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Exploratory Studies of Collembolan Populations in Iowa[1]

WILLIAM L. O'NEILL[2] AND LARRY P. PEDIGO[3]

Abstract. Collembola, primitive insects of the subclass Apterygota, were studied in Iowa during the summer of 1968 as part of the National Science Foundation Undergraduate Research Participation Program at Iowa State University. Soil cores were taken from woodlands, grasslands, cultivated fields, pastures, fencerows, marshlands, and caves, and animals were extracted with a modified Tullgren apparatus. Sixty-five collembolan species were collected, three of which were believed to be new. The results of systematic sampling at Ledges State Park, Boone County, Iowa, indicated that strong qualitative and quantitative differences existed among several woodland sites and a prairie-like site

Collembola are primitively wingless insects of the subclass Apterygota. Interest in this particular group has increased over the past few years because of emphasis on soil studies in connection with man-induced environmental pollution (Butcher and Shaddy, 1965; Butcher and Snider, 1966; Shaddy and Butcher, 1967). The importance of Collembola in this respect has been reported in recent studies (Anonymous, 1968). These indicate that Collembola are able to metabolize DDT, producing a less toxic metabolite, DDE. Collembola should also be important as indicators of soil pollution for the following reasons:

1. They are low on the food chain,
2. They are one of the most common soil arthropods,
3. As a group, they are active during the coldest weather and, thus may be collected year round.

Although Collembola are abundant, a general lack of knowledge exists concerning behavior, life history, population dynamics, and systematics. A monograph of Iowa Collembola (Mills, 1934), places this state considerably ahead of most others with regard to knowledge of the fauna. To our knowledge, quantitative studies of Iowa Collembola, are lacking, however, as are recent faunal studies using modern extracting equipment. We believed that a contribution could be made through a recent exploratory study of Iowa Collembola. This study was conducted at Iowa State University, Ames, Iowa, during the summer of 1968 under a National Science Foundation Undergraduate Research Participation Program Grant. Objectives of the study were the following: (1) to make a selective survey of Collembola in Iowa, (2) to provide the Iowa State Uni-

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versity Insect Collection with specimens of this order, and (3) to assess quantitative and qualitative differences primarily among woodland habitats.

Collembola are generally recognized by the presence of a furcula, or jumping organ. This structure, absent in some species, enables the insect to leap relatively great distances. All Collembola possess a collophore (ventral tubular structure), which may function as a grooming organ (Pedigo, 1967). Although species commonly inhabit soil and leaf litter, many may be found on plants and water surfaces.

Methods and Collecting Sites

General Collecting. General collecting trips were made to various portions of the state, including northwestern Iowa (Dickinson, Buena Vista, Pocahontas, Humboldt, and Webster Counties), northeastern Iowa (Jackson and Winneshiek Counties), southeastern (Lucas, Washington, Des Moines, Henry, and Louisa Counties), and central Iowa (Boone and Polk Counties). Several diverse habitats were sampled on these trips, including cultivated fields, pastures, woodlands, marshes, and caves. Soil cores were taken with a split corer and transported to the laboratory in pint ice-cream cartons. Specimens were also collected with an aspirator and by sweeping vegetation with a white enameled pan. Some of the more slug-

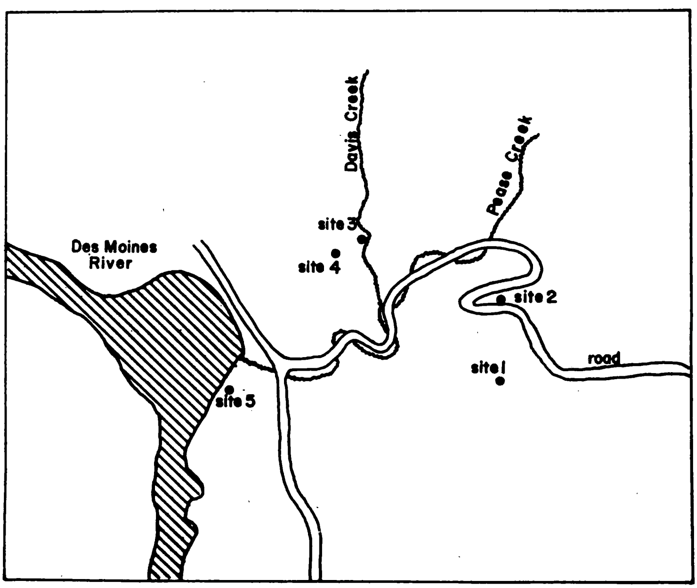

Figure 1. Location of sampling sites at Ledges State Park, Boone County, Iowa.

gish Collembola were captured with a brush dipped in alcohol.

