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A LIST OF WISCONSIN SPRINGTAILS WITH NEW RECORDS AND ANNOTATIONS (HEXAPODA: PARAINSECTA: COLLEMBOLA)

E. J. Rebek[2], D. K. Young[1] and D. B. Hogg[1]

ABSTRACT

Twenty Collembola species new to Wisconsin were collected from soil at two agricultural sites in southern Wisconsin, including an undescribed species of Isotomidae. The state faunal list now contains 52 species representing seven families.

Wisconsin lacks a survey of the Collembola found within its borders. This is surprising since there are detailed accounts of the springtail species inhabiting the surrounding states of Michigan (Snider 1967), Minnesota (Guthrie 1903) and Iowa (Mills 1934). The absence of a pedantic springtail survey for Wisconsin leaves a scattered state list of 32 species (Table 1) generated from only a few studies (summarized in Christiansen and Bellinger 1998).

The following contribution is in no way an exhaustive inventory of Wisconsin's Collembola. Neither is this work a formal survey or taxonomic description of Wisconsin springtails. This study is merely another contribution to the state record resulting from intensive sampling at two agricultural sites in southern Wisconsin.

MATERIALS AND METHODS

The Wisconsin Integrated Cropping Systems Trial (WICST) was established at two sites in 1989: Arlington Agricultural Research Station (ARS) in southern Columbia County and Lakeland Agricultural Complex (LAC) in central Walworth County (Fig. 1). A uniformity trial was held in 1989 while the first year of production began in 1990. For the purposes of this study, each site consisted of four replications, each containing 14 treatments (plots), embodying six cropping systems. These cropping systems included cash-grain and forage crops grown in various phases in yearly rotations.

Two replications of four cropping systems were sampled during the summers of 1995 through 1997: continuous corn (system 1); the corn phase of a three-year rotation of row soybean, wheat (autumn) and red clover (spring) and corn (system 3); the corn phase of a three-year rotation of oats/alfalfa companion seeded, alfalfa and corn (system 5); and continuous pasture (system 6). The third rotation for cropping systems 3 and 5 began in 1997. All

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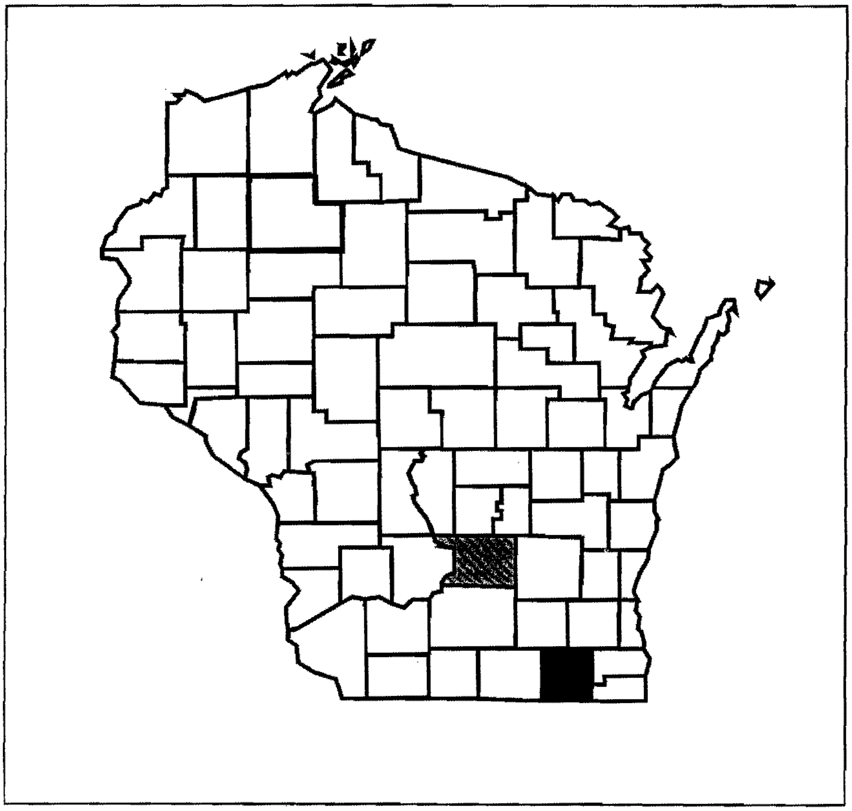

