



New records of harvestmen (Arachnida, Opiliones) from Minnesota, USA

A. KENJI SHOEMAKER¹, MERCEDES BURNS² & SARAH L. BOYER^{1,3}

¹Biology Department, Macalester College, 1600 Grand Avenue, Saint Paul, MN, 55105, USA

²Department of Biology, San Diego State University, San Diego, CA, 92182, USA

³Corresponding author. E-mail: boyer@macalester.edu

Abstract

Harvestmen (Opiliones) are a diverse order of arachnids composed of more than 6,600 described species which together span an almost global distribution. Although these animals may occur in extremely high abundance in both pristine and disturbed habitats, much of harvestman diversity remains undescribed, undocumented, and/or in need of taxonomic attention. In the current study, we focus on the harvestman diversity of the state of Minnesota, USA, where a lack of local expertise and effort has left the species richness of the state largely undocumented. We document two genera and seven species previously unrecorded in the state.—*Leiobunum aldrichi*, *L. calcar*, *L. flavum*, *L. politum*, *L. ventricosum*, *L. vitatum*, and *Odiellus pictus*.

Key words: *Leiobunum*, *Odiellus*, Eupnoi

Introduction

Over 20 years ago, Cokendolpher & Lee (1993) compiled and reviewed well over 1000 citations on North American Opiliones. At that time there were only five documented species of Opiliones present in Minnesota (Fig. 1), representing two of the four currently recognized suborders (as reviewed in Giribet & Sharma 2015). Two of these are from the suborder Dyspnoi: *Crosbycus dasycnemus* (Crosby 1911) and *Sabacon cavicolens* (Packard 1884), while the remaining three are placed in the suborder Eupnoi: *Eumesosoma roeweri* (Goodnight & Goodnight 1943), *Phalangium opilio* Linnaeus 1758, and *Trachyrhinus favosus* (Wood 1868). As far as we know, there have been no additional published records of Opiliones from Minnesota, so Cokendolpher & Lee's 1993 tally stands to this day. However, genera such as *Leiobunum* C. Koch 1839 have been documented in almost all of the US states and Canadian provinces surrounding Minnesota, leading us to suspect that diversity within the state is actually much higher than has been reported. Our suspicions were confirmed: examination of samples collected by the authors as well as specimens from the University of Minnesota Insect Collection has revealed an additional seven species, including two undocumented genera, to the list of Minnesotan opilionids. This work serves to connect and update the patchwork of information concerning Midwestern harvestmen, thereby shedding much needed light on a ubiquitous yet understudied group of arachnids in the temperate deciduous forest landscape.

Methods

Specimens for this project were acquired from the University of Minnesota Insect Collection, housed at the University of Minnesota – Saint Paul (UMSP), and from direct collection by the authors and collaborators. The specimens from UMSP were collected between 1923 and 1980 and preserved in ethanol of an unknown concentration. As far as we could determine, no record of these collections exists in the literature. However, labels in the specimen vials indicate that some were identified by A. L. Edgar in 1964. These samples were resuspended in 70% ethanol before identification. New collections were obtained in the summer of 2012 as part of a survey of leaf-litter arthropod diversity at Macalester College's Katharine Ordway Natural History Study Area (Fig. 1) and

through pitfall traps and hand collection in the summer of 2015. In total, 327 specimens were examined, 183 of which came from UMSP and the remaining 144 were caught live by the authors and students working in the lab of SLB. Specimens were examined using an Olympus SZX10 light microscope. Select individuals were photographed using Infinity Capture; Helicon Focus was used to integrate a series of partially focused images for each specimen.