Systematic Sampling. In addition to general collecting, a systematic study of collembolan populations was made at the Ledges State Park, Boone County, Iowa. Topographically, this park is characterized by upland, cliff, and flood plain regions. For this study five collection sites were chosen that differed in location and microclimate (Fig. 1). Three cores were taken from each site on June 6, June 20, July 3, July 17, and July 31.

Site one was located in a prairie-like habitat near the entrance of the park, and the remaining sites were established in the Ledges' woodland. Site one vegetation consisted of forbs and grasses, which reached a maximum height of three feet. The soil was covered with a layer of dead grasses and was generally dry. The site was well-drained, and there were no nearby trees.

The second site was located on a hill between the upland and cliff areas. The soil surface was covered with small herbaceous and woody plants and a thin layer of leafy debris. Two collections were made at the original site, but a severe windstorm on June 29 felled several trees, which obscured the site. A new site nearby was subsequently established. Overhead canopy cover was reduced to 80 percent after the storm.

Site three was located on an elevated strip of land between a creek bed and a sandstone cliff. The soil was very sandy and covered by a layer of leaves and a small decayed log. Overhead canopy cover was nearly 100 percent.

The fourth site was located on the bottom of a small ravine several hundred feet up the hill from the stream bed of site three. Overhead canopy cover for the first two collections was 100 percent but was reduced to 50 percent after the June 29 windstorm. Soil was relatively moist because of run-off after heavy rains. The soil surface was intermittently covered by leaf litter and short vegetation.

Site five was established in the flood plain of the Des Moines River. Samples were taken from both sides of a large fallen log and amid decaying bark and branches. Except for tall herbaceous weeds completely shading the soil, the soil surface was bare. Overhead canopy cover was estimated at 75 percent.

Identification and Preservation of Specimens. In the laboratory soil cores from the sampling sites were placed in modified Tullgren funnels for extraction of specimens. Temporary and permanent microscope slides were made for identification purposes, and specimens were stored in 95-percent ethanol.

Results and Discussion

Species Collected. Sixty-five collembolan species were collected.

Table 1 lists those species collected at the Ledges State Park. Additional species collected in other portions of the state were:

1. *Bourletiella hortensis* (Fitch)
2. *Entomobrya nivalis* (Linnaeus)
3. *Isotoma trispinata* MacGillivray
*4. *Lepidocyrtus lanuginous albicans* (Reuter)
5. *Megalothorax minimus* Willem
6. *Mesaphorura krausbaueri* Börner
7. *Orchesella hexfasciata* (Harvey)
*8. *O. villosa* (Geoffroy)
9. *Podura aquatica* (Linnaeus)
10. *Pseudisotoma sensibilis* (Tullberg)
11. *Pseudosinella octopunctata* Börner
12. *Psyllaphorura obesa* (Mills)
*13. *Salina banksii* MacGillivray
14. *Sminthurinus quadrimaculatus* (Ryder)
15. *Smithurus medialis* Mills
16. *Sphyrotheca curvisetis* (Guthrie)
17. *Willowsia nigromaculata* (Lubbock)

Based on Salmon's classification (Salmon, 1964), species collected were representative of all collembolan suborders and belonged to the families: Onychiuridae, Hypogastruridae, Brachystomellidae, Anuridae, Neanuridae, Tomoceridae, Isotomidae, Entomobryidae, Poduridae, Neelidae, and Sminthuridae.

Eleven species are not known to have been reported from Iowa and are indicated by an asterisk in the aforementioned species lists. Two species of the genera *Xenyllodes* and *Tetracanthella*, respectively, and another of a genus near *Tetracanthella* could not be identified with available taxonomic keys and were believed new.

Comparison of Sites at the Ledges State Park. Sampling sites at the Ledges State Park were compared by using cluster analyses (Sokal and Sneath, 1963). For analysis, the weighted pair-group method was used to compare sites according to species presence and according to a combination of species presence and quantity.

For presence comparisons, coefficients of association were first calculated for species presence between all possible pair combinations of the 5 sites. The following formula used for calculation is somewhat similar to that of Kulczynski (1927)[4]:

$$CA = \frac{c}{N_1 + N_2 - c}$$

In the formula, CA = coefficient of association, c = number of species in common to compared sites, N_1 = total number of

[4] Kulczynski used an equivalent of 2c in the denominator.

species at one site, and N_2 = total number of species at a second site.