Figure 1. Wisconsin counties with Wisconsin Integrated Cropping Systems Trial (WICST) sites. One site exists at the Arlington Agricultural Research Station (ARS) in Columbia County (light shade). The other site is located at the Lakeland Agricultural Complex (LAC) in Walworth County (dark shade).

four systems varied in management inputs and perturbations ranging from high (e.g. continuous corn) to low (e.g. pasture).

Three sampling methods were used: pitfall traps, decomposition (litter) bags and soil cores. We expected both the kinds and proportions of species to be different among the various sampling methods and cropping systems. Pitfall traps and decomposition bags were used in 1995–96 while soil cores were taken only in 1997.

Pitfall traps passively capture active to moderately active species at the soil surface. The pitfall trap design consisted of two 16-ounce plastic beverage cups stacked together and buried in the soil to the lip of the inner cup. This design allowed quick and efficient trap cleaning since the inner cup could easily be removed and reinserted into the outer cup. Into each trap, 8 ounces of 3:1 propylene glycol:water solution were placed. One trap was placed within each of two selected rows near the long sides of each plot. Traps were placed about 120 feet (i.e. 40 paces) inward from the front edge or alley. Samples were collected every other week from each site, though each trap was "charged" with clean propylene glycol roughly each week. Sixteen samples (4 systems by 2 reps by 2 traps) comprised a sample set for each study site.

Coarse mesh (pore size = 4 mm) decomposition bags filled with corn stover were buried 6 inches below the soil surface in pre-determined, random locations within each plot. The corn scraps placed into each litter bag originated from the plant material already present in the WICST corn systems. Hence, decomposers existing in the plots were drawn toward the litter bags from throughout the soil strata. Sampling both sites involved the scheduled (i.e. biweekly) removal of randomly selected bags over the course of the growing season from two pre-determined locations within each plot (i.e. randomized locations within two rows). Sixteen litter bags were recovered from a study site for each sampling effort (4 systems by 2 reps by 2 litter bags).

Soil cores are direct samples of organisms from the upper soil horizons. Soil core samples were taken to a depth of 6 inches using a soil probe of 2.5 inches diameter. Each sample consisted of three cores or "subsamples" combined into 1104.5 cubic centimeters of soil. These samples were taken at two randomly chosen areas in each plot (within one or two predetermined rows). Soil core samples were taken at the base of corn plants in corn systems or within two strips of grasses and forbs in pasture systems. Sixteen soil core samples were taken from each site for each sampling effort (4 systems by 2 reps by 2 samples).

Soil organisms were extracted from litter bags and soil cores with Berlese funnels.

Collembola examined in this study were identified using The Collembola of North America, North of the Rio Grande (Christiansen and Bellinger 1998). Identifications were verified by Dr. Royce Bitzer (Iowa State University) and Dr. Kenneth Christiansen (Grinnell College). The species reported here are vouchered by specimens located in the University of Wisconsin Insect Research Collection (UW-IRC).

RESULTS

Twenty-six Collembola species representing five families were collected from Arlington Research Station and Lakeland Agricultural Complex between 1995 and 1997 (Table 1). Twenty of these species appear to have not been previously recorded from Wisconsin (Christiansen and Bellinger 1998). One of these 20 species represents a novel *Isotoma* species. Each of the species noted below represents a new Wisconsin state record.