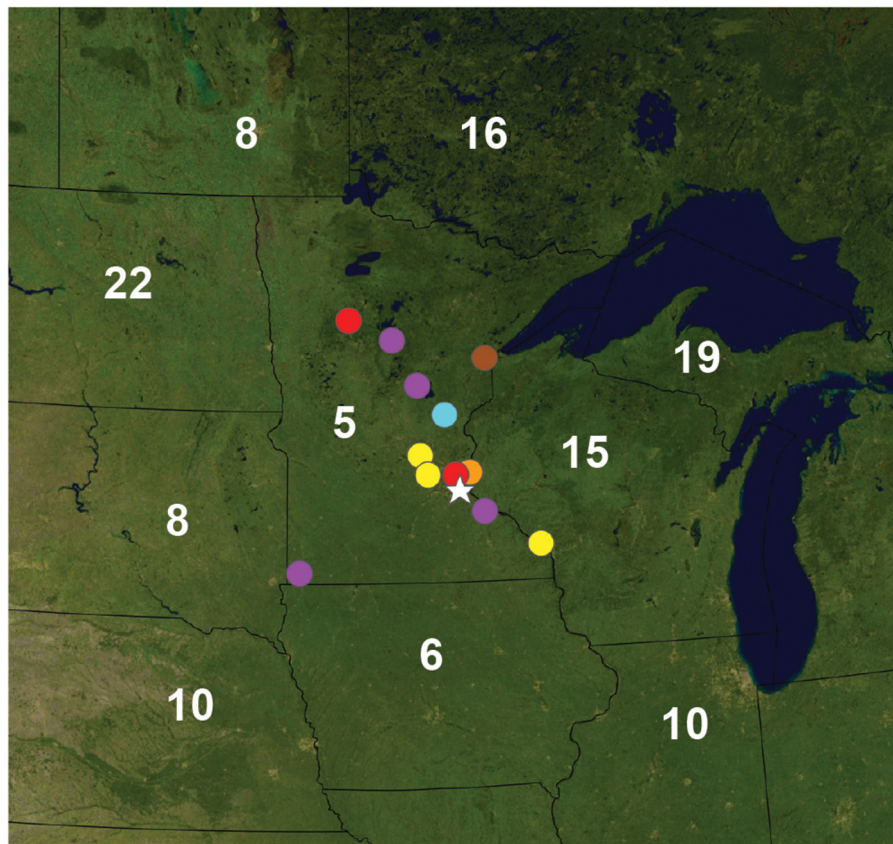


FIGURE 1. Map of Minnesota and surrounding US states and Canadian provinces. Numbers indicate the total documented species of Opiliones as reported by Cokendolpher & Lee (1993). Symbols indicate localities of species newly recorded in Minnesota. Yellow = *Leiodunum aldrichi*, blue = *L. calcar*, orange = *L. politum*, red = *L. ventricosum*, purple = *L. vittatum*, brown = *Odiellus pictus*, white star = Katharine Ordway Natural History Study Area (*L. aldrichi*, *L. calcar*, *L. flavum*, *L. ventricosum*, *L. vittatum*, and *Odiellus pictus*).

Results

Upon examination of existing museum collections and newly collected specimens, we have added two additional genera and seven additional species to the state's total count. Below, we indicate the diagnostic characters used to confirm the presence of each species in our collections; see Bishop (1949) for a detailed description of each species. See Cokendolpher and Lee (1993) for additional information on taxonomic history and relevant synonymies.

Leiodunum aldrichi Weed 1893 (Fig. 2A–C) was described from specimens collected from South Dakota. The species have also been documented across temperate areas in North America, with localities ranging from the southeast USA (North Carolina [Bishop & Crosby, 1924]) to southwestern Canada (British Columbia [Bishop, 1949]), including many areas that border Minnesota (USA: Wisconsin, North and South Dakota; Canada: Ontario [Cokendolpher & Lee, 1993]). Diagnosis: Both sexes have extremely long legs relative to their opisthosomal length, white annulations on the distal portions of tibia II (Fig. 2B), and dark, almost black eye tubercles and trochanters (Fig. 2A, C). Male: lack of a central figure (Weed 1890a) (Fig. 2C). Based on leg color patterns, Goodnight & Goodnight (1945) described juvenile *L. aldrichi* as a new species, *Leiodunum gordonii*, which has since been synonymized with *L. aldrichi* (Cokendolpher and Zeiders 2004).

