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Chris T. McAllister

Texas A&M University-Texarkana

Rowland M. Shelley

North Carolina State Museum of Natural Sciences

James T. McAllister III

W. T. White High School

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Millipeds (Arthropoda: Diplopoda) of Ark-La-Tex. II. Distributional Records for Some Species of Western and Central Arkansas and Eastern and Southeastern Oklahoma

Chris T. McAllister*

Department of Biology
Texas A&M University-Texarkana
Texarkana, TX 75505

Rowland M. Shelley

Research Laboratory
North Carolina State Museum of Natural Sciences
4301 Reedy Creek Rd.
Raleigh, NC 27607

James T. McAllister, III

W. T. White High School
1244 Forest Lane
Dallas, TX 75228

*Corresponding Author

Abstract

We collected millipeds between November 2001 and March 2002 at several sites in the Ouachita Provinces of western (Garland, Hot Spring, Pike, and Polk counties) and central Arkansas (Pulaski County) and the Ouachita and Kiamichi Provinces of southeastern Oklahoma (LeFlore and McCurtain counties). The following millipeds were found: *Eurymerodesmus dubius*, *Auturus louisianus louisianus*, *Pseudopolydesmus pinetorum*, and *Cambala minor* in Garland County; *Eurymerodesmus* sp., *A. l. louisianus*, *P. pinetorum*, and juveniles of the family Parajulidae (tribe Aniulini) from Hot Spring County; *E. dubius*, *A. l. louisianus*, and juveniles of the family Cleidogonidae from Pike County; *Brachycybe lecontei*, *A. l. louisianus*, *Abacion tessellatum*, and *P. pinetorum* in Polk County; *Eurymerodesmus pulaski*, *P. pinetorum*, *Auturus evides*, *C. minor*, *B. lecontei*, and a possible new species of *Cleidogona* in Pulaski County; *A. l. louisianus*, *Apheloria virginiensis ?reducta*, *P. pinetorum*, *Narceus americanus*, and *E. dubius* in McCurtain County; and *B. lecontei*, *A. l. louisianus*, *Eurymerodesmus b. birdi*, *A. ?tessellatum*, and juveniles of the family Parajulidae (tribe Aniulini) in LeFlore County. Two new state records are documented for Oklahoma: *B. lecontei* (Platydesmida: Androgonthidae), a record not only for the genus and species but also for the family and order; and *E. dubius*, the westernmost locality ever reported for the species.

Introduction

As part of an on-going worldwide effort to document the species within one of the poorest known arthropod classes, the Diplopoda, we continue our milliped samplings in various parts of the Ark-La-Tex region. Other than the concurrent report by McAllister et al. (2002), little collecting has been done in this area, particularly in Arkansas and Oklahoma, since the mid-1970's, when the late Dr. Nell B. Causey effectively retired. We have therefore focused our fieldwork on this relatively neglected area, particularly western and central Arkansas and far eastern and southeastern Oklahoma. This paper, the second in a series of works on the fauna of the Ark-La-Tex, details several new distributional records for Arkansas and Oklahoma counties and two new state records for Oklahoma.

Materials and Methods

Between November 2001 and March 2002, we collected millipeds in five counties (Garland, Hot Spring, Pike, Polk, Pulaski) of western and central Arkansas and two counties (LeFlore and McCurtain) of eastern and southeastern Oklahoma. Most of the sites were off trails in state parks and in the Ouachita National Forest where there was an

abundance of decaying logs and damp leaf litter, prime milliped habitat. Further methods for collecting and processing millipeds are described by McAllister et al. (2002). Voucher specimens are deposited in the North Carolina State Museum of Natural Sciences (NCSM), Raleigh, North Carolina.

Results and Discussion

A total of 11 species and subspecies of millipeds, representing nine genera, 10 families, and seven orders was found during our survey; there were also unidentifiable juveniles of *Eurymerodesmus* and individuals belonging to the families Cleidogonidae and Parajulidae (tribe Aniulini) that could not be assigned to genera. By far the most common order represented in our collection is the Polydesmida, the largest in the class Diplopoda, with seven species in four families. The most common species was *Auturus louisianus louisianus*, collected from four of five Arkansas counties and both Oklahoma counties surveyed. A complete list of taxa collected is presented below and annotated with distributional and ecological information.