ENTOMOBRYIDAE

Entomobrya (Entomobrya) multifasciata (Tullberg)

This species occurred in only one sample during the WICST study. Four specimens were collected from a pitfall trap placed in a continuous corn plot, 8–15 July 1996 (LAC). Snider (1967) reported this species as common throughout the state of Michigan.

Lepidocyrtus paradoxus Uzel

A ubiquitous species, *L. paradoxus* occurred in all cropping systems at both sites in 1995–96. However, this species was most abundant at ARS. *Lep-*

Table 1. Wisconsin Collembola with notes and county records. New Wisconsin county records in bold type.

Species and Author(s)	State Records and Notes	Counties
Entomobryidae		
Entomobrya (Entomobrya) assuta Folsom	WI (Christiansen and Bellinger 1998)	Columbia
Entomobrya (E.) confusa Christiansen	WI (Christiansen and Bellinger 1998)	Dane
Entomobrya (E.) multifasciata (Tullberg)	MI (Snider 1967) MN (Guthrie 1903) **New Wisconsin record**	**Walworth**
Entomobrya (E.) nivalis (Linnaeus)	WI (Christiansen and Bellinger 1998)	Ashland
Entomobrya (Entomobryoides) purpurascens (Packard)	WI (Christiansen and Bellinger 1998)	**Columbia, Walworth**
Lepidocyrtus cinereus Folsom	MI (Snider 1967) **New Wisconsin record**	**Columbia, Walworth**
Lepidocrytus paradoxus Uzel	MI (Snider 1967) **New Wisconsin record**	**Columbia, Walworth**
Orchesella ainsliei Folsom	WI (Lussenhop 1973)	Dane
Pseudosinella alba (Packard)	**New Wisconsin record**	**Columbia**
Pseudosinella rolfsi Mills	WI (Christiansen and Bellinger 1998)	Sauk
Pseudosinella violenta (Folsom)	MI (Snider 1967) **New Wisconsin record**	**Columbia, Walworth**

Willowsia buski (Lubbock)	WI (Lussenhop 1973)	Dane, **Columbia**, **Walworth**
Willowsia nigromaculata (Lubbock)	WI (Lussenhop 1973)	Dane
Isotomidae		
Folsomia bisetosa Gisin	**New Wisconsin record**	N/A
Folsomia candida Willem	**New Wisconsin record**	**Columbia, Walworth**
Folsomia elongata (MacGillivray)	WI (Christiansen and Bellinger 1998)	Dane
Folsomia nivalis (Packard)	WI (Christiansen and Bellinger 1998)	(many)
Folsomia stella Christiansen and Tucker	WI (Christiansen and Bellinger 1998)	Pierce
Folsomides parvulus Stach	**New Wisconsin record**	**Columbia, Walworth**
Isotoma (Desoria) albella Packard	WI (Christiansen and Bellinger 1998)	Sawyer
Isotoma (D.) flora Christiansen and Bellinger	**New Wisconsin record**	**Columbia, Walworth**
Isotoma (D.) notabilis Schaffer	WI, cave specimens (Christiansen and Bellinger 1998)	**Columbia**
Isotoma (D.) sp. (?)	Undescribed species	Columbia, Walworth
Isotoma (Isotoma) s.s. *delta* (?) Folsom	MN (Guthrie 1903) as *I. viridis* and *I. catena* **New Wisconsin record**	**Columbia, Walworth**