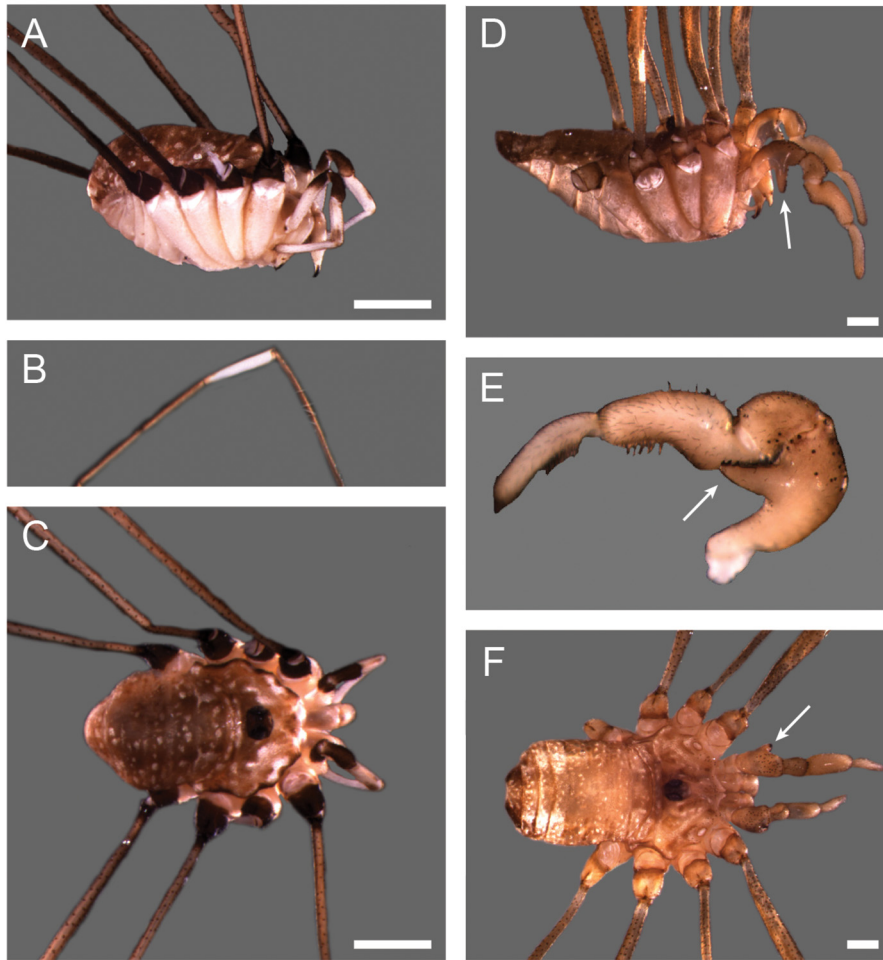


FIGURE 2. A) *Leiobunum aldrichi* MAC10 lateral view. B) *L. aldrichi* MAC10 tibia II. C) *L. aldrichi* MAC10 dorsal view. D) *L. calcar* MAC29 lateral view with palpal apophysis indicated by white arrow. E) *L. calcar* palp with apophysis indicated by white arrow. F) *L. calcar* MAC29 dorsal view with palpal apophysis indicated by white arrow. All scale bars = 1mm.