Annotated List

Order Polydesmida

Family Xystodesmidae

Apheloria virginiensis ?*reducta* Chamberlin, 1939. Nine males of *A. virginiensis* were collected along the David Boren Trail in Beaver's Bend State Park, McCurtain County, Oklahoma, in January and March 2002. Causey (1954) previously reported this millipede (a single male collected on 20 July 1954) from an unspecified locale somewhere in McCurtain County. Interestingly, the type locality of *A. reducta* is in the foothills of the Ozark Mountains at Imboden, Lawrence County, Arkansas (Chamberlin, 1939), over 400 km northeast of McCurtain County. Hoffman (1999) reduced *reducta* to subspecific status under *A. virginiensis*, the most widely ranging species in the genus, extending from the vicinities of Milwaukee, Wisconsin, and Montreal, Quebec, Canada, to southern Virginia and Kentucky and southeastern Oklahoma (Hoffman, 1999; unpublished specimens collected and examined by the second author). We provisionally assign our specimens to this race pending completion of a generic revision currently in progress by Dr. Hoffman. There is a third locality record for the state, a male, taken at Broken Bow, McCurtain County, by D. C. Arnold on 10 June 1982, in the collection at the Emerson Entomological Museum, Oklahoma State University. The presence of *A. v. ?reducta* in southeastern Oklahoma suggests occurrence in proximate parts of southwestern Arkansas and northeastern Texas, where the taxa are currently unknown, but more field work is necessary to determine whether the form occurs widely in the contiguous corners of these states or whether the McCurtain County samples represent an allopatric population. *Apheloria v. ?reducta* is a large-bodied species, dorsally black with yellow margins, and emits a fragrant aroma that smells sweet, like almonds or marachino cherries, because of the presence of benzaldehyde in the defensive secretions (Eisner, H. E. et al., 1963, 1967; Eisner, T. et al., 1963; Towers et al., 1972).

Family Euryuridae

Auturus louisianus louisianus (Chamberlin, 1918). Specimens were taken from several locales, including the Pioneer Cemetery Historical site (Polk County, vic. Queen Wilhelmina State Park), Lake DeGray State Park (Hot Spring County), Hot Springs National Park (Garland County), Daisy State Park and Crater of Diamonds State Park (Pike County), Choctaw Nation Historic site along St. Hwy. 1 (Talimena scenic drive) in LeFlore County, Oklahoma, just outside the Arkansas border, and Beaver's Bend State Park. This millipede inhabited a variety of environments from sites dominant with pines

and/or oaks to ones with mixed pines, oaks, and other hardwoods. Shelley (1982) revised the genus and summarized locales for Arkansas. All seven Arkansas counties reported previously for *A. l. louisianus* are south of the Arkansas River (Shelley, 1982). Hot Spring and LeFlore counties constitute new county records and supplement the known range in western Arkansas and eastern Oklahoma, respectively.

Auturus evides (Bollman, 1887). *Auturus evides* was collected in January 2002 from three sites south of the Arkansas River in Pulaski County, Arkansas, including Sweet Home, Boyle Park (western Little Rock), and Pinnacle Mountain State Park. It has the broadest distribution of any of the four species in the genus, extending from the vicinities of Minneapolis, Minnesota, and Champaign-Urbana, Illinois, to central Arkansas and eastern Oklahoma, primarily in the Mississippi Valley, and has been reported previously from Pulaski County at Camp Robinson, north of the Arkansas River (Shelley, 1982). Dowdy (1968) found *A. evides* exclusively in an oak-hickory forest; however, we collected specimens from predominantly pine areas.

Family Eurymerodesmidae

Eurymerodesmus sp. Juveniles not identifiable to species were collected from Pulaski County (Gilman Road site, Little Rock), Hot Spring County (Lake DeGray State Park), Pike County (Crater of Diamonds State Park), Beaver's Bend State Park (McCurtain County, Oklahoma), and Talimena State Park (LeFlore County, Oklahoma). These sites are well removed from each other with different habitat and elevations and probably involve a different species at each; additional collecting is necessary to obtain males for specific identities.

Eurymerodesmus birdi birdi Chamberlin, 1931. Two males with juvenile phoretic mites (hypopi) were taken at Talimena State Park (LeFlore Co., Oklahoma) in March 2002. Shelley (1990) previously reported *E. b. birdi* from Bear Den Cave, vic. Talihina, LeFlore County, which is near our collection site.

Eurymerodesmus dubius Chamberlin, 1943. In Arkansas, adult males and juveniles of this species were found along the Mountain Top Trail (elev. 300 m) of Hot Springs National Park (Garland County) and at Lake Greeson/Daisy State Park (Pike County); two males were also taken beside the David Boren Trail at Beaver's Bend State Park, McCurtain County, the first record of *E. dubius* from Oklahoma. The type locality is Delight, Pike County, Arkansas (Chamberlin, 1943), and specimens have been previously reported from Garland County (Hot Springs) and seven additional Arkansas counties (Shelley, 1990). More recently, McAllister et al. (2002) reported *E. dubius* from Hempstead County, Arkansas.