Continued

Table 1. Continued

Species and Author(s)	State Records and Notes	Counties
Isotoma (I.) difficilis Folsom	WI record published, but needs confirmation (Christiansen and Bellinger 1998)	N/A
Isotoma (Pseudisotoma) sensibilis Tullberg	WI (Lussenhop 1973)	Dane
Metisotoma grandiceps (Reuter)	WI (Christiansen and Bellinger 1998)	Sawyer
Proisotoma (Appendisotoma) dubia Christiansen and Bellinger	**New Wisconsin record**	**Columbia, Walworth**
Proisotoma (Proisotoma) frisoni Folsom	**New Wisconsin record**	**Columbia, Walworth**
Proisotoma (P.) minuta (Tullberg)	MI (Snider 1967) MN (Guthrie 1903) **New Wisconsin record**	**Columbia, Walworth**
Onychiuridae		
Onychiurus (Archaphorura) gelus Christ. & Bell.	WI (Christiansen and Bellinger 1998)	Richland
Onychiurus (Onychiurus) reluctus Christiansen	WI (Christiansen and Bellinger 1998)	Crawford, Pierce
Onychiurus (Protaphorura) encarpatus Denis	**New Wisconsin record**	**Columbia, Walworth**
Onychiurus (P.) obesus Mills	WI (Christiansen and Bellinger 1998)	Pierce
Onychiurus (P.) similis Folsom	WI (Lussenhop 1973)	Dane

Onychiurus (P.) subtenuis Folsom	WI (Christiansen and Bellinger 1998)	Sawyer
Onychiurus (P.) talus Christiansen and Bellinger	WI (Christiansen and Bellinger 1998)	Sauk
Tullbergia (Tullbergia) silvicola Folsom	WI (Lussenhop 1973)	Dane, **Columbia**, **Walworth**
Hypogastruridae		
Anurida (Anurida) tullbergi Schott	WI (Lussenhop 1973)	Dane
Brachystomella parvula (Schaffer)	WI (Lussenhop 1973)	Dane
Hypogastrura (Hypogastrura) brevispina (Harvey)	MI (Snider 1967) **New Wisconsin record**	N/A
Schaefferia (Bonetogastrura) variabilis Christ.	WI (Christiansen and Bellinger 1998)	Sawyer
Sensillanura millsi (Christiansen and Bellinger)	WI (Christiansen and Bellinger 1998)	Richland
Xenylla grisea Axelson	MN (Guthrie 1903) as *X. gracilis* **New Wisconsin record**	**Columbia**, **Walworth**
Sminthuridae		
Arrhopalites benitus (Folsom)	WI (Christiansen and Bellinger 1998)	Sawyer
Arrhopalites caecus (Tullberg)	WI (Lussenhop 1973)	Dane, **Columbia**, **Walworth**

Continued

Table 1. Continued

Species and Author(s)	State Records and Notes	Counties
Arrhopalites hirtus Christiansen	WI (Christiansen and Bellinger 1998)	Crawford, Richland, Sauk
Bourletiella (Bourletiella) hortensis (Fitch)	MI (Snider 1967) **New Wisconsin record**	**Columbia, Walworth**
Bourletiella (B.) sp. A	**New Wisconsin record**	**Walworth**
Ptenothrix (Ptenothrix) atra (Linnaeus)	WI (Folsom 1934)	N/A
Sminthurinus (Sminthurinus) latimaculosus Maynard	MI (Christiansen and Bellinger 1998) **New Wisconsin record**	**Walworth**
Sminthurus sp.	Species undeterminable; only immatures found	Columbia, Walworth
Neelidae		
Neelus (Megalothorax) minimus (Willem)	WI (Christiansen and Bellinger 1998)	Pierce
Tomoceridae		
Tomocerus (Tomocerina) lamelliferus Mills	WI (Christiansen and Bellinger 1998)	Sawyer

idocyrtus paradoxus is evidently an epigeic species since specimens were collected only from pitfall traps.

Lepidocyrtus cinereus Folsom

Like *L. paradoxus, L. cinereus* occurred in all systems at both sites in 1995–96, yet was most numerous at ARS. This species was also active solely at the soil surface since only pitfall trap specimens were recorded.