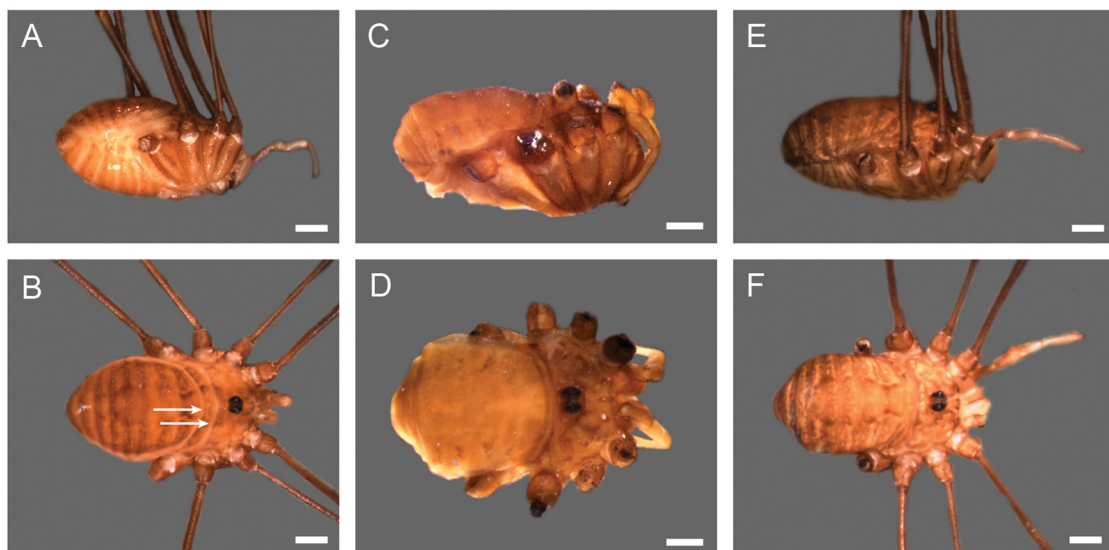


FIGURE 3. A) *Leiobunum flavum* MAC67 lateral view. B) *L. flavum* MAC67 dorsal view. C) *L. politum* MNSP-MNO53 lateral view. D) *L. politum* MNSP-MNO53 dorsal view, with membranous boundaries of metapeltidium indicated by white arrows. E) *L. ventricosum* MNSP-MNO53 lateral view. F) *L. ventricosum* MNSP-MNO53 dorsal view. All scale bars = 1mm.

Material examined. Hennepin County: 1 female, Katharine Ordway Natural History Study Area, 44°48'28"N/93°1'24.8"W, VI-10-2015 collected by the authors, Macalester Collections, MAC10. 5 males, same location, VI-30-2015 collected by the authors, Macalester Collections, MAC26. 1 male, same location, IX-10-2015 collected by author SLB's Invertebrate Animal Diversity class, Macalester Collections, MAC38. 5 females, same location, VI/10/2015 collected by the authors, Macalester Collections, MAC27. Wright County: 1 female, Lake Independence, 45°1'40"N/93°39'2.5236"W, IV-18-1937, K. Carland, University of Minnesota-Saint Paul Collections, UMSP-MNO49. Winona County: 1 male, La Moille Island, 44°0'11"N/91°27'55"W, VII-3-1933, W. E. Mins, University of Minnesota-Saint Paul, UMSP-MNO50. 3 males and 1 female, same location, La Moille Island, 44°0'11"N/91°27'55"W, VI-30-1933, W. E. Mins, University of Minnesota-Saint Paul Collections, UMSP-MNO51.

Leiobunum calcar (Wood 1868) (Fig. 2D–F) was originally described from specimens collected from the mountains of Southwest Virginia. Collections have been made in areas bordering Minnesota, including the US states of Wisconsin (Levi & Levi 1952), North Dakota (Cokendolpher & Lee 1993), and South Dakota (Weed 1893), and in the Canadian province of Ontario (Davis 1934). Diagnosis: Both sexes have an elongated opisthosoma (Fig. 2D). Males: Retrolateral apophyses on the pedipalpal femora (Ingianni *et al.* 2011), (Fig. 2D–F), and a lack of the penial sacs found in many other species (eg: *L. aldrichi*, *L. flavum*, *L. politum*, *L. ventricosum*) (Burns *et al.* 2012). Females: Elongate sternum (Ingianni *et al.* 2011) visible when genital operculum is removed.