Eurymerodesmus pulaski (Causey, 1950). The type locality for *E. pulaski* is just south of Sweet Home, Pulaski County, Arkansas (Causey, 1950), and the species was previously known only from this site and one near Little Rock (Shelley, 1990). We report *E. pulaski* from an additional Pulaski County site, the west summit trail off St. Hwy 300 (elev. 170 m) at Pinnacle Mountain State Park, which is about 31 km NW of the type locality. Shelley (1990) suggested that Pulaski County, particularly the area around Little Rock, should be meticulously sampled because at least three species may occur there.

Family Polydesmidae

Pseudopolydesmus pinetorum (Bollman, 1888). This is the most common species of the genus in woodlands west of the Mississippi River, and we found this milliped in Polk (Pioneer Cemetery Historical site), Pulaski (Pinnacle Mountain State Park), Hot Spring (Lake DeGray State Park), and Garland (Hot Springs National Park) counties, Arkansas, and McCurtain County, Oklahoma (Beaver's Bend State Park). The latter locale represents a new county record for *P. pinetorum*. Stewart (1969) reported *P. pinetorum* from Bowie County in extreme NE Texas. This genus is badly in need of revision.

Order Spirostreptida

Family Cambalidae

Cambala minor Bollman, 1889. This species was found at only two sites, Pinnacle Mountain State Park (Pulaski County) and Hot Springs National Park, Garland County; previous records from Arkansas include Benton, Clay, Columbia, Howard, Ouachita, Polk, Randolph, Union, and Washington counties (Shelley, 1979). Our specimens represent new county records.

Order Chordeumatida

Family Cleidogonidae

Unidentifiable Cleidogonidae. Several juveniles representing either the genus *Cleidogona* or *Tiganogona* were collected from Pike County (Crater of Diamonds State Park). Males are necessary to render a determination.

Cleidogona sp. Two males of a probable new species of *Cleidogona* were collected off St. Hwy 365 just south of Sweet Home (Pulaski County). They belong to the "*C. unita* species group," as defined by Shear (1972), and becomes the second representative of this assemblage along with *C. unita* Causey, which occurs in southern Illinois and western Kentucky. Studies on this and other potentially new cleidogonid species from the Ark-La-Tex region (see McAllister et al., 2002) are in progress, and those found to be truly new will be formally named and described.

Order Julida

Family Parajulidae

Unidentifiable Aniulini. Several juveniles of this tribe (unidentifiable genus and species) were collected at three sites, including Pulaski County (Little Rock, Gilman Road site), Hot Spring County (Lake DeGray State Park), and LeFlore County, Oklahoma (Choctaw Nation Historic site). Additional collecting of males is necessary to determine their identity.

Order Callipodida

Family Abacionidae

Abacion tessellatum Rafinesque, 1820. We collected one male and three females of *A. tessellatum* from Polk County (Pioneer Cemetery Historical site) in March 2002. The species, which ranges from northern Iowa and southern Michigan to the Gulf Coast from Florida to Louisiana, was shown by Shelley (1984, Fig. 12) on a dot map to occur in Polk and other Arkansas counties: Benton, Cleburne, Cross, Jefferson, Stone, and Washington. It is surprising that we did not encounter this species more often as it is relatively common throughout its range. A lone female that we tentatively assign to *A. tessellatum* because of its large size (i.e., *A. texense*, a sympatric species, is typically smaller) was collected in March 2002 from Talimena State Park, LeFlore County. *Abacion tessellatum* would represent a new county record and only the second one from the state of Oklahoma; Shelley (1984, Fig. 12) showed the species in Craig County near the Kansas border. Authentic males of *A. tessellatum* from this site are necessary to confirm our preliminary identification.

Order Spirobolida

Family Spirobolidae

Narceus americanus (Beauvois, 1805). Although this milliped is very common throughout much of the eastern United States, it is less common west of the Mississippi River. During our five-month study, we encountered only one individual, in March 2002, an adult female from the David Boren Trail at Beaver's Bend State Park, McCurtain County, Oklahoma. This milliped was taken beneath a decaying pine log that also harbored *Eurymerodesmus* sp. and *A. v. ?reducta*.

Order Platydesmida

Family Andrognathidae

Brachycybe lecontei (Wood, 1864). Gardner (1975) revised this family and summarized localities for this southeastern species, which occurs in Alabama, Arkansas, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, and West Virginia. In Arkansas, *B. lecontei* is known from Benton, Izard, Logan, Polk, Saline, Scott, Stone, and Washington counties (Gardner, 1975). We also encountered it in Polk County (Pioneer Cemetery Historical site) and document a new county record for the state (Pulaski County, Boyle Park, Little Rock). *Brachycybe lecontei* occurs in the western tier of counties

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along the Oklahoma state line (Benton, Washington, Scott, and Polk), and we officially extend it into Oklahoma (LeFlore County, Choctaw Nation Historic site just outside the Arkansas border), which constitutes new state records for the species, genus, family, and order. Our specimens display bright red paranota, in contrast to ones from the southern Appalachians, which are ivory colored. There appears to be a color gradient in *B. lecontei* with individuals becoming more reddish to the west, as the second author collected specimens from Cumberland Falls State Park, Whitley County, Kentucky, in June 2001, that were pink, an intermediate color.