Fig. 2 presents the results of a cluster analysis based on a matrix of CA values. As might be expected, site one was most dissimilar from the woodland sites. Three species, *B. stachi, E. bicolor,* and *P. s. colorata,* were collected only in this grassland site, contributing to its total dissimilarity from the woodland sites. The fauna of the woodland sites was not homogeneous, however, showing relatively low similarity percentages (56 percent similarity for sites three and four and 44 percent similarity for sites two and five).

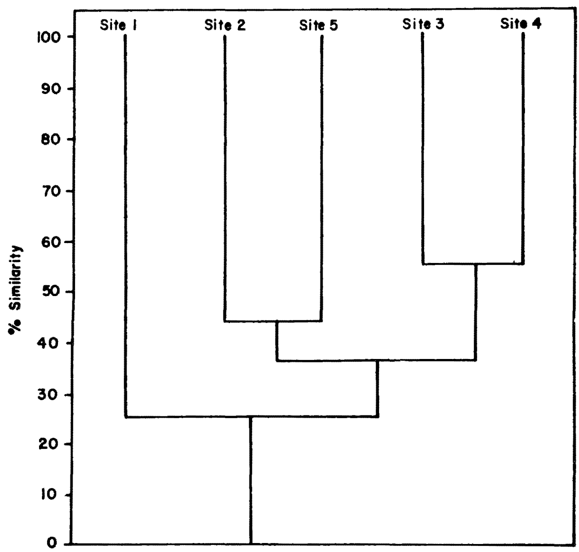

Figure 2. Dendrogram of cluster analysis based upon presence of collembolan species.

For species quantity comparisons, prominence values (PV) were first calculated for each species at each site with the following formula (Beals, 1960):

$$PV = \text{density} \sqrt{\text{frequency}}$$

where: PV = prominence value, density = $\dfrac{\text{total number of individuals collected}}{\text{total number of site collections}}$,

$$\text{frequency} = \frac{\text{number of collecting periods when species were collected}}{\text{total number of collecting periods}}$$

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Table 1. Prominence values of Collembola collected at the Ledges State Park.

	Species	Site 1	Site 2	Site 3	Site 4	Site 5	Total Species
1.	*Arrhopalites binoculatus* (Börner)	—	0.25	0.62	0.09	1.86	2.82
2.	*A. caecus* (Tullberg)	—	—	—	—	0.50	0.50
3.	*Bagnallella prima* Mills	—	0.18	—	—	0.76	0.94
4.	*Brachystomella stachi* Mills	1.26	—	—	—	—	1.26
5.	*Deuterosminthurus repandus* (Agren)	—	0.09	—	—	—	0.09
* 6.	*Dicyrtoma flammea* Maynard	—	—	0.09	0.09	—	0.18
* 7.	*Entomobrya atrocincta* Schött	0.25	—	—	—	0.09	0.34
8.	*E. bicolor* Guthrie	0.09	—	—	—	—	0.09
9.	*Entomobryoides purpurascens* (Packard)	0.45	0.09	0.09	—	0.93	1.56
10.	*Folsomia fimetaria* (Linnaeus)	0.89	49.20	21.60	14.20	10.90	96.79
11.	*Folsomides parvus* (Folsom	0.09	6.26	21.80	1.40	4.83	34.38
12.	*Friesa claviseta* Axelson	0.09	—	0.09	—	—	0.18
13.	*Handschiniella parvicornis* (Mills)	4.18	2.05	—	0.63	—	6.86
14.	*Hypogastrura armata* (Nicolet)	0.09	0.25	13.40	0.18	0.09	14.01
15.	*H. matura* (Folsom)	—	—	—	1.30	—	1.30
*16.	*H. pseudarmata* (Folsom)	—	0.09	—	—	—	0.09
17.	*Isotoma eunotabilis* Folsom	28.80	53.00	12.80	1.86	0.95	97.41
18.	*I. viridis* Bourlet	—	0.98	—	—	1.35	2.33
19.	*Isotomurus palustris* (Müller)	—	—	—	—	6.05	6.05
20.	*Lepidocyrtus cyaneus* Tullberg	5.00	27.80	0.62	—	1.30	34.72
21.	*L. cyaneus cinereus* Folsom	6.20	0.36	—	—	0.09	6.65
*22.	*Megalothorax maculosus* Maynard	—	0.98	8.40	38.00	—	47.38
23.	*Mesaphorura* near *collis* (Bacon)	—	6.45	20.80	5.90	59.60	92.75
24.	*Micranurida pygmaea* Börner	5.36	6.10	—	—	—	11.46

Table 1. (continued). Prominence values of Collembola collected at the Ledges State Park.