Material examined. Kanabec County: 2 males, Mora, 45°52'26"N/93°17'38"W, 1934, C. R. Yeagan. University of Minnesota-Saint Paul Collections, UMSP-MNO48. Hennepin County: 1 male, Katharine Ordway Natural History Study Area, 44°48'28"N/93°1'24.8"W, VI-14-2012, Domokos Laukó and author SLB, Macalester Collections, MAC05. 5 males, same location, VI-30-2015, collected by the authors, Macalester College Collections, MAC23. 7 female and un-sexed juveniles, same location, VI-30-2015 collected by the authors, Macalester Collections, MAC24. 4 males, same location, VI-30-2015 collected by the authors, Macalester Collections, MAC29. Minnesota county unknown: 3 males, "spring 1935" S. R. Daniels, University of Minnesota-Saint Paul, UMSP-MNO46.

Leiobunum flavum Banks 1894 (Fig. 3A–B) was described from specimens from Louisiana and West Virginia. This species has been documented in Wisconsin, which borders Minnesota to the east, but not in the Dakotas, which border Minnesota to the west. Phylogenetically, *Leiobunum flavum* is closely related to *L. ventricosum* and *L. verrucosum* (Burns *et al.* 2012) and the male intromittent organs of these species share the characteristics of distally opened, cuticular penial sacs. *Leiobunum flavum* is distinguished from *L. ventricosum* by membranous boundary around the metapeltidium (Fig. 3B), and from *L. verrucosum* by its light brown, rather than black, ocularium and trochanters (Fig. 3A, B).

Material examined. Materials examined: Hennepin County: 1 male, Katharine Ordway Natural History Study Area, 44°48'28"N/93°1'24.8"W, VII-XX-2016, Boyer Lab, Macalester College Collections, MAC68. 2 males, same location, VI-30-2015, Boyer lab, Macalester College Collections, MAC25

Leiobunum politum Weed 1889 (Fig. 3C–D, 4A–B) was first described from specimens collected in a shed in Champaign, Illinois. This species has also been documented in 29 states and provinces across North America (Cokendolpher & Lee 1993). Diagnosis: Both sexes are of a medium brown color, possess a short row of spines anteroproximally and around the distal end on the pedipalpal femur, and have eye tubercles armed with two rows of small sharp spines. (McGhee 1977). Males: "bulbate" intromittent organ with a conspicuous pair of ventrolaterally-extending, closed cuticular penial alae found at the distal end of the penis (McGhee 1977). Females: central figure that does not extend to the eye tubercle (Katayama 1969).

Material examined. Washington County: 1 male, Stillwater, 45°3'0"N/92°49'0"W, VI-30-1933, A. A. Gremmersley, University of Minnesota-Saint Paul Collections, UMSP-MNO52. Winona County: 1 female, La Moille Island, 44°0'11"N/91°27'54"W, VII-3-1933, W.E. Mins, University of Minnesota-Saint Paul Collections, UMSP-MNO53.

Note: North American collections of this species normally possess a sacculate penis (Fig. 4B, Burns *et al.* 2013). Some of our collections possess all other diagnostic characters of the species (McGhee 1977), but have penes with enlarged glans and reduced penial alae (Fig. 4A). Molecular delimitation approaches will likely be necessary to ascertain whether this morphology warrants description of a novel species or is instead indicative of intra-specific variation across the species range.

Leiobunum ventricosum (Wood 1868) (Fig. 3E–F, 4C) was first described from specimens collected in Pennsylvania and Nebraska, but has also been documented across 29 states and provinces east of the Great Plains (Cokendolpher & Lee 1993). Diagnosis: Both sexes are distinguished by their large size relative to other *Leiobunum* species, pointed opisthosoma, and narrowing of the central figure on the second opisthosomal tergite (Davis 1943) (Fig. 3F). Males: large penial alae, often with nuptial gift (Fig. 4C).