Pseudosinella alba (Packard)

Pseudosinella alba was collected in litter bags at ARS on 25 June and 9 July 1996. Small numbers of this species were recorded from all four cropping systems. One specimen was recovered from a soil core sample in continuous corn on 20 August 1997. Sharma and Kevan (1963) observed *P. alba* occurring in the same habitat as *Pseudosinella violenta* (Folsom) and found many samples containing both species together. In the WICST plots, *P. alba* almost always occurred with *P. violenta*.

Pseudosinella violenta (Folsom)

Pseudosinella violenta was frequently collected in small numbers from all systems at both sites. Additionally, specimens of this large species were recovered using all three sampling methods, although litter bags yielded the most individuals. *Pseudosinella violenta* is known to occur in a variety of habitats including caves (Christiansen 1960) and under rocks, logs and rotting leaves (Davis and Harris 1936). Soil-inhabiting specimens have been observed feeding on sugar cane roots, peanuts and wheat. In 1933, Folsom identified *P. violenta* as one of 40 springtails known to be injurious, although concern over economic damage is only warranted when high numbers of the species are present (Davis and Harris 1936). *Pseudosinella violenta* may be feeding on the roots of corn, grasses and forbs in the WICST plots. However, the small number of *P. violenta* generated from this study suggests this species is of minor, if any, economic importance in southern Wisconsin.

ISOTOMIDAE

Proisotoma (Proisotoma) minuta (Tullberg)

Proisotoma minuta was collected most commonly in litter bags and soil core samples, although large aggregations of this tiny species were collected in pitfall traps 20–27 June 1996 (ARS). This ubiquitous species was commonly found below the soil surface at both sites during all three years of the study.

Proisotoma (Proisotoma) frisoni Folsom

This species was rarely encountered in litter bag samples. One specimen of *P. frisoni* was found from each of three 1996 sample dates in ARS pasture samples. Late in that season, 11 specimens were recovered from two continuous corn samples at LAC.

Proisotoma (Appendisotoma) dubia Christiansen & Bellinger

A close relative of *P. minuta, P. dubia* was most often collected in close association with *P. minuta* early to mid-summer. *Proisotoma dubia* was found in litter bag samples at ARS and LAC, but one specimen was recovered from a soil core sample taken in corn (system 5) on 4 June 1997 (LAC).

Isotoma sp. 1

This undescribed species (*fide*, Christiansen, pers. comm.) was collected from ARS and LAC most frequently using soil cores in 1997. It was never found in litter bags, but small numbers were generated from pitfall trap samples taken 20–27 June 1996 (ARS). This isotomid is most likely an epigeic species and may not be attracted to decomposing plant material well below the soil surface.

Isotoma (*Isotoma*) s.s. *delta* (?) Folsom

Isotoma delta, often listed as a "variant" of *Isotoma viridis* Bourlet (Folsom 1937), occurred in large numbers in 1995–96 pitfall traps. This species was ubiquitous, occurring in all four systems at both sites. *Isotoma delta* evidently prefers the soil surface since all specimens were taken from pitfall traps.

The taxonomic status of *I. viridis* is currently in contention because many specimens carrying this name (including *I. delta*) are considered to represent separate species. Nevertheless, since *I. viridis* has been recorded from all over North America (Christiansen and Bellinger 1998), it is not surprising that *I. delta* should be found in Wisconsin.

Isotoma (Desoria) flora Christiansen & Bellinger

Small numbers of *I. flora* appeared in litter bags collected from both sites early in the summer of 1995. However, LAC recorded higher numbers than ARS that year. In 1996, even fewer specimens were collected from both sites late in the year. Soil cores taken 20 August 1997 (ARS) also yielded small numbers of this species.

Folsomides parvulus Stach

Folsomides parvulus was most commonly collected in 1997 soil core samples (ARS). One specimen was found in a litter bag retrieved 9 July 1996 (LAC). This species was most numerous in samples taken from continuous corn plots. Its reduced number of eyes (1+1 or 2+2) and white color suggest that *F. parvulus* lives below the soil surface. Our study supports this hypothesis because no specimens of *F. parvulus* were found in pitfall traps.