	Species	Site 1	Site 2	Site 3	Site 4	Site 5	Total Species
25.	*Neanura barberi* (Handschin)	—	—	6.20	0.46	21.60	28.26
26.	*N. muscorum* (Templeton)	—	—	0.09	0.09	2.00	2.18
27.	*Neelides minutus* (Folsom)	—	0.54	6.60	8.80	—	15.94
28.	*Odontella* near *cornifer* Mills	—	—	0.18	—	—	0.18
29.	*Orchesella ainsliei* Folsom	12.40	4.80	0.09	—	—	17.29
*30.	*O. zebra* Guthrie	—	0.25	0.62	—	0.09	0.96
31.	*Paranura sexpunctata colorata* Mills	0.18	—	—	—	—	0.18
32.	*Pseudachorutes corticolus* (Schaeffer)	028	—	—	—	0.18	0.46
33.	*P.* near *lunatus* Folsom	5.90	0.93	0.09	—	1.40	8.32
34.	*P.* near *subcrassoides* Mills	—	0.09	—	—	0.13	0.22
35.	*Pseudosinella violenta* (Folsom)	16.80	3.35	—	—	28.40	48.55
36.	*Ptenothrix marmorata* (Packard)	—	—	—	—	0.09	0.09
37.	*P. unicolor* (Harvey)	—	—	0.72	0.93	0.25	1.90
38.	*Sminthurides lepus* Mills	—	—	0.25	1.97	—	2.22
39.	*S. malmgreni* (Tullberg)	3.56	—	—	—	0.25	3.81
40.	*S. occultus* Mills	0.45	—	0.62	—	—	1.07
41.	*Sminthurinus aureus* (Lubbock)	—	—	—	—	0.09	0.09
42.	*S. similitortus* Maynard	—	0.09	—	0.18	—	0.27
43.	*Sphaeridia pumilis* (Krausbauer)	0.50	0.72	0.46	0.09	0.38	2.15
44.	*Sphyrotheca minnesotensis* Guthrie	—	0.25	0.09	—	—	0.34
*45.	*Tetracanthella* species	—	5.12	—	—	6.26	11.38
46.	*Tomolerus flavescens* Tullberg	1.24	—	0.18	0.38	25.00	26.80
*47.	*Xenyllodes* species	—	2.17	—	—	—	2.17
*48.	near *Tetracanthella* species	—	1.50	—	—	—	1.50

*Species not known to have been reported from Iowa.

Table 1 presents the PV of each species at the sites and species PV totals. The most prominent species in the study were *F. fimetaria, I. eunotabilis,* and *M.* near *collis.* Each of these species had a PV above 90.00 and was collected at all sites, excepting *M.* near *collis,* not found at site one. The remaining species of the study had relatively low PV's, and 11 were collected at only one site, emphasizing the heterogeneity of the sites.

Fig. 3 is a bar graph of the total PV at each site. Site two, an upland site, and site five, the lowland flood plain site, had the highest values. Partly, this is due to the great number of species collected at these sites (Fig. 4), but also because of the consistently large numbers collected there.

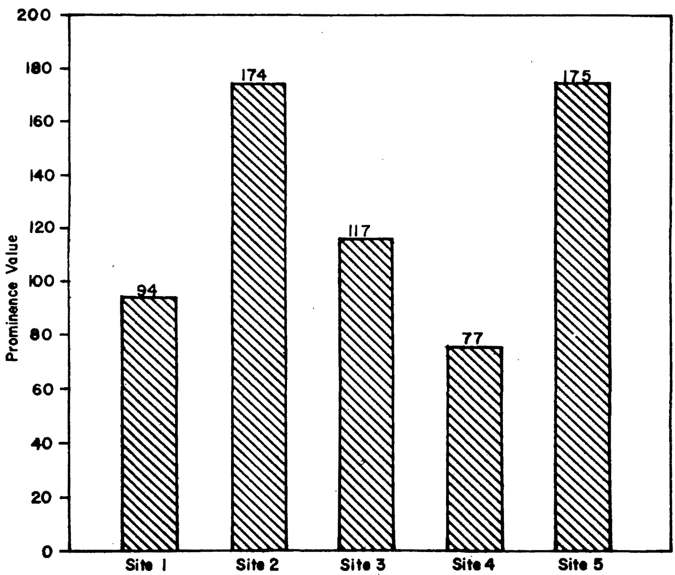

Figure 3. Total collembolan prominence value at each sampling site.