Material examined. Hubbard County: 1 male and 1 female, Itasca State Park, 47°14'23"N/95°12'27"W, V-27-1933, D.J. Pletsch, University of Minnesota-Saint Paul Collections, UMSP-MNO54. County unknown: 3 females, date unknown, Destlund, University of Minnesota-Saint Paul Collections, UMSP-MNO55.

Leiobunum vittatum (Say 1821) (Fig. 5A–B) was first described from specimens from an unknown locality “in the Southern States.” It has since been documented across 40 states and provinces, including all those surrounding Minnesota (Cokendolpher & Lee 1993). Diagnosis: Both sexes distinguishable by their dark, grey to black central figures extending from the tip of the abdomen through the eye tubercle (Katayama 1969) (Fig. 5B), dark patellae (Fig. 5B), and banding at the distal end of the tibia (Say 1821). Males: elongate palpal femur.

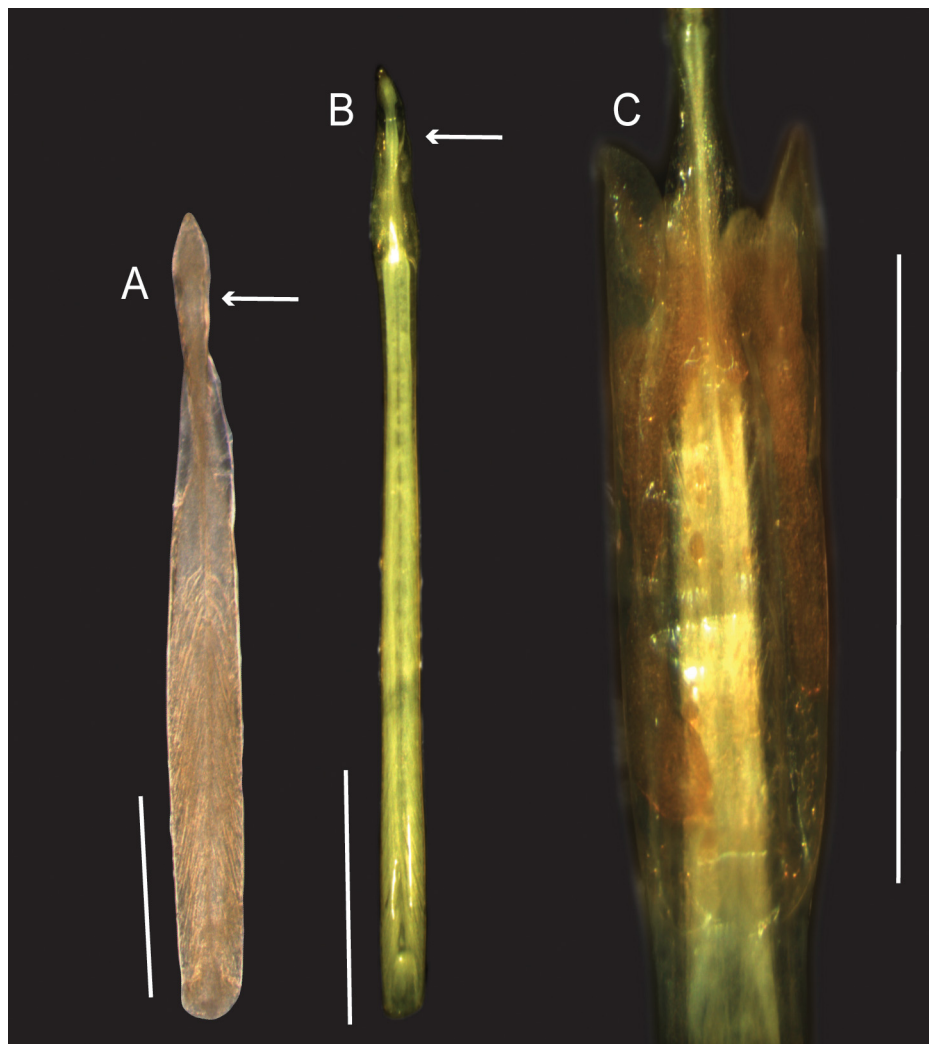