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Co-polymers of Furan with Pyrrole or Thiophene: A Synthetic Study

Rose M. McConnell*, Walter E. Godwin, Susan E. Baker,
Kenya Powell, Martha Baskett, and Amy Morara
School of Mathematical & Natural Sciences
University of Arkansas at Monticello
Monticello, AR 71656

Xiadong Ma
College of Science
and Engineering Technology
University of Arkansas at Little Rock,
Little Rock, AR 72204

*Corresponding Author

Abstract

The use of conductive polymers as a substitute for metallic conductors and semiconductors has attracted much attention in the literature. In particular, aromatic heterocyclic polymers constitute an important class since they possess chemical and electrical stability in both the oxidized (doped) and neutral (undoped) state. Doping a polymer allows one to vary its electrical, mechanical, optical, and thermal properties. The properties of these polymers are promising for their many technological uses such as antistatic coatings, solar cells, and electronic devices. Polyfuran is among the least common heterocyclic polymers. Polyfuran has been reported to be much less stable than either polypyrrole or polythiophene. The preparation of co-polymers of polyfuran with two percent pyrrole or thiophene is reported. The polymers are characterized by ^1H NMR, IR, and ESR spectroscopy, and the electrical conductivity of the doped and un-doped synthetic polyfuran and co-polymers is provided.

Introduction

Electronically conducting polymers have attracted a great deal of attention from scientific and technological groups. There are many applications for conducting polymers in fields such as gas sensors (Nigorikawa et al., 1995), rechargeable batteries (Choi et al., 2001), electronic and optical devices (Nguyen and Potje-Kamloth, 1999), and corrosion inhibitors of metal substances (Rajagopalan and Iron, 2001). In the U.S. many cities spend enormous resources maintaining bridges and high rise structures because of corrosion of the metal surfaces. Recently, conductive polymers have been shown to be very good corrosion inhibitors to metal substrates (Mikalo et al., 2001). For the past ten years polyaniline has generated tremendous interest as a corrosion inhibitor (Kumar and Sharma, 1998). Many investigators believe that redox forms of polyaniline

help stabilize a thin oxide layer on the surface of iron (Dalas et al., 2000). Polypyrrole has also received attention due to its ability to inhibit corrosion of metal surfaces (Su and Iron, 2000; Ivanov et al., 2001). Unlike polyaniline, polypyrrole can be prepared even at neutral pH, which can be an advantage (Kang and Geckeler, 2000).

Polymers constructed of heterocyclic aromatic compounds, such as polypyrrole, polythiophene, polyaniline, have also been of particular interest due to their small band gap (1.4 - 3.2 eV) and doping capability. Doping a polymer with a small amount of a metal salt can greatly vary the conductivity of the polymer and so makes it useful in microelectronics and sensors (Kumar and Sharma, 1998). The electrical conductivity of these polymers, both neutral and doped, seems to depend on the degree of disorder in the solid state, including the disorder caused by the dopant (Mikalo et al., 2001; Ivanov et al., 2001).

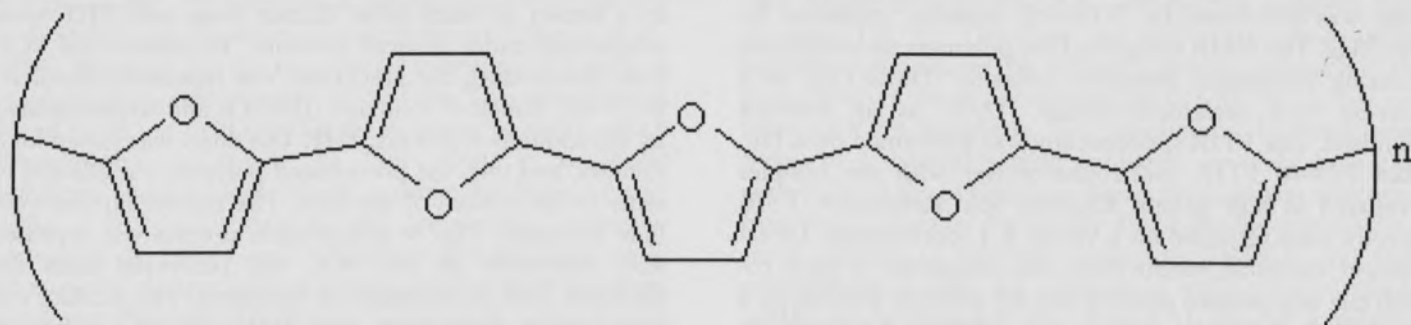


Fig. 1. Polyfuran in the more stable head to tail configuration.