansas are, for all intents and purposes, meaningless to the organisms that traverse them. Arkansas remains the only state in the Interior Highlands which has a comprehensive list of its endemic species, however, making it amenable to scientific research. It also has important implications for conservation, which are bolstered by having an updated and current list to inform conservation decisions. It should also instill pride in the state's natural heritage, a point that shouldn't be overlooked solely in favor of its scientific usefulness.

The review of the state's millipede fauna, particularly the key and species accounts, will prove valuable to anyone interested in the group. This extends outside the state's borders, as many of the included families and genera occur widely throughout the eastern United States. Arkansas is now the only state with both a checklist and (current) key to its millipede species, allowing non-specialists to work with the group and incorporate it into their studies. Millipedes



are a ubiquitous component of the ecological communities of the state and their biology may now be fully investigated from a more solid foundation.

The examination of leaf litter collection methods of forest litter arthropods showed agreement with previous studies that were based on pitfall trap data. Additionally, strengths and weaknesses of each collection method were identified, and the methods can complement each other according to the needs of a particular project. This should be pursued by researchers working in forest ecosystems to gain more understanding of the arthropods that inhabit them. Dawn, daylight, and darkness time periods were identified as being important collection times, and should be sampled for accurate reflection of abundance data.