FIGURE 4. A) Light microscope photograph of dorsal *L. politum* penis from Minnesota (specimen MNSP-MNO52), identifying lack of conspicuous penial bulb as is diagnostic for the species (McGhee 1977). B) Light microscope photograph of dorsal *L. politum* penis from Maryland (specimen from biomechanical study by Burns & Shultz (2016)), identifying penial alae forming bulb structure as originally described in McGhee (1977). C) Distal end of ventral penis of *L. ventricosum* (KY: Whitley Co.; from Burns & Shultz 2015), showing cuticular alae forming open-ended sacs. Amber masses within sacs are crystallized nuptial gift (not miscible in 70% ethanol). All scale bars = 1mm.

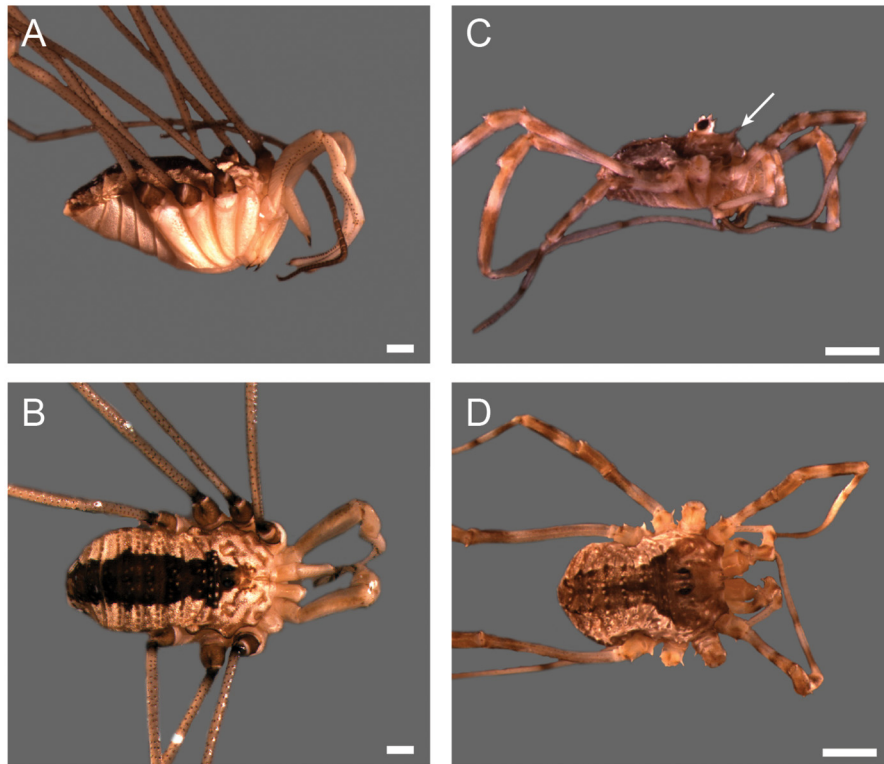


FIGURE 5. A) *Leiobunum vittatum* MAC15 lateral view. B) *L. vittatum* MAC15 dorsal view. C) *Odiellus pictus* MAC03 lateral view, with characteristic set of anterior spines indicated by white arrow. D) *O. pictus* MAC03 dorsal view. All scale bars = 1mm.