Folsomia candida Willem

This species was collected frequently from all cropping systems at both sites in litter bags and soil cores, but never in large numbers. *Folsomia candida* never appeared in pitfall traps. Hence, it is likely that this species primarily inhabits the soil horizon below the surface. The absence of eyes and strongly reduced pigment supports this view, suggesting that *F. candida* is a euedaphic species, living in the deeper, mineral soil layers. It is not surprising that this species of Isotomidae is found in Wisconsin since *F. candida* commonly appears across North America (Christiansen and Bellinger 1998).

Folsomia bisetosa Gisin

It is likely that *F. bisetosa* has similar habits to *F. candida* since both were found only in litter bag and soil core samples and the two species are very similar in form. Specific collecting information for this species is missing so county records are not provided (Table 1).

ONYCHIURIDAE

Onychiurus (Protaphorura) encarpatus Denis

This species was collected from both ARS and LAC in 1995 litter bag samples and especially 1997 soil core samples. *Onychiurus encarpatus* was most abundant in continuous corn plots, though single individuals were collected in the other corn treatments as well. This species most likely dwells only below the soil surface because no specimens were found in pitfall traps.

HYPOGASTRURIDAE

Hypogastrura (Hypogastrura) brevispina (Harvey)

Only two specimens of *Hypogastrura brevispina* were collected in the WICST plots. Specific collecting information for this species is missing so county records are not provided (Table 1).

Xenylla grisea Axelson

Xenylla grisea occurred in samples from all four treatments at both sites. The species was most common in 1996 pitfall trap samples. However, a remarkable 249 specimens were collected from a litter bag (pasture plot: LAC) 13 August 1996. In contrast, only three individuals were found in 1997 soil core samples, while 1995 pitfall traps generated but six specimens.

SMINTHURIDAE

Bourletiella (Bourletiella) hortensis (Fitch)

This species appeared occasionally in 1997 soil cores and 1995 pitfall traps. However, the population seemed to escalate dramatically in 1996 as evidenced by pitfall trap samples for that year. Thousands of specimens per trap were collected 20-27 June 1996 (ARS) and the population steadily declined thereafter. In contrast, fewer than 10/trap were found the prior year. This may be explained by the fact that 1995 pitfall trap sampling was not initiated at ARS until 19 July. Yet, the abundance of *B. hortensis* during mid-July, 1995 was still low compared to the same time frame in 1996. Relatively few specimens were recorded for a few soil cores in 1997. Since no specimens were found in litter bags, *B. hortensis* may dwell at the soil surface and is apparently not directly involved in below ground decomposition.

Bourletiella (B.) sp. A

No descriptive work has been done with this species so it is referred to as *Bourletiella (B.)* sp. A in Collembola of North America, North of the Rio Grande. Likewise, no records have been published for this species.

Two specimens of this species were recovered from a soil core sample taken from a pasture plot 4 June 1997 (LAC). This species may have occurred more commonly in this study, perhaps being mistaken for *B. hortensis* in pitfall trap samples in which *B. hortensis* occurred in great numbers.

Sminthurinus (Sminthurinus) latimaculosus Maynard

Only one specimen of *S. latimaculosus* was found for this entire study. This specimen was collected from a soil core taken from a pasture plot 4 June 1997 (LAC).

DISCUSSION

These 20 Collembola species new to Wisconsin surely represent but a small fraction of the total springtail species that actually occur here. Only two agricultural sites in southern Wisconsin generated these records (Fig. 1). In addition, only the soil fauna was studied. Many springtail species are known to occur in a variety of other habitats including caves, lakeshores and under bark (Hopkin 1997).

The Wisconsin state record for Collembola increased by roughly 40% based on this small study. The list now contains 52 species representing seven families (Table 1). One new *Isotoma* species which needs description was also recovered.

ACKNOWLEDGMENTS

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