A cluster analysis of the sites, based on collembolan PV, was performed by computing a coefficient of similarity and using the previously mentioned weighted pair-group method. The coefficient of similarity was computed for all possible site comparisons with the formula (Beals, 1960):

$$C = \frac{2w}{a+b}$$

where: C = coefficient of similarity, w = the sum of the lowest PV of each species in common to the two compared sites, a = sum

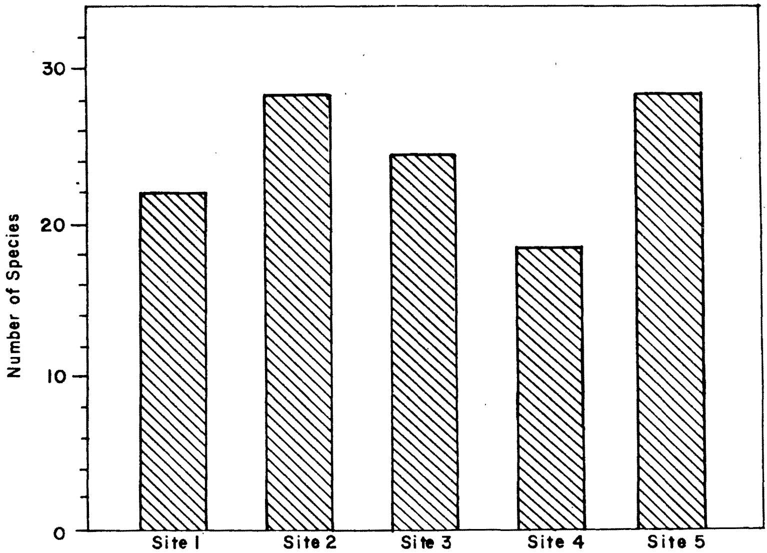

Figure 4. Total number of collembolan species collected at each sampling site.

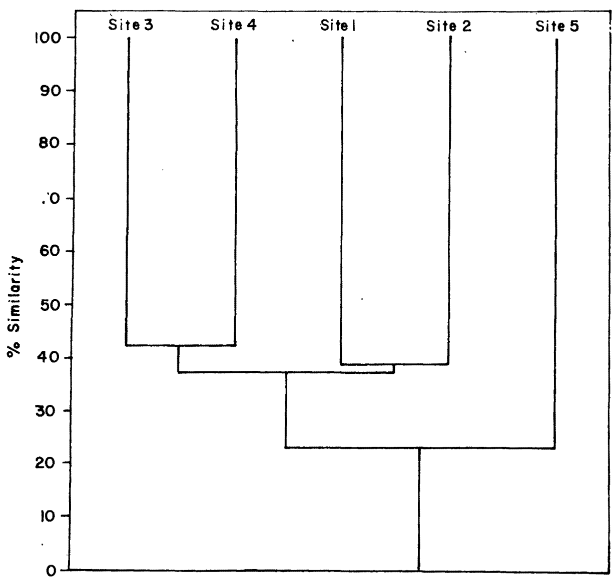

Figure 5. Dendrogram of cluster analysis based upon collembolan prominence values.

of the prominence values for all species from the first site, and b = sum of the prominence values for all species at the second site.

Fig. 5 is a dendrogram of the PV cluster analysis. The flood plain site, site five, is quite dissimilar, joining the remaining sites at only the 22-percent level of similarity. The species contributing most to this dissimilarity were two true-soil species, *N. barberi* and *M.* near *collis,* and a surface inhabiting species, *T. flavescens* (Table 1). These species had high PV's at site five relative to their occurrence at other sites, thus adding to high denominator values when computing coefficients of similarity. Environmentally, site five was most diverse from the other collecting sites, owing to its general lack of soil-surface cover. This factor probably had a marked influence on the numbers and kinds of Collembola collected there. Sites three and four were the most similar to one another (Fig. 5), despite overt environmental differences in soil type and topography.

The analyses of data in this study did not conclusively indicate factors influencing presence and numbers of Collembola. They do show, however, the great heterogeneity in populations within a relatively small area. From information gained in this study, we believed that conclusive evidence of environmental influences on collembolan populations can be achieved only through further faunal investigations and, especially, autecological studies.

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