Material examined. Hennepin County: 3 females, Katharine Ordway Natural History Study Area, 44°48'28"N/93°1'24.8"W, VI-16-2015 collected by the authors, Macalester Collections, MAC16. 16 female and un-sexed juvenile specimens, same locality collected by the authors, Macalester Collections, MAC21. 10 males, same locality, VI-30-2015, collected by the authors, Macalester Collections, MAC22. 1 male, same locality, VI-30-2015, collected by the authors, Macalester Collections, MAC15. Rock County: 1 female, Luverne, 43°39'21"N/96°12'37"W, H. S. Telford, IX-14-1935, University of Minnesota-Saint Paul Collections, UMSP-MNO65. Goodhue County: 1 female, Hay Creek, 44°29'31"N/92°32'38"W, H. B. Gurney, IX-20-1935, University of Minnesota-Saint Paul Collections, UMSP-MNO59. Crow Wing County: 1 male, Garrison, 46°17'40"N/93°49'37"W, C.E. Mickel, VIII-9-1935, University of Minnesota-Saint Paul Collections, UMSP-MNO63. Cass County: 1 female, 46°57'0"N, 94°19'12"W, P.M. Schroeder, VIII-22-1939, University of Minnesota-Saint Paul Collections, UMSP-MNO64.

Odiellus pictus (Wood 1868) (Fig. 5C, D) was first described from specimens collected near Salem, Massachusetts. This species has since been documented in 25 states and provinces across eastern North America, and also in Wisconsin and Ontario. (Levi & Levi 1952; Bishop 1949). Diagnosis: both sexes are distinguished by abundant ornamentation on the pedipalps, and three large spines (trident) positioned in front of the eye tubercle (Fig. 5C). Of the genus, only this species is known to be present in the region (Edgar 1966).

Material examined. Hennepin County: 2 males, Katharine Ordway Natural History Study Area, 44°48'28"N, 93°1'24.8"W, VI-14-2012, collected by students at Macalester College, Macalester College Collections, MAC03. 5 females, same locality, VI-14-2012, collected by students at Macalester College, Macalester Collections, MAC06. 1 female, same locality, IX-10-2015 collected by a Macalester Invertebrate Animal Diversity class, Macalester College Collections, MAC35. Carlton County: 1 unsexed adult, 46°39'50"N/92°25'30"W, IX-4-1935, R. H. Daggy, University of Minnesota-Saint Paul Collections, UMSP-MNO05.

Discussion

While the large and common “daddy long-legs” are perhaps the best known harvestmen, the results of our survey indicate that our current understanding of these animals’ species ranges is incomplete. Previous authors have recognized the need for taxonomic revision in several of the North American *Leiobunum* species groups, and we agree that this work should be a priority. Recent molecular phylogenetic work by Hedin *et al.* (2012) and detailed examination of morphology by Ingianni *et al.* (2011) has highlighted the inadequacy of the current taxonomy at both the genus and species level. In a phylogenetic analysis based on two nuclear and five mitochondrial loci, Burns *et al.* (2012) found that many species in the genus were not monophyletic, including *L. vittatum*, *L. ventricosum*, *L. politum*, and *L. calcar*.

Leiobunum has in recent years become a compelling system for studying genitalic evolution (e.g. Burns *et al.* 2013, Burns & Shultz 2015, Burns & Shultz 2016), and the unusual morphology of the penis of *L. politum* examined in this study (Fig. 4) may support the hypothesis that higher reproductive conflict in localities with short breeding periods can shift selection pressures in ways that favor different genitalic morphologies in populations with short vs. long reproductive seasons (Burns *et al.* 2013). More intensive sampling across species ranges, including within the state of Minnesota, will be crucial to understanding species boundaries within *Leiobunum*. Integrative species delimitation incorporating morphology, molecular data, and behavior will lay the groundwork for evolutionarily grounded comparisons of morphology and behavior in this intriguing but understudied taxon.

Acknowledgements

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